

The image features a background of a mountainous landscape with green hills and a valley filled with dense evergreen trees. The sky is overcast with grey clouds. The entire image has a semi-transparent green overlay. The GreenDelta logo is positioned in the upper left quadrant.

GreenDelta

sustainability consulting + software

Model-based LCSA

ISIE, Leiden, July 2nd, 2023

Dr. Andreas Ciroth

GreenDelta GmbH

Content

- Sustainability and LCSA
- System dynamics, and environmental modeling
- Combining LCSA and system dynamics: Model-based LCSA
- What did I just present? Summary, conclusions, next steps

A landscape photograph of a mountain valley, heavily tinted with a green color. The foreground shows a rocky, gravelly slope. The middle ground is a valley filled with dense evergreen forests. In the background, there are more mountains under a cloudy sky. A semi-transparent green banner is overlaid across the middle of the image, containing the text "Sustainability and LCSA" in white.

Sustainability and LCSA

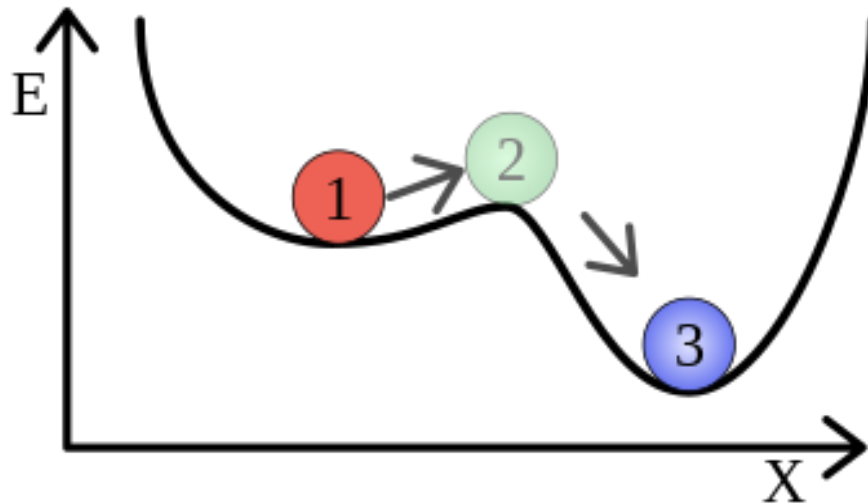
Sustainability

- Brundtland commission, for sustainable *development*
“meeting the needs of the present without compromising the ability of future generations to meet their own needs”
- Klöpffer introduced Carl von Carlowitz (Sylvicultura Oeconomia, 1713) as the first to address sustainability, in forest management: do not take more wood out of the forest than regrows.
In this definition, it is apparent that stress (withdrawal of wood from a forest) below a certain threshold, below a certain amount of wood withdrawn, is not affecting the sustainability, and thus is (still) sustainable.



Sustainability

→ Sustainability is about the stability of a system under pressure



Life Cycle Sustainability Assessment, LCSA

- Combination of three dimensions of sustainability, environmental impacts, economic impacts, social impacts: LCA, LCC, S-LCA
- Often-cited, “stupid” formula:

$$\text{LCSA} = \text{LCA} + \text{LCC} + \text{S-LCA}$$

(stupid since it is over-simplifying: this is of course not a plain addition)

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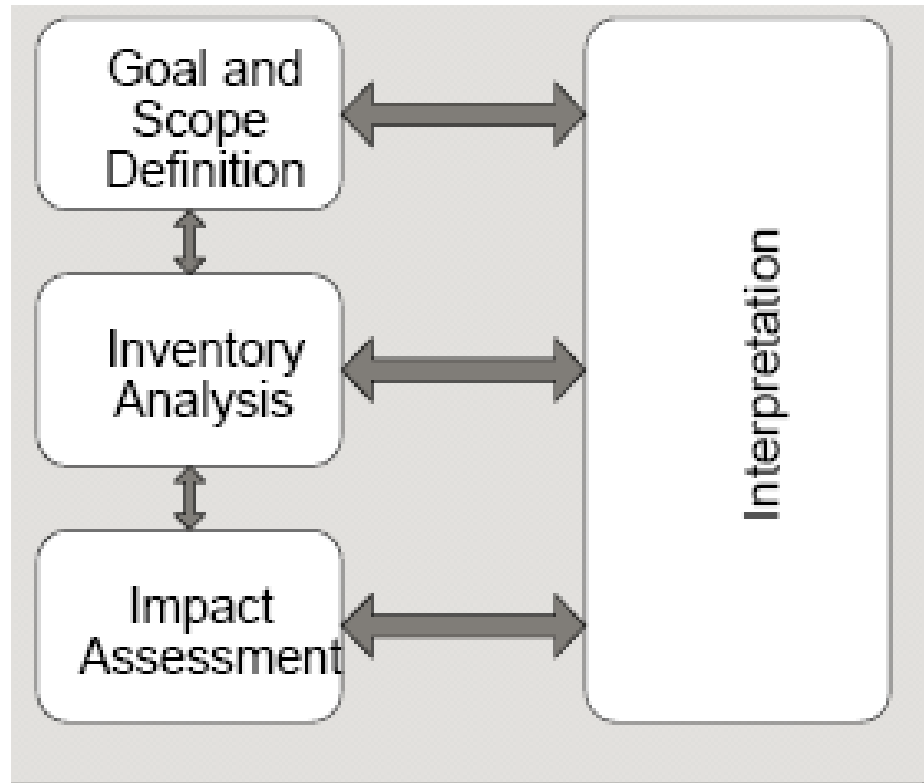
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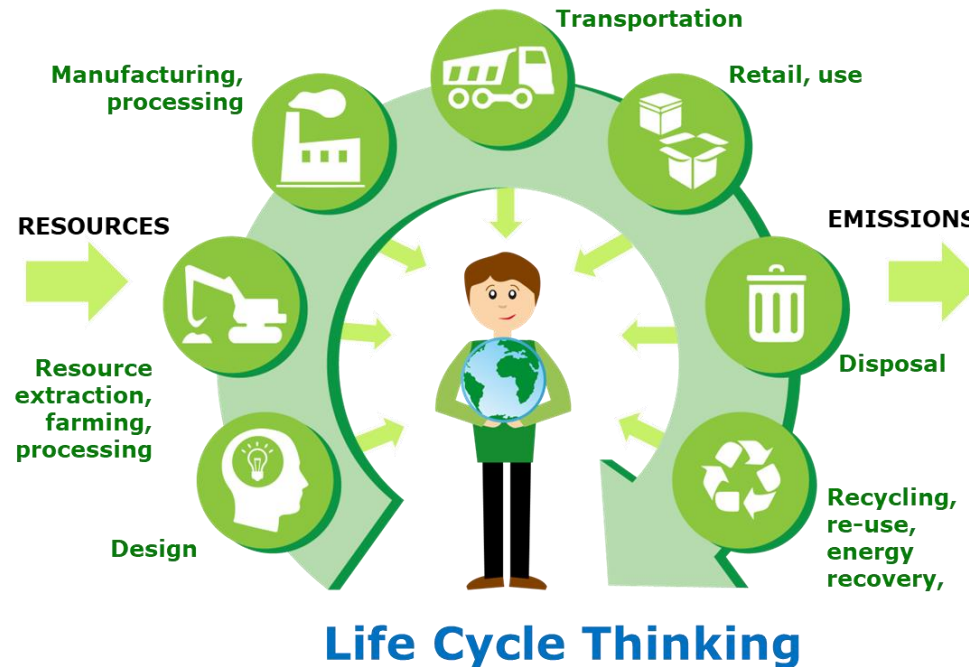
Limitations

Thresholds? Qualitative relations? Data demand! Modeling partial knowledge? No macroscopic system structure information considered. Accounting, grass-roots approach.

