MAB in the mountains of Europe and the former Soviet Union

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Contents

INTRODUCTION

This Man and the Biosphere Programme (MAB) Digest provides an overview of scientific activities undertaken within MAB Project 6, whose focus is on mountain areas. It considers MAB activities in the mountains of nine European countries -- Austria, Bulgaria, the Czech Republic, France, Germany, Poland, Slovakia, Spain, and Switzerland -- and the former USSR. It is in these countries

that the majority of MAB activities in European mountain areas have been conducted. This overview is based on the analysis of published and unpublished documents, and interviews and field visits in the ten countries in 1992 and 1993. For more detail about the organization, content, and implications of the research described in this document, as well as a comparative evaluation of MAB activities in the mountains of Europe and the former USSR, the reader is encouraged to read the book by Price (1995, see Notes to Readers).

MAB IN THE MOUNTAINS: BACKGROUND

Project 6, on 'The impact of human activities on mountain and tundra ecosystems,' was one of the first MAB Projects to begin its activities. The general themes of the Project were outlined by a 'panel of experts' and a 'working group' in Salzburg, Austria, and Lillehammer, Norway, in 1973 (Unesco, 1973, 1974).

At Lillehammer, the working group identified three `problem areas' as a basis for the development of a core programme of internationally-coordinated activities:

(1) Resource development and human settlement in tropical mountain regions;

(2) Tourism, technology and land use alternatives in temperate mountains;

(3) Land use in high-latitude mountain and tundra ecosystems, with special reference to grazing, Industrial development and recreation.

Clearly, the second problem area is the one of primary concern in Europe and the former USSR, though high-latitude mountains also exist in the latter and in Scandinavia.
The general objective for work in temperate mountains was "to give a better knowledge of the mountain ecosystems in the temperate zone in relation to human use, so that present ecosystems can be conserved and new stable ecosystems devised to replace old systems which are no longer socially relevant and economically viable. In essence, this research should make it possible to give management prescriptions to achieve desired aims in the management of the ecosystems of mountains in the temperate zone." It was proposed that research should concentrate on the problem of the impact of tourism, through the co-operation of natural and social scientists. Particular attention needed to be given to critical factors and threshold points in the process of change. A prime concern was the needs of local people, and their control of the environment or the means by which this control is lost. The main framework was to be the spatially integrated unit: a village and its hinterland, a mountain valley, or a region with similar or contrasting levels of change. Serious attention also needed to be given to the time dimension (Unesco, 1974: 33-34).

Most of this Digest is devoted to a description of the research activities and national meetings that comprised MAB-6 in Europe and the former USSR. However, meetings which provided opportunities for international transfer of research concepts, methodologies, and results were another important component of the MAB programme. After the Salzburg and Lillehammer meetings, the first to bring together MAB-6 researchers from different western European countries took place in 1978, in Grindelwald, Switzerland. It considered 'pressures and regional planning problems in mountain regions,' and was sponsored by the Council of Europe (1978). Another meeting took place later that year in Berchtesgaden, Germany (German National Committee, 1979).

In 1981, two meetings focusing on MAB-6 in Western Europe were held, in Vallouise, France and Berchtesgaden (Ministère de l'Environnement, 1985; German National Committee, 1982). These were followed by meetings in the Pays d'Enhaut, Switzerland, in 1983 (Messerli and Stucki, 1983) and again in Berchtesgaden in 1984 and 1985 (German National Committee, 1985a, b). Scientists from Bulgaria and the USSR attended a few of these meetings, but the only conference to focus on MAB-6 in eastern and central Europe took place in Vratsa, Bulgaria in 1983. Most of the papers considered Bulgarian mountains (Bulgarian National Committee, 1983).

In 1987, the first meeting of European MAB Committees (EuroMAB) took place in Berchtesgaden. Subsequent EuroMAB meetings have been held biennially in Trebon, Czechoslovakia (1989), Strasbourg, France (1991), and Zakopane, Poland (1993). The latter was followed by an international symposium on ecological zonation in mountain areas, with specific reference to global environmental change.

Meetings on the subject of biosphere reserves have provided other opportunities for communication between scientists working in the mountains of Europe. The first International Biosphere Reserve Congress took place in Minsk, Belarus, in 1983 (Unesco-UNEP, 1984). This has been followed by other regional meetings, notably in Ceske Budejovice, Czechoslovakia (1986) and Spindleruv Mlyn, Czech Republic (1993), and the second International Conference on Biosphere Reserves in Sevilla, Spain (1995). Biosphere reserves derive from MAB Project 8 (conservation of natural areas and the genetic material they contain), although the concept has gone significantly beyond the original version which, in a similar manner to MAB-6, was elaborated by an international task-force in 1974 (Batisse, 1986). Mountain biosphere reserves have been designated in all of the countries considered in this review. In eastern and central Europe, they were the focus of activities in mountain areas within the framework of MAB.

AUSTRIA

MAB-6 research programmes in Austria have been conducted in three Alpine regions: the Obergurgl valley in the Oetztal Alps, the Grossglockner and Gastein areas of the Hohe Tauern, and the Sameralm region of the Salzburg Alps. The research in each of these areas is described below. Other MAB-6 research has considered human physiological responses to activity at medium and high altitudes, and the demography of the Hohe Tauern from 1900 to 1971 (Franz, 1985). This is one of the series of publications of the Austrian MAB programme (Veröffentlichungen des Oesterreichisches MaB-Programmes), published by Universitätsverlag Wagner in Innsbruck.

Obergurgl (Oetztal Alps)

Obergurgl is a village in the Oetztal Alps of Tyrol, at an altitude of about 2,000 m at the head of the Upper Oetztal, with peaks to 3,700 m. The pattern of life probably changed relatively little from the 12th century, when the valley was settled, into the mid-20th century. The economy was a traditional one, based on agriculture and grazing, and the population of about 120 changed little in size. In the early 1950s, Obergurgl was one of the many villages where winter tourism took hold (Moser and Moser, 1986).
In the 1960s, the University of Innsbruck undertook a project on the Hoher Nebelkogel (3,184 m), within the framework of the International Biological Programme (IBP) of the International Council of Scientific Unions (ICSU). The availability of the IBP data, combined with the increasing anthropogenic pressures on the environment and society of the valley, led to a new project in 1971. The project's objectives were "to study in an integrated fashion the daily life and future options of an alpine village which had become a tourism centre, and to use the systems knowledge thus gained to raise awareness and provide a better basis for individual and communal decision making in the best long-term interest of the villagers" (Moser and Moser, 1976: 102). In 1973, the project formally became a MAB-6 project.

The methodology chosen for the project was systems analysis, already used during the IBP project. In 1974, a five-day workshop was organized, to "develop a preliminary model of human impact on a simple alpine ecosystem and the policy options, by combining the knowledge and insights of business men, government officials, and scientists" (Himamowa, 1974: 2-3). The participants included people from Obergurgl, representatives of local government, scientists from Austria and other European countries, and Canadian systems analysts from the International Institute for Applied Systems Analysis (IIASA). The resulting model included four major components: recreational demand; population and economic development; farming and ecological change; and land use and development (Figure 1).

The model led to the identification of problem areas and consensus on eight ranked research priorities (Himamowa, 1974: 44-45):

(1) Sociology of villagers in relation to attitudes about land ownership, emigration, and economic opportunities;

(2) Perception of environmental quality by visitors and tourists, initially through photographic Senarios;

(3) Basic mapping of ecological conditions, especially in relation to ski development and soil erosion;

(4) Determination of primary production of pastures and alpine meadows in relation to grazing by wild and domestic animals;

(5) Projection of potential recreational demands in relation to changing transportation systems and public attitudes across Europe;

(6) Continued policy analysis of alternative development schemes and research priorities;

(7) Experimental studies involving manipulation of grazing patterns, trampling of meadows by people, and construction activities;

(8) Economic analysis of the village in terms of employment, savings patterns, and costs of hotel construction.

The project was directed by a commission including the coordinators, local people, and representatives of the Tyrol government (Moser and Peterson, 1981). Unfortunately, the field component of the project was prematurely brought to an end in summer 1979. At this point, the intended natural science research had mostly been completed, but much of the social science research was in its initial stages. There were various reasons for the termination of the project, including internal political problems and the unwillingness of the national MAB committee to guarantee the financial support necessary to bring the project to its conclusion. These led to the final reason: the project coordinator's decision to move to Canada. His successor was told that funding would not be continued, and to close down the project within a year.

The final report of the project (Patzelt, 1987) brings together the results of the research until 1980. The first of the 15 chapters is a brief history of the project, which mentions that the original model was modified twice (Moser, 1987). The first revision, in 1975, was to simplify the model for the integration of field data and for discussion with local people (Figure 2). This model and scenarios derived from it were discussed at workshops involving international

scientists and policymakers. A second revision was made in 1978, and was discussed at an internal project workshop. The intention was to test and further revise this model using the quantitative data deriving from the research and compiled in a database. However, this final stage did not occur because of the cessation of funding, and the database was closed down. Much of the data it contained was never analyzed or published.

The remaining chapters of the final report cover a wide range of topics. Those deriving from the natural scientific studies consider: energy balances and budgets during the growing season; soils; vegetation (mapping and primary production); and the impacts of tourism (skiing and trampling) on alpine vegetation, soils, invertebrates, and grouse. The few papers from the social scientific studies consider socio-economic changes (demography, employment, tourism); changes in value systems relating to the development of tourism; physical anthropology; and land use and hunting.
In spite of the project's premature demise, it has had a number of significant results. The first of these was the development of an integrated model-based approach to the analysis and understanding of alpine environments, involving local people and decision-makers as well as scientists. This links to a second result: recognition of the need for direct communication between scientists undertaking research in an area and those living in, and responsible for it. Such communication has continued since the MAB project, throughout the whole Oetztal. A third result has been the utilization of the findings of the research in developing innovative planning approaches, such as the Tirolean government's designation of a "Ruhegebiet" (quiet area) in the Upper Oetztal, where traditional agricultural practices are permitted, but the construction of facilities for tourism is not. Finally, as noted by Moser (1987), the project gave the local people a greater awareness of the relative benefits and costs of tourism, changed investment patterns, and led to the creation and renewal of many communal activities. It is not clear whether this heightened awareness of the implications of development continues: a new phase of hotel construction began in the late 1980s (Ives and Messerli, 1990).

Grossglockner (Hohe Tauern)

The Grossglockner area is part of the Hohe Tauern National Park and is traversed by a scenic road that crosses the highest pass in Austria and experiences considerable tourist traffic in summer. The MAB-6 project included two sub-projects. One was process-oriented, focusing on a number of test sites, with comparative studies in the Gastein area (described in the next section), while the other was more analytical and descriptive.
The process-oriented sub-project built on the preceding IBP projects on the Hoher Nebelkogel (above Obergurgl) and the Patscherkofel (above Innsbruck). The work was divided into a synoptic phase, followed by a detailed research phase. The former, starting in 1974, used methods similar to those used in the

IBP projects, to provide an overall description of the biophysical environment. Building on these studies, the research phase (1974-76) began with the development and field testing of new methodologies for intensive ecosystem studies, with the intention of developing the best possible understanding of the flora, fauna, and micro-organisms of alpine grassland ecosystems, particularly for application in the management of the National Park. The first major field season was 1976, when comparative studies of stands along environmental gradients in alpine pastures were conducted on the alpine grass heath at Wallackhaus (2,300 m). The resulting report includes a number of studies of macro- and micro-climatology, botany, plant physiology and productivity, pedology, and entomology (Cernusca, 1977).

A second group of studies took place from 1978 to 1983, building on the work begun in the 1970s. These studies, undertaken by scientists from the full range of natural science field disciplines, considered an altitudinal transect with six sites, at altitudes from 1,085 to 2,528 m, on the south side of the Grossglockner pass. The research, together with continued work at Wallackhaus in 1977 and 1978, is described in Cernusca (1989). The primary theme of research was the structure and function of grassland ecosystems at different altitudes. This involved research on water and energy budgets; phytomass, canopy structure, and microclimate; energy content of plant material; fodder value of plant canopies; carbon budgets; canopy and soil respiration; soil microbiology; and invertebrate zoology. A second theme considered anthropogenic stresses on grassland ecosystems: grazing by cattle and sheep; abandonment of pastures; skiing and snow-making; hiking; and pollution from vehicles and roads.

The first series of studies in the other sub-project in the Grossglockner area, from 1974 to 1978, included both regional-level research and studies with quite limited spatial scales, particularly at the Wallackhaus (2,300-2,500 m) and the forefield of the Pasterze glacier (2,000-2,400 m). The research resulted in two reports. The first consists of 14 papers describing the overall environment (climatology, soils, vegetation); soil chemistry and its dynamics; and the water economy of meadows at and above timberline (Franz, 1980). The second includes 14 papers on soil zoology and the ecology of soil micro-organisms (Franz, 1981).

Other products of the first series of regional studies were a report on the climatology of the region, based particularly on research from 1974 to 1980 (Dobesch, 1983): and a report including maps at scales of 1:5,000 (soils, topography) and 1:25,000 (vegetation) with explanatory text, together with discussions of the use of aerial photography and LANDSAT images (Austrian MAB programme, 1983). Analytical/descriptive research continued in the Grossglockner region until 1981, on small birds (community structure,

territoriality, and human impacts); vegetation complexes and primary productivity of alpine pastures; and the impacts of heavy metal and air pollution on vegetation and lichens along the Grossglockner road (Franz, 1985). Since the conclusion of the field research in 1981, work has continued on the integration of its results -- particularly maps -- using geographic information systems (GIS) (Beissmann, 1989).

