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Biodiversity monitoring in Switzerland

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Abstract

The objective of the Biodiversity Monitoring in Switzerland programme (BDM) is to identify changes in Switzerland's biodiversity. These data can help to ensure that the country's nature conservation policy is made more effective and more efficient and to scrutinize the efficacy of national policies affecting biodiversity. The BDM allows Switzerland to meet one of the requirements of the Convention on Biological Diversity signed in Rio.

Although biodiversity means not only species diversity but also genetic diversity and habitat diversity, financial and methodical constraints have forced the BDM to focus on monitoring species diversity.

A comprehensive picture of species diversity can only be obtained if changes are monitored on the three levels of diversity. Different pressures come to bear at each level, and different protective strategies need to be pursued to maintain and promote biodiversity.

The change in the species diversity of a country (γ-diversity) depends predominantly on the occurrence of rare (and possibly threatened) species. The α-diversity of defined area types, in contrast, depends on the occurrence of common species, regional β-diversity on widespread species. The BDM employs a separate indicator for each of these three levels. It thus monitors not only rare and threatened species but also common and widespread species. This is done through two coordinated sampling grids. The presence or absence of all the species in selected species groups is recorded in both grids. These samples will allow conclusions to be drawn for Switzerland as a whole, for specific regions and (for α-diversity) for certain types of land use.

In addition to indicators showing the state of biodiversity, the BDM includes indicators for main factors probably affecting biodiversity and for measures that have been implemented. These indicators are presented using the "Pressure-State-Response model", which allows hypotheses to be developed about possible cause-effect relationships.

The annual results will be presented in a form, accessible to the various target groups and made available to users who need this information. The most important recipients of this information are nature conservation offices, agriculture and forestry, decision-makers in politics, environmental organizations and the media.

1 Why do we need biodiversity monitoring?

There is a lot of talk about biodiversity nowadays, but even experts do not really know how the diversity of species – the most popular form of biodiversity – has changed over the years, and indeed is still changing. However, without knowing the facts it is very difficult to formulate adequate measures for preserving biodiversity.

The chronology of changes in species diversity has been documented for very few taxonomic groups, one of which is breeding birds. This chronology provides us with valuable information about the development of breeding bird diversity. Interesting figures are provided by a study of the species diversity of breeding birds around Lake Constance (Tab. 1). These figures show that completely different developments may occur in the species diversity of the same area during the same period, and that these developments may even be contradictory. This is because the number of rare, widespread or common species is determined by different factors and can be influenced by different types of (human) intervention (Fig. 2). A baseline monitoring programme to document the development of biodiversity must identify change of rare, common and widespread species.

Table 1: Change in the species diversity of breeding birds around Lake Constance 1980–1990 (source: own evaluation of data from BÖHNING-GAESE & BAUER 1996).

Species of breeding birds	1980	1990	Change 1980–1990	
Number of breeding bird species living wild	141	146	+4 %	↗
Number of widespread breeding bird species	59	53	–10 %	↘
Mean species diversity per approx. 3-ha unit	11.6	11.1	– 4 %	↘

However, the Biodiversity Monitoring in Switzerland programme (BDM) is intended not solely to document changes in biodiversity. It is also designed to identify problems at an early stage and to form the essential basis for an efficient and effective nature conservation policy. Data on the development of biodiversity may be used to define objectives in nature conservation or to test the efficacy of national policy (HINTERMANN et al. 1999).

2 How does the BDM fit in with other concepts?

The BDM is a new task which needs to fit in with existing national and international concepts. On a national level the concept developed by the "Conference of Nature and Countryside Conservation Officers" forms the framework for future projects in Switzerland (MAURER & MARTI 1997; Fig. 1). It highlights the various components of environment policy, observation and reporting and describes their specific functions.

Environment policy must formulate clear objectives and create a framework for measures affecting the environment. The stated aims will be pursued with concrete **projects** and **programmes**. **Effectiveness monitoring systems** provide information on whether individual measures have been implemented, funding has been used efficiently and the objectives of the projects and programmes have been achieved. Effectiveness monitoring systems are always tailored to the individual projects or programmes and generally are operational only until the project or programme has been completed and evaluated. **Baseline monitoring programmes** (environment survey), in contrast, show how the quality of the environment, measured in terms of biodiversity for example, is developing independently of individual projects which run for a specific period. In general, monitoring programmes do not provide any information about the success of individual projects or cause-effect relationships because the indicators are selected with a view to identify long-term changes independent of specific projects.