(and LCA: 4 key phases, ISO 14040)

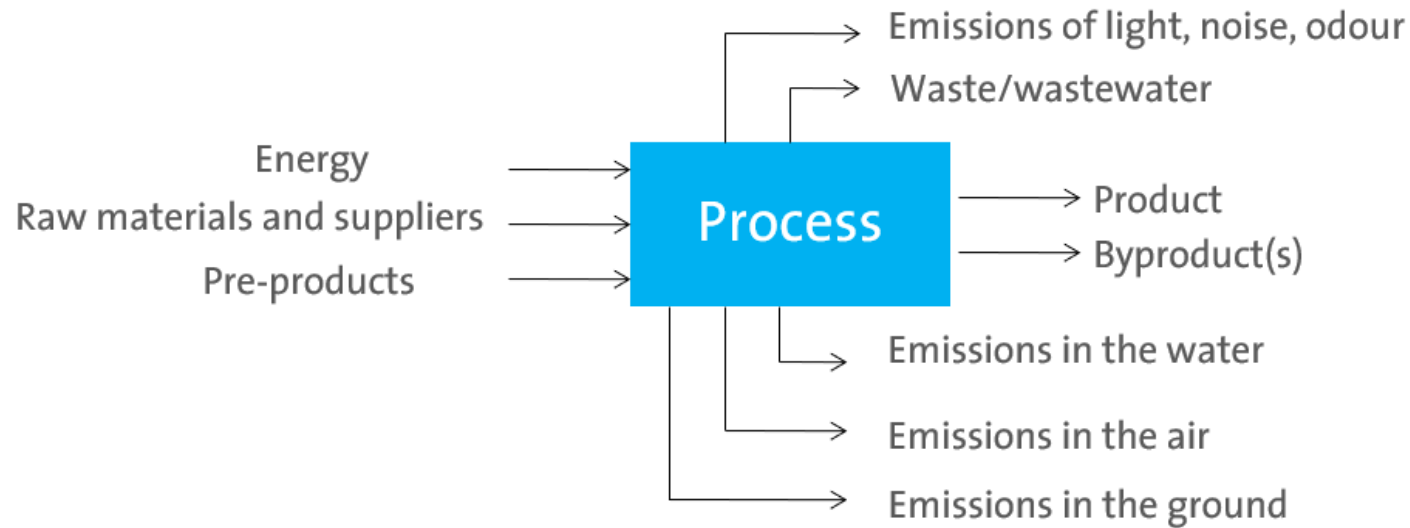


(and LCA: Life cycle structure



e.g. <https://epclca.jrc.ec.europa.eu/plasticLCA.html>

(and LCA: input and output types of a process in the life cycle

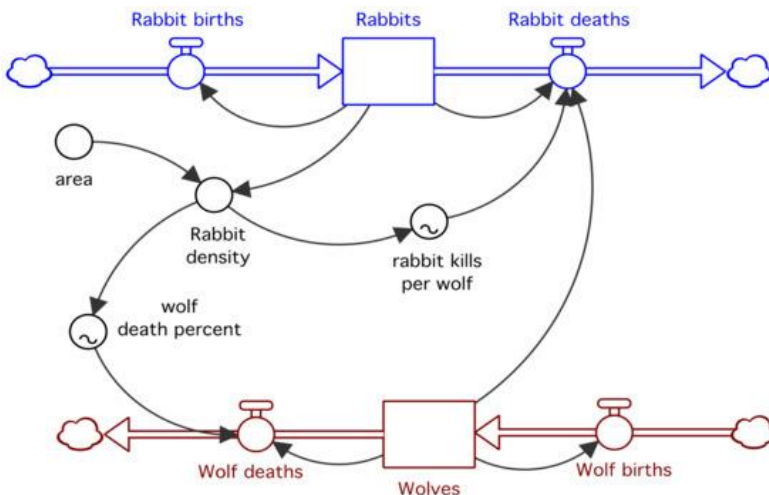


The image shows a mountainous landscape with a green overlay. In the foreground, there is a rocky, light-colored slope. The middle ground features a valley with dense evergreen forests. The background consists of more mountain ranges under a cloudy sky. A semi-transparent green box is centered over the image, containing the text "System dynamics and environmental modeling" in white.

System dynamics and environmental modeling

System dynamics

- Idea: modeling a system as a combination of stocks and flow rates
- Any system(!)
- Scope and level of detail totally up to the modeler
- E.g., wolves and rabbits

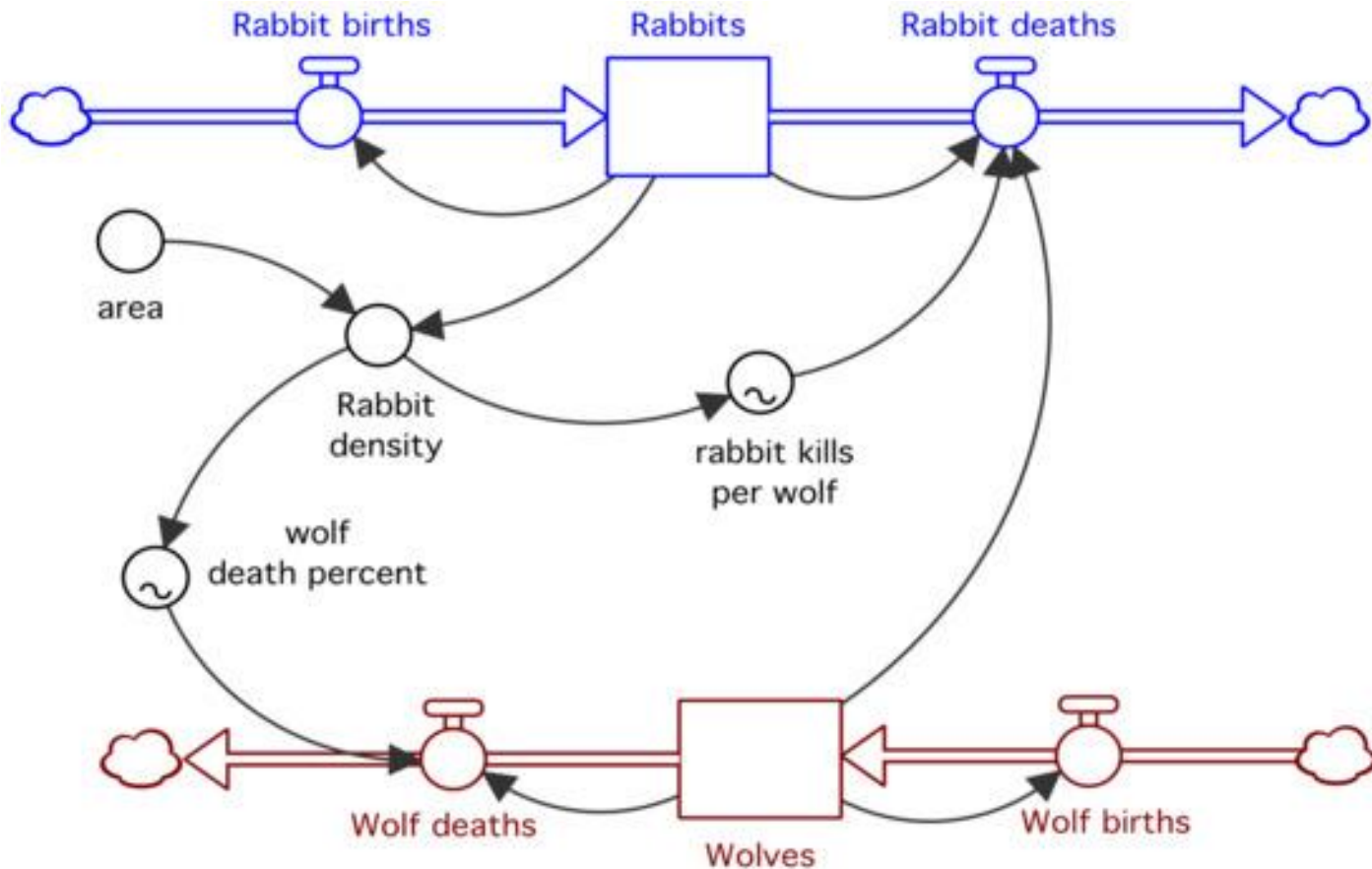


Fisher, Diana M. 2018. "Reflections on Teaching System Dynamics Modeling to Secondary School Students for over 20 Years" *Systems* 6, no. 2: 12.
<https://doi.org/10.3390/systems6020012>