Gastein (Hohe Tauern)

The thermal mineral waters of the Gastein valley have been the basis for spa-based tourism since 1830. The valley has also been developed for summer and winter tourism, and is now a major ski resort. The development of tourism has been linked to the decline of agriculture and damage to the forests. One reason for the choice of the Gastein valley for MAB-6 research was the extent of ecological impacts deriving from skiing, in contrast with the relatively unchanged Grossglockner area.

MAB-6 projects in the Gastein valley took place on three test sites near timberline (1,800 m): the Stubnerkogel and Schlossalm ski areas, and the Nassfeld area, where summer grazing continues. The first project was conducted in 1977 by the same group that had done process-oriented research in the Grossglockner area. This work considered alpine pastures that had been abandoned, particularly due to the growth of tourism. Most of the work was done on two meadows: one still under management and one that had not been grazed intensively for thirteen years, and had been mown once four years previously. The resulting report includes 26 papers on climate, hydrology, botany (emphasizing primary production and vegetation composition), zoology, soils, microbiology, and landscape changes (particularly in relation to the development of ski slopes) (Cernusca, 1978). This work was continued from 1982 to 1985, focussing on the impacts of downhill skiing on alpine ecosystems (Figure 3). The research was partly designed to complement the work in the Grossglockner area in similar, but relatively undamaged ecosystems (Cernusca, 1989). The results have contributed to guidelines for the management and regulation of, and financial compensation for, the development of ski areas and trails in Austria.
As in the Grossglockner area, analytical/descriptive studies were undertaken in the Gastein area. These studies, from 1977 to 1981, considered the hydrology of a small alpine catchment; soil protozoa and nematodes; vegetation mapping; and changes in forest cover based on palynological research (Franz, 1985). Later research, from 1984 to 1986, considered the impacts of downhill skiing on forest ecosystems (Mayer, 1990). The final report includes ten chapters, beginning with a literature review and a general description of the biophysical environment and development of tourism in the region. Subsequent chapters give a detailed analysis of the ecology and hydrology of the ski runs and surrounding forests, and of damage due to skiing, ski area expansion (runs and

lifts), and animals. The final chapters present a methodology for assessing the environmental impacts of ski runs and its application to the projected expansion of skiing in the Gastein valley.

Sameralm (Salzburg Alps)

The Sameralm region (980-1,702 m) of the Salzburg Alps underwent a major socio-economic change from the 1950s, with conversion from an agricultural to a tourism-based economy. This was linked to a change from intensive dairy farming to the extensive breeding of young animals, and the abandonment of pastures which reverted to forest. Both trends led to increasing soil erosion. The first series of MAB-6 studies took place from 1973 to 1980. The synthesis report (Riedl, 1983) includes ten chapters describing research results: geology and geomorphology (including hydrology); climatology; vegetation; evaluation of the natural potential of major sub-areas; cultural geography; recent socio-economic structural change; recent structural changes in pastoral agriculture - and in regional context; the impacts of socio-economic change on the morphology and soils of pastures; and brief conclusions for economy and landscape management.

A second series of MAB-6 'ecogeographical comparative studies' took place from 1981 to 1983. The final report (Riedl, 1987) includes an introduction and 11 chapters summarizing research on soils; relative humidity; the structure of alpine farming; impacts of tourism on subalpine landscapes; changes in vegetation and soil erosion linked to the expansion of extensive grazing and inadequate pasture maintenance; changes in timberline; and karst caves.

Conclusions

The Austrian MAB-6 projects are notable for their range of methodologies and the varying balance between natural and social science components. The Sameralm project largely consisted of qualitative and descriptive analyses which integrated natural and social science to some extent. The process-orientated and analytical/descriptive studies in the Grossglockner and Gastein areas are essentially collections of studies within a wide range of natural science disciplines. Human beings were treated only as agents of change; an approach that was also followed in the final project in the Gastein area, although this did have strong management implications. The Obergurgl project differed from the others in many ways. It is notable as the first attempt to apply systems modeling for decision-making in a complex mountain environment, and also for the involvement of not only social and natural scientists but also local people and decision-makers in its development. While it is unfortunate that the systems model was never tested because the project ended early, it provided the conceptual basis for many later MAB-6 projects in other countries.

A new MAB project began in Austria in 1992. Its first objective is to use survey data and field research, combined in a geographic information system (GIS), to objectively define the degree of naturalness (Hemorobie) of all of Austria's forest ecosystems, which cover a considerable proportion of the country's mountains. Using scientific analysis and consultation (Delphi technique), this information will be used to develop policy and management (including non-management) approaches in order to maximize the Hemorobie of the forests over the long term (Grabherr et al., 1992; 1994).

SWITZERLAND

The early history of the Swiss MAB-6 programme is described by Freiburghaus and Zimmermann (1984). Work towards the programme began in 1974, when the Federal Office for Environmental Protection established a Swiss National MAB committee and financed a coordinator. In 1975, 350 members of the Swiss Association for Environmental Research were sent questionnaires, to ascertain the extent of basic scientific research and interdisciplinary studies on the relationships between human and natural systems in the Swiss Alps. Eighty questionnaires were returned, providing the basis for identifying potential test areas for research to fulfill the aims of the MAB-6 programme.

In 1976, the National MAB Committee selected four test areas: Aletsch, Davos, Grindelwald, and Pays d'Enhaut. The following criteria were used:

(1) Level of ongoing or completed research relevant to the themes of MAB-6: a high level would provide a stronger basis for interdisciplinary research;

(2) Spatial distribution: representation from the east and west and French- and German-speaking parts of Switzerland, and from the outer and inner Alps;

(3) Accessibility to research institutions: to permit participation by scientists from as wide a range of institutions as possible;

(4) Increasing impacts and conflicts resulting from current land-use and management practices.

The National MAB Committee decided that projects had to be undertaken in an integrated manner and, in 1977, supported a feasibility study in the Grindelwald area. This aimed to define entire and partial systems, identify interactions between the components, and design a digital terrain model and computerized information system. This approach was partly based on the Austrian Obergurgl MAB-6 project.

As with all national research programmes in Switzerland, a multi-disciplinary expert group was established to provide a strong structure for decisions

regarding the objectives, methodology, and financing of research projects. The expert group also appointed a programme leader, an overall coordinator, and coordinators for the research in each test area. The first activity of the expert group and coordinators was to prepare a plan which outlined the objectives of the programme and expected areas of research (Ausführungsplan).

The overall theme of the programme, which began in 1978, was 'socio-economic development and ecological carrying capacity in mountain regions.' Its conceptual framework was based on three principal considerations (Messerli, 1984):
- there are a number of problems common to all Swiss mountain regions, which need to be solved within the specific natural, socio-economic, and cultural contexts of each community;
- the level of decision-making relevant to ecological conditions is local or individual, so that these levels are of greatest importance for integrated mountain management; and
- because the preservation of the natural environment is no longer ensured by adapted agricultural systems, types and intensities of land use have to be defined in relation to ecological constraints and changing socio-economic needs.

This framework was concretized in a model of a regional system, showing local- and regional-level linkages (Figure 4). The intention was to describe and analyze these linkages over recent decades, in order to provide information to:

- achieve a better understanding of relationships between socio-economic development, land-use practices and conditions, and availability of natural resources; and

- attain a better integration of individual problems, and approaches to their solution, within the context of the systems under review.

In each test area, one or two models (computer-based except in the Aletsch area) were used to support interdisciplinary research through the need to operate in a consistent framework and have complementary quantitative data inputs. There was relatively little coordination between the projects in the early field research. However, the degree of coordination increased later on, in order to obtain comparable results at the thematic level and compare the applicability of the results on similar topics from different models. Both during and at the end of the programme, some synthesis took place, with the aim of providing information for decision-making at all levels from individual to national.
The results of the programme have been disseminated through a wide range of scientific and popular publications. Only the major reports and publications are

cited below; a full bibliography may be found in the synthesis book (Messerli, 1989). There were two primary report series: the 27 technical reports (Fachbeiträge zur schweizerischen MAB-Information) and the 38 final reports (Schlussberichte zum schweizerischen MAB-Programme). Another important publication, early in the programme, was an edited book on "The transformation of Swiss mountain regions," published in German and French (Brugger et al., 1984b) and partially translated into English (Brugger et al., 1984a). This was a joint production of the Swiss MAB programme and the national research programme on 'Regional problems in Switzerland.'

Aletsch

The Aletsch test area (6,738 ha; 720-2,926 m) is on the north side of the deeply-cut glacial valley of the Rhone in the Canton of Valais. It includes 11 communes, many of which reach from the valley floor to the alpine zone. The main valley settlements are located where the valley floor is locally widened. The forested slopes are mainly steep and dissected by deep stream valleys. Most of the old permanent settlements are on "sun-slopes" at altitudes from 1,170 to 1,360 m. Above 1,900 m is the flatter Alp (pasture) zone and the tourist resorts of Bettmeralp and Riederalp, which began their development in the early 1950s, after the first cable-cars had been constructed. Since the mid-1950s, the basis of the area's economy has changed from the typical pattern of mountain farming (Messerli et al., 1980) to tourism. A considerable volume of accommodation has been constructed, and about 1.2 million visitor-nights are recorded each year (Mattig and Zeiter, 1984).

The MAB research in the Aletsch area took place from 1979 to 1983. With the exception of Mattig and Zeiter's (1984) research on the socio-economic system, and studies of agriculture (Nachbur, 1983; Staub, 1980) and landscape quality (Adamina, 1982), most of the research considered natural scientific themes, with varying degrees of emphasis on the influences of human activities. These included studies of vegetation and landscape, with particular emphasis on environmental protection (Beguin and Theurillat, 1982, 1987; Meessen and Luder, 1987), ornithology (Renevey, 1984), soils (Krause, 1982; Liniger, 1983), and forests (Bellwald and Graf, 1985). Many of the results of the project were used in the development of the master plan for the resorts of Bettmeralp and Riederalp in the early 1990s.

Davos

The Davos test area (17,130 ha) comprises the commune of Davos in the Canton of Grisons. Davos is the largest tourist resort in the Swiss Alps and an international commercial and conference centre, with around 2.5 million overnight stays a year. Davos and other smaller settlements are located on the flat valley bottom of the main Landwassertal, and there are also small farming

settlements in three side valleys. The sides of the valleys are steep, becoming flatter at c. 2000 m at the edge of the Alp zone. Above this is the rocky alpine zone, with summits up to 3,146 m.

Tourism, initially focusing on health cures, but soon on recreational activities, began in Davos in the 1860s. In the late 19th century, tourism resulted in a change of agricultural emphasis from cattle-breeding and arable farming to more intensive dairying. Even by 1900, employment in agriculture was only slightly more important than in the service sector. Most of the few remaining farmers also work in tourism, which is often their primary source of income. Since the 1950s, when a major period of construction began, winter has been the primary season (Kneubühl, 1987)

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MAB-6 research, which took place from 1981 to 1983, focused on relationships between the natural environment and land use. The framework for research was a grid-based (raster) geographic information system (GIS), with a minimum grid size of 50x50 m. A number of publications deriving from the project consider the biophysical environment and human influences in the test area, with respect to soils (Krause, 1986), forests and their management (Hefti and Bühler, 1986), wildlife and their habitats (Müller et al., 1988), and air quality (Moser, 1985). Other reports describe changes in land use, and nature and landscape protection, in relation to tourism (Günter, 1985; 1987), and the GIS-based simulation model and its application for soils, vegetation, avalanche hazards, and game animals (Binz and Wildi, 1988). An edited report with many maps summarizes all of these studies together with other research undertaken in the project (geomorphology, natural hazards, climate, vegetation), and provides brief recommendations (Wildi and Ewald, 1986).
The results of the research have been used in many ways. First was the establishment of an air-quality monitoring network, after a survey of air quality revealed considerable pollution. Many of the MAB results, particularly recognition of the importance of agriculture in the landscape, were used in the recent master plan for the commune. The GIS, which has now been transferred from a mainframe to a Macintosh micro-computer, has been used in many research projects.

Grindelwald

The Grindelwald test area (25,417 ha) in the Bernese Oberland, contains one main settlement. South of the town of Grindelwald are the steep rock walls of high peaks, culminating with the Jungfrau (4,158 m), and two glaciers which almost reach the valley bottom. The rest of the valley generally has forests on higher-angle slopes up to timberline (c. 1,800 m) and, on lower-angle slopes, fields and pastures up to two passes: the Grosse and Kleine Scheidegg (1,962 and 2,061 m).

Tourism began early in the 19th century, and grew considerably around its end (Figure 5). As early as 1900, about 40% of farmers' earnings came from tourism, and strong links between agriculture and tourism have continued; many farmers, while remaining active in the agricultural cooperatives that have existed since the 15th century, have hotels and small industries. Tourism increased rapidly from the 1950s to the mid-1970s, when overnight stays stabilized around 1 million a year, with a small dominance of summer over winter (Wiesmann, 1986). In spite of major societal changes, the very complex social structure -- involving about 120 groups concerned with agriculture, forestry, and tourism -- has persisted.

Three models were used in the MAB project, which began in 1978. The first of these was a rudimentary GIS, based on polygons with homogeneous characteristics, which provided an overall framework for the research (Steiner and Zamani, 1984). The other models were a system-dynamic model and an input-output model, which were compared during the project (Apel, 1983). Many of the large number of theses and publications emphasize the natural sciences, but give significant consideration to the importance of various resources for human populations: hydrology (Leibundgut, 1987), soils (Scheurer, 1985), climatology and air quality (Coendet, 1979; Kunz, 1983), wildlife (Schiess, 1988), and forests (Kupfer and Langenegger, 1985). Agriculture was a major focus of research, with studies on grassland vegetation and fodder production (Pfister, 1984); history, economic and labour force structure, land use, and effects of tourism (Aegerter, 1983; Naegeli-Oertle, 1986); and a detailed scenario-based evaluation of the availability and use of resources (Scheurer-Lietz, 1989).

