A general framework for carbon stock calculations in LCA

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Developing LCA methods for assessing the environmental benefits of biobased products, raw materials and side streams

Bio-LCA

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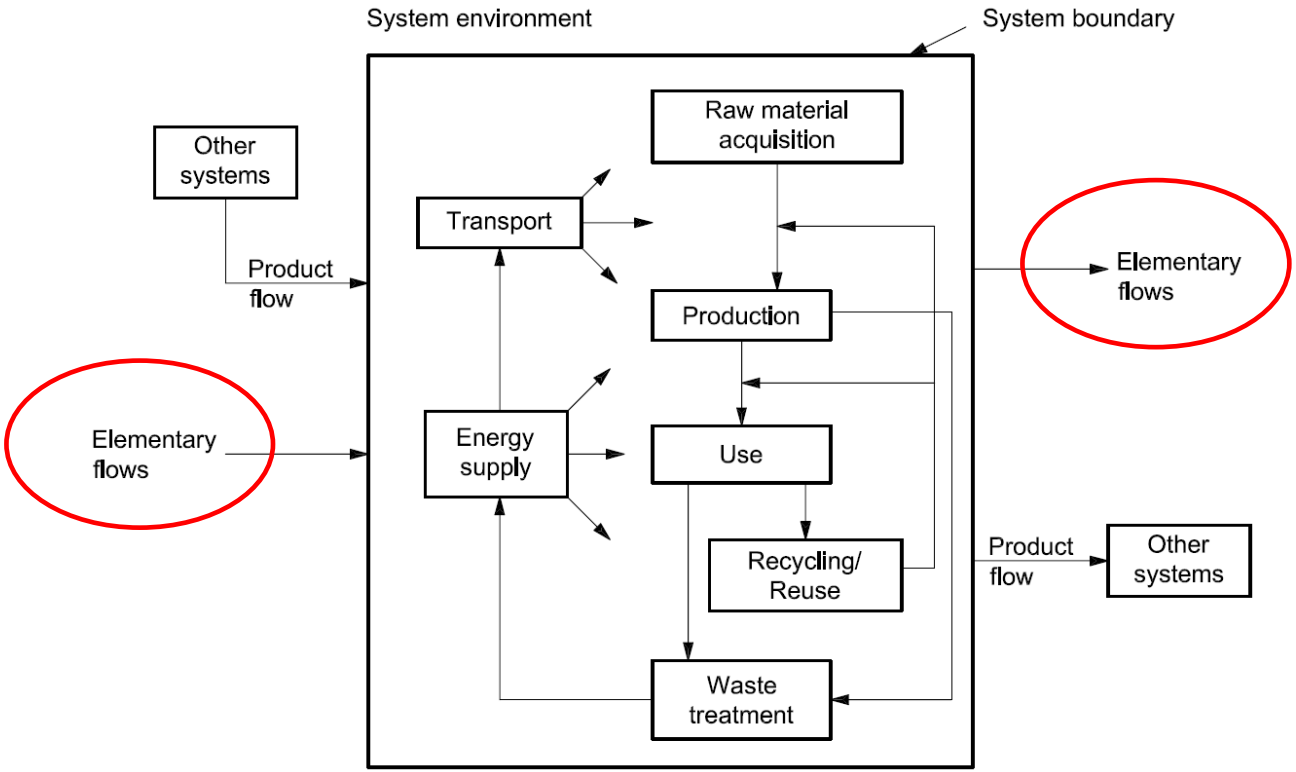
Contents

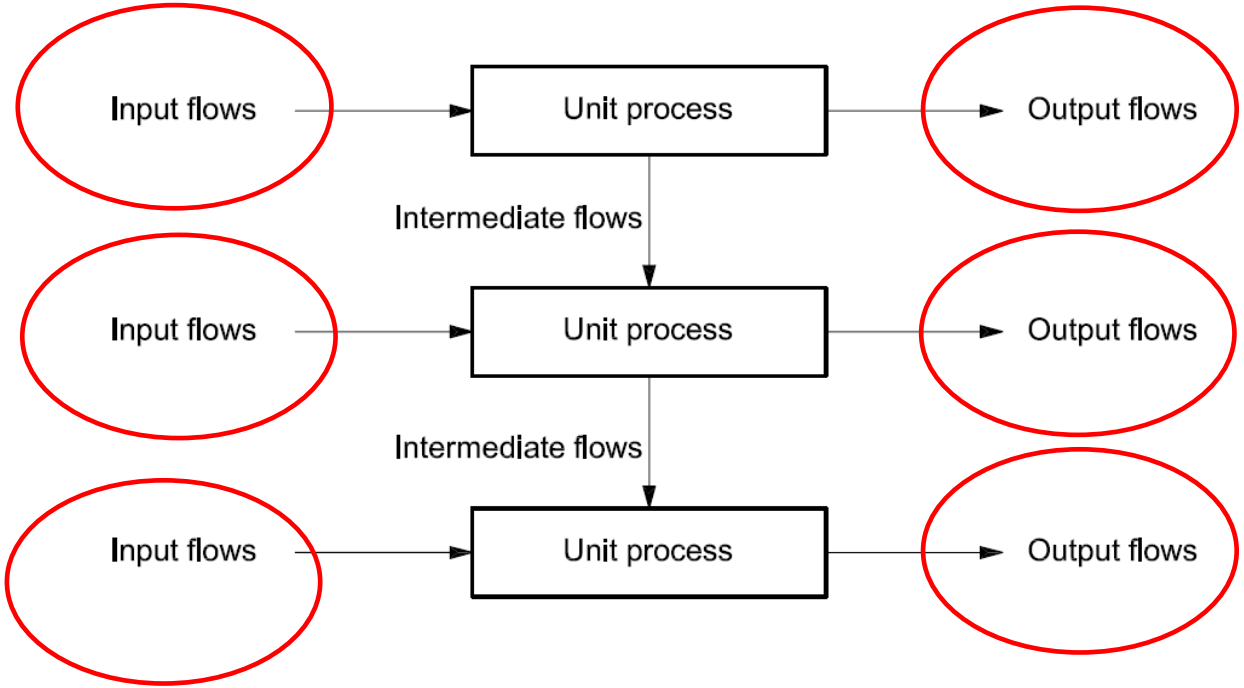
1. What is the relevance of carbon flows in environmental Life Cycle Assessment (LCA)?
2. Are there differences between fossil and biogenic carbon flows?
3. How to model the carbon flows in LCA (standards and guidelines)?
4. From theory to practice (with examples)

