Fitting ecosystem service assessment into LCA

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EAAP 29 aug 2016, Belfast

Agenda

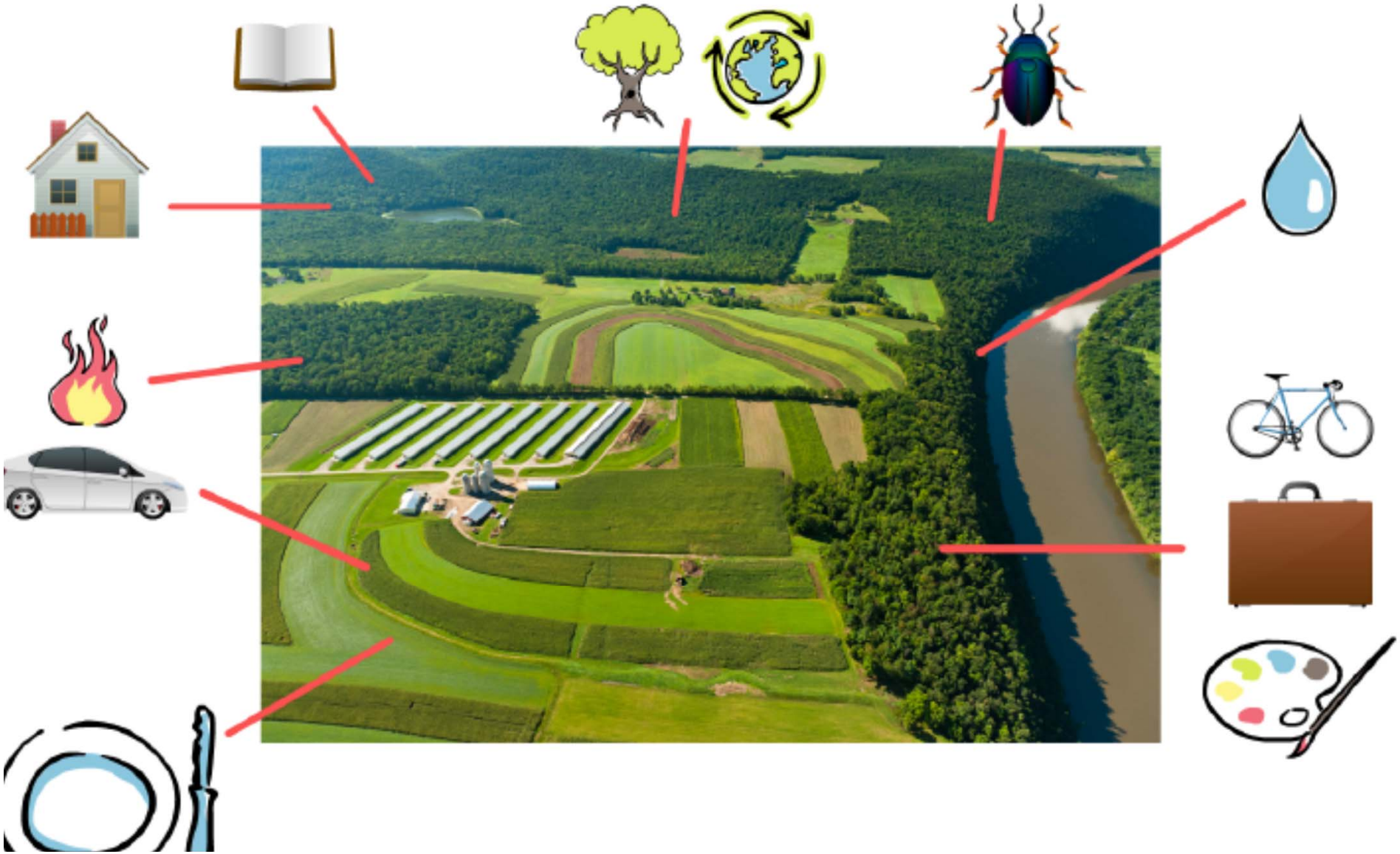
- Introduction – ecosystem services
- Impact Assessment in LCA
- UNEP-SETAC guidelines on Land Use Impact Assessment

- Impacts on ecosystem services in case study of animal protein production in Sweden – testing the guidelines
- Discussion and reflection on reference situation

- Short reflection around scale and ecosystem service assessment
- Short reflection around complex food chains and ecosystem service assessment

Ecosystem services

The benefits people obtain from ecosystems




Provisioning
Regulating
Cultural
Supporting

Provisioning

CICES 2013			TEEB 2010	MEA 2003	Costanza 1997
Nutrition	Biomass	Cultivated crops	• Food	• Food	• Food production
		Reared animals and their outputs			
		Wild plants, algae and their outputs			
		Wild animals and their outputs			
		Plants and algae from in-situ aquaculture			
		Animals from in-situ aquaculture			
	Water	Surface water for drinking	• Fresh water	• Fresh water	• Water supply
		Ground water for drinking			
Materials	Biomass	Fibres and other materials from plants, algae and animals for direct use or processing	• Raw materials • Medicinal resources	• Fibre • Biochemicals, natural medicines, and pharmaceuticals • Ornamental resources	• Raw materials
		Materials from plants, algae and animals for agricultural use			
		Genetic materials from all biota	• Maintenance of genetic diversity	• Genetic resources	• Genetic resources
	Water	Surface water for non-drinking purposes	• Fresh water	• Fresh water	• Water supply
		Ground water for non-drinking purposes			
Energy	Biomass-based energy sources	Plant-based resources	• Raw materials	• Fuel	• Raw materials
		Animal-based resources			
	Mechanical energy	Animal-based energy			

