BIOSCOPE

Methodology

2022

May 2022

This tool was originally developed by PRé Sustainability, Arcadis and CODE commissioned by Platform BEE (Biodiversity, Ecosystems and Economy); a collaboration between IUCN NL and VNO-NCW financed by the Dutch ministry of Economic Affairs.

The 2022 update of Bioscope was funded by the Partnership Biodiversity Accounting Financials and PRé Sustainability.

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About BioScope

BioScope provides businesses and financial institutions with a simple and fast indication of the most important impacts on biodiversity arising from their supply chain, their investments, or a specific sector.

The results brought by BioScope are aimed at helping you to formulate meaningful actions to further assess and reduce the impact of your business activity on biodiversity. It not only indicates the potential impact of the commodity you purchase or the investment you make, but also of the upstream supply chain of these products. Examples of questions which can be answered are:

- Which of the commodities purchased by my business could be the largest cause of impact on biodiversity?
- Which of the investments made or financial products provided by my financial institution cause impacts on biodiversity?
- What could the new purchasing strategy of my business mean for our impact on biodiversity?
- What commodity, investments, or financial products, purchased or provided by my business, do we need to focus on if we want to make a meaningful contribution to conservation of biodiversity?

BioScope makes use of Exiobase v3.4 enabling you to select commodities and resources purchased from 163 sectors in 44 countries (27 EU countries and all large economies outside the EU) and 5 rest-of-world regions, covering all global economic activities. The resulting impacts on biodiversity are calculated with the ReCiPe method, which was specially adapted for BioScope.

About this document

This document presents the methodology behind BioScope and a description of the Exiobase database is also included. Additionally, the impact drivers are discussed and how they are linked with biodiversity impacts in ReCiPe. Because we do not want to overload the reader with complex formulas and biological mechanisms descriptions, the focus was mainly put on climate change and land use, which are the two main drivers of the impact on biodiversity. The mechanisms described are however similar for the other impact drivers. Would you want a deeper understanding of the characterization method, or the database, please refer to the reports from the corresponding organization cited as references of this document.

I. Introduction

Assessing biodiversity is a complex task, since locally there are many levels at which biodiversity can be described, for example by:

- The species abundancy;
- The gene pool, the variety of genes, and with that the robustness of the system;
- The habitat; and
- The functional value of the ecosystem (what is the economic value it generates)

Species richness is one of the most common indicators to measure the damage to diversity. This indicator is described as the fraction of species that has been lost in comparison with a natural or undisturbed area. One of the main drawbacks of using this indicator is that the increase of certain species might not be desirable or could be seen as an invasion for certain areas or for other species. In our case, the model makes use of so called target species, and refers to a target habitat.

Moreover, understanding the biodiversity impacts on a local scale is one thing, but understanding the biodiversity impacts on a global scale from commercial activities adds another layer of complexity. This requires an evaluation of the influence of economic activities along the supply chain in different regions, and from there a measure of how such activities disturb habitats and cause a loss (or gain) in species numbers.

II. Biodiversity Footprint Methodology

BioScope aims to provide a quick scan tool to calculate biodiversity impacts due to economic activities. The two key elements for doing this are:

1. An inventory of commodities used in a given supply chain or financial product; this is done by specifying the expenditure per commodity for each stage.

2. A biodiversity impact model, which will translate these regionalized economical activities to a meaningful indicators that describe their influence on twelve impact drivers: Global warming (terrestrial & freshwater ecosystems), Ozone formation (terrestrial ecosystems), Terrestrial acidification, Freshwater eutrophication, Marine eutrophication, Terrestrial ecotoxicity, Marine ecotoxicity, Freshwater ecotoxicity, Land use and Water consumption (terrestrial & aquatic ecosystems).

Disclaimer: This tool gives an approximation of the biodiversity impact resulting from the commodities purchased or from investments made by businesses and financial institutions. The use of country level data on economic activities and their impacts mean that the confidence of the outcome is limited. For a complete impact assessment, subsequent steps will always remain necessary. The results of this tool are meant for internal purposes only and cannot be used for public communication.