System dynamics

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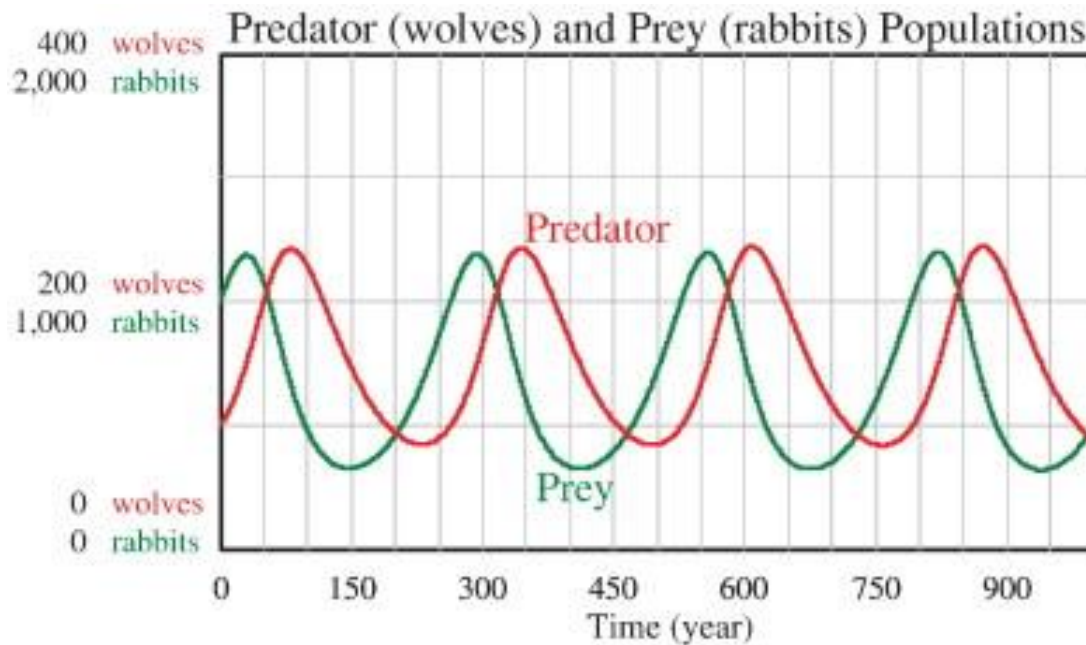
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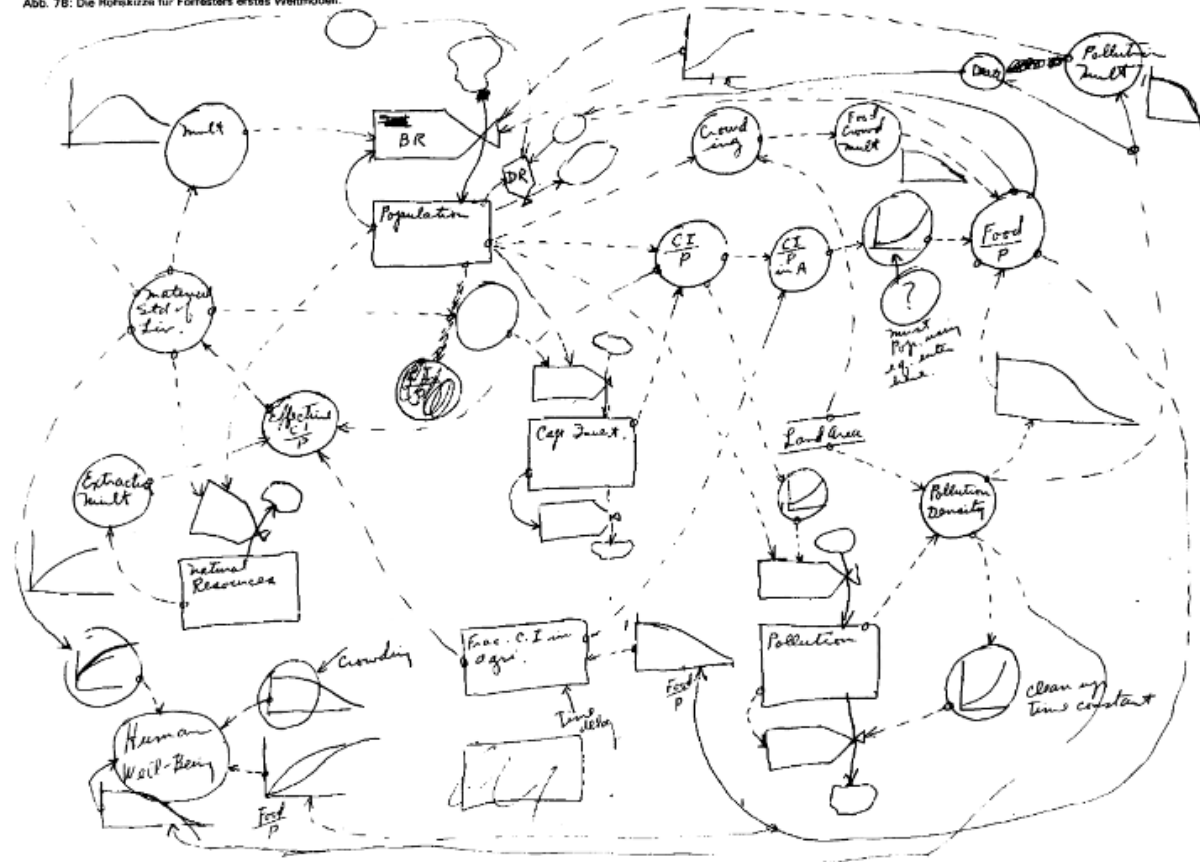
Motesharrei, Safa & Rivas, Jorge & Kalnay, Eugenia. (2014). Human and nature dynamics (HANDY): Modeling inequality and use of resources in the collapse or sustainability of societies. *Ecological Economics*. 101. 90–102. [10.1016/j.ecolecon.2014.02.014](https://doi.org/10.1016/j.ecolecon.2014.02.014).



System dynamics and environmental modeling

- Forrester et al. 1970's: a model of the entire world

Abb. 78: Die Rohskizze für Forrester's erstes Weltmodell.

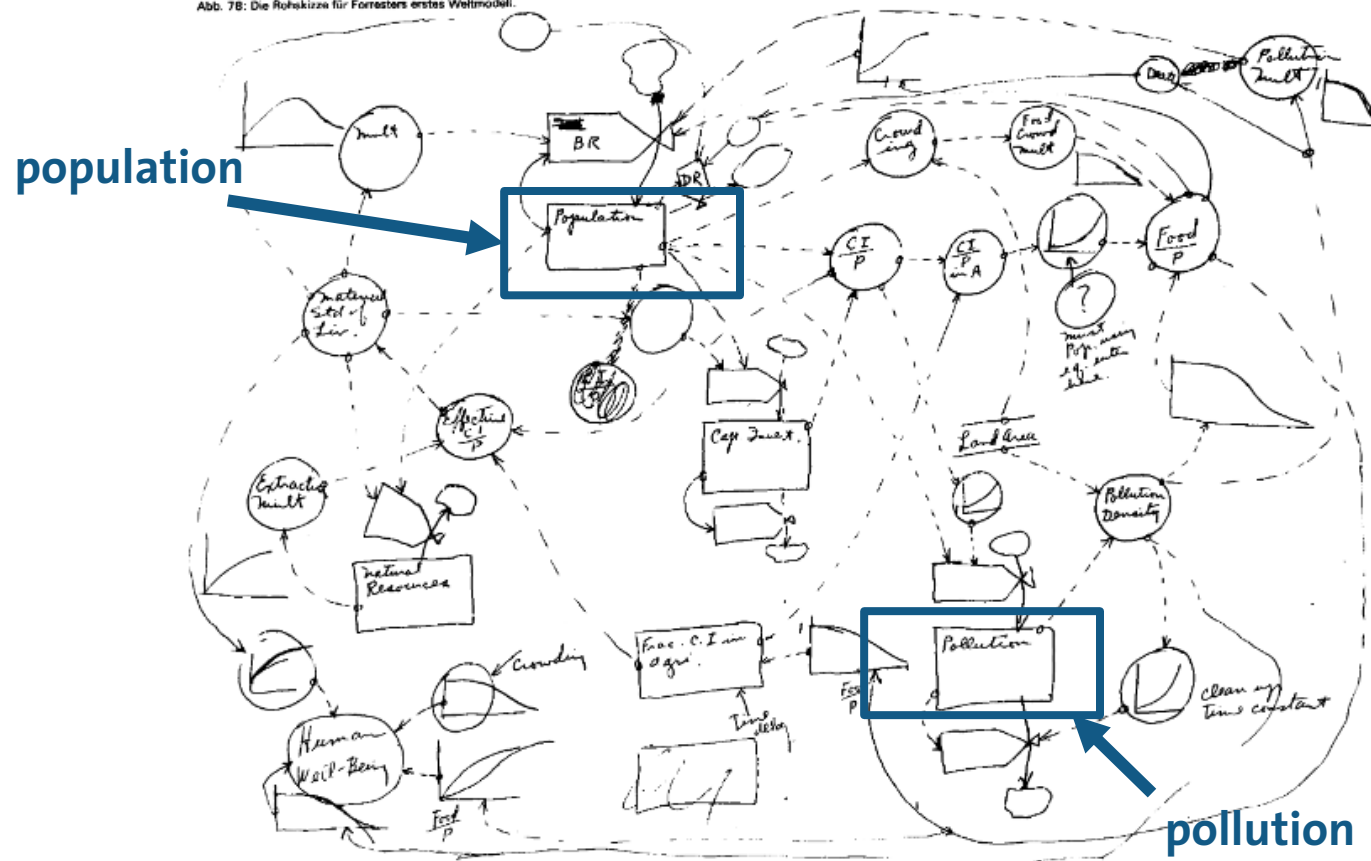


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System dynamics and environmental modeling

