Project no. GOCE-CT-2003-505298
ALTER-Net

A Long-Term Biodiversity, Ecosystem and Awareness Research Network

Literature review and questionnaire evaluation

Jutta Stadler & Stefan Klotz, UFZ Germany, Laurent Berges, CEMAGREF, France, Rob Brooker, CEH, United Kingdom, Silvia Matesanz, CSIC, Spain, Ilona Meszaros, IEB-HAS, Hungary, Wolfgang Schmidt, University Goettingen, Germany, Oliver Schweiger, UFZ, Germany, Fernando Valladares, CSIC, Spain

WP R3 – 2005-01

Instrument: Network of Excellence
Thematic Priority: Global Change and Ecosystems (Sub-priority 1.1.6.3, Topic 6.3.III.1.1)
Due date of deliverable: month 18
Submission date: month 18
Start date of project: 1st April 2004
Duration: 5 years
Deliverable lead contractor: UFZ

www.alter-net.info

Literature review and questionnaire evaluation

CONTENTS

Summary

1. There is a certain discrepancy between the supposed importance of drivers and the frequency of actual investigations considering these drivers. Hence the running scientific work does not match the importance of natural processes and our understanding of natural processes influencing biodiversity may be biased. This may be due to constraints set by grant giving institutions well as constraints set by scientific organizations (e.g. length of PhD-thesis). Although these constraints are well known by the scientific community, we need to make efforts to overcome these limitations. Considering pressures the discrepancy between the supposed importance of pressures and the running actual investigations are less obvious, although the ranking is far from being perfect.
2. For a fruitful comparison of drivers and pressures across ecosystems we need to develop a consistent framework of definitions of drivers and pressures which can be used across all ecosystems. Furthermore, the projects working on biodiversity of different ecosystems need to cover all levels of biodiversity. We need to overcome the traditional differences in the focus of biodiversity studies. Of course methodological differences between ecosystems may constrain such efforts. Nevertheless, the analyses of the drivers and pressures of the papers is a promising starting point to develop a consistent framework of concepts.

Literature review and questionnaire evaluation

Introduction

The management of biodiversity needs to build on a scientific framework to quantify and to understand the integrated impact of natural and anthropogenic drivers and pressures on biodiversity and its consequences for and the relationship to the structure and function of ecosystems. Natural drivers are forces that determine biodiversity under natural dynamics with minimal human influence. In contrast, pressures refer to the various influences resulting from human activities like pollution, land use change, persecution, climate changing activities and introduction of species (see DPSIR model, EEA 1999). Drivers ***and*** pressures influence biodiversity and ultimately ecosystem services and are responsible for the current, very rapid decline of biodiversity (Tilman et al. 2001, Mooney 1997, Sala et al. 2000). The impact of drivers and pressures on biodiversity is the focus of RA3.

For a first approach to understand the interaction and importance of drivers and pressures for biodiversity we followed two lines of inquiry:

1. Constraints of experimental design as well as constraints set by grant giving institutions lead to a discrepancy between the supposed importance of drivers and pressures and the actual projects run by scientists. If such a discrepancy exists, this would compromise our understanding of the dynamics of biodiversity. For this question we sent a questionnaire to the partners of RA3.
2. To document in more detail the interaction of drivers and pressures we surveyed the literature on biodiversity (in the broadest sense) for several ecosystems. At one hand this will give an idea of the projects during the last 10 years as well as the concepts used by the scientists for analysing the biodiversity of different ecosystems.

Material and Methods

To answer the questions posed in the introduction we used a questionnaire as well as an extensive literature survey:

1. We sent a questionnaire to the RA3 partners within Alter-net (for information on the questionnaire http://forums.ceh.ac.uk:8080/~alter-net: WP R3). In this questionnaire we asked partners for their opinion about the importance of certain drivers and pressures. The partners were asked to rank the drivers on a rank scale 0 to 5 and pressures on scale of 0 to 7 (the difference in the ranking scheme was due to the fact that we had more pressures than drivers). In a second step we asked for the projects run by the partners. By comparing the opinion (using the mean rank) with the frequencies of projects we can test whether scientists design their projects according to their opinion about the importance of drivers and pressures.
2. We analysed the supposed drivers and pressures used in published projects for three ecosystems: forests, arctic-alpine and montane regions, grasslands and arable fields. Originally we planned to include freshwater systems, but the data are not yet available for analyses. We searched the Web of Science using the following search strings *"biodiversity and <ecosystem* >" (*e.g. biodiversity and grassland*). We considered only papers since 1997. Review papers were excluded from the subsequent analyses. From the hits we selected randomly 25% of the papers for each ecosystem. Each paper was scored by the responsible experts for a set of concepts as well as information about time scale and spatial scale of the investigation. This information was coded into discrete characters. The matrix of characters across studies was then subjected to correspondence analyses using CANOCO (Ter Braak 1987).

