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INSTITUTE OF GEOGRAPHY AND SPATIAL ORGANIZATION
POLISH ACADEMY OF SCIENCES

CONFERENCE PAPERS 21

EURO-MAB IV
MOUNTAIN ZONALITY
FACING GLOBAL CHANGE

Edited by
Alicja Breymeyer

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EURO•MAB IV
CONFERENCE 6-11 SEPTEMBER 1993
ZAKOPANE, POLAND

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Preface

The Man and Biosphere (MAB) Program of UNESCO works towards the harmonious co-existence of man and the biosphere.

Responding to the continually-appearing problems experienced in keeping the natural environment in good condition, the Program initiates many actions on the world or regional scales and organizes (or co-organizes) scientific meetings and meetings for experts and managers. The MAB Program has created a network of more than 300 Biosphere Reserves which covers the whole globe and which acts as a kind of model network of protected areas which are at the same time available for use by the local human population.

Many Working Groups and regional organizations operate within UNESCO MAB, and EURO-MAB was established several years ago as just such a regional organization uniting countries throughout the European continent, along with Canada and the United States.

The conference which took place in Zakopane between September 6th and 11th 1993 was composed of two quite distinct parts:

1. EURO-MAB IV. The fourth Meeting of the National MAB Committees of European countries, Canada and the United States. Work in this part of the conference was devoted to information on the studies, reports and plans being worked upon by the Working Groups, as well as discussion of the contacts between the entire EURO-MAB organization and other organizations active in Europe in the field of the environment. The informational documents, resolutions and decisions on the future activities of EURO-MAB, which arose in the course of this part of the Conference, are appended at the end of the present volume. It is worth noting the creation in course of the Zakopane conference of a new Working Group within EURO-MAB entitled “Societal Dimensions of Biosphere Reserves”.

The new EURO-MAB Bureau chosen for the 1993-1995 term has the following makeup:

Chairperson: Alicja Breymeyer (Poland)
Members: Jacques Lecomte (France)
Jorgen Kirkegaard (Denmark)
Vladimir Soldatov (Belarus)
Rapporteur: Michael Morris (UK)

The headquarters to the year 1995 is Warsaw, though it is planned that the Bureau be moved to Denmark following the next EURO-MAB V Conference planned in Copenhagen. The proposal that the EURO-MAB headquarters be transferred to one of the Scandinavian countries for the 1995-1997 term was tabled from the floor of the meeting and the representative of the Danish

MAB Committe accepted it. Following the final adjournment of the EURO-MAB IV Conference, Dr Morris and Dr Breymeyer worked with the representative of the Paris UNESCO-MAB Committee to prepare a precise and fully-inclusive report. The report was printed and distributed to all National Committees in December 1993. The report did not contain materials from the scientific seminar.

2. The Scientific Seminar "Mountain Zonality Facing Global Change", to which specialists in montane ecology were invited. The subject matter of the Seminar was proposed by the undersigned and was linked with the place in which the Conference took place (the Tatra Mountains). Knowledge of mountains also seemed to be of great significance, since it was that they would probably serve as the most convenient and effective places in which to register any climatic changes might occur. The MAB Seminar on this subject represents one of the first steps towards an understanding of the ways in which the living world will react to warming. The papers presented at the Seminar are contained in the present volume.

At the end of the volume we print a Declaration which was prepared by local scientists active in the protection of nature in the Tatra Mountains and accepted unanimously by those participating in the Conference. The Declaration concerns the listing of the Tatra Mountains as one of the UNESCO World Heritage Sites. It would seem to be worthwhile to support the initiative and to make the necessary efforts to ensure that the Tatras do come to be honoured with this highest of titles. The Tatra Mountains are extraordinarily beautiful but very small, and without special protected status they may simply be destroyed under pressure from tourists, sports enthusiasts and businesspeople.

Alicja Breymeyer

SCIENTIFIC SEMINAR

A. Breymeyer (ed.) — EURO-MAB IV.
Mountain zonality facing global change,
Conf. Papers, 21, IGiPZ PAN Warszawa

UNESCO-MAB INTEGRATED MOUNTAIN RESEARCH AND ENVIRONMENTAL CONSERVATION

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Abstract. The author of this paper wishes to reiterate briefly the history of Project Area 6 UNESCO's Programme on Man and the Biosphere (MAB), entitled "Impact of human activities on mountain and tundra ecosystems" which for many years encompassed the various facets of integrated mountain research and also included aspects of environmental conservation. Highlighted in particular are the early days of the mountain part of the MAB Programme and a tentative balance sheet of some 20 years of MAB mountain research presented. The author then seeks to consider some of MAB's possible future orientations with regard to mountain environments. The views expressed in this paper are those of the author and may not necessarily be shared by all members of the UNESCO-MAB Secretariat.

Key words: UNESCO-MAB, Project Area 6, mountain ecosystems, mountain research, socio-cultural significance of mountains.

In early 1973 soon after the official launch of UNESCO's Programme on Man and the Biosphere (MAB), an expert panel for MAB Project Area 6 was convened in Salzburg (Austria) on the recommendation of the first (November 1971) session the MAB International Co-ordinating Council. The panel's task was to elaborate the scientific content of projects to be proposed under the MAB Programme. The expert panel recommended the study of the following problem areas:

(1) Human settlements at high altitude;
(2) The effects of land use alternatives on mountain ecosystems;
(3) The impact of large-scale technology on mountain ecosystems;
(4) The effects of tourism and recreation on mountain ecosystems.

As a complement to these four problem areas, comparative world-wide analyses were also to include studies of the timberline zone, the use and control of fire, the causes of erosion and stability, and the concept of carrying capacities in mountain regions (see UNESCO-MAB Report No. 8, 1973).

A working group session was held in Lillehammer (Norway) in November 1973 to further define the scope, objectives, methodologies and possible outputs of these problem areas (UNESCO-MAB Report No. 14, 1974). This meeting led to a stronger thematic and regional concentration of the problem areas to be studied, which were:

1) Problems of resource development and human settlements in high tropical mountains (i.e. mountains above 2,500 m and situated between approx. 30° of

Lat. N and S) including the tropical Andes, the South Asia mountain complexes, and the East African and "Ethiopian" highlands.

2) Tourism, technology and land use in temperate mountains in mid latitudes (approx. up to the 60° parallel), with distinct winter and summer seasons.

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

In its efforts to harmonize methodologies for comparative reasons, the working group in Lillehammer identified tentative "minimal" research requirements covering both natural sciences (e.g. climatology and soil science) and social and economic sciences (e.g. sociology and economics). Some examples of these are shown in Table 1.

Table 1. Tentative list of "minimal" research measures (excerpts) (see UNESCO-MAB Report No. 14, 1974)

1. Abiotic variables, climatic	
Minimal:	Optional for some purposes (essential for others):
— air temperature	— radiation
— precipitation	— surface soil temperature
— wind velocity	— snow cover and radiation
	— relative humidity
2. Biotic variables	
3. Economic system variables	
— Forms and amounts of taxation	
— Land tenure	
— Market for products	
— Organization of product sales and consumer purchase	
— Control and distribution of capital	
— Legal structure for land use	
— Legal structure for product sales	

Although the variables identified (e.g climatic variables such as air temperature, precipitation and wind velocity) appear rather obvious for mountain studies, the list shows nevertheless that an important effort was made to arrive at an internationally-agreed-upon and harmonized catalogue for carrying out research on mountain ecosystems within the framework of an inter-governmental scientific programme. According to the Lillehammer group, these variables could be used to compare the results of national mountain studies in an international context. Conceptually speaking, the establishment of this catalogue of minimal research requirements was an important step forward in international co-operative research.

Over the years, however, it turned out that the whole list of minimal research requirements was not always considered by the national scientific groups carrying out research under the "MAB banner". This was perhaps due to the fact that although common research topics had been identified (e.g. for the temperate mountains in mid latitudes, the topics of tourism, technology and land use), a common research hypothesis with a common objective was lacking. A common objective could have been, for example, the study of varying resource use and tourism in the context of climate variability and change — an initiative which had been suggested by the MAB Secretariat some time ago, but which never got off the ground due to lack of financial resources.

An overview of the evolution of mountain research over the last quarter century was prepared by Jack Ives and Bruno Messerli and presented in a paper at the "Conference on the Transformation of Mountain Environments" held in Tsakhadzor (Armenia), in October 1989. It is interesting to note that the authors choose the year 1973 as the starting point for their overview, because the first organizational meeting of MAB-6 was held in that year in Salzburg. Ives and Messerli rightly regret that the International Working Group for MAB-6 initiated after the Lillehammer meeting with a view to establishing a programmatic framework for mountain research, faded away because no provision had been made for its continued maintenance. However, the UNESCO/MAB Salzburg and Lillehammer meetings gave an important result as they provided a forum for the creation of an informal group of committed international mountain scholars who kept in close contact over the years.

It is perhaps worth noting that Ives, Jest, Loeffler, and Messerli: the first President and Vice-Presidents of the International Mountain Society — IMS, were all members of the UNESCO MAB-6 "panel of experts" that met at Salzburg in 1973. Thus, the continued work of the IGU Commission on Mountain Geoecology, the progressive expansion of the UNESCO/MAB-6 project, the development of the United Nations University (UNU) project on Highland-Lowland Interactive Systems, and the creation of the IMS and its journal "Mountain Research and Development" have all been closely interconnected, and have involved several of the same individuals in each case. Their initiatives included the foundation in 1989 of the French based International Centre for Alpine Environments (ICALPE) and the formation of the African Mountains Association (AMA) in 1986.

Apart from these efforts for international "institution building" on mountain research, MAB-6 gave rise to a large number of case studies world-wide. The UNESCO-MAB Secretariat has commissioned Martin Price to prepare a synthesis publication on MAB mountain studies in Eastern and Western Europe following a recommendation made by the MAB Council to prepare MAB synthesis on various MAB project areas. In his presentation at this symposium dr Price will focus on MAB mountain research in Europe and I will leave it to him to present some of the case studies.

In looking back at some 20 years of MAB mountain history, it is not easy to account for all the strengths and shortcomings of MAB Project Area 6. And it is made all the more difficult in view of the many actors involved and the fact that the MAB Programme is by its very nature a "decentralized programme" building on the active inputs provided by the MAB National Committees.

On the positive side of a balance sheet of MAB mountain accomplishments, the strengthening of international co-operation among mountain scientists can certainly be attributed to MAB-6. Building on personal contacts established among the participants of the Salzburg and Lillehammer MAB-6 meetings in 1973, MAB-6 has influenced a whole generation of scientific cadres interested in mountain studies, and later their own students. International conferences, seminars and workshops have led to an increased exchange of knowledge on the problems of mountain environments.

Institution building in the wider sense has been another asset of UNESCO/MAB-6. A few of the more prominent examples of institution building are *inter alia*, the creation, under UNESCO's sponsorship, of the Kathmandu-based International Centre for Integrated Mountain Development (ICIMOD) for the Himalayas-Hindu-Kush region, UNESCO-MAB's assistance to the journal *Mountain Research and Development* in its fledgling state, financial support for the preparation of ICALPE's *EuroMAB Mountain Newsletter*, and sponsorship for meetings of the African Mountains Association (AMA).

Another result of MAB-6 efforts is the development of modelling within the framework of MAB-6 case studies trying to elucidate the complex interrelationships of environmental and socio-economic factors and processes in a given mountain ecosystem. In particular, MAB scientists of the alpine region contributed to the methodological and scientific advancement of modelling — whose applications are not restricted to mountains alone.

On the conceptual level, MAB Project Area 6 has — perhaps better than other MAB Project Areas — succeeded in adopting the integrated and interdisciplinary research philosophy of the MAB Programme. In many cases, MAB mountain studies have tried to bridge the gap between the natural and socio-economic sciences. This is perhaps on account of the fact that mountain studies were — and still are — of particular interest to geographers, who due to the nature of their subject are used to working in an interdisciplinary way.

However, one shortcoming in the international MAB co-operation on mountains has been that the scientific literature emanating from MAB work is widely scattered and often rather inaccessible. In many cases, research results have been confined to a national context and have not been as widely distributed as one could have wished for work within the framework of an international research programme such as MAB. It is hoped that the synthesis on MAB mountain studies in Eastern and Western Europe authored by Martin Price will help to fill this gap as will a synthesis of MAB studies on tropical mountain environments (in preparation).

When using the three problem (or study) areas identified during the aforementioned Lillehammer meeting in 1973 as a yardstick to measure the accomplishments of MAB-6, it has to be noted that three problem areas were not tackled at the same intensity. Tourism, technology and land use in the temperate mountains in the mid latitudes received by far the widest attention from the MAB-6 scientific community. Fewer studies exist on Problems of resource development and human settlement in high tropical mountains (notably in Latin America, the Himalayas, and Kenya) and the problem area Land use problems in high-latitude mountain and tundra ecosystems received even less attention under MAB-6 (although, it has to be noted that the creation of the MAB Northern Sciences Network has somewhat remedied this situation).

In the more than 20 years of its existence, MAB Project Area 6 has yielded a wealth of scientific information, and the time is ripe to reflect up on the future development of MAB with regard to mountain environments also. In this context, I wish to recall some of the conclusions and recommendations made by the MAB International Co-ordinating Council at its 12th Session in January 1993.

The 12th MAB Council recommended that the MAB Programme should henceforth concentrate its action around five priority themes, which are:

(1) Conserving biological diversity and ecological processes;

(2) Exploring approaches to land use planning and sustainable management of resources;

(3) Formulating and communicating policy information on the sustainable management of resources and the promotion of environmentally-sound behavior;

(4) Building up human and institutional capacities for land use planning and the sustainable management of resources;

(5) Contributing to the Global Terrestrial Observing System (GTOS).

The MAB Secretariat has recently tried to visualize these five priority themes in a graphic representation (see Figure 1):

The activities under these five priority themes would build upon past MAB experience and would use as far as possible the international network of Biosphere Reserves. Biosphere Reserves lend themselves very well to contributing to the Global Terrestrial Observing System for the study of changing environmental conditions which is the major theme of the present symposium. Biosphere Reserves exist in practically every major ecosystem type including high mountains.

The five priority themes also respond to five of the main concerns of UNCED, namely the United Nations Conference on Environment and Development: biodiversity, sustainable development, information/communication, capacity building/training, and global change. In the light of this the MAB Council concluded *inter alia* that MAB with its interdisciplinary research approach and concern for environmental conservation, is preadapted to respond to the decisions of UNCED. The MAB Programme should serve as a key instrument in the implementation of UNESCO's contribution to UNCED.

This is important in the light of UNCED's Agenda 21, and particularly Chapter 13 entitled "Managing fragile ecosystems: sustainable mountain development". Although one may wish from UNCED's Agenda 21 to be more explicit and concrete in operational terms, Chapter 13 allows for enough flexibility to accommodate various initiatives for ecological research and mountain development for the sake of those living in mountain environments.

The 12th MAB Council also felt that "... MAB, in dealing with land use systems, should concentrate on three major areas of activity concerning humankind's relations with nature:

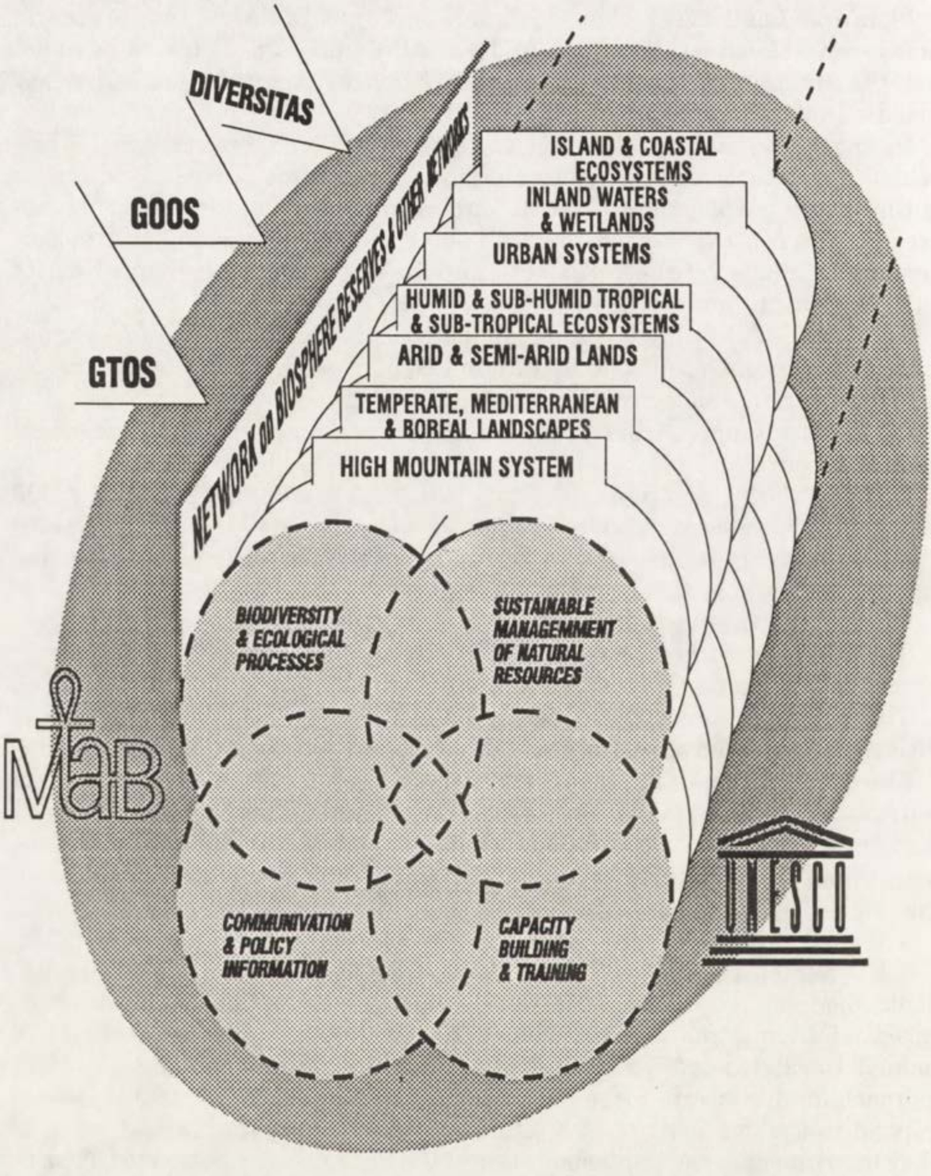

Fig. 1. Conceptual framework and thematic structure of UNESCO's MAB Programme
The interaction of the four priority themes:
Biodiversity and Ecological Processes; Sustainable Management of Natural Resources; Capacity Building; Communication and Information for Decision-makers, is presented with respect to the ecosystems concerned and with respect to the International Biosphere Reserves Network and other networks (e.g. ecotones, marine sites and urban systems).

GTOS: Global Terrestrial Observing System (UNEP-UNESCO-FAO-WMO)
GOOS: Global Ocean Observing System (WMO-UNESCO-IOC)
DIVERSITAS: Biodiversity Programme (IUBS-SCOPE-UNESCO)

a) the conservation and monitoring of biological diversity and ecosystem processes;

b) the sustainable management of natural resources at the ecosystem and landscape levels;

c) the integration of the socio-cultural and ethical dimensions in land development."

These major areas can easily be applied to integrated mountain research: the focus could be on mountains at the landscape level with a view to the conservation and monitoring of biological diversity and ecosystem processes, and the integration of socio-cultural and ethical dimensions into land development. While the first two major areas have been rather well reflected in MAB mountain research in the past, the socio-cultural, and ethical dimension may well be strengthened in the future.

Of course, tourism played a very important role in MAB mountain research with its many socio-economic ramifications and its impact on the environment. But did mountain tourism play an important role in its socio-cultural and ethical dimension? I believe that the socio-cultural significance of mountains has been largely neglected in MAB activities.

In virtually all societies, mountains have a tremendous cultural significance for religious, spiritual or metaphysical reasons. Mt. Olympus (a Biosphere Reserve in Greece) was considered to be the home of the Greek gods. The Changbaishan Mountain Biosphere Reserve in China which borders with the Mount Paekdu Biosphere Reserve of the People's Democratic Republic of Korea, is believed to be the point of origin of the Korean people. The Hawaiian Volcanoes National Park (which is part of the Hawaiian Islands Biosphere Reserve), houses the volcano goddess Pele. Numerous other examples such as the sacred mountains of the Navajo nation in North America could be added to this list. Common to all these sacred mountain areas is the traditional belief in supernatural powers which has helped to protect their environments from human disturbance. The metaphysical significance attributed to mountains involves sacredness, fear, ceremony and mystique and has given these mountain environments a culturally-inherent degree of protection. Inaccessibility, coupled with religious taboos often gives mountain environments outstanding conservation value. It is interesting to note that, in a recent publication entitled "Guidelines for Mountain Protected Areas" IUCN dedicates a whole chapter to the religious and cultural significance of mountains (see D. Poore, 1992).

Of course, religious sanctions were not so long-lasting in European civilization and culture, and most mountains have lost their sacredness. However, I imagine that basing studies on the socio-cultural significance of mountain environments, could open up a wide field for integrated research into the natural factors of ecosystem functioning, as well as the underlying cultural values which may be beneficial for the protection of ecosystem functioning.

The cultural dimension of mountain environments leads also to an ethical question for the needs of environmental protection. Valid reasons for environmental protection are often quoted in economic terms only (i.e. the long-term capitalizing on natural resources for future purposes; the use of genetic resources for improved seed varieties or pharmaceutical usages; undisturbed landscapes, flora, fauna-mostly megafauna — for the income-generating tourism sector etc.).

Ethical reasons for conservation receive less attention in European cultures than in non-European cultures. The Chinese word for landscape — Shan-shui — is a composite word of “mountain” and “water” which weds antagonistic forces into a harmonious whole in a Ying-Yang type of relationship. Perhaps it is time that we Europeans benefited more from a non-European type of thinking when it comes to considering mountains not only as elevated landmasses with various vegetation zones and places for tourism, but also as places with most interesting interrelationships between people and nature.

Of the 311 Biosphere Reserves entered on the international list by 1993, 42.7% were in mountain areas with their highest elevations at above 1,500 m a.s.l. Of these 71 (=51.3%) are located in the European region. It is hardly surprising that such a large number of Biosphere Reserves are situated in mountain environments since protected areas in mountain regions have hitherto been chosen mainly for their spectacular scenery, wilderness quality, and wildlife, as well as for the opportunities they offer to tourism. I should imagine that a fair number of European and non-European Biosphere Reserves in mountains would offer splendid research environments not only for examining ecosystem functioning from a purely natural scientist’s point of view, but also from an angle that includes cultural and ethical values. After all, our programme is called the Programme on Man and the Biosphere.

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PART 1
MOUNTAIN ZONALITY

A. Breymeyer (ed.) — EURO-MAB IV.
Mountain zonality facing global change,
Conf. Papers, 21, IGiPZ PAN Warszawa

REVIEW OF ALPINE RESEARCH IN THE POLISH TATRA MOUNTAINS

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Abstract. The most important results and achievements in the investigations carried out on the flora and vegetation of the Tatra Mountains are reviewed.

Key words: plant cover, vegetation belts, altitudinal vicariants, edaphic vicariants, endemic species.

In the territory of Poland, lying just in the centre of Europe (Fig. 1) there are three mountain systems: the old, Palaeozoic Sudety and Świętokrzyskie (Holy Cross) Mts and the young, Tertiary Carpathians — a large Alpide range situated between the Alps and the Caucasus. The Świętokrzyskie

Fig. 1. Location of Polish mountains in relation to other mountains in Europe
S — the Sudety Mountains, H — the Świętokrzyskie (Holy Cross) Mountains;
1 — young mountains the Tertiary Era in the Alpine system,
2 — old Paleozoic mountains, 3 — mountain areas in Poland

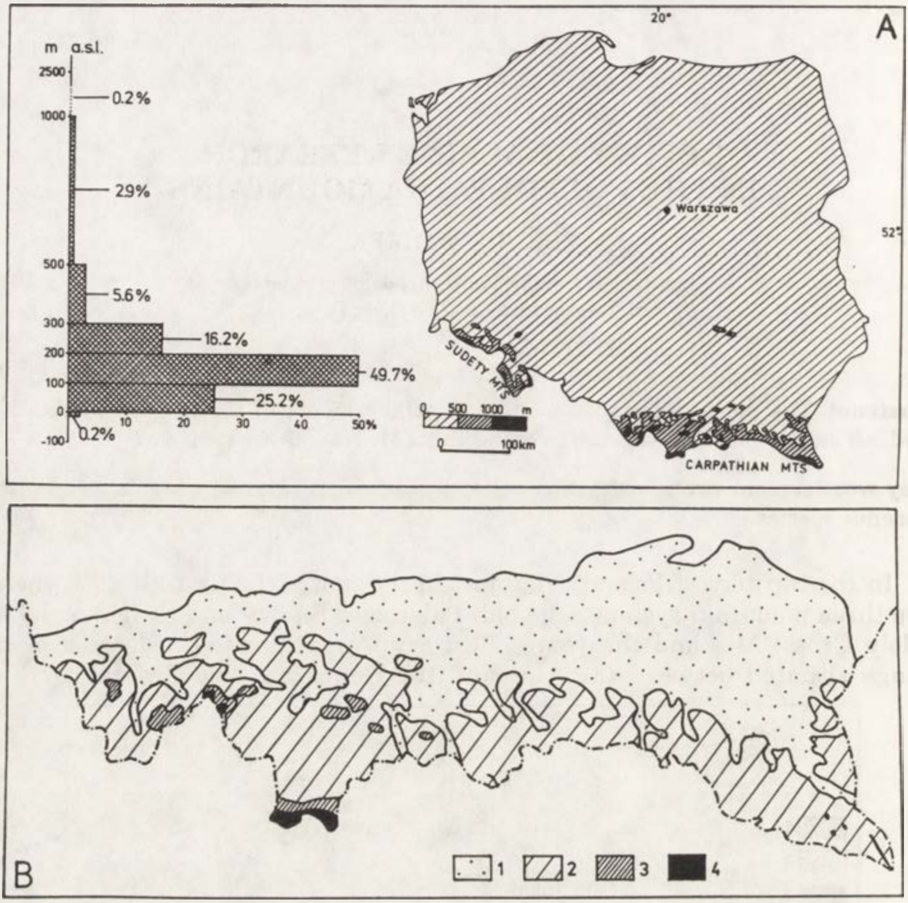

Fig. 2. Altitudinal differentiation of the Polish Carpathians: A — against the background of the hypsometry of the country, B — vegetation belts: 1 — colline belt, 2 — lower montane belt, 3 — upper montane belt, 4 — subalpine, alpine and subnival belts (Mirek and Piękoś-Mirkowa 1992b)

Mts are very low — only slightly above 600 m. Partly-developed alpine vegetation can be found in the highest range of the Sudety Mts — the Karkonosze (Giant Mts) (alt. 1603 m), as well as on 1725 m Mt. Babia Góra, highest peak of the area of the Carpathians known as the Western Beskidy Mts. But the main centre of alpine vegetation in Poland is in the Tatras (Fig. 2) which at up to 2663 m form the highest range of the Western Carpathians and the Carpathians as a whole-a fact that is well visible in the map of the Polish Carpathians and the Carpathians as a whole (Figs 2, 3). In turn, the distinctly high mountain character of the Tatra Mts is especially clear from Fig. 4. which compares the vegetation belts of the highest ranges of the Carpathians. It is clear that within the whole Carpathian arch it is only in the Tatras that the subnival belt is developed. Very significant is the limited participation of high mountain (subalpine and alpine) belts in the whole Carpathians, and especially in their north-western ranges, which

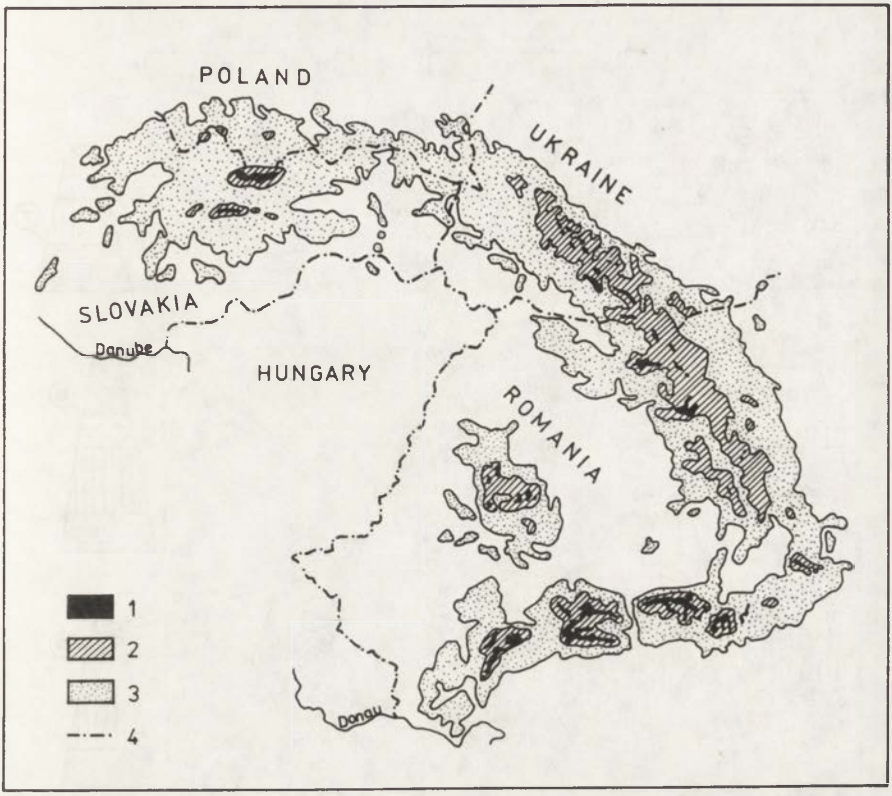

Fig. 3. Vegetation belts in the Carpathians: 1 — subnival, alpine and subalpine belts, 2 — upper montane belt, 3 — lower montane belt, 4 — state borders (Ozenda 1983, slightly modified)

include the Polish Carpathians. All of this merely enhances the importance of the Tatra Mts as a centre of high mountain vegetation in both Poland and this part of Europe. The massif supports 400 of the c. 450 mountain vascular plant species growing in Poland (Fig. 5) and in turn more than 200 (including the majority of high mountain taxa) have their only Polish localities in the Tatras.

The flora of vascular plants in the Tatras was already well known at the end of the last century when three important publications appeared (Berdau 1890, Kotula 1890, Sagorski and Schneider 1891). One of them *The distribution of vascular plants in the Tatra Mts* by Kotula (1890), remains valuable with its very detailed information on the vertical distribution and frequency of occurrence of all the then known vascular plant species, as well as its information on the boundaries of vertical vegetation belts. A good knowledge of the flora was futher improved at a later date by the taxonomical and chorological works of B. Pawłowski and his collaborators, which were carried out over a period of 50 years (1920-1970), and finished by the first of a planned volumes of the "Flora of the Tatras" (Pawłowski 1956). Thus from floristical point of view, the Tatras form today one of the best studied

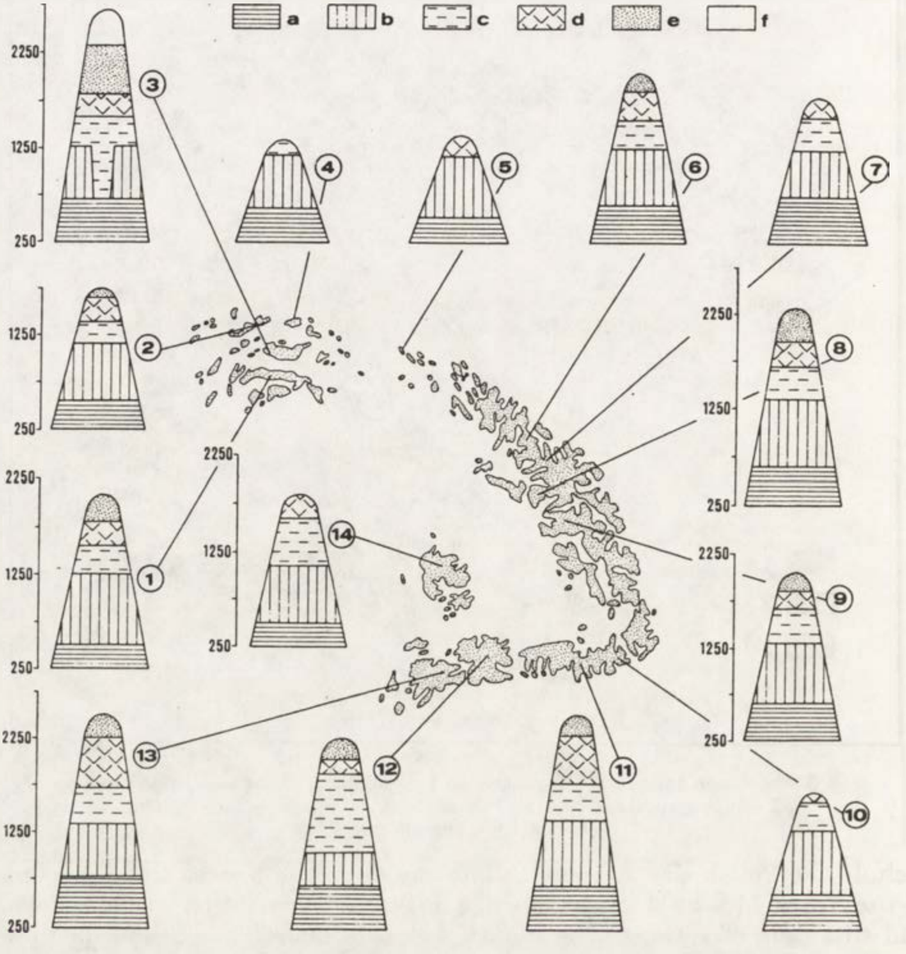

Fig. 4. Altitudinal vegetation belts in individual Carpathian ranges: 1 — the Nižne (Lower) Tatras, 2 — Babia Góra, 3 — the Tatras, 4 — Gorce, 5 — Bieszczady, 6 — Czarnohora, 7 — Czywczyńskie Mts, 8 — Rodniańskie Mts, 9 — Kelimenskie Mts, 10 — Siriu, 11 — Bucegi, 12 — Şebeşului, 13 — Retezat, 14 — Vlădeasa; vegetation belts: a — submontane, b — lower montane, c — upper montane, d — subalpine, e — alpine, f — subnival (Mirek and Piękoś-Mirkowa 1992b)

mountain regions in Europe or in the world. Furthermore many interesting discoveries have been facilitated by cartographic work done in the last 15 years in this small area (only 21 000 ha). Among these achievements is, e.g., the discovery of the only Carpathian locality for the relict subalpine species *Dryopteris villarii* (Fig. 6) as well as the new, sometimes quite numerous, stands of species formerly known from only one locality not proved for a hundred years (Fig. 7). The more than 100 000 floristic data collected during the last 15 years provided the basis for the detailed *Atlas of vascular plant distribution in the Polish Tatra Mts.* (Mirek and Piękoś-Mirkowa mscr.). The number of points on the distribution map of the common species *Vaccinium*

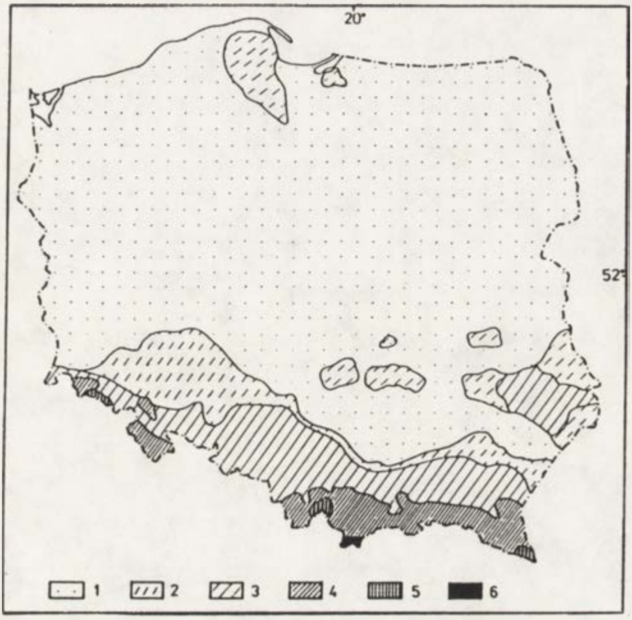

Fig. 5. Mountain vascular plant species in Poland:
1 — 1-15, 2 — 16-30, 3 — 31-60, 4 — 61-120, 5 — 121-240, 6 — over 240
(Mirek and Piękoś-Mirkowa 1992b)

Fig. 6. Distribution of *Dryopteris villarii*.
1 — main area of occurrence, 2 — single stands,
3 — stand in the Tatras (after Piękoś-Mirkowa and Mirek 1989)

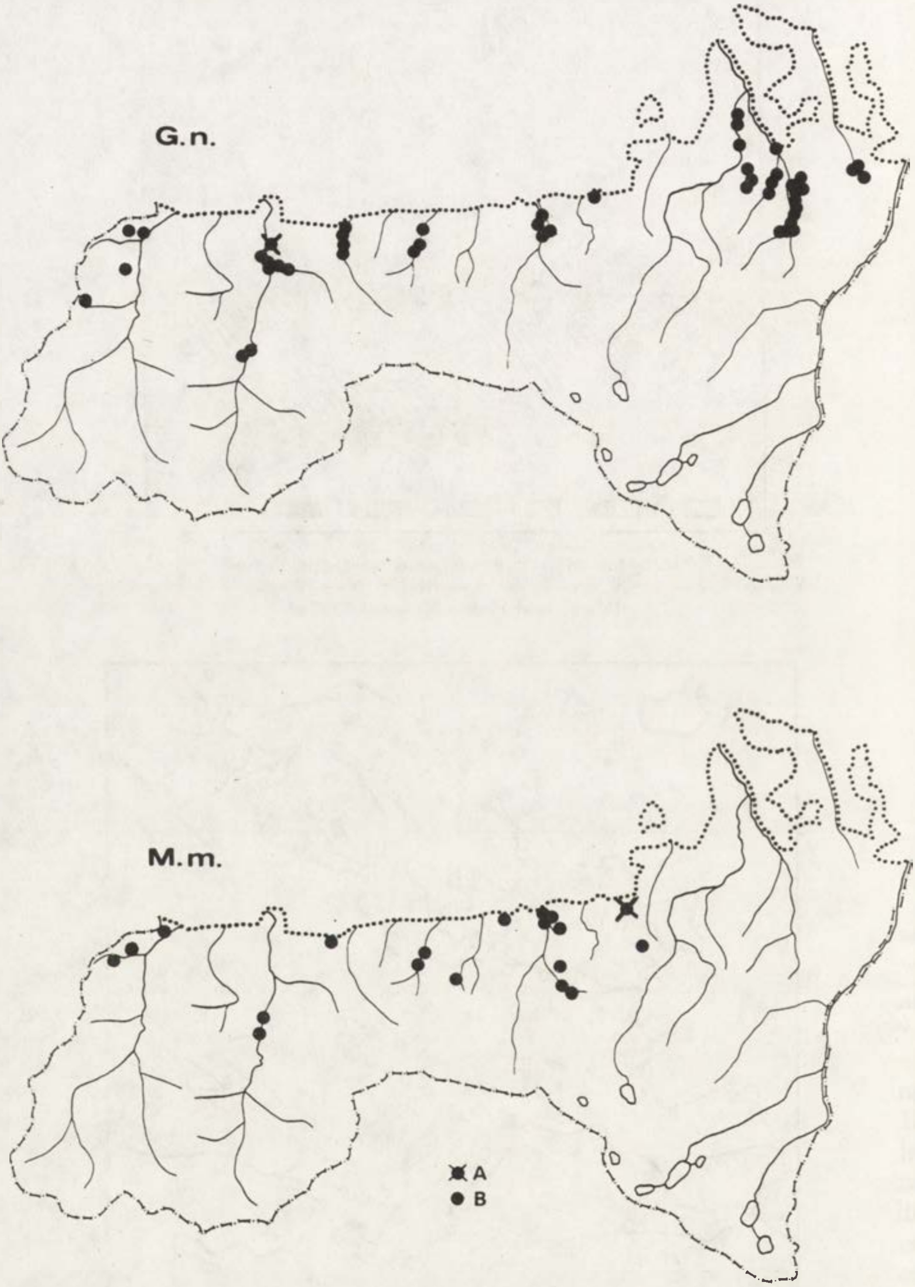

Fig. 7. Distribution of *Glyceria nemoralis* (G.n.) and *Malaxis monophyllos* (M.m.) in the Polish Tatras. A — the only stands recorded at the end of last century, B — stands discovered in last 15 years (Mirek and Piękoś-Mirkowa, orig.)