The principles of the Life Cycle Assessment (LCA) framework



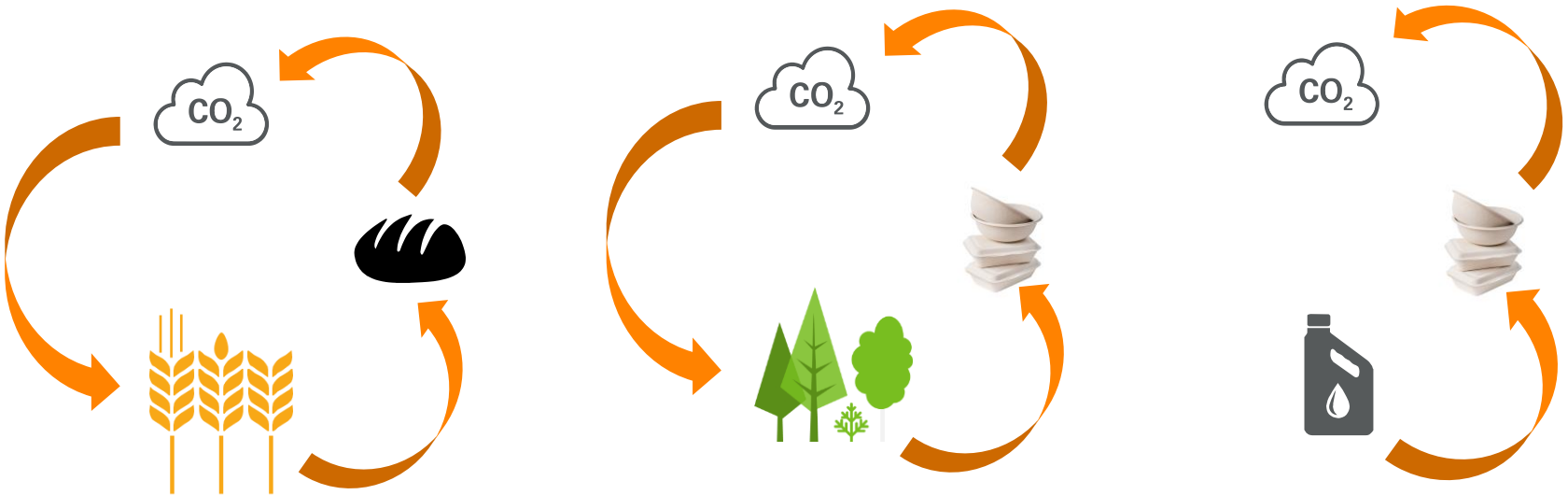
ISO 14040: Environmental management — Life cycle assessment — Principles and framework

The principles of the LCA framework

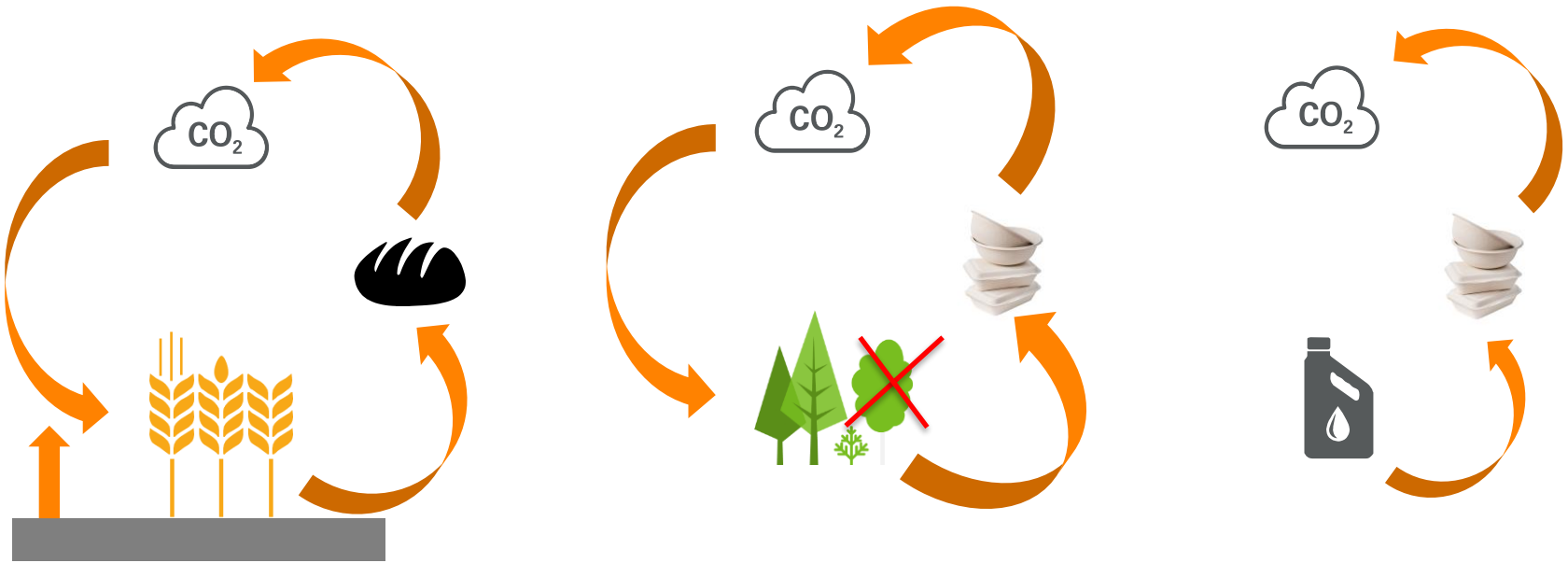


ISO 14040: Environmental management — Life cycle assessment — Principles and framework