Results and Discussion

From 55 research groups we received filled questionnaires. These responses cover 163 actual projects. Most partners work with terrestrial systems (73%). Most of the projects consider a time scale of less than 5 years (80 % of projects) and most of the projects consider plots of less than 100 m² in size (60 %; Fig.1). Overall the questionnaire revealed the well-known correlation of the time and spatial scale of ecological investigations (May 1989). This observation already suggests that there is a clear bias towards the investigation of processes operating on small scales.

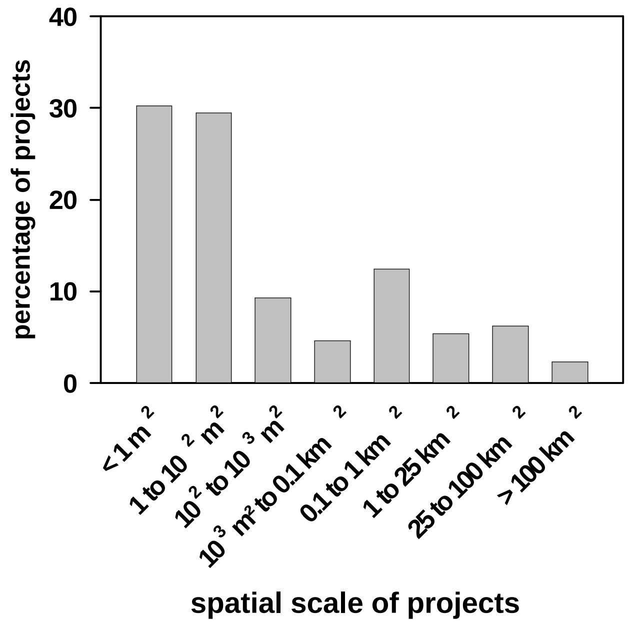

Figure 1: Spatial scale of running projects reported in the questionnaires.