I. Inventory of commodities

In this case an input-output approach is used, i.e. the use of a database that does not describe a specific industrial operation but average activities in an economic sector. For that reason, inputs and outputs are specified in monetary terms. For example: to produce one euro worth of steel, it is required to purchase X euro from the fossil fuel sector, and Y euro from the ore sector. Although the use of an input-output database is rough in terms of detail, it can adequately describe a complete economy.

The input-output database chosen for BioScope is Exiobase [1]. This database works with a standard model of the economy; it covers 43 countries, that together represent 90% of the World's economy and 5 'Rest of the World' regions that cover the remaining 10%. Exiobase team have collected data for all 48 regions on economic activities, environmental and some social aspects [2], distinguishing 163 industrial and service sectors. All trade flows between these sectors are also specified, which leads to millions of trade flows. Since for each sector, the main environmental impacts were collected, if one knows the expenditure per commodity for each sector, then it is possible to understand the impacts of a supply chain.

Some points of attention when using Exiobase are:

- Dividing an economy in 163 sectors provides a rather coarse classification of economic activities. So if expenditure is made in a specific industrial activity, it is not always clear to which sector it belongs.
  For instance, a lot of the big names in the apparel industry make, of course, apparel, but are also important players in retailing, which is considered to be another sector. Another issue is that apparel is also considered a very broad sector, from t-shirts to sport shoes. Since all inputs are considered per Euro, the use of this approach does not allow to add specific materials or the way it is produced and thus the price is what determines the impact.
- Data gathering per region is also important, as each country has its own way of defining sectors, and collects its data according to that sector classification. For instance, Germany uses a classification of just over 40 sectors, while the US and Japan use about 500 sectors, and the Netherlands use just over 130. For Exiobase, all that information had to be re-allocated to fit the framework of 143 sectors; this can of course create distortions.
- A particular problem are the Rest of the World regions, as often very little data is available.

II. Biodiversity impact model

For translating the influence of economic activities into biodiversity impacts a method is required. The method used by the first version of BioScope is an adapted version of ReCiPe 2008 [3], which links the emissions and resources used of each activity with several impact drivers by using characterization factors. In the latest update, we use ReCiPe 2016 [4] to translate emissions and resource use in biodiversity impact. Figure 1 provides an overview of how the emissions and resources specified by Exiobase are linked to loss of biodiversity:

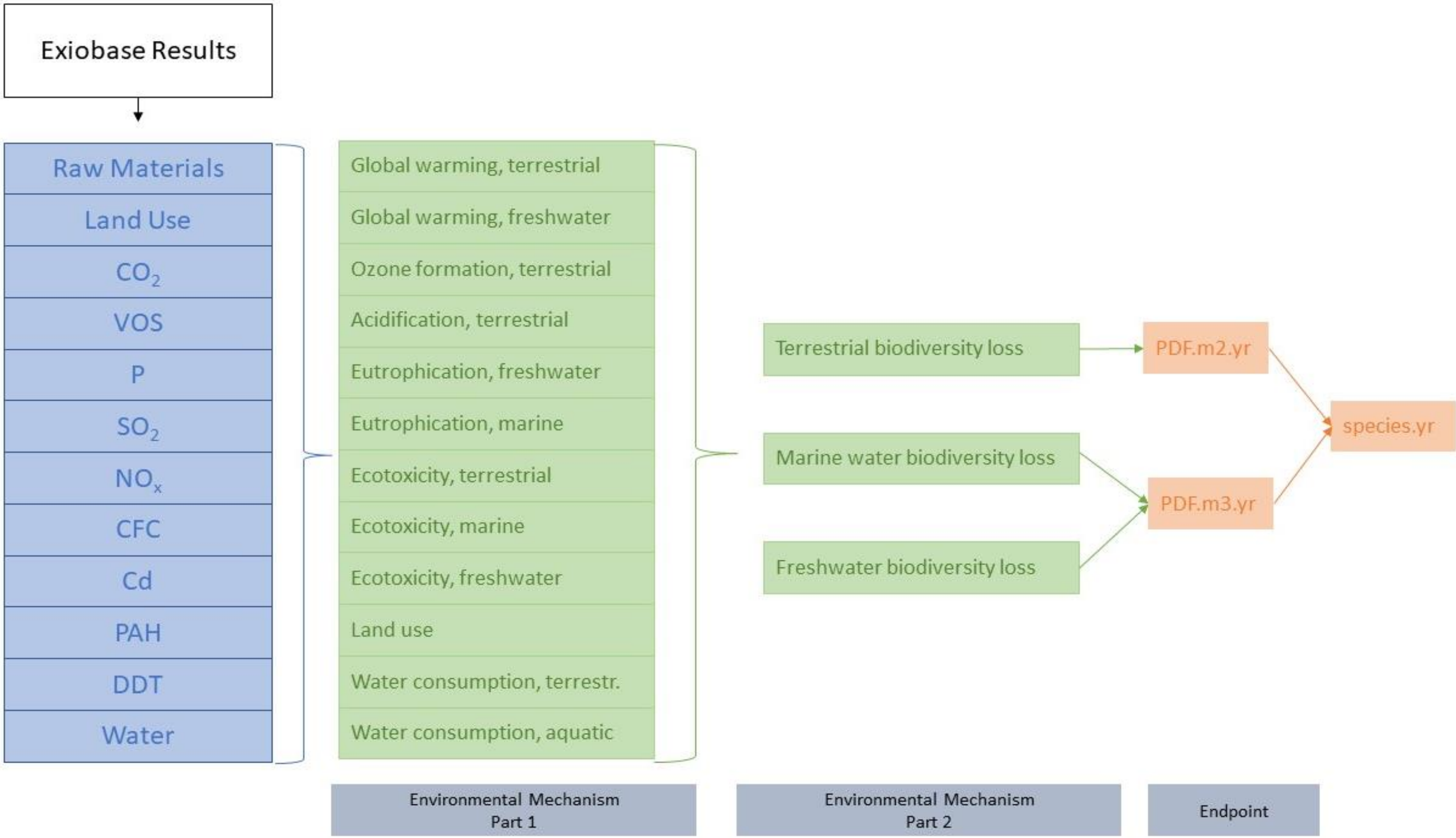

Figure 1. Adapted ReCiPe method for biodiversity

After the resources and emissions are derived from Exiobase, the impacts are calculated on land and in water via 12 impact drivers in a two-step approach. The unit for biodiversity impact is species.yr.

The unit species.year is a measure for how many vascular plants and lower organisms, on land and in water, are expected to disappear because of the assessed activities. These lower organisms are typically at the beginning of the food chain, and if something goes wrong there, it will have impact on the higher organisms, on which impacts are much more difficult to model. For this reason calculating from a focus on lower organisms and vascular plants provide an indicator of the health of the ecosystem. If the cause of this extinction stops (for example the activities of a company), then the number of species will start to go up again. For instance: 30 species.year means that 30 species are extinct for 1 year OR 3 species for 10 years. If, on the second year, the assessment from the same company shows 25 species.yr, it means that 5 species will start to reappear. The impact categories in ReCiPe were selected in terms of its link to biodiversity resulting in twelve impact drivers:

Global warming (terrestrial & freshwater ecosystems)

Large-scale, long-term shift in the planet's weather patterns or average temperatures. These changes affect species composition through complex interactions among species and between species and their habitats.

The link between global warming (climate change) and biodiversity can be described using the cause-effect mechanism. The specific problem is that, although the impact of the historic emissions on the climate is known, the objective is to assess the impact on biodiversity of adding or avoiding an additional CO_2 kilogram (equivalent).

Researchers [5] have compared the so-called climate sensitivity of the current climate models, which resulted in scenarios of temperature changes due to the impact of avoiding cumulative CO_2 emissions. This approach allows to connect CO_2 equivalents to temperature increase. In Figure 2 there are two lines; the lower describes the immediate response of such a reduction, the higher shows the impact of the equilibrium that is reached many years after the emissions have been avoided. From this graph it can be interpreted that every 1000 GtC (Gigatonne of carbon) has an effect of 2.6°C at equilibrium, or in other words, every kilogram of emitted CO_2 has a temperature effect of 65e-15°C.yr or written in full 0.000000000000065°C during one year.