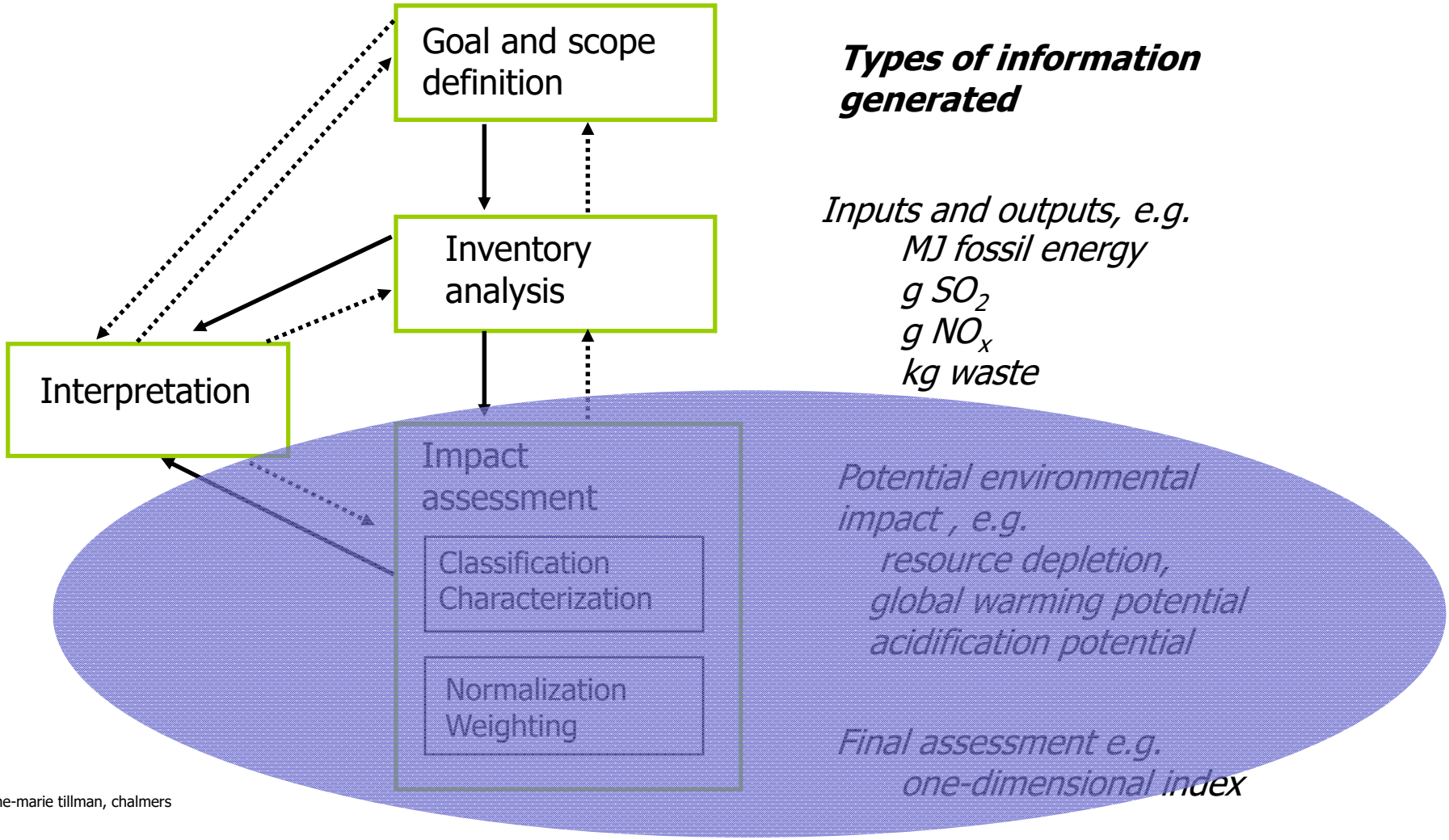
Regulating Supporting

CICES 2013			TEEB 2010	MEA 2003	Costanza 1997
Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	• Waste-water treatment • Local climate and air quality	• Water purification and waste treatment • Air quality regulation	• Waste treatment • Gas regulation
		Filtration/sequestration/ storage/accumulation by micro-organisms, algae, plants, and animals			
	Mediation by ecosystems	Filtration/sequestration/ storage/accumulation by ecosystems			
		Dilution by atmosphere, freshwater and marine ecosystems			
		Mediation of smell/noise/visual impacts			
Mediation of flows	Mass flows	Mass stabilization and control of erosion rates	• Erosion prevention	• Erosion regulation	• Erosion control and sediment retention
		Buffering and attenuation of mass flows			
	Liquid flows	Hydrological cycle and water flow maintenance	• Fresh water	• Water regulation • Water cycling	• Water regulation
		Flood protection	• Moderation of extreme events	• Natural hazard regulation	• Disturbance regulation
	Gaseous / air flows	Storm protection			
		Ventilation and transpiration			
Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination and seed dispersal	• Pollination	• Pollination	• Pollination
		Maintaining nursery populations and habitats	• Habitats for species		• Refugia
	Pest and disease control	Pest control	• Biological control	• Pest regulation	• Biological control
		Disease control		• Disease regulation	
	Soil formation and composition	Weathering processes	• Maintenance of soil fertility	• Soil formation • Nutrient cycling	• Soil formation • Nutrient cycling
		Decomposition and fixing processes			
	Water conditions	Chemical condition of freshwaters	• Habitats for species		
		Chemical condition of salt waters			
	Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations	• Carbon sequestration and storage	• Climate regulation	• Climate regulation • Gas regulation
		Micro and regional climate regulation	• Local climate and air quality	• Air quality regulation • Climate regulation	

Cultural

CICES 2013			TEEB 2010	MEA 2003	Costanza 1997
Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Physical and experiential interactions	Experiential use of plants, animals and land-/seascapes in different environmental settings	• Recreation and mental and physical health • Tourism	• Recreation and ecotourism	• Recreation
		Physical use of land-/seascapes in different environmental settings			
	Intellectual and representative interactions	Scientific	• Aesthetic appreciation and inspiration for culture, art and design	• Knowledge systems, • Educational values • Cultural diversity	• Cultural
		Educational		• Cultural diversity • Social relations • Cultural heritage values	
		Heritage, cultural			
		Entertainment			
		Aesthetic		• Aesthetic values	
Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Spiritual and/or emblematic	Symbolic	• Spiritual experience and sense of place	• Spiritual and religious values • Sense of place	
		Sacred and/or religious			
	Other cultural outputs	Existence			
		Bequest			

Life Cycle Impact assessment - LCIA



Types of information generated

Inputs and outputs, e.g.
MJ fossil energy
g SO_2
g NO_x
kg waste

Potential environmental impact , e.g.
resource depletion,
global warming potential
acidification potential

Final assessment e.g.
one-dimensional index

What is LCIA?

- a *translation* of LCI results (*many* parameters)
- into potential contribution to environmental impacts (for a *limited* number of impact categories)
- to help answer the questions of the goal definition

$$IS_{i,j} = \sum Q_i \times CF_{i,j}$$

Exampel impact category Climate Change

g CO2-eq = gr CH4 · $GWP_{100(CH4)}$

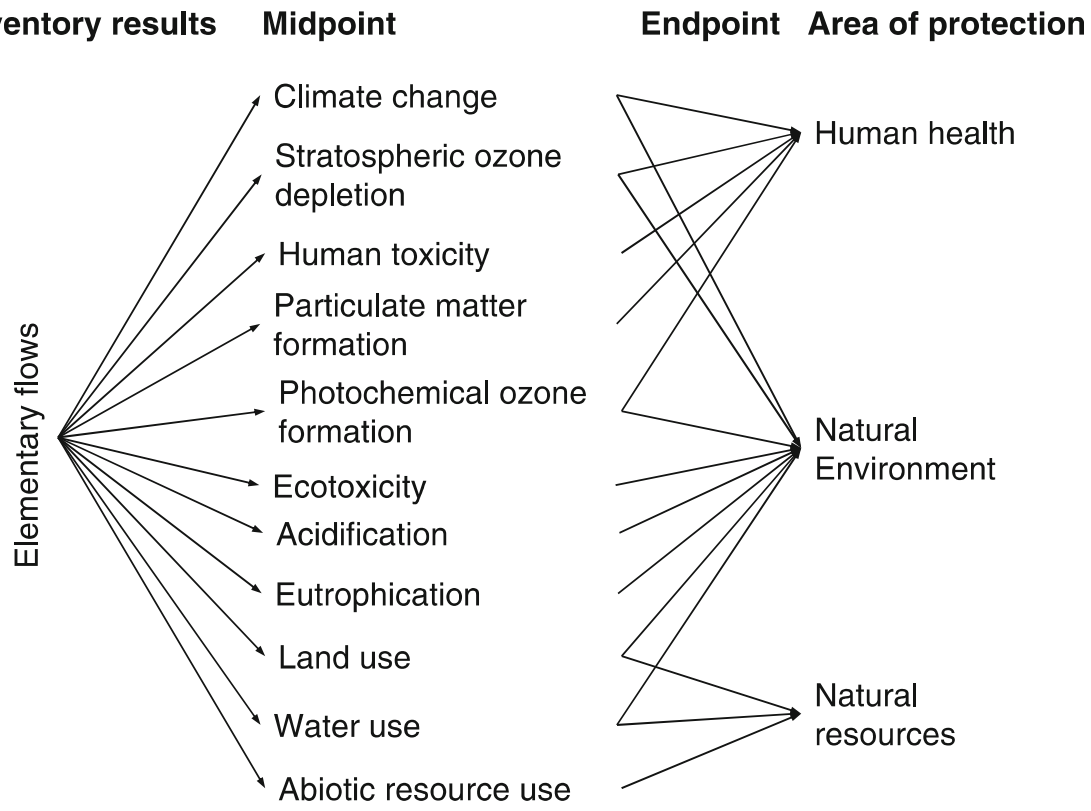
where

$IS_{i,j}$=contribution to impact score for impact category *j* from elementary flow *i*

