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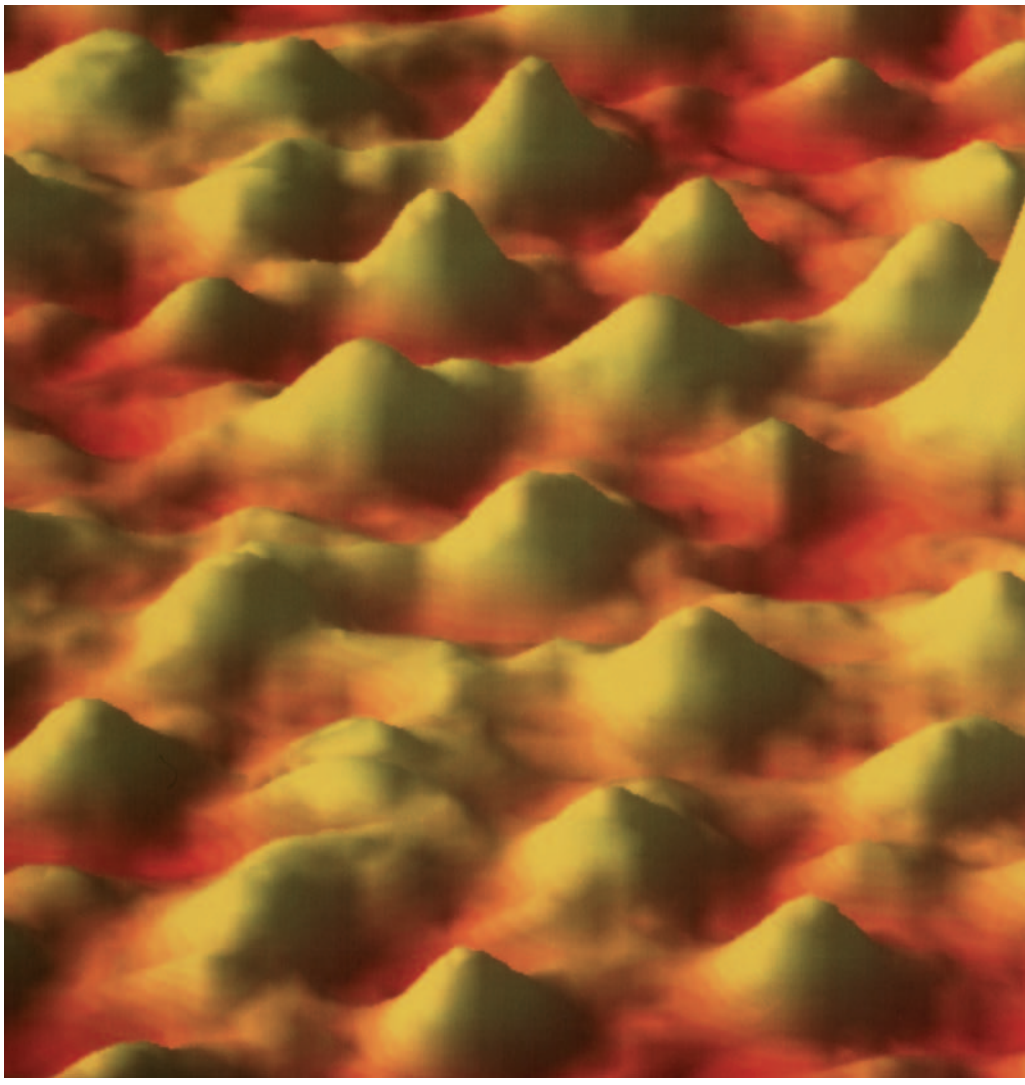

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ALARM: Assessing LArge-scale environmental Risks for biodiversity with tested Methods

The EU-funded research project ALARM will develop and test methods and protocols for the assessment of large-scale environmental risks in order to minimise negative human impacts. Research focuses on the assessment and forecast of changes in biodiversity and in the structure, function, and dynamics of ecosystems. This includes the relationships between society, the economy and biodiversity.

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1 ALARM Objectives

The general objectives are:

- To develop an integrated large-scale assessment of risks to biodiversity in terrestrial and freshwater ecosystems as a part of environmental risk assessment.
- To focus on risks consequent on climate change, environmental chemicals, rates and extent of loss of pollinators and biological invasions.
- To develop, for the first time, 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.
- To establish risk indicators related to the socio-economic drivers of biodiversity pressures as a tool to support long-term policies and to monitor their implementation.
- To provide a contribution to objective-based politics, to help integrating policy and to derive outcome-oriented policy measures in the field of biodiversity preservation by contributing to the integrated assessment of socio-economic drivers affecting biodiversity and integrated, long-term oriented means to mitigate them.