The results of effectiveness monitoring and baseline monitoring are analysed and presented using the instrument of **environmental reporting** in such a way that politicians and administrators can make rational decisions on objectives, framework conditions and (new) projects

and programmes and the public can be shown how well society's goals are being achieved and society's mandates to the administration are being implemented. Environmental reporting can focus on specific sectors, reporting only on developments in biodiversity, or it can give a global overview of all aspects of the environment (e.g. the Swiss government's report on the environment in Switzerland).

The difference between effectiveness monitoring and baseline monitoring is absolutely central to any understanding of the BDM concept. Effectiveness monitoring requires a different methodical approach than baseline monitoring. It is therefore inappropriate to expect the BDM to provide concrete conclusions about the impact of specific interventions (e.g. the construction of a motorway) or programmes (incentives to preserve orchards). It is equally unrealistic to expect effectiveness monitoring systems to provide specific conclusions about the long-term development of biodiversity. The first approach would be totally inefficient, the second practically impossible.

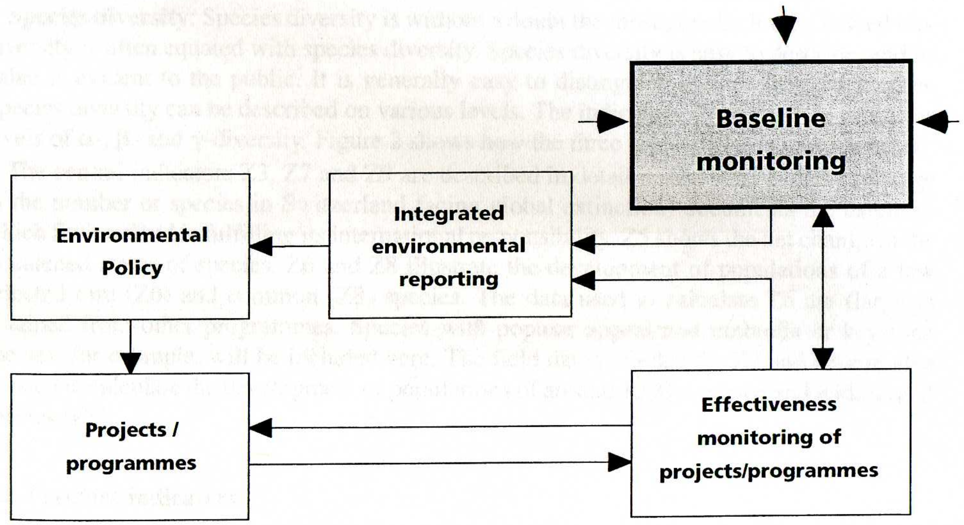

Figure 1: Relationships between environmental policy, effectiveness monitoring, baseline monitoring and reporting. The BDM is based on the draft concept put forward by the KBNL. See text for more detailed explanation. Source: modified from MAURER & MARTI (1997).

The "Pressure-State-Response model" (PSR model) is frequently employed in international monitoring programmes (OECD 1994). In this model, indicators are selected and grouped in such a way that they reflect the major sources of pressure on biodiversity or state of biodiversity, or reflect measures designed to preserve biodiversity. Since the PSR model must form the basis of the BDM, the indicator set used by the BDM comprises indicators of state as well as of pressure and response.

3 What information does the BDM supply?

The BDM currently provides information for 32 indicators. In Table 2 the indicators are arranged according to the PSR system. Table 3 summarizes all indicators. HINTERMANN et al. (1999) contains comprehensive information on all indicators.

Table 2: Grouping of indicators using the PSR system.

Pressures		States		Responses	
15 indicators:		11 indicators:		7 indicators:	
Valuable habitats	1	Genetic diversity	2	Protected areas	3
Natural features	4	Species diversity	7	Contract areas	1
Use of natural areas	2	Habitat diversity	2	Agriculture	1
Use of woodland	3			Enforcement	1
Use of watercourses	4			Finance	1
Settlement	1				

Table 3: An overview of the BDM indicators. All the indicators are defined as changes or net results since it is generally not the absolute but the relative figures (changes) that are of interest. The selection was based on the needs of the future users of the information and the recommendations put forward by UNEP (1993), OECD (1994), WCMC (REID et al. 1993) and NOSS et al. (1992). Z: State indicators; E: Pressure indicators; M: Response indicators.

