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# GLOBIO-aquatic, a global model for the assessment of aquatic biodiversity

## Introduction

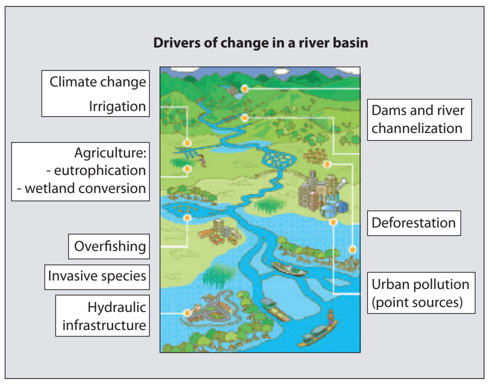
Aquatic ecosystems like **rivers**, **lakes** and **wetlands** contain a huge and often unique biodiversity, and deliver important ecosystem services. World-wide freshwater biodiversity is declining fast, however, due to many interacting drivers (MEA, 2005); see figure 1.
To halt further biodiversity loss (CBD), policy makers need a global model that couples (combinations of) these drivers with biodiversity change.

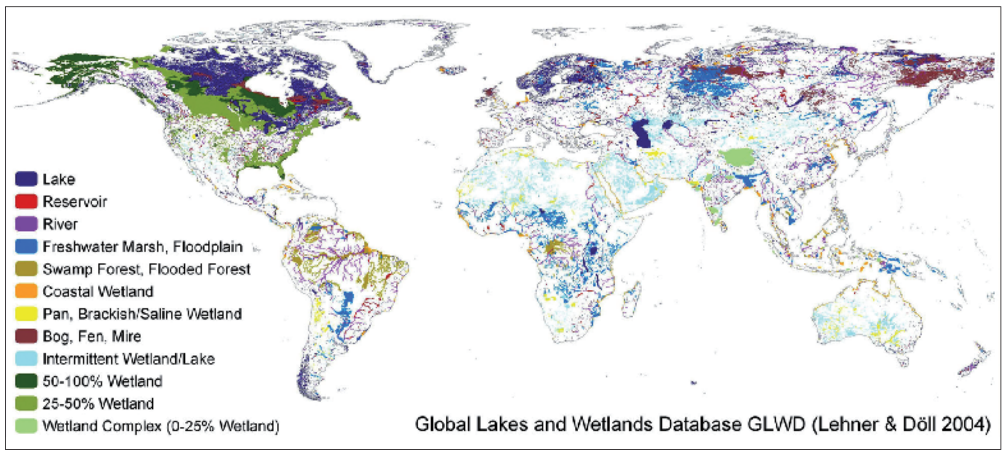
## Objectives

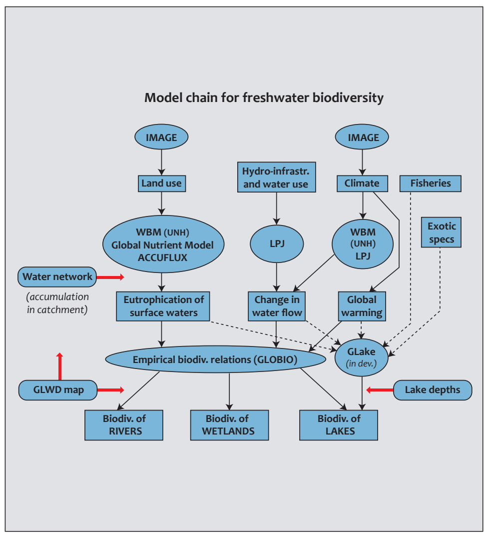
Development of a global model, ***GLOBIO-aquatic***, of the combined effects of these driving forces on aquatic biodiversity.
It complements the GLOBIO3 model for terrestrial ecosystems (Alkemade et al., 2009) and is part of the IMAGE model system for global change (MNP, 2007)