As well as a major study on the economic, societal, and spatial aspects of tourism (Wiesmann, 1986), other studies of this sector considered ecological impacts on vegetation and wildlife (Langenegger and von Grünigen, 1983; Stucki, 1984); access and traffic (Hoppler et al., 1985); and the potential environmental impacts of proposals for Winter Olympic Games in Grindelwald, using scenario techniques (Messerli et al., 1986). Other reports considered the different value systems of established residents, recent immigrants, and tourists (Meyrat-Schlee, 1983); and the evaluation of aesthetics, for which a specific methodology was developed during the project and applied to both past and current landscapes of Grindelwald and other parts of Switzerland (Grosjean et al., 1986).

Local interest in, and concern about, the findings of the project was stimulated by research results that showed that tourists would like better public transport facilities, and that local people were wary of the influences of immigrants. Research also showed that agriculture was important for tourism and in

maintaining the socio-cultural identity of the local population; and concern about the risks of the continued construction of tourist facilities, particularly second homes. Local recognition of the value of such findings led to the establishment of a planning group, to try to resolve incompatibilities between goals and develop draft guidelines for planning. Simulation models based on the MAB research were used in this process.

A final summary report of the results of the project and its implications for policy and practice was prepared as a result of this process (Wiesmann, 1988). In 1988, the resulting planning guidelines were developed into a master plan, which was accepted by 90% of the population in a vote in 1988. The GIS data base, was transferred from a mainframe computer to a personal computer, and has been used to update the local development plan and monitor biophysical changes since the MAB fieldwork concluded in 1982.

Pays d'Enhaut

The Pays d'Enhaut test area (18,608 ha) includes three communes in the pre-Alps of the Canton of Vaud. The wide valley floor, with an average altitude of 1,000 m, is surrounded by forests, with alpine pastures above, and mountains rising to 2,540 m. Tourism began in 1903, but collapsed almost totally in the 1930s Depression, with widespread bankruptcies. From this time, the population began to decline, and also to age, as younger people emigrated; trends that intensified in the 1960s with changes in agriculture. However, the area has largely maintained its rural characteristics, and employment in agriculture remains relatively high. Even now, only one-third of employment is in tourism; far less than in the other test areas or the Swiss Alps as a whole.

After a new phase of tourist development, mainly self-catering, began in the late 1960s, local people established a commission. Between 1969 and 1975, this commissioned studies on agro-sylvo-pastoral topics, tourism, and education. In 1975, the three communes created the Association for the Development of the Pays d'Enhaut, which sponsored the work necessary for a regional plan for federal investment assistance. The plan was approved in 1979, when the MAB project also began. It was coordinated by a committee of scientists from the region, with strong connections to a Pays d'Enhaut MAB Association (PEMA), established in 1979, with the objective "to improve the exchange of information between research workers and the population," and to maximize the complementarity of the MAB-6 and regional development projects (Darbellay and Stucki, 1984).

Both linear programming (Fracheboud, 1984) and dynamic balance models (Kyburz and Schmid, 1983) were used during the MAB project. Other research was divided into six themes, for each of which partial syntheses were

prepared: agriculture (DPMPE, 1985a; Mercier et al., 1987), demography and economy (DPMPE, 1985b), forestry (DPMPE, 1988a), land-use planning and nature protection (DPMPE, 1986), society and environment (Lieberherr-Gardiol, 1984), and tourism (DPMPE, 1985c). The results of the partial syntheses were drawn together into a two-volume final report (DPMPE, 1988b) with ten chapters. The first two of these are introductory. They are followed by summary chapters on the natural environment, its use and management, and human impacts; demography and economic activities; an anthropological analysis of relationships between the population and the environment; potential conflicts between land uses and the natural environment; and possible futures, with various scenarios. The three final chapters present the overall methodology, conclusions, and an evaluation of the project. Throughout the MAB project, local people were kept informed of its progress and took part in meetings where simulation models were developed and discussed. Near the end of the synthesis phase, PEMA invited a wide cross-section of local people to meetings which led to the publication of a book on possible futures for the Pays d'Enhaut (Lieberherr-Gardiol and Stucki, 1987). PEMA was disbanded in 1987. In general, the MAB project was instrumental in developing local awareness of the risks of excessive dependence on narrow economic sectors, such as construction or tourism, and conversely in showing the benefits of maintaining a traditional agricultural landscape and a diversified economy. Information obtained during the project is often requested for local decisions and the simulations are still used for teaching.

Thematic studies and syntheses

As well as the reports concentrating on individual test areas, referred to above, a number of thematic reports were published. Some were conceptual, others were based on research in all four test areas, and a few were on themes peripheral to the main MAB-6 programme, such as the environmental impacts of hydro-electric power plants (Aegerter and Messerli, 1981). An important early conceptual report was on ecological stability (Gigon, 1981). This theme was further explored at an international workshop on the stability and instability of mountain ecosystems in 1981 (Messerli and Ives, 1984). It was also the topic of the last technical report, on traditional solutions, current problems, and perspectives for the future of alpine cultural landscapes (Bätzing, 1988).

Most of the other thematic reports provided links from the MAB programme to regional-level issues. These latter included many of the early technical reports, which were integrated into the book edited by Brugger et al. (1984a, b) and will not be mentioned here, and Wanner's (1983) report on social change in peripheral agricultural areas. Spring et al. (1986) also considered changes in agricultural systems, with particular attention to symbioses between agriculture and natural environments. The future of forestry was considered by Combe and Frei (1986), drawing on the experience in the test areas to develop an empirical basis for guidelines for forestry management and policy

throughout the Swiss Alps. This comparative analysis was extended to the international scale in Price's (1990b) assessment of the origins, implementation, and results of forest policies in the Aletsch and Davos test areas and two comparable areas in Colorado, USA.
All of these studies, while focusing on agriculture and forestry, emphasized the importance of integrating tourism into considerations of the future of mountain systems. Two other reports specifically considered this issue: Schwarze et al. (1983), on the relationships between tourism and recreation, on one hand, and agriculture and forestry, on the other; and Müller (1986), on the implications of tourism in mountain communities, with particular attention to the development of tourism policy. In addition, Krippendorf (1986) published a book for the general public, based on the MAB tourism research, entitled 'Alpsegen, Alptraum' (Alpine blessing, nightmare), with the subtitle 'for the development of tourism in harmony with man and nature.' A final policy-oriented report was prepared by Schwarzenbach (1987), who presented guidelines for policies for nature, landscape, and environmental protection in mountain areas.

As well as these reports, the programme coordinator published two syntheses of the overall Swiss MAB-6 programme: a review of findings and conclusions, focusing on models and methods (Messerli, 1986) and a more wide-ranging book, entitled 'Man and nature in the Alpine living-space (Lebensraum): risks, opportunities, and perspectives' (Messerli, 1989). The report on models and methods (Messerli, 1986) contains five chapters. The first provides an introduction to 'system research between pretence and reality.' The second presents the theoretical and conceptual bases of the Swiss MAB programme, covering reductionist, analytic, and holistic approaches from the natural and social sciences. The third discusses the definition of problems at the regional scale; how these may differ from problems defined at larger scales; and presents the Grindelwald and Pays d'Enhaut simulation models, the Davos landscape model, and their results. The fourth discusses the methods and findings of scenarios, with respect to development in Grindelwald and Pays d'Enhaut and land use in Davos. The final chapter provides a summary and conclusions.

The synthesis book (Messerli, 1989) draws on the work in the four test areas, as well as the thematic reports, to provide an evaluation of the results of the programme and its policy implications. Its six chapters are entitled: 'Man in the Alpine living-space, a constant battle to maintain ecological stability'; 'the Alpine cultural landscape, the threatened basis of modern development in mountain regions'; 'tourism and growth since the Second World War: the trigger of the "erosion" of the cultural landscape'; 'the dynamics of the development of tourism, as reflected in the MAB test areas'; 'a new orientation of development strategies in mountainous tourist regions'; and 'a new balance between

agriculture, tourism, and nature'. Figure 6 shows the general model of interactions between the components of these systems. The book concludes with a summary of the main findings of the Swiss MAB programme in point form (in French, German, and Italian) and a complete bibliography of the programme.

Conclusions

In spite of the diverse research approaches and economic and cultural situations in the four test areas, there is significant congruence in the conclusions of the MAB-6 projects. The importance of a traditional agriculture in maintaining not only the Alpine landscape but mountain communities was generally recognized. This recognition has since been incorporated in national policies which stress the importance of mixed agriculture, particularly in relation to medium- and long-term uncertainties of various origins. Other general conclusions were that overdependence on one or two economic sectors -- particularly tourism and construction -- is undesirable, and that qualitative approaches to tourism are preferable for both local communities and visitors. Such findings, stressing the importance of environmental and cultural quality and diversity, have been incorporated into national policies for tourism. The typology of community structures, developed on the basis of the comparison of the four test areas, has been applied across the Alps (Bätzing et al., 1993), and may provide a basis for future work within the scope of the Alpine Convention.

Outside the realm of policy-making, the Swiss MAB-6 projects have led to advances in the theory and practice of man-environment research in other mountain regions. The overall model, developed early in the programme, was incorporated into the framework of the German MAB-6 project in Berchtesgaden and Soviet MAB-6 research in the Caucasus. The Pays d'Enhaut approach, involving local people from the planning stage and throughout the project, was adopted by the Spanish MAB-6 project in the High Catalan Pyrenees. Similarly, the approaches developed in the Aletsch and Grindelwald areas have been applied in other countries. In at least one case, this has led to a realization that some of the Swiss MAB-6 research was inadequate. Thus, research methods to assess the environmental effects of actor groups involved in multiple economic activities, developed in Kenya, are now being applied in Grindelwald by members of the original project team.

GERMANY

MAB-6 research in Germany has comprised one project in the Berchtesgaden Alps of Bavaria. There were four reasons for the choice of this area: the existence of a range of ecosystems, from montane to alpine, with anthropogenic influences varying from minimal to substantial; the wealth of existing information; an existing infrastructure for field research; and the recent establishment (in 1978) of an Alpine Park, which includes both the

National Park (20,780 ha) created in the same year and the 'forefield' to its north (25,820 ha). The Alpine Park and the MAB-6 test region are equivalent; this region was also declared a biosphere reserve in 1990. It ranges in altitude from 470 to 2,713 m.
The legislated objectives of the National Park emphasize the conservation of, and research in, natural systems, and the dissemination of information. Much of the National Park consists of relatively untouched natural ecosystems, but there are a wide range of management issues:

- forest management, including forest decline;
- the ecological and economic aspects of mountain agriculture (which is permitted in some zones of the Park);
- the impacts of summer tourism, especially relating to increased traffic, waste disposal, and cultural and economic aspects; and
- the conservation of the regional landscape.

The forefield includes a number of settlements (population c. 25,000) whose economies are generally dominated by summer tourism, which began in 1888. Tourism grew substantially after the Second World War, with stagnation since the 1980s, except for a brief boom associated with the end of the communist era in eastern Europe. About 80% of the tourist income derives from the summer season. Both agriculture and forestry continue, but are no longer the basis for a viable economy.
In 1978, the Federal Department of Environment asked the Chair for Landscape Ecology at the Technical University of Munich-Weihenstephan (TUMW) to coordinate the preparation of the project. A questionnaire sent to universities throughout Germany led to 66 applications for participation. These led to a feasibility study which was reviewed by federal, Bavarian, and National Park officials, and its authors. They concluded that the proposed multidisciplinary approach would not lead to the level of synthesis important for interdisciplinary ecosystem research.

In 1981, a consulting company (ESRI-Munich), the Chair for Landscape Ecology at TUMW, and the National Park administration developed a new feasibility study. This gave far greater stress to integrative approaches to research (i.e., interdisciplinarity, rather than multi-disciplinarity), and recognized that the availability of information suitable for model development was critical in defining the relative importance of research activities (d'Oleire-Oltmanns, 1985). The project was to be problem-orientated, emphasizing the development of applied, interdisciplinary methodologies. In addition, the study stressed that both strong coordination, for research within a well-defined framework, and central, open data management were essential.

Project activities

The project was divided into four phases over 11 years (1981-1991). In the preliminary phase, only a few months long, the plausibility of planned approaches was evaluated through research in a small portion of the project area (the Jenner) characterized by a high density of data from various disciplines. The second phase, in 1982, involved the establishment of a management framework by ESRI-Munich, and the evaluation, processing, and storage of available information in the geographical information system (GIS) developed throughout the project. It also included the first model runs, in order to establish where essential data were lacking and to identify possibilities for developments in system theory. The studies begun on the Jenner in 1981 were extended to include simulation modeling. Two reports summarize this initial phase, whose objective was to identify the optimal data and methods required for answering specific applied questions. The first report covers aims, problem formulations, and methods (German National Committee, 1983a). The second describes scenarios of forest decline and their evaluation; alpine pasture management, in particular the influence of human activities on vegetation and insects, and the socio-economic implications of changed management; and summer tourism, in particular its effects on alpine ecosystems and their fauna, and aesthetic-psychological research for the assessment of changes in use. A final chapter describes the sources of data and their processing and evaluation (German National Committee, 1983b).

The principal phase of research ran from 1983 to 1988, with three major objectives (Ashdown et al., 1988):

- to solve current ecological problems concerning land use in high mountain ecosystems, using data analysis to avoid problems associated with exceeding carrying capacity;

- to validate the data and results in real situations in order to improve the plausibility and transferability of the methods; and

- to ensure transferability of the techniques to solve problems in other high mountain ecosystems.

The project was based on geographical theories of landscape ecology (cf. Haber, 1990) and the systems approach developed in the Swiss MAB-6 programme (Figures 7 and 8). The best sources for information on these conceptual bases are the summary report (Kerner et al., 1991) and Ashdown and Schaller's (1990) report on the development of the Berchtesgaden GIS: an integral part of the project. These methodological products are among the project's most important results.