Z1	Change in the number of livestock races and agricultural plant varieties in Switzerland
Z2	Change in the share of different livestock races and agricultural plant varieties of total population/total production
Z3	Change in the number of wild species in Switzerland (γ-diversity)
Z4	Change in the number of species in Switzerland facing global extinction
Z5	Net change in the threatened status of species
Z6	Population trends of selected threatened species
Z7	Change in the mean species diversity per $1km^2$ (β-diversity)
Z8	Population trends for selected widespread or common species
Z9	Change in the mean species diversity in small areas of defined types of land use (α-diversity)
Z10	Change in the size of valuable habitats
Z11	Change in the quality of valuable habitats
E1=Z10	Change in the size of valuable habitats
E2	Change in the size of various defined area units
E3	Change in the size of wilderness areas
E4	Change in the length of linear natural features
E5	Change in the diversity of use in small areas
E6	Change in the nitrogen supply in the soil
E7	Change in the yield per area
E8	Change in the woodland area dominated by non-indigenous trees
E9	Change in the proportion of young woodland with artificial rejuvenation
E10	Change in the woodland area primarily used for special purposes
E11	Change in the length of watercourses affected by power stations
E12	Change in the proportion of adversely affected watercourses
E13	Change in the water quality of watercourses and captive water
E14	Change in the proportion of polluted waterways
E15	Change in the density of access options
M1	Change in the size of protected areas
M2	Change in the size of protected areas with adequate protection and protective measures which are actually observed and enforced
M3	Change in the proportion of threatened species living in predominantly protected habitats
M4	Change in the total size of "areas covered by contractual agreements"
M5	Change in the total size of "organic farms"
M6	Change in implementation of environmental regulations
M7	Change in resources for nature and landscape conservation

3.1 Indicators of the state of biodiversity

Most authors distinguish between three levels of biodiversity: genetic diversity, species diversity and habitat diversity. The BDM also uses these three levels.

Genetic diversity: The diversity below the species level is of major significance to the overriding objective of maintaining biodiversity. Diversity may disappear before a species becomes extinct. For financial reasons genetic diversity must be restricted to livestock races and agricultural plant varieties (Z1, Z2). Representative surveys of the kind carried out at the level of species diversity for widespread (Z7) and common species (Z9) cannot be financed at the genetic level.

Habitat diversity: Habitat diversity is very complex and difficult to record, and its significance is disputed (REID et al. 1993). The BDM is limited to one quantitative and one qualitative indicator for the habitats which have been defined as valuable under Swiss law (Z10 and Z11). Other changes in size and structure are measured by the E-indicators.

Species diversity: Species diversity is without a doubt the most popular level – indeed biodiversity is often equated with species diversity. Species diversity is easy to describe, and its value is evident to the public. It is generally easy to distinguish species from each other. Species diversity can be described on various levels. The indicators Z9, Z7 and Z3 cover the levels of α-, β- and γ-diversity. Figure 2 shows how the three levels differ from each other.

The central indicators Z3, Z7 and Z9 are described in detail in Chapters 4–6. Z4 (change in the number or species in Switzerland facing global extinction) documents the extent to which Switzerland is fulfilling its international responsibility. Z5 shows the net change in the threatened status of species. Z6 and Z8 illustrate the development of populations of a few selected rare (Z6) and common (Z8) species. The data used to calculate Z6 are (largely) obtained from other programmes. Species with popular appeal and umbrella or keystone species, for example, will be included here. The field data recorded for Z7 and Z9 can also be used to calculate the development of populations of around 1500 common and widespread species (Z8).

3.2 Pressure indicators

As Figure 2 shows, diversity is affected at all three levels by various pressure factors. α-diversity (measured by Z9) is affected particularly by the nutrient supply, the structure of the area, access techniques and management. These pressures are reflected mainly by the indicators E6, E7, E8, E9, E11, E12, E13, E14 and E15. β-diversity is determined by the heterogeneity of the habitats, the length of border lines and the size of areas used for a defined purpose, i.e. the factors illustrated particularly by E2, E4, E5, E11, E12 and E15. And finally, γ-diversity is affected predominantly by factors such as area shift, species formation and species extinction, which are reflected to some extent by E1, E3 and E10. The lack of available data means that not all relevant pressures are covered by indicators. For financial reasons the BDM must rely largely on the existing data.