Fossil and biogenic materials: the role of the carbon cycle

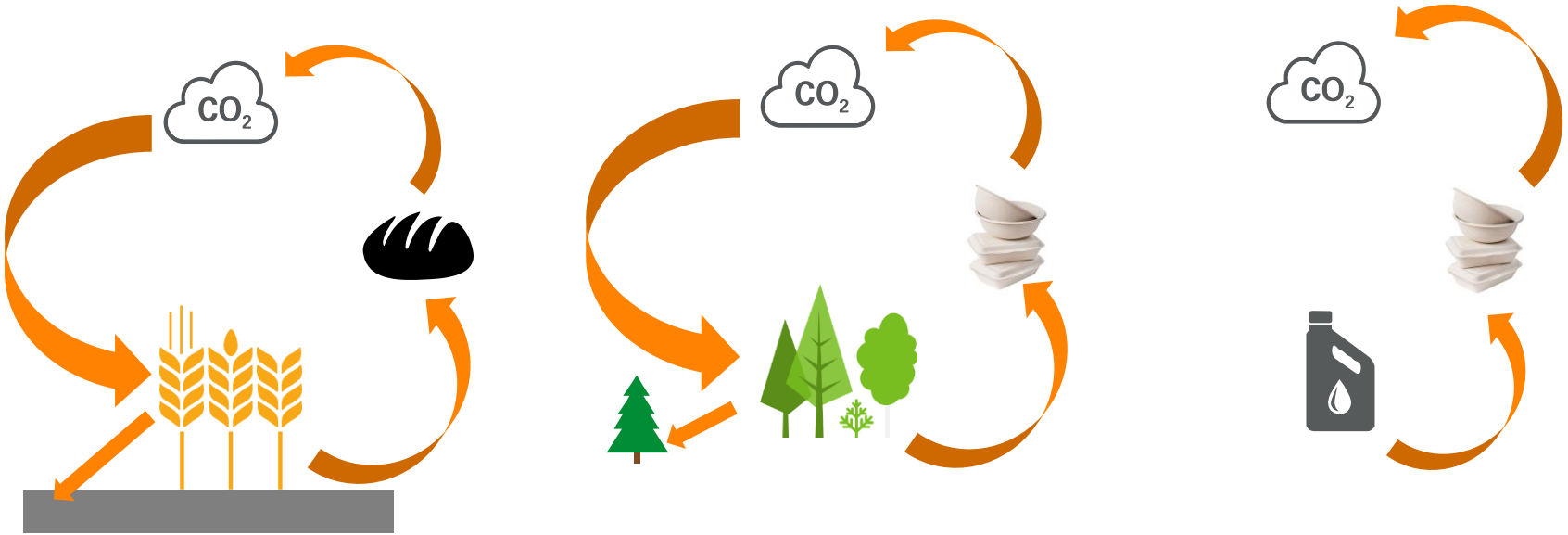


Losses of carbon stocks: Land Use and Land Use Change (LULUC) emissions



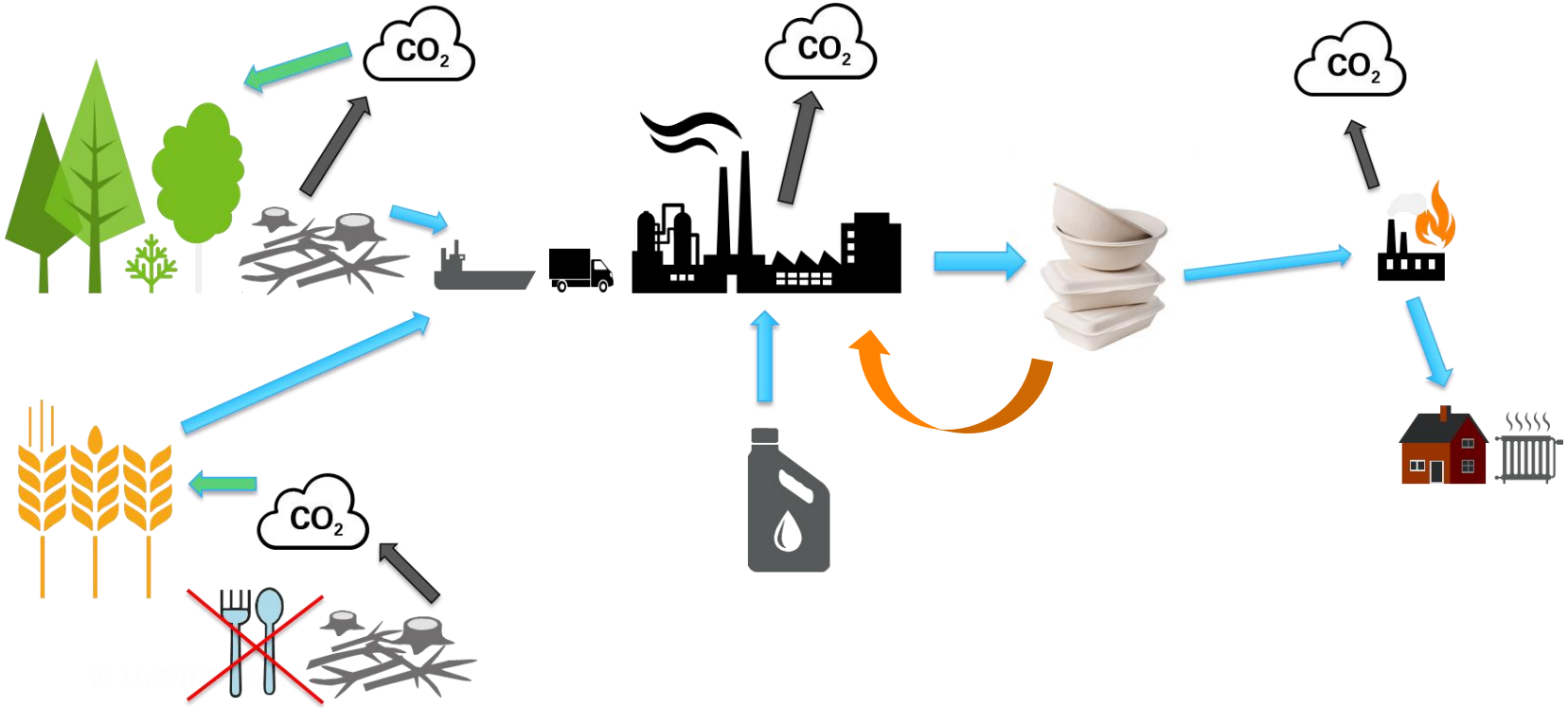
Leinonen 2022. The International Journal of Life Cycle Assessment 27, 1038–1043