Research within the project considered both the whole project area (National

Park and forefield) and, in greater detail, four test areas covering about 20% of the area, each with a range of different land use types.

These were:

- Jenner (3,292 ha; 603-2,350 m): a montane-alpine area on the boundary between the National Park and the forefield, with a substantial tourist pressure, where impacts of summer and winter tourism, as well as alpine and forest grazing and agricultural problems, were studied;

- Funtensee (470 ha:; 1,601-2,158 m): a high alpine area in the National Park dominated by abandoned pastures, where the effects of low-impact tourism were studied;
- Ramsau (2,671 ha; 670-2,607 m): an entire valley system centred on the tourist village of Ramsau, on the boundary between the National Park and the forefield, with many farms, where research concentrated particularly on socio-economic issues; and
- Untersberg (1,228 m; 719-1,972 m): a largely unmodified catchment in a massif on the northern edge of the forefield, where the relatively pristine montane forests and large, unmanaged former pastures (i.e., declining alpine grazing), were studied.

In addition to the research conducted according to the overall plan for the principal phase, three special studies were conducted. Their purpose, as with the scenario-based studies of the initial phase, was to use existing data to test the methods in their current state of evolution. The first special study, completed in 1987, considered the impacts of summer tourism on vegetation, extending the initial study on the Jenner. In this study, field research was linked to information in the GIS to evaluate critical factors determining the sensitivity of different areas to trampling. This predictive model was then tested in the Funtensee area and extrapolated to the entire National Park. The resulting maps and other knowledge were used to develop proposals for monitoring and management (Spandau, 1988).

The second special study was an opportunity to apply the methodologies to a real situation: the possible environmental and socio-economic effects of a Winter Olympic Games in Berchtesgaden (Haber, 1986). The study was undertaken in 1985-86, and would have continued longer, but the International Olympic Committee rejected Berchtesgaden's bid for the Games in the first round. Four variants of development were considered through scenario building:

- No Olympic Games: a null hypothesis for comparison;

- "Soft" Olympic Games: no new ski runs, maximum use of existing facilities;

- Wider planning: new ski runs, but with development integrated into the wider region;

- "Hard" Olympic Games: unrestricted development on the Jenner, making Berchtesgaden a leading winter sports centre.

Figure 9 compares some of the projected effects of the "soft" and "hard" scenarios.

The study involved both the project scientists and local people, who participated in multi-day workshops at which the study was explained, information sought and, later, results presented. The project team used the integrated approaches to provide an objective analysis of the potential positive and negative impacts of the Games. The conclusions, which were widely disseminated and utilized, found that the Olympic Games would have few especially negative or positive effects. Long-term planning and the promotion of the existing attractions of the Park -- its environment, culture, and individuality -- were the best approaches for the future. This meant an emphasis towards small, rather than large, hotels which were both more desirable to tourists and could provide more local employment. The critical limitations of the traffic infrastructure were also underlined.
A later special study (1989-90) used integrated research, scenario construction, and workshops to consider the long-term future of agriculture in the region. However, this study had a lesser impact, partly because the results were not disseminated and discussed at a workshop due to decreasing funding in the synthesis phase; but also because it was recognized that external influences, such as international agricultural and economic policies, were critical in determining future patterns (Kerner and Spandau, 1990).

The final activity of the MAB project was a seminar at the end of the four-year synthesis phase in 1991, at which the final report produced by the small group that developed and implemented the project (Kerner et al., 1991) was presented and discussed. This report has four sections: objectives and themes of the project; development of topics and methods; project activities; critical assessment and recommendations. The first three sections include methodologies and summaries of the results of research and case studies. Two major methodological publications also derived from the project. One is a book on the conceptual bases for applied ecosystem research (Tobias, 1991). The other is a report on landscape assessment, based on an environmental-psychological approach to landscape aesthetics (Nohl and Neumann, 1986). This was prepared to provide objective criteria for landscape impact assessment, as required by the federal nature protection law.
Another important publication resulting from the project is the final report of the specialist disciplines (Haber et al., 1990). This begins with brief introductions to the conceptual bases for the project, the project region, and the test areas. Subsequently, results are presented and discussed for each

specialist research group: publicity, botany, limnology, zoology, agriculture, geology/soils, climatology, air pollution, hydrology, technology (land use and settlement), forestry, socioeconomics, tourism, economics, demography, landscape aesthetics, and traffic. The report concludes with a summary of the special studies on the Winter Olympic Games and summer tourism, and a complete bibliography of the project.

Conclusions

The project has had a number of significant results both for the test area and at wider scales. The GIS has proved a functional tool for research, training, and management in the National Park and, to a lesser extent, the forefield. The integrated systems-based scenario approaches proved their worth, particularly in the Winter Olympic Games special study. Nevertheless, the full potential of integrating the GIS, scenario-building, and public workshops in integrated management planning has not yet been realized. This will be partly done during the current development of a master plan for the National Park, which will be integrated with an equivalent plan for the entire biosphere reserve. This presents considerable challenges, as it requires cooperation with local people and officials in this larger area, with a wide range of potential resource conflicts.
The experience gained in Berchtesgaden is being widely applied in biosphere reserves. In Germany, two examples are the recent development of guidelines for the protection, management, and (sustainable) development of biosphere reserves (German National Committee, 1995), and of a general methodology for ecological monitoring. The methods developed in Berchtesgaden have also been used for monitoring and management in other biosphere reserves, not only in mountains -- including Chiang Bai Shan (China) and Mount Carmel (Israel) -- but also in other biomes, such as the Wattenmeer.

SPAIN

MAB-6 research projects in Spain have been undertaken in two areas of the Pyrenees. The first studies began in the 1970s, in western High Aragon. A later project was undertaken in the 1980s in Catalonia.

Western High Aragon

Western High Aragon has been characterized by depopulation since the late 19th century. The remaining villages tend to rely on either seasonal tourism or cattle-breeding. Much high-quality agricultural land has been lost through the construction of both tourist accommodation and dams for hydro-electricity (Chocarro et al., 1990; Garc¡a-Ruiz and Lasanta-Martinez, 1990).
The first two MAB-6 projects in the region effectively began in 1971, continuing work started as part of the IBP, and a third project began in 1976. Two journals -- Pirineos, the journal of the Instituto Pirenaico de Ecologia, and the

Publicaciones del Centro Pirenaico de Biologia Experimental -- are the primary sources of published material concerning these projects. The only significant English-language sources of information are the guide for the 1986 field trip of the Commission on Mountain Geoecology of the International Geographical Union (Puigdef bregas et al., 1986) and a special issue of 'Mountain Research and Development' (Puigdef bregas et al., 1990). Most of the references cited below are major monographs and dissertations. However, while much of the most important work has been published in journals, some (including most dissertations) remains unpublished. There have been no final synthesis reports. The multidisciplinary study of the resources of western High Aragon ran from 1971 to 1984, and considered the entire region: about 3,750 km2, at altitudes from 400 to 2,800 m. Its objective was to provide a comprehensive description of the region's biophysical resources and human history and ecology, as a basis for both education and planning. There was no overall framework of research; the general concept was for scientists from a wide range of natural and social scientific disciplines to prepare monographs that would eventually be synthesized into an overall descriptive monograph. As well as more than 100 scientific papers, major publications deriving from this work concern geology (Puigdef bregas, 1975; Soler-Sampere and Puigdef bregas, 1972), climatology (Creus, 1983; Garc¡a-Ruiz et al., 1986), botany (Balcells, 1976b; Villar, 1980; 1982), zoology (Martinez-Rica, 1979a, b; Palanca, 1987; Pedrocchi, 1987), and human ecology and land use in both historical and current perspectives (Balcells, 1976a, 1984; Garc¡a-Ruiz, 1976). Many of the latter reports implicated the results of the other two projects, described below, and another report (Anglada et al., 1980) drew on the experiences of the project to propose policies for the management of mountain resources.

The project on the pine forests began in 1971. It focused on 60,000 ha of forests at altitudes from 600 to 2,000 m, with particular emphasis on two forests south-west of Jaca: El Boalar (950 m) and San Juan de la Peña (1,230 m). Fieldwork finished by 1982, and was briefly summarized, with a bibliography that also includes studies from the previous project, by Balcells (1983). Most of the major results of the research are in unpublished doctoral dissertations; over 40 papers also resulted, but much of the work has never been published. There were five themes of research. The first was the development of a typology of the pine forests, according to species, primary production, climatic regime, and forest structure (Puigdef bregas, 1981). The second theme was prehistoric, historical, and current human impacts on the forests. The third focused on primary production and biogeochemical cycling in typical forests, with research on the demography of 23 forests, the distribution of organic matter, nutrient distribution and cycling (Alvera, 1990), and studies of foliage. The fourth theme considered the influences of primary and secondary consumers at San Juan de la Peña, with research on small mammals, boars, birds, epigean invertebrates (Pedrocchi et al., 1985), and lepidoptera, which are frequent defoliators. The final theme concerned processes of decomposition (Franch, 1985).

The project on ecosystems which are utilized seasonally by large herbivores began in 1976. It considered an area of c. 17,000 km2 across the Pyrenees, at altitudes from 400 to 3,150 m. Specific study sites included the Puertos de Goriz (4,800 ha) of Ordesa and Monte Perdido National Park and the Puerto de Aisa (1,300 ha, 1,600-2,650 m) in the headwaters of the Aisa valley. Both transhumant livestock (cattle, goats, horses, and sheep) and wild herbivores (mainly chamois and grasshoppers) were studied. The overall objective of the project was to develop models of the traditional modes of exploitation and their evolution in response to external influences, particularly in relation to current and accelerating processes of socio-economic change, in order to project the future for the study areas (Figure 10).

Field research included studies of the influences of grazing animals on production systems with different botanical and topographic characteristics; interactions between consumers; relationships between abiotic and biotic factors with regard to grazing by livestock and wild herbivores; anatomic and ecophysiological studies of large herbivores; catalogues of parasites; and studies of characteristic ecological complexes. In later years, the research increasingly concentrated on the valley pastures near villages, which are an essential component of the grazing economy.

The majority of the research was prepared as doctoral dissertations (e.g., Chocarro, 1990; Fillat, 1980; Garcia-Gonzalez, 1987; G¢mez, 1989) or published in various journals and proceedings of conferences. While no synthesis has been made, significant parts of the research have been summarized in papers (e.g., Chocarro et al., 1987, 1990; Garc¡a-Gonz lez et al., 1990; Montserrat and Fillat, 1990). The project effectively ended in the early 1990s, when research on its themes received financial support from various national sources and through programmes supported by the European Communities. Thus, the work continues in the Pyrenees of High Aragon, particularly in the Aisa and Broto valleys (partly in the Ordesa and Monte Perdido National Park), often in collaboration with French scientists.

High Catalan Pyrenees

The High Catalan Pyrenees project began in 1985 in the districts of Urgellet and Barid... around the town of La Seu d'Urgell. The 1,097 km2 project area includes over 140 other small settlements in 14 municipalities. In recent decades, the area has been characterized by many of the typical problems of the Spanish mountains: a change from subsistence to market-oriented agriculture linked to the abandonment of pastures, fields, and villages; rural depopulation; and an inadequate physical infrastructure. However, the area has two atypical characteristics. The first is the long existence of an

agricultural economy based on the raising of cattle for milk and beef. A second, unique, characteristic is the presence of the principality of Andorra to the north. Consequently, smuggling has long been important in the economy and, in recent years, many local people have found work in the service and construction sectors of Andorra, which also provides an important market for food.

The origins of the project can be traced back to the foundation of the Grups de l'Alt Pirineu (Group for the High Pyrenees: GAP), a lobbying organization for the preservation and promotion of the mountains, in 1977. In the late 1970s and early 1980s, members of GAP and geographers from the Autonomous University of Barcelona (AUB) prepared a number of studies on the Catalan Pyrenees (Campillo et al., 1985). In 1983, members of GAP took part in the MAB-6 workshop in Ch*f*teau d'Oex, Switzerland, decided that the approach developed there would be appropriate for the Catalan Pyrenees, and submitted a proposal for a MAB-6 project to the Ministry for Public Works and Urbanization. After the Ministry approved funds for the project in 1985, the project coordinators asked for, and obtained, formal endorsement for the project from the National MAB Committee.

The project had two coordinators, one from GAP and a geographer from AUB, and received institutional support from the administration of La Seu d'Urgell, which established a secretariat with two full-time positions. The objectives of the project, which ran from 1985 to 1989, were to develop an understanding of the state -- and past history -- of the region through a series of linked studies, in order to propose solutions for specific problems and develop a regional development plan. To assist with these objectives, the spatial data were compiled in a GIS. The results of the project were published as a series of 18 reports; in a special issue (no. 12, 1988) of Documents d'An...lisi Geogr...fica, published by the Department of Geography at AUB; and in a short final report (Campillo et al., 1993). In addition, the conclusions of the studies were publicized through a newsletter, distributed throughout the study area.

The reports can be divided into four groups: background, demography, land use (forestry and agriculture), and infrastructure. The background reports include a general description of the biophysical characteristics, population, and economic activities of the area (Campillo et al., 1985) and extracts from historical documents from 1519 to 1925 (Campillo and Sanclimens, 1986). Two reports consider the demography of the area (Figure 11). Campillo et al. (1987) described the population and employment structure from 1950 to 1986, with projections to 2000, and considered commuting and second homes. Villar¢ and Campillo (1988) studied rural depopulation.