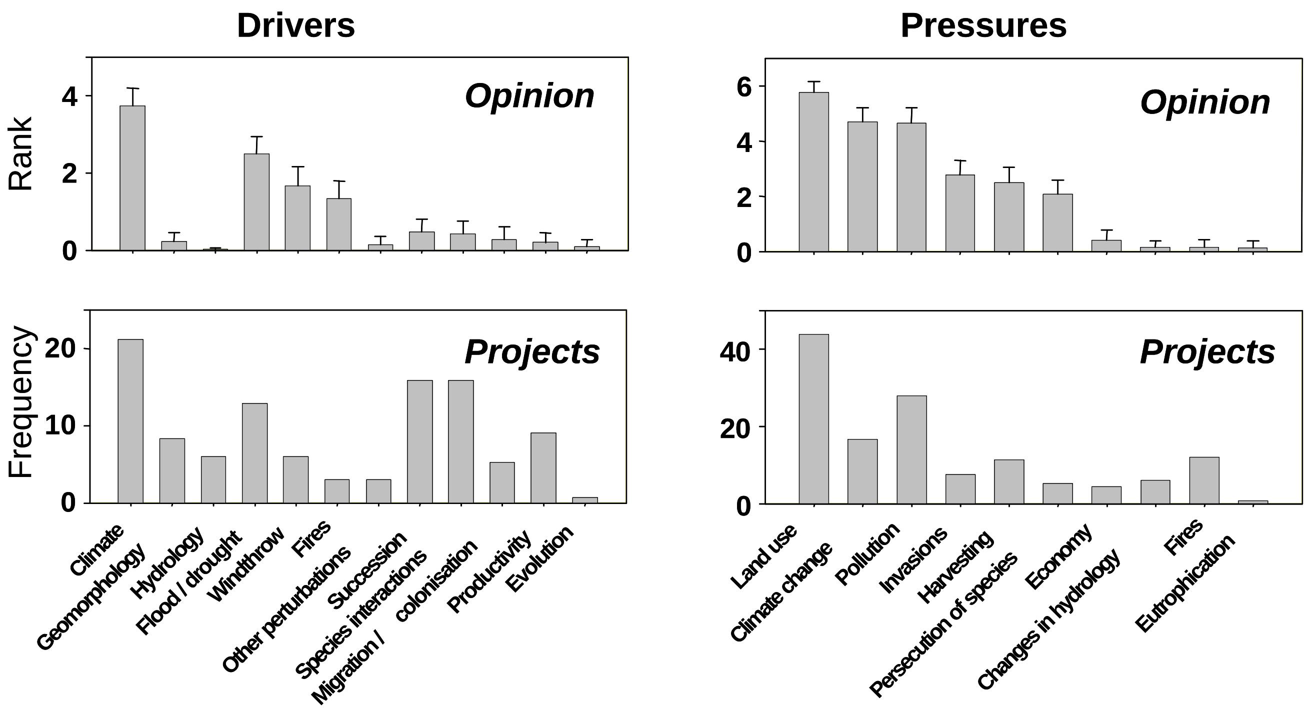

Figure 2: Mean rank (± SE) of drivers and pressures according to the opinion of partners and the relative frequency (%) of actual projects run by these partners.

The partners consider climate as the most important driver of biodiversity (Fig. 2). Other important drivers include natural disturbances (floods, windthrow, fire). Most of the projects do in fact consider climate. However, overall there is no good correlation between the ranking of drivers according to the opinion of our partners and the frequency of actual research activities ($r_{Spearman}$ = 0.54; P = 0.061; N = 10). Land use is considered as an important pressure and land use is also investigated by most of the projects of our partners. Climate change is considered as an important pressure, which is not really matched by the frequency of projects. Nevertheless we found a significant correlation between the opinion about the importance of pressures and the actual investigations of pressures ($r_{Spearman}$ = 0.78; P = 0.008; N = 8)

For a review of drivers and pressures in the literature we scored more than 535 papers. However, the scoring of the experts provided consistent information about concepts and scales for only 438 papers for which we coded 23 variables (Table 1). Again we found a good correlation between the time and the spatial scale considered in the papers ($r_{Spearman}$ = 0.23; $P < 0.001$; N = 438). This 438 x 23 matrix was submitted to CANOCO selecting the appropriate options. The variable *ecosystem* was not included. The sum of all eigenvalues was 2.23. The eigenvalue of the first axis was 0.19 (8.5%) and of the second axis 0.17 (7.5%). The plot of the scores of the 438 papers across the first two axes suggests a continuum of variation with no obvious discrete clustering. However, the envelopes for the three ecosystems suggest that the papers dealing with alpine and montane regions have more negative score along the first axis, whereas the papers on grasslands and arable fields have positive scores (Fig. 3a; ANOVA; F = 108; df=2 and 435; $P < 0.001$). This difference in the ordination of ecosystems may have at least four mutually non-independent reasons:

1. The different systems need different concepts.
2. Scientists working with different systems use different concepts during their work.
3. Scientists working with different systems have a different understanding of the biological background of the concepts.
4. Scientists working with different ecosystems concentrate on the different levels of biodiversity.

The plot of the 23 variables allows no straightforward interpretation of the axes and therefore of concepts used for the analyses of the different systems (Fig. 3b). The first axis may be interpreted as an axis of pressures with a gradient from land use and climate change to anthropogenic perturbations. Thereby climate change and land use change is investigated on the level of species, whereas anthropogenic perturbations are analysed on broader scale (e.g. landscape scale). The second axis is a mixture of drivers as well as pressures, and spans a gradient from introduction of aliens and human persecution of species to hydrological situation. The difficulty to interpret the axes in the light of drivers and pressures suggest that there is an urgent need to provide scientists with a framework of clear concepts for the everyday experimental work. Without such a framework of unambiguously defined concepts the understanding and quantification of natural and anthropogenic drivers and pressures and their impact on biodiversity as well as ecosystem processes will remain rudimentary.

