Use of GIS and Field Site Network for Assessing Changes in Biodiversity

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Abstract: - Climate change, environmental chemicals, biological invasions, and loss of pollinator are the main research topics in the ALARM project. All of theses environmental pressures are more or less of anthropogenic origin. These have generally been studied independently of one another. But it is clear that they interact, potentially producing effects on biodiversity and ecosystems that exceed all current assessments of potential risks. ALARM develops relevant assessment methods in two phases: a) concept and data base integration and b) ecosystem risk evaluation. These methods will be tested and standardised protocols will be developed.
The project links databases with a European-wide field site network and then generates common methods. At these field sites GIS is used as a basis to characterise the test location for ALARM researchers for joint on-site research. Maps are provided in a standardized way and merged with other site specific information. The application of GIS for these field sites and the information management is necessary to communicate the research and the results. Problems of data homogenisation and of unique quality standards of databases arise, but ways to solve this will be shown. GIS as a basis of risk maps on a European level and support the scientists to provide their results.

Key-Words: - ALARM, GIS, Multiple Pressures, Risk Assessment, Biodiversity, Field Site Network, Maps, Mapserver

1 Introduction

Assessment and forecast of changes in biodiversity and in structure, function, and dynamics of ecosystems are in the focus of ALARM research. This relates to ecosystem services and includes the relationship between society, economy and biodiversity. In particular, risks arising from climate change, environmental chemicals, biological invasions and pollinator loss in the context of current and future European land-use patterns will be assessed.

The knowledge on the concerted action of all these factors is poor and ALARM will be the first research initiative with the critical mass needed to deal with such aspects of combined impacts and their consequences. The ALARM project [1] consists of four general objectives:

1) To develop an integrated large-scale risk assessment to biodiversity as well as terrestrial and freshwater ecosystems as a part of environmental risk assessment;

2) To focus on risks consequent on climate change, environmental chemicals, rates and extent of loss of pollinators, and biological invasions;

3) To establish socio-economic risk indicators related to the drivers of biodiversity pressures as a tool to support long-term oriented mitigating policies and to monitor their implementation;

4) To develop a research network that is consistently thinking, interacting, and investigating on a continental scale across different environmental problems (impacts) and across different spatial and temporal scales of ecosystem diversity changes.

In order to achieve the objectives mentioned above, ALARM consists of seven modules: four natural science modules, the socio-economics module, a sixth module of cross-cutting analyses of multiple pressures across landscapes, and a seventh module which includes training activities, dissemination of scientific results, promulgation of toolkits as well as information and expert systems developed and tested within the ALARM project.

While detection of shifts in species ranges in Europe is possible by mapping the existing populations ranges [2, 3], population changes in wild bees need long-time monitoring on field sites, to measure impact and risk as it was done to measure the parallel declines of bees and pollinated plants [4]. The ALARM field site network (FSN) as a testing site for all different pressures across Europe belongs to the cross-cutting module.

The field site network FSN provides the necessary testing ground for aspects of all four modules of the ALARM research program. It is established with a comprehensive geographical and environmental coverage of Europe.

There are two central issues: first the establishment of a focal site network as an arena within which to examine the separate and interacting effects of the multiple pressures concerned in ALARM, and second, as a testing ground for the risk assessment tools developed during the project.

2 The ALARM Field Site Network FSN

2.1 Aims of the ALARM Field Site Network

The field site network FSN plays a central part for conducting joint research of all ALARM modules and is integrating research with different topics in ALARM on the same site for measuring multiple impacts on biodiversity. All sites include freshwater as well as terrestrial habitats, including both lotic and lentic environments. The FSN covers most of European climates and biogeographic regions, from Mediterranean environments through central European and boreal zones to the subarctic.

It allows detailed monitoring of environmental variables, species distributions and ecological interactions in a locally intensive but geographically extensive manner, providing a unique continent-wide perspective on the issues addressed by particular research programs within ALARM [1].