More efficient carbon uptake: soil and biomass carbon sinks

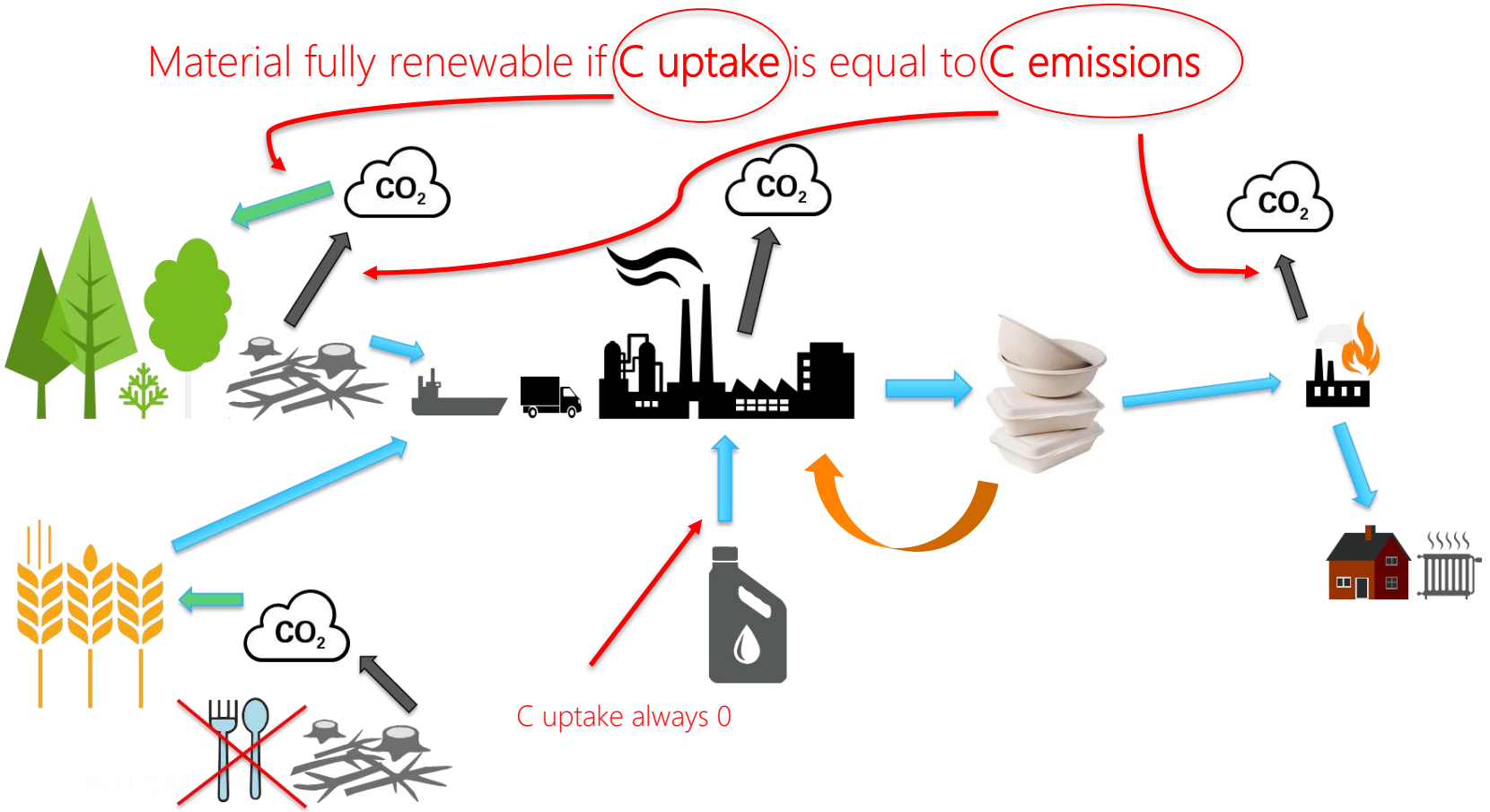


Leinonen 2022. The International Journal of Life Cycle Assessment 27, 1038–1043

GHG emissions of fossil and biobased production chains



Carbon neutrality of biobased material



How to model the carbon flows in LCA?

SUOMEN STANDARDISOIMISLIITTO SFS
FINNISH STANDARDS ASSOCIATION SFS

SFS-EN ISO 14067:2018
57

SFS-EN ISO 14067:2018

Greenhouse gases. Carbon footprint of products. Requirements and guidelines for quantification (ISO 14067:2018)

BRITISH STANDARD

BS EN ISO 14040:2006
Incorporating Corrigendum No. 1

Environmental management — Life cycle assessment — Principles and framework

Product Environmental Footprint (PEF) Category Rules (PEFCRs)

INTERMEDIATE PAPER PRODUCT

JORI RINGMAN ON BEHALF OF THE TECHNICAL SECRETARIAT FOR THE INTERMEDIATE PAPER PRODUCT

WMO

Intergovernmental Panel on Climate Change

UNEP

2006 IPCC Guidelines for National Greenhouse Gas Inventories

Volume 4

Agriculture, Forestry and Other Land Use

Edited by Simon Eggleston, Leandro Buendia, Kyoko Miwa, Todd Ngara and Kiyoto Tanabe

PUBLICLY AVAILABLE SPECIFICATION

PAS 2050:2011

Specification for the assessment of the life cycle greenhouse gas emissions of goods and services

defra
ENERGY & CLIMATE CHANGE
BIS Department for Business Innovation & Skills
BSI

ICS code: 13.020.40

Need for clarifying the framework

The International Journal of Life Cycle Assessment
https://doi.org/10.1007/s11367-022-02086-1

COMMENTARY AND DISCUSSION ARTICLE

A general framework for including biogenic carbon emissions and removals in the life cycle assessments for forestry products

Ilkka Leinonen[1]

Received: 15 July 2022 / Accepted: 10 August 2022

General principles of carbon balance modelling in LCA (1)

Completeness: "All GHG emissions and removals that provide a significant contribution to the CFP [carbon footprint] or partial CFP of the product system under study are included". *Greenhouse gases. Carbon footprint of products. Requirements and guidelines for quantification (ISO 14067:2018), section 5.7*

Avoidance of double-counting: "Double-counting of GHG emissions and removals within the studied product system is avoided when the allocation of the same GHG emissions and removals occurs only once" *Greenhouse gases. Carbon footprint of products. Requirements and guidelines for quantification (ISO 14067:2018), section 5.12*