Nearly half of the reports are on land use. A historical study (Martinez, 1988) considers changes in land use from 1957 to 1987. Maza and Aspinach (1987) prepared a study of the forests, which cover 90 percent of the project area, examining forest functions, structure, ownership, and management, as well as

forestry policies and markets for forest products. Farrero and Villamuera (1987) presented a methodology for preventing and extinguishing forest fires. A detailed survey of over half the agricultural enterprises (Alcala and Nunes, 1988) provided data for the four following studies. Mill and Valls (1988a, b) produced agricultural censuses and economic cost-benefit analyses for the municipalities. Tulla (1988) studied the structure and transformation of agriculture, and developed a typology of enterprises. Finally, Sanclimens et al. (1986a) described the agricultural policies of the European Communities, but with little discussion of their implications for the study area.

The studies on infrastructure consider transportation, telephones, energy, tourism, and municipal services. Gurrera et al. (1987) undertook a multi-criteria analysis of the road network. Gurrera (1988) described the public transport system in relation to the existing and projected population and infrastructure, and made recommendations for improvement. Similar studies consider the telephone network (Samclimens et al., 1986b) and energy, with particular attention to renewable energy (Corominas and Puig, 1988). The study on tourism (Sanclimens et al., 1987) focuses on cross-country skiing, accommodation, and other potential natural and cultural tourist attractions, and presents recommendations for the future of tourism in the area. Finally, Mateu (1988) assessed the legal and administrative services of the area's small municipalities.

A brief review of the programme (Ganyet and Tulla, 1988) notes that dramatic changes in land use and demography are the most visible expressions of the destruction of socio-economic and cultural structures. While they conclude that a specific policy for the Catalan Pyrenees is required, they note that the implementation of the proposals in the reports, which stress the need for a multi-sectoral economy and an adequate infrastructure, require the active participation of local institutions and people.
A number of actions, often implemented by individuals who participated in the MAB project, have taken place since it ended; though it cannot be said unequivocally that they result from it. First, some of the proposals on the telephone and road networks have been implemented. Second, the Ministry of Culture has funded a project on the development of multi-sectoral economies in the area, and the five-year regional plans have drawn heavily on the results of the MAB-6 project. In addition, two existing initiatives whose value was pointed out by the project have been expanded: a cooperative of the cross-country ski areas and the town of La Seu d'Urgell, to coordinate the development of tourism and promote it; and a multi-sectoral economy in the valley of Tuixén, which has stemmed depopulation. The fact that more recommendations were not implemented derives, at least partly, from the different political orientations of the local administration and the Catalan government during and since the MAB-6 project.

FRANCE

MAB research activities have taken place in most of the principal mountain areas of France. There are four French biosphere reserves which may be described as mountainous. However, research in only one of these is presented in detail below: the Cévennes, established in 1985, with an area of 323,000 ha. Research on Mont Ventoux, designated in 1990 (69,956 ha) has so far been confined to disciplinary studies in the fields of botany, entomology, herpetology, hydrogeology, ornithology, and silviculture. Although the Vosges du Nord biosphere reserve, designated in 1988 (124,000 ha) is quite mountainous, its maximum altitude is 580 m, so that research in the reserve is not included in this review. No research has been conducted in the mountainous part of the Vallée de Fango biosphere reserve, in Corsica, first designated in 1977 and revised in 1990 (23,400 ha). Details of activities in all biosphere reserves may be found in recent reports of the National MAB Committee. These have been published biennially since 1984 (French National Committee, 1984-1994), and also give general descriptions of recent, ongoing, and planned research, together with bibliographies of publications produced within MAB research projects.

Alps

The first MAB project began in 1974 in the Briançonnais, on the Col du Lautaret and the Vallée de la Guisane below it. This region was chosen because it was characterized by most of a range of desired criteria (Guet, 1974):

- a representative range of the development of human activities, of which some strongly affect the ecology and/or economy of the region;

- the possibility to expeditiously undertake research -- based where possible on existing knowledge -- which could be used to define operational management strategies for development;

- the local or nearby availability of research institutions already undertaking similar research; and

- a favourable local institutional climate for undertaking research and acting upon its conclusions.

The Briançonnais research programme ended in 1980. The primary synthesis report was published in 1981 (Dollfus, 1981), and a summary can also be found

in the proceedings of the 1981 Vallouise symposium (Ministère de l'Environnement, 1985). The 1981 report has five sections: an introduction, including a regional description and an overall summary; the vegetation and climate of the Vallée de la Guisane; aspects of local societal evolution in the Vallée de la Guisane, discussing pastoralism and tourism; the high-altitude pastoral ecosystem; an integrated study of the biophysical and pastoral functioning of the Lautaret-Galibier pastures.

The second research programme began in the canton of Aime (Savoie) in 1981 and concluded in 1984, as an anticipated second phase never took place. The results of the programme, on the management of high mountains and environmental consequences, were published in 1985 (Gensac, 1985). The report begins with a general description of the physical and human characteristics of the area, which includes part of the Vanoise National Park. Subsequent chapters consider: the use of pastures for grazing, and the decrease in this use; the forests, their dynamics and management; water resources; slope and soil stability, particularly on abandoned terraces; aspects of the natural heritage; and environmental economics. Figure 12 compares the area in 1960 and 1980, i.e., before and after the development of the local ski area.

Inter-park programme (Alps, Pyrenees, Corsica, Vercors)

From 1984 to 1988, a research programme on high-altitude rangelands (formations paturées d'altitudes) was undertaken in Mercantour National Park (Maritime Alps), the West Pyrenees National Park, and the Regional Natural Parks of Corsica and Vercors (pre-Alps). The synthesis of results continued through 1990, and resulted in the publication of a summary booklet (Fischesser and Dubost, 1990). Both this booklet and the 1988 and 1990 biennial MAB reports (French National Committee, 1988; 1990) list documents produced during the research phase.

With the general objective of developing better knowledge for the management of high-altitude rangelands, the programme considered two major themes: the evolution of high-altitude rangelands, and interactions between wild and domesticated ungulates. Research projects were as follows: - Mercantour: strategies of managing wild and domesticated ungulates to maintain an equilibrium in high-altitude rangelands; effects of declining agriculture and pastoralism on the dynamics of larch forests, and on pastoral, animal, and landscape resources;

- West Pyrenees: comparison of the historical, ergonomic, and socio-economic evolution of production systems in the summer pastures of two valleys; spatial

and pathological relationships between wild and domestic ungulates; impacts of tourism on chamois;
- Corsica: comparison of ecological management strategies for pastures to replace burning; improved management of maquis to provide autumn and winter pasture; scenarios for landscape evolution;

- Vercors: impacts of agro-pastoralism and tourism on the dynamics of wild ungulates; interactions of wild and domesticated sheep; integrated studies for management.

Pre-Alps

MAB research in the pre-Alps has focused on the Vallée des Duyes in the Mediterranean pre-Alps of Digne. The objectives of the first five-year phase (1984-88) were:
- the development of production systems linking sheep-raising, diversified plant production (productions végétales diversifiées), and the improvement of forest resources; and- pastoral management ensuring the improvement of forage on grazing land and oak copses. A first synthesis report was published in 1989 (Msika and Hubert, 1989). After an introduction which presents the history and general methodology of the research, the report includes three major sections. The first considers the farming operations of the area, both in a historical context and with regard to current agronomy, livestock-raising, pasture, and land use. The second describes crop and animal production and the management of different types of forage. The third outlines the agricultural system of the region with reference to population, agriculture, the evolution of silvo-pastoral systems from the 19th century to 1939, and land use and resource management strategies in the valley.

Research continues on the dynamics and interfaces between social and ecological systems, with a focus on the realignment of agricultural activities in rural areas facing new agricultural and environmental policies (French National Committee, 1994). Research in 1990-91 focused on: the use of forage and pastoral resources by sheep; hunting wild boar; implementation of a plan for removal of brush and forestry; landscape structures; the historical evolution of a commune; and disposal of agricultural property and assets. Research in 1992-94 involved the development of a research programme on crop systems; studies of landscape changes; and the modeling of relationships between herds of sheep and their use of different areas. Future work (until 1997) will concentrate on improving understanding of the relationships between different activity systems and the evolution of landscape structure; and the operational modeling of grazing land use decisions.

Massif Central

MAB research in the Massif Central has concentrated on the southeastern Causses and Cévennes massifs. These have similar orographic and mesoclimatic characteristics, but different geologies, human histories, and uses of renewable resources. The initial research in this area was a five-year project, which began in 1981 in the Causse Méjan and the Massif de l'Aigoual-Lingas and concluded in 1986. A second phase began in 1987. This has included the preparation of syntheses of the work done to date and increasing involvement with management-orientated programmes in the region, particularly in the Cévennes biosphere reserve.

The objective of the project has been to establish the scientific foundations for an 'Observatory of ecological, social, and economic changes,' emphasizing the factors and processes of change which influence the development of natural and altered environments, with respect to societal practices and their appropriate evolution. The 1981-86 project began with a phase of descriptive research, which was followed by experiments and surveys of local decision-makers. It has resulted in many publications and theses, a traveling exhibition entitled "To be a farmer on a Causse [limestone plateau]: Le Méjan" (Observatoire Causses-Cévennes, 1988), and two summary reports published within the series 'Annales du parc national des Cévennes.' The first summary report considers Le Méjan (Observatoire Causses-Cévennes, 1989). It contains an introduction, eight major papers, a conclusion, and a bibliography. The papers consider sheep raising, land clearing and associated risks of erosion, the management and quality of pastures, and the characteristics of local society. The second report, on the Aigoual-Lingas massif, has the same structure (Observatoire Causses-Cévennes, 1992). The nine papers consider the heterogeneity of settlement and land use patterns; changes in patterns of grazing; the physical geography and human uses of the massif; the interactions of agro-pastoralism and erosion; soils, especially for forestry; contrasts in forestry management practices; the evolution of agricultural landscapes and their potential for grazing (Figures 13 and 14); and the protection of nature and agriculture in the National Park. By the end of 1992, a first version of the observatory's baseline database had been achieved. With the intention of assisting ecological management and local development in the region, the database will be used for monitoring forested areas and their use, grazing systems, systems of rural enterprise, and rural society.

In 1993-94, work related to the observatory continued in three directions: discussions with local and regional decision-makers with regard to scenarios of agricultural evolution for Le Méjan; development of a relational database; and conceptualization of a structure for the long-term functioning of the observatory. This work was partially summarized in a seminar in October 1993; the proceedings will be published in a special issue of the Bulletin de la Société Languedocienne de Géographie (French National Committee, 1994). In

addition, a new project began on Le Méjan in 1993, to be completed in 1996. This focuses on the co-evolution and interactions of pastoral practices and vegetation, especially the expansion of brush and forests (Observatoire Causses-Cévennes, 1995).

Two additional projects began in 1991, building on other research conducted in the Cévennes biosphere reserve since 1981, and intensified since 1988. The first of the new projects was for four years (1990-94), in three experimental watersheds, each with a different vegetation cover, on Mont Lozère in the north of the biosphere reserve. This integrated multi-disciplinary study included work in climatology, hydrology, geomorphology, erosion, pedology, hydrochemistry, and biogeochemical cycling. The main focus was on the effects of atmospheric pollution (especially of sulphur compounds) on ecosystem functioning, including the establishment of hydrochemical budgets, and the identification, comparison, and modeling of processes (French National Committee, 1994). The second project (1991-93) was a case study of the sustainable development of marginal areas in the Cévennes, focusing on chestnut groves, coppices, and forests. Topics of research include the study of biological diversity in relation to different management regimes, socio-economic studies to identify dominant modes of functioning of agricultural enterprises, assessment of the transferability of results, the study of alternative forest management regimes, and the impact of large game animals on forest regeneration (French National Committee, 1992).

Conclusions

MAB projects have been taking place in the mountains of France almost since the beginning of the MAB programme. While all of these projects have been developed and organized by national government bodies and universities, the MAB programme has played an important catalytic role in providing an extra degree of support to projects involving scientists from a wide range of institutions and disciplines. In general, there has been a strong emphasis on descriptive research in the projects, and few have been particularly interdisciplinary. Since the mid-1980s, the projects have tended to become more directly applicable to resource management, and to involve local people to a greater extent; a trend that continues in recent and ongoing studies in the Vallée des Duyes and the Causses-Cévennes.

FORMER SOVIET UNION

Since MAB activities in the states of the former Soviet Union took place within the national programme for most of the period under review, this section considers activities within mountain ranges across the former Soviet Union. As discussed below, some coordination of activities continues within a number of the states of the Commonwealth of Independent States.

Activities before 1985

Early MAB-6 activities primarily took place in the Caucasus and the mountains of Central Asia (Unesco, 1981). Some of these were site-specific studies on limited themes, while most were long-term comparative studies. Primary sources for early work in the Caucasus are books by local scientists (e.g., Kobakhidze, 1985) and deriving from international field seminars with French and Bulgarian scientists. The first seminar, in 1974, primarily considered natural scientific themes, the one exception being anthropogenic changes in vegetation (Gerasimov et al., 1980). In contrast, the seminar in 1978 gave considerable attention to water resources, industry, agriculture, recreation, and population geography (Gerasimov and Galabov, 1984). Early MAB work in Central Asia is described in the summaries of papers given at a conference on semi-arid and desert mountains, held in Alma-Ata in 1982 (Chupakhin and Kochurov, 1982) and a number of reports (e.g., Mamytov et al., 1982; Mamytov, 1987).

These early studies (i.e., until the mid-1980s) were generally conducted by small groups of scientists working in relative isolation. While these groups often included scientists from a number of disciplines, each tended to work separately, and thus the general extent of multi-disciplinarity was that papers describing research in different disciplines were bound together in reports or books. Thus, while review of annual reports on the status of MAB-6, and plans for the Project until 1985, suggests that the programme was strong, in reality such reports and plans were merely compilations of projects with 'mountain' themes.