The addition of a time dimension requires some attention. One kg does not have an impact forever. After about 150 years, the CO_2 will be gone from the atmosphere, so one kg can only have a temporary effect.

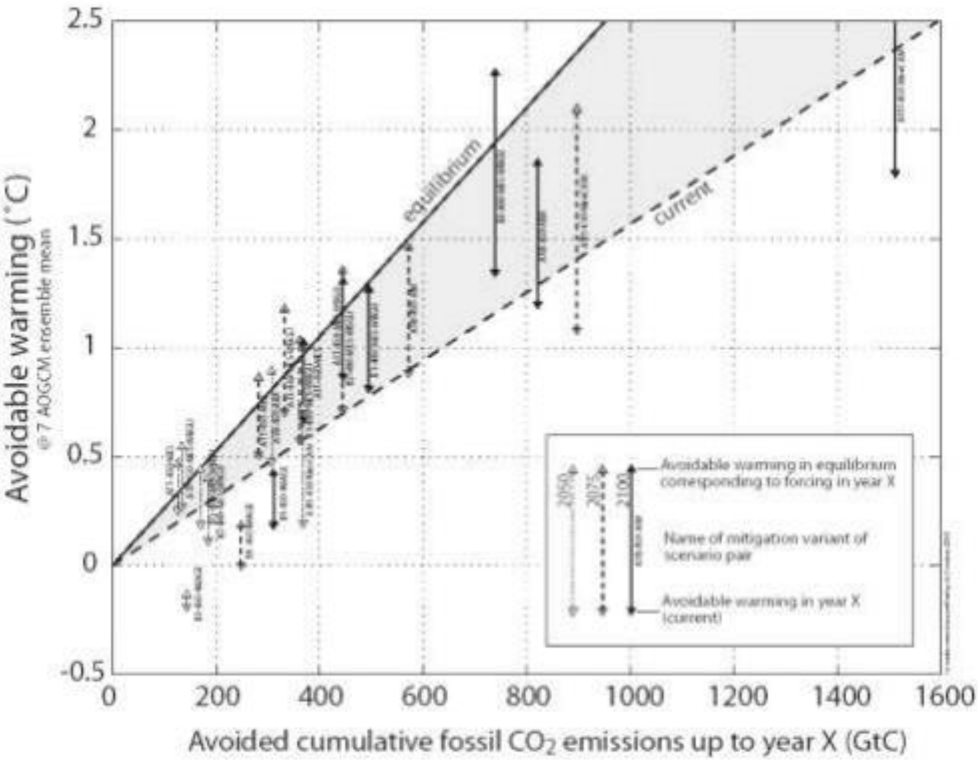

Figure 2. Climate models linking changes on CO_2 emissions to a change in temperature

The next step is to translate temperature increase into biodiversity impacts. Data has been compiled from several studies, were the link between temperature and loss of species has been established. The focus is on vascular plants and insects, as the impacts on higher species are more difficult to determine. If something goes wrong at the start of the food chain, most experts assume that this will determine much of the fate of the higher organisms.

The case of the butterflies will be used to illustrate the relationship between temperature and species loss. Figure 3 shows on the horizontal line the temperature increase and on the vertical axis the percentage of species that will disappear due to the temperature increase.