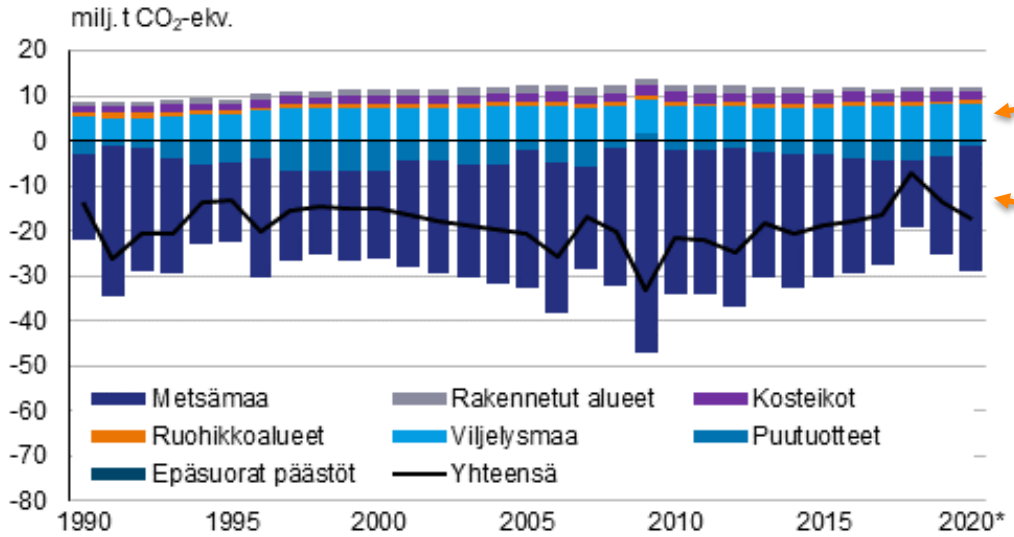
General principles of carbon balance modelling in LCA (2)

- "Biogenic GHG emissions and removals due to land use and dLUC, whether occurring as a pulse or a gradual change, are **divided amongst the products produced over a specified period**". *Greenhouse gases. Carbon footprint of products. Requirements and guidelines for quantification (ISO 14067:2018), section E.2.1*
- "The GHG emissions and removals occurring as a result of direct land use change (dLUC) within the last decades shall be assessed in accordance with **internationally recognized methods**, such as the **IPCC Guidelines for National Greenhouse Gas Inventories** and included in the CFP". *Greenhouse gases. Carbon footprint of products. Requirements and guidelines for quantification (ISO 14067:2018), section 6.4.9.5*
- "When changes in **management of land** cause changes in soil and biomass carbon stocks, compared with the reference land use, the GHG emissions and removals shall be documented and assigned to the system under study". *Greenhouse gases. Carbon footprint of products. Requirements and guidelines for quantification (ISO 14067:2018), section 6.4.9.6*

General principles of carbon balance modelling in LCA (3)

- "**The time period** selected for analysis shall be documented and justified. At a minimum, it shall include at least one full rotation period for processes that involve growing crops or trees". *Greenhouse gases. Carbon footprint of products. Requirements and guidelines for quantification (ISO 14067:2018), section 6.4.9.6*
- "The assessment of the impact of land use change shall include all direct land use change occurring not more than 20 years, or a single harvest period, prior to undertaking the assessment (whichever is the longer)" *PAS 2050:2011 Specification for the assessment of the life cycle greenhouse gas emissions of goods and services. British Standards Institution (BSI).*

LULUC emissions of Finland: results of the national GHG inventory



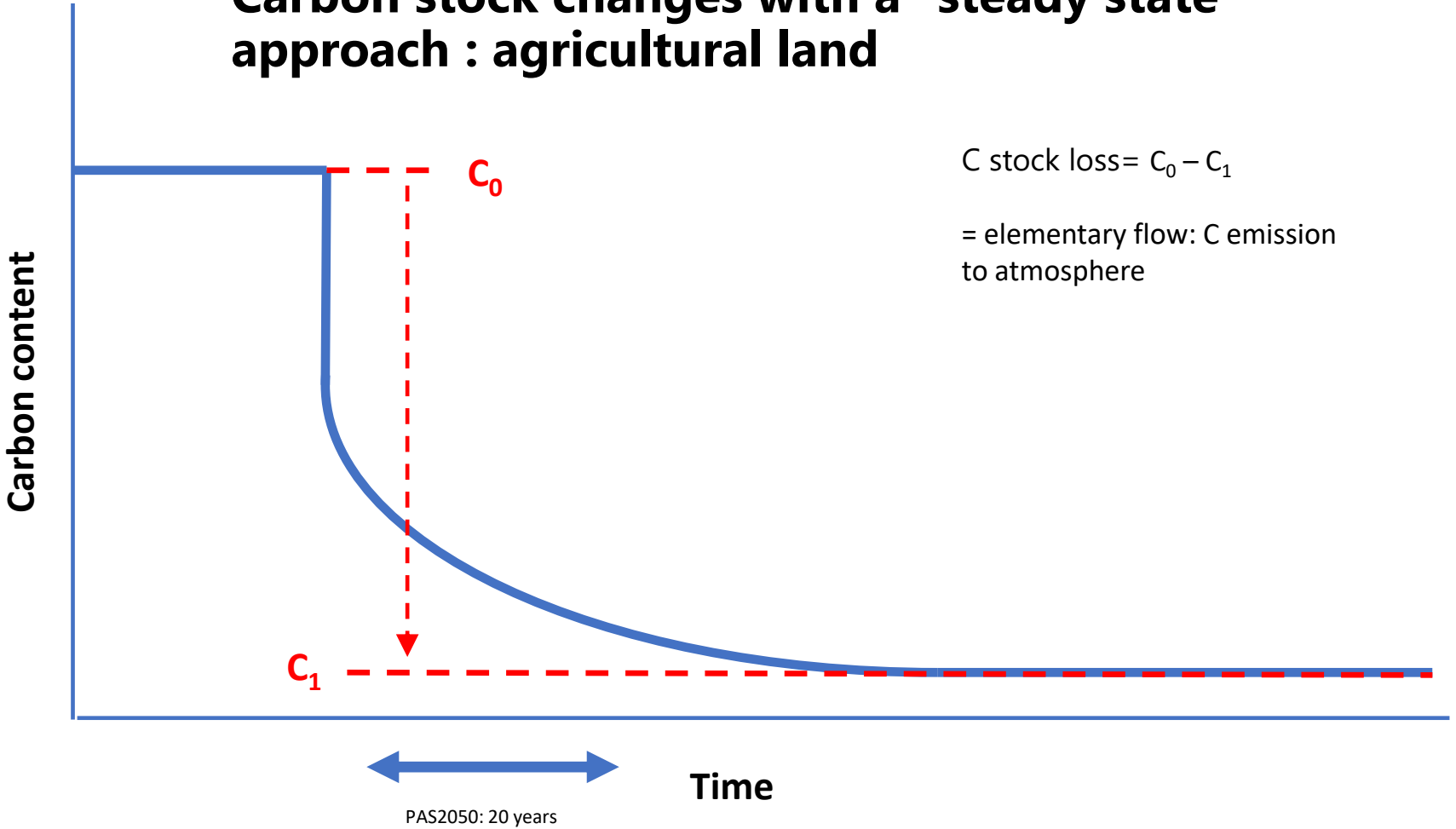
Agricultural land

Forest land

*Ennakkotieto

Kuvassa on esitetty päästöjen ja poistumien summa eri maankäyttöluokille ja puutuotevarastolle (nettopäästöt tai nettonielu). LULUCF-sektorin viimeisimpien vuosien luvut tarkentuvat jatkossa lähtöaineiston päivitysten myötä (mm. puusto, pinta-alat).

