Biodiversity nature (Background)

Objective
Quantify the effects of climate change and land use change scenarios on biodiversity

Assumptions
- CLUE-output ‘forest/nature’, ‘wetlands’ and ‘static land-use types’ is used, i.e. no distinction between forest, heathland, natural grassland etc.
- environmental zones (after Marc Metzger) specify type of nature, e.g. alpine, boreal, Mediterranean etc
- Major roads dissect natural areas

A monotonous function links area to biodiversity

Method
Two methodologies come together here. First, the LARCH approach developed at Alterra (refs: Opdam et al., 2003; Verboom et al. 2001; etc.) and simplified for the PEEN project (ref.) is used for assessing the effect of area, taking into account fragmentation by roads. Second, the GLOBIO approach developed at RIVM (refs) is used to account for other factors, i.e. nitrogen deposition and disturbance. For agricultural land-use types, only the GLOBIO approach is used because area effects are not expected to be a limiting factor for biodiversity. The core of the area-based assessment is the equation
IF AREA < 10.000 km2 THEN BD = 50+(AREA-1)**0.25
ELSE BD = 100
(after Thomas et al. 2004) assuming that in a natural area of 10.000 km2 biodiversity is maximal. The core of the GLOBIO assessment is the equation
B = X * Y * Z
where X, Y and Z are facors between 0 and 100%. In the current aplication, X can be interpreted as area-based biodiversity, Y as nitrogen deposition, and Z as disturbance by infrastructure. More globally, these two factors stand for high human pressure in the surroundings.

Current and historical situation

Biodiversity has been decreasing over the past decades, with most species and species groups showing decline in population size and/or distribution range, and a few showing increase.
- Climate change has in the past caused an overall increase in biodiversity, due to common species becoming more common and shifting northwards, and rare species becoming more rare or locally extinct.
- Fragmentation has led to many small nature reserves, due to increase of other land-use types, high traffic densities and intensive agriculture adding to the isolation of natural areas as ‘islands’ in a ‘sea’ of non-natural land-use types. In recent years, some de-fragmentation measures have taken place such as the construction of ecological networks (PEEN, EHS) and locally the construction of wildlife tunnels and overpasses.
- Nitrogen deposition and intensification of agriculture has caused a decrease in many plant species and animals living in rural areas

Disturbance by an ever-increasing and expanding traffic flow has led to a further decline of mostly large animals, while traffic mortality is an important threat to specific animal groups (e.g., mammals, amphibians).

Input (data sets)

input is CLUE output, EnZ output (Marc Metzger), NEA-road data base, traffic intensity, land-use intensity, and nitrogen deposition.. Land-use intensity can only be taken into account at the national (or NUTS2l) level. Nitrogen deposition has a c. 50x50 km resolution.

Results

- Decline of alpine ecosystems, rare alpine species replaced by wide-spread species. Local biodiversity may seem to increase, but this is caused by an increase in common species overcompensating the loss of rare specialists.
- Land abandonment leads to larger areas and corresponding higher biodiversity, especially in scenarios XX.
- Increase in population pressure, urbanization, nitrogen deposition and traffic intensity, especially in A1 scenario, lead to local decrease in biodiversity in densely populated area.

Output

per pixel: biodiversity indicator between 0 and 100%, different indicators for agricultural land-use and nature. As statistics the total area of different types of nature (e.g. alpine, boreal), average biodiversity, bar plot with frequency of pixels in biodiversity classes (0-20%, …, 80-100%)

Legend

see above: biodiversity in classes 0-20, …, 80-100%

Resolution of output

pixel level and overall statistics, if desirable specified for separate countries. Agricultural biodiversity has resolution of 0,5 ° (c. 50 x 50 km)

Accuracy

There are many sources of uncertainty: the scenarios themselves, the fact that the CLUE output classes are rather course and the resolution of 1 km squares with dominant land-use is rather coarse too for determining biodiversity. Dissecting nature areas into environmental zones might be a bit artificial, adding some fragmentation effect. All the other input data have uncertainties and scale problems too, the biggest problem being the fact that agricultural land use intensity is unknown at the pixel level. This will lead to an under-estimation of biodiversity on localities where agriculture will have low intensity and over-estimation at high intensity locations. Last, the algorithms are based upon certain simplifying assumptions such as that 10.000 km2 nature has a biodiversity of 100%. If the results will be used in a relative way, to highlight differences between scenarios rather than absolute interpretation (‘the biodiversity of spot x in year y under scenario z’) there will be no great problem with accuracy.

Conclusions

Based on the above the method will give a reasonable assessment of biodiversity for the climate change/land-use change scenarios, but will fail to deal with the change of low intensity agriculture (e.g. North-East Poland) into either high intensity agriculture or land abandonment. Low intensity agriculture is associated with high biodiversity which will drop either way, both by intensification and by land abandonment. As there will be no spatially explicit data about land-use intensity, this process will not be correctly described by the indicators, since land abandonment will lead to a rise in biodiversity – as nature areas become larger, instead of a drop.

References

Opdam, P., Verboom, J. and Pouwels, R. 2003. Landscape cohesion: an index for the conservation potential of landscapes for biodiversity. Landscape Ecology 18: 113-126.

Verboom, J., R. Foppen, P. Chardon, P. Opdam, and P. Luttikhuizen. 2001. Introducing the key patch appoach for habitat networks with persistent populations: an example for marshland birds. Biological Conservation 100: 89-101
Thomas et al. 2004 Extinction risk from climate change. Nature 427: 145-148.
PEEN: Bouwma I.M, R.H. Jongman & R.O. Butovsky (eds.) 2002 Indicative map of the Pan-European ecological network for central and eastern Europe. ECNC Report

Remarks

Note that the biodiversity-in-nature algorithm under-estimates biodiversity for a number of reasons.

- Fragmentation by roads does not take into account the fact that animals will occasionally successfully cross these roads. Nature patches on both sides of the road are handled as if in complete isolation, i.e. the populations in the patches are regarded as isolated from each other. All (major) roads are treated the same way, regardless of traffic intensity. These simplification leads to an under-estimate of biodiversity.
- The biodiversity algorithm takes into account populations, but not metapopulations. Thus, patches below the size for a minimum viable population (MVP) get the assessment 'not viable' for larger species, which decreases their biodiversity. In reality, patch populations can form metapopulations and biodiversity can be higher.
- Disturbance due to traffic intensity data are on the scale of 50 x 50 km cells, thus roads have an impact at larger distances than desirable.
- While disturbance is known to mainly affect fauna, and nitrogen deposition mainly flora, both factors affect total biodiversity in the algorithm, which leads to an under-estimation.