Criteria for good biodiversity indicators for forest management in the context of product life cycle assessment

Final report

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1. Introduction

This study has been performed for a confidential client.

The objective of the study is to develop a criteria list, outlining what criteria a good biodiversity indicator for forest management should fulfil, with a special focus on the indicator requirements of product life cycle assessments, and any specific requirements related to raw material acquisition.

The developed criteria list is intended to be used for a review of indicators already proposed in previous studies, to result in an assessment of the extent to which the different proposed indicators fulfil the suggested criteria.

Human activities influence biodiversity in numerous ways by increasing the likelihood of some species or ecosystems to survive at the expense of others, most often leading to a reduction in biodiversity. This happens through:

- *The release* of nutrients, toxic substances or invasive species.
- *The removal* of soil, nutrients or biomass.
- *Physical changes* to the flora, fauna, surface (including changes in its albedo) or soil (including soil compaction and other changes in water infiltration and evapotranspiration).

The impacts from releases (emissions) of nutrients and toxic substances are well covered in product life cycle assessments (LCA), through impact categories such as "climate change (global warming)", "stratospheric ozone depletion", "human toxicity", "eco-toxicity", "photo-oxidant formation", "acidification" and "nutrification". All of these categories of impacts may eventually lead to changes in biodiversity, and attempts have been made to aggregate such impacts on biodiversity in terms of biodiversity-weighted square-meter-years (also known as PDF*m^2*years, where PDF stands for Potentially Disappeared Fraction of species, a concept originating from ecotoxicity assessments).

While forest management may indeed have the potential to influence the above mentioned impact categories through regulating the releases from forestry activities, the purpose of this study is not to develop criteria for biodiversity indicators of these impacts (which also take place outside of the forests) or the impacts from releases of alien species. Rather, we shall focus solely on providing criteria for indicators of direct impacts of forests management on forest biodiversity, i.e. the issues of *physical changes* and *removal of soil, nutrients or biomass*. Nevertheless, it would be desirable that biodiversity indicators for such physical changes could eventually be related to the biodiversity indicators of the release related impact categories, so that this "compatibility" in itself could be a criterion for a good indicator, as we will discuss further in Chapter 3.

The possible criteria are discussed in three chapters. Chapter 2 describes the specific requirements of Product Life Cycle Assessment (LCA), while Chapter 3 describes the broader requirements for biodiversity indicators in general. Chapter 4 describes more general criteria that apply to indicators as such.

2. Criteria related to the use of indicators in the context of LCA

LCA is a technique for assessing the potential environmental impacts from a system of human activities that together are necessary to produce and consume a specific product. While the environmental impacts are caused by the individual human activities, such as forestry, the focus of LCA is on the products supplied by these activities, such as pulpwood. Rather than asking "What are the environmental impacts from the management of 1 ha of forest?" LCA asks "What are the environmental impacts related to 1 m^3 of pulpwood?"

This specific perspective of LCA influences what indicators are relevant for assessing biodiversity impacts of forests management. To be useful in the context of LCA and managing the biodiversity impact of raw material acquisition, biodiversity indicators should

- C1. Allow to distinguish between different raw material suppliers, or
- C2. Provide an overall measure of impact per kg or m^3 of forest raw material, to be used in comparisons with other raw materials.

The latter is the most demanding application, i.e. an indicator that can provide an overall measure per kg of raw material will also provide the ability to distinguish between different suppliers. Therefore, the second criterion is sufficient to fulfil the requirements of both applications.

The specific perspective of LCA, which thus relates biodiversity impact to yield, allows us to place different forest management systems in a more intelligible context than when focusing on biodiversity alone. Figure 1 shows how natural, undisturbed forests and the marginal plantation forests mark the two extreme ends of a straight iso-biodiversity line, i.e. a line along which forestry types have identical biodiversity impacts as measured by an imaginary, ideal, aggregated indicator of "biodiversity-adjusted hectare-years". Both ends of the iso-biodiversity line are relatively well-defined: In a natural, undisturbed forest, both the yield of products and the biodiversity impact from management are zero. A plantation forest has a well-defined yield, and the biodiversity impact is close to the maximum 100%, i.e. 1 biodiversity-adjusted hectare-year per hectare-year, corresponding to zero original, endemic species left.