Fig. 8. Distribution of *Vaccinium myrtillus* in the Polish Tatra Mts (Mirek and Piękoś-Mirkowa, orig.)

myrtillus shows the degree of recognition of this territory (Fig. 8). In turn a good knowledge of plant distribution makes possible the presentation in cartographic form of such phenomena as the allegiances of various species to vertical vegetation belts (Fig. 9A) or different substrata (Fig. 9B). The relation between the substratum and the plant in taxonomically close species results in the phenomenon of edaphic vicariance (Fig. 10A), while similar types of relations connected with altitude give altitudinal vicariance (Fig. 10B). A precise knowledge of vertical distributions in the Tatras and other Carpathian ranges makes it possible to prepare a detailed classification of distributional types (Fig. 11). The distribution of rare and relict species in the Tatras points to the role of some regions as refugia for mountain flora like the area around Morskie Oko, or the Czerwone Wierchy massif (Fig. 12A), which is the only Carpathian locality for *Sibbaldia procumbens* (Fig. 12B) and some other species.

During the last 10 years detailed ecological studies by Piękoś-Mirkowa (1990) have focused on very rare and relict species which are represented in the Tatras by extremely small populations of as few as tens or even several individuals growing in one place. These studies consisted of a full inventory of individuals, as well as several years of observation on the state of the population and its structure, on vegetative and generative propagation, on characteristics of phytocoenoses and soil conditions and on phenology. Evaluations were also made of the threat posed by different factors and of the possibilities for *in situ* and *ex situ* protection. Similar studies are now being carried out by Piękoś-Mirkowa and Mirek on the endemics of the Tatras, Western Carpathians and the Carpathians as a whole. It was only possible to start such studies after long-lasting taxonomic and chorologic investigation

Fig. 9. Various distribution patterns of vascular plants in the Tatra Mts:
A — lower montane species *Fagus silvatica* (a) and subnival species *Saxifraga bryoides* (b);
B — calcifilous alpine-subalpine species *Carex firma* (c) and calcifugous alpine species *Campanula alpina* (d) in relation to distribution of calcareous (e) and non-calcareous (f) rocks (dotted)
(Mirek and Piękoś-Mirkowa, orig.)

Fig. 10. Edaphic (A) and altitudinal (B) vicariants in the Polish Tatra Mts:
a — calcifilous *Saxifraga cernua*, b — calcifugous *Saxifraga carpatica* in relation to distribution of calcareous (dotted) and non-calcareous rocks, c — lowland-montane species *Juniperus communis*, d — subalpine-alpine species *Juniperus sibirica*; e — upper forest limit
(Mirek and Piękoś-Mirkowa, orig.)

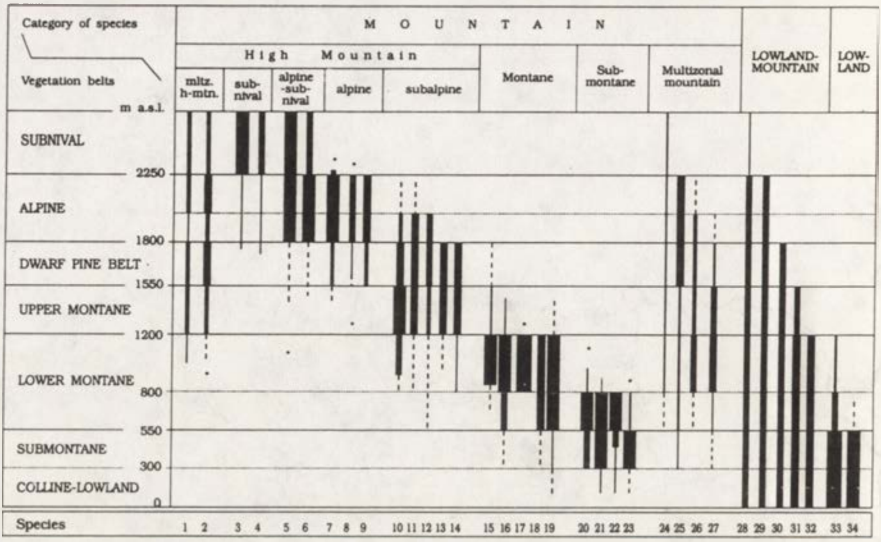

Fig. 11. Categories of altitudinal ranges of species and their representatives in the Polish flora in relation to vegetation belts (after Mirek 1990). 1 — *Potentilla crantzii*, 2 — *Geum montanum*, 3 — *Cerastium uniflorum*, 4 — *Gentiana frigida*, 5 — *Salix herbacea*, 6 — *Lloydia serotina*, 7 — *Myosotis alpestris*, 8 — *Pulsatilla alpina*, 9 — *Viola alpina*, 10 — *Polystichum lonchitis*, 11 — *Linum extraaxillare*, 12 — *Pinus mugo*, 13 — *Pinus cembra*, 14 — *Hieracium prenanthoides*, 15 — *Listera cordata*, 16 — *Luzula luzulina*, 17 — *Moehringia muscosa*, 18 — *Trifolium spadiceum*, 19 — *Dentaria glandulosa*, 20 — *Myricaria germanica*, 21 — *Calamagrostis pseudophragmites*, 22 — *Matteucia struthiopteris*, 23 — *Epilobium dodonaei*, 24 — *Soldanella carpatica*, 25 — *Huperzia selago*, 26 — *Carduus defloratus* ssp. *glaucus*, 27 — *Gentiana asclepiadea*, 28 — *Vaccinium vitis-idaea*, 29 — *Nardus stricta*, 30 — *Rubus idaeus*, 31 — *Campanula trachelium*, 32 — *Moehringia trinervia*, 33 — *Calamagrostis epigeios*, 34 — *Medicago falcata*. Abbreviation: mlts. h. mtn. — multizonal high-altitude species

of the endemics by Pawłowski (1970), and cytological studies on this group of species by Skalińska (1963) and collaborators. Synthesis of these works took the form of a comparative study on endemism in the Alps and the Carpathians (Pawłowski 1970). The results, supplemented later by papers from other botanists, allow for a synthetic presentation of endemism in the Tatras and the Carpathians against a broader background. It was proved that the Western Carpathians, and within them the Tatras, are the northernmost centre of endemism in the European continent (Fig. 13). It is also evident that endemism in Europe is connected with mountainous regions. However, the maximum extent of the Fennoscandian Ice Sheet which reached the foot of the Western Carpathians, caused the almost total destruction of the Tertiary flora and was decisive in limiting severely the present number of endemics, especially of higher rank. The number of these in the Carpathians is only one third of that in the Alps. The same factor decided on the distribution of endemic richness within the Carpathians, with the Western Carpathians having 1/3 fewer endemics than the Southern Carpathians (Fig. 14b). Nevertheless, the Tatras are still the territory richest in endemics in Poland (Fig. 14a), in the Polish Carpathians (Fig. 15) and in the whole of the Western Carpathians. This is without doubts connected with their high mountain character as the majority of endemics are alpine and subalpine species.

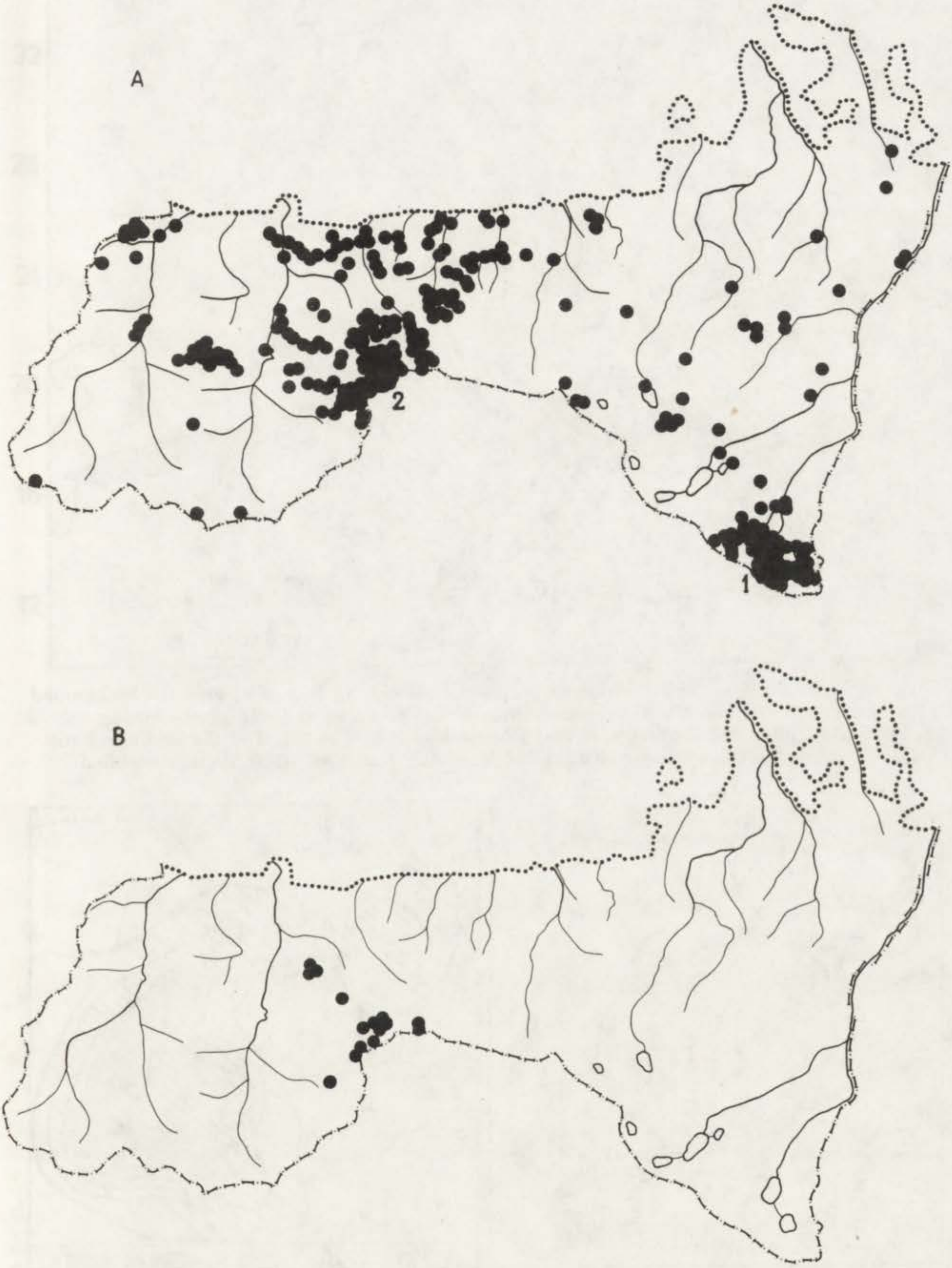

Fig. 12. A — distribution of very rare relic species in the Polish Tatras (Piękoś-Mirkowa 1982). Clearly visible is the concentration of stands in two regions: 1 — Morskie Oko, 2 — Czerwone Wierchy. B — Stands of *Sibbaldia procumbens* in the region of Czerwone Wierchy (Mirek and Piękoś-Mirkowa, orig.)

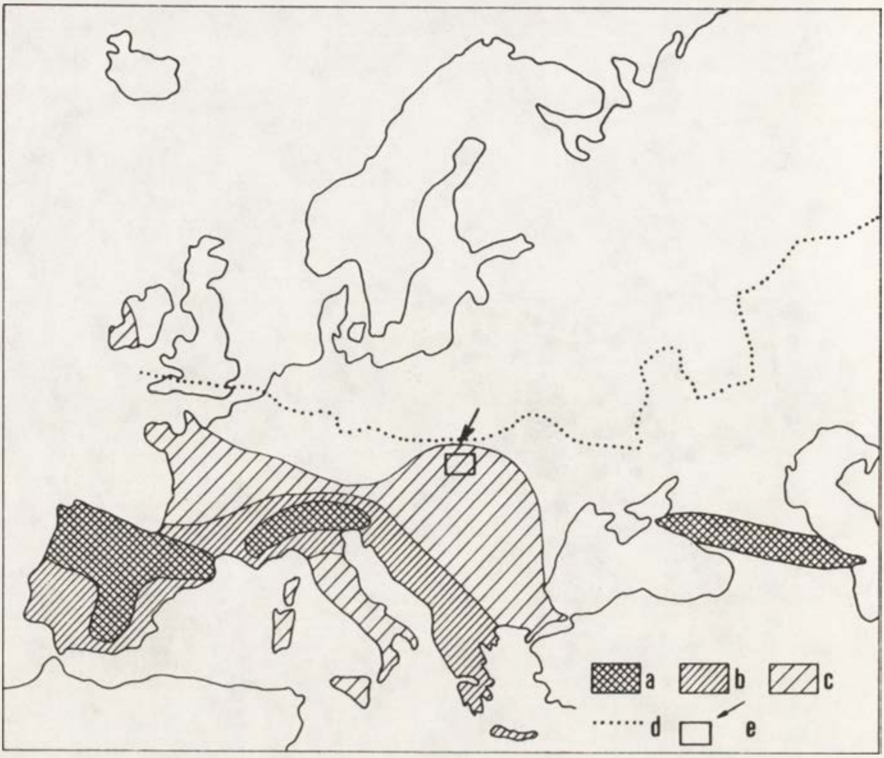

Fig. 13. The Tatras as the northernmost centre of endemism in Europe against the background of dislocation and quantitative representation of the European endemic genera having only relatively limited distribution; a — 14-7 genera, b — 6-4, c — 3-1, d — the southern limit of the greatest glaciation, e — the Tatra Mts (after Hendrych, 1980, slightly modified)

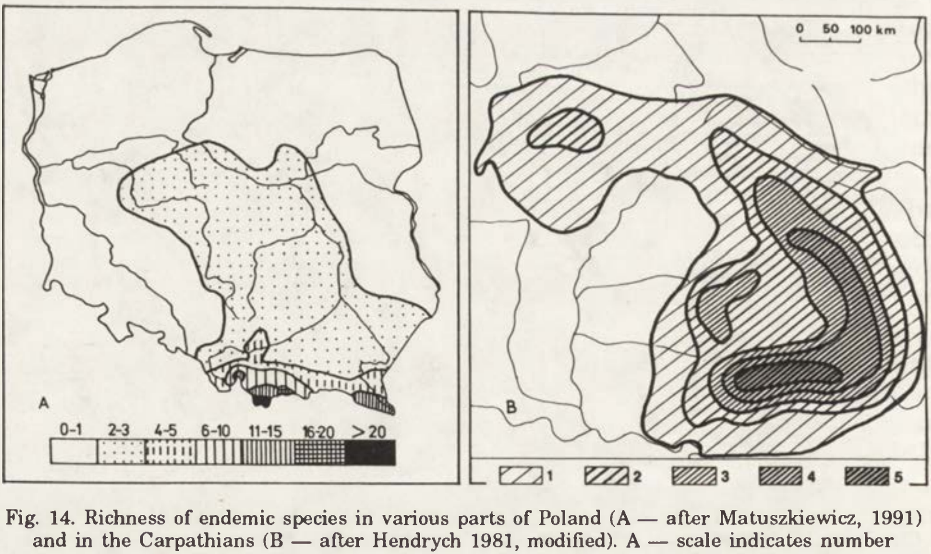

Fig. 14. Richness of endemic species in various parts of Poland (A — after Matuszkiewicz, 1991) and in the Carpathians (B — after Hendrych 1981, modified). A — scale indicates number of endemic species; B — local, western, eastern, and pan-Carpathian endemics in various parts of the Carpathians: 1 — 1-20, 2 — 21-45, 3 — 46-55, 4 — 56-60, 5 — 61-65

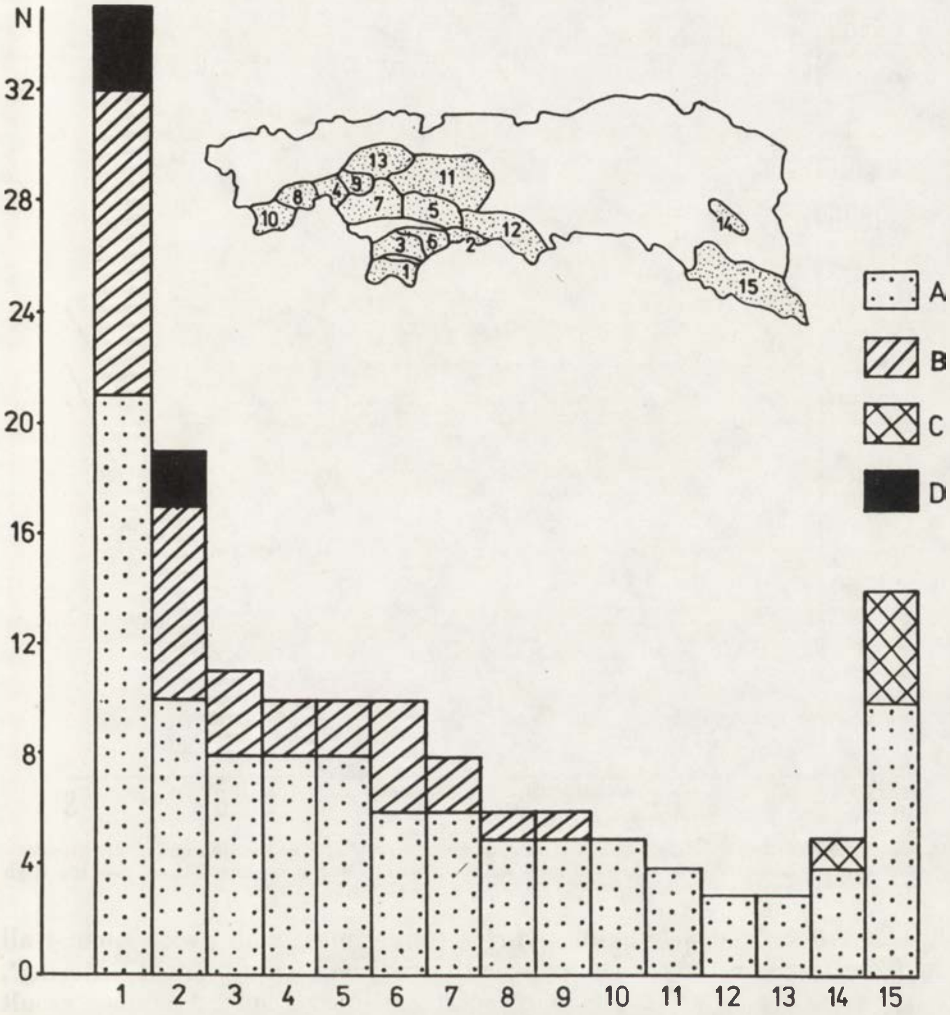

Fig. 15. Endemic and subendemic species in single Carpathian ranges (Mirek and Piękoś-Mirkowa 1992b). A — pan-Carpathian endemics, B — West-Carpathian endemics, C — East-Carpathian endemics, D — species endemic to the Tatras or Pieniny Mts. Mountain ranges and their location on the map: 1 — the Tatras, 2 — the Pieniny Mts., 3 — Wzniesienie Gubałowskie, 4 — Babia Góra, 5 — Gorce, 6 — Pas Skalicowy, 7 — Działy Orawskie, 8 — Pilsko, 9 — Polica, 10 — Wielka Racza, 11 — Beskid Wyspowy, 12 — Beskid Sądecki, 13 — Beskid Mały, 14 — Słone Mts, 15 — Bieszczady

Studies on the synanthropic flora of the Tatras and adjacent territories deserve separate mention. These studies (Radwańska-Paryska 1963, Piękoś-Mirkowa and Mirek 1978, 1982; Mirek and Piękoś-Mirkowa 1984, 1987) allowed for the determination of regularities in the horizontal and vertical distribution of alien species, in their routes of migration and rates of spread and in the degree of establishment and the threatposed to indigenous flora. It was found, for instance, that *Epilobium ciliatum*, an American newcomer, had

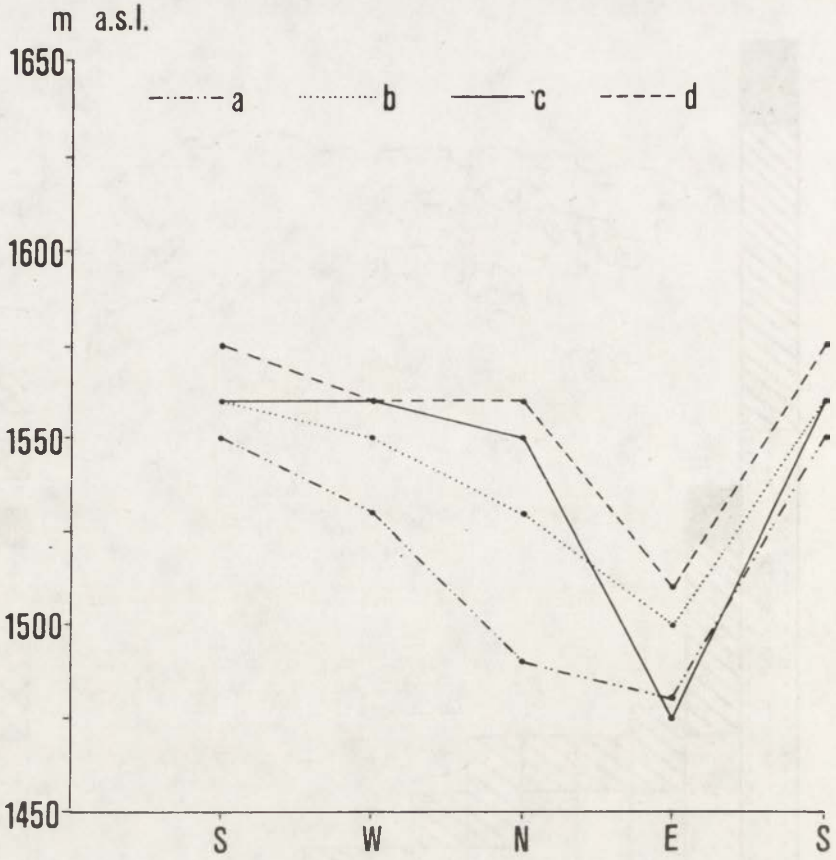

Fig. 16. Altitudinal differentiation of the mean upper forest limit in relation to various aspects (compiled from Sokołowski 1928); a — Siwy Wierch massif, b — the Eastern Tatras, c — the High Tatras, d — the Bielskie Tatras

already succeeded in making hybrids (sometimes triple) with almost all indigenous species. In the longer term this may lead to permanent "littering", of the gene pool of all native representatives of the genus. Also, as a result of meadow and pasture experiments from the beginning of this century, some alpine species settled for good in the Tatras.

Monographic studies have been devoted to the upper forest limit, and to its types and course in the whole Tatras (Sokołowski 1928). Earlier, the average course of the tree line in relation to exposure in various parts of the Tatras had also been described (Fig. 16). Special attention was paid to the phenomenon of its particular elevation through the existence of a mini-belt of arolla pine-spruce-larch forest, and its lowering (along with the lowering of all vegetation belts) in places locally conditioned by the climate, e.g. the so-called Mt. Sarnia Skała phenomenon (Sokołowski 1928, Piękoś 1968). The structure of spruce forests and spruce biogroups at the upper limit of the forest (Fig. 17) have been studied, as has the connection between these phenomena and snow cover (Myczkowski 1955, 1972). The occurrence of

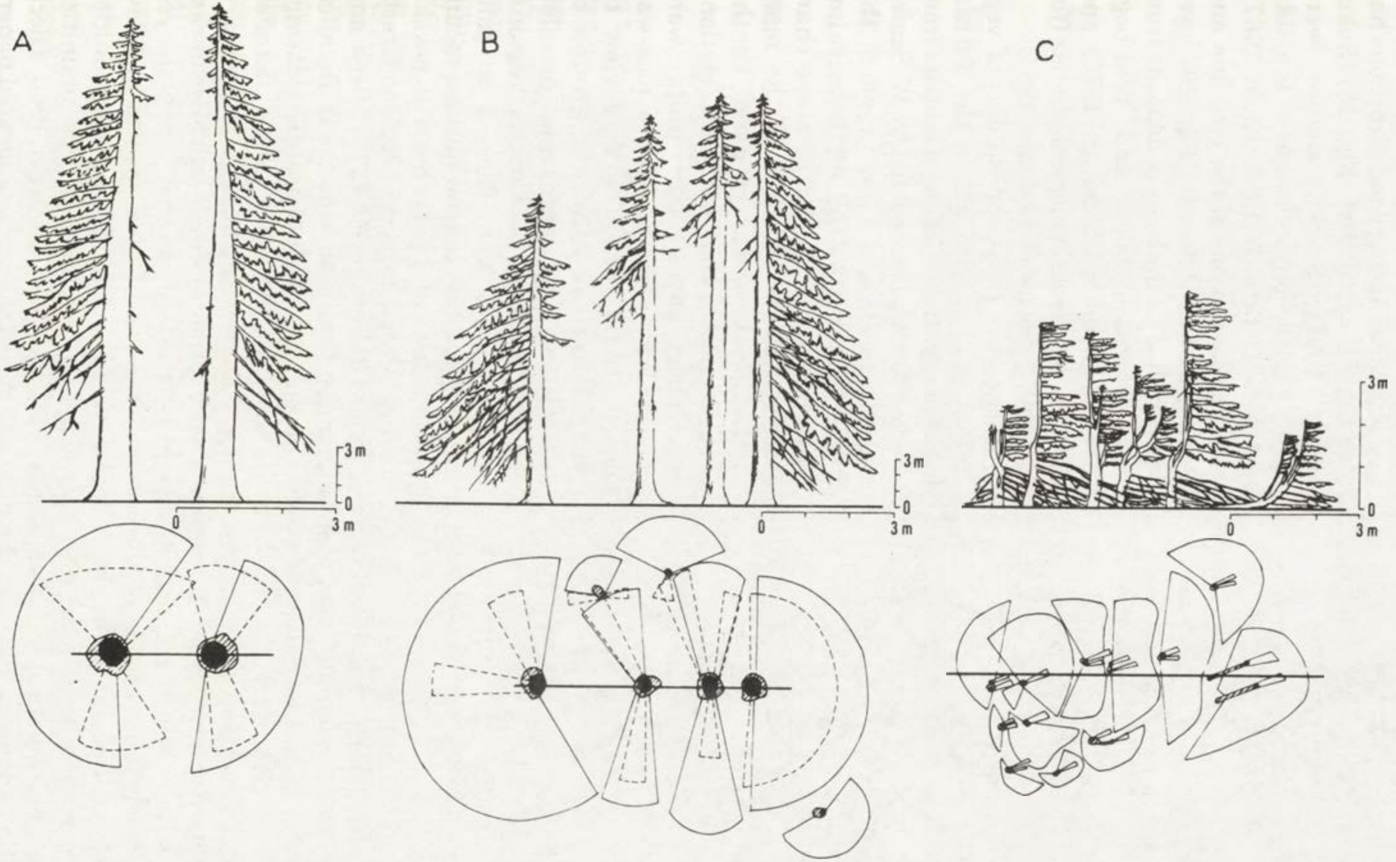

Fig. 17. Vertical and horizontal projections of *Picea abies* biogroups typical of: A — dense forest in fully stocked stands of the upper montane belt, B — open forest at the upper forest limit, C — subalpine (dwarf pine) belt (redrawn from Myczkowski 1972)

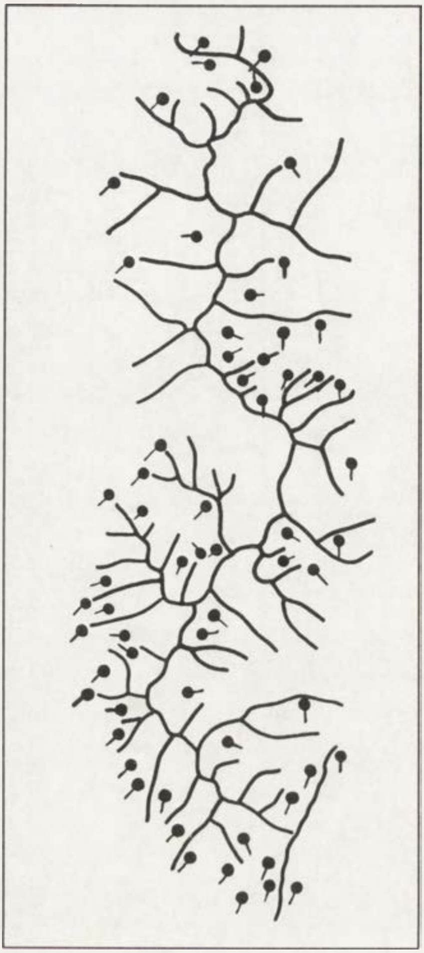

Fig. 18. Wind-trained forms of spruce at the upper forest limit indicating predominating wind directions (from Sokołowski 1928)

wind-trained forms of spruce in relation to the predominating wind directions has also been investigated (Fig. 18) (Sokołowski 1928). Special studies were devoted to the phytoclimate of the subalpine belt (Ermich 1957, Klein 1967), and the fluctuations of the tree line and climate in the Holocene (Fig. 19) have been studied on the basis of deposits from high mountain lakes and peat-bogs (Krupiński 1983, Obidowicz 1975) and through dendrochronological studies (for youngest periods — Bednarz 1984).

Pioneering European studies of vegetation were carried out in the Tatras, in the period 1922-1927 by scientists from Cracow botanical school led by W. Szafer and B. Pawłowski, who applied the Braun-Blanquet method. All the more important plant associations were characterized then and maps of the most interesting places were prepared. For the first for science time many associations or higher phytocenotic units were described for science. In the post-war period studies began with a view to recognizing the different groups of associations and preparing detailed vegetation maps of various regions. Special studies were focused on soils and communities of semi-natural mountain meadows and pastures (Pawłowski, Pawłowska and Zarzycki 1960), on forests (Zarzycki 1983), synanthropic communities (Balcerkiewicz 1978, Mirek and Skiba 1984) and on high mountain vegetation (Balcerkiewicz 1984). Detailed phytocenotic, soil, and floristic studies on the vegetation of pasture clearings have been done recently and have included, among other things, detailed vegetation and soil maps at the scale 1 : 2500 which have been prepared in manuscript form for 110 Tatra clearings by Mirek, Holeksa, and Miechówka. The usefulness of these studies should be stressed, as they are employed to establish the methods of the active protection of semi-natural meadow ecosystems. Special studies have been devoted to synanthropic communities and separate studies have also been done on high mountain communities with a predominance of lower plants (Motyka 1924, Lisowski 1966, Olech 1985, Balcerkiewicz 1984). In the interwar period there also appeared papers on some phytogeographical or ecological problems, e.g. on a climax association

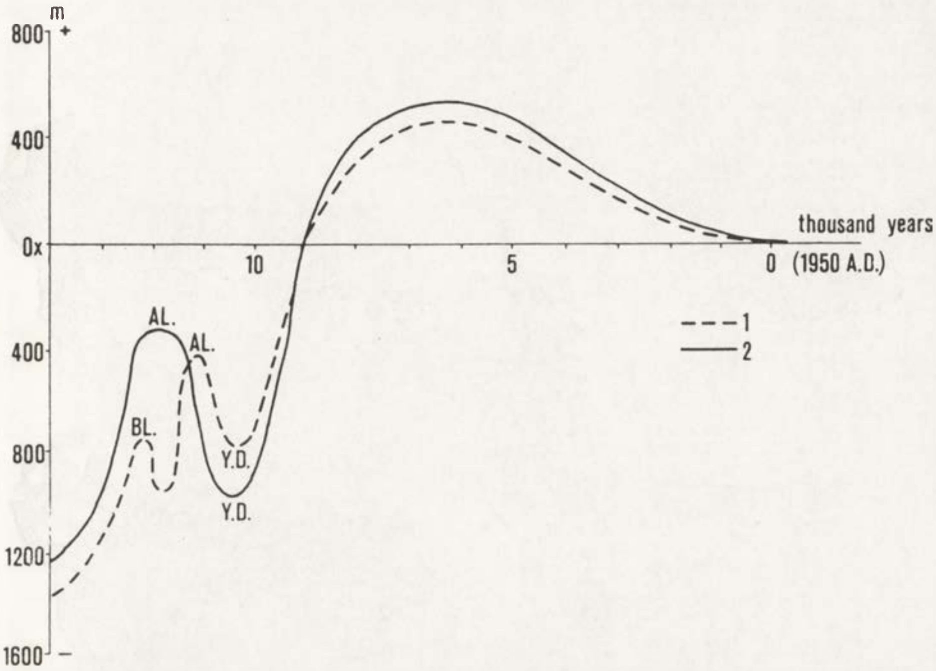

Fig. 19. Changes of the upper forest limit during the late glacial and the Holocene (from Krupiński 1983): 1 — in central European mountains, 2 — in the Polish Tatras, Y.D. — Younger Dryas, AL. — Alleröd, BL. — Bölling

in the alpine belt of the Tatras (Pawłowski 1935) and on the origin of subnival vegetation in the Tatras (Pawłowski 1929). Several papers on the relation between the acidity (pH) of soils and various associations in the Tatras were published in the 1920s by J. Włodek and K. Strzemiński. They were supplemented later by a series of papers on mycotrophism in plant communities in various vertical belts (Dominik and Nespiak 1953; Dominik, Nespiak and Pachlewski 1954a, b; Dominik and Pachlewski 1956) and studies on the genesis of the flora of hay meadows in the Tatras by Pawłowska (1965). The advancement of cartographic works is shown in Fig. 20 A-E. The first summing up of cartographic works is the map of vegetation at the scale 1:75,000 (Fig. 20 D). Another type of synthesis is presented by the map of vegetation transformation in the Tatra National Park, which is, of course, based on other maps prepared previously (Fig. 21).

The “Ecological atlas of vascular plants in the Tatras” (Mirek and Piękoś-Mirkowa, Miechówka mscr.) should be mentioned at the end. Its basis is constituted by floristic data collected from 1 x 1 m plots, in parallel with samples of soil and descriptions of other environmental factors from almost 1500 points chosen in a systematic-random way along altitudinal transects. Similar work has been done in the Pieniny Mts. and on Mt. Babia Góra.

Recent years have seen more and more importance attached to research on pollution and the damage and transformation of different elements of

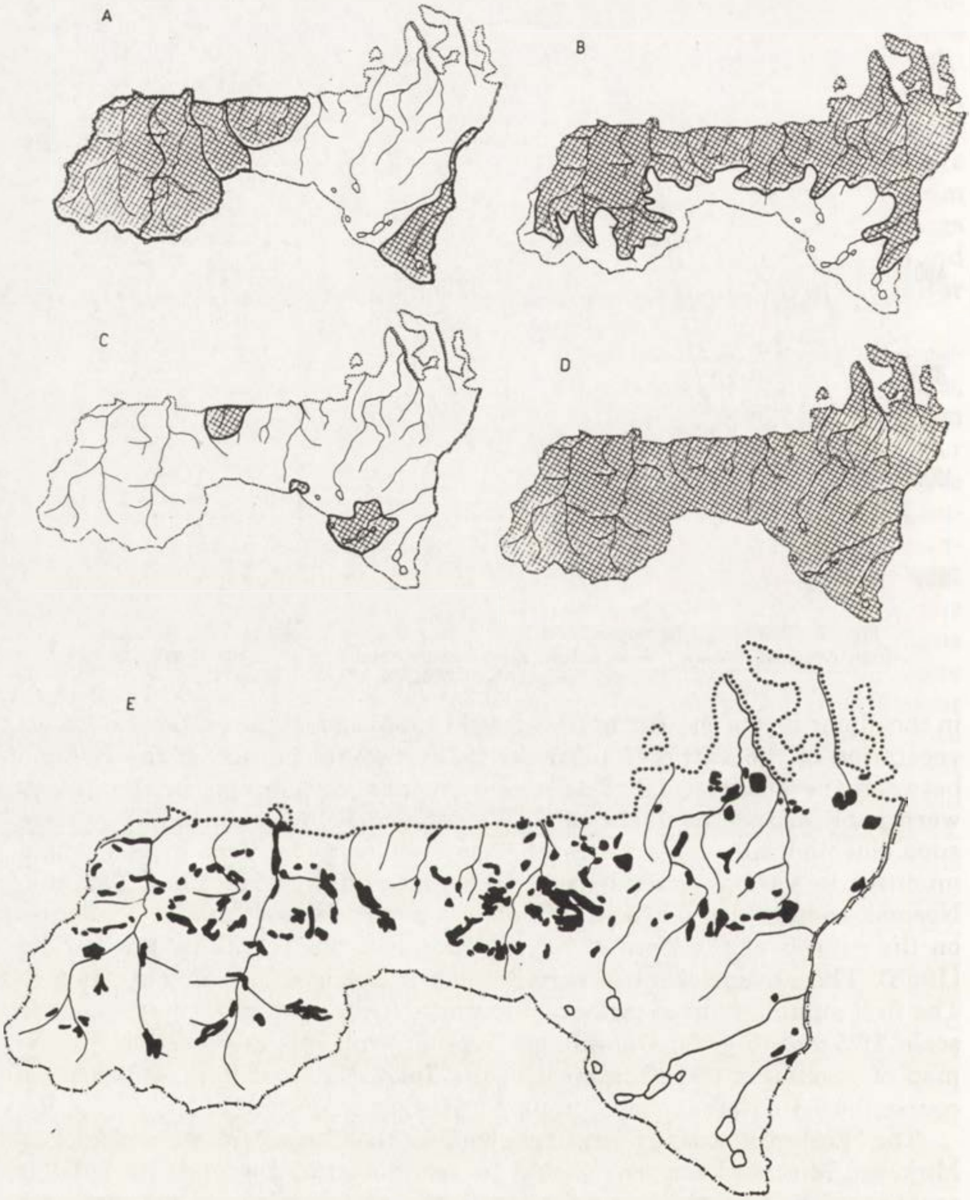

Fig. 20. Published and non-published vegetation maps of various areas of the Tatra National Park A — maps of the five valleys published in the 1920s at the scale 1 : 37 500 (by Szafer, Pawłowski et al., 1923); B — map of forest communities at the scale 1 : 30 000 (Myczkowski et al.) C — map of Sarnia Skała at the scale 1 : 10 000 (Horvat et al., 1981), map of Dolina Pięciu Stawów Polskich at the scale 1 : 10 000 (Wojterski et al., npbl.) D — map at the scale 1 : 50 000 (Myczkowski, Piękoś-Mirkowa and Baryła, 1985), E — maps of over 110 glades of the Tatra National Park at the scale 1 : 2500 (Mirek, Holeksa and Miechówka, 1994, npbl.)