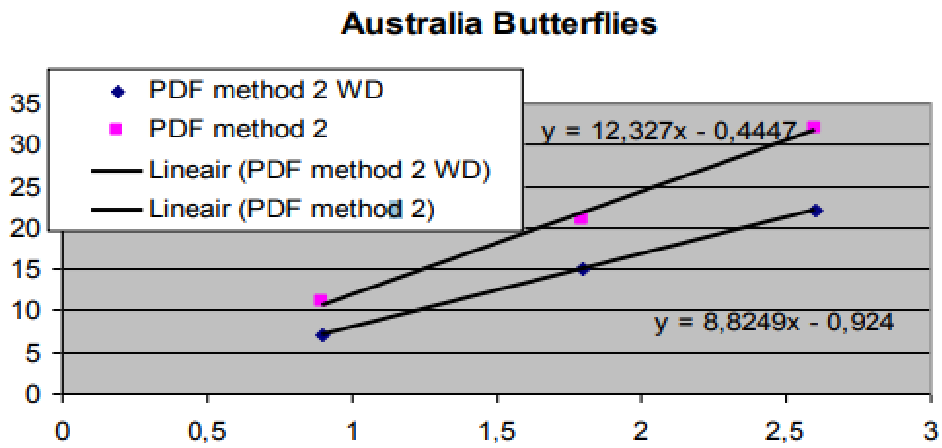

Figure 3. The link between temperature changes and species loss.

The analysis is made under two assumptions: one assumption is that the butterflies have enough time to migrate with the change in temperature (the lower line); the higher line takes the assumptions that the butterflies cannot do so, causing a higher predicted damage.

It is important to note that a temporary change of the temperature was calculated; this implies that emitting a kilogram of CO_2 has only a temporary impact on the species richness. Moreover, this model assumes that when the emissions stop, and the temperature decreases, the species may return. The model treats all species equal and cannot distinguish between red-listed or endangered species and other species. However, if the emission flow is constant or increasing over many years, the temperature increase will also stay high, and the loss of species is permanent.

Ozone formation (terrestrial ecosystems)

Changes in species composition in terrestrial ecosystems due to air pollution causing tropospheric ozone in the atmosphere. This impact category includes regionalized results.

Ozone formation starts with an emission of NOx or NMVOC to the atmosphere by for example car exhausts. Once in the air those emissions are transformed in air to ozone. Subsequently, this tropospheric ozone can be inhaled by humans or taken up by plants, leading to an increased number of mortality cases and final damage to human health, as well as disappearance of plant species and final damage to terrestrial ecosystems.

The ReCiPe method uses characterisation factors that account for ozone formation caused by emitted precursor substances. This characterization factor for ecosystem damage is composed of a Fate Factor, which quantifies the relationship between the emission of precursor substances in a specific region and ozone exposure, and an effect factor, which quantifies the relationship between ozone exposure and the occurring damage to natural vegetation (forest and grassland).

Terrestrial acidification

Changes of acidity in the soil due to atmospheric deposition of inorganic substances, which can lead to shifts in species composition. This impact category includes regionalized results.

Atmospheric deposition of inorganic substances, such as sulphates, nitrates, and phosphates, cause a change in acidity in the soil. For almost all plant species, there is a clearly defined optimum of acidity. A serious deviation from this optimum is harmful for that specific kind of species and is referred to as acidification. As a result, changes in levels of acidity will cause shifts in species occurrence. Major acidifying emissions are NOx, NH_3, and SO_2.

The ReCiPe method accounts for the persistence of acidifying substances by combining an atmospheric deposition model and a dynamic soil acidification model. Then, the ecosystem damage effects due to acidification can be calculated with a dose-response curve of the potential occurrence of plant species. In this method, Base Saturation (BS) was used as an indicator to express acidity. BS is the degree to which the adsorption complex of a soil in is saturated with basic cations, cations other than hydrogen and aluminium. For higher BS, more basic cations are present, which enhances the buffer capacity of the soil for acidic equivalents. Changes in BS in mineral soil can influence the occurrence of plant species in a given area, so a dose-response relationship is created that relates the PDF to BS. This relationship is found to be location independent. As shown in Figure 4, the potential of disappearance of species due to acidity increases for higher BS values.