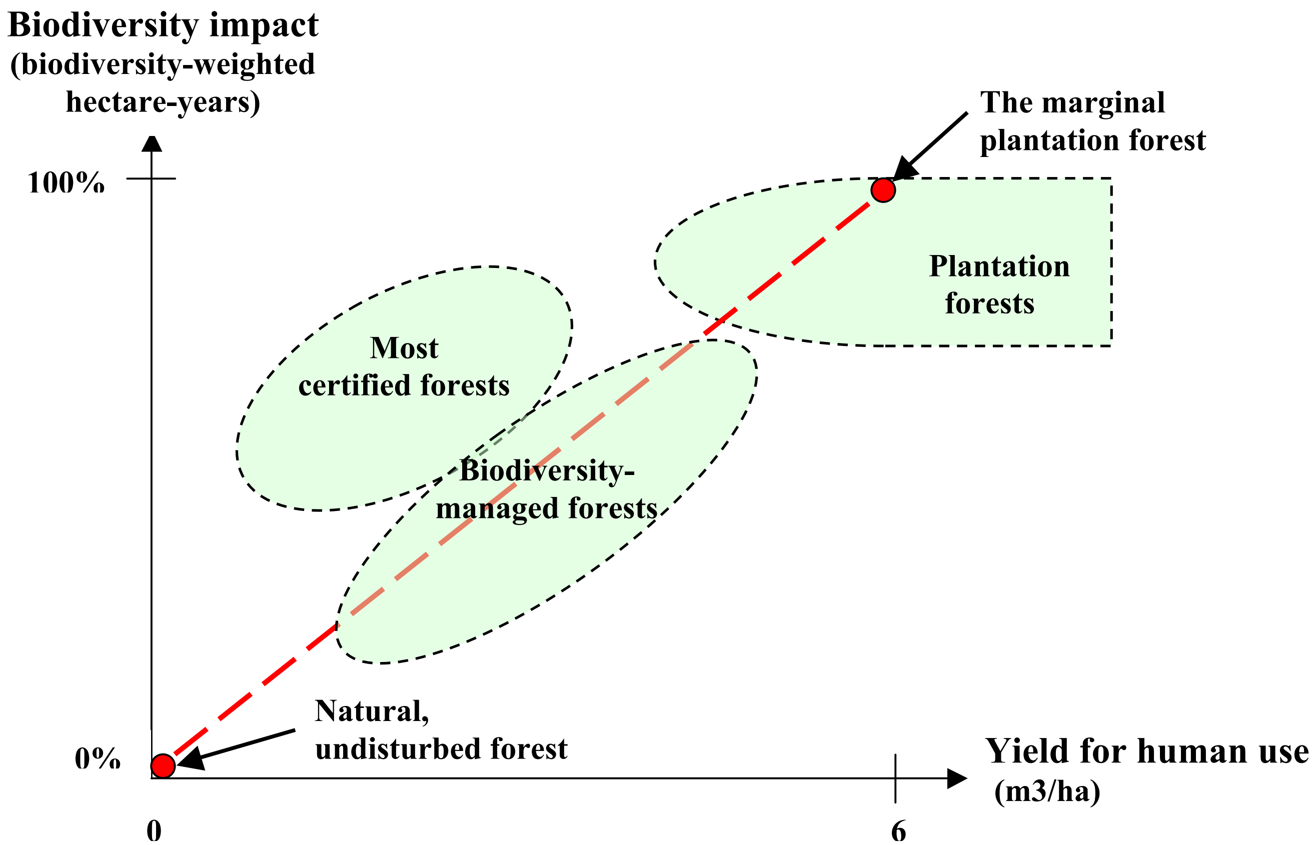

Figure 1. The place of different forest management systems ( ) relative to the iso-biodiversity line ( ), its determining extremes ( ).

It is less easy to determine the biodiversity impact of those forest management types that lie in-between these two extremes. However, it should be safe to assume that to remain *at or below* the iso-biodiversity line would require forest management efforts specifically directed to preserve biodiversity. Without prejudice as to the actual existence of such forests, we may call such forests for "biodiversity-managed forests". Any credible forest certification aimed at biodiversity conservation should aim at ensuring that the certified forests are at or below the iso-biodiversity line, since a position above the iso-biodiversity line per definition implies that its products have a higher impact than those of plantation forestry.

Likewise, it should be safe to assume that whether certified for "sustainability" or not, most managed forests other than plantations lie well above the iso-biodiversity line.

It is interesting to note that the iso-biodiversity line is a "moving target", since the marginal plantation forest, i.e. the plantation that will change its area with changes in demand for plantation wood, is likely to have an increasing yield over time because more intensive plantations are more economically competitive. Thus, the iso-biodiversity line will be lowered over time, and a "biodiversity-managed forest" will become even more difficult to realise.