2 ALARM Research Approach

The main pressures analysed within ALARM (climate change, environmental chemicals, biological invasions, pollinator loss) are each substantial environmental changes resulting from human activities. These have generally been studied independently of one another. Yet it is clear that, on a large scale, they do interact, potentially producing effects on ecosystem diversity that exceed all current assessments of potential risk. There are currently no methods that allow continuous integration across these pressures, especially as new information and understanding is developed (within each sector) and new concerns arise about sustainability. In addition there are no methods that interconnect the pressures with sentinel indicators of changes in biodiversity. ALARM will attempt to develop such methods in two phases: data base integration and ecosystem risk evaluation. The project will link databases using Geographical Information System (GIS) modelling, creating European-scale information, and then generating standardised methods for further data-base development and probability analysis. Finally, these methods will be tested and protocols developed for the assessment of environmental risks in ecosystems.[1] The ALARM approach is summarised in figure 1 (p. 70).

The level of analysis of biodiversity can be classified in a nested way from genes via populations to species and ultimately to ecosystems. Indicators of environmental impacts are on the genetic (e. g. hybridisation due to cross-breeding with invasive species), populations or species (e. g. decline of species numbers or abundance), and ecosystem level (e. g. change in species composition and community structure and functioning).

To quantify the impacts of the pressures, ALARM will use combined risk likeli- >

1 In the context of ALARM, *large-scale risk assessment* refers to processes which have an impact at a large extent, but could affect biodiversity and ecosystems from a local to a continental scale. This includes natural processes as well as anthropogenically triggered change or direct impacts of socio-economic systems in Europe (the EU and beyond).

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BOX: The ALARM Project

The ALARM project (Assessing LArge-scale environmental Risks for biodiversity with tested Methods) started in February 2004. ALARM (GOCE-CT-2003-506675) is an Integrated Project (IP), funded by European Commission (EC) within the 6th Framework Programme.

The ALARM consortium is co-ordinated by the Helmholtz-Centre UFZ – Centre for Environmental Research Leipzig-Halle. It combines the expertise of 54 partners from 26 countries (19 EU, Romania, Bulgaria, Israel, Switzerland, Russia, Chile and Argentina). ALARM encompasses seven small or medium sized enterprises (SME) as full partners.

General management of the ALARM project is the main task of the co-ordination team headed by UFZ. For further details regarding the management structure of ALARM see figure 4 (p. 72) and *www.alarmproject.net*.

hood and risk consequence scores throughout to identify low, medium or high risks associated with the respective pressure(s). Scenarios will be applied to simulate future environmental threats and to quantify risks subsequent to these. Results of these different risk assessment approaches will be communicated to stakeholders as tested methods for broader application. Socio-economics as a cross-cutting theme will contribute to the integration of driver-specific risk assessment tools and methods, develop instruments to communicate risks concerning biodiversity to end users, and indicate policy options to mitigate such risks.

3 General Project Structure and Scientific Contents

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 ALARM (see figure 4, p. 72).

3.1 Climate Change Module

The climate change module covers the effects not only of shifts in temperature and precipitation patterns (means, variability and seasonality), but also of land use changes and nitrogen deposition. Within this module there are three working groups: (i) scenarios, (ii) biodiversity and (iii) ecosystems. Scenarios of climate change, land use change and nitrogen depositions are being obtained from methodologies developed in previous EU projects and being extensively modified and further developed in ALARM. The biodiversity and the ecosystem groups analyse methods to assess impacts caused by the drivers modelled in the first group. The impact on biodiversity will be analysed by tracing fingerprints of climate change and by modelling possible ranges of habitats, species and species assemblages.

3.2 Environmental Chemicals Module

Methods to assess the influence of environmental chemicals on biodiversity will be tested for atmospheric emissions, surface runoff, rivers, lakes, and soil. The groups of chemicals to be considered encompass heavy metals, polycyclic aromatic hydrocarbons, persistent organic pollutants and pesticides. Furthermore, nitrogen deposition in riparian systems is considered.