After establishing the research sites, it was necessary to agree upon standardised and detailed field protocols for the use across the site network to assure quick and simple data transfer for analyses. Field data were collected 2006 for the first time, analysed and fed back to the main research modules. This work program allows detailed monitoring of environmental variables, species distributions and ecological interactions. Senior researchers, representing the research modules of ALARM, assist the field site program. These researchers are responsible for working with their module teams to recommend a set of research priorities for use of the site network to advance their module's work. These activities may involve direct observations or the collection of samples to be analysed elsewhere.

Each researcher associated with the field site network has administrative responsibility for a subset of the sites. In addition to being involved in selecting sites and experimental plots for each site under their supervision, the researchers are responsible to recruit and supervise field assistants. Where possible, these field assistants are recruited locally. These field workers will work under the supervision of the regional coordinator and local partners. Samples and data collected by the field research teams are distributed back to the relevant research team.

Each research team within the consortium proposes specific research protocols for that year, with precise descriptions of the methods to be employed, any training that might be necessary, constraints on the timing of the work, and the approximate time demands on the field staff. The field research coordinators of each research team prioritise together the research and reconcile conflicting demands on time and resources to bring these into a single, practicable research agenda for each field team.

ALARM research projects that were started in 2006 on these field sites include: Richness of trap-nesting bees across landscapes, spider diversity across landscapes, and spread of escaped bumblebee (Bombus terrestris) genes, germination efficiency of plants from different sources, and many more still in progress of development.

2.2 Study design of the Field Sites

The field sites are specially selected for ALARM to assess the effect of different land-use disturbances on biodiversity. Each of the field sites consists of two study sites, each 4x4 km and within 50 km of each other. These two sites are chosen to be as similar as possible in all aspects except land-use intensity: 1) Extensive areas dominated by semi-natural vegetation, with some agriculture embedded. The "natural" site of the paired sites is located here. 2) Areas dominated by extensive agriculture, with remnants of semi-natural vegetation. The "disturbed" site is located here.

The sites should be as similar as possible in topography, geology, soil and other environmental parameters so that human disturbance is the main distinction between the pair of sites.

FSN selection criteria: The main criteria for selecting the focal regions in which pairs of field sites are located were partly scientific, partly pragmatic. Unfortunately, within ALARM we lacked the resources

to design FSN using a stratified random sampling approach, but particularly to use a large-scale FSN as a research tool. Therefore, we built on existing activities by ALARM partners, i.e. chose field sites close to partner institutes and preferably already in use by partners.

2.3 Selected ALARM field sites

Though still open to integrate new suitable field sites, research is done on the so far selected field sites, which are: Abisko (Northern Sweden), Uppsala (Central Sweden), Tartu (Estonia), Lithuania (Eastern Lithuania), Galway (Western Ireland), Berkshire (Southern England), Goettingen (Central Germany), Ile de France (Northern France), Krakow (Southern Poland), Cluj (Romania), Meolo (Northern Italy), Avignon (Southern France), Garraf (Northeastern Spain), Toledo (Central Spain), and Lesvos (Greek Island) (see Fig. 1).

The field site in Abisko (Northern Sweden) does not have a disturbed site due to a lack of anthropogenic influence in the area. All other sites show the paired design.