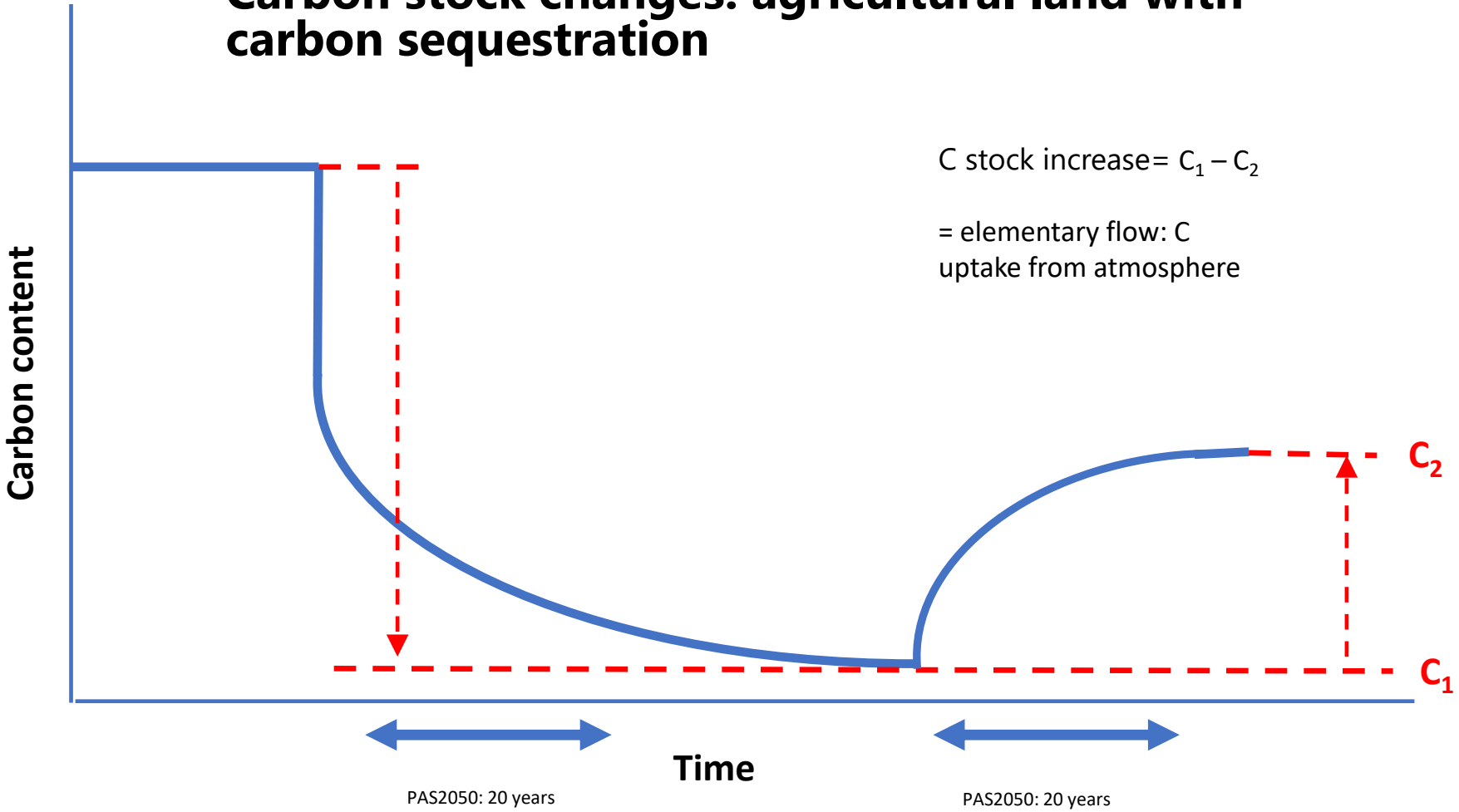
Carbon stock changes with a “steady state” approach : agricultural land