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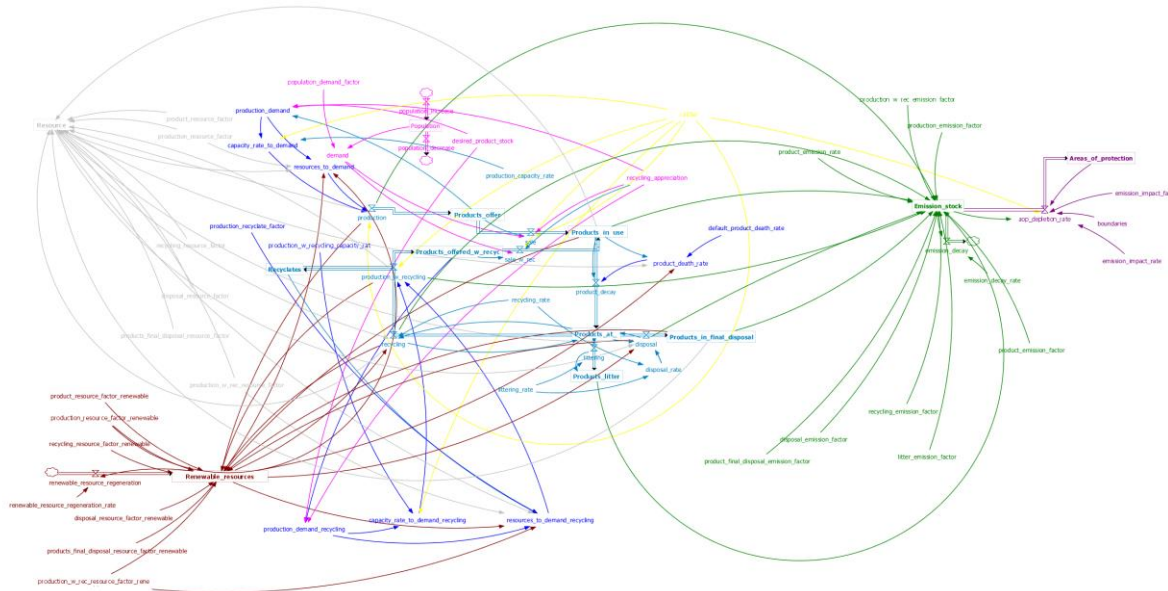
- Quite well able to reflect sustainability
- Data demand not necessary high (in quantity):
“population” ...
- ..but demanding in quality: system behavior and
“results” depend a lot on whether the population
reproduction rate is 1.0 or 1.01 (e.g.)

A green-tinted landscape photograph of a mountain valley. The foreground is a rocky, gravelly slope. The middle ground shows a valley floor with sparse vegetation and a few trees. The background features rolling green hills and mountains under a cloudy sky. A semi-transparent green rectangular box is overlaid on the middle of the image, containing white text.

A generic system dynamics model for life cycle sustainability

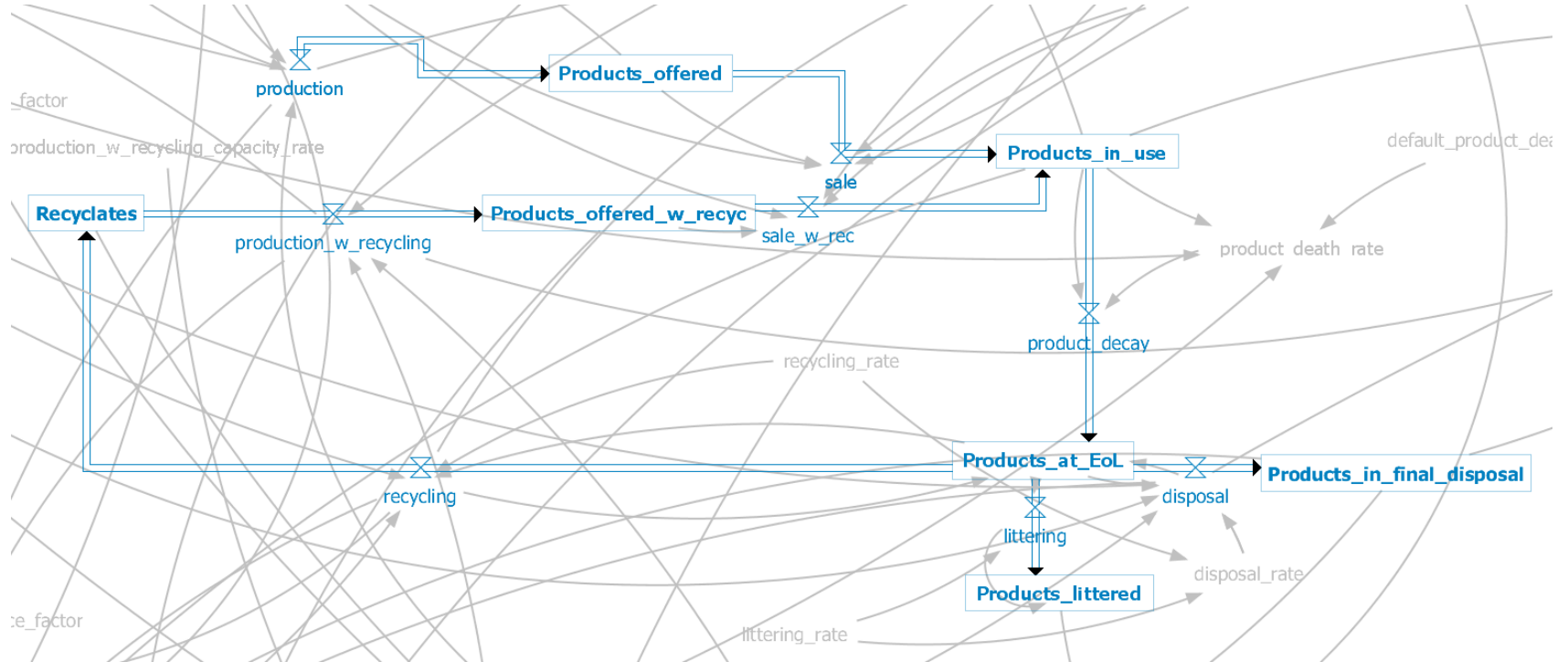
A generic system dynamics model for life cycle sustainability

We developed a model to combine system dynamics and LCSA: “model-based LCSA”.



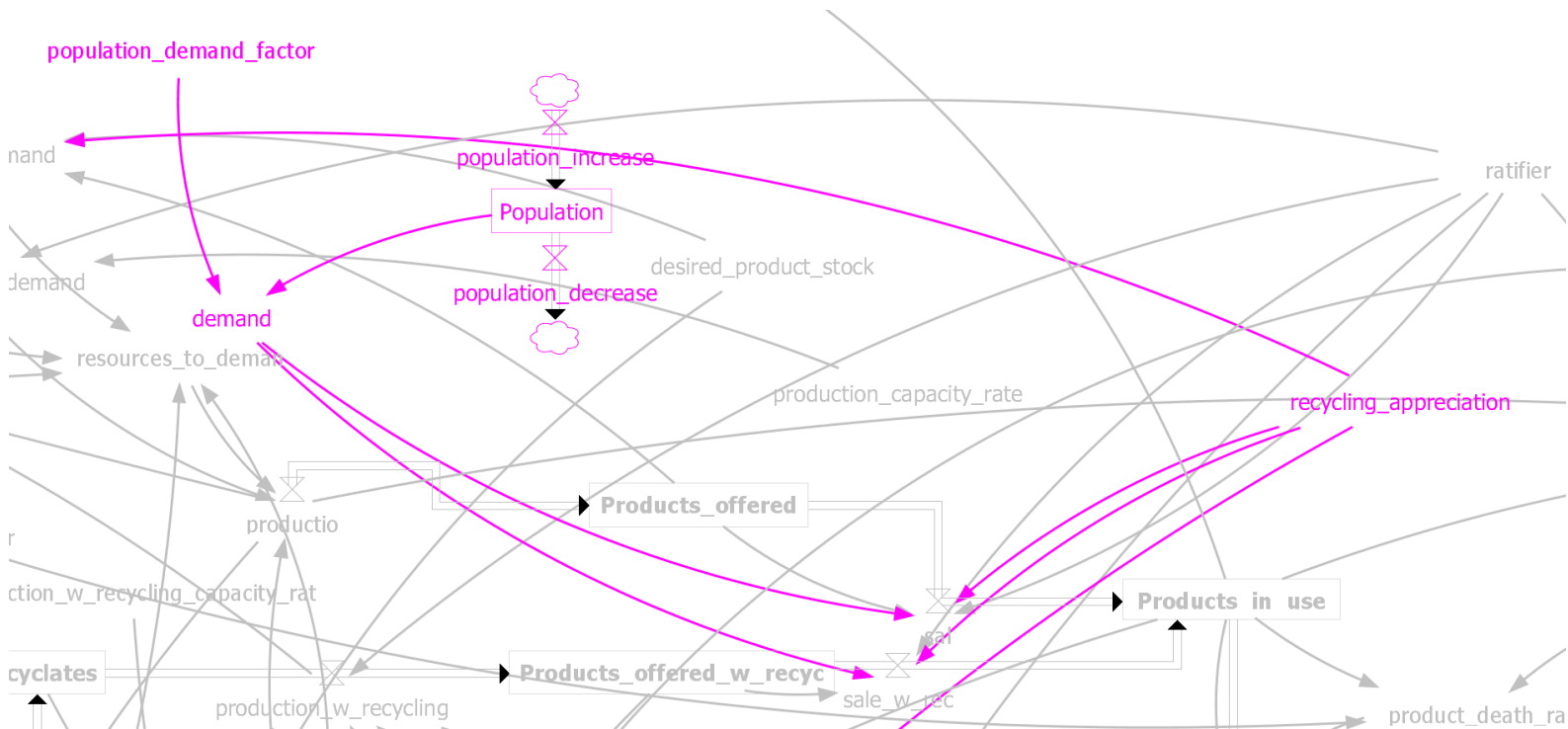
A generic system dynamics model for life cycle sustainability