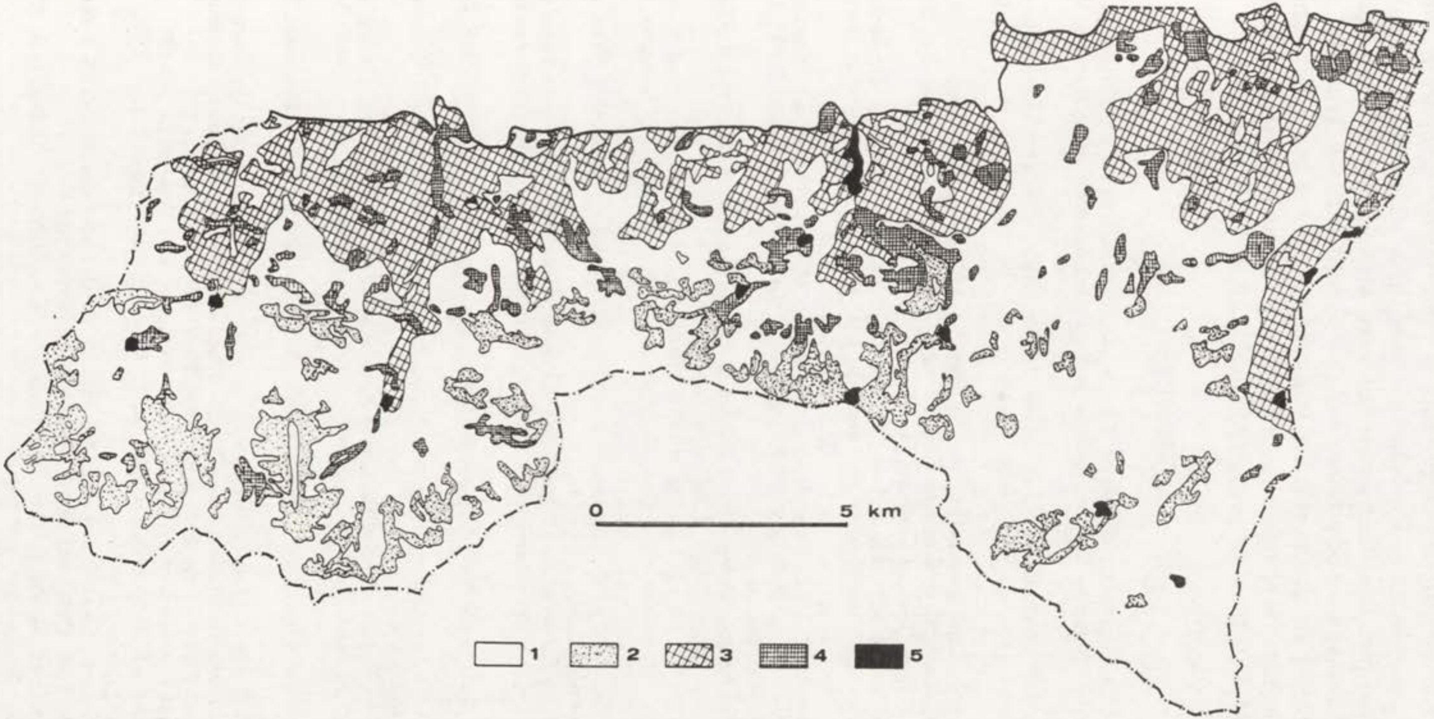

Fig. 21. The anthropogenic transformation of vegetation (after Piękoś-Mirkowa 1981, 1986)
1 — primeval and native plant communities, 2 — secondary grasslands composed of native species, 3 — secondary stands of forest (mainly in the lower montane belt) with significantly changed tree composition, 4 — semi-natural non-forest vegetation, 5 — anthropogenic vegetation

the natural environment. However, this is material for a separate, albeit also very interesting, lecture. The importance of these studies is inestimable, on account of the fact that this small but very unique region of Europe is situated within the sphere of influence of the so-called “Black Triangle”, the most polluted region in the world. Moreover, the area was previously under strong pressure from local mining, metallurgy and pastoralism and is now visited by c. 3 million tourists per year (Mirek 1992).

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THE HUMAN-INDUCED TRANSFORMATION OF THE ECOSYSTEMS OF THE CAUCASUS MOUNTAINS

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Abstract. The six regional variants in the zonality of Great Caucasus are described. Practically all the European latitudinal zones can be found in the Caucasus: steppe and forest-steppe, subtropical, broad-leaved, dark coniferous and light coniferous forests, subalpine and alpine meadows, pioneer groups in the subnival belt and a great variety of intrazonal ecosystems connected with river valleys and rocks. Four important periods in the mountain political and economic development are distinguished.

Key words: Caucasus Mts., ecosystem transformation, zonation in Caucasus, altitudinal/historical Mts conditioning.

There is no question that mountain territories may by regarded as kinds of "isles", which differ completely from the adjacent plains. The main peculiarities of mountain nature are the mosaic structure of vegetation and ecosystems and the high density of natural boundaries of different ecosystems per unit of area. These peculiarities depend on the diversity of physico-geographical conditions. The specific character of the mountain environment is also determined by altitudinal zonality, i.e. the replacement of natural microbiomes with changes in absolute height (owing to the altitudinal gradient of the hydrothermal regime).

As a rule it emerges that the real complete composition of natural montane belts and the order of their altitudinal change are specific not only in different mountain systems, but also in separate parts of a large mountain country (Gerasimov and Zimina 1986).

THE ALTITUDINAL DIFFERENTATION OF THE ECOSYSTEMS OF THE GREAT CAUCASUS

The Great Caucasus Mountains are characterized by an unusually wide variety of ecosystem. This results from its geographical location at the boundary of two natural zones and also from a great number of other historical, local climatic, orographic, litho-geomorphological factors. The diversity of variants in the altitudinal zonality of the Great Caucasus is caused by the interaction of these factors. The minimum number of six regional variants in the zonality structure cannot be observed in any other mountain system in our country.

Two western variants — the Kubanian and Colchidian — were formed under the influence of the air masses of the Mediterranean Black Sea. This factor created more or less mild and damp climate in this part of the Great Caucasus and permitted the full development of dark coniferous and broad-leaved forest ecosystems. The zonations of these two variants are rather alike, especially at altitudes of more than 1000 m above sea level. The main differences are noted in the lower belts, by reason of the fact that the northern macroslope is within the temperate zone, and the southern — within the subtropical zone. It is for this reason that there is no forest-steppe belt on the southern macroslope and that forest ecosystems in primary conditions extend here from sea-level.

There is an abrupt weakening of the influence of moist air masses on nature in the Great Caucasus as one goes East from the watersheds of the Teberdino-Dautian (on the northern macroslope) and the Rioni-Kurinian (on the southern macroslope). It is for this reason that all the central and eastern Caucasian variants in zonality (unlike those in the Western Caucasus) have signs of xerophytization to varying extents.

Under these conditions the Elbrusian variant has a status of its own. Its peculiarities are determined first and foremost by the orography. On the one hand, the Caucasian ridges reach their greatest height here, almost totally preventing the penetration of Mediterranean Black Sea moist air masses. On the other hand, the gentle outlines and bush-like structure of the forward Rocky and Cretaceous ridges make it easy for dry air masses from the North to penetrate right up to the high mountains. Moreover, the sufficiently powerful freezing of the axial ridges, above all of Elbrus, intensify the continentality of the climate even in comparison with that in the Eastern Caucasus. As a result, the Elbrusian variant of zonality is characterized by the absence of mountain forest ecosystems and by the aridization of the whole altitudinal spectrum; steppe species of plant and animal penetrate up to the alpine and subalpine belts.

The forward Tersky, Sungenian and Rocky ridges play an important role in the forming of the altitudinal zonality spectrum of the Tersky variant. Their outlines are not smooth (as in the Elbrusian variant) but steep and abrupt, preventing the penetration of mountain regions by dry winds from the Eastern Precaucasian semideserts. The belt of dark coniferous forests in high mountains is naturally absent in this variant, but ecosystems of broad-leaved forest do reappear here. In comparison with the Elbrusian variant, the degree of xerophytization of the primary alpine and subalpine meadows is lower, and mountain steppe ecosystems are found, as a rule, in the broadened river valleys — intermontane depressions in the "rain shadow" of the Rocky ridge.

In the Eastern Caucasus, the mountain system expands to 160-170 km in the Daghestanian zonality variant. This results from the wide scarceness of ridges: a factor which plays an important role in forming the specific ecosystem cover. The ring of ridges forms the so-called “Interior Daghestan”, which is characterized by heightened aridity of the climate, and accordingly, by intensive steppization of the vegetation cover. Precipitation in Daghestan is only half that in the Western Caucasus (Makunina 1986) and mountain steppes spread widely between the belts of fragmentary broad-leaved forests and subalpine meadows. Nowhere do they cover such large areas as in the Great Caucasus.

The Eastern Transcaucasus is, on the one hand, isolated orographically from the South, North and West. This prevents access of moist air masses. On the other hand, the area is open to the free invasion of dry air streams from the East. It is mainly these two factors which shape the enhanced continentality of climate in this region with the Lagodech-Zakatalian variant (Chubukov 1966). As a result of the dry climate, semidesert and arid steppe ecosystems appear in low mountains. While increased altitude precipitation also increases and promotes — in conjunction with adequate warmth — the spread of a broad-leaved forest belt and a high mountain meadow belt above that.

Thus, in the Caucasus, even in recent times, it was possible to see in a short linear distance changes in montane belts which were analogous to practically all the European latitudinal zones: steppe and forest-steppe; subtropical, broad-leaved, dark coniferous and light coniferous forests; subalpine and alpine meadows; pioneer groups in the subnival belt and a great variety of intrazonal ecosystems connected with river valleys and rocks. The general regularities of the distribution of these primary ecosystems in the Great Caucasus are shown in the map of reconstructed ecosystem cover (Fig. 1).

THE MAIN PERIODS IN THE HISTORY OF LAND USE IN THE GREAT CAUCASUS MOUNTAINS

Since ancient times the biota of the Great Caucasus has been used as a source of food, building materials, fuel and other raw materials for man. Thus, even from the middle holocene, human economic activity becomes an important factor which has, to some extent, had an influence on the trend and intensity of changes in primary mountain vegetation communities (Kvachakidze 1979).

It should be noted that each historical period of the socio-economic and political development of the Great Caucasus was characterized by various combinations of impacts and by different loads on the natural ecosystems. The following stages in the mountain region’s political and economic development can therefore be distinguished:

(1) The period of early feudalism (up to the 13th century).

(2) The period of wars and conquests: invasions by the Tataro-Mongols, Timur and Turks, and Persian expansion (up to the 19th century).

(3) The period of economic and political consolidation in the Great Caucasus (up to the beginning of the 20th century).

(4) The period of intensive agro-industrial development (since the beginning of the 20th century).

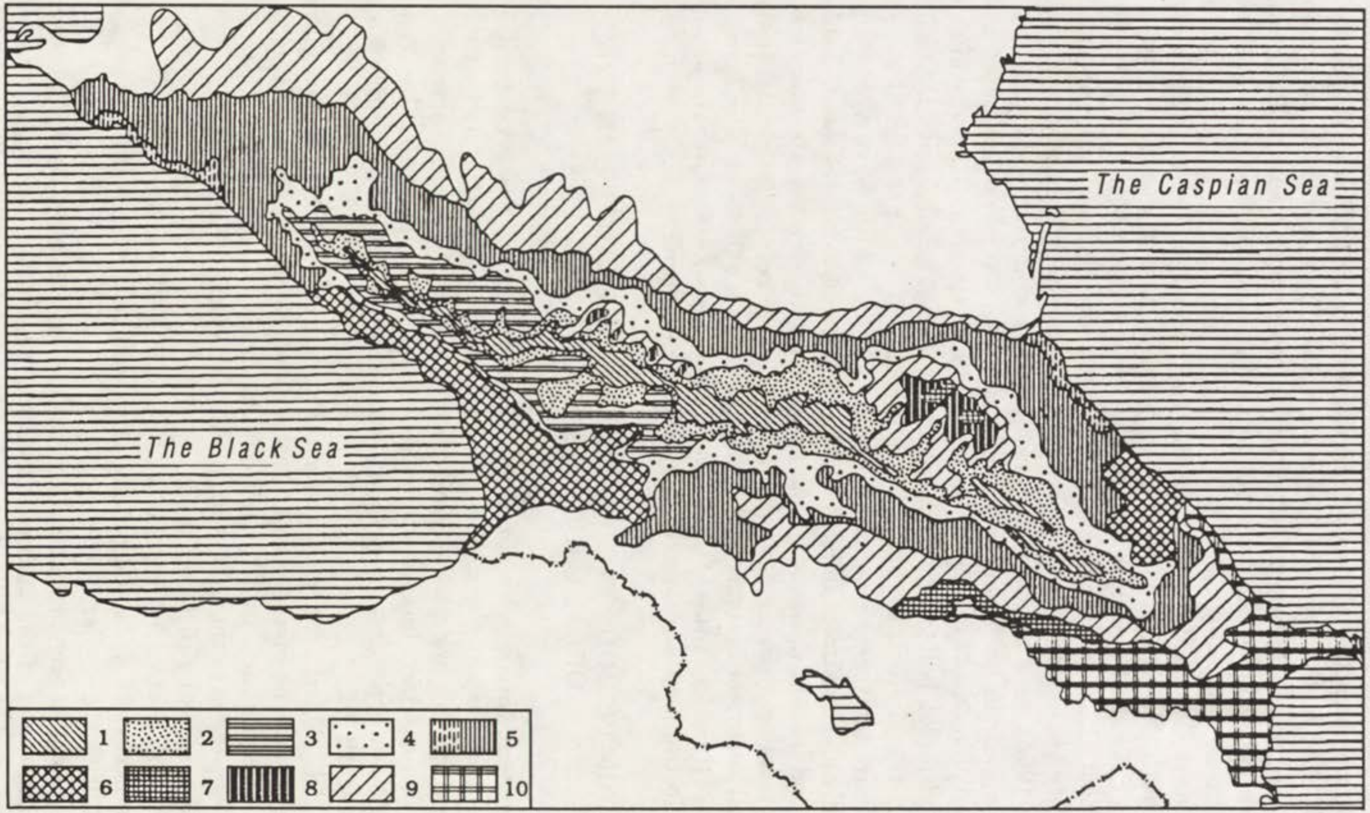

Fig. 1. Reconstructed ecosystem cover of the Great Caucasus
1 — alpine meadows; 2 — subalpine meadows & elfin woodland; 3 — dark-coniferous forest;
4 — beech forest; 5 — broad-leaved forest; 6 — oak forest; 7 — juniper forest; 8 — forest-steppe; 9 — steppe; 10 — semideserts

In the period of early feudalism and in previous ages it was above all the low mountain zone which was affected by anthropogenic impacts. This region was optimal for habitation by early man. It lies in the contact zone of large geosystems and therefore has the richest natural resources (Belonovskaya and Yasny 1990). From ancient times man was picking fruits, berries, mushrooms and medical plants, and was hunting in the forests. This took place everywhere, but particularly in low mountain oak forests with their great variety of species. In this particular period, the area of mountain and foothill steppes began to reduce as they were ploughed up. The middle and high mountains remained basically untouched, though early man did have settlements in the most accessible regions there. From the first ages A.D. the people of the Northern Caucasus started to bring intermontane depressions under the plough. This entailed the destruction of hornbeam-beech and pine forests and was followed by the utilization of the unforested areas as ploughed fields or pastures (Serebryany et al. 1980). The same processes took place in the Transcaucasus, in Abkhazia (Voronov 1975).

According to data from historical and linguistic research, it was early as in the 5-4 centuries B.C. that the first nomad tribes occupied comfortable and available valleys in the Eastern Caucasus. It is for this reason that widespread in the area since ancient times have been secondary communities of arid steppe with *Andropogon ischaemus* and mountain-xerophytes (in place of true and meadow steppes), as well as shibliak and phryganoid vegetation derived from oak, pine and juniper forests.

The next period — the period of wars and conquests — saw the inhabitants of foothills and low mountains forced to hide from invaders in the mountains. This increased the load on the middle mountain ecosystems, mainly the forest ones. The main forms of impact were the same: selective felling to satisfy local needs, the picking of fruits, berries, mushrooms and roots, and hunting. In addition, people grazed cattle in the forest and mowed glades and forest edges. At that time the area of forest in the middle mountains began to decline to make way for cultivated land. To stabilize the ploughed slopes, people applied terracing which caused a change in the whole ecological situation: redistributing precipitation all over the slope, altering surface runoff, insolation and evaporation and above all changing vegetation cover (Borunov and Bochaver 1987; Belonovskaya and Morozova 1989). Concentrated intensive grazing provoked the severe local xerophytization of meadow ecosystems, both the postforest or primary subalpine meadows. In these changed conditions there was a decrease in the variety of animals and great reduction in the populations of some big game species. In addition, the forays of nomadic tribes caused the complete destruction of large tracts of forest in the most accessible foothill regions, and in intermontane depressions.

Beginning at the start of the 19th century was a new period of total economic upsurge. Forest industry then became one of the main human activities in the mountains. Selective felling of high-quality trees spread widely. By the end of the 19th century the development of industry (and of foreign oil companies in particular) had intensified the predatory destruction of forests, especially in the foothills and low mountains. Beech and dark-coniferous forests on steep slopes in the middle mountains were felled with lesser intensity than the more accessible low mountain oak forests. At the same time, mountain cattle-breeding continued to develop at high speed. The increase in the number of livestock caused the degradation of mountain pastures. Finally, the intensification of erosion processes began and anthropogenic seats of mud-stream and landslip formation appeared in the mountains as a result of industrial felling and neglect in overgrazed pastures.

In the Soviet period, anthropogenic factors took the leading role in forming and transforming biota and biotic interactions. Some new types of economic impact, such as mining (including open cast), industrial, military and civil building and recreation (popular mountain-skiing and summer tourism) were added to the more intensified traditional types: the ploughing of land in the foothills and intermontane depressions, felling in accessible regions, uncontrolled grazing and cutting for hay.

Thus, the forms of using the natural resources remained practically unchanged from the beginning of historical time to the end of the 19th century. The gradual increase in the load and the development of new lands were the main processes. From the middle of the 20th century there began a sharp leap in the transformation of ecosystem cover, and this caused a destabilization of the cover. Traditional forms were intensified, and some previously unknown forms appeared.

In the past, ecosystems "had the time" to adapt themselves to new conditions and more or less retain the stability of ecosystem cover, because of the low intensity and uniformity of the impact. Now the high speed of transformations and the change in the forms of impact in one area (felling, then hay-mowing, then grazing, then ploughing, then building) make it very hard for ecosystem biota to adapt, and often make progressive succession impossible.

HUMAN-INDUCED TRANSFORMATIONS OF THE CAUCASIAN ECOSYSTEM COVER

The mosaic structure of ecosystem cover and gradientality of the natural mountain environment play a double role in the stability of mountain ecosystem. On the one hand, the biota of mountain ecosystems, taken separately, are more vulnerable to many aspects of anthropogenic impact on its structure and functioning, than that of plain ecosystems. This results from their transitory locations, dissected relief, great richness in potential energy, and special conditions of reduntant wetting. An equal intensity of load leads to more severe results and a greater degree of transformation in the mountains than on the plain. On the other hand, the mosaic structure of ecosystem cover and the proximity of analogous ecosystems with differing degrees of accessibility (and therefore safety) combine with the more intensive biological relations to allow the restoration of the biotic structure of destroyed ecosystems via the biotic fund of ecosystem-refuges. This may be achieved quickly enough in cases of the absences or remission of anthropogenic press. Thus, the safety of biological diversity can at least be guaranteed more easily in main-

Table 1. The human-induced transformation of the montane ecosystems of the Great Caucasus. I. Changes in species composition: a — impoverishment; b — species change; c — quantitative decrease. II. Transformation of community structure: a — reduction in density and coverage; b — decrease in stand and herbage height; c — decrease in productivity; d — change of communities. III. Change of habitats

Ecosystems Forms of impact			Semi-deserts				Steppes				Forests and light forests																												Sub-alpine meadows				Alpine meadows			
											Xerophilous				Pubescent oak				Oak				Mixed				Beech				Dark-coniferous				Pine											
			a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Agriculture	Irrigated	I		+				+				+																																		
		II				+				+				+																														
		III	salinization																																									
	Unirrigated	I		+				+				+																																
		II				+				+				+																														
		III	soil degradation, erosion																																									
Cattle-breeding	Winter pasture	I	+	+			+	+			+	+			+	+			+	+			+	+																				
		II	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+																		
		III	aridization, xerophytization																				slope-washes																					
	Summer pasture	I					+	+			+	+			+	+			+	+			+	+							+	+			+	+			+	+			+	+		
		II					+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+					+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		III									river drying up, erosion												slope-washes								river drying up, soil degradation, erosion, avalanche danger															
	Hay-mowing	I																					+				+				+				+											
		II																									+	+	+		+	+	+		+	+	+									
		III																																										
Forest felling	Selective	I										+			+	+			+	+			+	+			+	+			+	+			+	+										
		II												+				+				+				+				+				+				+								
		III									aridization, erosion																																	
	Clear	I										+								+			+	+			+	+			+	+			+	+										
		II									+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+								
		III									aridization, river drying up, slope-washes, erosion, avalanche danger																																	
Recreation	Tourism	I	+				+	+							+	+			+				+				+				+				+				+				+			
		II				+	+	+	+	+									+	+			+	+			+	+			+	+			+	+			+	+			+	+		
		III	aridization, soil degradation, erosion, fires, avalanche danger																																									

tains than on the plain, where horizontal links between isolated fragments of ecosystems are far weaker, and the changes in the destroyed fragments more severe.

Such a specific character of mountain ecosystems allows stability to be maintained in the face of anthropogenic impacts and allows for the restoration of the structure of ecosystem cover after reserving for a long time in those variants of Great Caucasus's zonality structure, where the diversity of ecosystems is the greatest.

Analysis of the series of anthropogenic transformations in ecosystem biota of the Great Caucasus has allowed the main forms of impact to be revealed and has shown regularities in the reactions of the ecosystem to them. Explored by field experimentation, the forms of anthropogenic impact on ecosystems leading to change in its structure, biotic composition and overall status are summarized in Table 1.

A map shows the distribution of the main forms of impact on the ecosystem cover of the Great Caucasus (Fig. 2). The diversity of Caucasian ecosystems supposes not only the various utilization of biotic resources, but also the different reactions of biota to these impacts.

Tables 2, 3 and 4 give several examples of transformations of steppe, forest and high mountain meadow ecosystems as a result of human activity. The map of the modern distribution of ecosystems in the Great Caucasus shows the results of this impact, or, precisely, the history and summary effect of human activity in this region (Fig. 3). The comparison of maps allows transformations in regional and zonal types of ecosystem cover to revealed. The map of human induced transformation of ecosystem cover in the Great Caucasus shows the extent of these changes (Fig. 4).

Table 2. The transformation of ecosystems of the mountain steppe zone in the Great Caucasus

Location and ecological conditions		Intermountain depressions and high mountain plateaus of the Northern Caucasus	Mountain steppes of the Transcaucasus
Form of impact	Degree of disturbance		
No impact	Undisturbed	Steppe-meadows, meadow feather grass-mixed herb steppes, true steppes	Meadow feather grass-mixed herb steppes, dry steppes
Mowing, light grazing	Weakly disturbed	Weed infested steppe-meadows, meadows and true steppes	Meadows, true and dry steppes
Moderate grazing	Moderately disturbed	Overgrazed true (grass-herb) steppe, secondary dry steppe with *Andropogon ischaemus*	
Heavy grazing	Strongly disturbed	Phrygonoide xeroph. tragacanth (*Astragalus sp.*), semideserts (*Artemisia sp.*)	
Overgrazing	Completely disturbed	Petrophyte steppe fragments, groups of weeds, erosional sites without vegetation cover	

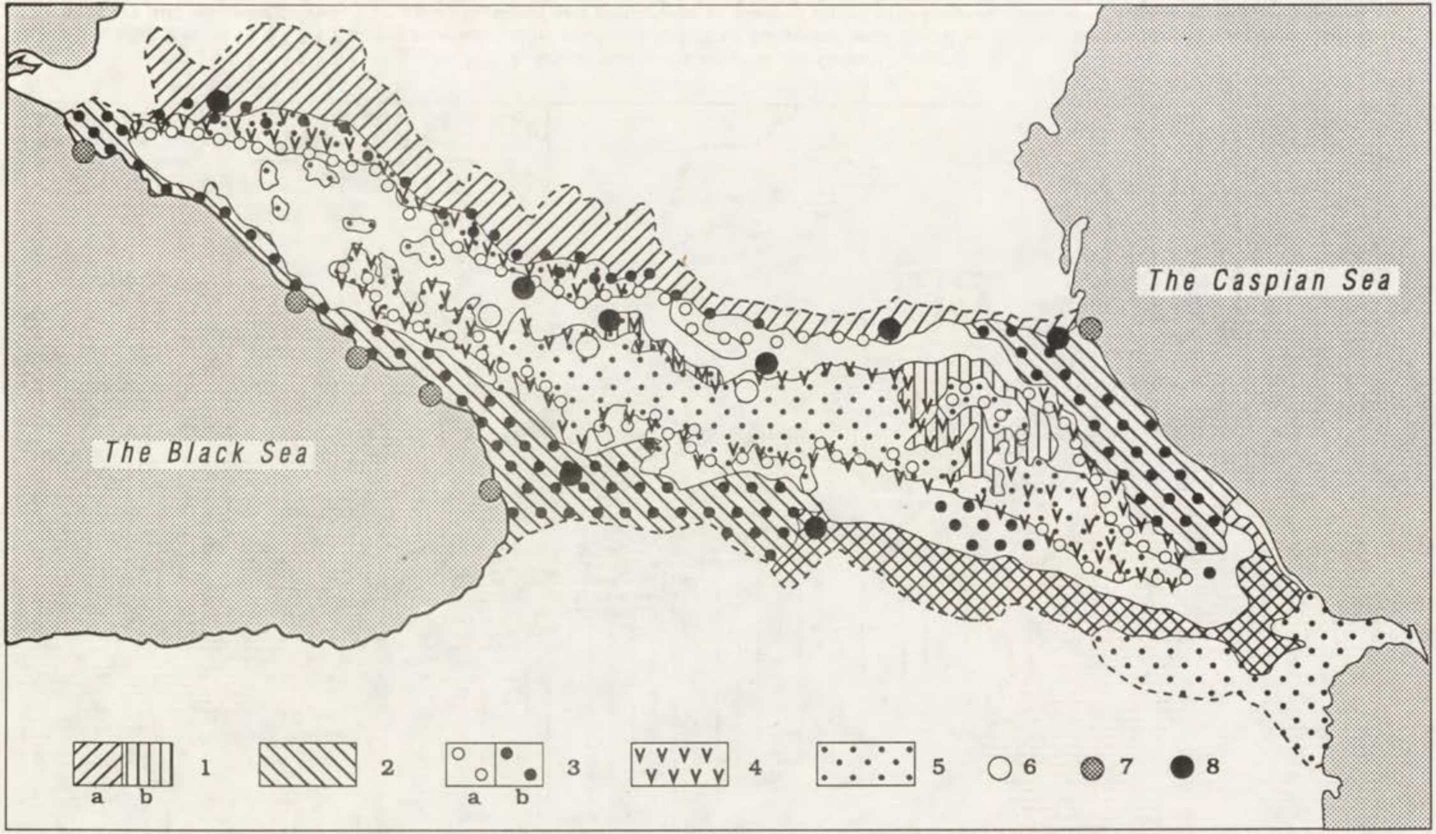

Fig. 2. Types of anthropogenic impact on the ecosystems of the Great Caucasus
1 — ploughing for cereals; a) modern, b) ancient; 2 — plowing for fruit plantations; 3 — cutting: a) modern, b) ancient; 4 — mowing; 5 — grazing; 6 — ski and tourism centres; 7 — recreation coastal zones; 8 — industry

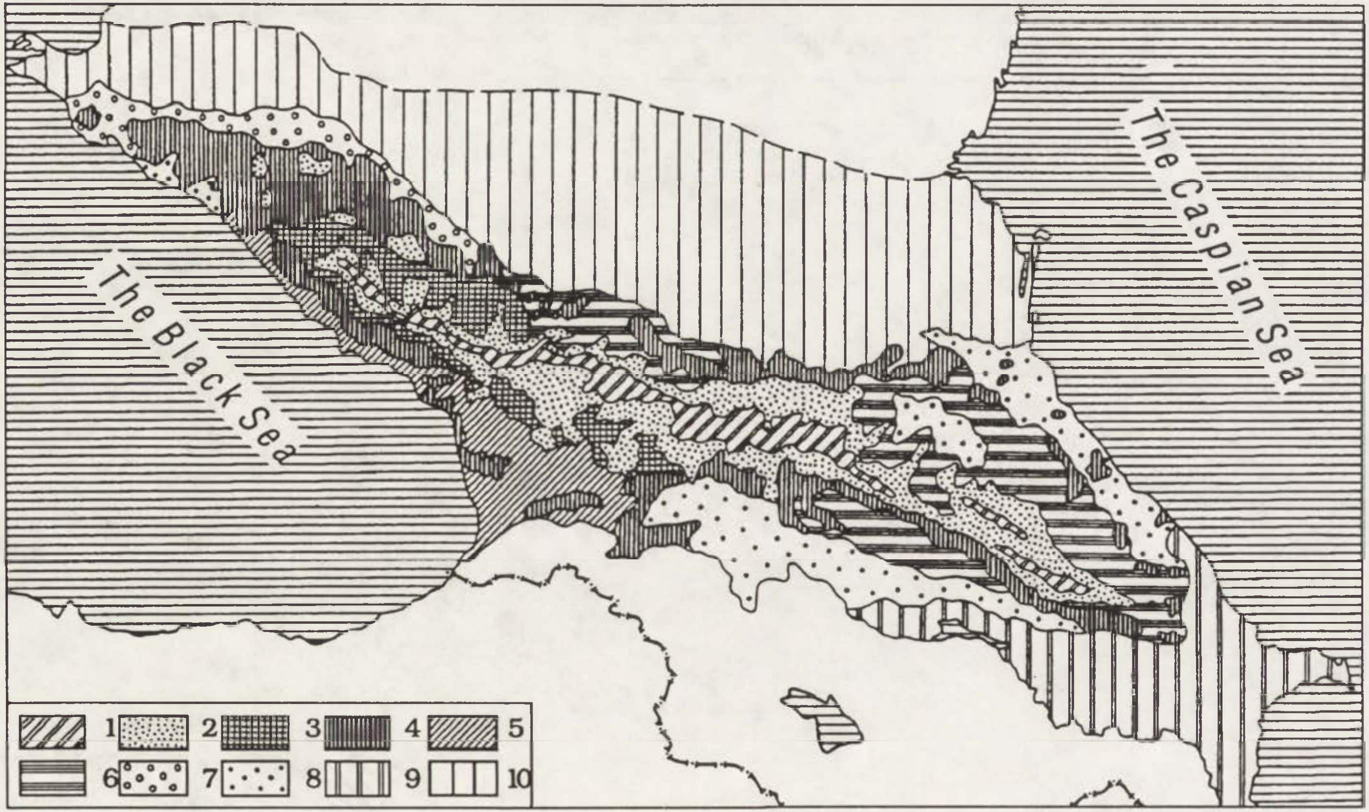

Fig. 3. Actual ecosystem cover of the Great Caucasus
1 — alpine meadows; 2 — subalpine meadows, elfin woodland including deforested localities; 3 — dark-coniferous forest; 4 — broad-leaved primary and secondary forest; 5 — agroecosystems and plantations in place of mixed broad-leaved forest; 6 — secondary steppe-meadows with fragments of steppe; 7 — deforested slopes with open woodland and scrub; 8 — phrygana with fragments of dry steppe and cultivated localities; 9 — dry steppe and semidesert with cultivated localities; 10 — cropland mainly

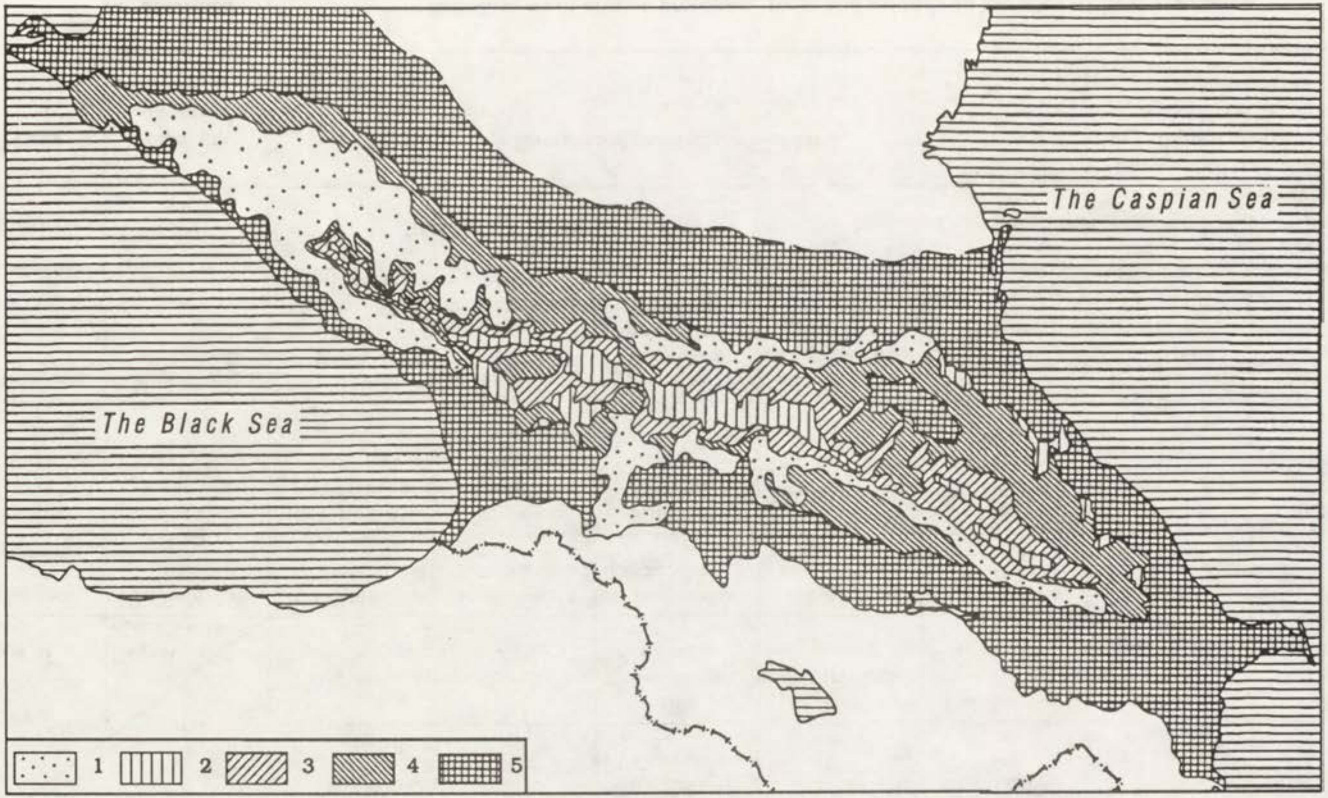

Fig. 4. Degree of human-induced transformation of ecosystem cover in the Great Caucasus
1 — undisturbed ecosystems; 2 — weakly disturbed ecosystems; 3 — moderately disturbed ecosystems; 4 — strongly disturbed ecosystems; 5 — completely disturbed ecosystems

Table 3. The transformation of forest ecosystems in the Great Caucaus

Location and ecological conditions		The upper part of the forest zone			The lower part of the forest zone			
		The Western Caucasus		The Central and Eastern Caucasus	The Western Transcaucasus		The North-Western and Eastern Caucasus	The Eastern Caucasus
Forms of impact	Degree of disturbance	Wet moderate-continental climate		Dry continental climate	Wet subtropical climate	Moderate wet-continental climate	Arid submediterranean climate	Arid continental and subtropical climate
No impact	Undisturbed	Dark-coniferous forests	Beech forests (*Fagus orientalis*)	Pine forests (*Pinus slvestris*)	Mixed broad-leaved forests	Oak forests	Forests with pubescent oak	Juniper xerophilous light forests
Selecting felling	Weakly disturbed	Montane marple open woodland (*Acer trautvetteri*)	Hornbeam forests, montane marple open woodland	Pine light forests	Hornbeam forests		Forest with pubescent oak	Secondary steppe communities
Clear felling	Moderately disturbed	Ericaceae brakes (*Rhododendron ponticum, Rhododendron flavum, Vaccinium arctostaphylos*) tall herbaceous meadows		Secondary subalpine communities, meadows	Bush brakes (*Rhododendron ponticum, Vaccinium arctostaphylos*)	Bush brakes (*Rhododendron flavum*)	Bush brakes (*Quercus pubescens, Carpinus orientalis*)	Secondary steppe communities
Mowing		Grass-herb meadows			Meadows and meadow-steppes			Secondary steppe communities
Grazing	Strongly disturbed	Overgrazed short-grass meadows					Phryganoid communities on dry steppes and semideserts, petrophylos vegetation, tomillares	
	Completely disturbed	Soil slope wash erosion processes, rocks and mounds on the sites without vegetation						

Table 4. The transformation of ecosystems of the high-mountain of the Great Caucasus

<table>
<tr><th colspan="2">Location and ecological condition</th><th rowspan="2">Cold and wet northern slopes of the Western, Central, Eastern Caucasus</th><th rowspan="2">Warm and wet slopes of the Western Caucasus</th><th rowspan="2">Warm and dry southern of the Central Caucasus</th><th rowspan="2">Warm and arid southern slopes of the Eastern Caucasus</th></tr>
<tr><th>Forms of impact</th><th>Degree of disturbance</th></tr>
<tr><td>No impact</td><td>Undisturbed</td><td>Birch (<i>Betula litwinowii</i>) elfin woodlands, <i>Rhododendron caucasicum</i> brakes, subalpine and alpine meadows</td><td>Beech (<i>Fagus orientalis</i>) and birch elfin woodlands subalpine and alpine meadows</td><td>Pine (<i>Pinus silvestris</i>) light forests, subalpine and alpine meadows</td><td>Oak <i>(Quercus macranthera)</i> light forests, subalpine and alpine meadows</td></tr>
<tr><td>Felling</td><td>Weakly disturbed</td><td colspan="2">Beech and birch elfin woodlands maple (<i>Acer trautvetteri</i>) light forest, subalpine and alpine meadows</td><td>Oak light forests, subalpine and alpine meadows</td><td>Oak light forests subalpine and alpine meadows</td></tr>
<tr><td>Mowing</td><td>Moderately disturbed</td><td colspan="2">Tall herbaceous meadows with shrubs</td><td colspan="2">Subalpine and alpine meadows</td></tr>
<tr><td>Grazing</td><td>Strongly disturbed</td><td colspan="3">Short grass meadows-pastures, overgrazed matgrass, communities of alpine meadows</td><td>Xerophytic-ruderal communities</td></tr>
<tr><td></td><td>Completely disturbed</td><td colspan="4">Open subalpine and alpine meadows, local rock-mound species on the slopes without vegetation and with erosion forms of relief</td></tr>
</table>

CONCLUSIONS

Analysis of tables and maps allows for the following conclusions to be drawn.