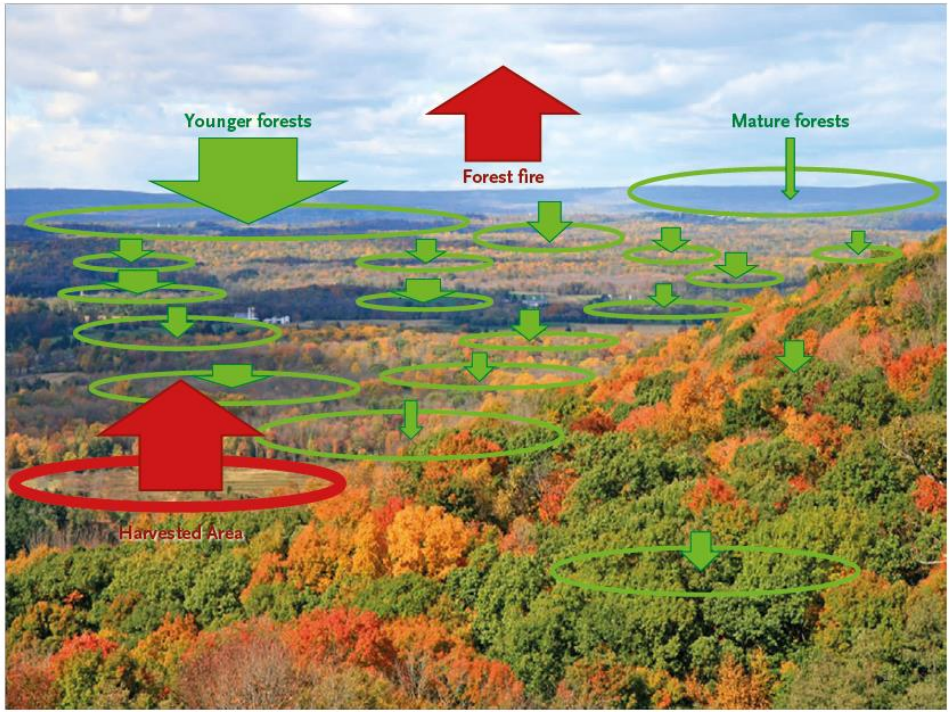
C stock loss= $C_0 - C_1$

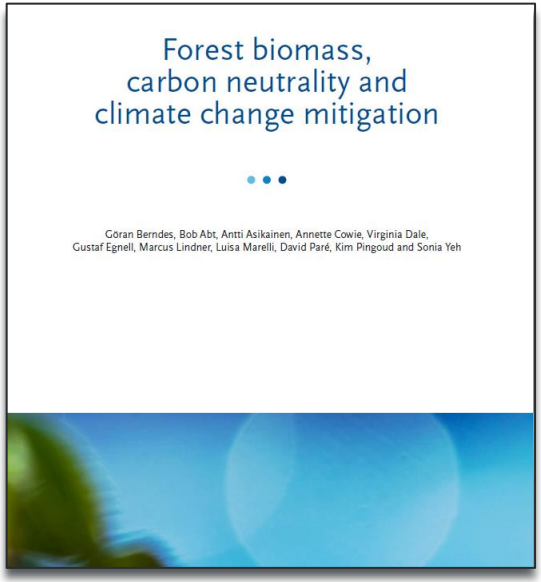
= elementary flow: C emission to atmosphere

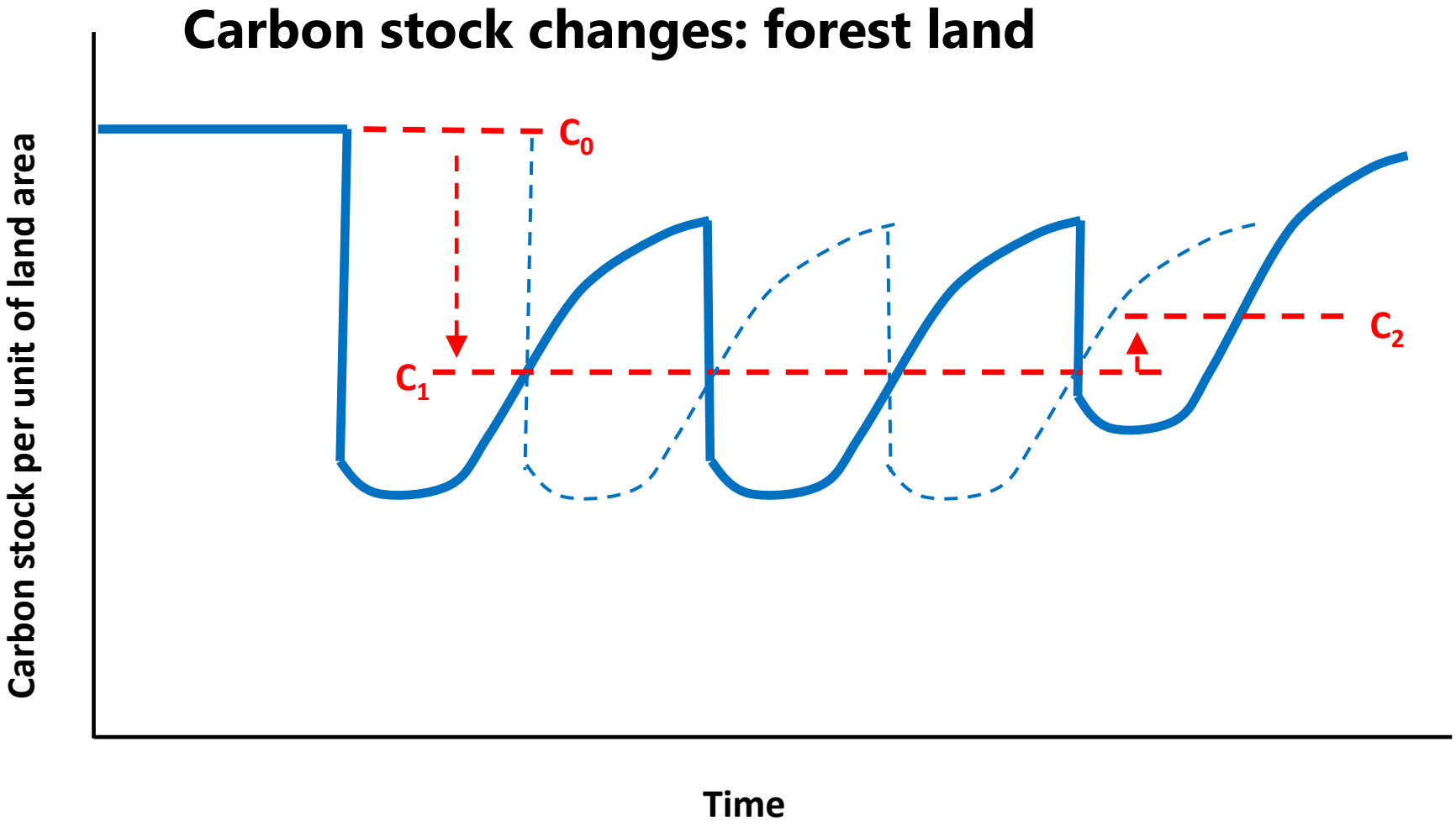
Carbon stock changes: agricultural land with carbon sequestration