Central concepts within this module are *exposure* and *effects*. Exposure is the composition and concentration of the chemicals that have an impact on the focal species. Effect is the action that these species display, e. g. changes in diversity or density, behavioural changes etc. Throughout Europe we plan to model emissions for several chemical substances and measure the exposure onto focal organisms. Furthermore, for appropriate chemicals, we will measure the effect of the focal organisms. Both exposure of and effects for large-scale systems will be assisted by indicator toolboxes. By employing several modelling techniques, it will be possible to derive indicators from diversity change in natural communities and to develop European

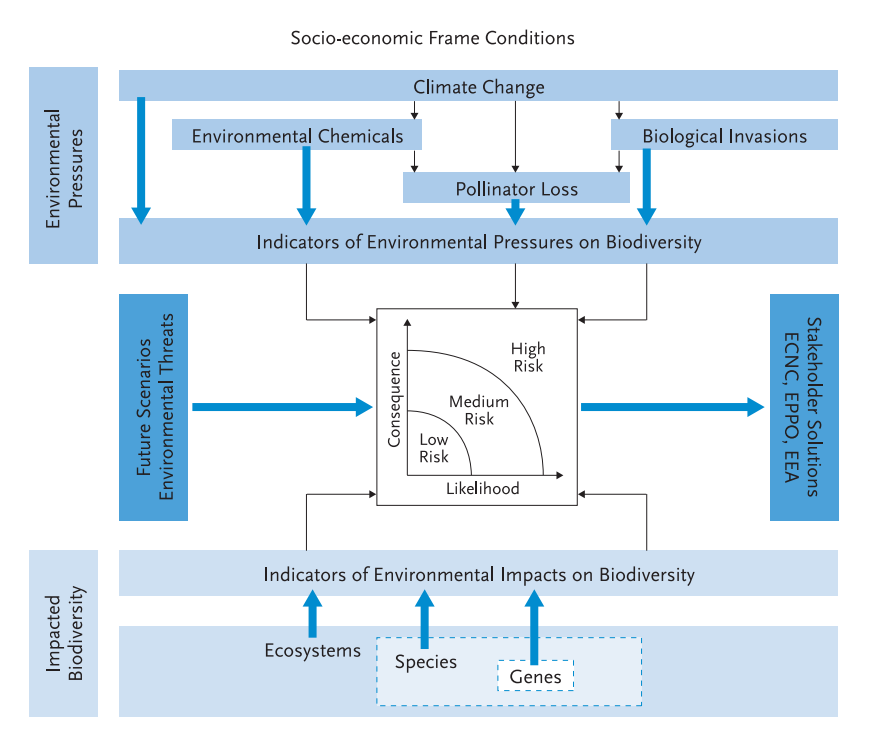

FIGURE 1: ALARM scheme to describe the relationships among the four main environmental pressures and the development of methods for Integrated Risk Assessment for the different levels of biodiversity. Socio-economic pressures and indicators form the general background of the ALARM approach (bold blue arrows: principal effects; fine black arrows: additional/indirect impacts.

risk indicators to couple these results to large-scale environmental pressures.

3.3 Biological Invasions Module

The aim of this module is to develop and test comprehensive, systematic protocols to help preventing the introduction and spread of invasive species to European ecosystems. A range of taxonomic groups will be analysed (such as terrestrial and freshwater vascular plants, insects, freshwater and estuarine invertebrates, freshwater fish, birds, mammals) using both global and European databases. In several risk analyses, we will look at (i) the pathways of invasions (where do the species come from, how were they introduced and what is the importance of the pathways), (ii) the invasibility of European ecosystems, i.e. identifying habitat susceptibility thereby producing a European risk map, (iii) characteristics (traits) of successful invaders, (iv) environmental drivers of invasion related to climate, land cover and population density, and (v) the testing and integration of the elements named above where traditionally, these factors have been assessed separately. The impacts that will be taken into account encompass hazards associated with: (i) the gene pool of native species; (ii) the decline of native populations; (iii) the richness and functioning of ecosystems; (iv) socio-economic pressures (such as declines in agricultural, silvicultural or fishery yields); (v) the management of invasive species, i.e. what is the effort of removing an invader from a system and (vi) the integration of the previous analyses.

3.4 Pollinator Loss Module

The objectives for the Pollinator Module are to (i) quantify distribution shifts in key pollinator groups across Europe, (ii) measure the biodiversity and economic risks associated with the loss of pollination services in agricultural and natural systems through the development of standardised tools and protocols, (iii) determine the relative individual and combined importance of drivers of pollinator loss (land use, climate change, environmental chemicals, invasives and socio-economic factors) and (iv) to develop predictive models for pollinator loss and consequent risks.