Activities from 1985

In 1985, working groups for the coordination of MAB-6 activities were established for six regions: Altai-Sayan, Carpathians-Crimea, Caucasus, Central Asia, Siberia and the Far East, and Urals. These groups were to coordinate work on the following themes (Badenkov, 1987):

- theoretical bases of the development of mountain regions;
- patterns of the formation and development of natural complexes and their components in different altitudinal zones;

- scientific substantiation of rational use of natural resources and nature conservation;
- natural hazards;

- problems caused by the development of agriculture, industry, transport, and different land use systems;

- environmental monitoring;

- recreational use;

- impacts of economic activities and problems of ecological-economic planning;
  - systems of settlement and human ecology.
- The MAB-6 network encompassing the working groups was strengthened by annual meetings and an annual bulletin. In 1986, a new Laboratory of Mountain Geosystems (now International Mountain Laboratory) was established within the Soviet Academy's Institute of Geography, and took over the functions of a MAB-6 Secretariat. The Laboratory's director introduced the concepts of MAB-6, deriving particularly from the Swiss MAB-6 programme and also from contacts with the Institut de Géographie Alpine in Grenoble, to other Soviet scientists. As a result, research by scientists of different disciplines -- primarily human and physical geographers, but also biologists and economists, among others -- began to be integrated to some extent although, as before, many 'MAB-6' research activities were only labeled as such; i.e., their conceptual basis was rarely, if at all, interdisciplinary or integrated.
- Important published sources for information about projects within the scope of MAB-6 in the former USSR are the annual MAB-6 bulletins (1985 to 1990); a listing of scientific researchers and publications, published in 1987 (Sokolov, 1987); a state-of-knowledge review of MAB-6 in the Soviet Union (Dzhaoshvili et al., 1988); and national MAB newsletters published in 1989, 1990, and 1991. These documents are the source of the remainder of this and the next section of the report if no other source is given.
- In addition to these documents, books and publications deriving from conferences bring together the findings of research by scientists working in mountains across the former Soviet Union. From a conceptual viewpoint, one important product of MAB-6 research is the book "People and mountains" (Avakyan, 1989). The books edited by Zaionchovskaya and Polan (1988) and Akhaminov and Polan (1990) are collections of papers based on MAB-6 research on economic development and settlement in mountains. The majority of papers in both books consider the Caucasus, but a few consider the Carpathians, Kyrgyzstan,

Tajikistan, and the Altai. The papers in Zaionchovskaya and Polan's (1988) book focus primarily on agriculture and the dynamics and distribution of mountain populations. Akhaminov and Polan's (1990) book also considers these themes, together with a wider range of topics, including forestry, nature conservation, recreation, transport, and urban and industrial development.

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A number of conferences permitted scientists working in MAB-6 projects across the USSR to present and discuss their research. The first of these, on ecological and social-economic problems of mountain regions, was in 1986 in Telavi, Georgia. Papers were presented by Soviet and a few foreign scientists on four topics: rational land use, recreation, population distribution, and industrial development. Among the papers presented by Soviet scientists, about one-third considered the Caucasus, while others considered the Carpathians, the northern Siberian mountains, and the Tien Shan, or presented comparisons of the mountain regions of the USSR.

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In October 1989, a major international conference on 'The transformation of mountain environments: regional development and sustainability; consequences for global change' took place in Tsahkadzor, Armenia (Badenkov et al., 1990, 1991). The conference was divided into four sections in which papers were given by Soviet and foreign scientists:

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- theory, methods, models: evolution and progress;

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- implementation of the results of scientific research in practical management: case studies;

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- mountain hazards and human activities; and

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- regional and global problems: space-time scales and relationships, future research orientations.

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In addition, a session was devoted to papers given by Armenian scientists, on problems of mountain regions in their republic. The case studies from the Soviet Union considered all mountain regions, on topics including agriculture, botany, climatology, demography, economics, forestry, natural hazards, nature conservation, pedology, range management, recreation, and water resources.
In addition to these conferences with foreign participants, and annual meetings of the national MAB-6 Secretariat and the heads of the regional working groups, two conferences brought together MAB-6 scientists from across the USSR. At the first, in Barnaul, Siberia in 1989, papers addressed six main themes: hydro-power development and its potential impacts; ecological-economic approaches to the development of

mountain regions; assessment of natural hazards; recreational development; industrial development; and climate and glaciology. The second conference took place in Bishkek, Kyrgyzstan, in 1991. The abstracts of presentations have been published (Osmonov et al., 1991). Four main themes were considered, each in relation to the overall theme of rational land use in mountain regions: geoecology of mountain landscapes; interdisciplinary studies; economic and ecological aspects of land use; and mapping. Most of the papers derived from research in Central Asia, particularly Kyrgyzstan, but there were also many based on research in the other mountain ranges of the USSR. The papers covered a very wide range of topics, including human impacts on flora and fauna, soil erosion and desertification, recreation and its impacts, natural hazards, agricultural development and interactions with other land uses, water resources, nature protection, and environmental monitoring.

Altai-Sayan

MAB-6 activities in the Altai-Sayan have mainly considered climatology, natural hazards, and the use of nival-glacial resources as water sources and for recreation. A conference held in Barnaul in 1985, on the role of nival-glacial forms in the dynamics of mountain systems, provided an initial review of ongoing work and provided the bases for further research. While the conference was attended by scientists from across Russia and Kazakhstan, its emphasis was on the Altai-Sayan. The primary foci of recent research are the analysis of natural hazards and environmental stability in general, and the study of climatological influences on glaciers. Field work has mainly concentrated on the Ob and Katun river basins, especially in relation to the Katun dam, now under construction.

Carpathians-Crimea

Research within the scope of MAB-6 in the Carpathians and Crimea has primarily been undertaken by Ukrainian botanists, forest scientists, zoologists, and pedologists. In addition, some research on nature protection and recreation has been done. The primary emphases of these studies has been:

- forest ecosystems, with emphasis on studies of structure, function, productivity, and the impacts of human activities;

- water resources, with particular consideration of the protective role of forests and the effects of different harvesting regimes;

- nature protection; and

- in the Crimea, the chemical composition of rainfall, and recreation potential and impacts in forests.

While most MAB-6 research in the Carpathians has been done by natural scientists, many of their findings have been integrated with studies by social scientists. The primary result of this integration, undertaken within the interdisciplinary spirit of MAB, is a series of four books edited by members of the Ukrainian Academy of Sciences. Golubets et al. (1988) consider physical geography, forests and their management, agriculture, wildlife, and nature protection. Dolishniy et al. (1988) present a variety of economic topics, including industrial structure and inter-sectoral linkages, demography and employment structure, regional economic development, interactions between economic development and environmental protection, and changes in the quality of life. Goshko et al. (1989) consider ethnography, demography and settlement, industry, transport and other infrastructure, family life, psychology, and art. Slivka et al. (1989) present the history of the region. An important recent initiative in the Eastern Carpathians has been the designation of an international Biosphere Reserve in Slovakia, Poland, and the Ukraine (Stuzica reserve). It is expected that the Stuzica area will be a focus for future MAB-6 activities in the Ukraine, and funds for work in the reserve are part of a project financed by the Global Environment Facilty (GEF). MAB-6 activities in the Carpathians and Crimea are now being coordinated by the Ukrainian National Committee for MAB. Unfortunately, the only information about such activities that was obtained during the preparation of this review is a listing of research themes until 1995 (Ukrainian National Committee, 1989), which shows that research in the fields of study described in the first paragraph continues.

Caucasus

As described above, the Caucasus has been a major focus of MAB-6 activities since they began in the former Soviet Union. In addition to research on a wide range of topics in both natural and social sciences, a number of conferences have been held. When the new coordinated structure for MAB-6 was established in 1985, four major areas of scientific research were identified:

- the formation and function of mountain geosystems;

- regional land use and the protection of natural resources;

- natural hazards and their prevention; and

- social-economic processes.

environment, economy, and population in the Caucasus.' A preliminary report was published in the proceedings of the major 'Earth Transformed' conference, held in the USA in 1987 (Badenkov et al., 1992: Figures 15 and 16), and a final report is almost complete.
Regional MAB-6 meetings in the Caucasus mainly considered work conducted by social scientists. The first conference, on the socio-economic development of mountain regions, took place in Yerevan, Armenia, in 1985 (Vartanian et al., 1985). It focused on the development of agriculture, particularly from an economic perspective. Most papers concerned Armenia, Azerbaijan, and Georgia, while a few described work in central Asia and the Ukraine. A second conference in Yerevan, in 1987, discussed problems associated with mapping the distribution of population in mountain areas. Most participants were from the Caucasus, with a few from Tajikistan. A third meeting, in Dombae, considered the demography of the northern Caucasus.

In addition to the work on agriculture, demography, and economics, social scientists have considered the development, interactions, and impacts of forestry, industry, transport, tourism, and urbanization in the Caucasus. Papers on many of these topics were published in a book edited by Kotlyakov and Yashina (1987), which also includes papers on botany, glaciology, hydrology, micro-climatology, pedology, and zoology. Papers presented at the 1989 international conference in Tsahkadzor provide a later overview of MAB-6 work in the Caucasus. Most of the work based on the physical sciences has been applied, often including collaboration with social scientists. Topics of research, principally in Georgia, have included:

- the water regime and anthropogenic changes in subalpine soils;

- the protection function of forests;

- anthropogenic changes in the biology of water and terrestrial organisms, particularly resulting from heavy metal pollution;

- the productivity of high mountain meadows; and

- multiple uses of forests (i.e., production, protection, and recreation).

Research has also focused on the assessment of natural hazards and their impacts, particularly with respect to central and western Georgia and two specific events: the major rains and snowfalls of winter 1986-87 in the northern Caucasus, and the December 1988 earthquake in Armenia. In the northern Caucasus, water resources have been a major focus of research (Vladimirov, 1991).

Central Asia

MAB-6 research has been conducted in all of the former republics of the USSR in Central Asia. The two main foci have been Tajikistan and Kyrgyzstan, both of which are primarily mountainous. Two conferences have primarily been based on work in Tajikistan. The first was an Indian-Soviet conference on regional development in mountain areas, held in Dushanbe in 1985 (Alam and Kidwai, 1987). Papers from Tajikistan considered agriculture, forestry, land reclamation, nature protection, hydro-electric power development and its environmental impacts, and water resources. A conference in 1988 specifically considered the integrated development of Badakhstan. This is the most south-easterly portion of the Pamirs of Tajikistan, characterized by high population growth rates, limited land for agriculture, and low accessibility, income, education, and energy supplies. In addition to the development-orientated work described at these meetings, other research in Tajikistan has concentrated on geobotany, forestry, anthropogenic changes in meadow ecosystems, and recreation. To date, no summary or synthesis of MAB-6 research in Tajikistan has been prepared.

Research in Kyrgyzstan, particularly the Tien Shan mountains, has considered a wide range of natural and social science topics. The primary published source for this work is the collection of abstracts of papers presented at the conference in Bishkek in 1991 (Osmonov et al., 1991). A number of studies described the glaciers, soils, water resources, and forest and other vegetation communities of Kyrgyzstan. Many of these studies have provided information used both for assessments of anthropogenic impacts and as inputs in land use planning, the focus of the 1991 conference. Research, often involving natural scientists, has also been done on agriculture, the construction of power stations, forestry, and recreation. Unfortunately, no synthesis of the large volume of scientific knowledge deriving from MAB-6 research in Kyrgyzstan has been undertaken, or is planned.

In comparison to Tajikistan and Kyrgyzstan, much less work has been done in the mountains of Uzbekistan, Kazakhstan, and Turkmenistan. However, a book summarizing many aspects of the mountains of Uzbekistan, deriving at least partially from MAB-6 activities, has been published (Jumayev, 1989). This

describes the natural resources of these mountains and their various economic uses -- agriculture, mining, recreation, and tourism -- and discusses problems of socio-economic development. MAB-6 research in Kazakhstan has concentrated on forests, avalanches and, especially, various aspects of soils: including their composition, erosion, water regime, and biota. A few studies have considered geobotany and land use in the mountains of Turkmenistan.

Siberia and the Far East

MAB-6 studies in the many ranges of mountains in Siberia and the Far East have primarily been conducted by natural scientists in the fields of botany (in both tundra and forest ecosystems), geomorphology, glaciology, pedology, and zoology. A few investigations have been more interdisciplinary, considering environmental impact assessment, medical geography, and nature protection. The only MAB meeting to have specifically brought together MAB-6 scientists from Siberia took place in Irkutsk, in 1988. Within the general theme of the influence of human activities on mountain ecosystems, the meeting considered:

- approaches to mapping current and likely future anthropogenic changes in Siberia and the Far East;

- anthropogenic changes in the vegetation of the mountains south of Lake Baikal (Chamar-Daban range);

- stability of the cryogenic landscapes of Yakutia in response to industrial activities; and
- revegetation of land after drainage in the valleys of the Magadan region (Far East).

To date, there has been no summary or synthesis of MAB-6 activities in Siberia and the Far East.

Urals

The only meeting which specifically considered MAB-6 research in the Urals, in relation to the general topic of rational land use in mountain ecosystems, took place in 1986. Botanists, ecologists, foresters, pedologists, and zoologists from the European part of the USSR participated. As the Urals extend across about 15ø of latitude, from the industrialized south almost to the Arctic Circle, MAB-6 activities in each of the different parts have had rather different emphases. However, the establishment of reserves to protect endangered or rare ecosystems and species populations has been an important focus of studies in all parts of the range.