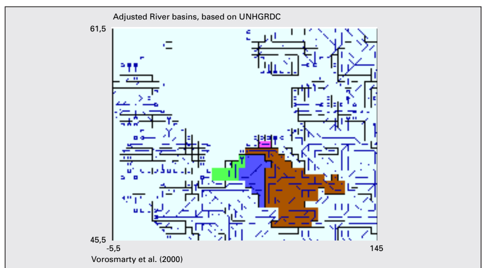
## Methods

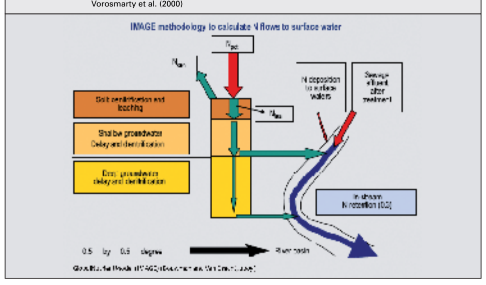
The model framework combines several 'driver' models with impact modules:
*(a) Driver models and data*: the IMAGE model of land use and climate change (MNP, 2007); the WBM network and discharge model (Vorosmarty et al, 2000); the LPJ water flow module; the Global Nutrient Model (including ACCUFLUX) for diffuse and point sources of N and P (Bouwman & Van Drecht, 2005); and the Global Lakes and Wetlands Database map (Lehner & Doll, 2004). Drivers are modelled (at present) at a spatial resolution of 0.5° (lat/long) (approx. 50 km), and fluxes are accumulated downstream.
*(b) Impact modules*: describing the relation between environmental drivers and biodiversity in rivers, lakes and wetlands, based on meta-analyses of literature data. Biodiversity is expressed as 'naturalness': the remaining abundance of native species, relative to the corresponding natural abundance, on a 0-1 scale ('Mean Species Abundance (MSA)', comparable to the 'Biodiversity Intactness Index', or a proxy for that). Drivers are (as yet) assumed to be independent (multiplied).