Q=quantity elementary flow *i* (emission or resource use, inventory results)

CF = characterisation factor for elementary flow *i* to impact category *j*

LATEST RECOMMENDATION FOR IMPACT CATEGORIES – ILCD



Source: Hauschild and Huijbregts, LCA compendium on Life cycle impact assessment, Springer 2015

Land use impact assessment in LCA – the work of UNEP-SETAC

- The UNEP-SETAC Life Cycle Initiative's guideline provides **general principles** aimed at supporting comprehensive and consistent assessments of impacts due to **land use and land use change** in LCA.

GLOBAL LAND USE IMPACTS ON BIODIVERSITY AND ECOSYSTEM SERVICES IN LCA

UNEP-SETAC guideline on global land use impact assessment on biodiversity and ecosystem services in LCA

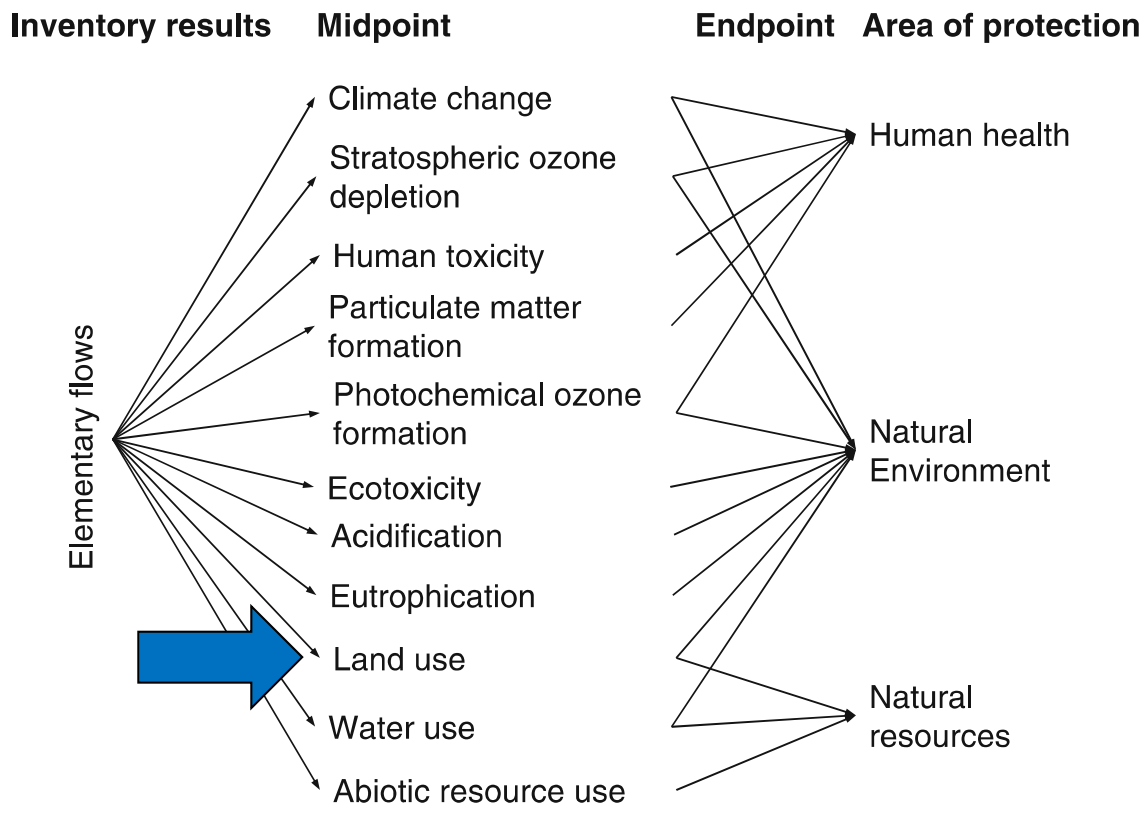
Thomas Koellner · Laura de Baan · Tabea Beck · Miguel Brandão · Barbara Civit · Manuele Margni · Llorenç Milà i Canals · Rosie Saad · Danielle Maia de Souza · Ruedi Müller-Wenk

Received: 14 June 2011 / Accepted: 2 April 2013 / Published online: 1 May 2013

Abstract
Purpose As a consequence of the multi-functionality of land, the impact assessment of land use in Life Cycle Impact Assessment requires the modelling of several impact pathways covering biodiversity and ecosystem services. To provide consistency amongst these separate impact pathways, general principles for their modelling are provided in this paper. These are refinements to the principles that have already been proposed in publications by the UNEP-SETAC Life Cycle Initiative. In particular, this paper addresses the calculation of land use interventions and land use impacts, the issue of impact reversibility, the spatial and temporal distribution of such impacts and the assessment of absolute or relative ecosystem quality changes. Based on this we propose a guideline to build methods for land use impact assessment in Life Cycle Assessment (LCA).
Results Recommendations are given for the development of new characterization models and for which a series of key elements should explicitly be stated, such as the modelled land use impact pathways, the land use/cover typology covered, level of biogeographical differentiation used for the characterization factors, the reference land use situation used and relative or absolute quality changes are used to calculate

KOELLNER, T. et al. 2013. UNEP-SETAC guideline on global land use impact assessment on biodiversity and ecosystem services in LCA. ***The International Journal of Life Cycle Assessment,*** **18, 1188-1202**