The impoverishment of species composition and the reduction of animal and plant populations; the simplification of ecosystem structure (decreased density or cover, the dissapearence of strata, the lowering of the height of the stand or herbage); declining productivity; and the destruction of primary ecosystems and their replacement by secondary ones which are mostly less valuable and productive, and by anthropogenic ecological complexes (cultivated land with artificially spread crops and groups of animals best adapted to the conditions of the economic development of lands as well as pests specialized of cultivated plants) — all these phenomena appear as a result of prolonged and intensive human economic activity.

The impractical utilization of land resources, i.e. the non-optimal selection of rural cultures for present natural conditions, can, along with wrong agrotechnics and overgrazing, cause the drying of slopes, changes in the regime of unconfined ground water, the slope wash of fine earth, the intensification of erosional processes and so on.

A specific feature of the mountain environment — high gradientality — combines with the dissected relief and potential gravitational energy to ensure that natural processes in the mountains are intensive. These processes are connected with the transportation of energy and matter (avalanches, landslips, mud-streams, rockfalls, glacial motion, soil slope wash and linear erosion). In such a "mobile" environment, anthropogenic factors act as a catalyst for catastrophic natural factors, intensifying and speeding-up the transformation of ecosystems over and over again.

The vulnerability of ecosystems is a function of their usefulness to man, and above all to the human economy. Under these conditions there can be ecosystems of three types: those in which the impact is directed respectively at the ecotope (relief or soil), at the biotic cover or at the separate species of biological resources. The first are most destroyed, the second destroyed to a lesser degree, and the third — minimally (Zlotin et al. 1989). The possibility of the restoration of an ecosystem depends on the stages of destruction (Fig. 5).

Thus (if it is examined separately), the reaction of each mountain ecosystem to the impact of natural and anthropogenic factors is similar to the reaction of analogous plain ecosystems. But the specific character of mountain country lies in the unity of functioning of all its parts, from mountain glaciers to piedmont plains. So in the mountains, the transformation of one part will have an effect on all the others. It is for this reason that measures to protect ecosystem cover ought to be complex, with the exploitation of mountain resources taking into account the unity of the cycle of matter and energy in the "mountains — plain" system.

It is necessary to preserve the typological diversity of ecosystem cover in the Great Caucasus, and the in-depth ecological and geographical ex-

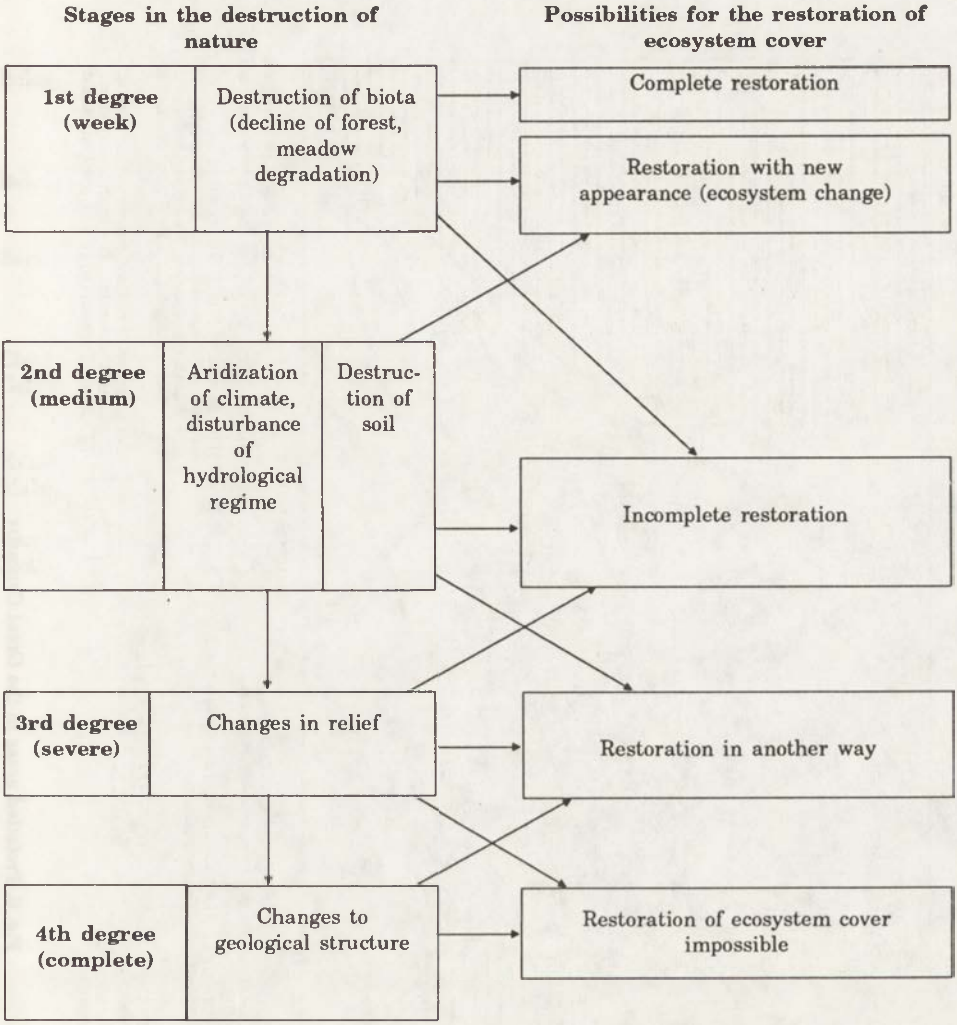

Fig. 5. The possibility for restoration of ecosystems in the Great Caucasus

ploration and inventoring of dissappearing ecosystems, their modern status and degree of destruction is therefore an urgent matter. With regard to the aforementioned criteria, three categories of ecosystem requiring particular protection and special restoration measures are singled out.

The analysis of the present status of ecosystem cover and the modern network of reserves in the Great Caucasus has allowed some proposals to be made as to how to improve this network. The way to do this is to change the status of some reserves and to create new ones for the preservation of the unity of ecosystem cover and variety (Fig. 6).

Reserves:

■ existing (1 - Caucasian, 2 - Teberdinian, 3 - Kabardino-Balkarian, 4 - North Osetian, 5 - Ricinian, 6 - Picundio-Mjusserian, 7 - Staplijskian, 8 - Saguramian, 9 - Mariamian, 10 - Bacaro-Babaneurian, 11 - Lagodechian, 12 - Zakatalian)

○ planned (13 - Checheno-Ingushian, 14 - Daghestanian)

Republic game reserves:

▥ existing (22 - Golovinian, 23 - Cejsian, 24 - Checheno-Ingushian)

○ planned (25 - Samurian, 26 - Mineral Waters, 27 - Agrachanian)

▨ Local game reserves

National parks:

▨ existing (15 - Sochian)

○ planned (16 - Montane-Black Sea coastal or Gorno-Chernomorian, 17 - Gagrian, 18 - North Caucasian, 19 - Elbrusian, 20 - Vladicaucasian, 21 - Upper Svanetian)

○ unique landscapes

● rare phytocoenosis

boundaries of nature conservation zones: I - North Caucasian, II - Transcaucasian, III - Seaside resort's, IV - Great Caucasian

Fig. 6. Protected areas in the Great Caucasus

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THE RESPONSES OF MONTANE BEETLES (*COLEOPTERA*) TO CLIMATIC CHANGE

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Abstract. Selected species of beetles were studied in the laboratory bar with gradient temperature from -4 to 35°C. Beatles show very significant differences between species preferred temperatures. The narrow range of temperature variation was preferred by montane species. The same species were collected at different altitudes on Mount Snowdon, North Wales.

Key words: montane beetles, temperature gradient, response to climate change.

INTRODUCTION

Although changing climate can pose problems for many plants and animals of conservation importance, these problems are particularly acute for montane organisms, particularly those at the highest elevations. This is because high mountain peaks can be regarded as "islands" and a mountain range as an "archipelago". Species adapted to montane conditions are likely to be driven off these islands by amelioration of climate, either because of physiological constraints or because of inability to out-compete other species better adapted to the new climatic regime.

The Holocene and Pleistocene periods have been characterized by very rapid and extreme fluctuations of climate, and by equally rapid and profound changes of range in plants and animals; the migrations of *Coleoptera* have been particularly well documented (Coope, 1994). However, current perceptions of the responses of such organisms to climatic change have to take into account the land-use changes brought about by man during the historic period especially in the developed world (Thomas and Morris, 1994). It is highly likely that interaction of these changes with climatic modification will inhibit the large-scale migrations of species which were characteristic of the prehistoric period. It is particularly important to emphasize this point, because it is generally recognized that land-use in montane areas has been slight, at least in the large tracts inaccessible to tourist pressure, when compared to change in the lowlands. This is especially true in North Wales (Hughes et al., 1973).

Particular interest therefore attaches to the responses of organisms to climatic change, and especially to species of conservation importance. Hard decisions may be required in allocating resources for the conservation of species at risk, in particular those with “nowhere to go”. First, however, the responses of these species, and others, to changing climatic characteristics need to be assessed.

SITE, MATERIAL AND METHODS

The work described was undertaken by the senior author in collaboration with the colleagues named in the Acknowledgments; the junior author has merely presented the findings at the Zakopane symposium and in this paper.

The mountains of North Wales have a relatively low relief and the coleopterous fauna is not species-rich compared with that of higher, continental mountain ranges such as the Tatras. Only 38 species of *Coleoptera* have been recorded in the study area. Nevertheless, the North Wales mountains support species of conservation importance, most notably *Chrysolina cerealis* (Col., Chrysomelidae) (Buse, 1993). This colourful species is not known to occur in the British Isles outside the Snowdon Range and is a protected species under British domestic legislation. Because of this, and other factors, it was not possible to study the responses of this beetle to climatic variation, but other *Coleoptera* occurring on an elevational gradient in the same area were studied in the field and in the laboratory.

The study area was situated on Mount Snowdon (53°04’N 4°04’W) from about 610 m to the summit at 1085 m a.s.l. Full details are given by Buse et al. (in press).

FIELD WORK

Sampling montane beetle faunas presents considerable problems for a number of reasons. The problems were reduced, if not resolved, by restricting the study to one habitat-type (biotope), namely grazed *Festuca* grassland (Festucetum rubrae) and by using pitfall (Barber) traps to record the occurrence and surface activity of beetles. On a restricted site it was thought that indices of surface activity would approximate well to abundance.

Groups of 10 traps, spaced at about 1 m, were set at four different elevations, 660, 860, 980 and 1055 m (approximately). Each trap contained a small quantity of ethylene glycol and was emptied weekly, weatherpermitting. The periods of recording were July-October 1989 and April-October 1990. Names of *Coleoptera* follow Kloet and Hincks (1977).

Because temperature is the climatic variable most frequently assessed in studies of climate change several measures of the temperature regime at the study site were recorded. These included fortnightly records of maximum and minimum temperatures, recorded in the grass sward in the shade. Also taken were diurnal temperature profiles in the grass sward in the shade, sward in full sun and under a boulder. These temperature profiles were recorded on both sunny and cloudy days. Full details are given by Buse et al. (in press).

LABORATORY STUDIES

The aim of work in the laboratory was to determine the temperature preferences of montane beetles, including species perceived to be mountain specialists and others which were more generally eurytopic. To this end, an apparatus was constructed which provided a gradient of temperature from -4 to 35°C. The apparatus, or 'arena', consisted of an aluminium bar 1.15 m long which was thermally insulated. A heat source was attached at one end and a heat sink at the other. Details of the construction of the apparatus and the physical characteristics of the heating and cooling devices are give in Buse et al. (in press).

The apparatus was used to determine the 'prefered' temperatures of a range of montane beetles collected from five different Snowdon sites of which four equated to the fieldwork sites. The effects of the site of origin of the tested beetles, and of their initial positions when placed on the on the heated bar were also assessed. Because of its abundance at the site, the harvestman *Mitopus morio* (Phalangida) was also included as a test animal.

Although the exact significance of 'temperature preferences' is controversial, so little is known about the responses of invertebrates (other than pests) to climatic factors that such information is regarded as a useful contribution to the subject.

RESULTS

THE SNOWDON FAUNA

The beetle species collected in pitfall traps on the Snowdon study area were dominated by *Carabidae*, with relatively few *Staphylinidae* and very small numbers of representatives of other families (Table 1). Stenophagous species (eg *Chrysomelidae* and *Curculionoidea*) were not recorded (though some are known from the Snowdon region) and other phytophagous species were few in number. Predacious and detritivorous species made up the bulk of the fauna, though some dung-feeding species were also recorded.

The eight most numerous beetle species in the pitfall traps include three regarded as characteristically montane, two typically lowland species, and two which occur at both high and low elevations but which appear to be more abundant in upland areas. *Hypnoidus riparius* appears to be commoner at high elevations than low ones, but is also riparian as well as being occasionally found on the sea coast (Table 2).

EFFECTS OF ALTITUDE

Truly montane species, such as *Nebria gyllenhali* (Fig. 1) and *Geodromicus longipes* (Fig. 2) were virtually confined to the three highest sampling sites, although there were statistically significant differences between the numbers taken at these higher elevations. *Pterostichus madidus*, a typically lowland species, was taken in small numbers, but mostly at the lowest sampling station (Fig. 3). *Notiophilus germinyi* (Fig.4) and *Byrrhus pilula* (Fig. 5) tended to increase in numbers at successively higher altitudes. *Patrobus assimilis* showed a significant difference in its abundance at 980 and 1055 m (Fig. 6).

Table 1. Beetle species collected in pitfall traps on Snowdon

CARABIDAE
Carabus problematicus
Leistus rufomarginatus
Nebria gyllenhali
N. salina
Notiophilus aquaticus
N. biguttatus
N. germinyi
Patrobus assimilis
Trechus obtusus
Bembidion aeneum
Pterostichus adstrictus
P. aethiops
P. diligens
P. madidus
P. niger
Abax parallelepipedus
Calathus melanocephalus
Bradycellus ruficollis

CHOLEVIDAE
Catops nigricans

STAPHYLINIDAE
Arpedium brachypterum
Acidota crenata
Geodromicus longipes
Anthophagus alpinus
Lathobium fulvipenne
Othius angustus
Philonthus varius
Quedius boopoides
Mycetoporus angularis
M. lepidus

GEOTRUPIDAE
Geotrupes stercorosus

SCARABAEIDAE
Aphodius depressus
Aphodius lapponum

DASCILLIDAE
Dascillus cervinus

BYRRHIDAE
Byrrhus pilula

ELATERIDAE
Hypnoidus riparius
Athous haemorrhoidalis
Ctenicera cuprea

COCCINELLIDAE
Coccinella septempunctata

Table 2. Characteristics of the eight most numerous species in pitfall traps on Snowdon

Nebria gyllenhali	* Montane
Notiophilus germinyi	Eurytopic
Patrobus assimilis	* Montane
Pterostichus madidus	Typically lowland
Geodromicus longipes	* Montane
Byrrhus pilula	Eurytopic
Ctenicera cuprea	Upland/lowland
Hypnoidus riparius	? Eurytopic

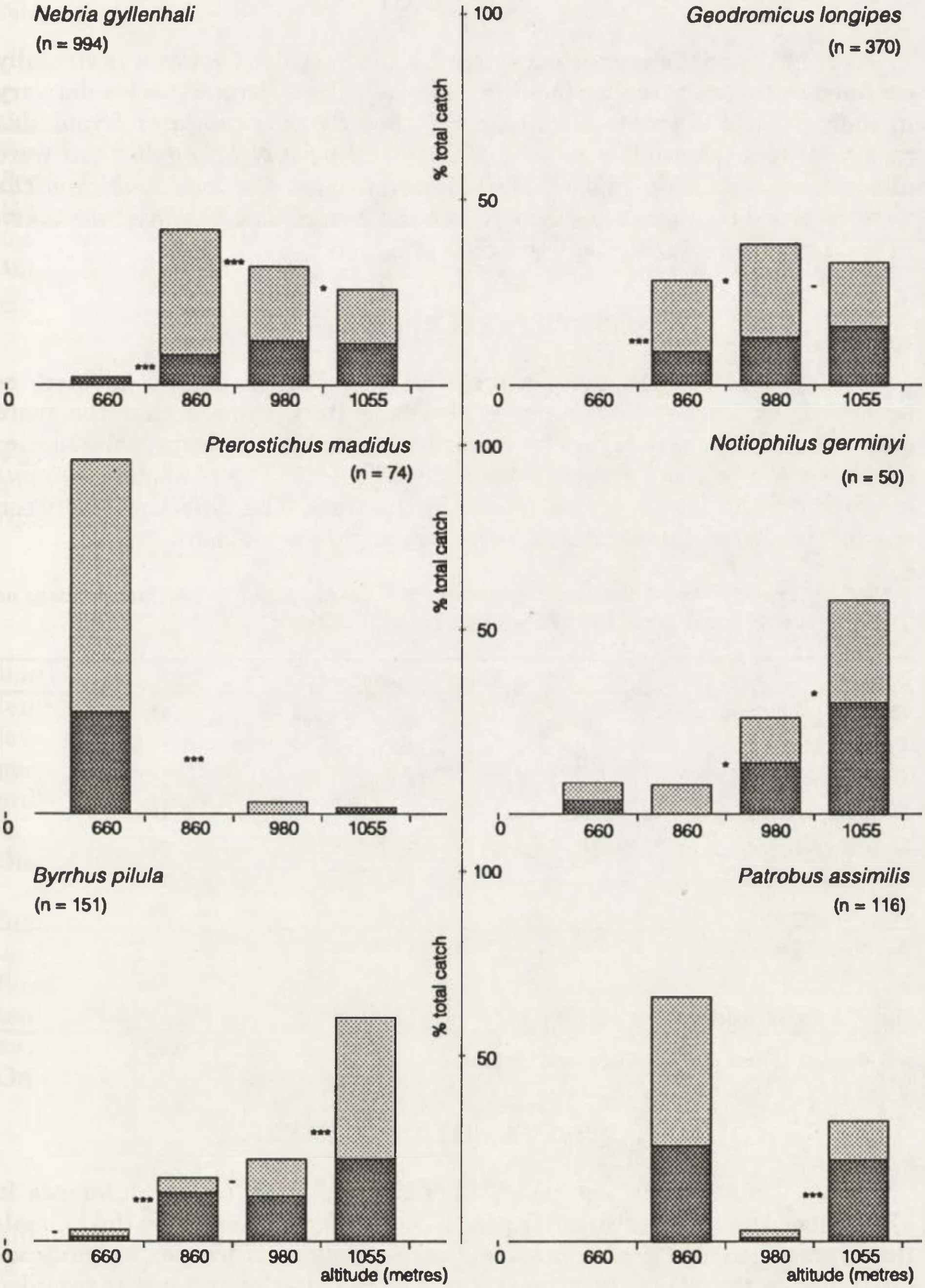

Fig. 1. Total numbers of individual adult beetles of six species collected in pitfall traps set in *Festuca rubra* swards at four elevations, Snowdon, North Wales. Solid columns: July-October 1989. Hatched columns: April-October 1990. Significant differences between catches at different elevations: * $p<0.05$, *** $p<0.001$

PHENOLOGY

As might have been expected, activity of the Snowdon beetles was virtually confined to the midsummer months. However, the different species did vary in their periods of greatest activity. Very few *Byrrhus pilula* or *Hypnoidus ripiarius* were taken after the end of July, and most *Nebria gyllenhali* were also collected in early midsummer. However, most *Carabus problematicus* were recorded in August and September and *Notophilus germinyi* was taken in some numbers throughout the recording periods.

PREFERRED TEMPERATURES

A comparison of the temperatures at the positions finally adopted, or preferred, by the species tested in the laboratory showed that the more eurytopic beetles chose higher temperatures than the strictly montane species (*Nebria gyllenhali* and *Patrobus assimilis)* (Table 3). The phalangid *Mitopus morio* chose the lowest temperatures in the tests. The differences between species' preferred temperatures were very highly significant.

Table 3. A comparison of the mean temperatures for each species of the final positions on the thermal bar in the temperature gradient trials

Species	Mean temperature	N
Carabus problematicus	15.5	14
Byrrhus piluia	14.8	15
Hypnoidus riparius	14.1	15
Notiophilus germinyi	12.9	12
Nebria gyllenhali	7.1	30
Patrobus assimilis	5.6	17
Mitopus morio	3.4	52
Average SE	1.07	
R^2	0.541	
Significance of species effect	$p < 0.001$	

N = number of runs contributing to the mean

INFLUENCE OF SITE OF COLLECTION

In most cases there was no effect of the site of collection (difference in altitude) on the temperatures adopted in the choice apparatus by the animals that were tested (eg *Carabus problematicus* — Table 4). However, a significant difference in the SD of the temperatures at the sites of origin was recorded for *Nebria gyllenhali* and probably also for *Mitopus morio* (Table 4). In both cases the temperatures preferred by the tested animals were more variable when they had been collected at lower elevations compared with the more elevated sites.

Table 4. The effect of origin (site of collection) on the final position of species on the thermal bar in the temperature gradient trials

		Origin (M)					
Species	means	1066	980	860	SE	R^2	P
Carabus	temp.		17.6	14.7	3.01	0.009	>0.05
Problematicus	SD			6.85	1.870	0.034	>0.05
Nebria	temp.	7.9	6.2	7.6	1.19	0.043	>0.05
Gyllenhali	SD	3.96	1.64	1.52	0.456	0.562	<0.05
Mitopus	temp.	6.2	2.7	2.2	0.88	0.234	0.05
Morio	SD	5.96	5.8	3.57	0.890	0.161	=0.05

INFLUENCE OF POINT OF INTRODUCTION TO THE CHOICE ARENA

There were few cases in which the point on the heated/cooled bar at which the animals were initially placed influenced the final position. However, a significant difference in SD was recorded for the test specimens of *Hypnoidus riparius* which were introduced at lower temperatures in the choice apparatus.

SITE TEMPERATURES

On the study site there was a general correspondence of recorded site temperatures with altitude. However, although maximum temperatures tended to be lower at the higher elevations, the site at 860 m (the second lowest) was coldest for most of the records. Temperature minima were in general more closely correlated with altidude, with some interchange in order between the two upper, and the two lower, sites. The range of variation in maximum temperatures was about 10°C in August and 2°C in October; the corresponding range of minimum temperatures was about 5°C and 1°C.

The diurnal range of temperature at the site was greatest for the sward in full sun on a sunny day, at about 16°C; the highest and lowest temperatures were also recorded under this regime. Also on a sunny day the smallest fluctuations (temperature range), highest night temperatures and lowest day temperatures were all recorded under the boulder. Temperatures in the shaded sward were roughly similar, though slightly lower by night and higher by day. On a cloudy day the three temperature profiles were much closer together.

DISCUSSION

It is plausibly hypothesized that climatic change of any magnitude would alter the distribution and abundance of plants and animals, through a variety of secondary effects. Montane plants and animals are widely perceived to be particularly at risk because, unlike many lowland species, 'they have nowhere to go'. In this short paper results are presented which examine the basis of these ideas in three ways: the current abundance and distribution of montane *Coleoptera*; the temperature regimes they encounter; and the responses they make to temperature variation under laboratory conditions.

The fauna recorded on Snowdon was species-poor. In contrast to the 38 species of *Coleoptera* recorded during the study within the altitudinal range 660-1055 m Buse (1988) found 120 at a nearby hill' site (310-390 m). However, there was more diversity of biotopes at the lower site. The Snowdon fauna, though small in numbers of species, included beetles which could be characterized as truly "montane", "upland" and "lowland", with some subdivision of these categories being possible. Of special significance in the Snowdon mountain range is the rare chrysomelid, *Chrysolina cerealis*.

The differences in preferred temperatures between the montane species (eg *Nebria gyllenhali*) and the upland and lowland ones was very marked, as was the narrow range of temperatures preferred by the montane beetles. Although the simple choice tests which were made should be repeated under conditions in which humidity and other physical variables can be controlled, and where the effects of hunger and thirst can be assessed these preliminary results do suggest that montane species certainly have a narrow range of climatic variation under which they can survive. The significance of such a constraining climatic regime may lie in reduced competition or predation as well as physiological adaptation.

It is notoriously difficult to relate temperatures, and temperature regimes, to the occurrence and activity of animals in the field. The records of annual and diurnal temperature variation at the Snowdon site do, however, give an indication of the climatic regime under which the animals live. Most of the species recorded are active at night, though *Notiophilus germinyi* is a large-eyed diurnal predator. The minimum, night time temperature is therefore probably the one under which most activity is undertaken. The equable temperature regime to be found under stones and boulders causes no surprise to the field coleopterist who is acustomed to find beetles abundantly in such situations, but the protection from predation, food supply; humidity and aggregation for mating are a few of the additional factors which need to be assessed before temperature can be judged to be a major factor in the distribution of *Coleoptera* under stones.

From studies of their present distribution, together with supporting evidence, *Nebria gyllenhali* and *Patrobus assimilis* can be regarded as glacial relic species in Snowdonia. Calculations based on the recorded lapse rate for air temperatures in the British Isles (Giddings 1980) and postulated temperature increases under "global warming" of 2°C or 3°C can be made to assess the possible fate of these species in the Snowdon Mountain range. A 2°C rise in temperature would be equivalent to a 333 m decrease in altitude and a 3°C rise equivalent to one of about 500 m. Under these crude estimates of the effects of climate change, and assuming an effect of temperature alone, montane animals such as *Nebria gyllenhali* and *Patrobus assimilis* would fail to survive in North Wales.

Such simple calculations can do no more than suggest possibilities, since they fail to include a wide range of other factors, physical and biotic, and pay little attention to the variation in ecological conditions encountered in the field. In particular, under conditions of climatic change "extreme events" have been widely predicted as likely to have more severe, far-reaching and long-lasting effects than gradual increases in temperature or other climatic facors. However, the results presented here, incomplete as they are, can indicate where future research might be usefully directed.

Further, more detailed, studies on microclimate in the field are required, with emphasis on the interaction of other factors with temperature. The relevance of microclimatic regimes and their variation needs to be better explored. The influence of climatic factors on the survival of all stages of *Coleoptera* (and other animals and plants), for instance active and diapausing developmental stages, requires exploration, with perhaps emphasis on cold-hardiness. The behaviour of montane and upland invertebrates needs to be examined under field, and under realistic laboratory conditions.

Finally, the conservation of montane species, such as *Chrysolina cerealis*, under climatic change needs particular attention. Currently, emphasis could be given to two aspects: the international picture and the “safety net” provided by *ex situ* conservation. *C. cerealis* is widely distributed in central Europe (Lucht 1987), and may not be so severely threatened by climatic change as in the British Isles. The species is easy to rear in captivity, and maintenance of the species *ex situ*, though far from ideal in the context of its conservation, may be a useful fall-back position in the event of increasing threat to its continued existence in situ in North Wales.

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THE ZONALITY AND HEALTH OF FOREST IN THE TATRA NATIONAL PARK

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Abstract. Paleontological findings, the history and the present condition of Slovakian Tatra forest are introduced. Human influence on its natural occurrence and zonality is analysed. As a basis for forest management the grouping of geobiocoenoses according to their natural distribution is proposed.

Key words: forest zonation, mountain forests, paleoecology in Tatra Mts.

The naturalness of the plant communities was one of the major reasons for declaring the Slovakian Tatras and the surrounding area a National Park in 1948.

The zonality of vegetation plays an important role in the management of the National Park, and is considered in the zonation of the Tatra Biosphere Reserve.

I'd like to focus your attention on the forest, as one component of the natural environment of the Tatras. The Slovak part of the Tatra Biosphere Reserve has an area of 110 000 hectares, with forest occupying 60 000 ha of this.

The forest has been an object of human interest since the 13th century, when shepherds found places to graze cattle and sheep by burning and cutting the dwarf mountain pine, the original spruce forest with larch, stone pine, fir and maple trees. Other undesirable traces in the forest, and in dwarf mountain pine stands, have been left by mining activities, older iron works, charcoal burning and (in the last century) by lumbering. All these activities caused changes to the structure of the forest, especially along the accesible edges, in the valleys, and at the upper treeline. Nevertheless in spite of this long-term human presure, the zonation of vegetation with altitude has survived in almost its original form.

The first recognition of the outstanding nature of the Tatra forest came from Professor Tchermak of Vienna University, in the 40's. In the 50's the "Investigations of the Natural Conditions of Slovakia" confirmed that the natural environment of the Tatras differed from that in other mountain regions of Slovakia, in the absence of beech (*Fagus silvatica*) and yew (*Taxus baccata*), the poor occurence of fir (*Abies alba*) in the central parts, and also in the presence of autochtonous pine (*Pinus sylvestris*), stone pine (*Pinus cembra)* and larch (*Larix decidua*) and in the absolute prevalence of spruce (*Picea abies*).

The natural spatial distribution of tree species has been most affected by climatic conditions, which stabilized roughly 2000 years ago.

Pollen analysis in peat bogs shows the historical development of the Tatra forest, arising from the last (würm) glacial period, when the majority of the Tatra area was covered or influenced by glaciers. When the glaciers receeded, conditions developed for colonization by low vegetation and later by trees. In the preboreal period (8-10 000 years BP), almost 50% of the area was covered by a forest with pine and birch, and the upper treeline was at 1000 m above sea level. Warming in the boreal period gave rise to the strong expansion of spruce. The dry and warm Atlantic period (7500-4500 years BP) created conditions for the spread of oak, even to altitudes of over 1400 m on the south slopes. The wet part of the Atlantic period was the time of the replacement of pine and birch by spruce and fir. A drastic fall in humidity led to a significant decline of the forest in the subboreal period (4500-2500 years BP).

The next, sub-Atlantic period is assumed to be stable from the climatic point of view (nevertheless, time series analysis from a 60-year period of climatic observations in the Tatra region shows that symptoms of global changes are occurring here also). Most changes from that time have been caused by human activities.

The Tatra mountain ridge is the first constraint to the predominant westerly winds and precipitation. It is for this reason that the windward NW and N slopes have much more precipitation and higher air humidity than S slopes. On south slopes, the continental type of climate increases from west to east. These climatic conditions are apparently reflected in the spatial distribution of beech which occurs on the northern slopes of the Slovak and Polish Tatras and in the Oravica catchment, from the south site to the stream Jalovecky Potok. Continentality is less marked in the eastern part of the Tatra mountains and it is for this reason that beech occurring in the Belianske Tatry mountains and along the Javorinka creek ascends quite high into the Tatra massif.

The continental climate is a limiting factor for fir too, though is not of course as important as for beech. In the central (most continental) part, fir occurs individually or in small groups, and then mainly on wet stands.

The relationship between climatic conditions and vegetation is expressed in altitudinal forest zones. The basis for zonality is vegetation, which reflects macroclimatic conditions. From this point of view, 5 altitudinal forest zones occur in the Tatras; according to the Slovak forest classification there are:

— beech zone,
— fir-beech zone,
— spruce-beech-fir zone,
— spruce zone,
— dwarf mountain pine zone.

As was mentioned above, the Tatras do show some regional deviations in the zonation of forest with altitude; they are identified by increases or decreases (or even the presence or absence) of specific tree species and are called variants of zonality.

The larch-spruce central Carpathian variant occurs in the High Tatra Mountains, besides being dominanted by spruce, it is characterized by the natural occurrence of larch and stone pine, and especially by the absence of beech and the poor occurrence of fir.

The oak-coniferous Carpathian variant occurs on the border between the Biosphere Reserve and the Podtatranska Kotlina basin. It has typical continental features. Close to the city of Poprad is the most northern site of occurrence of oak in Slovakia. The area is protected as a nature reserve. Pine stands on limestone rocks in the Liptovska Kotlina basin also have a relict character. Also typical for continental basins is the lime-spruce community occurring in the south-eastern part of the Biosphere Reserve.

The altitudinal forest zones create the vertical elements in an ecological network. Horizontally growth conditions are divided into ecological ranks according to soil conditions. Each specific type of climatic or soil condition corresponds to a specific type of vegetation (phytocoenosis). Permanent ecological conditions together with vegetation cover create a type of nature, in this case a forest type.

More than 120 forest types (geobiocoenosis) have been mapped within the Tatra Biosphere Reserve. This is a surprisingly high number considering the rather limited tree species composition. Species composition is as follows:

— 95% coniferous trees (spruce 66%, dwarf mountain pine 18%, larch 5%, pine 4%),

— 5% broadleaved trees (alder 2%).

Geobiocoenoses are the basis for forest management (i.e. proposals for target species composition, target vertical and horizontal structure, density, silvicultural system and its form, felling age and regeneration period).

According to their ecological similarity, geobiocoenoses are combined into groups providing a framework for the natural distribution of tree species and their areas (Annex 1).

In the 1960s the target for forest management in the Tatras was to rebuilt parts of the forest with non-natural features. Local pollution, acid rain and global changes brought an urgent need for a new assesment of the Tatra forest. Initial optimism arising from the naturally greater resistance of natural ecosystems has disappeared, as current knowledge shows that we were mistaken. The first symptoms of forest decay were observed in the early 1970's, and by the late 1980's, the forest of the Tatras was amongst the most threatened in Slovakia.

A regular 2x2 km network with 188 plots was established in the period 1989-1991 for the assessment of forest health conditions. Estimated on each plot was the defoliation of 15 trees. This tree-wise system for describing forest health is identical to the ICP system used for ground survey. Mean defoliation on monitoring plots was found to range from 6.6 to 64.3%. More than 2700 individual spruce trees were evaluated. Figure 1 shows the frequency histogram for defoliation in different categories. The mean defoliation is 31% (of the Slovak mean of 28%), standard deviation 18, Cv 58%. This result confirms that only 23% of the evaluated trees were healthy (with defoliation less than 10%).

Defoliation in different groups of geobiocoenoses is shown in Figure 2.

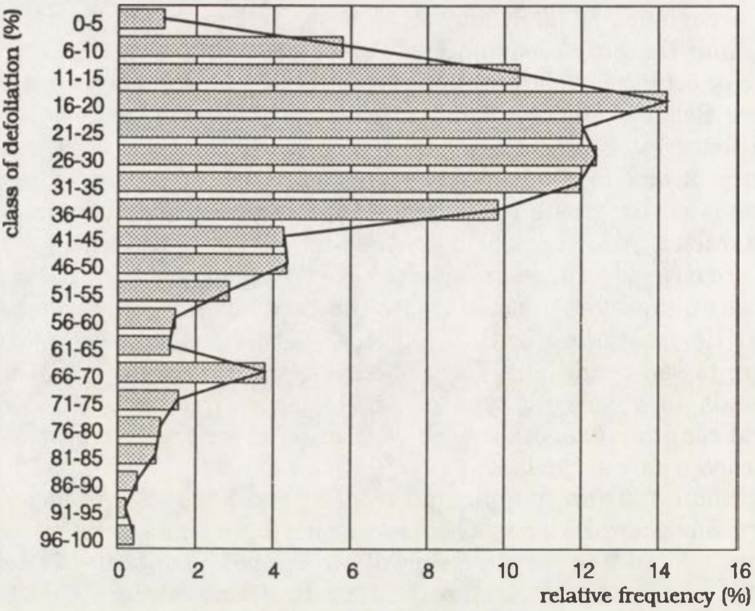

Fig. 1. Defoliation frequency histogram

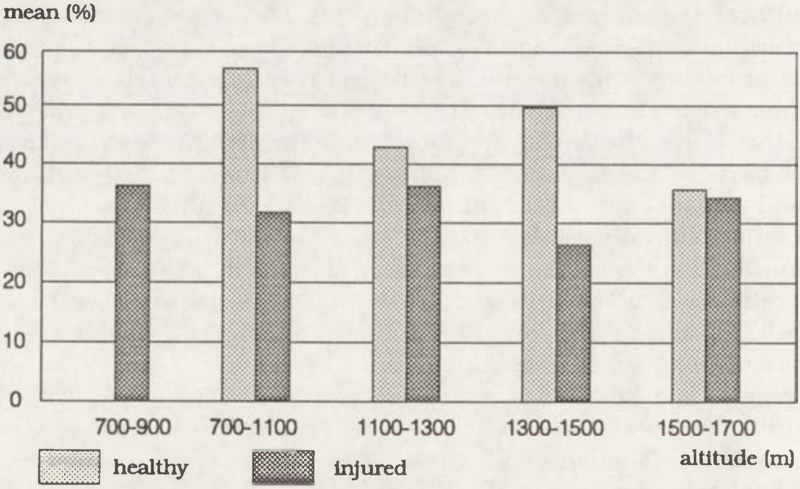

Fig. 2. Germinative capacity

From the results obtained it may be deduced that altitude and soil conditions are factors contributing to defoliation.

The results show that the worst situation is to be found in the northern and western parts of the Tatras, most frequently on shallow rendzina or ranker soil types, and usually close to the upper tree line.

These results were substantiated by LANDSAT TM data. The standwise system for the description and categorization of health is identical to that used in the Czech Republic by LESOPROJEKT in The Institute for Forest Management.

The percentage areas in different health categories, determined from LANDSAT imagery in August, 1991 were:

— healthy 13,
— slighty damaged 76,
— moderately damaged 8,
— severely damaged 3.

Table 1. The percentage areas with different degrees of defoliation in Slovak Tatras (from data obtained from LANDSAT, August 1991)

Degree of defol.	altitude above sea level (m)					
	600-800	800-1000	1000-1200	1200-1400	1400-1600	1600-1800
0	-	0.2	0.2	0.2	-	-
1	39.0	52.0	36.2	23.2	24.2	6.2
2	61.0	47.8	63.6	76.4	75.7	83.8
3	-	-	-	0.2	0.1	-

In order to assess the health of the forest as objectively as possible, we have used ground surveys, remote sensing, needle analysis, and germinative capacity analysis for spruce seeds.

Seed analysis confirmed a decrease in the germinative capacity with altitude. A very important change was found for seeds collected from damaged trees (Fig. 3). The average germinative capacity for healthy trees was 50% and for damaged trees 30%.