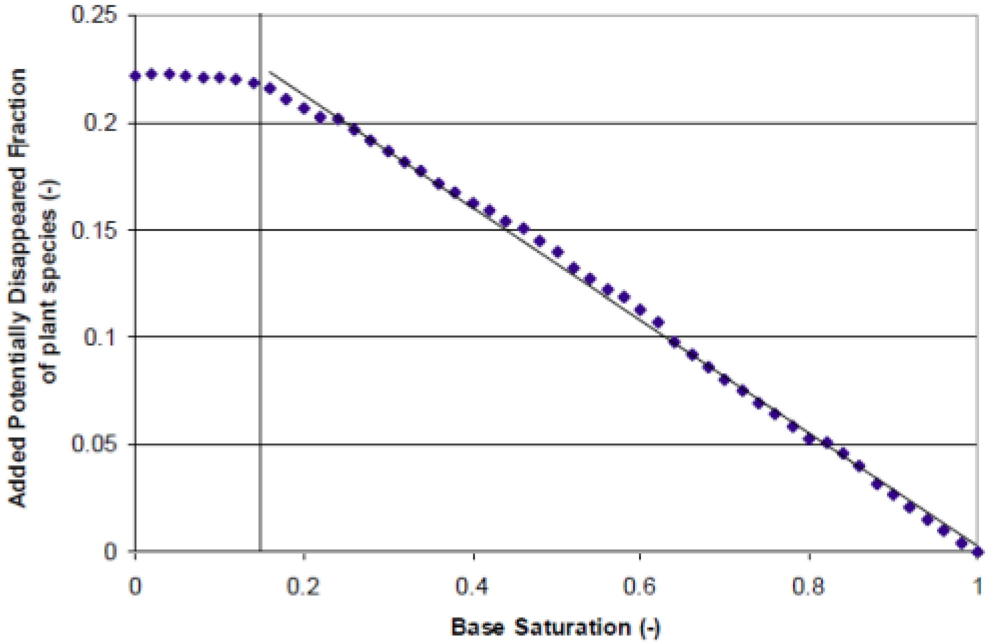

Figure 4. Dose response function of the PDF of plant species due to acidifying emissions as a function of BS in mineral soil.

Eutrophication (freshwater & marine ecosystems)

Nutrient enrichment of the aquatic environment which can lead to shifts in species composition. This impact category includes regionalized results.

Eutrophication in inland waters as a result of human activities is one of the major factors that determine its ecological quality. On the European continent, Eutrophication generally ranks as a more severe water pollution than, e.g., emissions of toxic substances. The long-range character of nutrient enrichment, either through air or rivers, implies that both inland and marine waters are subject to this form of water pollution, although due to different sources and substances and with varying impacts.

The ReCiPe method utilizes characterisation factors that take into account the effect of nutrients limiting the yield of aquatic biomass, which is merely phytoplankton (algae) but also duckweed. “Limiting” implies that only one nutrient is controlling the growth of these primary producers and that there is an excess of the other nutrients. Growth of phytoplankton depends strongly on the availability of Nitrogen and Phosphorus (N/P) and on the season. In large industrial and agricultural regions, N/P sources exceed natural inputs by far due to the use of fertilizers or emissions to water or soil. As a result, an additional amount of N/P leads to increased growth of phytoplankton causing a chain of adverse ecological effects. To account for these effects, ReCiPe uses the integrated assessment model CARMEN (acronym for Cause effect Relation Model to support Environmental Negotiations), which calculates the fractions of the N/P emission flux that actually reach freshwater or coastal seas.

Whether aquatic nutrient enrichment leads to an environmental problem or not depends on local factors like topography, physical and chemical nature of water bodies.

Ecotoxicity (Terrestrial, freshwater & marine ecosystems)

The environmental persistence and accumulation in the food chain, and toxicity of chemicals, affecting species composition in terrestrial ecosystems, inland freshwater ecosystems or in marine ecosystems.

The characterization factor of human toxicity and ecotoxicity accounts for the environmental persistence (fate) and accumulation in the food chain (exposure), and toxicity (effect) of a chemical. Fate and exposure factors can be calculated by means of 'evaluative' multimedia fate and exposure models, while effect factors can be derived from toxicity data on human beings and laboratory animals. ReCiPe makes use of a fate, exposure, and effect model (USES-LCA) adapted to track the concentration changes and emission of toxic substances in different compartments (soil, freshwater or sea water, air, etc.) and determine the ecotoxicity effect of different mixtures of toxic chemicals on sets of species.

Land use

Changes in species composition due to use of land for agricultural activities.