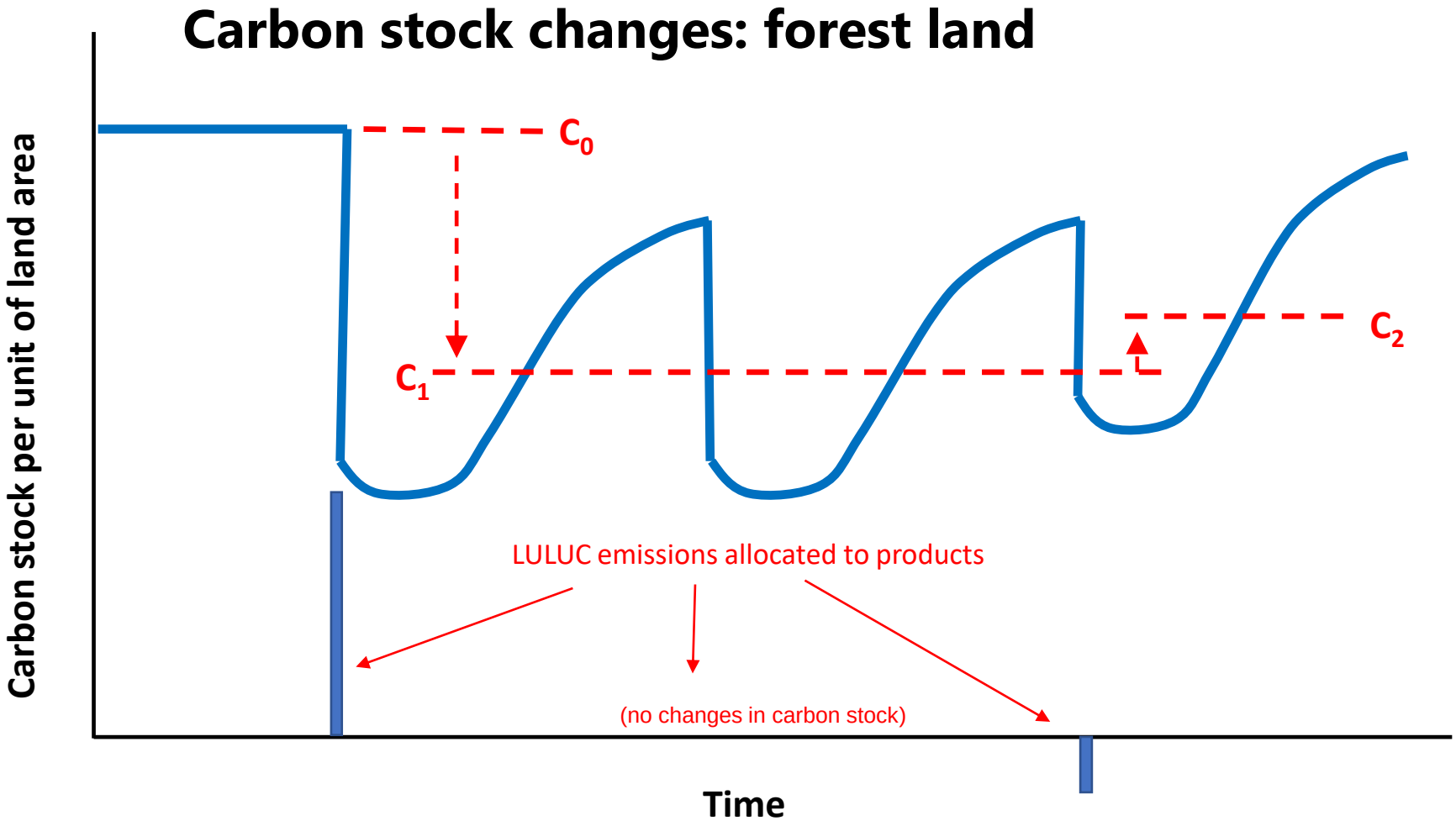


How to handle the forest regrowth in LCA?

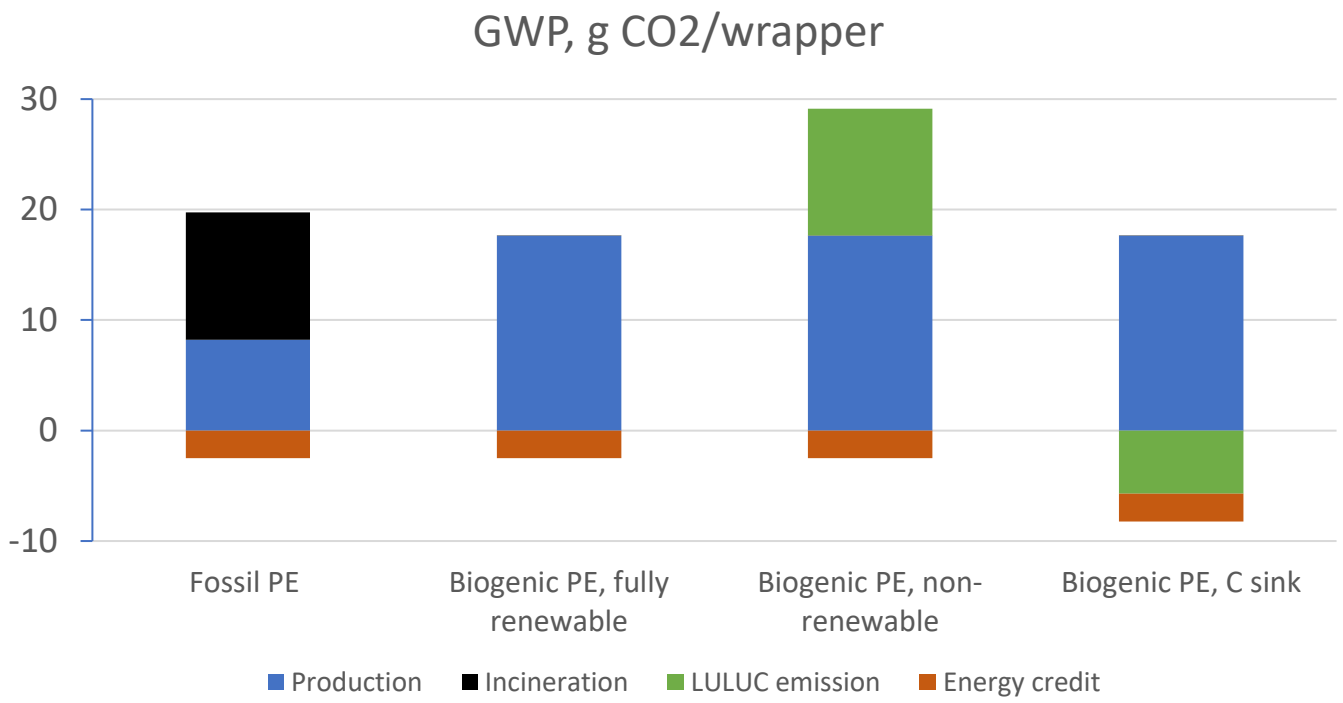





Carbon stock changes: forest land
Carbon stock per unit of land area
C0
C1
C2
Time


Carbon stock changes: forest land
Carbon stock per unit of land area
C_0
C_1
C_2
LULUC emissions allocated to products
(no changes in carbon stock)
Time

Climate effects of fossil and biobased materials: food packaging (salad wrapper) as an example



Source: Leinonen et al. (2022) Materials and solutions replacing traditional plastic: final report

Conclusions and next steps

- The mass balance principle is essential in modelling the biogenic carbon flows in LCA
    - Completeness
    - Avoiding double counting
- This principle allows consistent comparison between different biobased (e.g. from field or forest) and fossil materials and solutions
- International standards and guidelines allow transparent communication and comparability of the LCA results
- More detailed guidelines needed: e.g. region-specific and management-specific emissions factors
- Need for application of mechanistic forestry and soil carbon models for determining the emission factors
- Bringing the modelling into practice with LCA case studies