FIGURE 2: The ALARM logo.

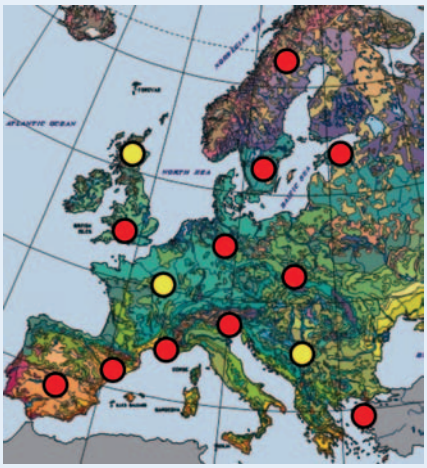

FIGURE 3: Field site network within ALARM.

We will identify pollinator indicator groups to develop thresholds for the quantification of pressure (probability of pollinator loss) linked with impact (consequences of loss of pollination function). This ecological basis for risk assessment will use a package of standardised protocols which allow comparable assessments to be undertaken in different ecosystems and in different EU regions.

Based on this, European pressure and impact risk assessment maps identifying vulnerable ecosystem types, risk zones and pollinator groups will be developed. Further, the economic risks associated with pollinator shifts and loss of pollination services will be evaluated.

3.5 Socio-Economics Module

Socio-economic research has a dual purpose within ALARM. First, there are socio-economic partners within each of the previous modules (and subsequently in each of the following ones). Second, within the respective natural science modules, socio-economic partners are responsible for providing relevant socio-economic information and for receiving the results of the natural science research to incorporate within their own analyses. Thus, the socio-economic team plays a crucial role in integrating the results and promoting cross-cutting research. The first work package analyses pressures and trends for biodiversity and ecosystems risks, i.e. to link drivers of biodiversity and ecosystems pressure to their underlying socio-economic driving forces and hence to identify the most relevant socio-economic driving forces, be they global trends or the results of European or national policies. Both are preconditions for identifying relevant policy drivers in the second work package. At a later stage, the project will draw conclusions regarding policy formulation at the European and the national level.

3.6 Methods for Multiple Pressures and the Geographical Information Systems (GIS) Module

This module is congruent with the third work package of ALARM with relevant tools and technologies. The two central issues are the establishment of a focal site network (figure 3) as an arena within which to examine the separate and interacting effects of the multiple pressures concerned and a testing ground for the risk assessment tools developed. The site network will span the continent in north-south and east-west directions, thus providing a comprehensive coverage of the European biogeographic and climatic zones, while at the same time allowing landscape scale and local patterns to be examined. The network will be designed to include paired sites within 50 km of one another and in similar abiotic environments (altitude, geology, climate) but with sharply contrasting land use patterns. One site of each pair will be dominated by natural or semi-natural habitats, whereas the other will be dominated by relatively intensive anthropogenically modified areas, with only small fragments of natural habi- >

tats remaining. Wherever possible, both terrestrial and freshwater habitats will be represented.

The tests of multiple pressures across landscapes encompass all bilateral interactions between the four modules of the natural sciences, plus analyses amongst more than two disciplines, ideally including the four-way interactions among climate, pollinators, invasions, and chemicals.

3.7 Method Tests, Training, and Dissemination Module

This module includes the work packages four (Method Tests and Protocol Development for Application), five (Dissemination and Toolkit) and six (Training Activities). Since many of the aspects that are being analysed within the ALARM project are highly dynamic and the methodologies will gradually evolve during the first years, the actual work plan for the later tasks will be developed more thoroughly during the course of the project.

During the project, we will develop tests to verify the analyses within the first six modules (pressures analysed in the first modules by the natural sciences, socio-economics, and multiple pressures). This will be done with datasets that are set-aside specifically for this purpose, with datasets that are newly acquired for this purpose (e. g. from areas not previously analysed), or data from the field site network, employing and testing scaling techniques.

The results of ALARM will be disseminated through journals, conferences, books, the internet, stakeholder organisations and other means. Furthermore, we will develop risk assessment toolkits for the individual pressures and their interactions. An idea that is well formulated is the development of a toolkit to assess European invasive species according to the knowledge developed in the third module.

Finally, ALARM offers a wide range of training activities in the fields of risk assessment, modelling, expert systems and GIS.