This reasoning implies that:

- It is relatively uncomplicated to define relevant biodiversity indicators for plantation forestry,
- Plantation products in general can be recommended as having lower biodiversity impact than similar products from other management systems,
- The real challenge for a good biodiversity indicator is its ability to distinguish whether a forest is at or above the iso-biodiversity line and can therefore be identified as a "biodiversity-managed forest" having a neutral or positive biodiversity impact relative to that of plantation forestry.

The forest management systems discussed in relation to Figure 1 are all systems that are assumed to maintain a specific biodiversity condition over time, i.e. systems that do not change the state of biodiversity on the occupied areas (although fluctuations in biodiversity over a rotation period may occur). Other forest management systems or practices involve more drastic changes to the biodiversity state, either by deteriorating it (harvesting in a previously undisturbed forest, changing to a management system with a lower average level of biodiversity) or by improving it (restoration activities). Such changes to the biodiversity state of an area have more far-reaching impacts than the systems discussed in relation to Figure 1, since they significantly affect the relaxation period, i.e. the period before the disturbed system reaches a new stable condition (the current relaxation potential). These issues are discussed in detail by Weidema & Lindeijer (2001) but will not be elaborated further here, since they do not contribute any additional criteria for good biodiversity indicators.

It is obvious that some indicators will be easier to relate to the output of forest products than others. For example, an indicator like "biodiversity-adjusted hectare-years" is straight-forward to express per m^3 wood when the annual yield per ha is known, while it is more difficult to express "core forest area" per m^3 wood, because more information is needed about the size of the harvested plot and its specific position in relation to the existing core forest area.

3. Criteria for biodiversity indicators in general

In addition to the specific use in the context of raw materials aquisition, it could be seen as an advantage if the biodiversity indicators could also be of more general interest, i.e.

C3. Be generally applicable across different products and human activities,

C4. Be organised in a hierarchy that ensures consistency when combining local-scale indicators with indicators at national, regional or international level, as well as across the genetic, species, biotope, habitat and biome levels.

To be generally applicable and consistent across different conceptual levels, an indicator does not necessarily need to be general in nature, but it must be possible to interpret it in more general terms, so that it can be compared and ideally aggregated with other indicators for other products of human activities. This implies that an indicator like "Core forest area", which is obviously mainly relevant for forestry, still may fulfil the requirement of general applicability if it can be interpreted in general terms such as “area of undisturbed ecosystem”, i.e. relative to a more general reference.

Ability to distinguish between relevant and irrelevant elements is an obvious quality of an indicator. An overall biodiversity indicator should be sensitive to antropogenic changes to endemic species, but should not include natural variation as a negative impact nor increases in exotic species as a positive impact, biodiversity indicators should:

C5. Be able to distinguish between endemic and exotic species.
C6. Be able to distinguish between anthropogenic and natural variation.

Another general criteria of relevance is that a biodiversity indicator should preferably:

C7. Indicate particularly sensitive elements, thus providing early warning of change.

Examples of indicators that would score high on this criterion are focal species indicators (focal species are vulnerable species that can represent a larger set of vulnerable species) and hard and thick deadwood, since changes in its value can be detected over relatively short periods.

4. Criteria for good indicators in general

While the criteria listed in the previous chapters may be seen as “ideal” criteria, an indicator is by definition a simplified descriptor, which also means that the practical applicability is of foremost importance. This means that a specific indicator may be less than ideal, but still provide a better measure than no information. In general, indicators should therefore:

C8. Be integrated in a framework that can be improved as more information becomes available over time.
C9. Be easy to understand and translate into decision making.

Olivier et al. (2003) provide a checklist for desirable properties of impact pathway descriptions. Some of these properties can also be seen as desirable properties of indicators:

C10. Have explicit documentation of models and variables including the conditions under which the model is valid, in terms of temporal and spatial validity and other boundary conditions.
C11. Describe marginal impacts rather than average
C12. Applying continuous variables rather than discontinuous
C13. Be relevant for the further integration and modelling towards other indicators in the framework, i.e. be integrated in a framework that represents cause and effect relationships.
C14. Be modular rather than aggregated
C15. Be quantifiable rather than qualitative
C16. Be feasible through availability of the needed data, i.e. be easy and inexpensive to obtain reliable measurements for.
C17. Have uncertainty information on available data for variables and background data.

References

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