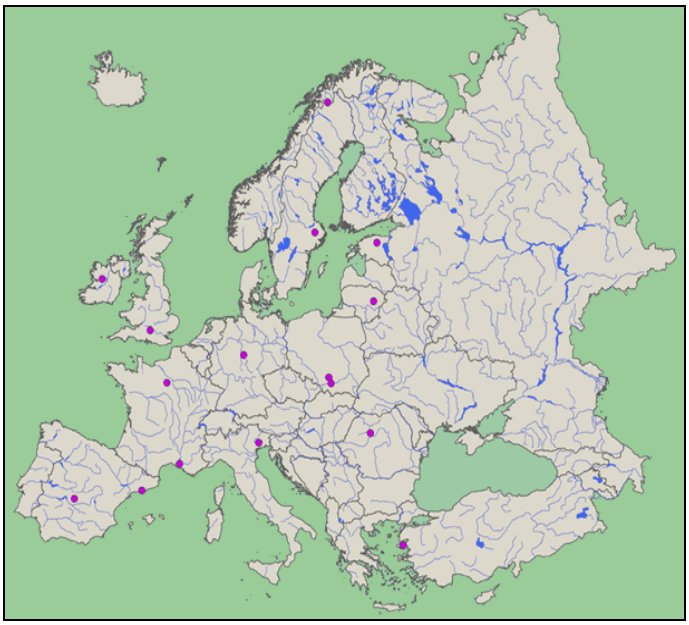

Fig. 1: The ALARM field sites across Europe (magenta dots).

2.4 Intended future of the ALARM field sites

The SATELLITE sites are established sites from ALARM research partners not in the FSN, or from other projects including GREENVEINS [5, 6], BioAssess [7], BioPress [8] and Alter-Net [9]. These sites are not yet finally selected and are intended for the second half of the project.

The established field sites of the ALARM project will be merged with the Long-Term Ecosystem Research sites, LTER.

3 Managing European-wide GIS information

3.1 Basic data

We need some basic GIS data to represent the field sites and providing ALARM research a local basis for testing and comparing the research results. While field sites need data on a local scale, the data for all field sites should be comparable in a European context. Hence, there is a need for a unique source of GIS data.

Concerning land–use, digital data available on a European level are the CORINE data. Hence, the CORINE land cover 2000 vector data is used as a basis for every field site to get a comparable overview of this field site. The scale of this data is approximately 1:100.000. Other European datasets available are the European soil data base (grid based 1x1 km data, original scale 1:1.000.000) and a worldwide digital elevation model (GTOPO30, 1 km elevation grid, source U.S. Geological Survey). These data could not be used for field site representation because of the inappropriate scale.

Additionally, some of the field site partners have their own database. More detailed information on land-use, soil, elevation and climate is partially available. But formats and scales are rather different, and comparison is therefore difficult.

Concerning ALARM research, different types of data will be obtained in the future. These are point data, line data, polygon data and raster data. The aim is to produce among the field sites comparable GIS data which can be used to derive assessments on possible risks. Some of the most important scientific results should be presented by maps using the field site network website. Therefore, a mapserver is available where the data can be integrated. The mapserver is in use to present the CORINE land-use information of the field sites. Other data are not available at present.

Biogeographical questions are part of the project as well. One goal is to find out similarities in the behaviour of different species (e.g. wild bees) all over Europe and changes of their distribution and their loss of diversity [4]. GIS is used to show the trends of projected species development in different regions all over Europe.

3.2 Map concept and web presentation

Besides the difficulties with different data sources and software, there was a need to develop a unique layout (Fig. 2) for presentation of results. The entire project should be presented to the science community, the European public and the EU in a corporate design. In principal, two different ways are possible to manage this goal. First, one project partner is responsible to produce the maps. Second, a map layout was developed in a common format, which can be used by all partners for

their maps. Partners with GIS experiences used the developed layout to put their data into. During the project GIS training lessons were carried out to enable more partners to work with the provided layout. Furthermore, one partner in the consortium offers the service of producing the maps on the basis of delivered data.

Some of the field site partners use their own GIS and collected information and data about the field sites. This information is usually not known by other partners. A standardized data base is necessary to utilize this data within ALARM. Furthermore, some of the partners only have analogue maps or raster data. For the field site data standardized protocols were used to carry out the research.

Developing the map layout three considerations had to be taken into account. First of all, we had to use simple cartographic standards because some of the maps should be presented to official agencies etc. Second, the maps should be as simple as possible to use it in scientific publications. And third, all necessary information concerning the project should be integrated.

