Making biotic resources count in the LCIA framework

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Human population derives essential goods from natural ecosystems for many production chains. The increasing demand for resources is raising concerns about the sustainability of the existing production-consumption patterns both for abiotic and biotic resources. The substitution of abiotic resources with biotic ones is part of the transition towards the so called *Bio-economy* [1], under the assumption that their renewability implies a potentially more steady and efficient provision of resources. However, the **carrying capacity of the ecosystems providing biotic resources should be taken into account in order to ensure a sustainable use of biotic resources**.

Traditionally, life cycle assessment has given little attention to biotic resource and their sustainability. The accounting at the inventory is limited to few and relatively generic elementary flows (e.g. less than 30 in Ecoinvent™ 3) and only a couple of approaches have been proposed to assess biotic resource depletion [e.g. 2,3].

Since LCA inventories lack of a complete list of elementary flows for biotic resources as well as models for a comprehensive characterization of the potential impacts on natural resource provision, the present study (Crenna et al., 2017 [5]) aims at contributing to the ongoing discussion on the **relevance of biotic resources into the LCA context**, by: improving their **accounting as material input in the socio-economic systems** and their **impact assessment based on their renewable nature.**

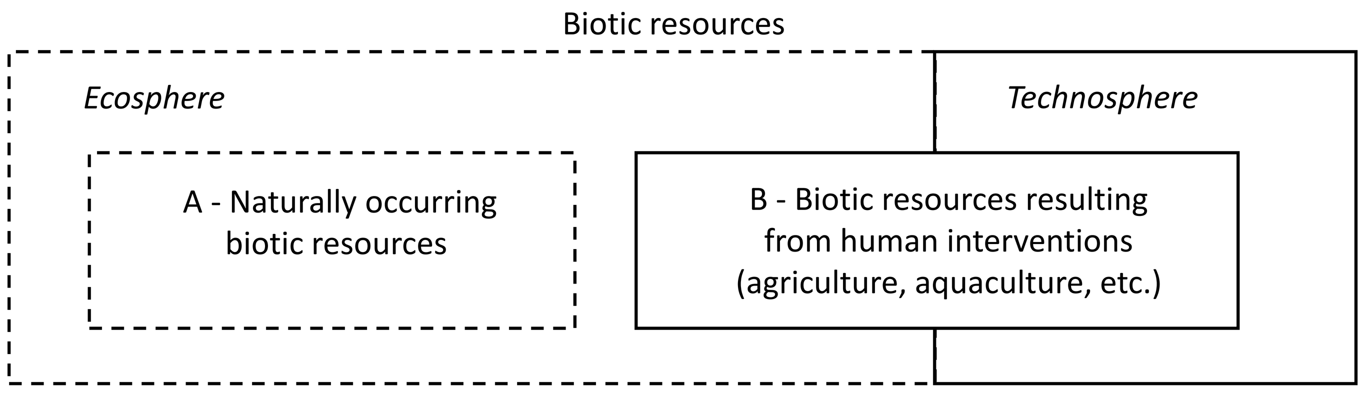

Figure 1 - System boundary for biotic resources, that are distinct in those naturally occurring (A) and those resulting from human interventions (B).

Improving the inventory of biotic resources

Based on the distinction made in Fig.1 and data from the existing literature [e.g. 6], a preliminary list of the most commercially valuable biotic resources at species level was drawn in order to cover the conceptual gap of elementary flows within the inventories of the LCA framework. The focus for defining the list was on naturally occurring resources, following the scheme reported in Figure 1, and covering: aquatic and terrestrial vertebrates, aquatic and terrestrial invertebrates, aquatic plants and algae, terrestrial plants, fungi, aquatic and terrestrial animal products, terrestrial plant products.