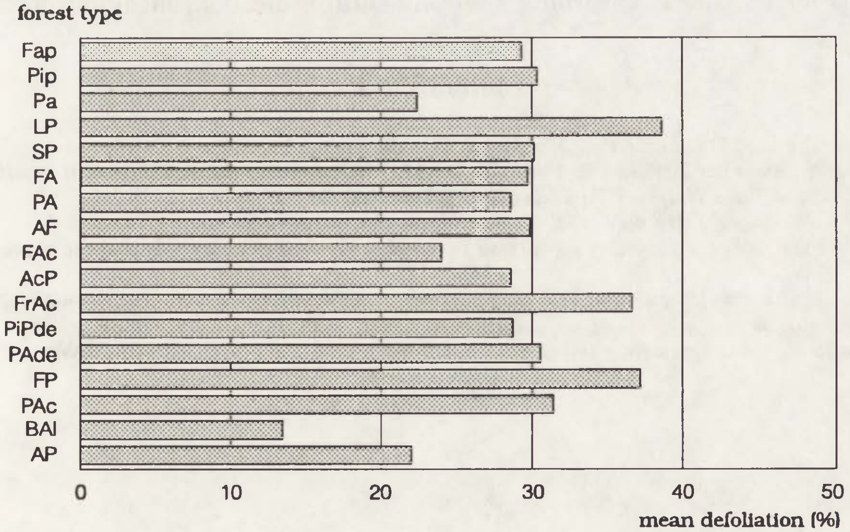

Fig. 3. Defoliation by forest type

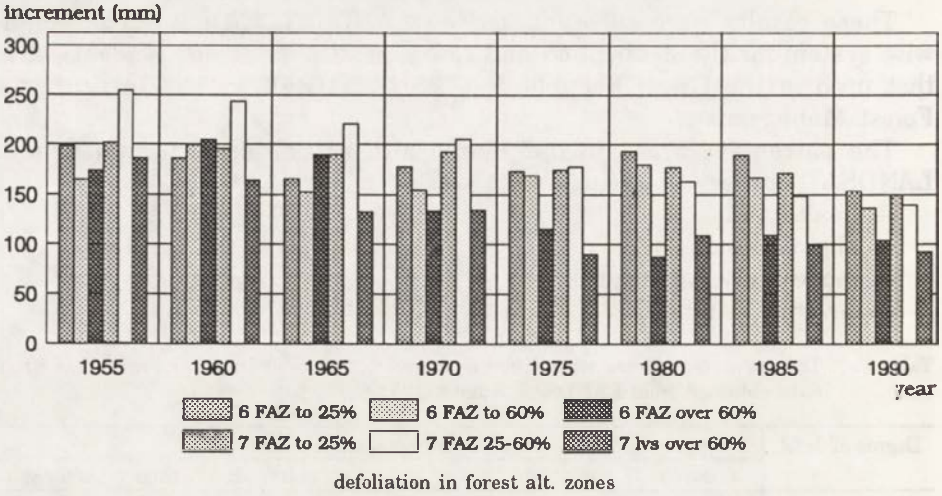

Fig. 4. Mean periodical increment

The most significant decrease in the increment was noted for ecological rank “D”, on carbonate soils. Fig. 4. shows the changes with time in rank “A”. Histograms demonstrate the general trend for mean periodic increment to decrease with elevation. The most significant change occurs for trees with more than 60% defoliation.

The results of our work have shown that the global deterioration of forests probably caused by wide-scale pollution and extremes of climate has also affected the Tatras — an area of outstanding natural value and beauty.

The main task for foresters in the Tatra National Park is to assess periodically the changes in the health of the forest. The results are an essential basis for decisions concerning environmental protection, including forestry.

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Annex 1. Summary of groups of geobiocoenoses

	Ecological ranks					
Forest alt. zones	A	A/B	B	B/C	C	D
4			Ft*			Fde*
5	Fap* Pa PiP	FA* PA	AF*	FAc*		Fde PPide** PAde**
6	Fap LP** PiP Pa	FA PA	AF*	FAc AcP	FrAc AAc**	FP PiL
7	LP SP CP			AcP		FP PiL*
8	M CM PM*				RM	Mc

	a	c
	BAl Pil AP	Ali Saf**

* occurrence in the Western Tatras only
** occurrence in the Eastern Tatras only

ecological rank A — acid soil
Fap (Fageto abietino-piceosum)
Pa (Piceeto-abietinum)
PiP (Pineto-Piceetum)
SP (Sorbeto-Piccetum)
M (Mughetum acidifilum)

ecological rank A/b — acid/fertile soil
FA (Fageto-Abietum)
PA (Piceeto-Abietum)

ecological rank B — fertile soils
Ft (Fagetum typicum)

ecological rank B/C — fertile/ranker soils
FAc (Fageto-Aceretum)
TiP (Tilieto-Piceetum)
AcP (Acereto-Piceetum)
RM (Ribeto Mughetum)

ecological rank C — ranker soil
FrAc (Fraxineto-Aceretum)
AAC (Abieto-Aceretum)

ecological rank — rendzina soil
Fde (Fagetum dealpinum)
PPide (Piceeto-Pinetum)
PAde (Piceeto-Abietum dealpinum)
EP (Fageto-Piceetum)
PiL (Pineto-Laricetum)
Mc (Mughetum calcicolum)

ecological rank a — acid wetland
BAl (Betuleto Alnetum)
Pil (Pineto ledosum)
AP (Abieto-Piceetum)

ecological rank c — fertile wetland
Ali (Alnetum incanae)
Saf (Salicetum fragilis)

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FACTORS OF VEGETATION DYNAMICS IN THE AREAS OF SPRUCE FOREST OF THE UPPER MOUNTAIN ZONE WITH DECLINING STANDS OF TREES IN THE KARKONOSZE NATIONAL PARK — BIOSPHERE RESERVE

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Abstract. One of the most important problems of nature conservation in the Karkonosze National Park — Biosphere Reserve is the protection and restitution of forest of the upper mountain zone, which have been suffering a disastrous decline of *Picea abies* trees for more than a decade. In order to establish the extent of the deforestation, an estimate was made in 1989 of the health status of the upper-zone stands of trees. Simultaneously, two permanent experimental plots were delineated to study the possibilities of spontaneous restitution of the damaged phytocoenoses of Plagiothecio-Piceetum hercynicum. The results obtained so far are summarized in the present article.

Key words: vegetation dynamics, mountain spruce forest, *Picea abies*, extinction of tree stands, Sudeten Mountains, Karkonosze National Park.

INTRODUCTION

The Plagiothecio-Piceetum hercynicum association is regarded as one of Poland's most endangered forest communities (Boratyński et al. 1987, 1988, 1989, Raj 1992). The reason is the rapid decline of *Picea abies* tree stands that has been taking place over the last decade or so, mainly in the upper mountain zone of the Western Sudeten Mountains. There are many factors responsible for the tree decline and the disintegration of forests of the upper mountain zone. The most important include: air pollution, mainly by sulphur compounds (Kmieć et al. 1993, Zwoździak et al. 1993), plagues of insects and damage caused by game (Capecki and Zwoliński 1984, Fabiszewski 1985 and others), droughts and low resistance of trees to hurricanes, as well as snow caps forming on the branches of trees and snowbreaks (Boratyński et al. 1987).

The forest habitats of the upper mountain zone in the Karkonosze Mountains are located at altitudes of (840) 940 — 1,200 (1,300) m a.s.l. and occupy more than 50% of the total area of the Karkonosze National Park. Some of them have become tatally or partly deforested. Depending on the extent of tree stand disintegration and the degree of damage to the phytocoenoses, further transformations of the vegetation will probably follow different patterns. Throgh their efforts to drawn up forest inventories and studies involving the documentation of periodic changes in the vegetation on the experimental plots, the authors seek to define factors and patterns of vegetation dynamics, with a special focus placed on the possibilities of spontaneous regeneration of the damaged phytocoenoses.

METHODS

The assessment of the degree of decline of *Picea abies* specimens in the forests of the upper mountain zone was made in 1989 using an estimation method. The research embraced an area of 2,094.01 ha. A conventional scale was used which employed the per centage of dead treed in the stands under analysis (Table 1).

Since 1989 research has been carried out in two permanent areas of 1 ha each located at an altitude of some 1,200 m a.s.l. in forest sections no. 157c and 158a. They represent two forms of Plagiothecio-Piceetum hercynicum phytocoenoses differing in the origin of the stands (157c — probably natural, 158a — probably artificial). In the first stage of the research, the condition of the phytocoenoses was characterized using selected features relating mainly to living and dead trees and their natural regeneration.

RESULTS AND DISCUSSION

In 1989, out of the total area of 2,094.01 ha of Plagiothecio-Piceetum hercynicum habitats, 635.4 ha (30%) were occupied by stands of trees with no apparent damage. Most of them were cultures and young stands which had grown over the last 30 years as a result of artificial forest regeneration in areas deforested mainly by hurricanes. Stands were found to be unnaturally sparse and their density broken over an area of 1,458.61 ha (Table 1). An area of 163.03 ha (7.8%) was practically forest-free. The largest area was occupied by stands in which 31-50% of trees were. In the years 1978-1989 an area of 415 ha suffered complete deforestation (Raj 1992). The stands that turned out to be the most vital ones were the youngest ones, below 60 years of age. Those that suffered the greatest losses were old stands, especially those over 80 years of age. To this let us add the observations made by Boratyński et al. (1987) that dead and declining stands were found largely on slopes and redges having western or north-western exposures i.e. those facing the prevailing winds. The tree decline was most intensive in Plagiothecio-Piceetum sphagnetosum. All this indicates great spatial differences in the condition of the vegetation in forest habitats of the upper mountains zone. The appearance of the three typical forms of spruce forest phytocoenoses with declining stands of trees is presented in Figures 2-4.

Table 1. Conditions of stands in the Karkonosze National Park in 1989

Conservation district	Deforestation	Reforestation of gaps	Bating up of regeneration	Natural regeneration	Share of dead trees in %					Total stand surface
					<10	11-30	31-50	51-70	>70	
	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)
Śnieżka	26.40	0.50	9.33	6.00	80.98	50.84	9.40	40.01	37.65	261.11
Stanica	6.16	-	3.03	-	73.35	24.30	40.06	5.85	1.50	154.25
Wang	21.88	0.80	13.34	3.60	36.63	59.17	44.65	43.46	69.46	292.99
Przełęcz	5.01	0.10	5.78	-	2.37	68.79	58.84	4.82	32.21	177.92
Śnieżne Kotły	13.27	-	29.33	-	5.21	29.48	36.52	18.54	26.22	158.57
Szrenica	6.10	-	22.00	-	13.31	63.54	233.50	31.42	43.90	413.77
Total	78.82	1.40	82.81	9.60	211.85	296.12	422.97	144.10	210.94	1,458.61

A comparison of data from the two permanent experimental plats gartered in Table 2 reveals differences in the advance of the decline of *Picea abies* trees and in the self-seeding dynamics of this species. They show the plot in forest section no. 157 c to have a greater capacity for spontaneous regeneration of its phytocoenosis that the other one. A rough distribution of juvenile specimens of *P. abies* on this plot is shown in Figure 5.

Table 2. Selected data from experimental plots

Specification	Experimental plot in section 157 c	Experimental plot in section 158 a
Altitude above sea level (m)	1155-1200	1200-1255
Mean age of stand	150	150
Number of live trees	111	42
Volume of live trees (m^3)	102.21	18.79
Volume of fallen rooting trees (m^3)	75.6699	83.8975
Number of juvenile specimens of *Picea abies*	4262	878
Mean height of juvenile specimens of *Picea abies* (cm)	59.6	45.6
Cover of natural regeneration (%)	11.7	1.4
Number of juvenile specimens of *Sorbus aucuparia*	58	96
Prevailing types of herb layer	1. *Deschampsia flexuosa* 2. *Vaccinium myrtillus* 3. *Calamagrostis villosa*	1. *Calamagrostis villosa* 2. *Deschampsia flexuosa* 3. *Vaccinium myrtillus*

Analysis of the results obtained so far seems to corroborate the hypothesis that there is a relationship between the ability of the damaged spruce forests to regenerate and the origin of their stands. The hypothesis will be tested at successive stages of the research carried out at intervals of 5 years.

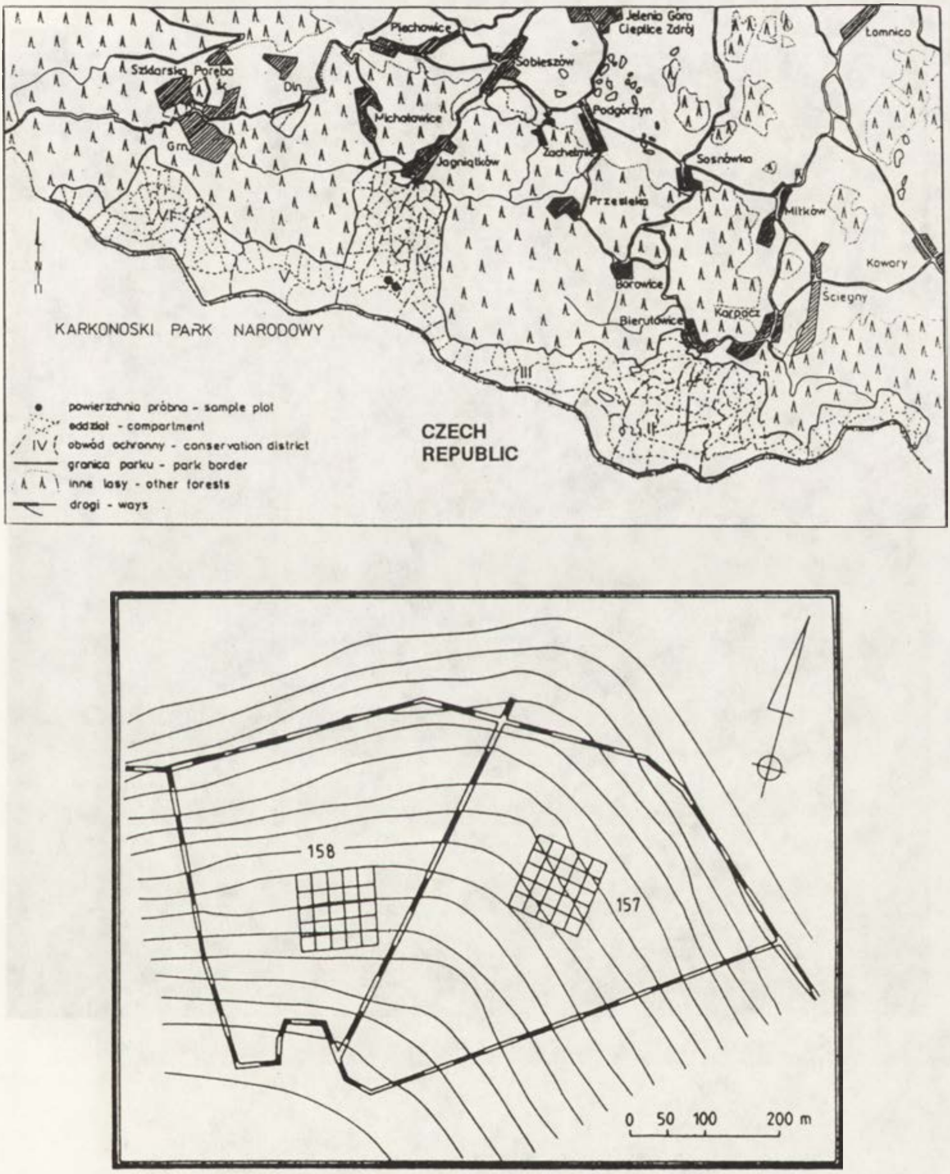

Fig. 1. Location of the study area

Fig. 2. Dead stand of trees in district No. 157c. Photo by J. Zientarski (1990)

Fig. 3. Natural regeneration of *Picea abies* on the margin of a declining stand of trees; district No. 157c. Photo by J. Zientarski (1990)

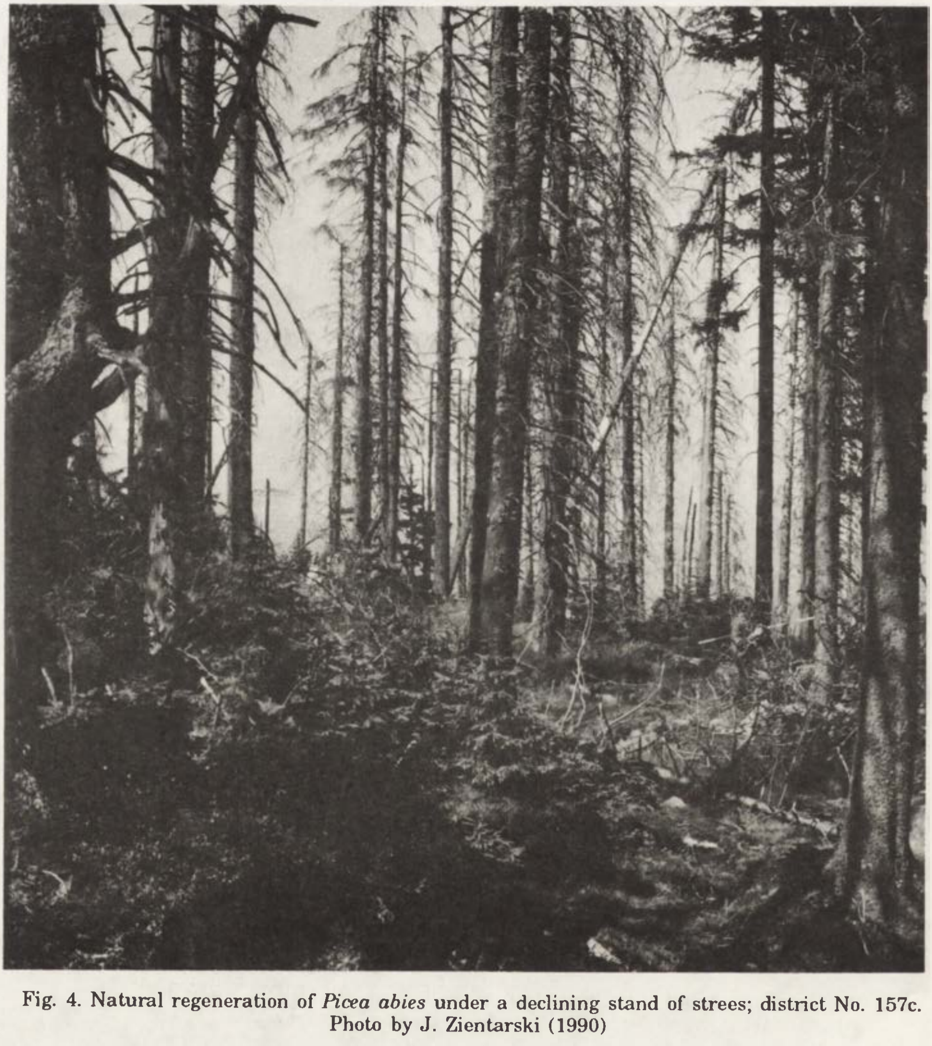

Fig. 4. Natural regeneration of *Picea abies* under a declining stand of strees; district No. 157c. Photo by J. Zientarski (1990)

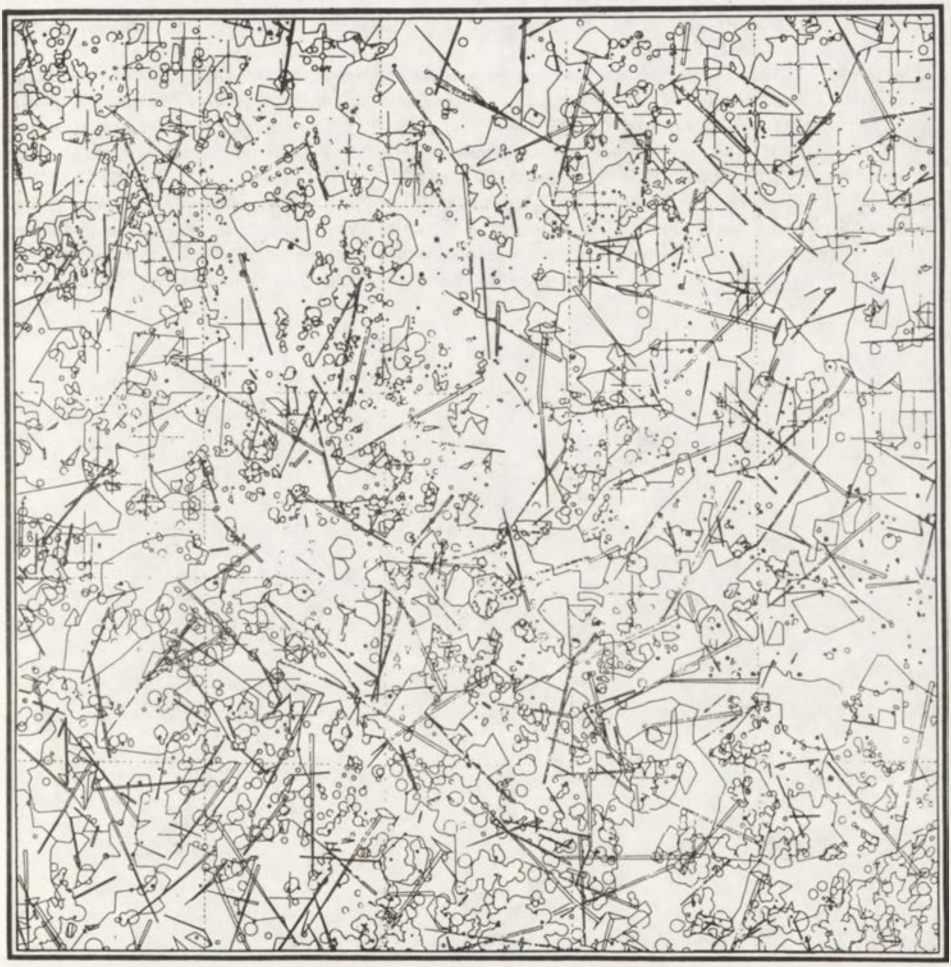

Fig. 5. Cartographic interpretation of the condition of the vegetation on the plot in district No. 157 c; regeneration of *Picea abies* marked with circles

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Mountain zonality facing global change,
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VEGETATIONAL SUBZONES IN MOUNTAINS — A NATURAL OR ANTHROPOGENIC FEATURE?

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Abstract. On a base of the vegetational maps of some fragments of Hala Gąsienicowa in Polish Tatras, an attempt of subzones division in subalpin zone has been carry out. The anthropogenic lowering of boundaries within altitudinal zones has been upon a subject. According of this hypothesis a differentiation into subzones may be result of human management in high mountains environment.

Key words: Tatras vegetation, altitudinal zonation, mountain natural/anthropogenic belts.

The aim of this presentation is to give a short outline of a problem which arose during my field work around Hala Gąsienicowa in the Tatra Mountains. I had considered it possible as this feature is observed over a wider area (not only in Hala Gąsienicowa and not only in the Tatras). It is connected with human activity transforming the mountain environment and could be the starting-point for more general considerations.

It has long been recognized that there is a stepwise reaction of vegetation to the sequential worsening of the climate with increased altitude a.s.l. This reaction is very visible in changes of the dominant plant formations, in other words in the zonality of vegetation. The division into montane, subalpine, alpine, subnivale and nivale vegetation belts is accepted as a typical pattern differentiating the vegetation of mountains.

The Alps are very well known and investigated, and it has been possible to describe plant zonality there in detail, and even to divide zones into subzones on the basis of the mosaic of plant formations (Ellenberg 1986). For the much lower Tatra Mountains the scheme is much simplified. The nivale belt is lacking for climatic and altitudinal reasons and no subzones have been distinguished. The existence of such subzones was only indicated as a transitional forest belt between the lower forest and the upper forest montane belts. It has also been wondered if the occurence of the stone pine (*Pinus cembra*) at upper timberline is evidence of the existence of a "stone-pine and larch" belt, or it forms an ecotone zone only.

Detailed phytosociological investigations were carried out in the Dolina Pięciu Stawów Polskich (Valley of the Five Polish Tarns) by Balcerkiewicz (1983). These allowed him to distinguishe — within the dominant alpine grasslands on the silicate rocks (Oreochloo distichae-Juncetum trifidi = Trifido-Distichetum), forms with different altitudinal characters. Next to the series of plant subassociations of the alpine belt he discerned subnivale and subalpine forms. The author suggested an anthropogenic origin for some of these, particularly the subalpine form, but he left the matter of spatial distribution to be determined in the course of the production of vegetation maps.

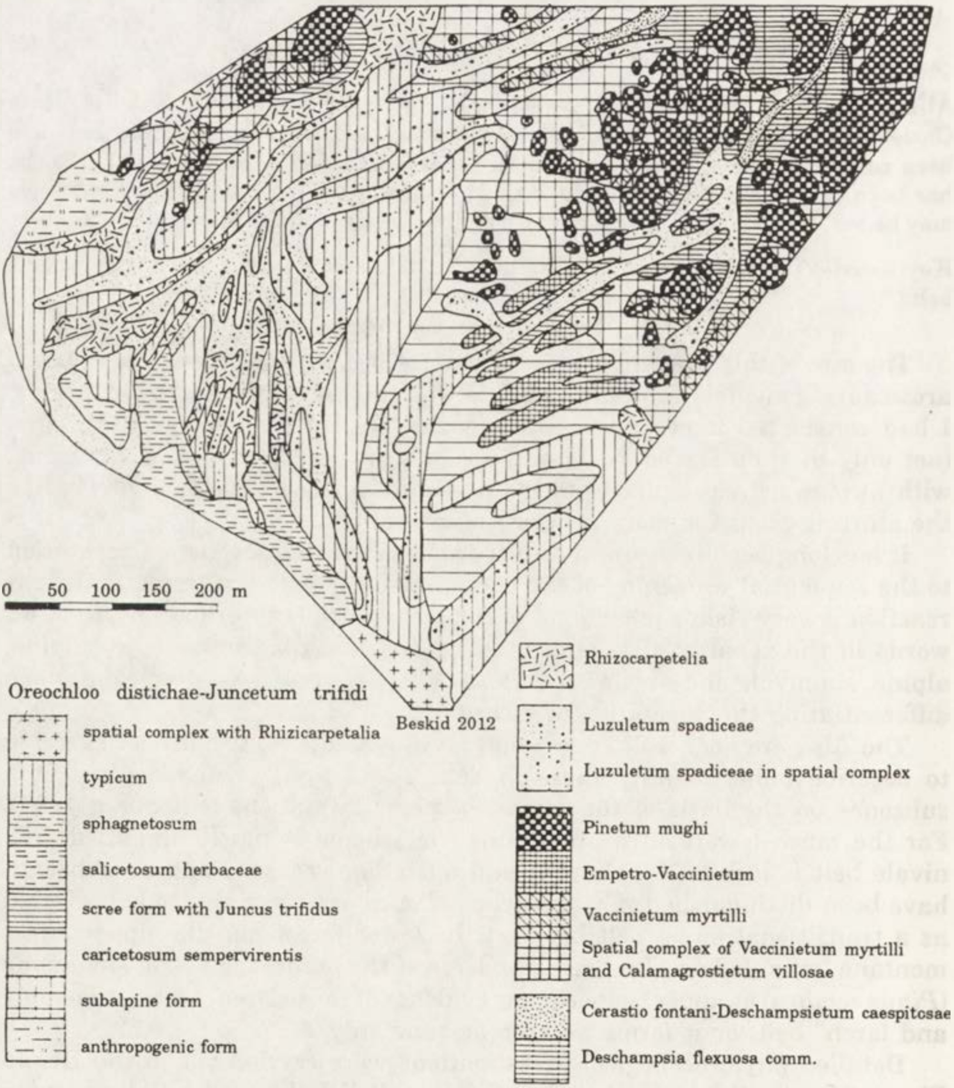
VEGETATION MAP OF KASPROWY CIRQUE

Fig. 1. Vegetation map of Kasprowy Cirque

The units of alpine grasslands, distinguished by Balcerkiewicz have different "altitudinal "significance. They have been distinguished by me too, on Hala Gąsienicowa, which is close to the Valley of the Five Polish Tarns. During detailed mapping at scales of 1:1000 and 1:2500, it emerged that the subalpine variety of alpine grasslands has a well-marked vertical range. It occurs from 1730-1810 m a.s.l., and even from 1690 m a.s.l. on the shaded northern slopes. The phytocenoses which belong to this form have a similiar physiognomy to alpine grasslands (with a prevalence of narrow-leaved grasses and small perennial plants with showy flowers). They occupy the space between alpine grassland and subalpine scrub of dwarf mountain pine (*Pinus mugho*) and other dwarf shrubs of the family *Ericaceae* (Fig. 1). Their species composition indicates a typological affiliation with alpine grasslands, but with the occurence of some species typical of the subalpine belt and the upper forest montane belt (Fig. 2).

In the light of statements above it might be possible to follow the example of the Alps and to introduce the differentiation of the Tatras' vegetation into subzones. This would refer to the upper part of the subalpine belt, where grasslands still dominate, and the lower part, which has sub-shrubs and shrubs (members of the family *Ericaceae* and mountain dwarf pine).

The width of these belts and the lower boundaries of the grasslands are dependent on slope angle: the more gentle the slope, the further the subalpine

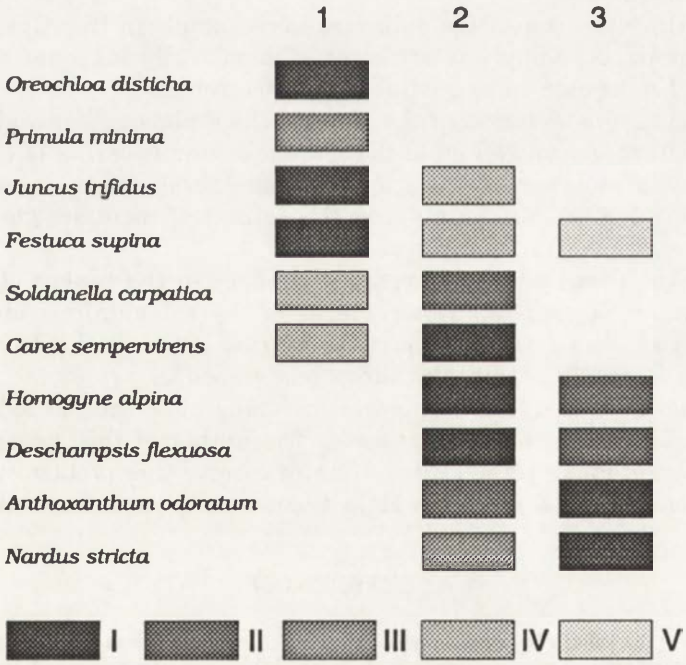

Fig. 2. Frequency of differential species
I-V — frequency classes; 1 — Oreochloo distichae-Junecetum trifidi typicum, 2 — Oreochloo distichae-Juncetum trifidi, subalpine form, 3 — Hieracio alpini-Nardetum

form of grassland descends. This spatial phenomena goes against the observations and rules obtained hitherto. Usually communities from upper zones descend further where microclimatic conditions are worse than usual in the lower zone, and where these conditions prevented the typical spatial vegetation structure from emerging. This happens on steep slopes within deep gullys. The observation of the reverse phenomenon suggests rather that the subalpine form of grassland is a result of factors other than natural climatic ones. It is obvious that grazing has a significant role in the high mountain landscape, and it is also true for the Tatras. It has been the cause of the lowering the upper forest belt and the upper limit of the dwarf pine belt and has created suitable conditions for the expansion of grassland communities.

The problem of the upper forest belt and scrub (of dwarf pine or Rhododendrons) is often discussed in the literature (Holtmeier, 1989 and his review of subject bibliography). Human activity, mainly shepherding, has been recognized by many authors to give a real, versus potential (in accordance with climatic conditions), upper timberline, which is modified by local conditions (the orographic and edaphic upper timberlines). Less is known about anthropogenic changes in the upper belts but it may be expected that these have occured too.

The data presented in this paper have given rise to more questions rather than to conclusions:

(1) Is the character of the subzones (for example in the Alps) natural or anthropogenic? And any way are some of them really subzones or the result of the anthropogenic spread (widening) of ecotones?

(2) Should consideration not be given to the limits of other higher-altitude vegetational zones as well as to the anthropogenic lowering of the treeline?

(3) How is the process of lowering the limits of vegetational zones modified by the warming of the climate and the retreat of montane glaciers which has been suggested by many researchers?

(4) As the climate warms up, what changes in the ranges of altitudinal vegetation zones, and in the structures of the communities making them up, will occur in areas under enjoy protection (such as the Tatra National Park) and in which grazing by sheep has ceased?

Long term observation on permanent study plots are needed if answers to these questions are to be obtained. The author of this paper is hopeful that she could make some contribution to resolve this problem through the observations of the changes on Hala Gąsienicowa permanent plots.

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CHANGES IN THE NATURAL ZONATION OF THE TATRA MOUNTAINS CAUSED BY ANTHROPOGENIC FACTORS

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Abstract. Tatras natural zonation is introduced and its changes under historical and current stresses are discussed. Tourism and pollution are considered as factors influencing strong the Tatras nature.

Key words: Tatras protection, natural/anthropogenic zonation, historical/current stress in Tatras.

INTRODUCTION

The Tatra Mountains are the only area in Poland with alpine characteristics, and several different types of natural zonation occur in this area. The primary mechanism of zonation is climatic and is correlated with altitude. A secondary zonation is determined by men annual temperatures: the lowest, temperate zone has mean annual temperatures above 6°C and extends to 1100 m a.s.l.; the next, cool temperate zone (with mean temperatures of 4 to 6°C) is found between 1100 and 1550 m a.s.l.; and is followed by the cool zone (with mean temperatures of 2 to 4°C) at elevation of up to 1850 m a.s.l. The cold zone (0 to 2°C) is next, at up to 2200 m a.s.l., and this is finally followed by the very cold zone (0 to -2°C), which included the highest mountain peaks.

Another type of natural zonation is the zonation of vegetation which is also related to changes in climate and altitude. The lowest parts of the Polish Tatra Mountains are covered by forests. Rich mixed forests occur to 1250 m a.s.l., and are then replaced by upper forests composed of spruce, with stone pine in some locations. Above the natural timber line (1550 m a.s.l.), the Tatra forests gradually merge with the zone dominated by dwarf mountain pine, which extends to 1800 m a.s.l. Toward the tops of the ridges and peaks, this zone is replaced by alpine grasslands and by artic-alpine communities associated with bare rock and scree.

There is no specific zonation of wildlife, but the fauna does change with the changing biotopes. As a result, there are different animal species at lower and higher altitudes, and several of these are characteristic of the Tatra Mountains (Krzan et al. 1993).

Zonation can also be found in Tatra soils, which vary from rich forest soils at lower elevations and young basic soils and bare rock at higher altitudes.

This complicated natural structure of the Tatra Mountains has been influenced by man since the Middle Ages. The objective of this presentation is to explain how past anthropogenic stress has altered the zonation and how such stress is continuing to affect the natural zonation of the Tatra Mountains today.

HISTORICAL INFLUENCES

Until the beginning of the 15th century, the Tatra Mountains were not widely-known to society, and had retained their primeval, natural characteristics. The first historically-documented settlements occurred several kilometres from the mountains in the 13th and 14th centuries (Liberak 1929). In the course of the next three centuries, the developed areas became denser, and began to approach the mountains themselves. The intensive cutting of timber began at that time and residents cut trees for both housing and heating. The first non-natural meadows appeared. Royal laws attempted to limit the exploitation of the forest, but these proved inadequate due to poor enforcement.

Appearing from the late 14th century onwards was another factor which was to influence nature in the Tatras — pastoralism. This was initially limited to the bases of mountains. Wandering groups of shepherds passed through occasionally and caused local changes in Tatra nature. Later, permament pasturage from nearby settlements, ventured closer to the Tatra peaks and ridges. In the 18th and 19th centuries, the number of grazing sheep was rather stable, at up to 12 000 head. A maximum of 27,000 head was reached during World War Two, and this was followed by a rapid decrease to 7 or 8 000 head by 1954 (Śmiałowska 1960).

Regulations of the National Park led to a gradual reduction in sheep grazing, and finally to its complete elimination at the end of the 1970 s. Limited pasturage returned to the mountains in 1981, and there are now about 1 200 sheep grazing, under clearly defined rules, and in certain meadows only.

Historically, pasturage took place in both the forests and the subalpine meadows of the Tatras (Kolowca 1962). This resulted in the introduction to the area of shepherds wooden housing, tools, other equipment and bonfires. Pasturage also led to the penetration of almost every location in the mountains, and in many cases, to the creation of permanent settlements. Significant impacts on nature included:

— a lowering of the natural timberline by up to 300 metres in the worst case,

— disturbance to the water cycle,

— the beginning of erosion on exposed slopes,

— disturbances to the natural development of the forest, through elimination of seedlings and through reduced resistance to pests and diseases,

— the enlargement of forest glades, which also encroached upon higher elevations.

Whilst today's controlled pasturage plays an important cultural role, and even helps to protect semi-natural meadow ecosystems, the other impacts of the historical, intensive sheep grazing have left numerous scars upon the natural landscapes of the Tatra Mountains.

Other, more significant human activities to influence our region (and especially the Tatra Mountains) were mining, and the steel industry. This began in the 16th century, with the extraction of gold in the Kościeliska Valley. Mining for silver and iron ore commenced at the beginning of the 17th century. Mining and the associated iron industry were later to spread to other areas of the Tatras, and were especially intensive at the beginning of the 19th century. Unprofitability finally ended this industrial period in the year 1880.

Mining and the steel industry had terrible impacts on nature in the Tatras. Forests were heavily exploited, and even destroyed in many places. Wood was the basic energy source in stoves, and timber was also used in mines, for housing and for other purposes. In addition, harvesting and forest usage followed by replanting, produced many spruce monocultures at lower altitudes, and thus resulted in the complete destruction of the primeval forests (Fabijanowski 1962). A lasting consequence of this has been the increased sensitivity to current, global human influences which is now shown by most of the existing forest stands in the Tatra National Park.

CURRENT PROBLEMS

Today, it is the pollution of air, water and soil, as well as acid rain, which pose the most significant threats to nature in TNP. These problems are widespread, and may soon result in an ecological disaster, especially in the mountain forests. We have now been conducting permanent monitoring of air pollution for eight years, using 36 sampling points located throughout the Park. The results show that TNP is not affected as badly as Polish industrial regions, but that in some areas, and during some short time periods the scale of air pollution is equal to that of big cities and areas near factories (Krzan 1989). This is the case for emissions of SO_2, and to a lesser degree for those of NO_x, dusts and another pollutants. The emissions which enter the Park have two main sources:

— “long distance emissions” from large industrial regions in Poland, the Czech Republic, Slovakia, Germany and probably many other European countries,

— “local emissions” from the densely populated area near the Park border, including Zakopane and the nearby villages, where coal heating systems predominate.

The local and Park authorities have a very limited ability to confine long-distance emissions, and these negative influences will be not limited significantly in the near future.

However, the spatial distribution of, and seasonal changes in, emissions volume are sufficient to indicate that the majority of air pollutants are local in origin. This element of the air pollution affecting the National Park can be reduced significantly if energy sources are changed within the Park boundaries, and in the sorrounding area.

Acid rain is closely related to air pollution. In the last few years, the average pH of rain water has been approximately 4.0–4.2, but pH readings below 3.0 have been obtained.

The influences of air pollution and acid rain on the flora of the Tatras can be easily observed over time, especially in coniferous forests. Many trees show a looser crown, than was seen just a few years ago, and a greater number of yellow leaves. In fact, the trees and other plants are slowly dying.

Water pollution is another major problem in protecting the nature of TNP (Krzan and Kot 1991). Long-term investigations show that the water from most streams is of class II purity, and this means that it cannot be used directly for drinking. The water has been found to contain physical and chemical pollutants, and even pathological bacteria in some streams. The sources of these last pollutants are the mountain huts and other structures existing within the Park. Most of these have old, inadequate sewage facilities, which were designed for much lighter touristic traffic. The Park is now visited by about 3 million tourists a year, which is 10 times the number 30 years ago. A few new biological sewage installations have been built in some of the huts in the last years, but only just beginning to introduce on overall improvement in water quality in the National Park, which is the only source of water for Zakopane and its surroundings.