3.3 Response indicators

The selection of response indicators is also determined largely by the available data. The change in (adequately) protected areas (M1 and M2) and the change in the proportion of threatened species in protected areas (M3) is important for γ-diversity. The indicators M4 (change in total size of "areas covered by contractual agreements") and M5 (change in the

	α-diversity	β-diversity	γ-diversity
Definition	Diversity within a habitat	Diversity within a mosaic of habitats, including borderline effects	Diversity in a biogeographical region / in a country
Pressure	- Nutrients - Structure - Access techniques - Management	- Heterogeneity - Length of border - Size of areas of a defined area type	- Area shift - Species formation - Species extinction
Major protection strategy	Develop / optimize access techniques	- Biotope protection - Compensatory areas - Biotope networking	- Species protection - Reintegration - Large corridors - Possibly isolation
Assumed development in the 1990s	Reduction (except perhaps in woods and settlements)	- Increase in lowland areas - Decrease in the mountains	Increase in Switzerland
Sensitive species	Common, widespread species	Widespread, uncommon species (RL3 species)	Rare species (RL0 / 1 / 2 species)
Rate of development	moderate	rapid	slow
Suitable size of unit	Units of a defined area type	- Regions - Altitude bands	Biogeographical regions
BDM indicator	Z9	Z7	Z3

Figure 2: The three levels of species diversity.

total size of "organic farms"), in contrast, have an impact primarily on α- and β-diversity. The indicators M6 (change in implementation of environmental regulations) and M7 (change in resources for nature and landscape conservation) exercise an influence on all three levels of diversity.

4 How is the species diversity of a country / a biogeographical region (γ– diversity) measured?

γ-diversity describes the diversity in a country or in its biogeographical regions. The number of species is determined largely by changes in the populations of threatened species: it decreases when the last representatives of such species disappear from a region and increases if species succeed in establishing themselves or returning to the region and when new species

Z3: Change in the number of wild species in Switzerland

The change in the total number of species in Switzerland is recorded using the indicator Z3: "Change in the sum of all wild species in a taxonomic category whose existence in Switzerland was recordeded in nine of the ten preceding years using standardized methods, or whose existence can be assumed as highly probable".

Although Z3 is not described explicitly as an indicator of rare species, it is determined by the processes of "extinction" and "colonization" of rare and threatened species. These species generally inhabit special locations on the periphery of normal landscape development in Switzerland. For this reason, Z3 records changes in special habitats (for example areas with nature conservation activities) and large-scale development such as changes in the size of species areas. In contrast, changes in agricultural and forestry land use have little impact on Z3.

It would be preferable to calculate the sum of all the species that occur in Switzerland. However, for obvious reasons this is impossible (e.g. cost, methodical problems). For this reason the indicator Z3 has to be limited to a selection of taxonomic categories representative of Swiss biodiversity as a whole. These are groups of species for which reliable information on their presence or absence can be obtained using standardized methods in a countrywide survey (see Table 4).

Table 4: Species groups intended for inclusion in the calculation of Z3, Z7 and Z9. Assessment of the possibilities for operationalization produces four categories:
1: operational; 2: probably operational in the short term; 3: possibly operational in the medium term; –: almost impossible to operationalize at the moment.

Taxon	Z3	Z7	Z9
Mammals without bats	1	2	
Bats	–	–	
Birds	1	1	1
Reptiles	1	2	
Amphibians	1	1	
Fish / Cyclostomes	3	2	3
Decapod crustaceans			
Molluscs		3	1
Dragonflies	2	2	
Grasshoppers	2	1	
Ground beetles			
Ants			
Butterflies	2	1	1
Moths		3	
Wild bees		3	
Mayflies	3		2
Stone flies	3		2
Caddis flies	3		2
various other invertebrates		3	
Vascular plants	–	1	1
Mosses	–	–	1
Lichens	–	–	2
edible Fungi	2	3	–

5 How is the species diversity within a habitat measured (α-diversity)?

α-diversity describes the species diversity within a habitat. It can be considered as a kind of "point diversity". Within-habitat diversity is affected by the quality and quantity of existing resources (such as nutrients, food supply, structures). In accessed areas the nature and intensity of land use or land management also have a decisive impact on diversity.