4 The Future of and Links to the ALARM Project

The ALARM project is scheduled to continue until January 2009. After approximately one year of research the project has already achieved a high degree of integration and cross-fertilisation amongst the representatives of quite different research communities. Some initial scientific results will emerge (and in part are already published). As the whole project will continually evolve, the opportunity exists to adjust to new developments. If readers are interested in the progress of the research, regular updates will be provided through the project website *www.alarmproject.net*. Contributions, such as data research collaborations and joint publications are always welcome!

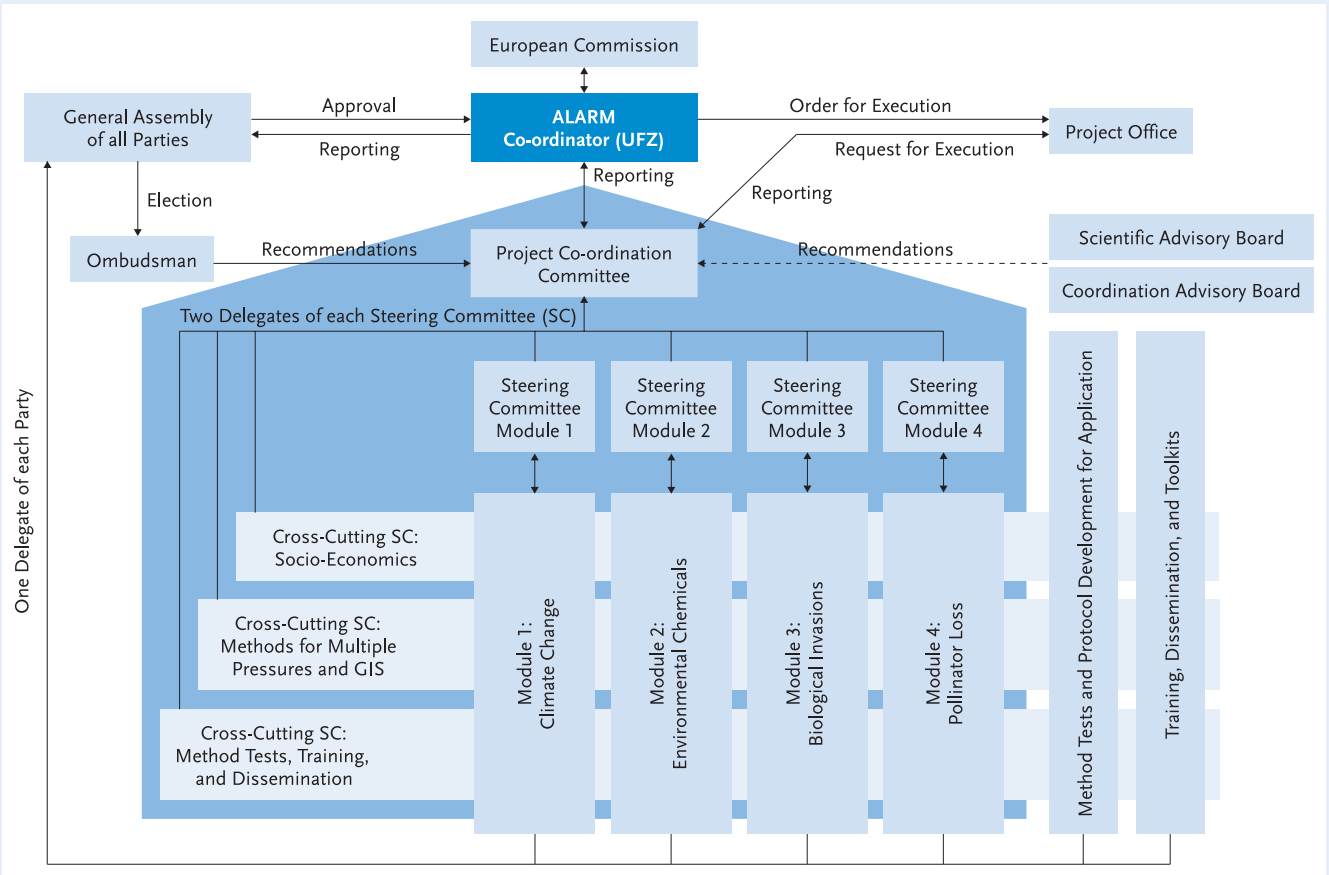

FIGURE 4: Modular and management structure of the ALARM project. The Project Co-ordination Committee (medium blue area) serves as the central management and decision unit within ALARM.