In other words, it is assumed that, during the time the land is used, it cannot return to a natural state; if an area is used to produce X kg of cotton during a year, then during this year a certain fraction of species is lost.

To expand on this, Figure 5 depicts the changes in species richness over time due to the use of land. Between time 1 and time 2, there is a rapid decrease. After that it is assumed there is a stable situation and there are no further changes in the species richness. It is also assumed that at some point in time, the use stops, and a restoration takes place between time 5 and 6. Whether a natural system can restore to the original species richness is unclear, and when this will happen is also unclear. However, it was found reasonable to assume that it is valid to compare between the current impact and a situation where no impact has taken place.

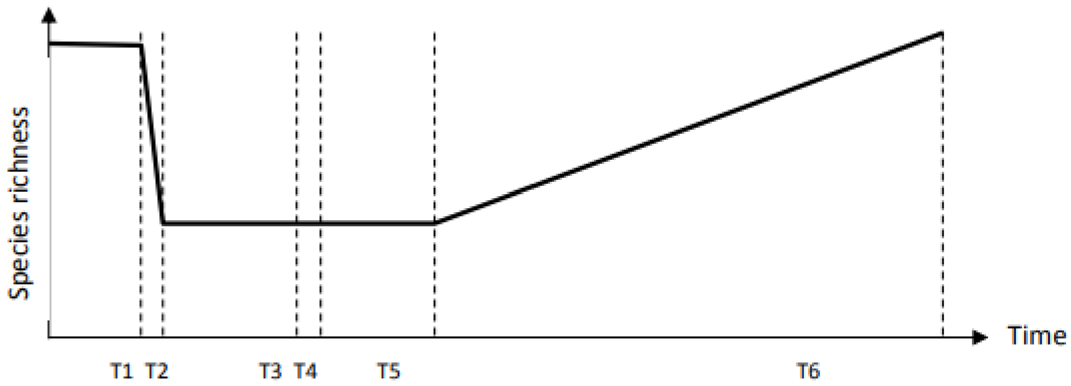

Figure 5. Temporal changes over species richness for land use.

In the case of agriculture, if farmers using an already converted land between time 3 and time 4, cannot be held accountable for the conversion that happened at T1. However, as long as the land is occupied it cannot restore to nature. So the impact allocated to the farmer can be calculated by multiplying the loss of species with the duration of the use and of course the area size. The actor that has converted the land is responsible for the damage between time 1 and 2, as well as the damage done between time 5 and time 6, during the restoration time. As the conversion time is usually much shorter than the restoration time the first period can be neglected.

In the end, the impact in biodiversity for land use is calculated in species.year.

A biodiversity map of the world is shown in Figure 6, this illustrates the large differences in the number of plant species for different regions. The ReCiPe method assumes that the absolute number of species is not so important as the relative number, so the 20 to 200 vascular plant species that can be found in the Sahara together form the ecosystem and halving that number of species is seen as being equally important as halving the species number in Peru, where there can be more than 5000 species. This implies that losing one species in the Sahara has a much bigger impact than losing one species in Peru.