LATEST RECOMMENDATION FOR IMPACT CATEGORIES – ILCD



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Land Use

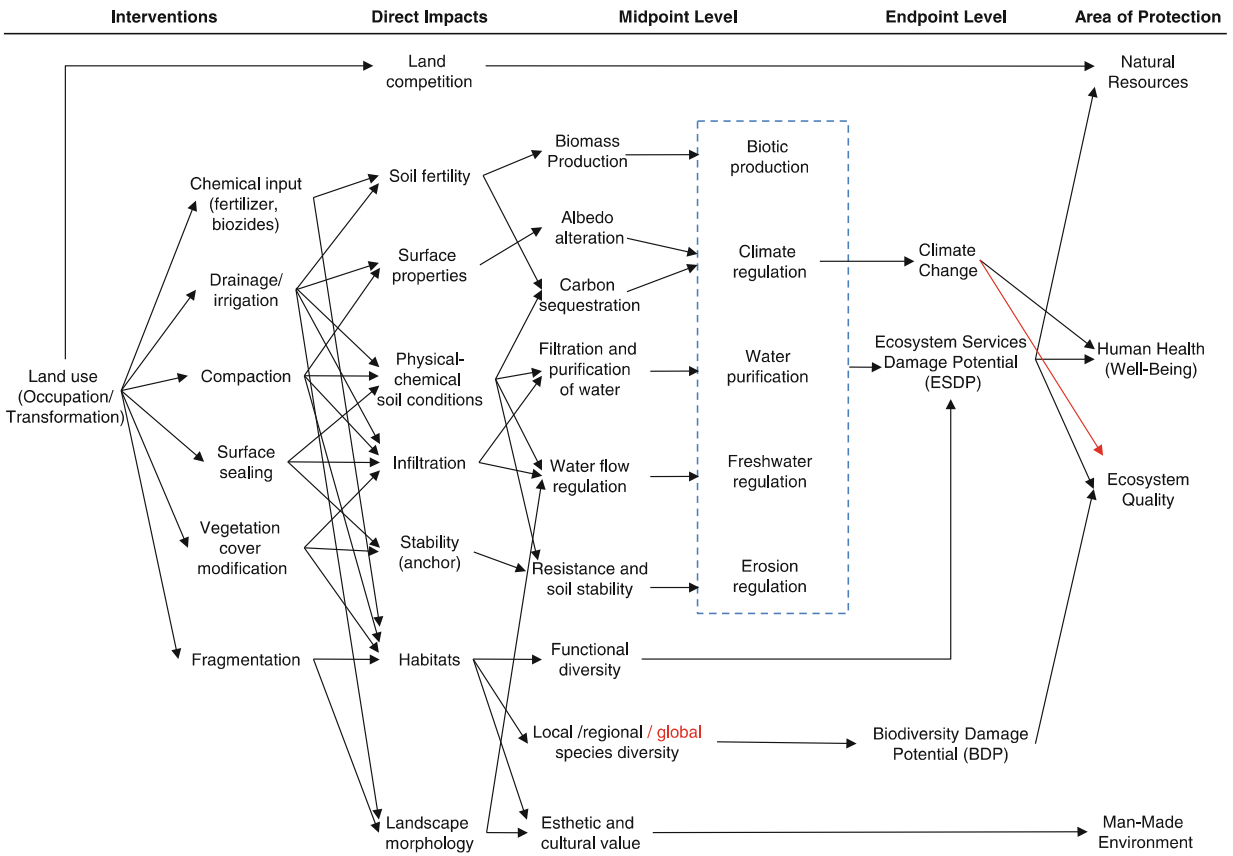


Fig. 11.2 Impact pathways from land use interventions to impacts on biodiversity and ecosystem services. Based on Koellner et al. (2013a), main modifications are marked in *red*. At the midpoint level most impacts should refer to land's 'capacity' (e.g. biomass productive capacity, see Koellner et al. 2013a), but the labels have been simplified for clarity

Framework exists

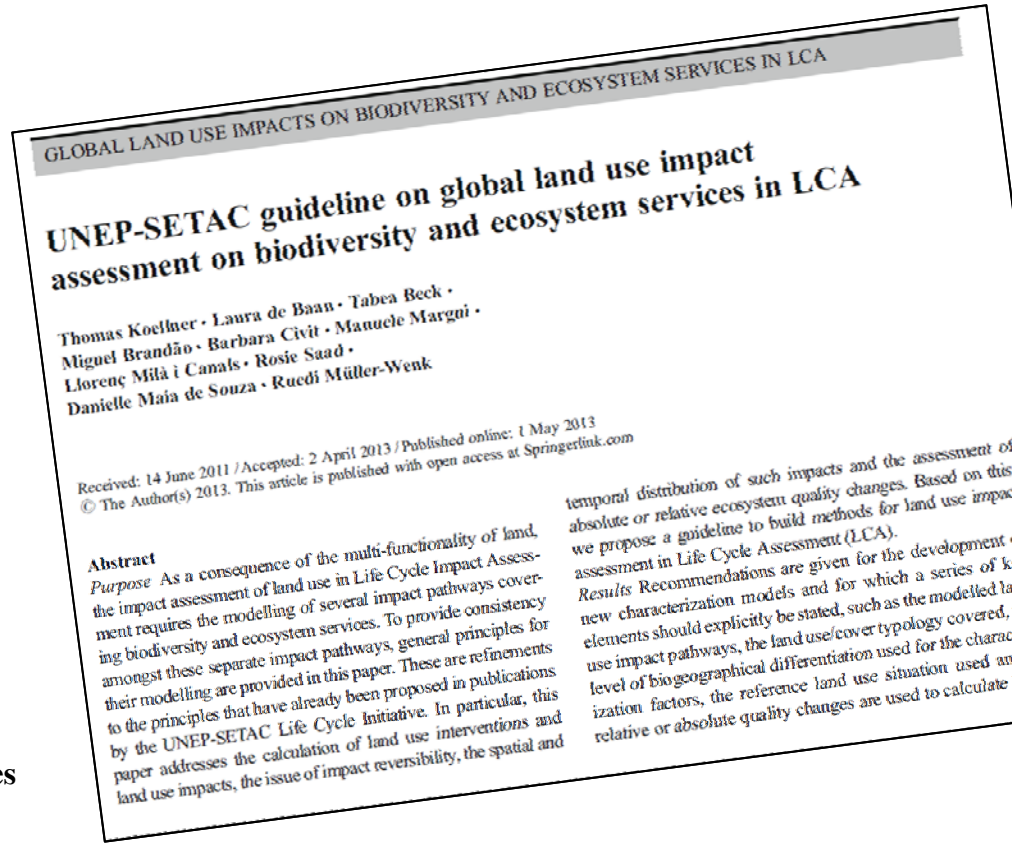
... plus proposals...

... largely untested...

Source: Hauschild and Huijbregts, LCA compendium on Life cycle impact assessment, Springer 2015

Land use impact assessment in LCA – the work of UNEP-SETAC

- Has published **ready-to-use characterization factors** for land use impacts on biodiversity and selected ecosystem services, at the **biome level**.
- CFs are available for **five ecosystem services**, measured by ecosystem service **indicators.**
- Impacts are assessed in relation to a **reference situation**.