Nature in the Tatras is subject to many other impacts as a result of the mass pressure from the millions of tourists visiting Park, and some of the most attractive places and paths have been ruined. An example of this is given by the summit of Kasprowy Wierch, which is easily accessible by cable car. As a result, some 40% of the area around the cable car station has been completely destroyed. Many tourist paths that were originally 1 or 2 meters wide are now 20 or more meters wide. With the cooperation of outside agencies, we have been attempting to rectify the erosion in this area. Erosion is a serious problem, and permament penetration of the Park causes disturbances so severe that many wild animals are forced from their territories.

Finally, proponents of sport are in favour of the development of new sports facilities in the central area of the mountains. This would change the natural landscape drastically, and disturb the ecological balance of this section of the Tatra National Park.

CONCLUSIONS

The unique and valuable nature of the Tatra Mountains, with their specific zonation, has continued to develop under centuries of heavy human pressure. Zonation has been changed significantly, and its natural characteristics have been preserved in part only. A brief comparison of human pressure past and present makes easy to see the different characteristics of these influences:

Historical pressures were more or less limited to specific places and particular ecosystems: housing was associated with timber cutting, and whilst trees were cut in some easily accesible areas, forest stands were not destroyed. Pasturage caused significant threats to alpine meadows and the forest zone, but deforestation was again incomplete. Mining and industry damaged the forest zone significantly, but did not produce major changes in other ecosystems.

The current stresses to the nature are completely different; the influence of pollution is a danger touching all ecosystems, and every single living thing in the area. This process is much more dangerous, and it can result in the total destruction of our natural heritage.

Historical human influences were strongly limited by comparatively primitive technology, and the chances of man causing complete destruction were therefore small. In contrast, current technology is easily capable of destroying nature, and of allowing not the slight possibility for rehabilitation.

Historically, there were many regions with untouched nature, and if one were lost, other similar regions still existed.

Today, the area of seminatural ecosystems under effective protection in Polish National Parks is only 0.4% of the total area of the country. If nature is destroyed in the Tatra National Park we will not find any other adequate area in Poland or elsewhere.

This is the primary reason why effective protection of nature in the Tatras is essential. We hope that our participation in the Man an Biosphere programme will allow stronger conservation measures to be brought in and will thus permit this beautiful part of our country to survive.

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THE NECESSITY TO MAINTAIN THE ECOTYPICAL VARIATION OF NORWAY SPRUCE CHARACTERISTIC FOR ALTITUDINAL ZONES IN THE POLISH SUDETIC AND CARPATHIAN MTS

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Abstract. Many foresters are convinced that trade in seeds of unknown origin has destroyed the natural zonality of stands of Norway spruce in the Polish Sudetic and Carpathian Mts. However, ecogenetic progeny tests show that this zonality is close to natural today — a fact which leads the author to make some silvicultural recommendations.

Key words: *Picea abies*, progeny test, ecological adaptation, genetic cline, mountain zonality, Sudetians, Carpathians.

INTRODUCTION

Most Polish foresters are convinced that artificial migration has destroyed the natural zonality of Norway spruce (*Picea abies* /L./ Karst.) in the Carpathians and especially in the Sudety Mountains. It is certain that such migration occurred in the past, as a result of trade in seeds of unknown origin (Bouvarel 1974, Schmidt-Vogt 1975). Involved in this problem as a silviculturalist (Modrzyński 1989), the author has performed some ecogenetic studies to determine the share of native and foreign ecotypes of Norway spruce in the Polish mountains.

The ecologically — important traits of native spruce populations form altitudinal clines, which means that they change gradually (continually) along the gradient of altitude (Schmidt-Vogt 1976, Holzer 1985). Being unadapted to the site they present occupy, foreign ecotypes must stand out markedly in such clines.

An altitudinal cline may be considered as a sequence of overlapping zones.

MATERIALS AND METHODS

In 1987 and 1988, cones were collected from 11 stands of adult spruce in the Tatra Mountains, 8 in the High Beskid Mts, 29 in the East Sudetic Mts, and 6 in the West Sudetic Mts (Fig. 1). These stands were well distributed across the studied areas and up to the timber line. The seeds were used to establish progeny tests in two nurseries, with three blocks of 54 populations

Fig. 1. Location of studied areas (hatched): 1 — West Sudetic (Karkonosze), 2 — East Sudetic (Śnieżnik Kłodzki and Góry Bialskie), 3 — High Beskid Mts (Pilsko and Babia Góra), 4 — Tatra Mts

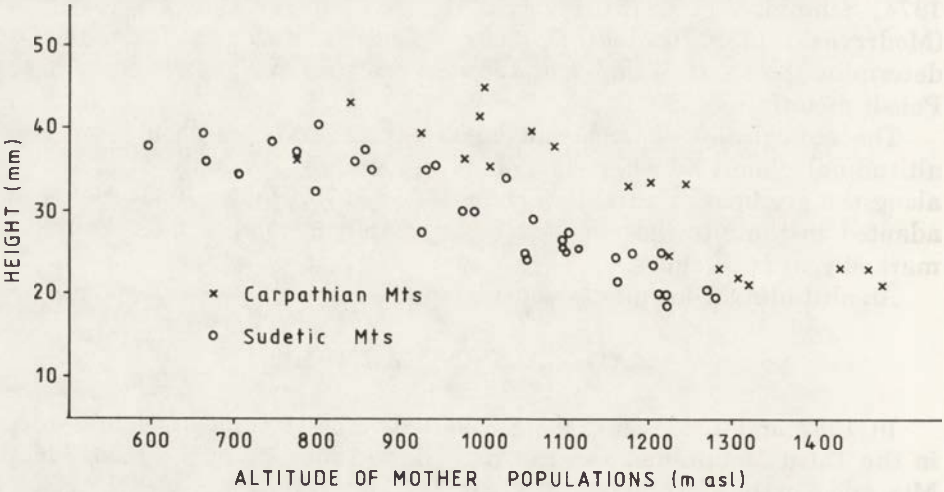

Fig. 2. Relation between the height of 1-year-old seedlings of Norway spruce and the altitude of mother stands in the Sudetic and Carpathian

in each. The phenological and growth characteristics of the young spruces were observed and measured, and the paper will concentrate on the results obtained for the heights of 1-year-old seedlings.

RESULTS

Both the Carpathian and the Sudetic populations formed rather regular clines — Fig. 2. Only two populations in the Carpathian Mts showed deviations from the average for the cline. These were of the order of 200 m a.s.l. In the Sudetic cline it was hard to find populations with deviations exceeding 100 m a.s.l.

Also obvious in Fig. 2 is the relative shift of the two clines. The heights of trees from the Carpathian populations reach the same values as those of the Sudetic ones from altitudes that are about 200 m a.s.l. higher.

DISCUSSION AND CONCLUSIONS

The clines found in the study have a genetic character and are indicative of the good ecological adaptation of Norway spruce stands (Schmidt-Vogt 1977, Holzer 1981, 1988, Nather 1988) in both the Sudetic and Carpathian Mts.

Even the greatest deviations from the average for the cline in the Carpathians do not exceed the tolerance zones of 200-300 m a.s.l. which are accepted in forestry for seed transfers in the mountains (Rhomeder 1964, Holzer 1985).

The shift in the clines is above all the result of the more southerly location of the Carpathians in relation to the Sudetic Mts. Similar shifts can be observed when populations from the Polish mountains are compared which those from the Alps (Holzer and Nather 1987).

The zonality of Norway spruce stands in the Polish Sudetic and Carpathian Mts would seem to be close to natural. This should therefore be maintained and respected in silviculture, and this means giving preference to natural regeneration and to local seed sources with a tolerance of about 200 m a.s.l.

In case of the necessity to transfer seed between the Carpathian and Sudetic Mts (e.g. because of the lack of local stands in the upper forest zone), account must be taken of the shift of the clines. For instance, for the zone of 1000-1200 m a.s.l. in the Karkonosze Mts, seeds from the zone of 1200-1400 m a.s.l. would be appropriate.

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FUNGI OF THE PLANT COMMUNITIES IN THE ALPINE/SUBALPINE ZONES OF THE BABIA GÓRA MASSIF — PRELIMINARY RESULTS

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Abstract. Preliminary results of mycocoenological studies performed in the 15 subalpine and alpine vegetation units on Mt. Babia Góra are presented. Ecological amplitude of selected macrofungi is discussed and remarks on an impact of tourism on vegetation and fungi are made.

Key words: Fungi of Babia Góra Mt., alpine fungi and vegetation.

Babia Góra Mt. (49°30'N, 19°25'E) is located in the Western Carpathians and forms and isolated massif north-west of the Tatra Mountains. It runs along the parallel of latitude and has a north side sloping down more steeply, with glacial relief and rich diversified vegetation. The highest peak is 1725 m.

Mycocoenological research in the alpine and subalpine zones on Babia Góra was started in 1984 and is continued on 50 permanent plots (and in transects) laid out in 16 syntaxa of vegetation from the upper forest limit (at 1390 m a.s.l.), to the alpine mires (at 1725 m a.s.l.) (Bujakiewicz 1993).

PRELIMINARY RESULTS

Data on selected species of macrofungi (based on the presence of ascomycete and basidiomycete carpophores) that seem to be indicative of syntaxonomical units of vegetation are presented in Table 1.

1. There is a significant concentration and complexity of fungus taxa and diversity of forms in an ecotone zone where the upper forest limit adjoins the dwarf pine zone (Pinetum munghi carpaticum) and the Anthyrio-Sorbetum association.
2. There is a gradual, significant decrease in the number of taxa of fungi as altitude increases.
3. There are differences in mycofloristic composition between north and south slopes in some plant associations, e.g. in dwarf pine thickets (Pinetum munghi carpaticum). Dwarf pine thickets on northern slopes are distinguished by the occurrence of (1) fungi associated with planted *Pinus cembra*, e.g. *Cortinarius miniatopus* s.l. and (2) various montane species, e.g. *Chroogomphus helveticus* (Singer) Moser. On the southern slopes, mycorrhizal symbionts seem to form more carpophores.

Table 1. Range of selected species of fungi in the alpine and subalpine vegetation zones of the Babia Góra Massif

Phytosociological unit	PP	Pmc	AS	Ata	PK	Aal	Cv	SFv	Vm	EV	HN	Ls	TS	Aj	Ts	Ls	HN	EV	Vm	SFv	Cv	Aal	PK	Ata	AS	Pmc	Ra	I'
Altitude in m	1310–1385	1370–1670	1350–1398	1350–1455	1455	1505–1510	1450	1340–1520	1410–1565	1505–1640	1580–1625	1705–1720	1705–1720	1710–1720	1705–1720	—	1520	—	1600–1625	—	1450–1515	—	—	—	—	1390	1400	
Number of plots	2	7	2	2	2	2	2	3	3	2	3	2	3	3	3	—	1	—	2	—	2	—	—	—	—	5	1	
Number of observations	12	12	11	12	13	12	11	12	10	11	11	13	14	12	14	—	11	—	10	—	11	—	—	—	—	12	10	
Average No. of species per plot	55	24	73	45	37	25	34	24	19	17	5	6	10	4	10	—	10	—	7	—	13	—	—	—	—	26	28	
Omphalina trigonospora														—														
Hygrocybe reai													▬		▬													
Hygrocybe miniata													—		—													
Brunnipila calycioides													▬		▬													
Omphaliaster asterosporus										—				—	—													
Omphalina luteovitellina									▬	—	—	—	▬	▬	▬	—	—		▬									
Clitopilus hobsonii							▬					—	—															
Dasyscypha rosea									▬	▬	▬						▬				▬							
Entoloma cetratum									▬										▬									
Omphalina ericetorum								—	▬	▬	—						—		▬									
Omphalina obatra								▬											▬									
Rickenella fibula								▬																				
Arrhenia acerosa								—																				
Entoloma asprellum								—																				
Helvella arctica								—																				
Laccaria altaica								—																				
Omphalina hudsoniana								—																				
Sclerotina curreyana							▬																					
Galerina laevis																												
Marasmius limosus					—	▬	▬														▬							
Peziza cfr. howsei					▬																							
Flagelloscypha kavinae					▬																							
Scutellinia macrospora					▬																							
Hebeloma stenocystis					▬																							
Hemimycena pseudocrispula					▬		—																					
Nochascypha filicina				▬	▬																							
Psilocybe crobula			▬	▬		—																						
Phytosociological unit	PP	Pmc	AS	Ata	PK	Aal	Cv	SFv	Vm	EV	HN	Ls	TS	Aj	Ts	Ls	HN	EV	Vm	SFv	Cv	Aal	PK	Ata	AS	Pmc	Ra	I

Mycena longiseta		r	a	a																							
Mycena pterigena	r	n	a	a																							
Typhula sclerotioides			r	r	a	a																					
Typhula athyrii			n	n		n																					
Mycena cyanipes			n	n		n																					
Melastiza flavorubens						n																					
Cortinarius miniatopus s.l.		a																									
Dermocybe bataillei		a																									
Guepiniopsis alpina		a																									
Lachnellula suecica		a																								a	
Suillus variegatus		a																								n	
Trichoscyphella fuckelii		a																									
Trichoscyphella fuscosanguinea		a																									
Amanita submembranacea		n																									
Collybia succinea		n																								n	
Hygrophorus hypothejus		n																								n	
Russula decolorans		n																								n	
Chroogomphus helveticus	n	a																								n	
Hygrophorus olivaceoalbus	n	a																									
Pholiota scamba	n	a																									
Russula emetica	n																										
Russula vinosa																										n	
Cudoniella clavus																										n	
Calyptella capula																											a
Ombrophila violacea																											a
Climacocystis borealis	n																										n
Clitocybe ditopa	n																										
Hygrophorus pustulatus	n																										
Lactarius lignyotus	n																										
Lyophyllum gibberosum	n																										
Phellinus viticola	n																										
Russula ochroleuca	n																										

Explanations: — r rare: ▬ n numerous: ■ a abundant:

Aal = Adenostyletum alliariae: Aj = snowbeds with Anthelia juratzkana: AS = Ahyrio-Sorbetum: Ata = Athyrietum alpestris: Cv = Calamagrostietum villosae: EV = Empetro-Vaccinietum, HN = Hieracio-Nardetum: Ls = Luzuletum spadiceae: PK = Petasitetum Kabilkiani: Pmc = Pinetum mughi carpaticum: PP = Plagiothecio-Piceetum: Ra = Rumicetum alpini: SFv = Saxifrago-Festucetum versicoloris: TS = Trifido-Supinetum: Vm = Vaccinietum myrtillii

4. There is striking correspondence between macrofungi and syntaxonomical units of vegetation. Particularly significant is a group of fungi associated with the habitats of the Vaccinio-Piceetea class (Plagiothecio-Piccetum, Pinetum mughi carpaticum, Vaccinietum myrtilli, Empetro-Vaccinietum) and including *Lactarius rufus* (scop.: Fr.), *Marasmius androsaceus* (L.: Fr.) Fr., *Pholiota scamba* (Fr.: Fr.) Moser, etc. Fungi associated with the habitats of the Betulo-Adenostyletea class (Athyrio-Sorbetum, Athyrietum alpestris, Petasitetum kablikianii, Adenostyletum alliariae, Calamagrostietum villosae) also have a significant group of fungi, e.g. *Mycena pterigena* (Fr.: Fr.) Kummer, *Typhula sclerotioides* (Pers.) Fr., *Melastiza flavorubens* (Rehm) Pfister and Korf.

5. Within a plant association there are differences in habitat, which result in differences in the number of taxa and carpophores. For example, with regard to mycorrhizal symbionts, Pinetum mughi carpaticum silicicolum has fewer taxa (11) but more carpophores (73) than Pinetum mughi carpaticum calcicolum (14 taxa, 45 carpophores). Only 30% of species are common to the two subassociations.

6. The Saxifrago-Festucetum versicoloris association is endemic to the massif it, forms “grassmats” on abrupt sandstone rock-steps and, has a distinctive mycological character. Such species as *Omphalina obatra* (Favre) P. D. Orton, *Arrhenia acerosa* (Fr.) Kühner, *Entoloma* cfr. *asprellum* (Fr.) Moser and *Helvella arctica* Nannf. have been found only in this specific habitat.

7. The rather small alpine zone, is only 75 m of absolute elevation (1650-1725 m). It has small patches of snowbeds with *Anthelia juratzkana* where fungus, *Omphalina trigonospora* Lam., a rare and interesting species, has been recorded. Patches of the *Luzuletum spadiceae* association are poorest in fungi (in frequency and taxa). A constant species in patches of the Trifido-Supinetum association, which dominates the alpine zone is *Brunnipila calycioides*. This species grows on dead blades of *Juncus trifidus* and was recently recorded from Babia Góra by Chlebicki (1990). *Hygrocybe reai* Maire and *H. miniata* (Fr.) Kummer are often noted, but *Omphalina luteovitellina* (Pilàt & Nannf.) M. Lange *(Phytoconis viridis)* and *O. ericetorum* (Fr.: Fr.) M. Lange are the most common. They are associated with algae forming loose Basidiolichen relationships.

8. Several synanthropic (nitrophilous) fungi species have been recorded in areas heavily influenced by tourists. One example of these is *Conocybe semiglobata* Kühner (Watling.

9. The decline or absence of the fungi (*Omphalina obatra* (Favre) P. D. Orton and *O. trigonospora* Lamoure), especially in the alpine zone, has been observed. Alpine snowbeds are trampled in many places along tourist trails and around the summit.

10. Tourism in the Babia Góra National Park (recognized as a Biosphere Reserve in 1977) should be considerably limited and regulated, particularly in the small alpine area.

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PART 2
WATERS IN THE MOUNTAINS

A. Breymeyer (ed.) — EURO-MAB IV.
Mountain zonality facing global change,
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THE IMPACT ON ALPINE HIGH-MOUNTAIN LAKES OF ATMOSPHERIC NUTRIENT LOADING AND STOCKING WITH FISH

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Abstract. Remote Alpine lakes above or just below the tree-line, are not directly influenced by man, but are increasingly affected by non-point nutrient loading from both wet and dry deposition. In contrast to other elements or compounds such as SO_x, NO_x etc. only occasional data have been collected in recent decades for atmospheric P-loading. However, there is no doubt that concentrations in precipitation have increased and that eutrophication and its consequences can therefore be observed in most such lakes which otherwise have no increased source of loading.

Key words: Mountain lakes, phosphorous loading, eutrophication.

Of even more concern is the stocking of Alpine high-mountain lakes with fish where they have never been before. Though the introduction of fish to many Alpine lakes had already begun by the 15th century many small lakes remained without fish until recent times. But along with increasing sport-fishing activities, these lakes have now been claimed for this kind of recreation — a progress strongly promoted by the present legislation. Described here are the most obvious consequences of stocking, such as the loss of certain invertebrates.

If not directly influenced by man high mountain lakes (i.e. those above the tree-line) most often have extremely low concentrations of nutrients (especially P), and are therefore ultra-oligotrophic. Many examples of this kind have been described from Peru (Löffler 1960) (Table 1), from Colombia, Venezuela and Central America (including Mexico) (Löffler 1972), from East Africa (Löffler 1969) and from New Guinea (Löffler 1973). Exceptions to this typical feature may occur in connection with glacial erosion in a watershed where minerals are relatively rich in soluble P (e.g. Lewis Tarn, Mt. Kenya). In addition, most lakes may be loaded by organic debris if there is a prevalence of frequent strong up-winds from the upper mountain forest belt (POP, fraction of the “empneuston”, coined by Steinböck 1958). In addition, high concentrations of waterfowl may sometimes contribute to nutrient loading in shallow high-mountain lakes.

In contrast to the remote and exotic high mountain lakes mentioned above, recent research in Austria including more than 3100 lakes above 1500 m a.s.l. and approximately 2000 in the region above the timber-line, has revealed P values that are generally higher, though well within the oligotrophic range. Table 1 gives the comparative figures.

Table 1. P values from Alpine lakes and from lakes in some of the exotic mountain regions

Location	Number of lakes	Number of lakes with less than (or) 2 μg/l
Austrian Alps (2000 m a.s.l.) (Psenner 1989)*	73	12
Peruvian Andes (Löffler 1960)	19	17
High mountains of East Africa (Löffler 1968)	36	30
Mt. Everest Region (Löffler 1969)	24	23

*) Values for the Tyrolean and Carinthian Alps are for TP, whilst the remainder are for PO_4-P. However, at these concentrations it is unlikely that organic particulates or even organic soluble P plays significant role, so the comparison would seem to be justified. Moreover, among the Alpine lakes above 2000 m, 13 have concentrations of more than 10 μg/l TP (total P).

Since the lakes in Table 1 are hardly or not at all, influenced by human activities which could result in P-loading, the relatively high values for P in the Alpine lakes of Austria must be explained by increased concentrations in rain water, and most likely also in dry deposition. The latter accounts for 39% of P in the the small forest lakes (e.g. Pilburger See, Psenner 1984b). So far concentrations of P in rainwater (or snow) have been measured relatively infrequently. Little has happened to date in spite of a proposal for the inclusion of P analysis in routine precipitation research, which was put forward on the occasion of a relevant SCOPE Conference (on N-, C-, and S-cycles) held in Stockholm in 1979. It is not at present feasible to do any mapping of P — concentrations in precipitation, even on a regional scale (as has been done for SO_x, NO_x) The values so far obtained from Alpine region have been measured occasionally, or for short periods only. Moreover, they relate mainly to sites at or well below 600 m above sea-level. TP concentrations of between 18 and 44 kg/km^2/y have been found in these places. In the high-mountain region of the Tyrol, concentrations were measured for a 20-week period near the three lakes mentioned in Table 1 (Psenner 1984a). A mean value of 123 μg/l TP was obtained, with extreme values of 6 and 1641 g/l TP, and peak concentrations during summer.

There would seem to be no doubt that a large portion of this considerable atmospheric loading is derived from human activities such as agriculture, settlement, industry and traffic; and that eutrophication with all its consequences will eventually be of concern in even the most remote high-mountain lakes of the Alps. Loss of diversity will be one of the main features of this process, although it may proceed slowly. More evidence for this development may be obtained by relevant paleolimnological investigation.

In contrast to this kind of impact, the consequences of stocking inland waters with fish are most often immediate. The best known examples of this relate to Lake Titicaca and Lake Victoria, where introductions, especially of carnivorous fish, have led to the disappearance of on unknown number of indigenous fish species. It should, however, be added that stocking with planktonivorous fish may sometimes have rather limited impacts on the ecosystem. Such is for example the case in Lake Kariba, where the clupeid species *Limnothrissa miodon* has been introduced with some economic success. On the other hand, in the Lunzer Obersee (at 1112 m in the Alps), massive stocking with char some years ago has almost resulted in the extinction of *Arctodiaptomus denticornis*.

Most of the high-mountain lakes in the Alps were originally lacking fish: a condition which obviously allowed for the existence of certain large invertebrates. However, stocking of high-mountain lakes in the Tyrol began as early as during the 15th century (by Archduke Sigismund and later by the Emperor Maximilian I). As a result, only a few such lakes have been left without fish. One of the consequences has been the rapid disappearance of large invertebrate species like *Daphnia middendorffiana* and possibly also of the arctoalpine fairy-shrimp *Branchinecta paludosa*, which is now restricted to one lake in the Tatra Mountains, and to the Himalayas albeit being still wide-distributed in the circumarctic zone.

It is obvious that, centuries ago, any new food resource for man was vital and therefore most desirable. In our time, however, when we are concerned about the preservation of genetic diversity, further stocking of high-mountain lakes serves recreation alone and is therefore obsolete as a major need of man. Thus it seems rather strange that recent report (Steiner and Stampfer 1987) called for the stocking of 31 high-mountain lakes in the Tyrol which are lacking fish. In conclusion, I would therefore appeal that in industrial countries at least high-mountain lakes be added to the list of endangered ecosystems and that the authorities responsible for legislation in the relevant countries should be advised about the impact on biodiversity of fish-stocking.

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A. Breymeyer (ed.) — EURO-MAB IV.
Mountain zonality facing global change,
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THE CHEMISTRY AND ACIDIFICATION OF THE WATERS IN THE NATIONAL PARKS OF SOUTH POLAND

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Abstract. There are nine National Parks in southern Poland (Fig. 1). Seven of these are in mountains and two in uplands. Although the mountainous Parks are situated in different ranges, they can be divided into three groups depending on the geological structure of bedrock. Parks of the first group (1-3) are situated on hard crystalline rocks, parks of the second (4-6) on Carpathian Flysch and parks of the third (7-9) on carbonate rocks. The upland parks belong to the last group since they are also located on carbonate rocks.

Key words: mountain waters acidification, pollution, southern Poland National Parks.

The ionic composition of surface waters reflects the geological structure of the watersheds. The water of streams in the Karkonosze and Tatra Mts is very soft and a similar composition has been found in the Świętokrzyskie Mts, but only during dry seasons. The lower parts of the Tatra Mts are built of sedimentary rocks, and these change the composition of water.

The chemical composition of the water of the streams in Babia Góra National Park varies according to location. The water in the streams of the north slope contains more electrolytes than those on the south slope; water of streams crossing Carpathian Flysch is diluted during wet periods.

The waters of Pieniny National Park and the upland parks show high contents of calcium and magnesium bicarbonates.

Acidification of water is noted in three national parks (1-3) (Table 1). Acidification reaches its highest level during snowmelt and falls of rain.

The process of acidification is underway not only in streams in national parks but also on Barania Góra Mt — a source of the Vistula River, the biggest river in Poland (see square on the map in Fig. 1). The Vistula has two source streams — the White and Black Vistula. The area is now a nature reserve created to protect brown trout. Showing high acidification Black Vistula is located on the south and west slopes of Barania Góra Mt, where deposition of pollutants from the Czech and Slovak Republic occurs.

There is a high concentration of aluminium in acidified water (Table 1). The highest concentration was found in the Świętokrzyski National Park and the lowest in the Tatra Mountains National Park — but even there the concentration was twice that shown to be toxic for brown trout.

A high concentration of aluminium was also found in the Black Vistula,

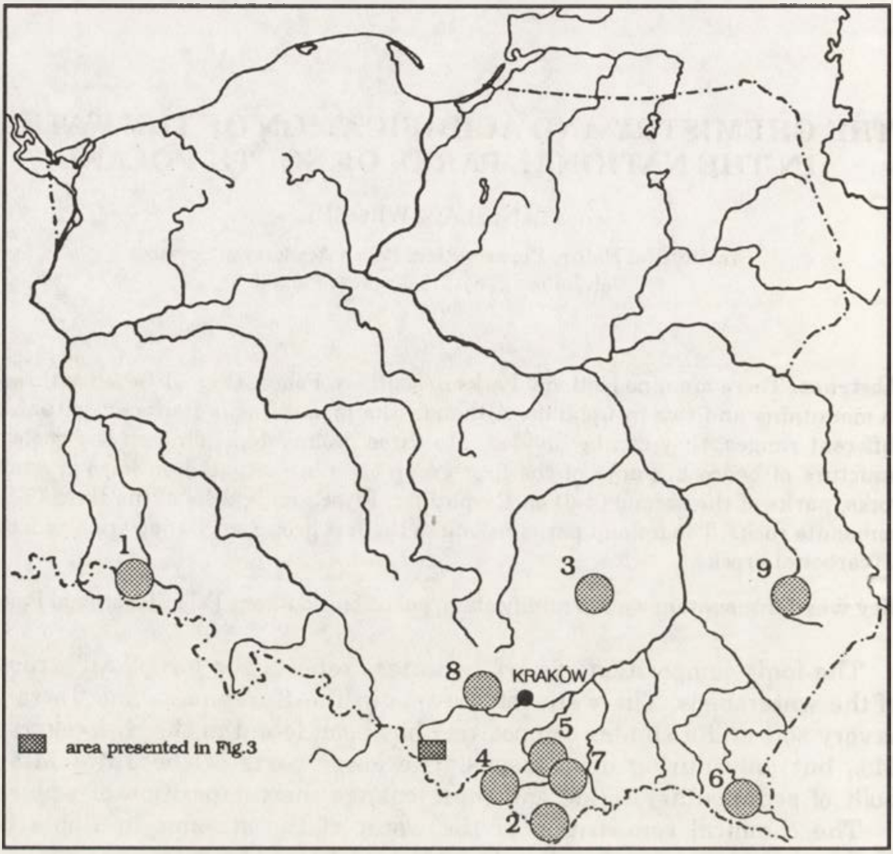

Fig. 1. Location of national parks in southern Poland
Numbers — see Fig. 2

Table 1. Some chemical features of the water in the following streams:
1. Waksmundzki — High Tatra Mts, 2. Podgorna — Karkonosze Mts,
3. Podłysicki — Świętokrzyskie Mts, 4. Black Vistula — Barania Góra Mt.

Feature		1	2	3	4
Conductivity	µS/cm	22.70	57.00	108.10	57.50
pH-value	pH	4.40	4.30	4.20	4.60
Alkalinity	meq/dm^3	0.07	0.04	0.04	0.04
Tot. Hardness	G^o	0.45	0.80	2.25	1.00
Calcium	Ca^{2+}mg/dm^3	2.14	4.80	10.00	3.90
Magnesium	Mg^{2+}mg/dm^3	0.65	1.20	3.90	1.20
Aluminium	Al^{3+}mg/dm^3	0.14	0.72	1.00	0.60
Sulfate	SO_4^{2-} mg/dm^3	1.60	6.12	31.20	4.20
Ammonium-N	N–NH_4^+ mg/dm^3	0.20	0.18	0.27	0.41
Nitrate-N	N–NH_3 mg/dm^3	0.47	0.70	3.50	0.66

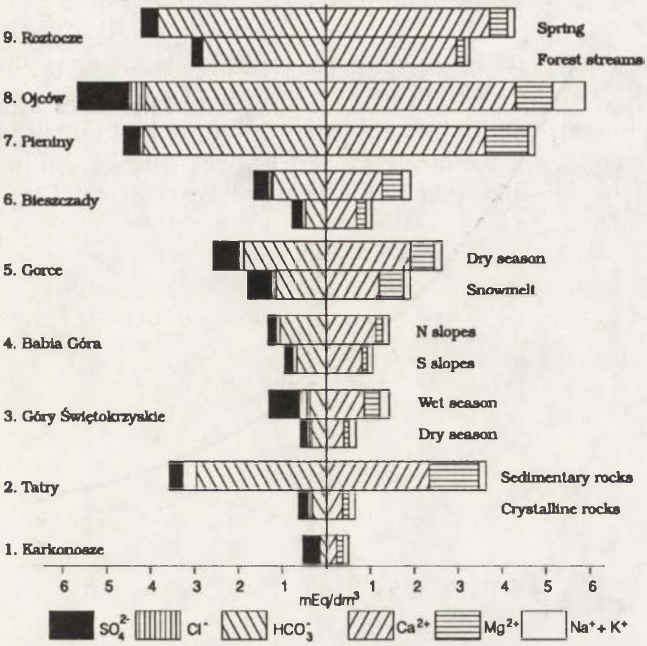

Fig. 2. The ionic composition of the waters in the national parks of southern Poland

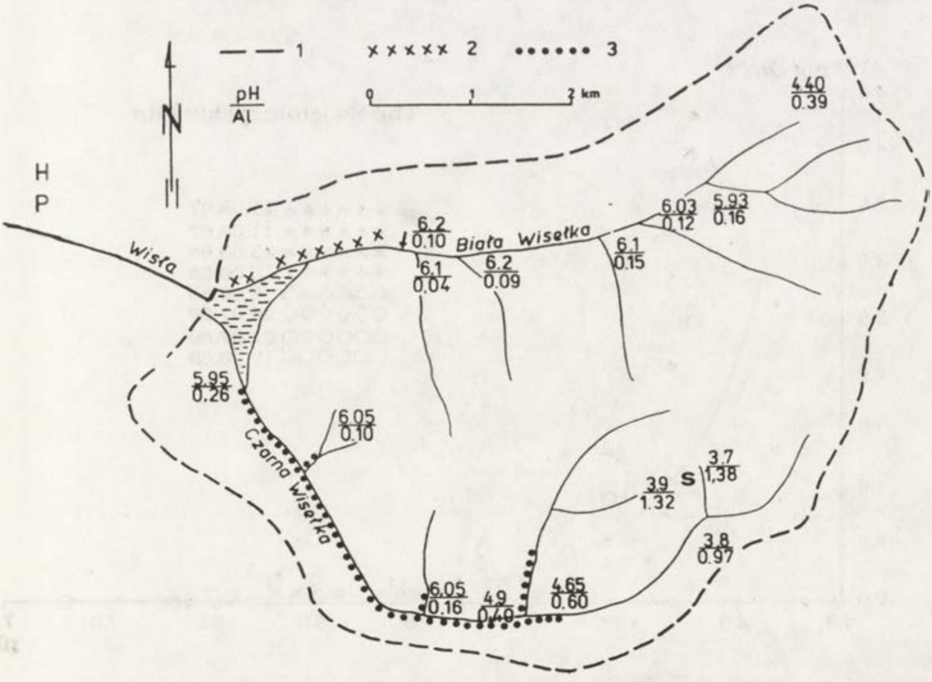

Fig. 3. Biała i Czarna Wisełka (White and Black Vistulas) and their tributaries
1 — catchment area, 2 — village, 3 — part of stream prepared for liming, S — shelter home,
H — hatchery, P — water treatment plant

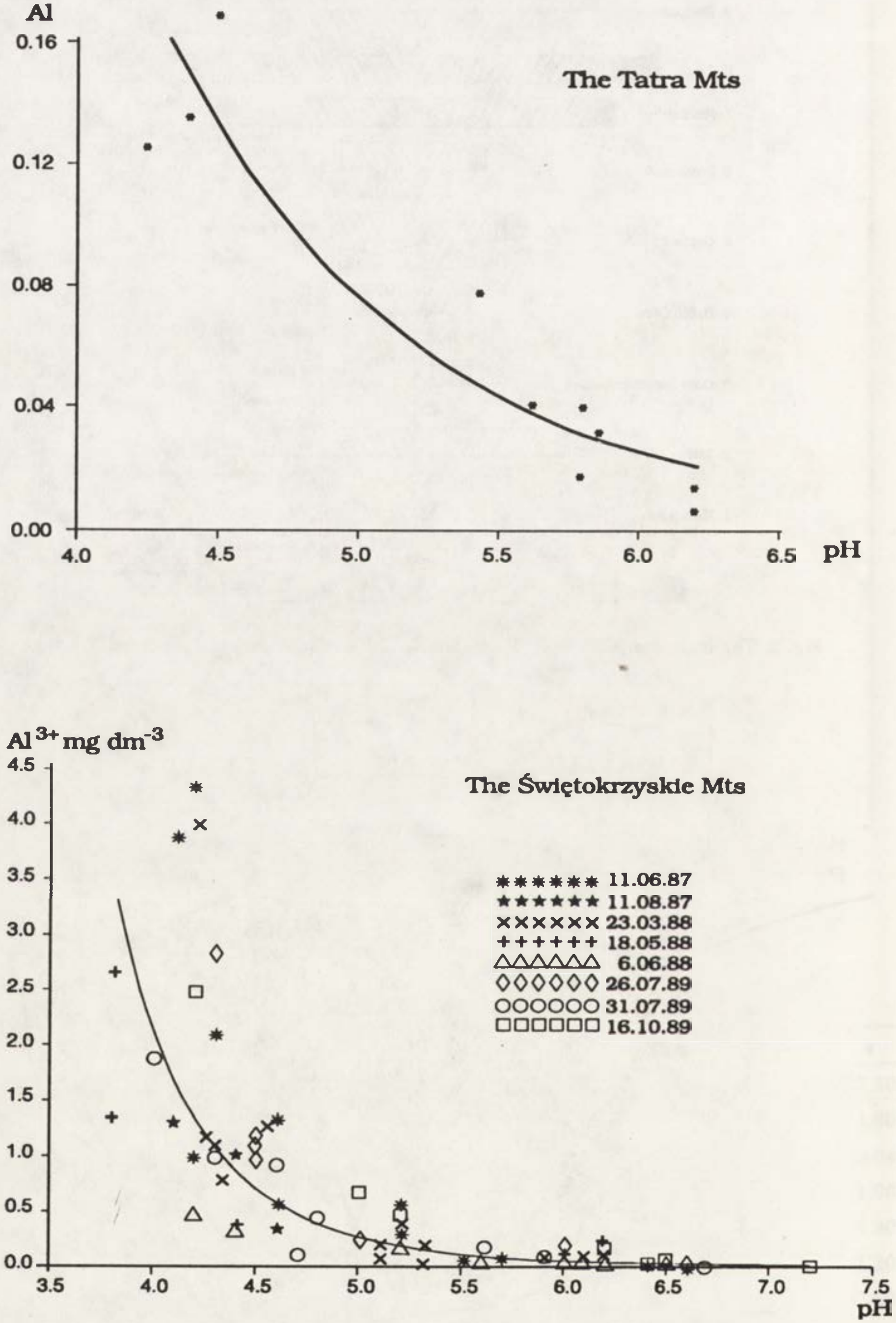

Fig. 4. pH values and concentrations of aluminium in the water of some streams in the Tatra Mts and the Świętokrzyskie Mts

giving the likely reason for the disappearance of brown trout and other changes noted in the flora and fauna.

In Poland the acidification of water is found almost exclusively in protected mountain areas. The highest mountains are the places with the most divergent communities of plants and animals, hence the founding of the national parks there. But mountains (built of hard rocks containing only traces of calcium and magnesium) have increased deposition of pollutants from the air.

These unfavourable changes in protected areas will be ever greater, since the butter capacity of both soils and water have been depleted. As a result, naturally structured communities will only survive in areas located on carbonate rocks. The question thus arises as to how to prevent those changes in national parks from occurring. Soils and water may be limed if the area is not too large, and such a project using dolomite is now underway in the Black Vistula.

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These [illegible] the better [illegible] naturally structured communities [illegible] rocks. The question [illegible] parks from [illegible] lakes, and [illegible] Vistula.

PART 3
GIS, TELEDETECTION AND REMOTELY-SENSED DATA IN MOUNTAINS

A. Breymeyer (ed.) — EURO-MAB IV.
Mountain zonality facing global change,
Conf. Papers, 21, IGiPZ PAN Warszawa

SEQUENTIAL MONITORING OF TATRA SUBALPINE FORESTS ON THE BASIS OF CARTOGRAPHIC AND REMOTELY-SENSED DATA

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Abstract. The authors present the results of their study carried out in order to delineate changes to the forest in the Tatra Mountains. Types of cartographic and remote sensing data are discussed. Procedures used to generate a regional, special-purpose Geographic Information System (GIS) for the Tatra Mountains are demonstrated. The application of GIS in multitemporal data analysis on the reconaissance scale is commented on. Highlighted in brief are several problems related to the digital processing of geodata including image geocoding, resampling and enhancement as well as the effects of mountainous relief. Quantitative aspects related to changes in the forest are ilustrated on several schematic maps and diagrams. An overview of procedures applied in the study is depicted in a flow-chart.

Key words: GIS, remote sensing data, forest change in Tatras, mountain forest damage.

INTRODUCTION

It is already well known that satellite remote sensing and Geographic Information Systems provide excellent tools for the efficient monitoring, mapping and inventory of the Earth's resources. They are indispensable for the fast and reliable integration of multisource, thematic layers of data used for spatial and sequential (multitemporal) analyses. Offerring synoptic, up-to-date and highly objective overviews of areas they are especially useful for the assessment of regional development, environmental impacts and hazard as well as for ecological modelling and simulation, physical planning, resource management and decision-making. In view of the deteriorating environmental and living conditions resulting from the over-exploitation of resources, increasing air pollution, soil erosion, flood hazard and general anthropopressure (incl. tourism) the interest in and demand for operational GIS applications is growing constantly.