It has seven main sections: 1, product life cycle



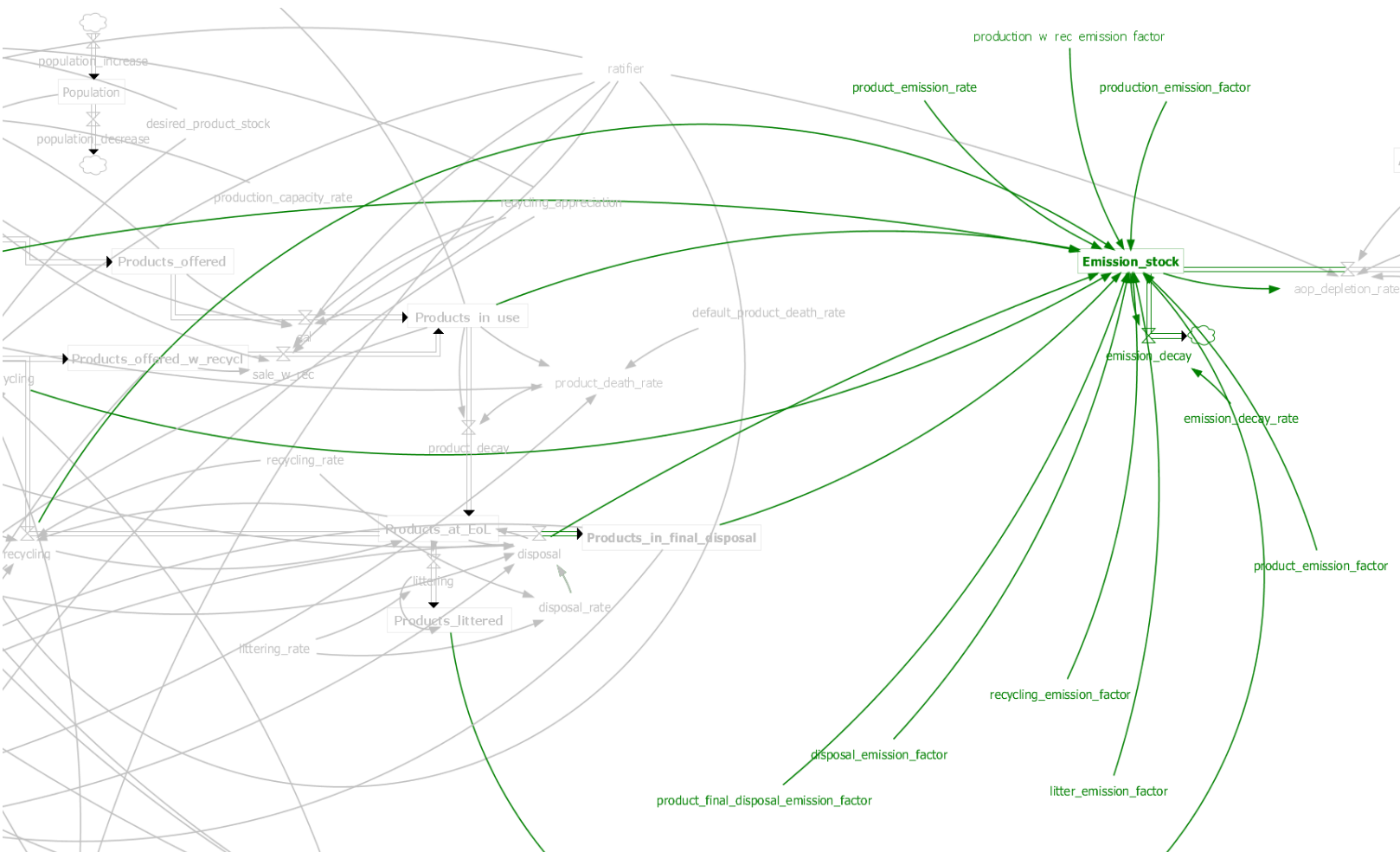
A generic system dynamics model for life cycle sustainability

It has seven main sections: 2, the demand side



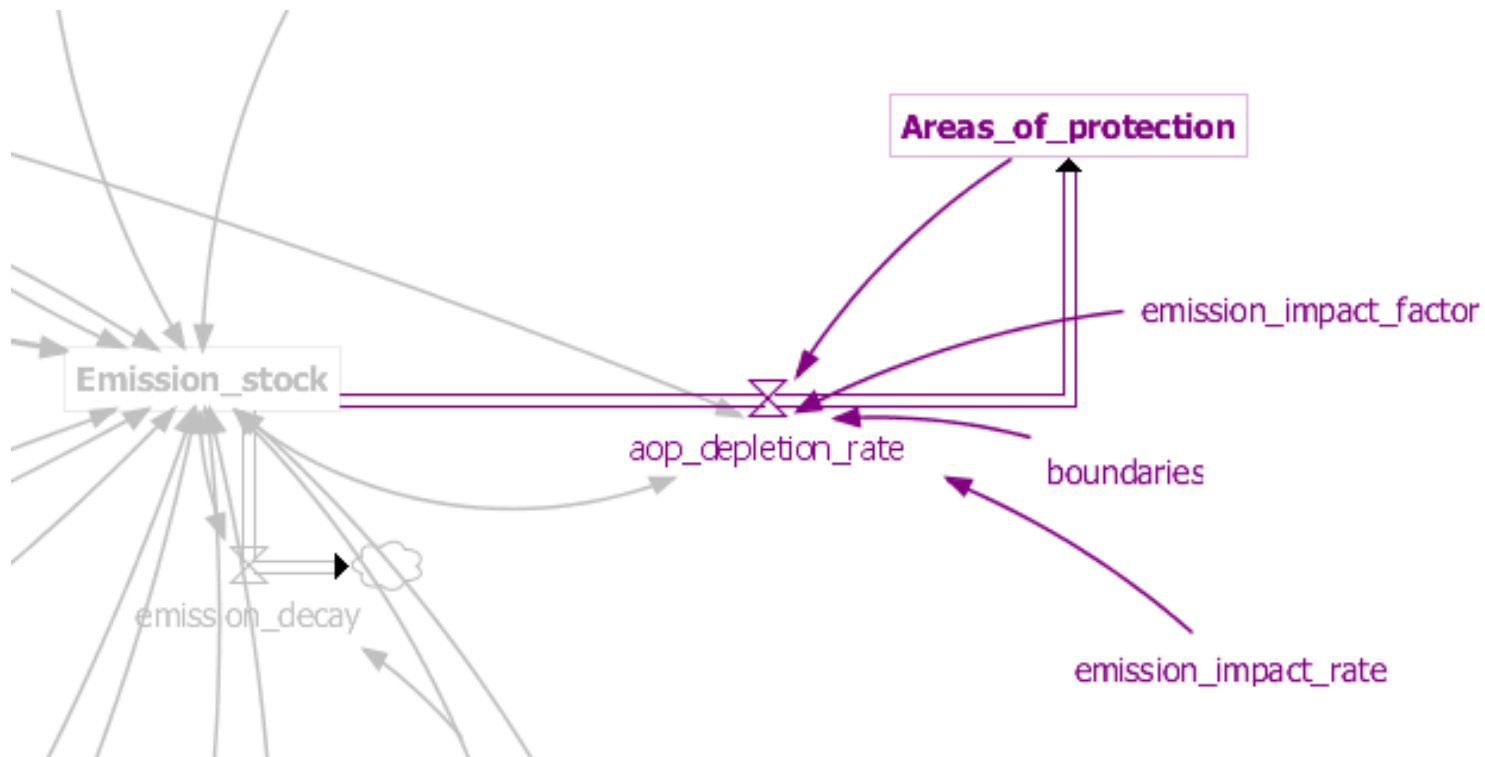
A generic system dynamics model for life cycle sustainability