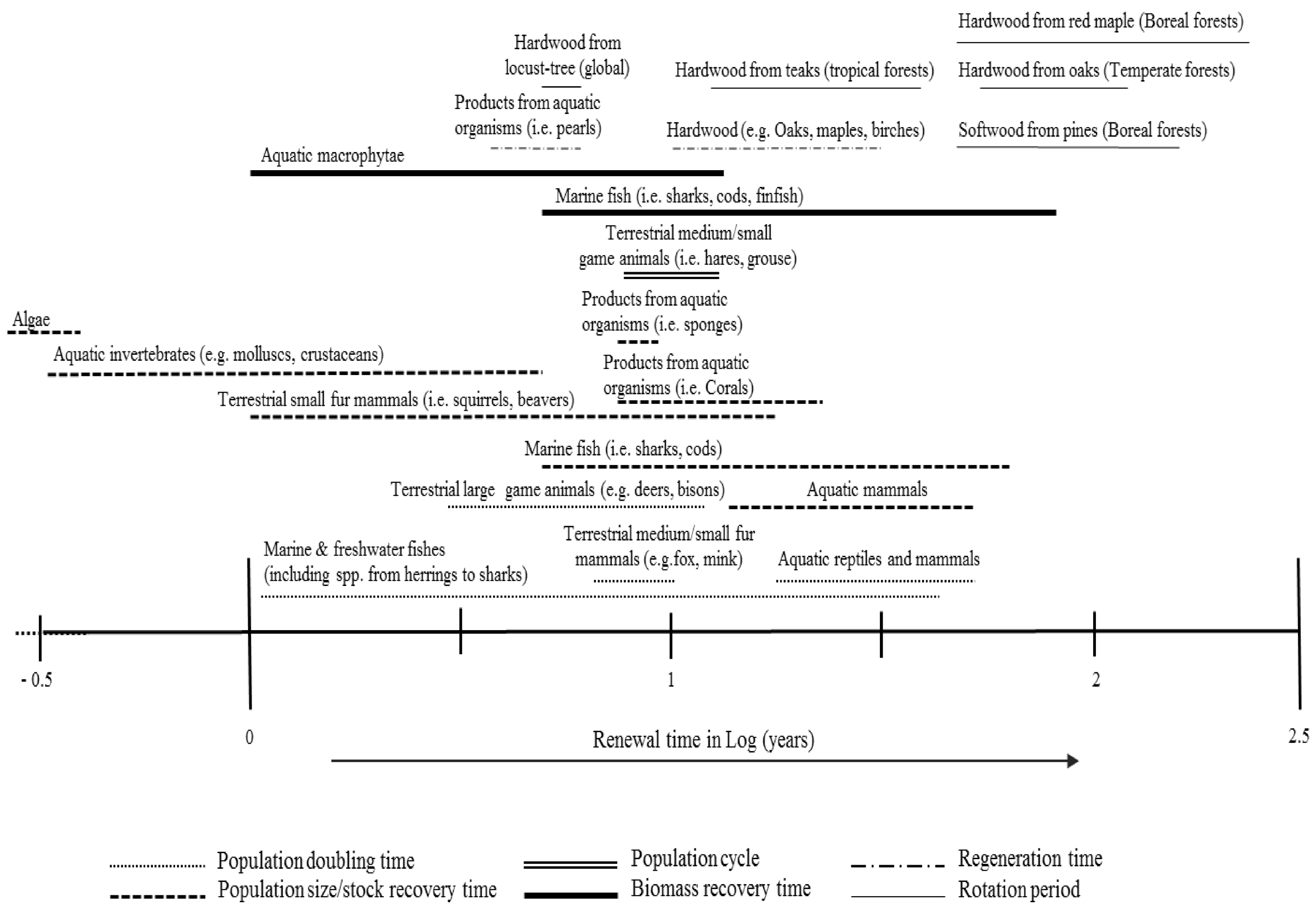

Figure 2 - Renewability rate of several naturally occurring biotic resources, expressed in Log(years).

Conceptualising an impact assessment model based on renewability

The proposed impact assessment model is based on data regarding the **renewability and regeneration rate** of biotic resources (some examples are reported in Figure 2). Since biotic resources are by their very nature dependent on re-growth, we identified the potential of using **renewability time as a basis for calculating the characterization factors for biotic resources and their depletion**. In fact, characterization should be focused on measuring the potential constraints to the availability of resources, ensuring a sustainable harvesting. Example of characterisation factors (CFs) are reported in Table 1.

Commercial group	Species	Common name	Renewal time - Range from literature (years)		Average renewal time (years/kg)
Anchovies	*Engraulis encrasicolus*	European anchovy	1.4 - 4.4	*D*	2.9
Sturgeons	*Acipenser oxyrinchus*	Atlantic sturgeon (caviar)	> 14	*D*	14.0
Tunas, bonitos, billfishes	*Thunnus albacares*	Yellowfin tuna	1.4 - 4.4	*D*	2.9
	Thunnus thynnus	Atlantic bluefin tuna	4.5 - 14	*D*	9.3
	Xiphias gladius	Swordfish	4.8 - 6.9	*D*	5.9
Fur terrestrial vertebrates	*Mustela erminea*	Stoat	10	*D*	10.0
	Mustela lutreola	European mink	10	*D*	10.0
Game mammals	*Bison bonasus*	European bison	5.0 - 6.0	*D*	5.5
	Cervus elaphus	Red deer	10.0 - 14.0	*D*	12.0
Hardwood	*Prunus avium*	Wild cherry	60 - 80	*R*	70.0
	Quercus spp.	Oak spp.	60 - 120	*R*	90.0
	Quercus suber	Cork oak	10 - 12	*R*	11.0
	Robinia pseudoacacia	black locust	5	*R*	5.0
Softwood	*Pinus strobus*	White pine	90 -150	*R*	120.0
	Pinus sylvestris	Red pine	150-200	*R*	175.0

Table 1 - Examples of CFs based on average renewal time, expressed as "population doubling time" (D) and "rotation period" (R) for some commercialized species. Chromatic scale ranges from green (lowest renewability rate) to red (highest renewability rate).

The study (Crenna et al., 2017) has highlighted significant gaps and challenges for modelling biotic resources in LCA.

The main challenges at the **inventory level** are:

- *Completeness and harmonization of the nomenclature at the inventory*, (e.g. dry/wet weight, species names, etc.) .
- Dealing with the *comparability* between naturally occurring biotic resources (resource as an elementary flow) and biotic resources from the Technosphere (i.e. resource as a product).

The main challenges at the **impact assessment level** are:

- *Univocal metric for the evaluation of regeneration time*, namely for plants, animals, etc. Different metrics for the regeneration exist.
- *Non-linearity of impacts*, namely understanding how to include the non-linear growth rate of natural populations in the LCA system.
- Including *Ecological features*, such as vulnerability expressed e.g. by IUCN red list values, could be used as a term of weighting for CFs.

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