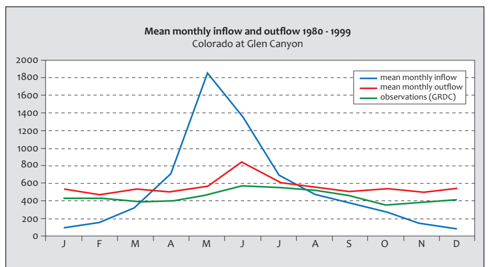


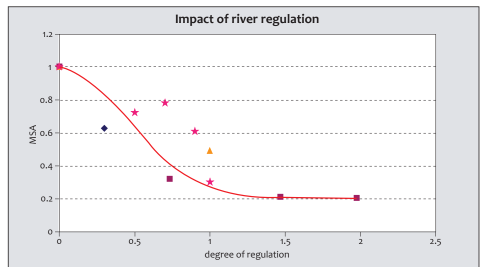



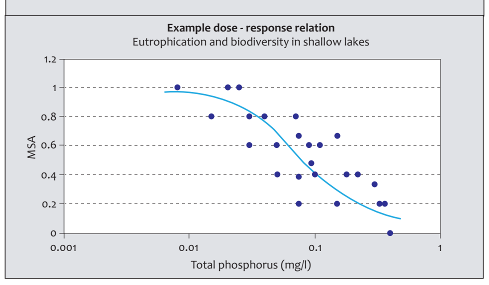



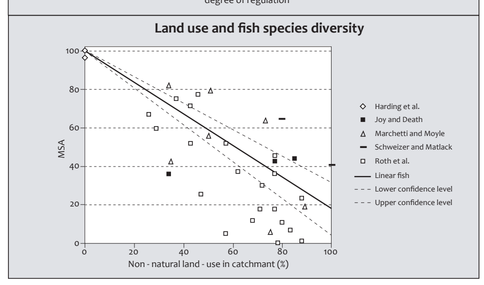



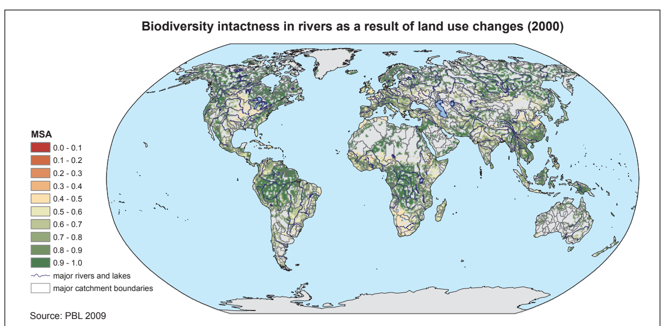



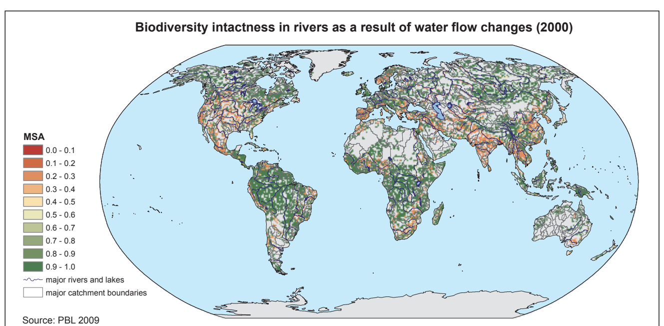

## Results and discussion

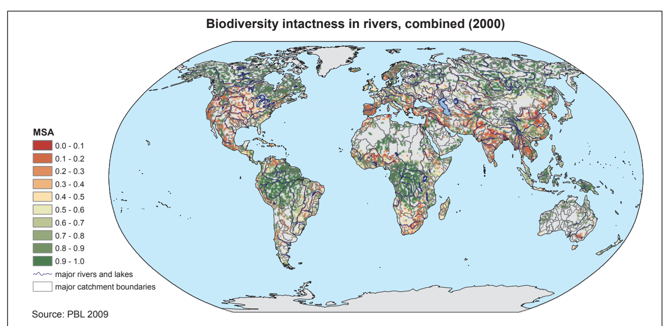
Land use changes and eutrophication in catchments result in considerable loss of original biodiversity in aquatic ecosystems of all types. The results are often compatible with the terrestrial model. In regions with high human land use, downstream waters are most affected. Damming and water extraction (irrigation) add to the biodiversity loss in rivers, also in regions with lower human land use.
(All maps only show those cells where the water type exists in the GLWD.)

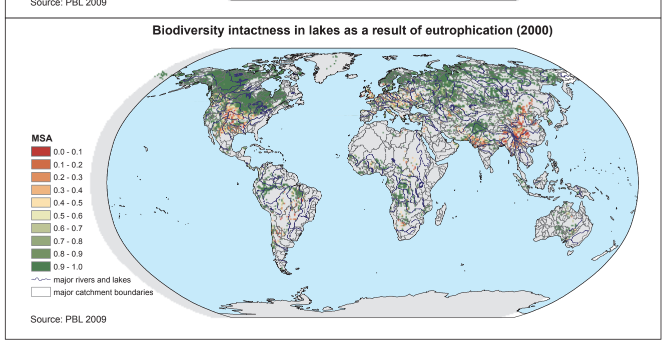
Future developments of the model will comprise:
- refinement of biodiversity relations; inclusion of fisheries
- development of an integrated (functional) module for lakes (GLake)
- inclusion of wetland conversion (e.g. historical maps)
- model validation

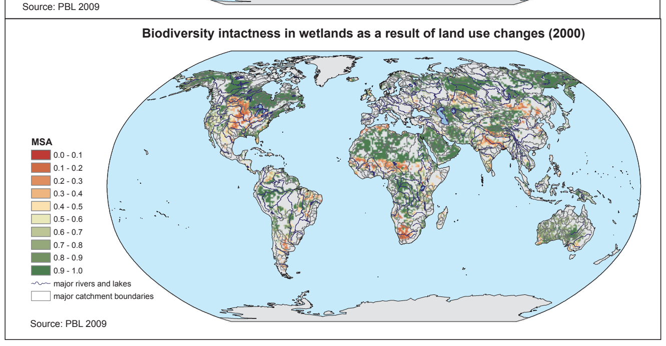
**Conclusion:** The model is a useful tool for global projections of aquatic biodiversity for combined scenarios, e.g. from the MEA and others.

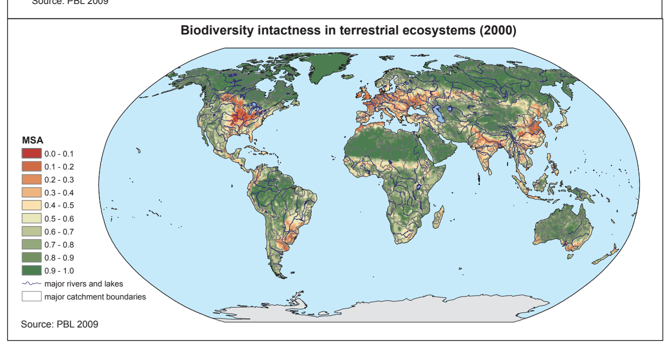



**References**
- Alkemade, R., Van Oorschot, M., Miles, L., Nellemann, C., Bakkens, M., Ten Brink, B. (2009). GLOBIO3: a framework to investigate options for reducing global terrestrial biodiversity loss. Ecosystems 12: 374-390.
- Bouwman, A. F., Van Drecht, G., Knoop, J. M., Beusen, A. H. W., Meinardi, C. R. (2005). Exploring changes in river nitrogen export to the world's oceans. Global Biogeochemical Cycles. 19, 1-14
- Lehner, P & Doll, P. (2004). Global Lakes and Wetlands database.
- MNP (2006) (Bouwman, A.F., Kram, T., Klein Goldewijk, K., eds.) Integrated modelling of global environmental change; an overview of IMAGE 2.4. Netherlands Environmental Assessment Agency (MNP), Bilthoven, The Netherlands. (www.mnp.nl)
- Vorosmarty, C. J., P. Green, et al. (2000). "Global Water Resources: Vulnerability from Climate Change and Population Growth." Science 289(5477): 284-288.
- Weijters, M.J., J.H. Janse, R. Alkemade and J.T.A. Verhoeven (2009). Quantifying the effect of catchment land-use and water nutrient concentrations on freshwater river and stream biodiversity. Aquat. Cons.: Mar. Freshw. Ecosyst. 19: 104-112.