In the southern Urals, research has focused on interactions of human activities -- particularly agriculture, industrial pollution, and recreation -- with meadow vegetation and animals. Both impacts and recovery have been studied. In the central boreal portion, research has concentrated on the formation and development of forest ecosystems, particularly in response to human activities. Work in the northern Urals has included both basic research on mountain meadow flora and fauna (especially rodents) and more applied research on the impacts of human activities on the populations and productivity of these species, many of which are endemic. To date, no synthesis of MAB-6 research in the Urals has been prepared.

CZECH REPUBLIC AND SLOVAKIA

For most of the period under review, the Czech Republic and Slovakia constituted one country: Czechoslovakia. Consequently, most of this section and the conclusions consider MAB within all the mountains of the former Czechoslovakia.

Scientific research in the mountains of the Czech Republic and Slovakia has been associated with MAB within the scope of Project 2 (temperate forests) and Project 8 (Biosphere Reserves), rather than MAB-6. Apart from the lack of a functioning MAB-6 committee to develop projects in specific mountain areas, another reason for the lack of `official' MAB-6 projects was that the two major mountain National Parks (Krkonose [Czech Republic] and High Tatras [Slovakia]) have considerable numbers of permanent scientists, and there is a long tradition of scientific research in these areas, particularly by members of the Czechoslovak and Slovak Academies of Sciences.

None of the first four biosphere reserves designated in Czechoslovakia was in a mountain area. This was a conscious decision of the nominating committee which felt that, given constraints on staffing for scientific research and management, less attention should be given to areas that were already adequately protected as National Parks (Jenik, 1987). The High Tatras and Krkonose National Parks were designated in 1949 and 1963, respectively. Sumava was declared a Protected Landscape Area (PLA) in 1963, and nearly half of this was designated a National Park in 1991, one year after the whole PLA had been designated a biosphere reserve. In the 1990s, the additional value of international recognition for the ecosystems of Krkonose and the High Tatras led to proposals for the designation of bilateral biosphere reserves with their Polish counterparts. These were approved by the MAB-ICC in 1993 (Jen¡k and Price, 1994). Another proposal for a trilateral Polish-Slovak-Ukrainian biosphere reserve in the eastern Carpathians (including the Slovak PLA designated in 1977) was finally approved in 1994. In spite of the lack of `official' MAB-6 projects in the mountains of the Czech Republic and Slovakia, and although the history of biosphere reserves in these mountains is rather short, this review focuses on the scientific research that has been conducted in the four mountain National Parks/biosphere reserves since 1975. This is an

appropriate focus for the review because MAB concepts were a conceptual stimulus to research during this period; and also because future activities in biosphere reserves and proposed networks on Hercynian and Carpathian mountains will build on this work.

Krkonose (Czech Republic)

The Giant Mountains form the highest part of the border between the Czech Republic and Poland. They have a very diverse biota, a reliable and regular snow cover and steep, glaciated scenery. Unfortunately, they have been affected by air pollution from Germany, the Czech Republic, and Poland, which has greatly affected much of the vegetation, most obviously in the highest spruce forests. Major anthropogenic impacts also derive from tourism. The National Park comprises the core zone (8,432 ha) and buffer zone (27,925 ha) of the biosphere reserve. The transition zone, where most of the population of 26,700 live, is 18,430 ha in area (Figure 17).

In relation to their size, the Giant Mountains must be one of the most-researched mountain ranges in the world, with published scientific research since 1607 (Sykora et al., 1983). During the review period, an essential source of scientific documents is the annual collection of scientific papers, Opera Concortica, published since 1964, with English and Russian summaries. Bibliographies of scientific works have been published within this series (e.g., Dvorak and Pilous, 1988), and also as separate documents (e.g., Belochova, 1982).
The majority of scientific research conducted in the Krkonose has been undertaken by natural and physical scientists, with examples from all disciplines and a wide variety of sub-disciplines. A smaller proportion of work has considered subjects such as nature protection, history, ethnography, and tourism. One example of the predominance of natural science is provided by the bibliography in volume 25 of Opera Concortica (Dvorak and Pilous, 1988). This shows that less than ten percent of papers -- published by scientists from both the National Park and the Academy of Sciences -- from 1964 to 1988 were on other subjects. However, there is little evidence of multi- or inter-disciplinary work, particularly conducted jointly by natural and social scientists.

Sumava (Czech Republic)

The low mountains of Sumava (highest peak in the Czech Republic: Plechy, 1,378 m) adjoin the Bohemian Forest in Germany and the Austrian Mühlviertel. This region contains almost 200,000 ha of continuous forests. Although many of the forests have a long history of human use, during the communist era Sumava was a 'frontier security zone', in which forests were left to regenerate without management. There are many rare and endangered plant and animal species in both forests and wetlands, mainly in the core zone (42,224 ha) of the biosphere

reserve. The buffer zone has an area of 68,893 ha, and the transition zone, with a population of 22,900, is 56,000 ha in size.
Post-war scientific research in Sumava was limited until recently by `security' considerations and the consequent constraints of military administrative requirements; and also by lack of cooperation between local administrative authorities until the creation of the National Park in 1991. Consequently, research was restricted to studies conducted by individual scientists who were willing to fulfill the military requirements and by others who undertook routine hydrological and climatological monitoring. Independent research primarily focused on mires and forests, both managed and natural. Since the creation of the biosphere reserve, which is organized according to MAB principles, the amount of scientific research has been increasing, most recently in connection with a GEF project. At present, a MAB pilot project is underway on a development concept for Sumava and adjacent areas in the Bavarian Forest of Germany (including the Bayerischer Wald National Park) and the Mühlviertel region of Upper Austria (German National Committee, 1994).

High Tatras (Slovakia)

The High Tatra massif is the central and highest part of the Tatra National Park (TANAP), which also includes the West and Belianske Tatras. From a biogeographical viewpoint, the Tatras are an 'island' including rare montane and alpine ecosystems with a unique range of plant and animal species. Pastoral agriculture began in the 14th century, and commercial forestry in the 16th century. However, the area remained largely uninhabited until the late 19th century, when the first health and tourist resorts were built. The economy of the area is now based on tourism, with about six million visitors a year in the late 1980s. The core zone (49,633 ha) and the buffer zone (23,744 ha) of the biosphere reserve are in TANAP. The transition zone (39,844 ha) includes all of the tourist settlements.
Scientific research in the High Tatras dates back to the early 18th century (e.g., Koncek, 1974; Pawlowski, 1956). While there is no overall synthesis of scientific work undertaken in the Slovak Tatras, many of the volumes of the annual compilation Zbornik Prac o Tatranskom Narodnom Parku (Treatises concerning the Tatra National Park) have specific themes, including botany, zoology, meteorology and climatology, and anthropogenic influences on ecosystems. This series, which includes English, German, and Russian summaries, has been published since 1957. It has also included a number of bibliographies, of which the most complete was published on the 35th anniversary of the National Park (Marcek, 1984).
During the review period, research in TANAP has been conducted both by members of the Park's research station and other scientists, particularly members of the Slovak Academy of Sciences and Slovak universities, who have published their findings in a wide range of publications. This research has primarily considered natural and biological sciences, although research in archaeology, ethnography, nature protection, and recreation has also taken

place. There has been little, if any, interdisciplinary work, although some may take place within GEF-funded projects. Cooperative research and monitoring activities have been undertaken since 1985 with the adjacent Polish Tatrzanski Park Narodowy, focusing on acid precipitation and its effects on forests. It is anticipated that such cooperative work will increase within the context of the bilateral biosphere reserve.

Eastern Carpathians (Slovakia)

The Eastern Carpathians biosphere reserve is at the junction of Slovakia, Poland, and Ukraine. While the area is mainly covered by beech forests, of which a relatively high proportion has never been managed, the most unusual ecosystems are alpine grasslands (poloninas). The local economy is based on forestry, with some agriculture as well as hunting and fishing, the main activities for which tourists visit this remote area. The Slovak part of the biosphere reserve has a population of 3,700, who live in the transition zone (23,585 ha) of the reserve. The core zone (seven components) and buffer zone have areas of 2,643 ha and 14,373 ha, respectively.

Scientific research has taken place intermittently in this area since the early 19th century. In the inter-war period, a major multidisciplinary project was conducted by Czechoslovak scientists in the Stuzica valley, which is now in Ukraine. After the second world war, silvicultural research was conducted in the forests. Other work in both forests and areas above timberline was conducted by individual scientists, from a number of disciplines. Hadac and Terray (1991) published a major summary of scientific information for the area. More recently, research has been stimulated by GEF funding.

Other mountain areas

In addition to the research described above in the four mountain National Parks/biosphere reserves, some work has been conducted in lower-altitude mountain areas within the scope of MAB, particularly in forest areas within the framework of MAB-2. In the Little Carpathians of Slovakia (maximum altitude: 768 m), members of the Slovak Academy of Sciences conducted a project on soil ecology from the mid-1970s to the mid-1980s. Most of the published report is rather narrow in scope: following two papers on the ecology and forest types are 13 papers on soil fauna (Nosek, 1986). There is no synthesis. Since the mid-1970s, research has also been conducted in the lower mountains of the Czech Republic, by scientists from the Faculty of Forestry at the Agricultural University of Brno. This work has considered the ecological consequences of mechanization and clear-cutting in spruce monocultures in the Bohemian-Moravian uplands, and the ecological impacts of acid precipitation -- and its amelioration by liming -- on forests in the Beskid mountains (Klimo, 1981, 1990; Prax and Raev, 1985).

POLAND

Polish MAB-6 activities began in 1978, with the compilation of syntheses of scientific information on various themes for the Polish Carpathians. Only the compilation on the botany of the Carpathians was ever published (Mirek and Piekos-Mirkowa, 1992a, b; Zemanek, 1992). In 1981, the Polish National Committee published a bibliography of 80 items published from 1960 to 1978, which were regarded as contributing to MAB-6 (Polish National Committee, 1981). The MAB Secretariat's 1981 compilation of MAB-6 research activities also lists seven projects in Poland (Unesco, 1981). All were organized, in various parts of the Carpathians, by scientists in Krakow. Six projects concentrated on the impacts of tourism, reservoirs, and other land uses on mountain environments; all were four- to six-year projects starting in 1976 or 1977. However, while papers on these topics were published, these MAB-6 projects do not appear to have resulted in publications that identify their origins.

In spite of the lack of `official' MAB-6 projects, much scientific research has been done in mountain regions during the MAB programme. Significant amounts of information about the various Carpathian ranges have been published with regard to nature protection (Klimek, 1989) and tourism (Anon, 1989; Zabierowski, 1982). A particular focus for research has been the areas which are now biosphere reserves. Only one of Poland's first four biosphere reserves, created in 1976 and 1977, was in a mountain area: Babia Gora. However, three more were designated in 1992 (Breymeyer et al., 1994). All are joint biosphere reserves, with the Czech Republic (Giant Mountains [Karkonosze]), Slovakia (Tatras), and Slovakia and Ukraine (Bieszczady). The following review briefly describes research conducted in these areas during the course of the MAB programme. This research forms an essential basis for future research in, and management of, these reserves.

Babia Gora

Babia Gora includes the highest peak in the Beskids (Diablaka, 1,725 m), and is mostly covered by forests of many types, from beeches at the lowest altitudes to dwarf pines in the subalpine zone, with a small alpine zone above. Since the declaration of the National Park (1,734 ha) in 1954, forestry and pastoral activities have ceased. It was approved as a biosphere reserve in 1977.

Scientific research in Babia Gora has been conducted since 1804, and the information available by the early 1980s was compiled in 1983 (Zabierowski, 1983). In addition to chapters on all of the major natural and biological science disciplines, this synthesis includes chapters on agriculture, forestry, hunting, tourism, the cultural heritage, policy, and education. During the 1980s, forest areas were the primary focus of research, which emphasized forest succession

and age structure. Another focus has been on the precipitation and accumulation of heavy metals in soils and vegetation. Research on other diverse topics, including phytosociology, entomology, and tourism, has also been undertaken.

Bieszczady

The Bieszczady mountains (highest peak: Tarnica, 1,346 m) are unusual because a subalpine coniferous forest zone does not separate beech forests from subalpine grasslands (poloninas). Most of the Bieszczady is occupied by beech forests, including many virgin stands. In 1973, 5,725 ha of the region were protected as a National Park, which was expanded to 27,064 ha in 1990. The adjacent San Valley and Cisniensko-Wetlinski Landscape Parks (35,835 and 46,025 ha, respectively) were established in 1992. Together, these protected areas form the Polish portion of the Eastern Carpathians biosphere reserve. In spite of the remoteness of the Bieszczady, scientific research has been conducted in the area since the early 19th century, and a bibliography of 1,875 publications until 1975 has been published (Partyka, 1977). Research during the 1970s and 1980s was limited; a few studies by individual scientists considered mammal populations, vegetation succession on poloninas, stream invertebrates, and theoretical considerations for tourism. In 1991, a scientific research station with ten staff was established, and is now developing research and monitoring activities.

Karkonosze

The Polish side of the Giant Mountains (Karkonosze) is similar in many ways to the Czech side (Krkonose) described in the previous chapter. Both air pollution and tourism -- about 2.5 million visitors a year in the late 1980s -- are major management concerns in the forests. In 1959, a National Park (5,564 ha) was established. This has been divided into a core zone (1,117 ha) and a buffer zone (3,864 ha) within the new biosphere reserve. Scientific research has been conducted in the Karkonozse since the 18th century. A major synthesis was published in 1985 (Jahn, 1985), and a bibliography of 3,344 publications from 1945 to 1984 in 1989 (Kuzma, 1989) in the series of Papers of the Karkonosze Scientific Society. This series began in 1973, and more than 50 volumes have been published, including a recent group of papers on the 30th anniversary of the National Park (Konca and Bugaj, 1991).