Z9: Change in the mean species diversity in small areas of defined types of land use

The species diversity, measured as the number of species in a unit area, is one of the most conclusive and persuasive indicators since it can be understood intuitively. Indicator Z9 shows the "change in the mean species diversity in a taxonomic category living in small areas of standardized size of a defined area type".

In order to produce representative data for Switzerland, the raw data are obtained using a systematic sampling grid (comprising some 1600 sampling units). In theory it would be possible to calculate Z9 for all types of habitats. However, in order to identify reliable trends for a certain area type, a minimum number of sampling units are needed. This is why for financial reasons data can only be produced for the common types of land use like woodland, arable land, meadowland, settlements, and natural alpine areas.

Like other indicators, Z9 can only provide a representative view of biodiversity using a limited number of species groups (Tab. 4).

6 How is species diversity measured in habitat mosaics (β-diversity)?

The species diversity of a mosaic of habitats is described in terms of its β-diversity (between-habitat diversity). The number of species in specific parts of the landscape is determined by the heterogeneity of the different habitats involved, the length of borders between the habitats, the quality of the transitional areas (ecotones) and the size of each defined area type. Since a high α-diversity may be found in conjunction with a low β-diversity (and vice versa), it is vital to observe changes in β-diversity as a separate element.

Z7: Change in the mean species diversity per 1 km^2

In the BDM indicator Z7 is defined as follows: "Change in the mean species diversity of selected species groups per 1 km^2 grid unit."

Z7 looks at selected species groups to measure the changes in the mean landscape (Tab. 4). It is an easily understandable indicator. Richly structured areas with long, well developed ecotones and different types of habitats can be home to many different species, some of which may be widespread but not common in any location. Landscapes like this are perceived by people as being varied; landscapes whose structure has been destroyed, in contrast, are perceived as monotonous.

The value recorded for this indicator is affected primarily by widespread but not common species, since their occurrence is determined most significantly by changes over wide areas of landscape. Z7 decreases if populations of widespread species are eradicated locally in the normal landscape (such as the European hare). A general trend towards more ecological buffer zones and improved connectivity of habitats, on the other hand, will improve the living conditions of such species and hence lead to an increase in the indicator. Changes in rare species which occur only in a few sites in the region will have little impact on Z7. The indicator is recorded using a sampling grid of around 520 1 km^2 units. The vital element in monitoring is the reproducibility of the data. For this reason, the BDM is restricted to identifying the presence of species but not their abundance within the individual grid units. Our own method tests for various species groups have shown that recording the abundance of species within individual grid units leads to considerable scattering of the values because of surveyor variability. Statistically significant trends can only be calculated from abundance figures if surveyor variability is minimized by considerably more time- and cost-intensive methods.

7 How are data gathered?

The basic data for calculating the indicators in the BDM come from a variety of sources. Wherever possible, data are taken from ongoing surveys. This is the case particularly with pressure and response indicators.

7.1 Data for Z3

Changes in Z3 are influenced by rare species. Therefore Z3 must be calculated using a very extensive reporting network covering the entire Switzerland (rare species would be very unlikely to occur in a sampling grid). The necessary level of surveying is achieved by using volunteers, instructed and coordinated by professionals. Several reporting networks are already working since years. They will be used and further developed for the BDM.

7.2 Data for Z7 and Z9

In order to reach representative conclusions applicable to the whole of Switzerland about changes in widespread and common species which have the greatest impact on indicators Z7 and Z9, data have to be obtained from samples throughout the country. In view of the expected steady changes in the mean species diversity per grid unit, the obvious approach is to use fixed surveying areas which are sampled repeatedly at regular intervals (paired measures). A systematic sampling grid has been chosen for the BDM (Fig. 3) which is similar to existing surveying programmes (particularly the Swiss Area Statistics and the National Forest Inventory). As long as it is dense enough, a grid of this kind allows evaluation strata to be formed retrospectively (post-stratification). The sample size is a trade off by the desired degree of precision in the statements on change of biodiversity and the financial resources available (HINTERMANN et al. 1999).

Data gathering for Z7 and Z9 will be staggered. Each year, one fifth of the entire sample for Z7 and Z9 will be surveyed (Fig. 4). This means that in the sixth year the survey will produce paired measures for one fifth of the total sample for the first time. In the tenth year paired measures will be available for the full range of sampled areas. A staggered survey like this has several advantages, like levelling off of extreme annual fluctuations, and allows for annual up-to-date reporting.