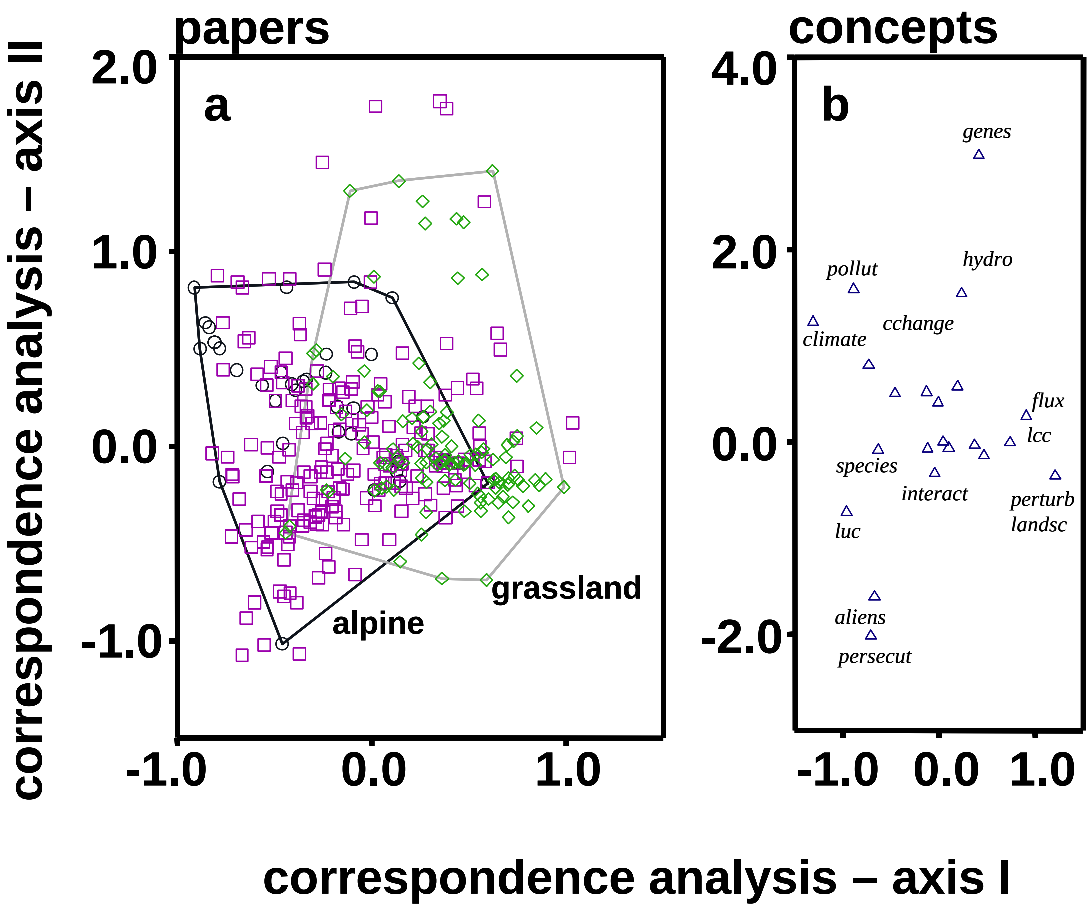

Figure 3: Scatterplot of sample scores (publications) and scores of variables (concepts) along the first two axes of a correspondence analysis. We have drawn envelopes for papers dealing with alpine and montane regions and grasslands (including arable fields). Note the different position of the two envelopes.

The interpretation of the first axis shows that there is a certain difference in the level of biodiversity investigated for the three considered ecosystems. Investigations on alpine systems concentrate on the species level whereas papers dealing with agricultural systems and grassland ecosystems concentrate more on the community and landscape level (see also Fig. 4). Such (traditional?) differences in the focus of studies between groups working with different ecosystems may slow down the development of a general framework of concepts.

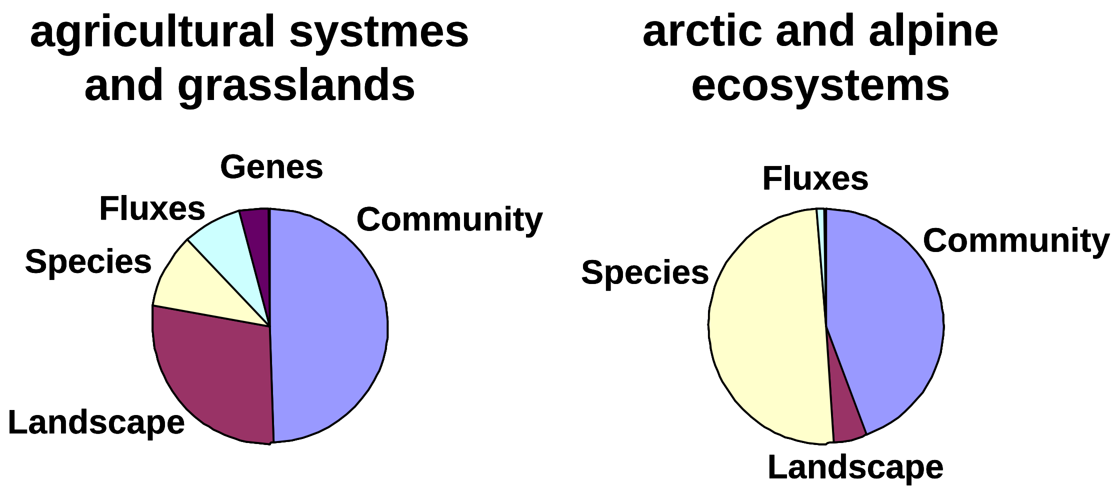

Figure 4: Levels of biodiversity considered in studies on agricultural and grassland systems compared to studies on arctic and alpine ecosystems.