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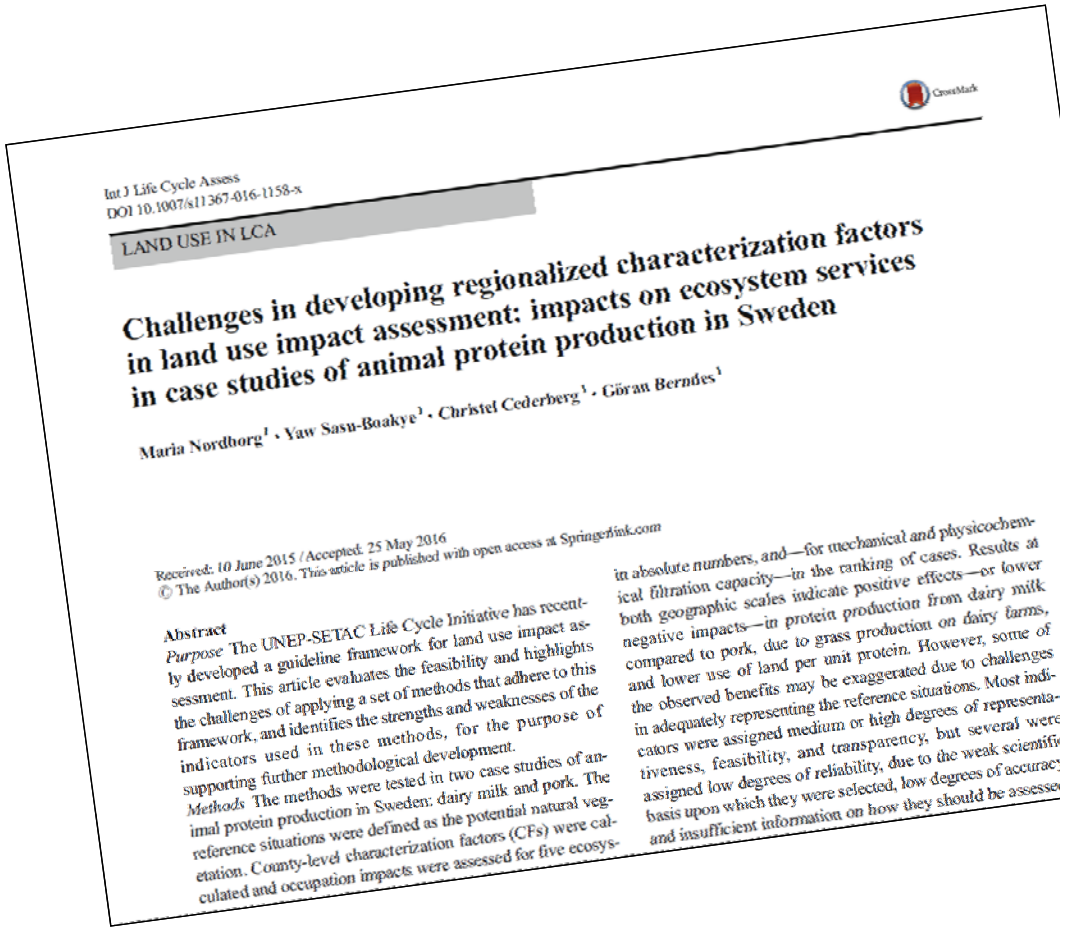
KOELLNER, T. et al. 2013. UNEP-SETAC guideline on global land use impact assessment on biodiversity and ecosystem services in LCA. ***The International Journal of Life Cycle Assessment,*** **18, 1188-1202**

Impat on ecosystem services in case study of animal protein production – recent paper where we:

- **Test and evaluate the land use impact assessment models and** ecosystem service indicators recently proposed by UNEP-SETAC.
- Develop **regionalized CFs**
- Focus on **the use of reference situations**.



Int J Life Cycle Assess
DOI 10.1007/s11367-016-1158-x

LAND USE IN LCA

Challenges in developing regionalized characterization factors in land use impact assessment: impacts on ecosystem services in case studies of animal protein production in Sweden

Maria Nordborg[1] · Yaw Sasu-Boakye[1] · Christel Cederberg[1] · Göran Berndes[1]

Received: 10 June 2015 / Accepted: 25 May 2016

Abstract

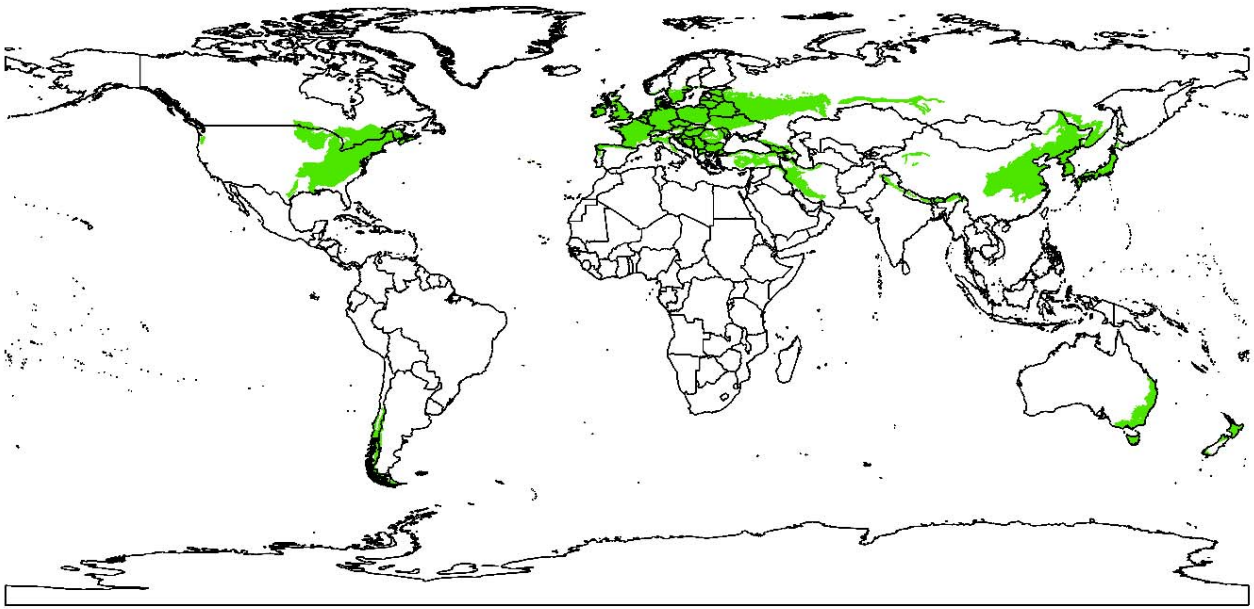
Purpose The UNEP-SETAC Life Cycle Initiative has recently developed a guideline framework for land use impact assessment. This article evaluates the feasibility and highlights the challenges of applying a set of methods that adhere to this framework, and identifies the strengths and weaknesses of the indicators used in these methods, for the purpose of supporting further methodological development.

Methods The methods were tested in two case studies of animal protein production in Sweden: dairy milk and pork. The reference situations were defined as the potential natural vegetation. County-level characterization factors (CFs) were calculated and occupation impacts were assessed for five ecosys-

in absolute numbers, and—for mechanical and physicochemical filtration capacity—in the ranking of cases. Results at both geographic scales indicate positive effects—or lower negative impacts—in protein production from dairy farms, compared to pork, due to grass production on dairy farms, and lower use of land per unit protein. However, some of the observed benefits may be exaggerated due to challenges in adequately representing the reference situations. Most indicators were assigned medium or high degrees of representativeness, feasibility, and transparency, but several were assigned low degrees of reliability, due to the weak scientific basis upon which they were selected, low degrees of accuracy and insufficient information on how they should be assessed