8 How will the results of the BDM be used?

The major objectives of the BDM – better understanding of biodiversity, a better decision-making basis for nature conservation policy, information on the effectiveness of national policies – have to be communicated to a wider audience in a certain way. Various target groups must be provided with very specific information. The most important recipients of this information are nature conservation offices, agriculture and forestry, decision-makers in politics, environmental organizations and the media. The needs of these target groups were established

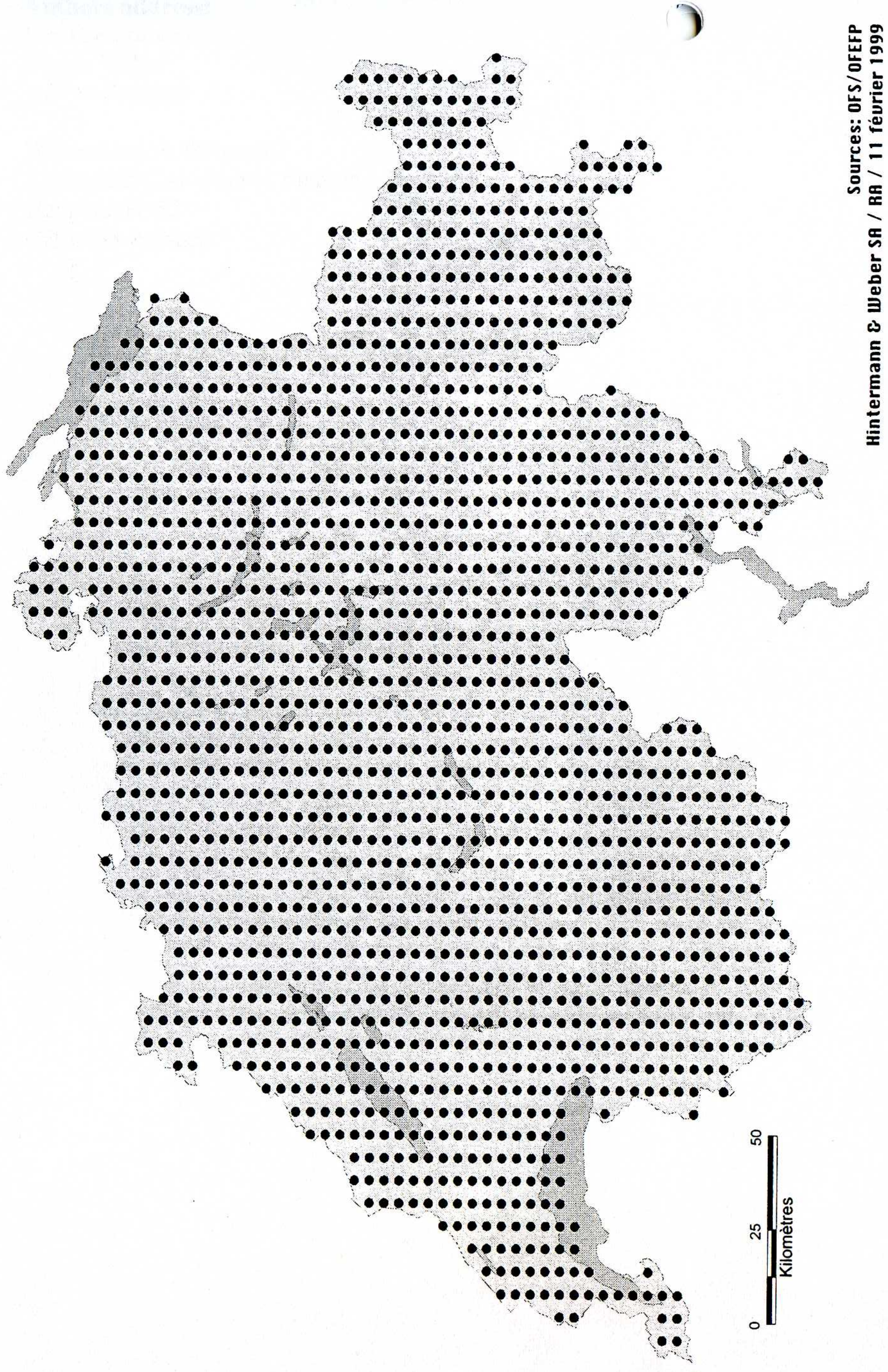

Figure 3: Sampling grid for Z9.