Climatological data are available from Snieszka, the highest peak (1,603 m), since 1824, and also for other stations. Air quality is measured at 17 sites, and more are planned. Forest ecosystems, particularly above 1,000 m, have been a primary focus of research during the 1980s. These forests have experienced -- and continue to experience -- massive changes deriving from various

combinations of the effects of acid precipitation, windstorms, and insect epidemics. However, in contrast to the Czech side, where many damaged forests have been logged, those on the Polish side have been left for natural processes to take their course.

Research in forests has considered succession (especially after damage by acid precipitation), the survival of tree seedlings, soils, and insects. A major objective of the entomological research is to develop methods of bioindication of damage to ecosystems by acid precipitation. With respect to regeneration, an important focus is the role of mycorrhiza in forest regeneration, particularly for beech, which was largely replaced by spruce plantations during the 19th century, but appears to be more resistant to acid precipitation. Other research has considered vegetation succession, phytosociology, geology, hydrology, and tourism. In the early 1990s, a number of major projects are beginning. One, involving scientists from the Academy of Sciences and institutions in Wroclaw, considers stressed mountain ecosystems. It has four major components: small mammals, vegetation, air pollution, and climate. Others are a GEF project and a joint Czech-German-Polish project on forest biodiversity.

Tatras

The Polish part of the Tatras occupies only a small proportion of the range. Since the mid-19th century, the area has experienced increasing levels of anthropogenic impacts from air pollution and tourism (Figure 18). The tourist resort of Zakopane has 30,000 inhabitants and is visited by about 1.6 million people a year, a significant drop from the 3 million in the 1980s. Most tourists visit in summer, but there is also a winter season. The ski area is within the National Park (21,164 ha), established in 1954. Since then, limited forestry has continued in private forests (6,350 ha) within the Park boundaries. Sheep grazing was eliminated by 1970, but began again in 1981 to a limited extent, after recognition of its cultural value.

Scientific research in the Polish Tatras has a long and rich history since the late 18th century. In addition to the great volume of knowledge deriving from past studies, long-term data sets are available for vegetation and climate. A meteorological station was established in Zakopane in 1911, and high-altitude stations were established at Hala Gasienicowa (1,520 m) in 1913 and Kasprowy Wierch (1,991 m) in 1937. Research has been organized through the local museum since the late 19th century, and by the research stations of the national Meteorological and Hydrological Service (founded in 1911, but closed in 1991), the Polish Academy of Sciences (PAS) Institute of Geography (1948), the PAS Nature Protection Centre (1951), and the National Park (1980).

In 1962, a major monograph, synthesizing all research to date, was published (Szafer, 1962). An updated and greatly expanded synthesis has been prepared, but has not been published due to lack of funds. However, partial syntheses are provided by the special issue of Parki Narodowe i Rezerwaty Przyrody (Vol. 5, No. 1, 1984) for the National Park's 30th anniversary; the Atlas of the National Park, with thematic maps at scales of 1:50,000 and larger (Trafas, 1985); a special issue of 'Mountain Research and Development' (Kotarba, 1992); and the proceedings of a conference in 1993 on 'The endangered nature of the Polish Tatra mountains' (Cichocki, 1993). All of these contain papers deriving primarily from research in a range of natural science disciplines, with a few papers on nature conservation and the impacts of various human activities. One measure of the great depth and volume of scientific research is that 300-400 scientists, working on about 100 projects, have applied each year for permits to the director of the scientific station since the early 1980s. Together with the register of permits kept since 1957, the short reports required for the renewal of permits provide a valuable record of research. In recent years, research has been conducted in probably every natural science field discipline, with perhaps the greatest depth in botany, geology, and geomorphology. Many projects are very long-term; for instance, some current botanical and entomological studies began in the mid-1950s. Most projects are basic natural science research, conducted by scientists for the Academy and universities, in roughly equal numbers, with little involvement from National Park scientists. The smaller number of applied projects directly involves National Park scientists, who undertake both short- and long-term monitoring studies and also initiate and encourage projects of direct relevance for park management. These include studies of the impacts of human activities -- including sheep grazing, skiing, and tourism -- on various ecosystem components. Among the ongoing monitoring studies are two on levels of air pollution and its impacts on conifers at 36 sites, which began in 1985 and are now undertaken in conjunction with similar studies conducted by the scientists of the Slovak Tatra National Park. The amount of trans-border research and monitoring has been increasing since restrictions on travel were lifted in 1989. In addition, a few scientists from other European countries work in the National Park each year. Most of these are basic studies, although some consider applied themes, such as the impacts of acid precipitation.

BULGARIA

The mountains of Bulgaria are remarkable for their large number of biosphere reserves. These were chosen to encompass as much of the great diversity of Bulgaria's mountain ecosystems as possible, and were established in 1977 (Nedialkov, 1986). There are fourteen mountain biosphere reserves:

- two in the Pirin mountains (Alibotouch, Doupki-Djindiritsa);

- four in the Rhodopes (Chervenata Stena, Doupkata, Koupena, Mantaritsa).

- two in the Rila mountains (Marichini Lakes, Parangalitsa);

- five in the Stara Planina (Boatin, Chouprene, Djendema, Steneto, Tsarichina); and
- Bistrichko Branishte on Mount Vitosha;

All of the biosphere reserves are all quite small: from 812 to 6,101 ha. Some have been enlarged in the 1990s, and further increases in size are planned. Most of those in the Pirin, Rila, and Stara Planina are within national parks. All are managed as strict nature reserves, sometimes with a buffer zone in which all activities are strongly controlled. As all MAB research in Bulgaria's mountains has taken place in biosphere reserves, and all but three are in mountain areas, MAB Projects 6 and 8 have generally been treated as one.
In the early 1980s, four meetings brought together scientists working in mountain biosphere reserves and other protected areas in Bulgaria. The first, in 1981 and 1982, were national conferences on biosphere reserves and nature protection. In 1983, an international conference on high-mountain ecosystems was held in Vratsa. The proceedings (Bulgarian National Committee, 1983), have the following sections:
- general ecological problems of mountain ecosystems;

- ecological-economic and settlement problems of mountain ecosystems;
- mountain forests and recreational ecosystems;
- mountain agricultural and meadow ecosystems;
- mountain ecosystems and ecological education.

In 1985, a conference in Blagoevgrad considered 'the conservation of natural areas and the genetic material they contain' (Nedialkov et al., 1985). Most of the papers presented at the two meetings were based on short-term studies, conducted by independent scientists who were not part of interdisciplinary research programmes.
Other than the two sets of proceedings, there are few published sources of information about scientific research in Bulgaria's mountain biosphere reserves. Much of the work conducted by members of the Bulgarian Academy of Sciences (BAS) Institute of Forestry Research has been published in their journal Nauka Zagorata (Forest Science) and in the proceedings of forestry conferences (e.g., Tsankov et al., 1984; Velkov et al., 1988). Some publications are at various stages of preparation, a process which has always been limited by available

funds. Still other studies have been prepared as internal reports for different ministries and government committees, and there are no plans for their publication.

The lack of published scientific findings means that this synthesis of research is drawn largely from extensive discussions with scientists in many institutes and academic and government departments, and the proceedings of the 1983 and 1985 conferences. However, given the general lack of communication and collaboration between -- and even within -- scientific and academic institutions, and the limited time available for this review, the information below is probably not quite complete.

Pirin

The flora of the Pirin Mountains includes over 500 vascular species, many of them endemic. In addition, the forests are extremely productive, and include the oldest trees in Bulgaria. Most research in the Doupki-Djirinditsa reserve has focused on tree growth, nutrient cycling, succession, pathogens, and insect pests in forests. Other ongoing studies consider birds, flora, and vegetation dynamics. In the Alibotouch reserve, research has been limited to studies on the structure and dynamics of the pine forests and floristics.

Rhodopes

Of the four reserves in the Rhodopes, only Doupkata has been the subject of much scientific research, on forest structure and function. A short-term programme on forest genetics, entomology, and pathogens in Scots pine and spruce forests in currently underway. In Chervenata Stena, ornithological research has continued since the mid-1980s. Floristic surveys have been conducted in all reserves in the same period.

Rila

The spruce forests of Parangalitsa reserve are the most productive in Europe. Since 1978, there has been a major research programme on the structure and functioning of these forests. Studies have focused on nutrient uptake and cycling, competition, succession, tree growth, pathogens, insect pests, soil microbiology, meteorology, and hydrology. The results have been published in the proceedings of the 1983 Vratsa and 1985 Blagoevgrad conferences and other international conferences (e.g., Tsankov et al., 1984; Velkov et al., 1988), and also in a book on the water balance of spruce forests (Prax and Raev, 1985). This work continues, and has recently been given impetus by a two-year in-depth project, comparing Parangalitsa with Bistrichto Branishte, Steneto, and Strandja reserves.
Less research has been done in Marichini Lakes reserve, in spite of its floristic

richness. A list of over 500 vascular plant species has been compiled, and research on vegetation dynamics and succession has been conducted.

Stara Planina

A considerable amount of research has been done in the reserves of the Stara Planina, particularly in connection with the development of the Central Balkans national park, established in 1991.

Most of the forests of the Boatin reserve are beech, with spruce at higher elevations. One focus of research has been pedology, microclimatology, tree metabolism, organic matter uptake, and forest succession following canopy opening by severe winds. Since 1978, research has also considered forest composition and changes in vegetation composition resulting from grazing, and the distribution of birds and large mammals. The publication of a synthesis of research in the reserve by the Polish Academy of Sciences' Nature Conservation Research Centre in Krakow is planned.

The Tsarichina reserve has the widest range of ecosystems of any in the Stara Planina, from beech forests at the lowest elevations to subalpine meadows. Research conducted in the reserve from the mid-1970s was compiled in a report with chapters on soils, geology, geomorphology, mammals, birds, flora, ecosystem structure, and tree biomass (Klimek, 1987). Research continues on forest productivity and structure, and on the influence of vegetation on soil evolution.

Less scientific research has been undertaken in the other three reserves. In the Steneto reserve, studies have been done on the structure and processes of the forests. In 1991, work began on the structure and function, and particularly water balance, of spruce forests, as part of a two-year project comparing this reserve with Bistrichko Branishte, Parangalitsa, and Strandja. In addition, ongoing studies consider soils, tree populations, hydrology, and bird and large mammal populations. Similar work is conducted in Djendema reserve. In the Chouprene reserve, research has been done on the genetics of the predominant spruce forests, and surveys of bird species have been undertaken.

Vitosha

In the Bistrichko Branishte reserve, research dating back to the first decades of the century is the foundation of long-term studies of changes in vegetation resulting from recreational use. Research in the spruce forests, conducted since the late 1970s, considers the genetics of tree populations, organic matter accumulation and microflora in soils, meteorology, and groundwater hydrology.

In 1991, work began on the structure and function, and particularly water balance, of spruce forests, as part of a two-year project comparing this reserve with Parangalitsa, Steneto, and Strandja.

CONCLUSIONS

More than two decades after the MAB-6 working group met in Lillehammer, this overview of scientific activities shows that their objectives for the mountains of Europe and the former USSR were only partially realized. Overall, natural science research predominated in MAB projects in these mountains; although in Western Europe, especially France and Spain, there was an increasing emphasis on social science research over the years. Many projects were characterized by difficulties which typically limit the success of applied interdisciplinary research (Price, 1990a; 1995). These included (limited) funding through traditional channels for fundamental research; lack of attention to the development of functional interdisciplinary research frameworks; unwillingness of scientists from different disciplines to work together; and inadequate resources for carrying projects through to the synthesis stage.

In spite of these limitations, MAB activities in the mountains of Europe and the former USSR have made important contributions to scientific knowledge which is useful not only of itself but, in many cases, for the lives of mountain people. This was particularly true of the projects in which local people were directly involved, whether from the planning stage (Pays d'Enhaut, Catalan Pyrenees) or later on, leading into regional planning (Berchtesgaden, Davos, and Grindelwald). In the three latter areas, geographic information systems (GIS), unforeseen in 1973, were of great value in compiling information and then - when linked to simulation models - assisting local people and scientists to interact. These GIS have subsequently been used for research, environmental monitoring, and planning, and the approaches developed in MAB-6 test areas were among the first in a rapidly-growing field (e.g., Price and Heywood, 1994).

The objectives set in Lillehammer emphasized new approaches to the management of ecosystems, and the conceptual models developed successively in Obergurgl, Switzerland, and Berchtesgaden (Figures 1, 4, and 7) - as well as some of the applied research in the French mountains - showed various ways to achieve these at the local scale. The most valuable example of the use of the results of MAB-6 projects at a wider scale is provided by the Swiss MAB programme. This recognized that traditional agriculture is important in maintaining not only the Alpine landscape but also its communities; and that overdependence on one or two economic sectors - especially tourism and construction - is undesirable, so that qualitative approaches to tourism are preferable for both local people and visitors. These findings have been influential in the development of both Swiss national policies and those deriving from the 1991 Alpine Convention, and are widely applicable in

temperate mountain regions.
The MAB-6 projects in Western Europe took place in regions that have experienced huge economic, social, and cultural transformations in the post-War period. In the 1990s, the mountain regions of central and eastern Europe and the former USSR are also undergoing very rapid transformations. In the communist era, it was barely possible to implement the localized, interdisciplinary, applied ideas of MAB-6 in these countries. Today, it is vital for their inhabitants and local scientists and decision-makers to develop new ways of thinking and action. As discussed above, there is substantial knowledge of the ecosystems of the mountain biosphere reserves in these countries. While this knowledge is an important basis for formulating new approaches, understanding of the societal dimensions of biosphere reserves is also essential, so that greater attention should be given to research involving social scientists (Kruse-Graumann et al., 1995). The mountain biosphere reserves of eastern and central Europe, especially those shared between two or more nation states, have the potential to be model areas in which to build on the legacy of MAB-6, in order to further the needs of mountain people in a rapidly changing world.

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Notes to readers

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