It has seven main sections: 3, emissions



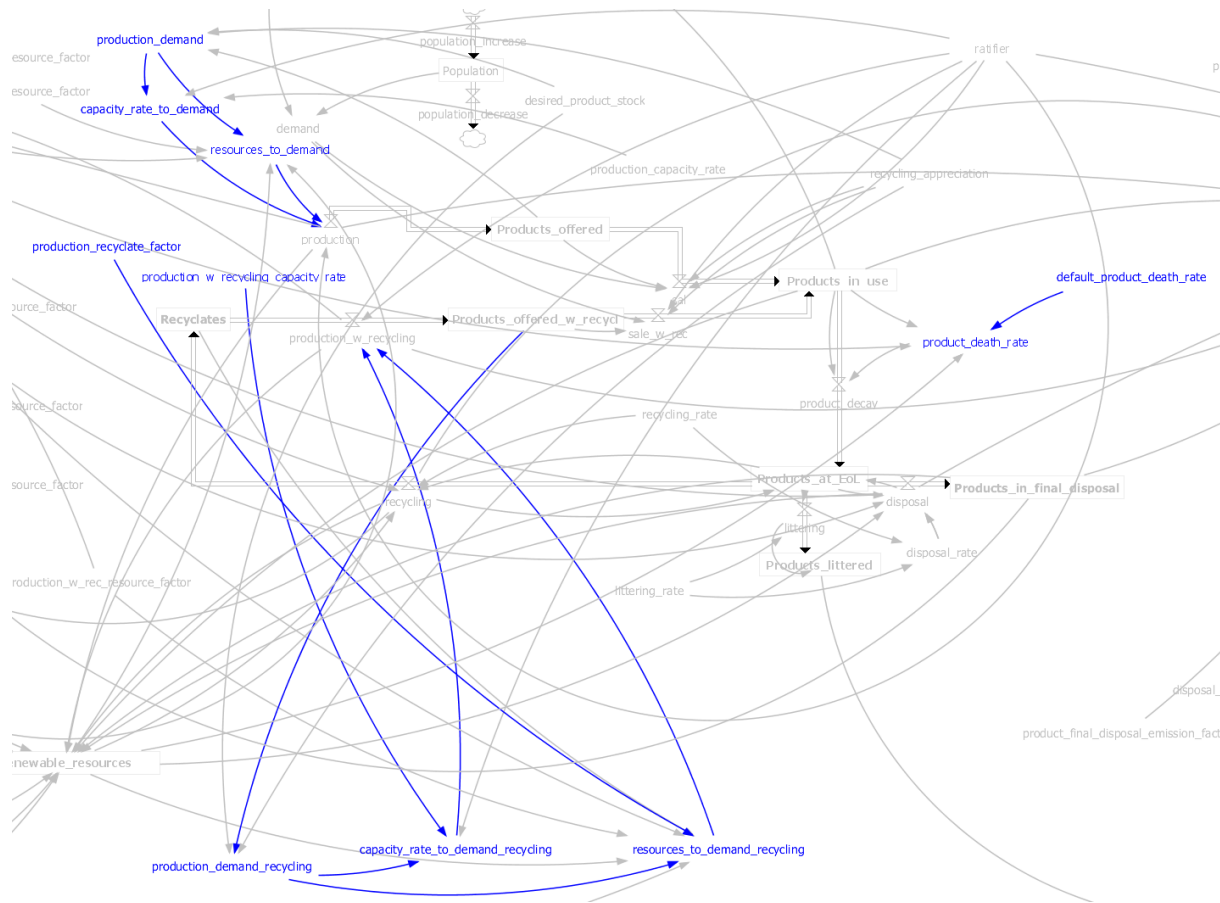
A generic system dynamics model for life cycle sustainability

It has seven main sections: 4, areas of protection



A generic system dynamics model for life cycle sustainability

It has seven main sections: 5, technical conversions



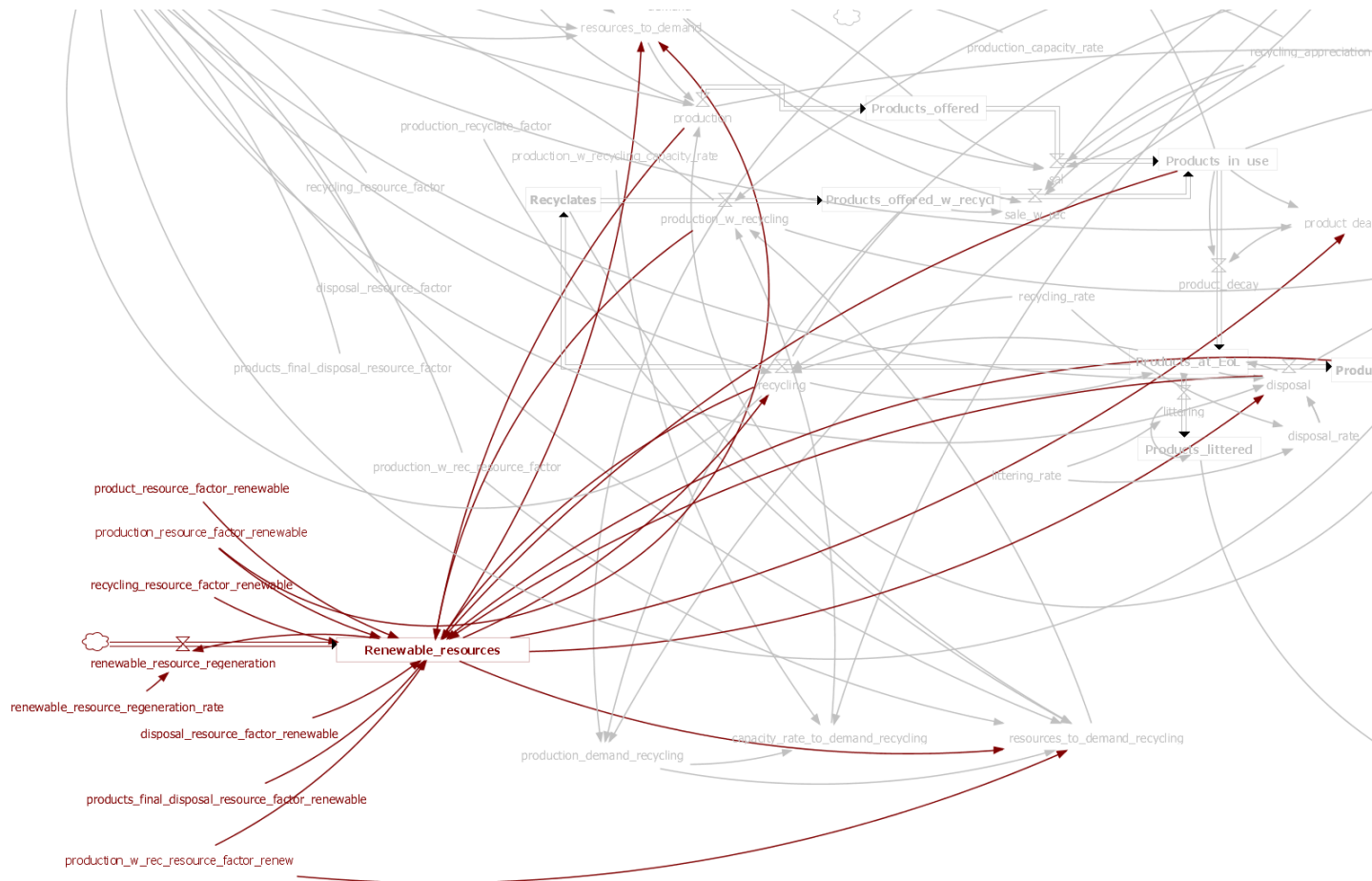
A generic system dynamics model for life cycle sustainability

It has seven main sections: 6, resources



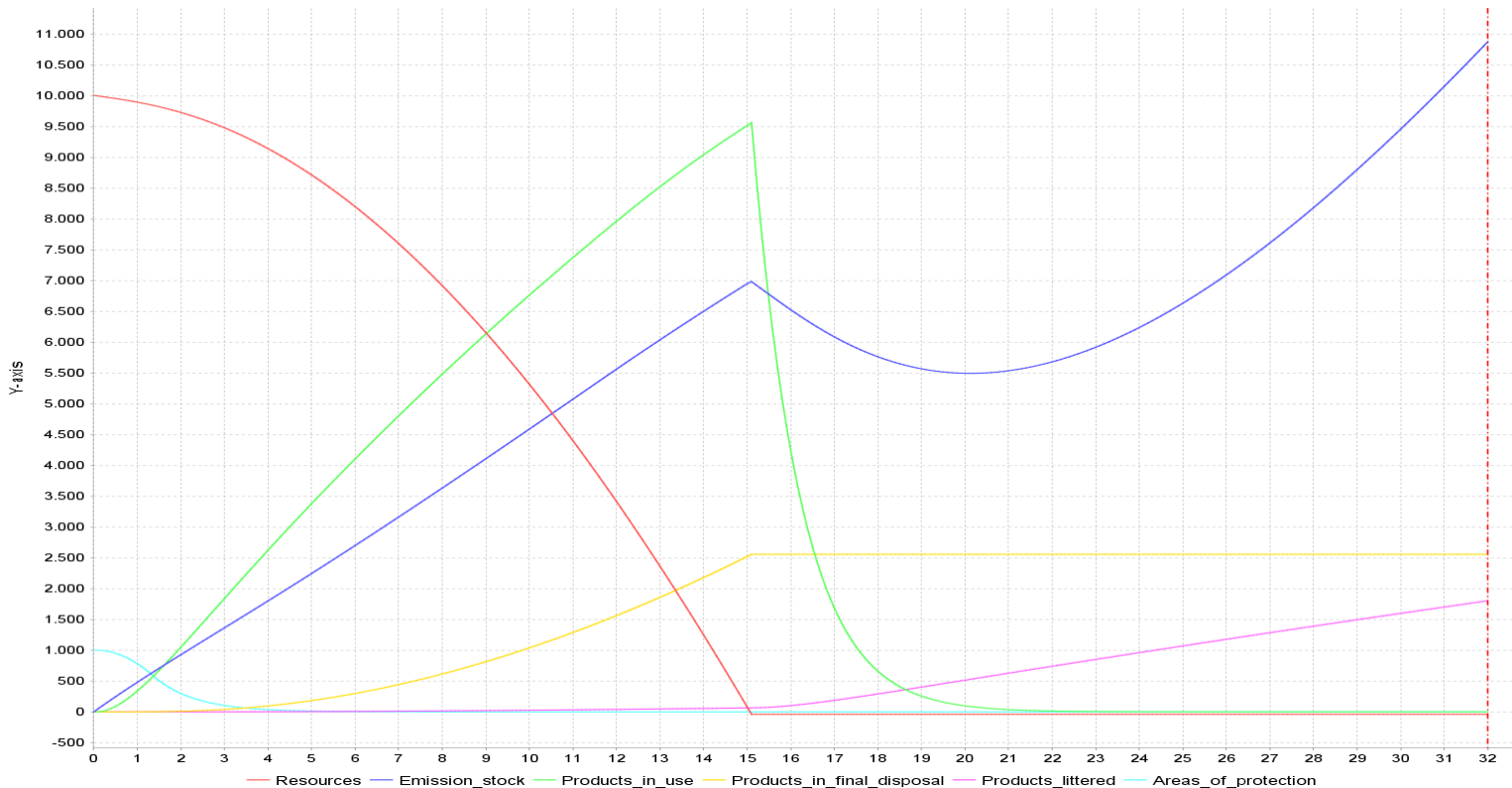
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It has seven main sections: 7, renewable resources