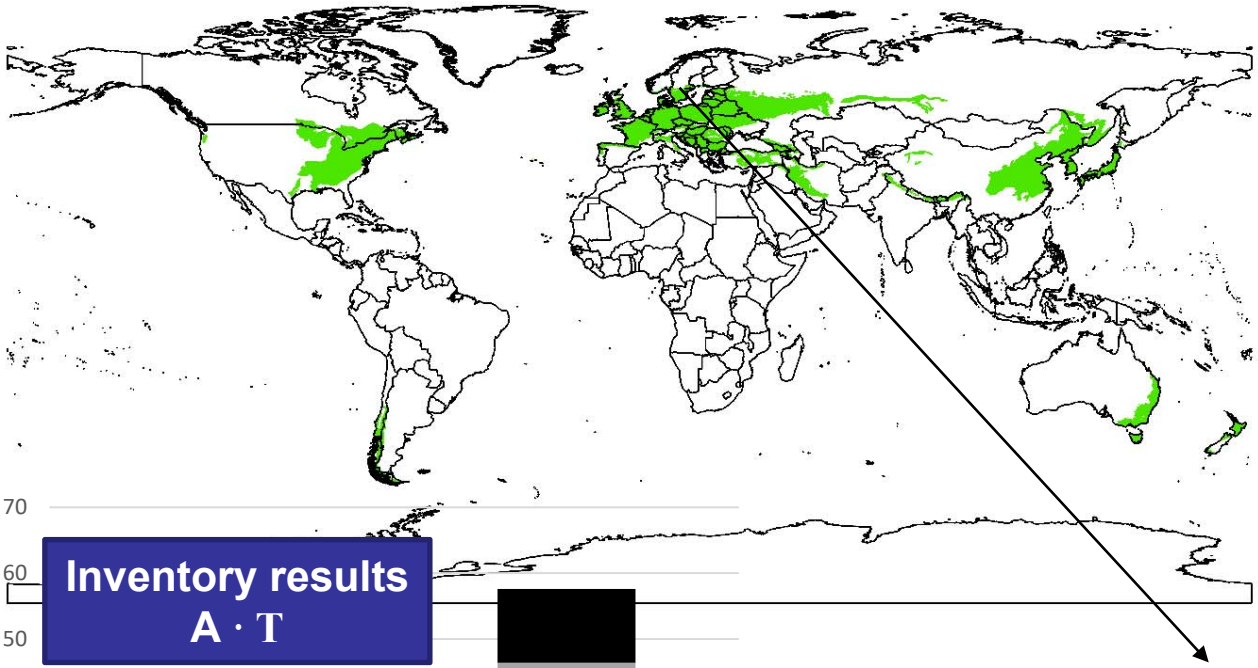
Nordborg M, Sasu-Boakye Y, Cederberg C, Berndes G. 2016
Int J Life Cycle Assess DOI 10.1007/s11367-016-1158-x

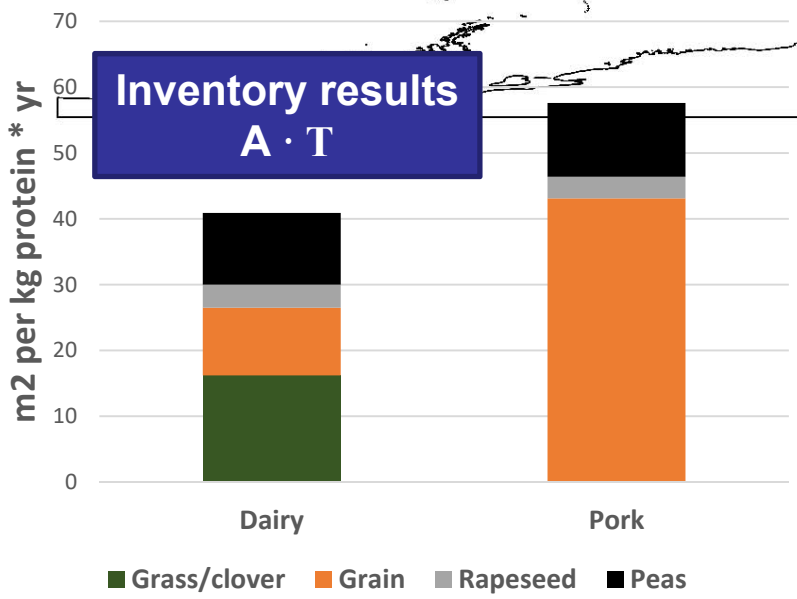
UNEP-SETAC guidelines give CFs at biome level for land use impact assessment: impacts on ecosystem services

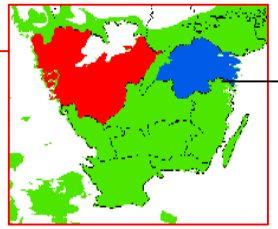


Biome 4
Temperate, broadleaf forest

Case study: Comparing ecosystem service impact due to production of animal protein in Sweden







Case dairy (West)

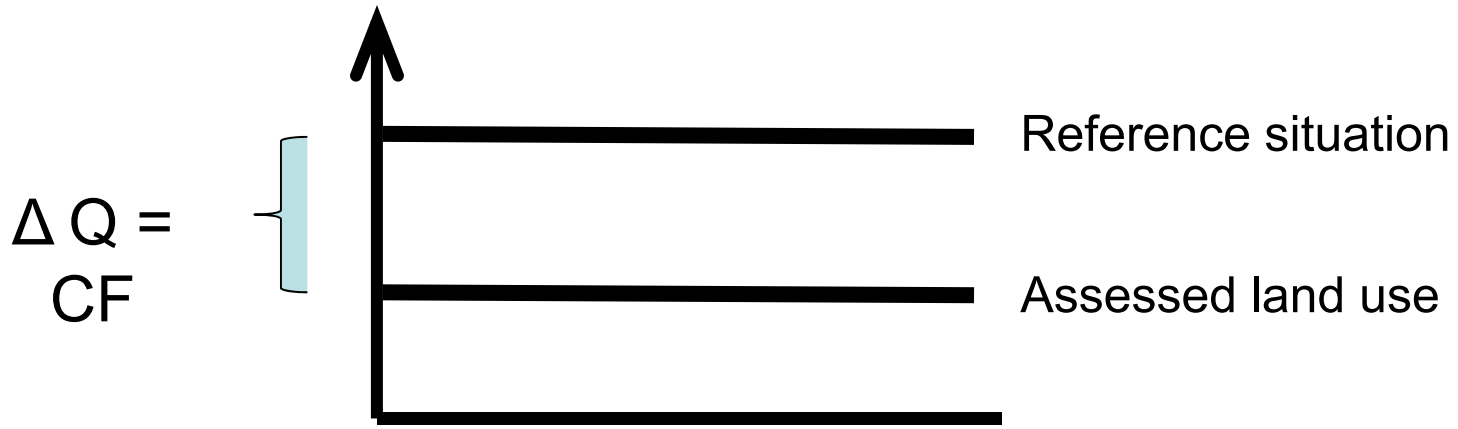
Case pork, (East)

1 kg animal protein from….

Principal for calculating a characterisation factor in land use impact assessment (UNEP SETAC)

Land occupation impact =
CF (Δ Q) · A ·T

Q: Quality of ecosystem serivce



Quality of Ecosystem service

Reference situation

Current land use

For reference situation, we chose the **potential natural vegetation (PNV),** defined as the expected state of mature vegetation in the absence of human intervention

Broadleaf forest based on records of historic vegetation

How to parameterize PNV?
- suggested approach:

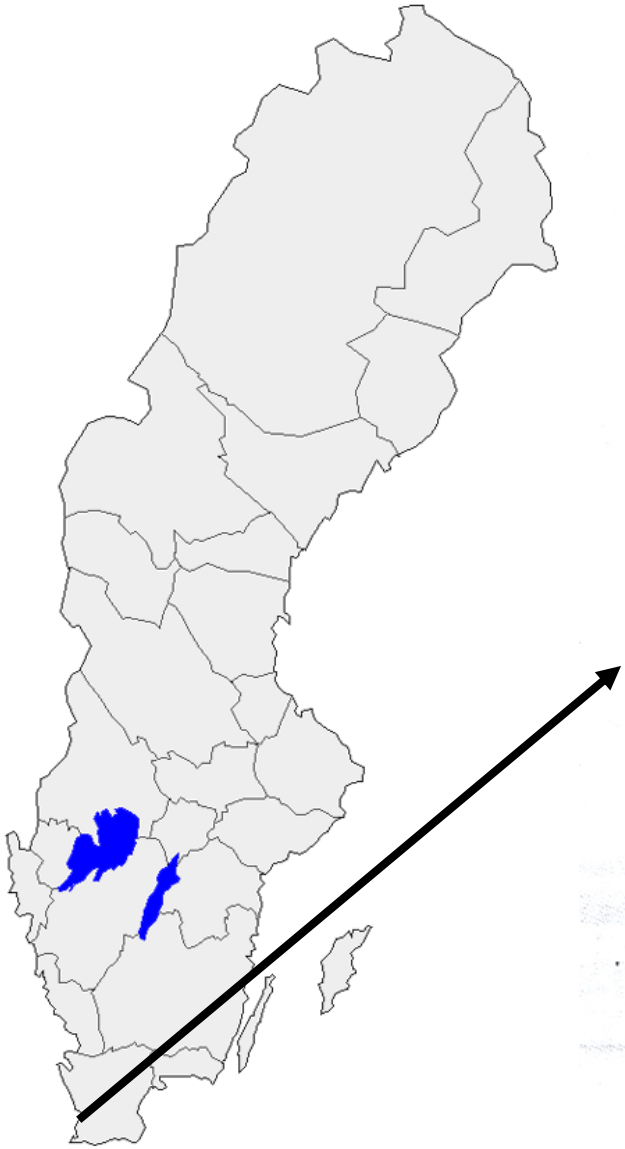
interpolate data from neighboring land areas that are representative for the reference situation

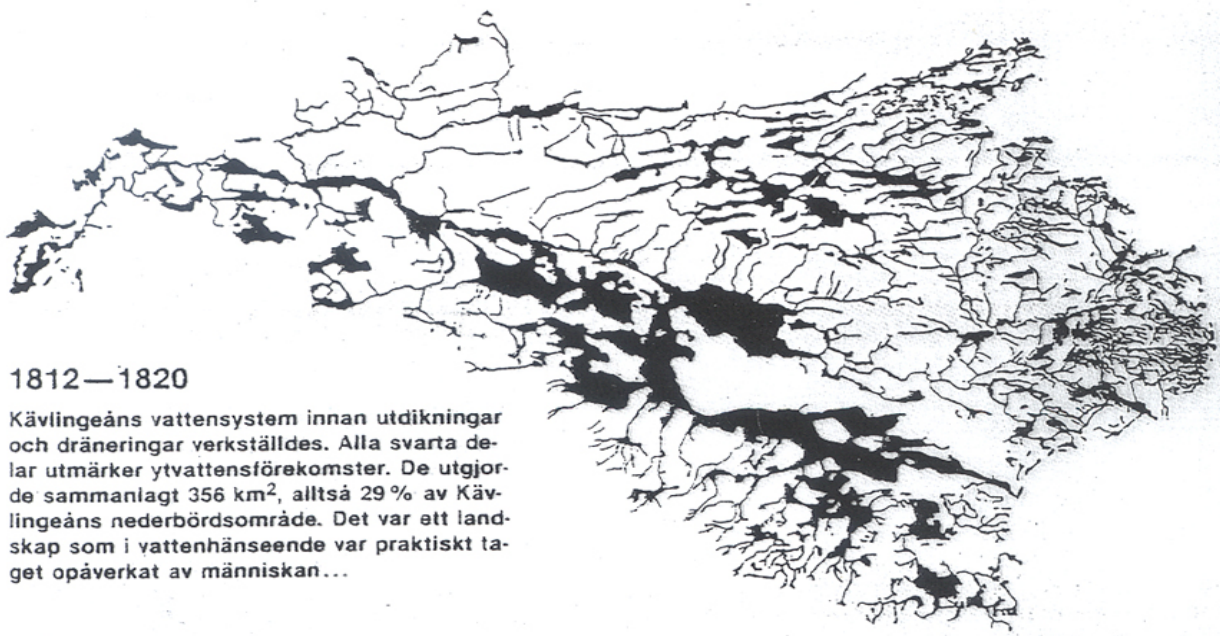
Main input parameters for calculating characterization factors (CF)

Ecosystem service	Ecosystem service indicator	Main input parameters
Climate regulation	Carbon flow change	Soil organic carbon stock (1 m), carbon stock in vegetation
Freshwater regulation	Groundwater recharge	Evapotranspiration, precipitation, distance from surface to groundwater, slope
Freshwater purification	Mechanical filtration capacity	Soil texture, distance from surface to groundwater
	Physicochemical filtration capacity	Effective cation exchange capacity (CEC_{eff})
Erosion prevention	Soil loss (LANCA)	Slope, soil texture, precipitation, soil stone content, soil organic matter content
	Soil loss (RUSLE)	Rainfall runoff erosivity, soil erodibility, slope length, slope steepness, cover management, supporting farm practices
Biotic production potential	Soil organic carbon	Soil organic carbon stock (30 cm)

Model LANCA used for calculating several ecosystem services related to soil quality

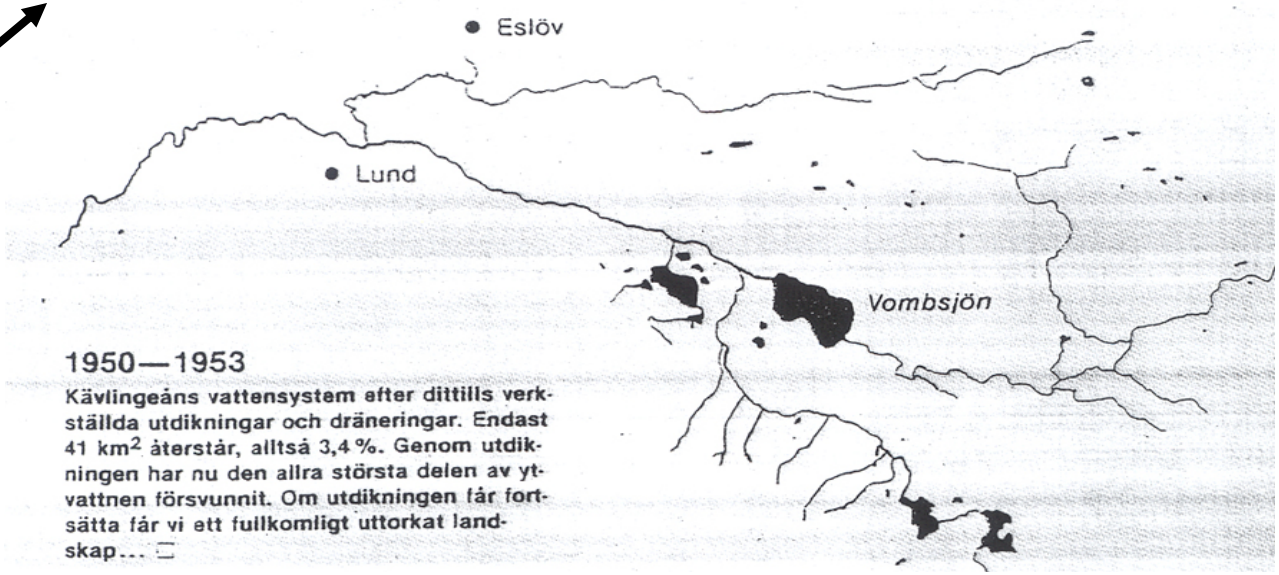
Problems with data setting the reference – example water drainage





1812—1820

Kävlingeåns vattensystem innan utdikningar och dräneringar verkställdes. Alla svarta delar utmärker ytvattensförekomster. De utgjorde sammanlagt 356 km^2, alltså 29 % av Kävlingeåns nederbördsområde. Det var ett landskap som i vattenhänseende var praktiskt taget opåverkat av människan...