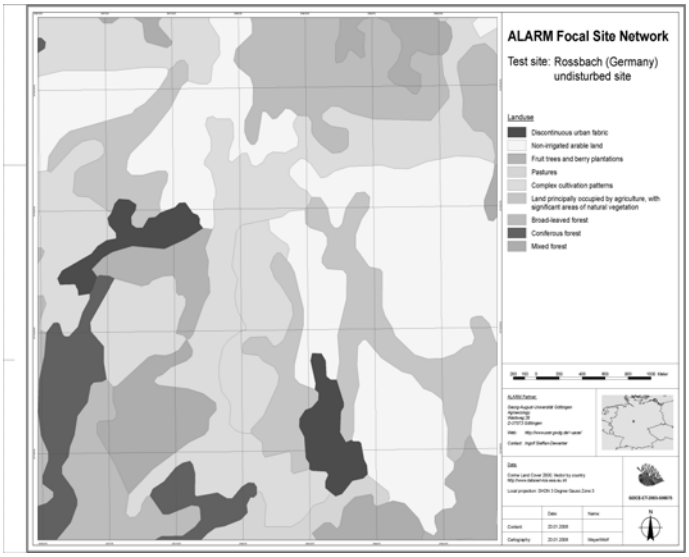

Fig. 2: Example of an ALARM map showing CORINE land use for one field site.

Using ArcGIS all field site related data can easily be placed in this layout to produce the thematic maps of the different research themes (biological, chemical, climate). In future presentations this layout will be used to present the European data as well as the field site data.

Currently the data are accessible via internet at two web mapping services available. One service covers the entire project and focuses on European data, the other is especially developed for the FSN. In this way, information is provided to partners and to the public. Therefore it is necessary to decide if the information should be publicly available or not. These restrictions can be handled by the mapserver administrator.

One mapserver is only available for registered users. The field site mapserver is open for all. It is available on the webpage "www.alarmproject.net" using the menu entry "Field Site Network". The data shown in this service will be extended when results of the field research are available.

3.3 GIS problems in a European-wide application

Focusing on using GIS in such a large-scale and heterogeneous project some difficulties can be expected.

In ALARM a large number of scientists cooperate for interdisciplinary results. Some are less familiar with GIS and its possibilities to present and produce spatial information. Taken into account that one result of the project will be risks maps, GIS knowledge is basic. Therefore, one partner manages GIS activities and training.

GIS is integrating the project in several aspects: Since data sources, maps, and software vary within ALARM, communication and standardization across scientific fields is necessary. Also the immense heterogeneity of the research topics within the project, ranging from environmental chemicals and climate change to invasive species and further on to the loss of pollinators, is integrated via the same location using GIS. Additionally, the proposed output of ALARM research consists partly of large-scale maps or tools derived from all over Europe and those need a consistent basis on which they were obtained. And last, the training in GIS as a skill of all researchers is strengthening the overall cooperation within the different research topics.

One basic question is how to process the data to deliver it in one common standard. Another problem arises with isolated applications of the GIS software, and therefore, in the data standards. In the project three different GIS solutions were used: ArcGIS, MiraMon (a spanish GIS product) and PCMap. Using these software systems the partners had previously established local information systems of their field sites. It was necessary to put these data into a common standard to make it usable for all partners.

Last but not least, there was the difficulty of getting available common data of Europe in a usable scale as described in chapter 3.1. Scale is a central issue for scientists when assessing large-scale risks from local research. Therefore, the European data (scale at least 1:100.000) have to be derived on the basis of locally obtained data (scale 1:10000). Besides, data on the local scale are quite different in quality and quantity across locations. By using common protocols for the field site research, the results are standardized data on a local scale which then can be used to derive European-scale maps.

4 Outlook for the ALARM FSN

The ALARM field site network FSN provides a proper and extendable basis for research on at present and in the future important pressures (climate change, environmental chemicals, biological invasions, pollinator loss).

Since this research should go on behind the end of the project, the field sites will be integrated into the long-term ecosystem research sites, LTER, as described by Parr et al. [9].

Furthermore, the ALARM field sites are open to other scientist to use the facilities and cooperate on integrated research across different scientific fields providing research an even broader basis.

Acknowledgement

Research is funded by the EC within the FP 6 Integrated Project ALARM "Assessing Large-scale environmental Risks for biodiversity with tested Methods" (GOCE-CT-2003-506675).

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