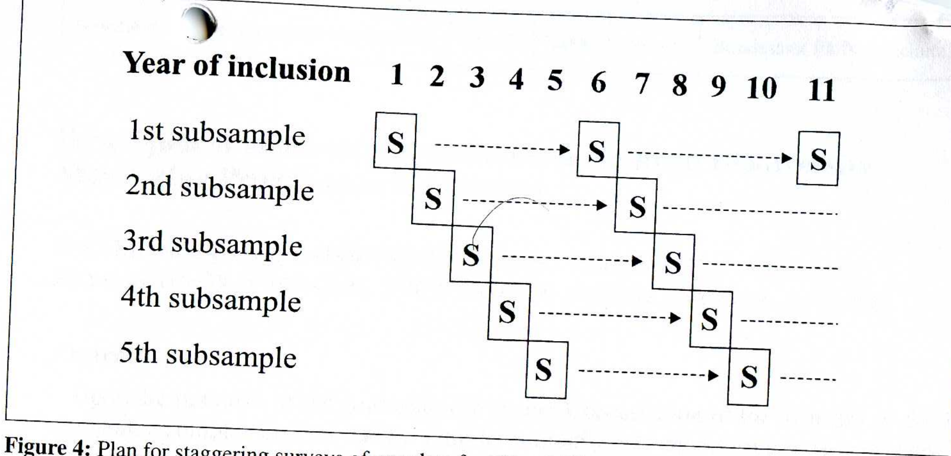

Figure 4: Plan for staggering surveys of raw data for Z7 and Z9.

at the start of the project in the course of two workshops and in a number of events during the development phase of the project. A range of products was described which are intended to meet these needs (HINTERMANN et al. 1999): basic data in printed and/or electronic form; six-monthly bulletin with current findings; annual national media conference; annual meeting of politicians; reports coproduced with other offices and organizations; articles in technical journals and presentations; data transfer for international surveys.

9 When will the BDM be carried out?

The preparatory phase will be largely completed by the end of 1999. The implementation phase of the programme will start in 2000 with the field surveys for Z7 and Z9, and this phase will last until approximately 2005. The initial survey of Z7 and Z9 will take five years since only 20 % of the total sample will be surveyed each year. From about 2006 the BDM will move into the operational phase.

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Development and implementation of a National Biodiversity Monitoring Programme in Hungary

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Abstract

Upon the initiative of the Authority for Nature Conservation of the Ministry of the En ronment, a complex programme for long-term biodiversity monitoring in Hungary has be elaborated by a large group of experts during 1995–1997.

The 110 plant communities, 315 plant and about 250 animal species selected for monito ing represent the common and characteristic, the rare and therefore protected, the threaten and the invasive elements of the biota.

Ten volumes of manuals for monitoring biodiversity have been published, and they conta the characterization of the selected entities and attributes, the localisation and timing of mor toring and the exact but simple methodology for gaining broad but reliable data in the fiel

As part of the programme, experts have elaborated a comprehensive national habitat cla sification system compatible with EUNISHAB[1], which serves as basis for landscape-lev habitat mapping and monitoring. The first steps towards setting up a National Biodiversi Monitoring Service have been taken to implement the programme.

1 Introduction

The signing of the Convention on Biological Diversity (CBD)(GLOWKA 1994) by 1 states and the European Union gave enormous stimulus to the development of glob regional and national biodiversity programmes.

Article 7 of the CBD requires signatory parties to identify components of biodivers important for conservation and sustainable use, to monitor the components of biologi diversity, to identify and monitor processes and activities having or likely to have significa adverse effect on conservation and sustainable use, and finally to maintain and organize data derived from the above activities.

Based on the principles stated by the CBD, an increasing number of excellent natio strategies and action plans are already available. A Hungarian preparatory work (FEKETE al. 1994) was among the first such documents to be produced (e.g. FPT-BWG 1994, D 1994); the fully-fledged National Biodiversity Strategy and Action Programme is be developed using Global Environmental Facilities (GEF) support.

In Hungary with the joint efforts of the state nature conservation bodies and biologi research institutions, a complex nature inventory programme was launched in 1991 usin standard methodology (TARDY 1994), which served as precedent for starting to develo biodiversity monitoring programme.

[1] EUNISHAB = EUropean Nature Information System, HABitats