1950—1953

Kävlingeåns vattensystem efter dittills verkställda utdikningar och dräneringar. Endast 41 km^2 återstår, alltså 3,4 %. Genom utdikningen har nu den allra största delen av ytvattnen försvunnit. Om utdikningen får fortsätta får vi ett fullkomligt uttorkat landskap...

Short on results

- Protein production from dairy generally scored better than pork due to
  - Grassland
  - Lower land requirements
- Some positive effects (due to feed production) may be exagegerated due to problems with data for the reference situation (soil data)
- When regionalising LCIA for ecosystem services, practioner´s assumption on reference situation (e.g. data) can have a big impact on result and thereby make it difficult to compare different studies

What alternative reference situations exist?

- Soimakallio et al. (2015) identified **four types** of reference situations:
  - Zero baseline
  - Business as usual
  - Natural or quasi-natural steady state
  - Natural regeneration
- The UNEP-SETAC guideline mentions **three options:**
  - Potential natural vegetation (PNV)
  - Quasi-natural land cover (the natural mix of land cover)
  - The current mix of land uses
- Most biodiversity assessment methods recommend the PNV
- Other possible option: relate to a goal or a threshold (consider varying environmental conditions and sensitivities)

Ref: SOIMAKALLIO, S., COWIE, A., BRANDAO, M., FINNVEDEN, G., EKVALL, T., ERLANDSSON, M., KOPONEN, K. & KARLSSON, P. E. 2015. **Attributional life cycle assessment: is a land-use baseline necessary?** *International Journal of Life Cycle Assessment,* 20**,** 1364-1375

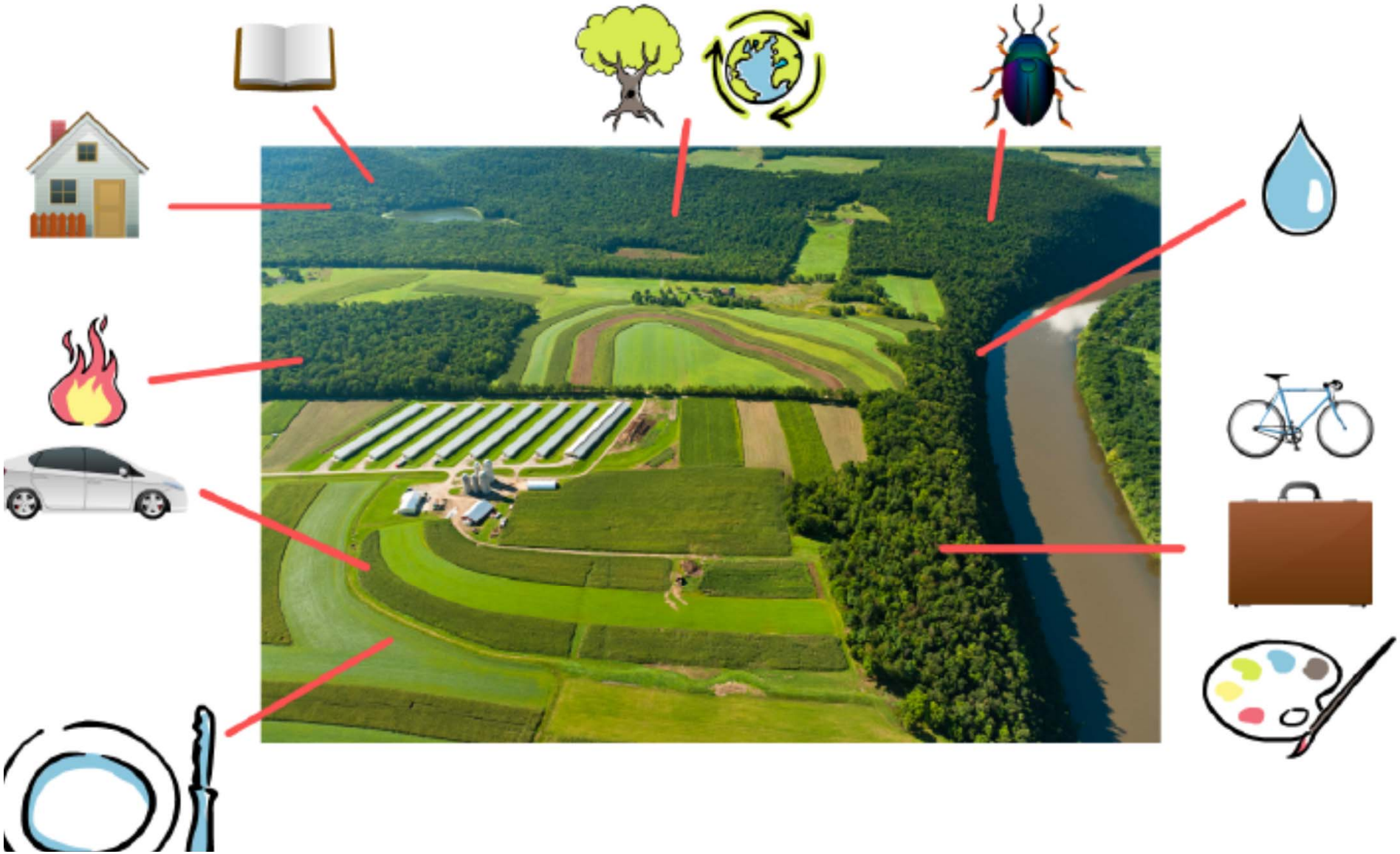
Criticism against the PNV concept

- Chiarucci et al. 2010
  - **Impossible to model** due to methodological problems associated with its definition
  - The concept **should be abandoned** unless its utility is more clearly demonstrated
    - **Impossible to determine** the vegetation in the absence of human influence
    - There are **no stable endpoints** – ecosystems constantly change
    - Vegetation surveys are **not representative**
    - Some vegetation types that are considered "natural" may in fact be the results of **human influence over millennia**

Ref: CHIARUCCI, A., ARAÚJO, M. B., DECOCQ, G., BEIERKUHNLEIN, C. & FERNÁNDEZ-PALACIOS, J. M. 2010. **The concept of potential natural vegetation: an epitaph?** *Journal of Vegetation Science,* 21**,** 1172-1178.

Ecosystem services

The benefits people obtain from ecosystems



Which is the appropriate scale for assessing ecosystem services?

Many regulating ecosystem services must be assessed on scale larger than field/farm, i.e. landscape scale, for example

- pollination
- disease controll
- water regulation

More and more complex agri-food supply chain – what does this mean for LCA and ecosystem service assessment?

Summing up

- Including land-use impacts on ecosystem services is new in LCA

- Proposed methodology: not so much tested, many ecosystem services not included
- Setting a reference situation – challenging and difficult!

- Several ecosystem services must be assessed at landscape scale – how do we fit product-based LCA into this scale?