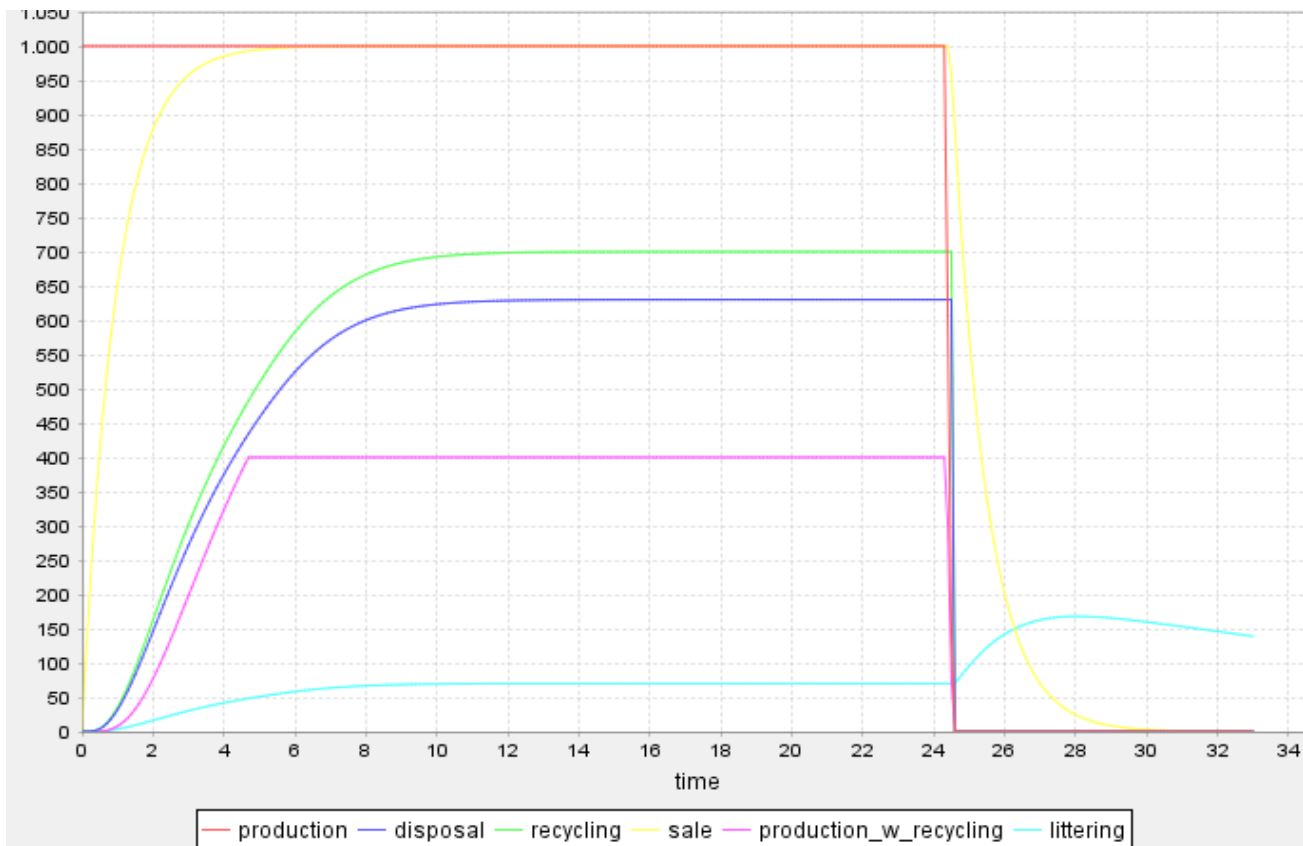
A generic system dynamics model for life cycle sustainability

Simulation results, default

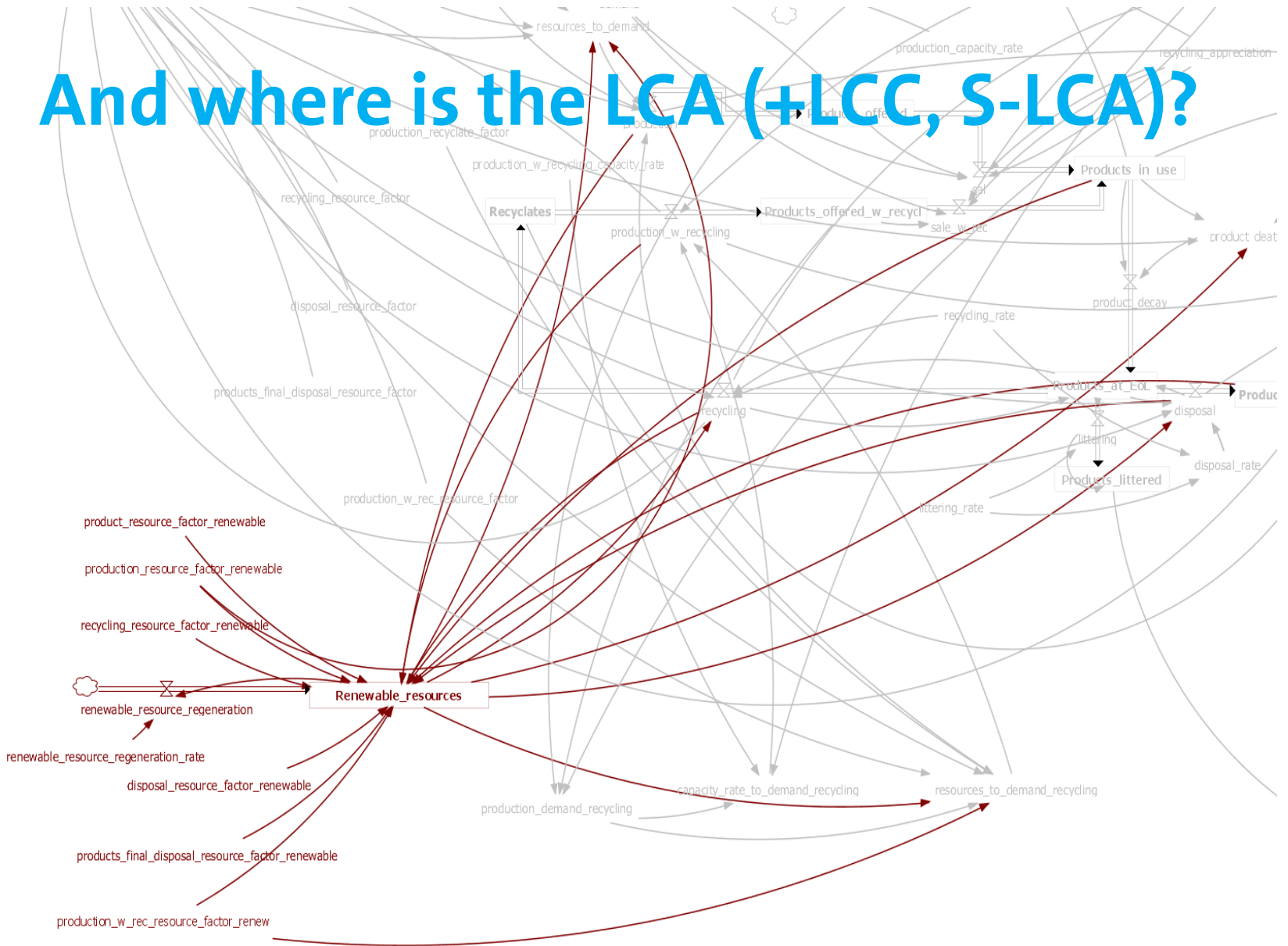


A generic system dynamics model for life cycle sustainability

Simulation results, yoghurt cup (short use without emissions, littering)