This study has been undertaken as part of a larger effort aimed at the implementation of a GIS for the Tatra National Park which is regarded as a means to provide unprejudiced and unbiased information. This is especially important in view of the existing discrepancies in opinions concerning the development of the Tatra region expressed by environmental conservationists and various groups of interests. Changes in forests are relatively easy to monitor and assess with the aid of computers and are at the same time highly informative as regards the trends and intensity of environmental degradation. The most important symptoms of forest damage caused by biotic and mainly abiotic factors (air pollution) are the following (Kenneweg et al., 1993):

(1) Total destruction of stands (deforestation);
(2) Lower stand density due to damage;
(3) Needle loss (defoliation symptoms);
(4) Discolouration of foliage (discolouration of symbols).

The spectral signatures of forests registered on satellite remotely sensed data are analysed in order to reveal the aforementioned symptoms and therefore to assess environmental damage. This study, with its preliminary and reconaissance character is concerned only with the spatial distribution of changes in the forest which have occurred in the Tatra Mountains between 1934 and 1992. Amore detailed survey may be also undertaken if the necessary funds are secured and interest shown by the appropriate authorities.

MATERIAL

DATA

The following sources have been used for the generation of the digital data analysed within the scope of this study:

— A photogrammetric 1:20 000 scale map published in 1934;

— A thematic map displaying the results of the survey of changes in the range of subalpine forests in the Tatras based on the photointerpretation of 1:20 000 scale aerial photographs from 1977, (Bielecka 1986);

— Topographic 1:50 000 and 1:100 000 scale maps;

— Thematic maps published in the *Atlas of the Tatra National Park* (1985);

— Remotely sensed data from the French Earth observation satellite SPOT. Two cloudfree, multispectral scenes from 30.08.1992 and 09.10.1992, with 20x20 metre ground resolution have been aquired in order to experiment with the stereoscopic capabilities of the satellite system and to demonstrate its usefulness for the detection and monitoring of vegetation change. Both of them are well suited to forest research, but because vegetation cover is still well developed in the earlier scene and already deteriorated in the later one — it is the first scene which has been selected for further processing and analysis;

— Panchromatic 1:20 000 scale aerial photographs are available and have been used in a limited way as reference data for checking and comparing. An interesting experiment has been undertaken in order to merge scanned aerial photographs with SPOT data, produce a Digital Elevation Model form an aerial stereo pair, generate an orthophotograph and create a 3-dimensional

(3-D) view of the Giewont Mountain. This work, however, is beyond the scope of the present report.

SOFTWARE

The PC ARC/INFO ver. 3.4 D+ with SEM, ARC/INFO ver.6.1, VGA ERDAS ver.7.5, ERDAS-Imagine ver.8.0.1 and 8.0.2 and pre-release version of ORTHO-MAX photogrammetric package have been used for the data automation, image processing, and spatial and statistical analyses carried out during this study.

HARDWARE

The Computing environment consisted of following networked platforms:

— PC (IBM compatible) with Orchid Pro Designer display device (1024x768), 3.2 MB Expanded Memory and 2x200 MB HDD;

— Sun SPARC IPX Workstation with 8-bit standard display, 32 MB of memory and 1.05 GB HDD (OpenWindows ver.3.0);

— Hewlett-Packard 9000 Series 720 Workstation with 8-standard display, 32 MB of memory and 1GB HDD, (OSF/Motif).

Tablet digitizing was performed with an Altek Series Model 33240 with AC 31 controller. Visualization of black and white maps and diagrams was done with the aid of HP LaserJet III printer.

A preliminary version of the satellite image map of the Tatra Mountains, prepared in completely digital workflow (Map Composer Module of ERDAS-Imagine), was generated on a STORC Ink Jet Printer in cooperation with GEOSYSTEMS GmBh, Germany.

PROCEDURES

A simplified overview of the procedures used in this study is presented on the flow-chart. Cartographic data have been digitized and rectified into a uniform coordinate system. A digital Terrain Model has been generated from the contour lines digitized from the 1:50 000 topographic map.

The processing of satellite remotely-sensed data involved image-to-map registration, resampling using the near neighbour method and image enhancement. This last step was based on a trial and error approach aimed at improving the interpretability of the image. Interactive contrast stretching, convolution filtering and spectral transforms including RGB to IHS and reverse IHS to RGB were carried out to extract information and to mitigate the effects of mountaineous relief on the illumination (shadows). Although the Digital Elevation Model was available it was not used during this reconaissance study for correction of the adverse impact of relief on the geometric properties of the imagery. However, it is acknowledged that for more detailed study the effects of topography should be eliminated (e.g. by generation of orthoimagery with ORTHO MAX), and the accuracy of the rectification procedures should be estimated quantitatively. Corrections of

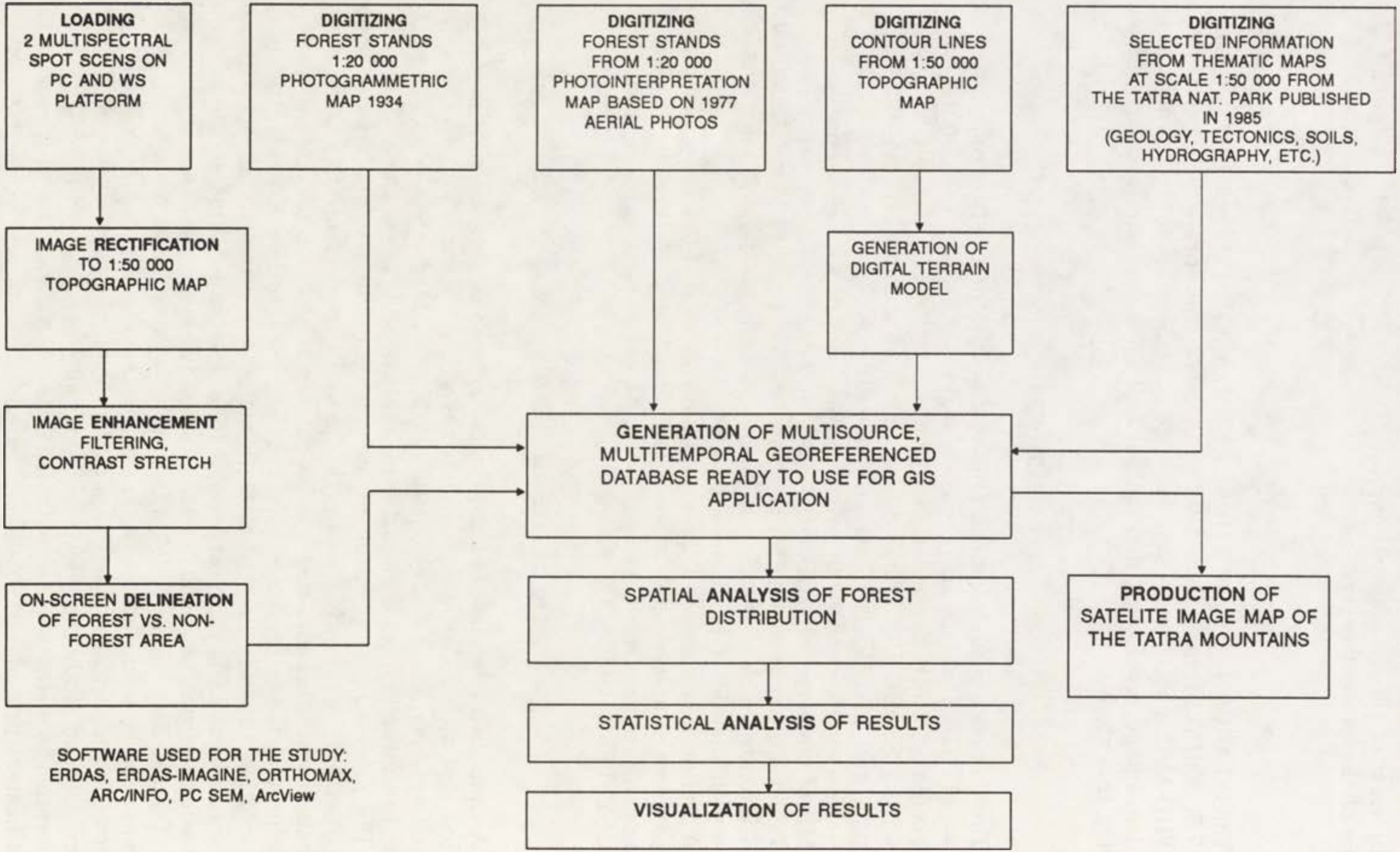


Fig. 1. Overview of procedures applied for the study

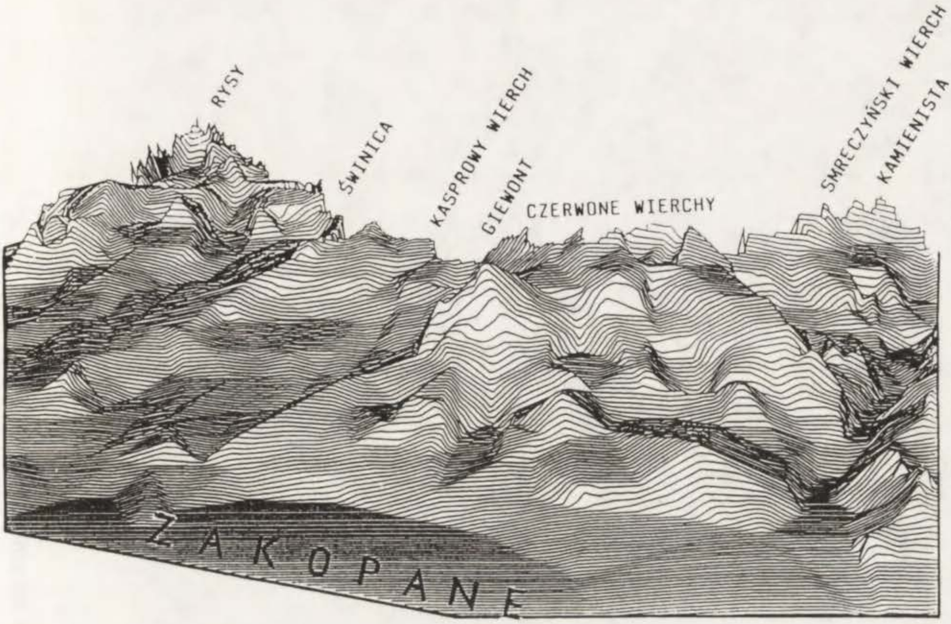


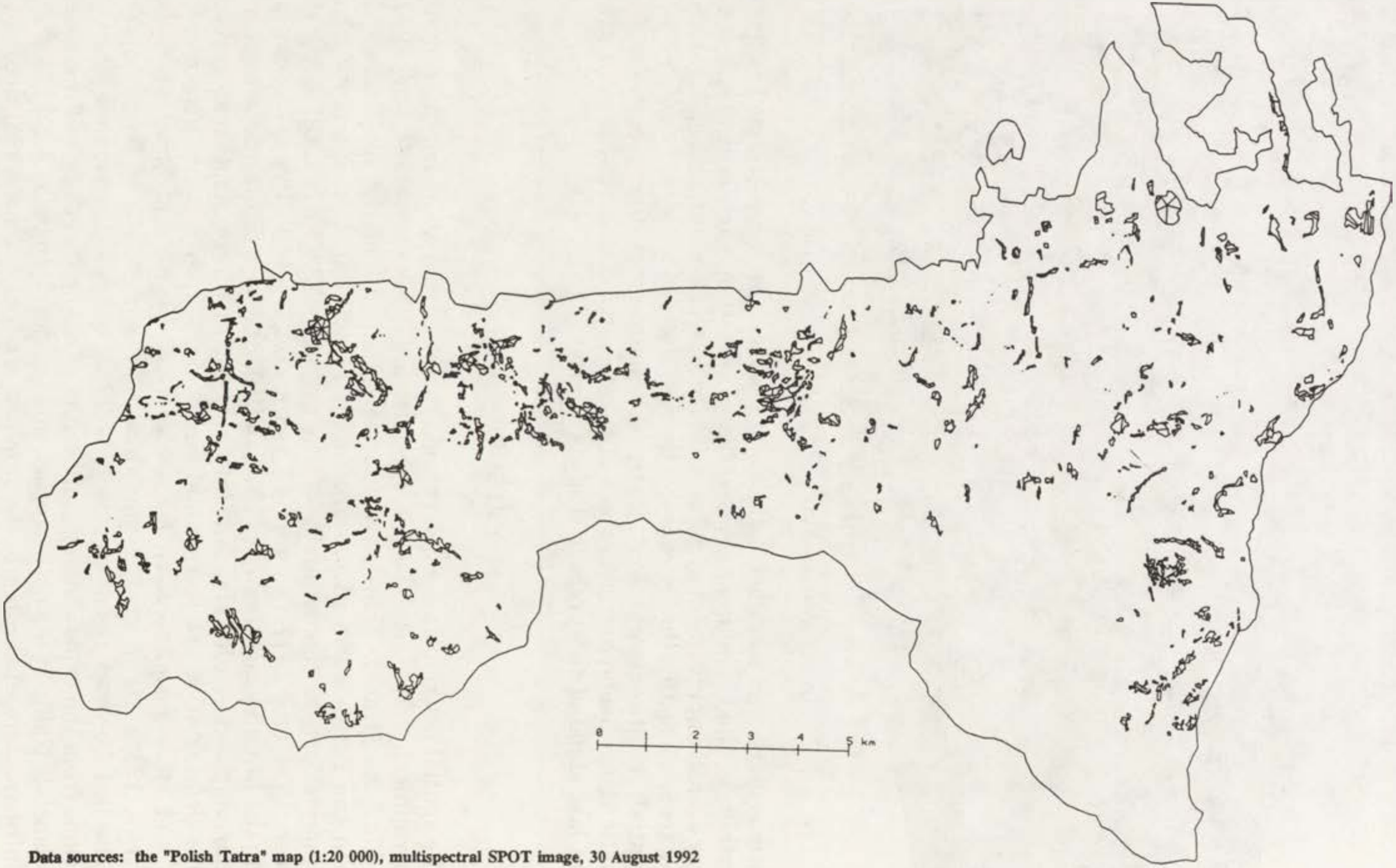
Fig. 2. Digital elevation model of the Tatra Mountains

the atmospheric and so called “adjacency” effects were not performed either. Nevertheless, the reconaissance character of the study, the limited time and the low overall improvement of the accuracy of forest vs. non-forest delineation would seem to justify this approach (Richter, 1991).

Spatial, multitemporal and statistical analysis of the georeferenced thematic data displaying deforested and reforested areas was carried out as the last stage of the present study.

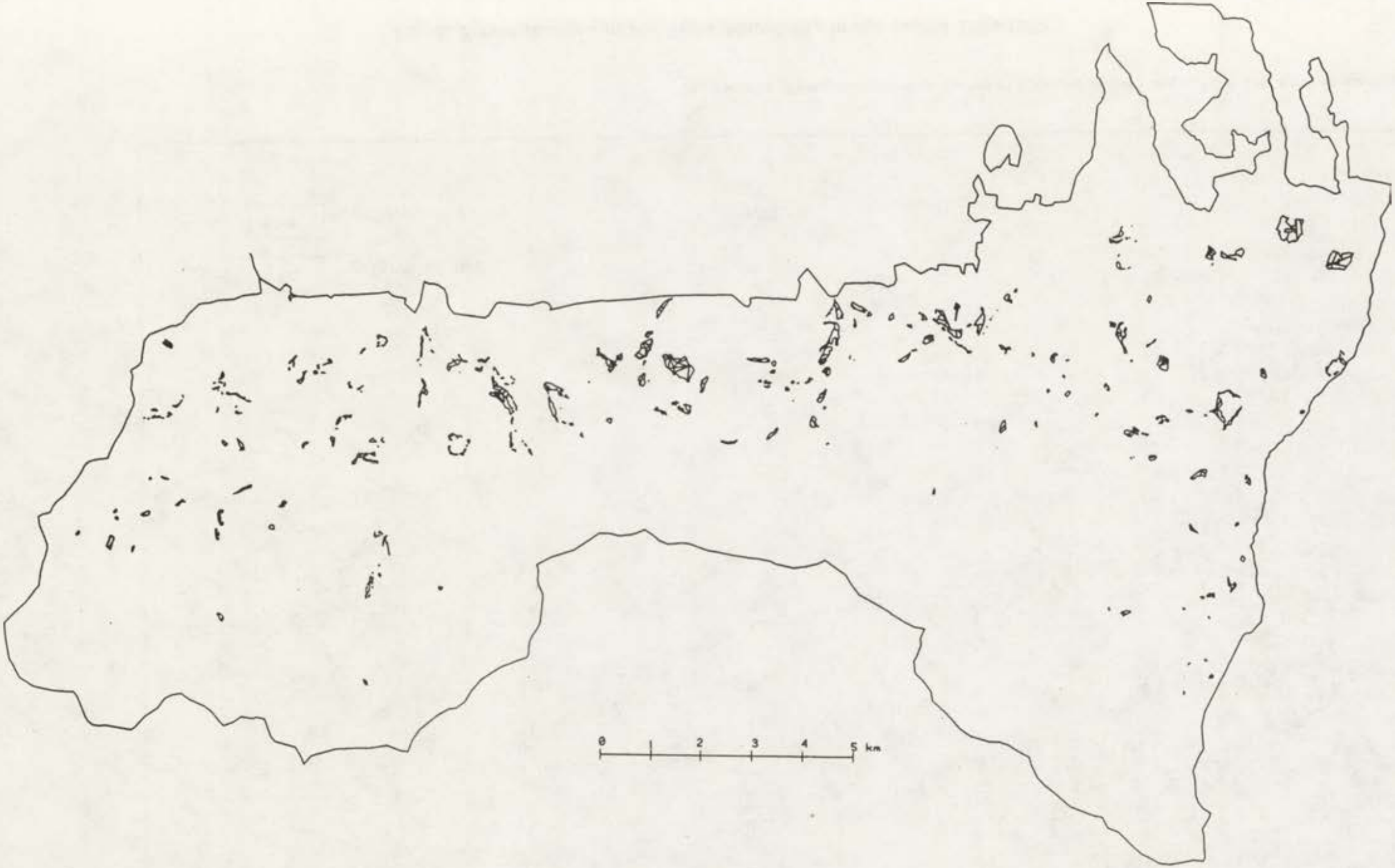
RESULTS

The spatial distribution of deforested and reforested areas is represented cartographically. The total loss to forested areas between 1934 and 1992 was 974.7 ha (100%). This constitutes less than 9% of the total forested area in the Polish Tatra Mountains (appr. 11 400 ha). It is interesting to look more closely at the dynamics of this process. 652.6 ha (66.9%) was lost between 1934 and 1977 i.e. over 43 years. 322.1 ha (33.1%) disappeared during the last 15 years (between 1977 and 1992). These figures demonstrate the alarming acceleration of deforestation. The main direct factors responsible for this deforestation are storms and foehn winds (halny), mass movement, frost and snow formations on trees and bark beetle and other animals (Bielecka, 1986). However, it seems that the rapid growth of deforestation over the last 15 years is linked closely with the air pollution caused by SO_2 emissions from the expanding agglomeration of Zakopane, the great increase in automobile traffic in the entire region, and the development of local industry and infrastructure. According to the previous study (Bielecka, 1986) the most



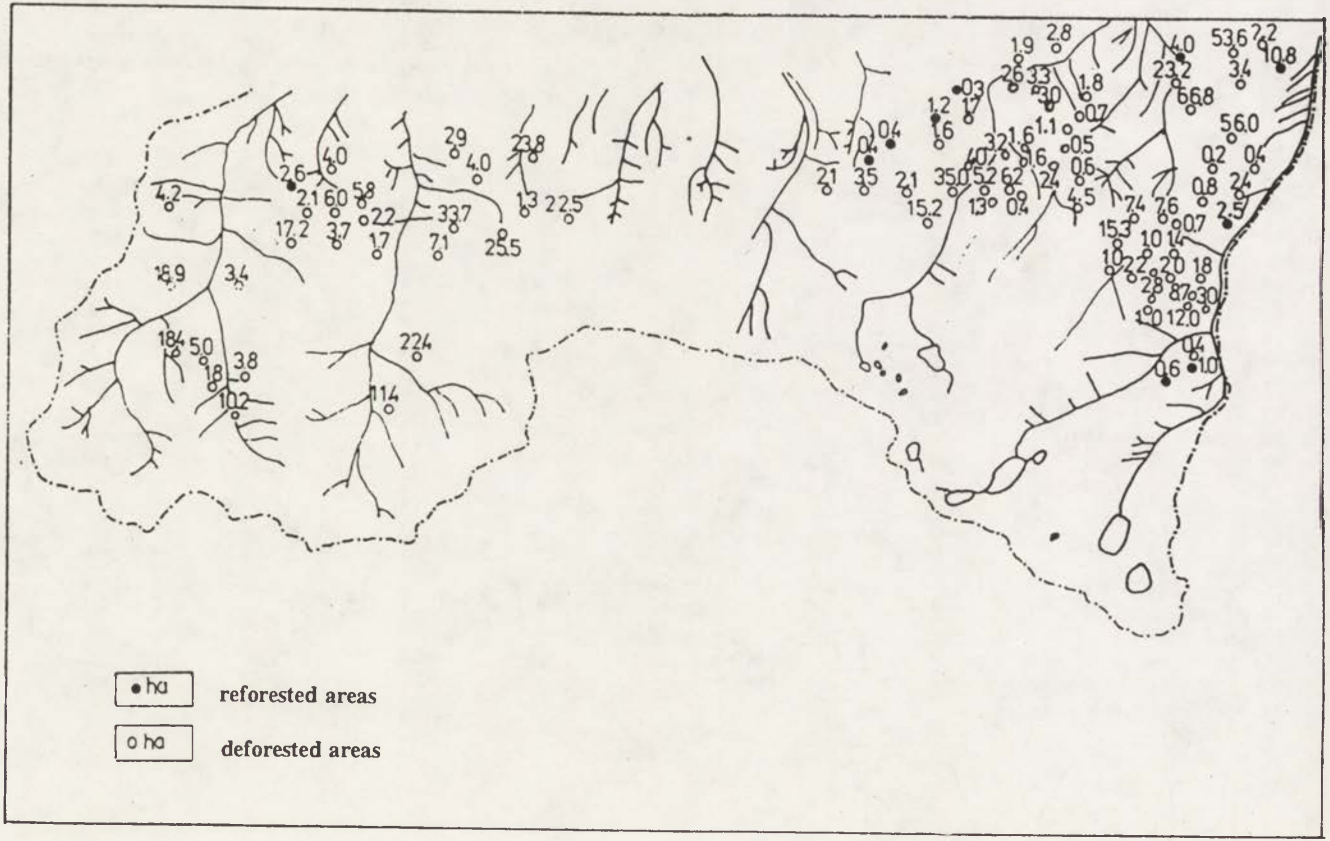
Data sources: the "Polish Tatra" map (1:20 000), multispectral SPOT image, 30 August 1992

Fig. 3. Deforestation in the Tatra Mountains in the period 1934-1992



Data sources: the "Polish Tatra" map (1:20 000), multispectral SPOT image, 30 August 1992

Fig. 4. Reforestation in the Tatra Mountains in the period 1934-1992



Data source: Photointerpretation Survey of Changes in the Range of the Tatra Subalpine Forests.

Fig. 5. Forest changes in the Tatra Mountains in the period 1934-1977

significant elements responsible for the vulnerability of forests are the following:

— exposure of slope (aspect),
— inclination of slope,
— height above sea level (altitude of the forest stand),
— geological and pedological character of the site (bedding, fracturing, soil formation, etc.),
— species-oriented composition,
— age.

In order to ensure comparison between multitemporal data sets the following factors have been investigated:

— deforestation and reforestation in relation to height above sea level (Fig. 6);
— deforestation and reforestation in relation to the inclination of the slope (Fig. 7);
— deforestation and reforestation in relation to the exposure of the slope (Fig. 8);
— deforestation and reforestation in relation to exposure of the slope and height a.s.l. (Fig. 9).

The results of these analyses are presented on the attached, highly informative diagrams. They confirm and coincide very well with trends revealed previously. The areas most susceptible to deforestation are located between 1000 and 1400 metres above sea level, have slopes with a northern exposure and are inclined between 19°-45°. In a closer look at the maps showing the spatial extent of deforestation, it is interesting to note that apart from the previously affected areas between the Białka Valley and the Waksmund stream, new deforested areas have appeared in the last 15 years in the northern part of the Sucha Woda Valley, Mała Łąka Valley and in the entire region of Upłaz Miętusi, in the close vicinity of Zakopane (Krokiew, Strążyska, Lejowa, Jaworzynka, Kondratowa) as well as in Roztoka, Rybi Potok and Biała Woda. It is also worthy to note that direct countermeasures undertaken to mitigate forest destruction (i.e. reforestation) are lagging behind this process in terms of intensity and spatial extent (only 236.7 ha were reforested in the period 1934-1992). Areas deforested and reforested between 1934 and 1992, according to heights above sea level are shown in Table 1.

Table 1. Deforested and reforested areas according to height a.s.l.

Height	Deforested area		Reforested area	
(metres a.s.l.)	ha	%	ha	%
800-900	26.5	2.7	1.1	0.5
900-1000	123.7	12.7	35.8	15.1
1000-1100	142.9	14.7	50.9	21.5
1100-1200	162.3	16.7	61.7	26.5
1200-1300	155.4	15.9	42.3	17.9
1300-1400	147.5	15.1	30.9	13.1
1400-1500	102.9	10.6	11.4	4.8
More	113.6	11.7	2.6	1.0
Total	974.7	100.0	236.7	100.0

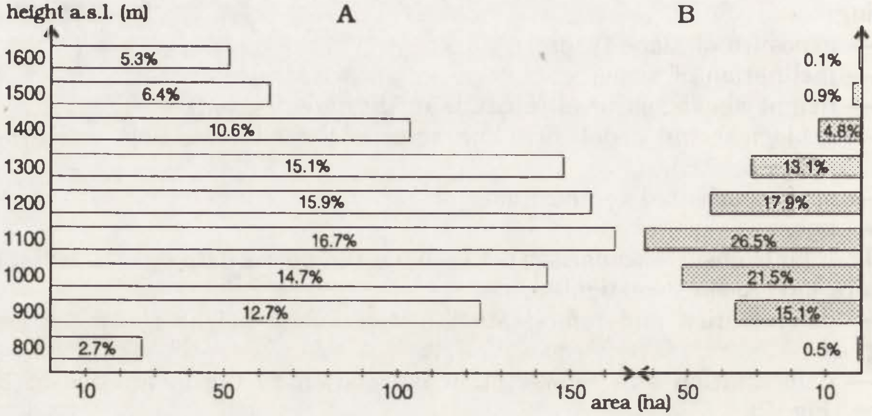


Fig. 6. Forest changes in the Tatra Mountains in the period 1934–1992 according to height a.s.l.: (A) deforestation, (B) reforestation

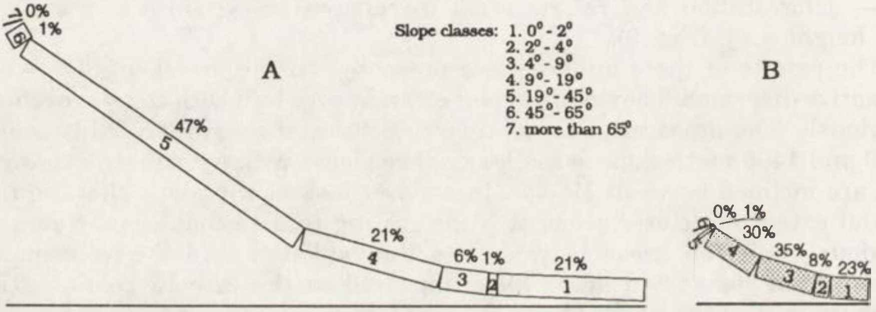


Fig. 7. Forest changes in the Tatra Mountains in the period 1934–1992 according to inclination of slope: (A) deforestation, (B) reforestation

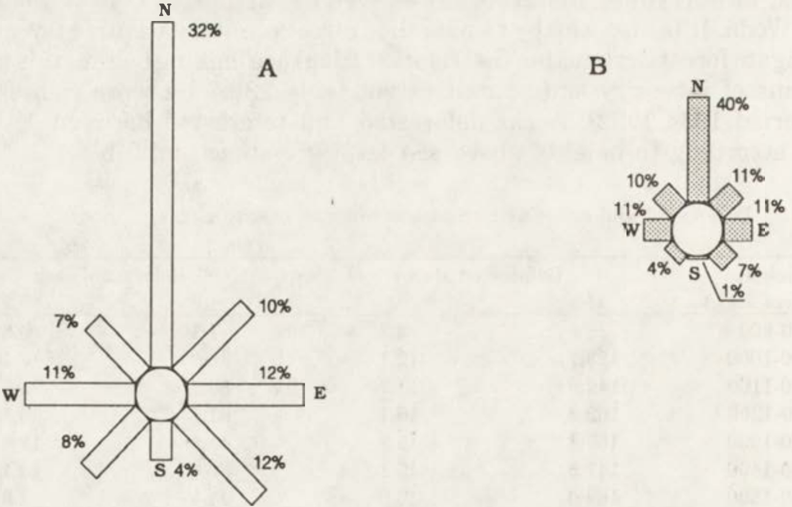


Fig. 8. Forest changes in the Tatra Mountains in the period 1934–1992 according to exposure of slope: (A) deforestation, (B) reforestation

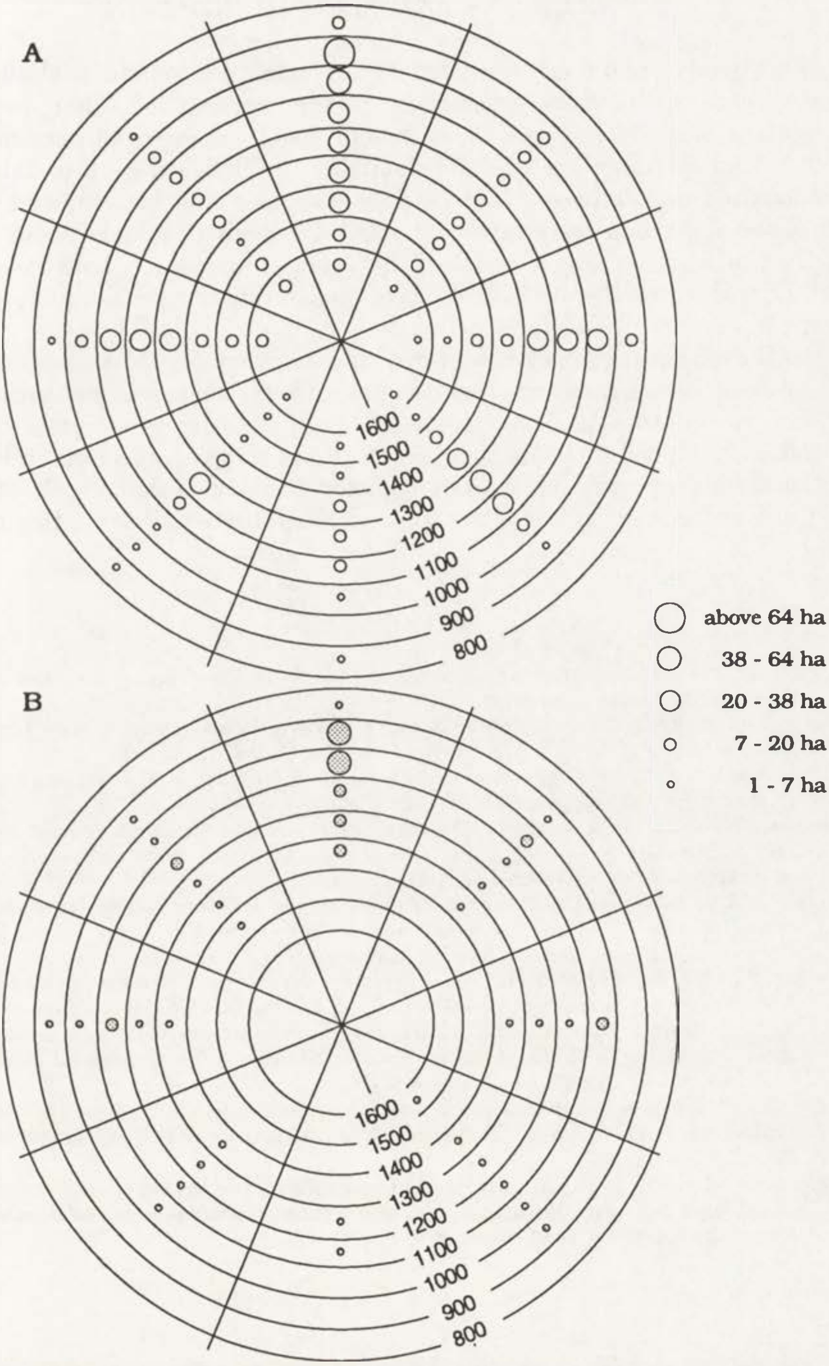


Fig. 9. Forest changes in the Tatra Mountains in the period 1934–1992 according to exposure of slope and height a.s.l.: (A) deforestation, (B) reforestation

CONCLUSIONS AND RECOMMENDATIONS

This study should be regarded as an introduction and a challenge to make more detailed investigations taking account of other important symptoms of environmental degradation. Tools, experienced personnel and well tested methods are already available for delivering up-to-date, well-documented and unbiased information. It is this information, and not the interests of particular groups and lobbies, which should be used for the further sustainable development of the Tatra Mountains of both Poland and Slovakia which are beautifully depicted on satellite images as an inseparable unity.

In these circumstances it would seem necessary for closer contacts to be established between international organizations, research institutions and private consultants such as NEOKART GIS, in order to facilitate the flow of information, avoid the duplication of efforts and secure funds from international funding and development agencies. It is hoped that the EURO-MAB IV Conference, held in Zakopane in September 1993, will serve this purpose well.

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THE USE OF GIS IN THE TATRA NATIONAL PARK

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Abstract. Integration of various computer platforms and software packages will result in a powerful system for modelling and database management. A distributed computing environment allows work groups to be flexible and to combine to solve problems. The aggregate resources of several computers facilitate the flow of information among scientists, specialists, managers and the top-level decisionmakers.

Key words: GIS in mountains, Slovak Tatras, Tatra biosphere reserve.

INTRODUCTION

The Project for the Environmental Monitoring of the Tatra National Park (Project MONTAN) proposes long-term systematic observation of the state of the natural environment of the Slovak Tatra National Park (TANAP) (Koren sen. 1993). In order to monitor the environment of the Tatra National Park large quantities of data are collected and entered into extensive databases. These data come in various forms and structures: documents, land records, survey information, scientific tabular data, maps, drawings, aerial photographs, satellite images, etc. Much of these data have a time and spatial element. Both geographic and relation database management systems are needed. The integration of various systems and software packages will result in a powerful hybrid information system which will allow users to enter and maintain documents and data of any kind, enable data to be queried and extracted, produce reports on the state of the environment, produce high quality map outputs and present results. The comprehensive modelling database system (MDBS) does allow scientists and managers to take careful note of the many changing environmental conditions throughout their properties.

Development of the Information System of the Project MONTAN (IS MONTAN) began in autumn 1992 (Fig. 1). Due to support from the Slovak Ministry of the Environment, the building of a digital database for Project MONTAN began in late 1992. Sources of tabular and spatial data have been identified and three types of library for spatial data have been defined. IS MONTAN is constructed to be a part of the Integrated Information System of the Slovak Republic (Ministry of Environment SR 1991). Its main purpose is to provide up-to-date information about the state of the environment, to scien-

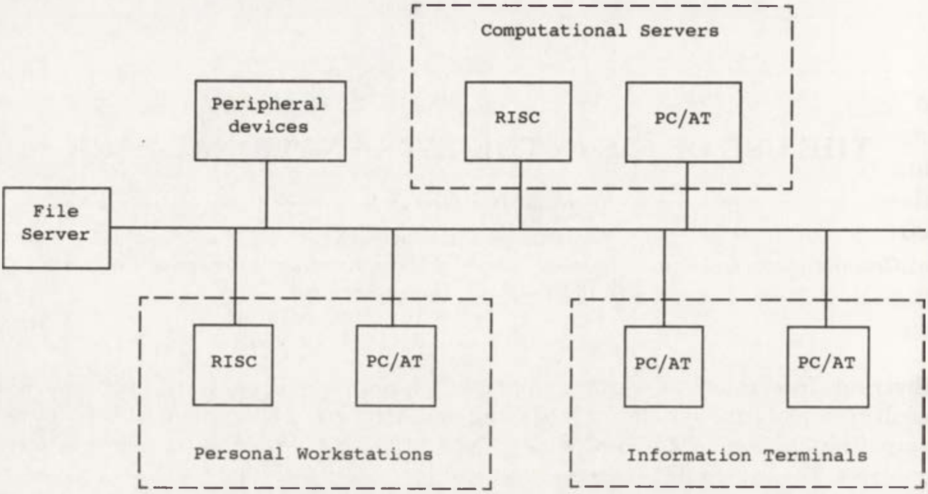

Fig. 1. Proposed organization scheme for IS MONTAN

tists, politicians, and industrialists, to allow them to make decisions which will be least harmful to TANAP's environment.

The Geographic Information System (GIS) is seen as a convenient way to organize and analyse spatial data. Its capabilities to receive and edit spatial data, to combine vector, raster and tabular data in a natural way, to manage them in thematic layers and to query data by geographic on position and/or by attribute, predetermine its importance as part of an environmental database. GIS tools such as overlay analysis, buffer generation, calculation of length and area of features and interpolation of point data are important for analysis and synthesis of the data produced by monitoring and research activities. Visualization of data and results, interactive graphic query functions and the production of presentation hard-copy plots are also very helpful to scientists and decision-makers.

SPATIAL AND NON-SPATIAL DATA

There are three sources of non-spatial data: data from Project MONTAN (regular source, data of known quality and method of acquisition), data created outside Project MONTAN (archival data, data from other projects, etc.) and data from other information systems.

Four sources of spatial data have been distinguished: manually digitized maps (topographic and thematic), aerial photographs and satellite images, outputs from geodetic measurements and GPS and the automatic generation of regular networks.

Spatial data are organized in three libraries (GIS-50, GIS-10, GIS-1). The libraries differ in scale, precision, accuracy and thematic layers.