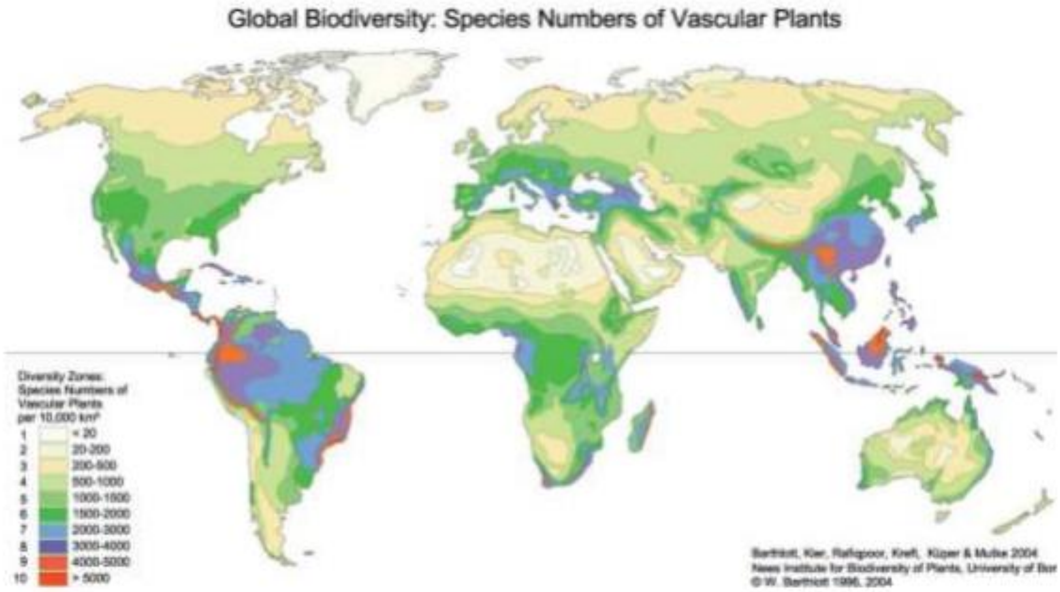

Figure 6. Biodiversity World Map

The next question is how to determine the species numbers on agricultural land. For agriculture it is assumed that a farmer only wants one type or few species on the land. However, agricultural farmlands are in fact quite rich in species, and that is because there is a rich diversity in the edges and the small unused plots and pathways. For this a very detailed inventory was developed [6] and consists of counted species on the land itself (X-plot) (see figure 7), the area just inside the fence (A-plot) and the area just outside (the B-plot).

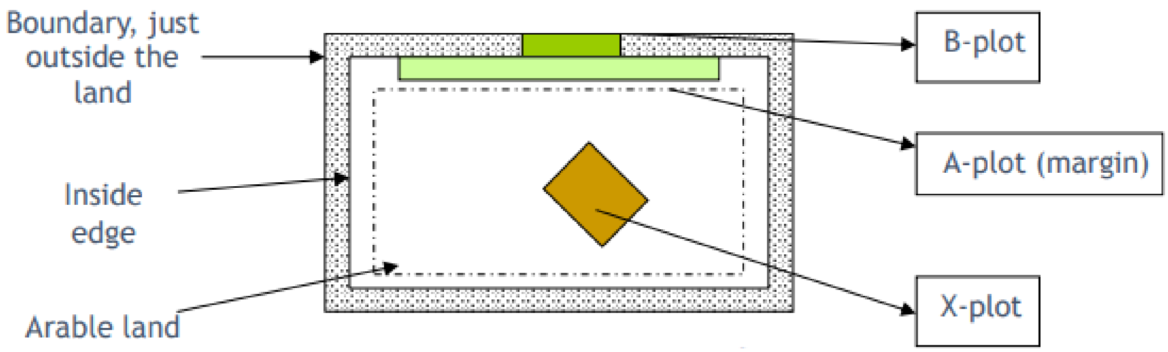

Figure 7. Illustration of agricultural plot

This inventory shows that the species richness is not really determined by the crop itself, but by the presence of edges, hedges, and small bushes or rows of trees. So a large scale monoculture, or a small scale traditional landscape makes all the difference. Unfortunately, that aspect is usually not commonly reported in literature or databases, and an average of species loss of around 40% compared to the reference was used. To what extend this has a global validity is unclear, but it is assumed that this number is valid in several parts of the world except where there are huge monocultures.

Water consumption (terrestrial & aquatic ecosystems)

The changes in species composition due to the use of water in a specific region. This impact category includes regionalized results.

Calculation of the midpoint characterization factors and the endpoint characterization factors for impacts on human health and terrestrial vegetation (ecosystem quality) are based on Pfister et al. (2009) and De Schryver et al. (2011), while Hanafiah et al. (2011) forms the basis for the impacts from water consumption on the endpoint aquatic ecosystems.

The databases used for this project report three types of water extraction, and one flow of water being returned to nature. In this way, the water balance can be understood. The data are specified per country, and that information is mapped on a global water stress model. The link between water stress and species lost was then added to come to a unit expressed as species.yr.

III. References

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