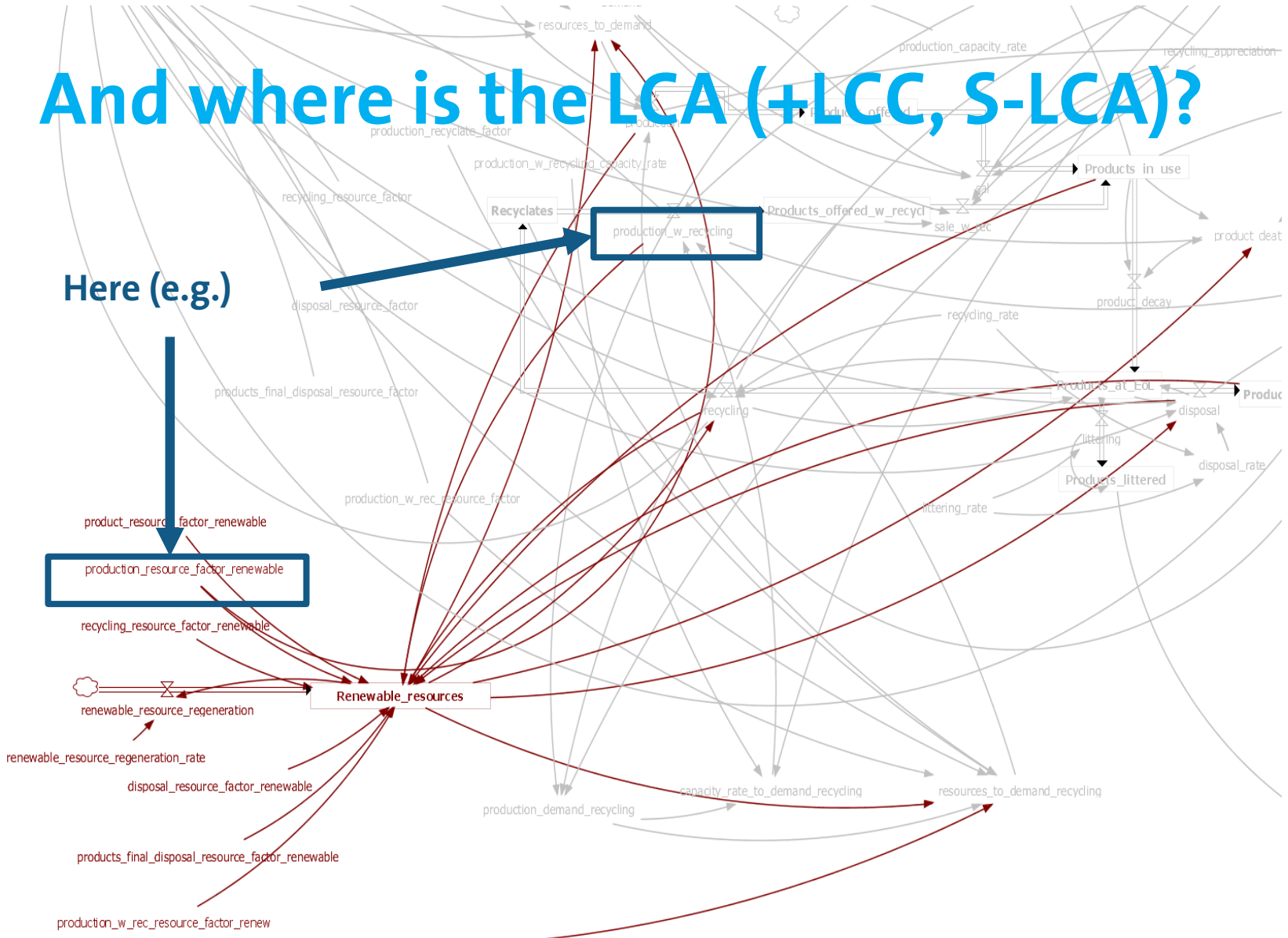


And where is the LCA (+LCC, S-LCA)?



And where is the LCA (+LCC, S-LCA)?

Here (e.g.)



A landscape photograph of a mountain valley with a green overlay. The foreground shows a rocky, gravelly slope. The middle ground is a valley filled with dense evergreen forests. The background features high, rugged mountain peaks under a cloudy sky. A semi-transparent green rectangular box is centered over the image, containing the text "What did I just present?".

What did I just present?

What did I just present

A generic System Dynamics model for life cycle sustainability

System dynamics + LCSA = Modelbased LCSA (!)

System dynamics: system understanding, structure, attention to detail, few relations, variables, and settings can model „the world“; system behaviour over time

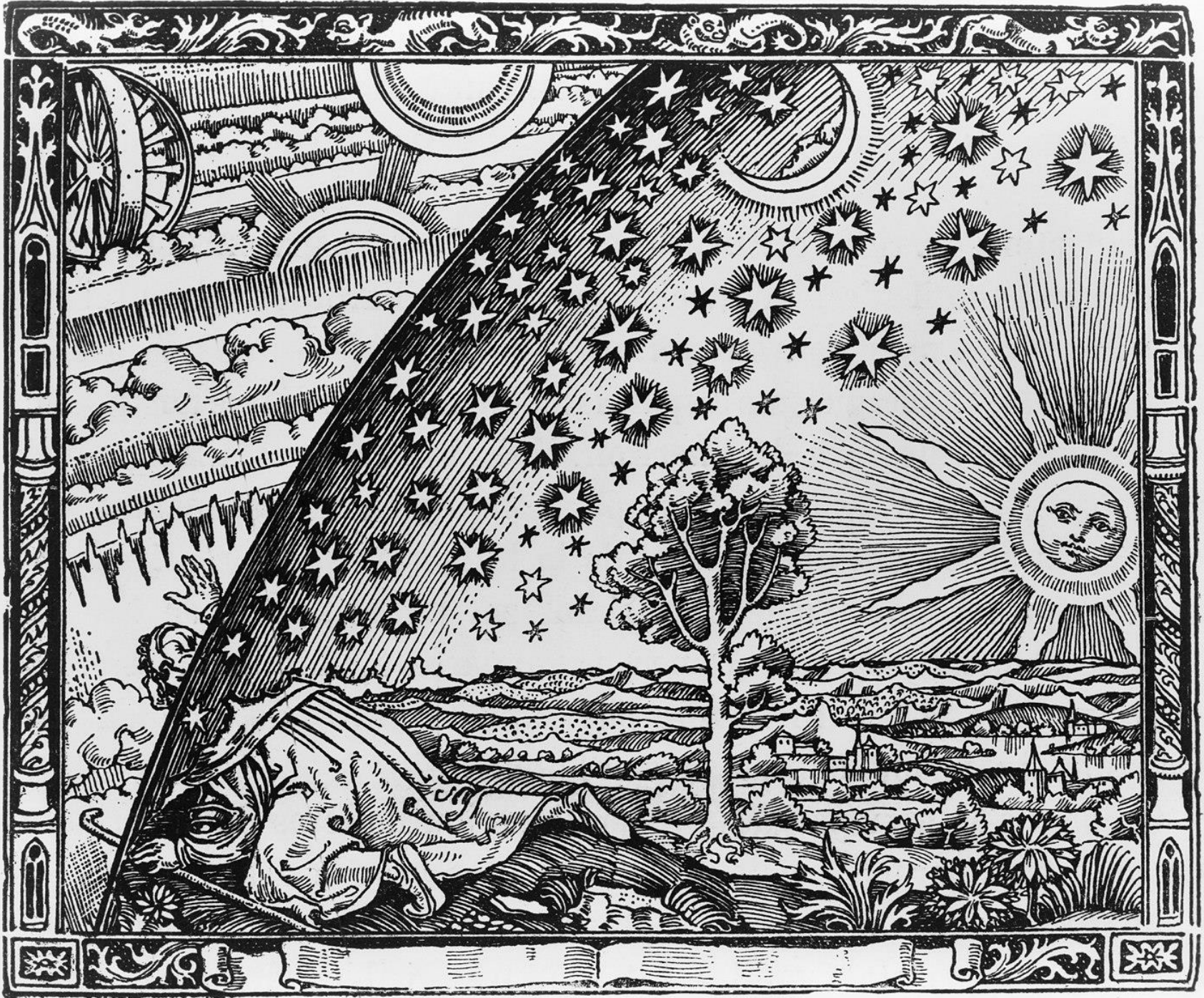
LCSA: ~ large, linear model, can cover worldwide supply chains, created without system knowledge, grassroots / bottom up

What did I just present

System dynamics: system understanding, structure attention to detail, few relations, variables, and settings can model „the world“; system behaviour over time

LCSA: ~ large, linear model, can cover worldwide supply chains, created without system knowledge, grassroots / bottom up

This combination is better able to reflect sustainability, and system know-how as well. Promising and powerful. To be tested and explored in future cases.





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Thank you!

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