Figure 4 shows a limitation of our literature review: Only few papers considered during our review focussed on the genetic side of biodiversity. This is very surprising, if one takes into account that several journals are devoted to the study of molecular ecology (e.g. *Molecular Ecology*). Furthermore, all these journals started to flourish during the last decade of the 20th century. Note that our literature survey considered only studies since 1997. Hence, we covered a time span during which ecology was faced with a flush of molecular papers. The low number of genetic studies in our review needs further consideration. However, this may also indicate that molecular ecologists sell their studies within a conceptual framework not covered by the concepts traditionally used in biodiversity studies on higher levels.

Summary

From these results we want to draw two general but still preliminary conclusions:

1. There is a certain discrepancy between the supposed importance of drivers and the frequency of actual investigations considering these drivers. Hence the running scientific work does not match the importance of natural processes and our understanding of natural processes influencing biodiversity may be biased. This may be due to constraints set by grant giving institutions well as constraints set by scientific organizations (e.g. length of PhD-thesis). Although these constraints are well known by the scientific community, we need to make efforts to overcome these limitations. Considering pressures the discrepancy between the supposed importance of pressures and the running actual investigations are less obvious, although the ranking is far from being perfect.

2. For a fruitful comparison of drivers and pressures across ecosystems we need to develop a consistent framework of definitions of drivers and pressures which can be used across all ecosystems. Furthermore, the projects working on biodiversity of different ecosystems need to cover all levels of biodiversity. We need to overcome the traditional differences in the focus of biodiversity studies. Of course methodological differences between ecosystems may constrain such efforts. Nevertheless, the analyses of the drivers and pressures of the papers is a promising starting point to develop a consistent framework of concepts

References

EEA 1999. Environmental indicators: typology and overview. Technical Report No. 25. European Environment Agency, Copenhagen

May R.M. 1989. Levels of organization in ecology. In: Ecological concepts (ed. Cherrrett, J.M.). Blackwell, London, pp. 339-363.

Mooney H.A. 1997. Ecosystem function of biodiversity: the basis of the view point. In: Plant functional types: Their relevance to ecosystem properties and global change. (eds. Smith T.M., Shugart H.H., Woodward F.I.) pp-. 341-354.IGBP book series1. Cambridge University Press, Cambridge.

Sala O., Chapin FS, III, Armesto J.J., Berlow E, Bloomfield J., Dirzo R., Huber-Sanwald E., Huenneke L.F., Jackson R.B., Kinzig A., Leemans R., Lodge D.M., Mooney H.A., Oesterheld M., LeRoy Poff N., Sykes M.T., Walker B.H., Walker M., and Wall D.H. 2000: Global biodiversity scenarios for the year 2100. SCIENCE, Vol. 287, pp. 1770-1774

Ter Braak C.J.F. 1987. CANOCO – A FORTRAN program for canonical community ordination by partial detrented canonical correspondence analysis, principal components analysis and redundancy analysis (version 2.1). DLO-Agricultural Mathematics Group, Wageningen.

Tilman D., Fargione J., Wolff B., d´Antonio C., Dobson A., Howarth R., Schindler D., Schlesinger W., Simberloff D., Swackhamer D. 2001. Forecasting agriculturally driven global environmental change. SCIENCE, Vol. 292, pp.281-284

Table 1: List of variables, acronyms and the coding of these variables used during the correspondence analysis.

Acronym	***Description***	***Coding***
eco	ecosystem	1-3 (1=alpine, 2=forest, 3= grassland)
Level of biodiversity		
genes	genetic parameters	0/1
species	species level	0/1
com	community level	0/1
landsc	landscape level	0/1
flux	material and energy flow	0/1
Drivers		
climate	climate	0/1
geo	geomorphology	0/1
hydro	hydrology	0/1
pertub	natural perturbation	0/1
interact	biotic interaction	0/1
product	natural productivity	0/1
migrat	migration/colonization	0/1
Pressures		
clchange	climate change	0/1
pollut	pollution	0/1
lcc	land cover change	0/1
nitrogen	nitrogen deposition	0/1
luc	land use change	0/1
anthrpert	anthropogenic perturbation	0/1
persecut	persecution of species	0/1
aliens	introduction of alien species	0/1
Scales		
gscale	geographical scale	1-4 (1= local, 2= regional, 3= national, 4 = international)
tscale	time scale	1-5 (1= 1 year, 2= 2-5 years, 3= 6-10 years, 4= 11-50 years,5 > 50 years)