GIS-50 will cover the entire area of the Tatra Mountains (it should cover both the Slovak and Polish parts of the Tatra Biosphere Reserve). Its main

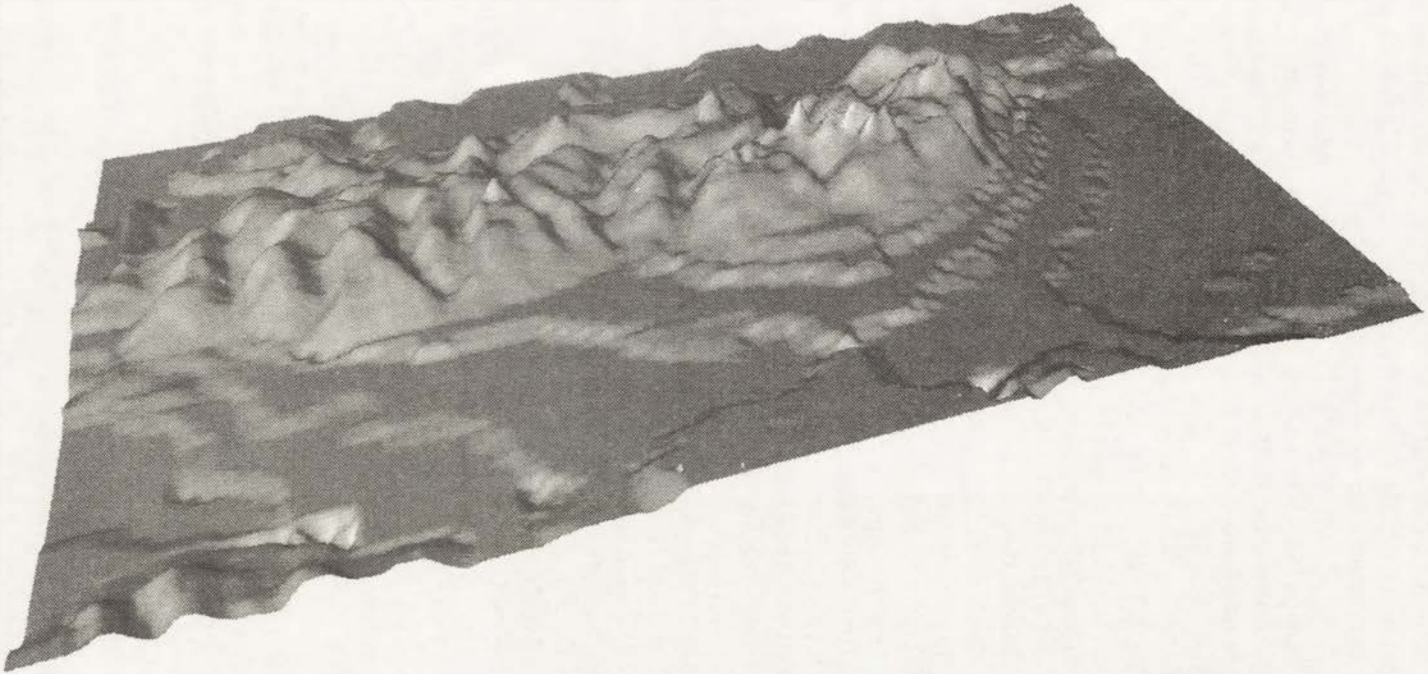

Fig. 2. An example of output from the GIS-10 generated by IDRISI: A digital map of forest stands in Tristarska dolina showing the coincidence of actual and potential forest structure. The darker areas correspond to the greater differences

scale is 1:50 000. It is planned that 65 thematic layers will be digitized. The GIS-50 spatial data library is used in analysis and phenomena-modelling for the whole region and for its surroundings.

GIS-10 is a core library of TANAP's geographical database. It is created from 1:10 000 maps and will consist of at least 78 thematic layers. Data transfer and generalization from/to GIS-50 and GIS-1 will be supported. To data about 30 layers have been digitized from forest maps which cover about 75% of TANAP's area (Fig. 2). Several databases will be linked to it: the forest stand database, the mosses biotope database and other data coming from Project MONTAN.

GIS-1 will contain monothematic user-defined layers at scales from 1:1000 to 1:1 for special use in monitoring plots, profiles and monitoring points.

All spatial data libraries are stored in one geographical database. Users can create their own view on each of the libraries, choose the spatial data needed and link them to their thematic tabular data. The exact definition of the monitoring networks and monitored parameters will enable spatial and non-spatial data to be linked automatically in the future.

There are two reasons for the separation of spatial and non-spatial databases. The first is the difficulty of the control, of the quality and correctness of data. Not all users are trained to handle spatial data. If spatial data are stored in separate database and handled only by trained staff, their correctness (accuracy, precision, topological integrity constraints and primary keys) can be guaranteed. On the other hand, the correctness of thematic data can be guaranteed only by specialists in the scientific fields they concern (data about forest stands must be maintained by a forester, data about mosses by a biologist, etc.). Another reason to separate the geographical and thematic databases is the lack of computer networks, computers and software licenses. Thematic databases are created on stand-alone IBM PC computers and then transferred on floppy disks into a computer running GIS.

There are no restrictions on data quality. Data are accompanied by information about their author, owner, acquisition method, history, precision and accuracy. By including all source information where data are requested, the user will decide for him/herself whether the data are of use in his/her project.

Data structures, formats and the coding of attributes will be coordinated with other subsystems of the Integrated Information System for the Environment of the Slovak Republic, and if necessary also with foreign environmental databases. Environmental information systems are rather expensive and the lack of a standard for data transfer slows the return of means.

THE ORGANIZATIONAL SCHEME FOR "IS MONTAN"

Figure 1 shows the physical organization of IS MONTAN. IS MONTAN consists of six hardware units: the file server, computational server, personal workstations, information terminals, peripheral devices and local area network. The file server renders disk space to databases and the computational server provides CPU to computational and data-intensive applications. Scientists and researchers use the personal workstations to enter data, to do their processing and to access the services of other systems. Information terminals provides managers and decision-makers with up-to-date information about the state of the environment, allowing them to query data easily and to visualize them in order to make better decisions, develop schedules and guide the use of resources.

There is a need for various hardware and software platforms and operating systems to be integrated into a unique network-computing architecture which enables user communication, the sharing of data and resources, and distributed applications. Personal workstations and information terminals serve as small independent computing centres for everyday tasks like office automation or the management of thematic databases. Additional data and resources can be acceded to (particularly expensive peripheral devices — laser printers, plotters, CD ROMs, tapes, ...) via network services. The distributed computing environment allows the work groups to be flexible and to combine to solve environmental problems. The aggregate power and resources of several computers facilitates the flow of information among scientists and managers. The distributed open system emphasizes individual initiative and the decentralization of responsibilities.

The standardized graphical environment — X Windows — allows access to the resources of the information system via any platform that can support X-Windows. This includes PCs running X Windows simulation software, but also workstations and X-terminals on LAN. GIS and thematic data sets, analytical and presentational tools need to be made as user-friendly as possible to enable inexperienced users to use them. A user-friendly work environment will be developed, allowing users to store and retrieve data, to carry out analysis and to present results, "by pointing and clicking with the mouse".

CURRENT STATE AND RESULTS

The Research Station of the Tatra National Park now runs two IBM PC/XT and one 286-, one 386- and one 486-based IBM PC/AT computers. From donations from Salford University and TYDAC, one license of SPANS and one license of IDRISI were acquired, and those are now running on our most efficient computer.

The most developed databases are: the forest stand database with more than 15 000 records describing in detail all forest stands, the forest monitoring database which contains the data from field surveys of percentage defoliation and contents of Pb, S and Hg in pine-needles; and the mosses database which stores data about moss biotopes and the content of some elements (Zn, Pb, Cd, Cu, Fe, Cr, F and Mo).

Several pilot projects using GIS were introduced in the period 1990-1993: a study of landuse in the Tatranska Lomnica area, a study of the actual and potential structure of forest stands in Tristarska dolina, an assessment of the spatial distribution of forest damage, and digital terrain model of the Tatra Biosphere Reserve. The mosses database will be linked with GIS-10 next year.

The spatial distribution of damage to the forest in the Tatra National Park was researched using GIS-50. From measurements of forest damage in 182 nodes of a regular rectangular 2x2 km forest monitoring network the percentage of defoliation was interpolated for the entire wooded area. The spatial interpolation enables a better estimation to be made of the distribution of forest damage. The northern (especially north-western) parts of the Tatras appear to be more damaged then the southern ones. By combining the interpolated data with a digital terrain model, a relationship between altitude and forest damage was observed. Comparison of the actual and potential forest structure in Tristarska dolina was based on GIS-10. The knowledge of actual and potential forest structure and differences between them helps foresters to carry out better forest management (to increase the diversity in terms of species and age, to enhance the value of the forest for wildlife habitats and nature conservation, to increase the easthetic values of the forest and its potential for recreational use, and to maintain its economic value and develop schedules of harvesting and reforestation). The layers of forest stands and forest types from GIS-10 were linked to a database describing actual and potential forest structure. The differences in density were calculated for each of the tree species growing in Tristarska dolina. The final layer (Fig. 2) shows categories of coincidence between the actual and potential forest structure.

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TELEDETECTION AND GEOGRAPHICAL INFORMATION SYSTEMS IN THE ASSESSMENT OF THE STATE OF FORESTS

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Abstract. OPOLIS — The Centre for Teledetection and Spatial Information of the Institute of Geodesy and Cartography in Warsaw has been co-operating with the Forestry Research Institute and the Laboratory for Teledetection and Forestry Management of the University of Gent, in work on the use of geographical information systems in the monitoring of forests. OPOLIS is currently running the pilot project which is building up information systems for the forests of the Sudetic Mountains.

Key words: GIS, Sudetic Mts, forest damage, teledetection.

INTRODUCTION

In the course of the implementation of this project it was noted that appropriately-processed satellite photographs provided much information which could augment statistical work characterizing the state of health and sanitation of forests, as well as reports on the results of forestry monitoring. Colour maps derived from processed satellite images and showing, for example, the spatial differentiation of the state of health and sanitation of forests, should give a fuller understanding of statistical presentations by describing defined areas in geographical space.

The forestry geographical information system created in OPOLIS accumulates information on the environment in two interconnected databases: a spatial database and a descriptive database.

The spatial database not only contains information gained from satellite photographs, but also the results of interpretations of aerial photographs from aircraft, digitalized data from topographical and thematic maps and a numerical model of the terrain. Aircraft photographs and maps supply the reference information indispensible for the correct classification of satellite photographs. On the other hand, the numerical model of the terrain provides a particular service in the analysis of mountainous areas. The descriptive database is created with information from the inventorying of forest management as well as descriptions collected as research projects are carried out.

These are connected with spatial information by reference to specific tree stands, sections of forest and units of the forestry administration.

Employed in the work described was the INTERGRAPH system, whose great advantages are its effective graphics and the ease with which it may be used. It is based on computers created by the firm INTERGRAPH, though some modules may also work on other platforms and computers of the PC class. The system has excellent modules for image processing and ensures a full technological sequence from digitalization, through analysis (full vector-raster and raster-vector conversion), to editing and the printing of maps. Part of the work was also done with the aid of ARC/INFO programming and the ERDAS system for image processing.

THE MONITORING OF DEGRADED FORESTS

One of the OPOLIS projects carried out was concerned with the assessment of the state of the environment in the Western Sudetic Mountains (Zawiła-Niedźwiecki 1994). Created to meet the needs of this project was a geographical information system which made possible the drawing-up of maps, as well as the carrying-out of spatial analysis which took into account multi-source and multi-term data on the state of the forest (including data obtained from the analysis of satellite photographs). In the course of the research, the following data were introduced to the database of the system, thereby creating informational layers:

(1) Data introduced to the spatial database:

— a numerical model of the terrain (NMT) — produced on the basis of a scanned contour map at the scale of 1:25,000;

— a characterization of the condition of the forest in 1984 — drawn up on the basis of spectrozonal aerial photographs taken in that year. Presented in this characterization were the following classes distinguished via the interpretation of the aforementioned photographs: weakened stands of spruce, severely-weakened stands of spruce, dying stands of spruce, dead stands, broadleaved and mixed stands, renewed or afforested areas, cut areas, areas of dwarf mountain pine scrub, others;

— tree stands of lower density assessed on the basis of aerial photographs;

— hydrography: watercourses, non-flowing waters,

— the transport network: national routes, local roads, forest roads, railway lines,

— administrative units: boundaries of forestry divisions and National Parks, boundaries of forest districts, lines of forest sections and backwoods, boundaries of tree stands;

— the results of the analysis of satellite photographs.

(2) Introduced to the descriptive database were data from inventorying and monitoring.

The organization of the two databases was such that it was possible to add any information which might have proven useful in the carrying-out of spatial analysis.

The analysed informational layers were created on the basis of forestry maps, topographical maps and satellite photographs relating to an area of 32 000 ha in Karkonosze National Park — Biosphere Reserve and the forest districts of Świeradów, Szklarska Poręba, Piechowice and Śnieżka.

Analysis of data accumulated in the spatial information system produced made it possible to determine the spatial distribution of the different classes identified in the forests of the Western Sudetic Mountains, as well as to follow changes in the state of the forest in the period 1984-1990, on the basis of satellite photographs. This made it possible to separate out three regions in the study area which were characterized by forests degraded to differing extents (Polawski and Zawiła-Niedźwiecki 1987). These three regions are:

— the western area of 18 630 ha coinciding with the eastern part of Świeradów forest district, Szklarska Poręba forest district, and the northern complex of the Piechowice forest district;

— the southern area of 5 557 ha including the whole of the Karkonosze National Park;

— the central area of 7 813 ha, including the Śnieżka forest district as well as the southern complex of the Piechowice forest district.

The western area is characterized by the greatest changes. Forest has been displaced from ridge areas, and changes of comparatively uniform intensity may be observed on the slopes, irrespective of their exposure. The threat of deforestation is noted from altitudes of 600 m upwards, and there is mass dieback at altitudes in excess of 750 m. In 1984, areas affected by changes in the forest cover occupied about 34% of the area under discussion, with 26% having been affected by deforestation and 2% by reduced density, while 6% was dead forest. The great majority of the areas of dead forest are to be found in the ranges of Wysoki Grzbiet and Kamienicki Grzbiet.

The southern area is characterized by changes of similar intensity affecting 28% of the forest area. Deforestation affects 12% of the area, dead forest covers 3% and reduced density is noted on 12%. Changes attesting to the degradation of the forest are to be seen in the whole area, and although the lower boundary of the damage is generally noted along the 1000 m contour, there is also some, albeit less intense, deforestation and thinning-out of tree stands at lower levels.

The central area is covered by forest in a much better condition than that referred to above. Reduced density is noted sporadically (over 1% of the area), while deforested areas (covering 10% in total) are grouped at the eastern end.

In addition, analysis of the condition of tree stands in particular administrative units of the State Forests indicates that Karkonosze National Park — Biosphere Reserve has the greatest share of dying tree stands (covering 7% of its area), while only sporadically do such stands occur in the Śnieżka forest district. Severely-weakened tree stands occur over a relatively large area (about 35% of Szklarska Poręba forest district, 22% of Karkonosze National Park and Świeradów forest district and 10-13% of the forest districts of Piechowice and Śnieżka). On the other hand, tree stands in the best condition are found over about 60% of the areas of Śnieżka and Piechowice forest districts.

It may in general be stated that the condition of the forest decreases with increased altitude, and that there is an increase in the proportion of tree stands that are dying and in the area that is deforested.

The information accumulated in the system was also used in an attempt to define the mass of timber lost as a result of degradational processes in the study area (Ciołkosz and Zawiła-Niedźwiecki 1990). Classes denoting the condition of tree stands with spruce which had been distinguished on satellite photographs were ascribed to experimentally-defined percentage losses in timber increment (Trampler 1987). In accordance with these data, the annual losses in timber increment brought about by industrial pollution amount to:

— 10% in the case of trees experiencing physiological changes,
— 25% for those suffering light damage,
— 50% for those suffering moderate damage,
— 75% for those suffering severe damage.

To define annual losses of timber, the aforementioned indices were related to the appropriate class of damage distinguished on satellite photographs. This made it possible to estimate losses in increment in the whole of the area under analysis.

When losses brought about by premature cutting to save forests are taken into account, it can be estimated that annual losses in the area covering around 32 000 ha are of the order of 45 000 m^3, giving a mean of 1.4 m^3/ha/year. The national mean figure for areas influenced negatively by emissions of SO_2 is 0.6 m^3/ha/year. These data should be treated as orientational only, because note has not been taken of the living conditions of individual stands, but only of the mean condition of classes identified on satellite photographs.

As part of the spatial database of the geographical information system for the Sudetic Mountains, analysis of the results of the classification of satellite photographs allow it to be stated that the following phenomena have affected the study area in the time interval between successive imaging, i.e. the 6 years between 1984 and 1990:

— an increase in the area of weakened tree stands, with an overall reduction of nearly 30% in the area covered by tree stands in older age classes;

— a decrease in the area covered by dead or dying tree stands from about 15% to about 5% of the area under analysis;

— an increase in the area deforested (from 8% to 15% of the area under analysis), with the reservation that the 6 years have seen a reduction in the deforested areas with exposed soil, and a concomitant increase in the deforested areas with vegetation cover.

The results of the long-term analysis of satellite photographs attest to the continued degradation of forests in the Sudetic Mountains, albeit at a reduced rate. It is also important to note that actions taken by the forest services are now much more effective than was the case in the first half of the 1980s.

(3) Closing remarks

The aforementioned example of the use of satellite teledetection and spatial information systems in forestry make clear — even within their relatively limited scope — that these techniques and technologies are of value in the ongoing activities in forestry. It would be of value to plan for full imaging linkage of informational layers (including forestry maps updated and improved continually on the basis of teledetection data) and the already existing databases on forest management, forest fires and monitoring, with modelling procedures (e.g. the prediction of threats posed by fire) and with the informational systems of the forestry services which concern ongoing economic activity. Such a set of information accumulated in spatial and descriptive databases would allow for the operational use of geographical information systems in forestry practice.

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PART 4

ORGANIZATION AND MANAGEMENT OF BIOSPHERE RESERVES

A. Breymeyer (ed.) — EURO-MAB IV.
Mountain zonality facing global change,
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THE TERRITORIAL SYSTEM OF NATURE CONSERVATION IN THE SLOVAKIAN PART OF THE TATRA BIOSPHERE RESERVE

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Abstract. Slovakian system of management of Tatra Biosphere Reserve is introduced. It is based on mountain landscapes, the evaluation of their differentiation and function.

Key words: mountain landscapes, reserve management, Slovakian Tatras.

The conservation of the natural landscape in the broadest sense arose as a counterpoise to inadequate, often short-sighted directed utilization of environment. Basic conservation tasks declared by Conventions have been augmented by new tasks, based on the renovation of original nature landscapes. Utilized more recently is knowledge from other scientific branches on observed surface phenomena mainly knowledge of landscape ecology.

The central problem of landscape ecology is the functional study of the landscape, which began in the times of Dokuchayev and Humboldt. Already discovered by that time (i.e. the end of the 19th century) were some of the basic rules of the spatial differentiation of natural landscapes (horizontal and vertical zonality).

We now understand horizontal and vertical zonality as a spatial regularity dealing with the transition of quantity to new quality. The quantitative changes through which the new quality arises are in both cases a function of changes in temperature and rainfall; and the results are natural zones with characteristic plant and animal communities and different anthropic utilization.

A change in the zone-creating factor defines not only the content, but also the form (shape) of the zone on the earth's surface. Therefore zones are not arbitrary parts of the earth's surface, but parts which are either enclosed by approximately parallel lines or radiating out around some center. In consequence, they have stretched shapes as belts, or mostly irregular intercircles.

The aim of our contribution is, in the case of the Slovak part of the Tatra Biosphere Reserve, to show the coincidence between the natural distribution of landscapes into natural zones, and natural-conservancy and to explain its significance for practical nature conservation.

One of the most important principles of present nature conservation is the principle of preserving life in its maximum possible diversity and abundance of forms. This requires targeted management of socio-economic processes in the landscape. To secure this optimal (model) condition in Slovakia a project has been prepared for a territorial system of landscape ecological stability (USES). Forming the basis of this system are biocentres, biocorridors and interaction elements.

A biocentre represents an ecosystem or group of ecosystems with permanent conditions for the reproduction, shelter and nourishment of organisms, and for the preservation and natural development of their communities.

A biocorridor is set of ecosystems linked spatially, which join biocentres and enable migration and the exchange of the genetic information of living organisms and their communities to occur.

The territorial system of nature conservation (USOP) of the Slovak part of the Tatra Biosphere Reserve consists of territorial units at two hierarchical levels: macrochoric and mesochoric.

The macrochoric level represents zones of nature conservation analogous with the usual distribution of Biosphere Reserves. In establishing relationships with natural zonation it is possible to characterize:

— zone A (core), including, in the main, natural ecosystems of the supramountain, subalpine and subnival zones at altitudes of over 1250 m a.s.l. and exceptionally adjacent ecosystems of the mountains zone above 800 m a.s.l.

— zone B (buffer), including in the main ecosystems of the mountain zone at altitudes from 800 to 1250 m a.s.l. and exceptionally adjacent ecosystems of the submountain zone above 750 m a.s.l.

— zone C (transition), including ecosystems of the submountain zone at altitudes from 600 to 800 m a.s.l.

As can be seen from this brief characterization there is only free coincidence between natural zones and nature conservation zones. Although natural and nature conservation distributions are functional, we judge them from two viewpoints: first of all from the causal viewpoint, which is a property of nature, are secondly from the teleonomic viewpoint, which is a property of man. In the first case it is possible to understand it also as “dependence” and in the second as a “mission”; or in both cases as a modification of landscape-ecological distribution.

From the methodological point of view zonation belongs to working procedures which are treated in geographical sciences as deductive (proceeding from higher units to lower ones) and regional (stressing the uniqueness of given units). Zonation is regularly of use on the small and middle scales and creates the assumptions only for frame management of processes in the landscape.

In practical nature conservation, especially in ecologically diversified areas like the Tatra Biosphere Reserve such distribution does not suffice. It is necessary to have a knowledge of the more detailed distribution of territorial units at the lower-mesochoric hierarchical level, reflecting rules of inter-zonal structure. In Slovakia we use the term “ecological function space” for such units.

Stressed in these spaces is reversible speciality (it refers to typological distribution). They are created in similar types of ecotope structure according to natural zones and functional types of territory. Arising this way within the Tatra Biosphere Reserve are 20 ecological function spaces, in the following combinations (Table 1):

Table 1. Types of ecological function space in Tatras

Function type	Natural zone	A/Sbn	SbA	SM	M	SbM
A	1	x	x	x		
	2	x	x	x		
	3	x	x	x		
B	1				x	
	2				x	
	3	x	x	x	x	
C	1					x
	2					x
	3					x
	4					x
	5					x

Function types:
A1 — strict nature reserves
A2 — managed nature reserves
A3 — multifunctional highaltitude natural spaces
B1 — managed nature reserves
B2 — multifunctional mountain natural spaces
B3 — intravilane of settlements, forest parks and rest-sport areas
C1 — managed natural reserves
C2 — submountain forests
C3 — ecostabilized ecosystems on non-forest soils
C4 — intensively-utilized grasslands and arable land
C5 — intravilane of villages
Natural zones
A/SbN — alpine and subnival
SbA — subalpine
SM — supramountain
M — mountain
SbM — submountain

A separate forms of ecological-function spaces are the so-called "collision ecological-function spaces" whose present state requires reconstruction. Theoretically it can occur in all zones except function spaces A1, A2, B1, B2 and C1.

The significance of the territorial system of nature conservation (USOP) in the Slovak part of the Tatra Biosphere Reserve is threefold:

(1) It serves in the planning of nature protection-helping to resolve relationships inside the system;

(2) Derived from it are conditions for the protection of territory-helping to resolve relationships to the anthropic environment of the system;

(3) It enters in to connection with the Slovak territorial system for ecological building of territory — supporting the function structure of the system.

Within the framework of the territorial system of the condition of nature conservation (USOP), there are certain possibilities to improve the system of planning the protection of a Biosphere Reserve, in accordance with the following scheme:

Planning document	Planning territorial unit	Time horizon of planning
Program of preservation	Zone of nature conservation	10-15 years
Plan of preservation	Ecological-function space	5 years
Project of reconstruction	Collision ecological-function space	-

In relation to the territorial system of nature conservancy (USOP) it is possible to give a much concrete formulation of the condition of nature conservation, which we propose for the Slovak part of the Tatra Biosphere Reserve as follows.

A1. The most well-preserved (and from the nature conservation viewpoint the most valuable) are ecological-function spaces A1. These include representative "samples" of ecosystems of high-mountain territory, which have been left to autoregulation. Apart from activity with scientific and information aims, all other activities are excluded.

A2, A3. Ecological-function spaces A2 and A3 include other, mostly very valuable, high-mountain ecosystems. Allowed in such spaces are some traditional activities carried out in mountain landscapes (tourism, mountainering, less alpine skiing and exceptionally paragliding) according to strict capacity, space and time regulation. Possible and in some parts recessing is reconstruction of ecosystems, mainly by means of raising the timber line and dwarf pine line.

B. In zone B (mainly at the foot of the East Tatra Mountains and at the beginning of them) preference is given to the curative — rehabilitation and healthy functions.

C. Management activity in zone C (which creates a transition between the strongly-urbanized, intensively-utilized landscape of the Tatra depression and the natural Tatra landscape) is based on the general principles of sustainable development.

In the terminology of the territorial system of landscape ecological stability (USES) zone A represents a biocenter mostly created by specific ecosystems linked with the high-altitude environment. Manifested strongly from the biogeographic point of view (and more precisely from the view-point of the variety of indigenous plant and animal species) is the so-called "island" effect.

The migration of plant species, and especially animal species, occurs between zones B and C. From this point of view ecological function spaces B1 represent a real gene source — biocentres of regional significance; ecological function spaces B2 are migration ways — biocorridors which should be connected to ecological-function spaces C1, C2 and C3 — as biocentres, biocorridors and interaction elements of the territorial system of landscape ecological stability (USES).

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THE WORK PLAN FOR THE POLISH PART OF THE EASTERN CARPATHIANS INTERNATIONAL BIOSPHERE RESERVE — VOICE IN A DISCUSSION

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Abstract. The ways of managing of the International Biosphere Reserve (IBR) are discussed. 16 projects are proposed as necessary for the launch of Eastern Carpathians IBR. In the result of proposed revision of Bieszczady National Park borders the whole Park become a core zone for the Biosphere Reserve.

Key words: Biosphere Reserves management, nature protection, Eastern Carpatians Biosphere Reserve, Bieszczady Mts.

The Eastern Carpathians International Biosphere Reserve is situated in the western part of Eastern Carpathian Range (known also as the Bieszczady or Eastern Beskidy) along the Polish-Slovak border. Its Polish part encompasses 109 000 ha between the San and Osława rivers. 65% of the area is forested with beech-fir (Fagetum carpaticum) forest dominating. The timberline here is at 1150 m above sea level, and higher ridges (including the highest peak, Tarnica, at 1346 m a.s.l.) are covered with tall grass alpine meadows (Nardetum carpaticum orientale, Trollio-centauretum). The Eastern Carpathians Biosphere Reserve has three zones, of which core and buffer zones in Bieszczady National Park cover 27,000 ha (i.e. only 25% of the Biosphere Reserve). The Reserve has a community of large predators including wolves (*Canis lupus*), lynxes (*Lynx lynx*), brown bears (*Ursus arctos*) and otters (*Lutra lutra*) that is unique an a world scale as well as ungulates like red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), wild boar (*Sus scropha*) and European bison (*Bison bonasus*). There are also more that 100 species of bird in the Bieszczady Mountains, including numerous raptors such as golden eagle, lesser spotted eagle, goshawk, common buzzard and eagle owl. The rivers and creeks are inhabited by species important for the fishery like brown trout and reolific cyprinids *Chondrostoma nasus*, barbel and chub.

The density of the human population in the Biosphere Reserve is low (5 inhabitants per sq. km) and the region is well known from its economic under-development. At present, unemployment has reached 35% of the population of working age. The main sources of income are forestry, charcoal burning, extensive cattle and sheep breeding, small-scale agriculture without the use of artificial fertilizers, hunting, fishing, and recently developing tourism.

According to contemporary ideas, every Biosphere Reserve should participate in nature conservation (mainly in the core area), as well as in development (in the transition zone), and should also fulfil a logistical role in the coordination of scientific research, cultural and economic events (Batisse 1990). The concept of the Biosphere Reserve presented here assumes economic development of the transition zone which is based on the sustainable use of natural resources in order to eliminate conflicts between the local community and the members of staff of Bieszczady National Park.

The first step in organizing the Eastern Carpathians International Biosphere Reserve (IBR) in Bieszczady Mountains is to create the Research Assembly which:

1. In one year could produce "The report on the current condition of the Bieszczady Mountains",
2. Prepare written proposals for research expert reports and applicable solutions, according to the projects listen below,
3. After obtaining the necessary financial means, will be able to start actual work on these topics.

The Research Assembly should be led by the Chairman, who will supervise the leaders of particular projects. Leaders will be responsible for appointing their research teams, and for preparing proposals, final reports, expert reports etc. For the sake of the good circulation of information, there should be mutual involvement of representatives from the various research teams. It would also seem necessary to appoint a Coordinating Council which would consist of the chairman, leaders of the research teams, representatives of the State administration and local inhabitants, delegates from Slovakia and a plenipotentiary of the Ministry of Environmental Protection, Natural Resources and Forestry, who would be the person in charge of the Council.

The following projects are proposed as necessary for the launch of the Eastern Carpathians IBR:

1. The Biological Assessment of Natural Communities of Plants and Animals

Trends in natural succession in forest ecosystems and local agriculture. An inventory of rare and endangered species. Evaluation of heterogeneity in forests and grasslands. Ecotones and patchiness in natural and planted forest stands. Guidelines for the restructuring of forests.

2. The Flow of Energy and the Cycling of Matter in Selected Forest Ecosystems

The influence of logging on the pool of major nutrients. The heavy metal budget. The role of producers, consumers and decomposers in the flow of energy and matter through the forest ecosystem. Guidelines for forest management concerning alterations to the logging system to minimize erosion.

3. Rules for the Protection and Management of Game Populations

The distribution, numbers and migration patterns of the most important game species. The assessment and means of protection of forest plantations from damage done by deer. Population dynamics of the large predators (brown bear, wolf, lynx and otter). Conflict between the brown bear and man. Perspectives for the further development of the population of the European bison. The reintroduction of beaver, capercaillie and black grouse. A model for game management within the Biosphere Reserve. Fish populations in creeks, rivers and lakes — their protection and exploitation.

4. A Model for the Management of Forests

Guidelines for the restructuring of disturbed forest stands. Protection of the main species of trees. Exploitation on timber in natural forest stands. The cyclic rotation of forest stands to ensure maximum productivity and longevity. Modification of the current charcoal-burning procedures — the use of byproducts. Creation of a gene bank based on local seed-trees, propagation of such material in forest plantations and rejuvenation of forest stands. A dynamic model for forest exploitation — reestablishing and maintaining soil-site variability. The elimination of heavy machinery which destroys the upper-soil. Guidelines for the exploitation of ground vegetation (mushrooms and berries).

5. A Concept for Ecological Agriculture

Changes in the system of land use. Maintaining and improving traditional methods of food production, developing new methods of land-use (deer farming). Biodynamic agriculture-elimination of artificial fertilizers. Bee-keeping, herb-growing, fish-ponds. Production of "healthy" food — a system for subsidizing biodynamic growers (for 3-4 years). Proper processing of "healthy" food, marketing in Poland and abroad. A certificate for "ecologically-grown" food, and negotiations on export quotas with the U.S. and European Union. The parceling-out of former state farms, integration of comminuted farms. A multifunctional model of farming within the IBR.

6. Water Management

A budget for water resources. An inventory of water resouces, including seasonal variability. Estimation of the local demand for water. Protection of surface waters. Improvement of existing methods of water retention and a new approach (the reintroduction of beavers). Hydrobiological and physicochemical evaluation of the quality of local waters. Assessment of eutrophication. Waste disposal. Bio-blocks for water treatment. Compact water treatment units.

7. The Monitoring of Pollution in the Environment

Identification and characterization of the main sources of pollution (including airborne transboundary pollutants). Assessment of the pollution of air, water and soil (by sulphur dioxide, nitrogen oxides, heavy metals). Acid rain bioindication. The contribution of low emissions to the contamination of the region. The establishment of a permanent monitoring network. Satellite phothography. Dump sites.

8. Alternative Energy Sources

The assessment of the area with regard to the possible installation of small water generators, wind turbines or solar panels. The use of local firewood resources (including sawdust) for heating. The design of an exhibitory "energy field" where various modern devices using alternative sources of energy would be displayed. Involvement of the local people in installing such devices. The use of local sources of natural gas. The energy budget of the region — the assessment of the possibility of eliminating coal and coke as energy sources in the Biosphere Reserve.

9. Geological Resources

An inventory of the main geological resources of the region, including mineral springs and deposits of natural gas. Developing environmentally-harmless methods for the exploitation of natural resources (including rock-quarries and gravel pits).

10. Touring and Ecotourism

Working out the rules for sightseeing in the three zones of the Biosphere Reserve. Establishment of a network of small shelters, cabins and mountain refuges for tourists. Allocation of "cross country" ski trails and trails for horseback riding. Assigning areas suitable for ecotourism. Estimation of the recreational capacity of particular zones within the Biosphere Reserve. Training of guides for ecotourism. Development of small sanatoria and rehabilitation centres.

11. Architecture and Spatial Planning

The recommendation of a typical design for local housing in compliance with traditional regional architecture. The creation of a general plan of habitation in the region according to the result obtained by the Research Team.

12. Ecological Education

Publicity on the principles of the "ecological" development of the region. Establishment of the Center for Ecological Education. Modification of educational programmes at schools. Establishment of "Nature Trails". Permanent information in the press. Publication of informational brochures. Educational courses for the local population.

13. Material and Spiritual Culture

Inventory of historic monuments and sites. Report on local folk and religious customs. Support for regional ensembles. Plen-airs for painters and sculptors. Regional craftmanship and handicraft. Support for disappearing traditional trades like blacksmith, cooper, miller etc.

14. Demography and Changes in the Employment Structure

Character of demographic trends. Defining the main sources of income, the share of particular professions and the level of education among local inhabitants. Planning the necessary changes in the structure of local employment considering the rate of development of ecotourism, the exploitation of forest resources, game management and the production of "ecological" food.

15. GIS in Bieszczady

Establishing geometrical and thematic data bases. Common punctual, linear and planar informational GIS strata. Selected spatial analyses. Generating thematic maps. Training for research team members in the use of the GIS system.

16. Legal Office and Economics Units

Feasibility study and business plan regarding the functions of the Biosphere Reserve. Amendment to the "Nature Conservancy" Statute Perspectives for the economic development of the region. Legal advice for local business. Financial coordination of the whole program.

The swift and efficient launching of the IBR would provide the best evidence to the local inhabitants that nature conservation does not necessarily lead only to bans, but also opens up new perspectives for rising living standards.

CONCLUSIONS

1. Ecotourism, the exploitation of forest resources, game management "ecological agriculture", craftmanhip, handicraft and local art should be crucial to the economic development of the "Eastern Carphatians" Biosphere Reserve, and become the main source of income for local inhabitants.

2. It is necessary to revise the present borders of Bieszczady National Park, by including the most valuable natural habitats neighbouring the Park, and by excluding the areas planted with pure spruce stands located mostly in Sianki Forest District. In this way, the whole National Park could become a core zone for the Biosphere Reserve. Bieszczady National Park should cease its present commercial activities (logging, hunting, breeding horses, running hotels etc.), and instead focus on crucial issues for nature conservation in this area (e.g. the decline of fir stands).

3. The Ministry of Environmental Protection, the Provincial Government in Krosno and the State Council for Nature Conservation should stop pushing for the further extension of the Park into agriculture areas and commercial forest, and should rather focus on organizing the Biosphere Reserve.

4. Until a new bill on the status of Biosphere Reserves is introduced in Poland, the Reserve should be supervised by a Management Board consisting of representatives of Bieszczady National Park, the local administration and the State Forest Service, rather than solely the staff of the Park. Other solutions may only inflame the conflict between Bieszczady National Park and the local community.

5. There is a need for funds (about 100,000 USD) for a scientific team which could in one year, prepare a report on the current status of the area within BNP, and suggest the most urgent research topics, applicable solutions and restructuring of the local economy. The authors of this paper are looking for potential sponsors of such a report.

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RELATION BETWEEN THE BIOSPHERE RESERVES OF MAB AND THE START INITIATIVE OF IGBP

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Abstract. The Biosphere Reserve initiative of the Man and the Biosphere Programme and the START initiative of the International Geosphere Biosphere programme have many aims and activities in common. Close cooperation between both should therefore be pursued. ENRICH and START also have comparative objectives, although the ENRICH aims have a European context and are top-down and policy-directed, where as START and the BR-MAB are global and bottom-up and more science-oriented.

Key words: Biosphere Reserves UNESCO, START initiative IGBP

INTRODUCTION

Together with companion programmes that address research into global change (WCRP and HDP), the IGBP requires that research be carried out in all regions of the world. There is a critical need to stimulate and facilitate regional aspects of these global research programmes worldwide. To meet this urgent need the IGBP has developed, as an essential component of the overall programme, the START concept of a global system of regional networks for analysis, research and training.

One of the most important and successful activities of the Man and the Biosphere programme of UNESCO is constituted by the Network of Biosphere Reserves. Biosphere Reserves are protected areas of land and coastal environments which together constitute a world-wide network linked by in international understanding on purposes, standards and the exchange of scientific information. The network includes significant examples of biomass throughout the world.

The two networks share some aims. In some cases one site could act as both a Regional Research Centre (RRC) for START, and a Biosphere Reserve. The START network and the wetwork of Biosphere Reserves should cooperate as much as possible to exchange experiences.

THE START CONCEPT

The START concept was developed at the Bellagio meeting of December 1990 (IGBP report 15, 1991). The initiative deals with activities from International Geosphere Biosphere Programme (IGBP), the World Climate Research Programme (WCRP) and the Human Dimensions of Global Environmental Change programme (HDP) and their core programmes. The START idea grew a.o. out of the idea of Geosphere Biosphere Observations. Such Observation Systems are now being developed worldwide for monitoring the atmosphere, the oceans, and terrestrial ecosystems, some are in operation already.

The START concept concerns a global system of regional networks devoted to analysis research and training. This System for Analysis, Research and Training (START) aims to be a world-encompassing system of regional research networks (RRN), each of which includes a regional research centre (RRC) and a number of affiliated regional research sites (RRS). A region in this concept comprises several nations, and is generally of sub-continental size.

Each Regional Research Center in START has five functions:

— research, including documentation of environmental change

— training

— data management

— synthesis and modelling

— communications between scientists and decisionmakers in the private and public sectors. There is ongoing discussion between decisionmakers, politicians and scientists, who influence each other and in turn influence the choice of scientific priorities.

START has a bottom-up approach: scientists direct the START initiative toward internationally-agreed scientific priorities.

Affiliated Regional Research Site (RRS) are the research institutions and stations. Within one region they form together the regional research centre (RRC). These sites and regions together are the Regional Research Network. RRN = RRC + RRS.

A major function of each Regional Research Network is the implementation of research activities within core projects of the IGBP, WCRP, HDP and other programmes on global environmental change. This will require coordination with other RRN's, through the efforts of the RRC.

Necessary components and relations to other ongoing programmes of a START initiative are:

1) observations (contributions from the Global Climate Observatory System IGCOS), Global Ocean Observatory System (GOOS), Global Terrestrial Observatory System (GTOS), and Global Atmosphere Watch (GAW);

2) research (cooperation with WCRP, IGBP, HDP),

3) capacity building (START itself),

4) assessments (International Panel on Climate Change),

5) policy (framework convention on climate change, UN)

6) applications (International Hydrological Programme, UNESCO, FAO, IUCN, WMO).

THE EUROSTART INITIATIVE

To promote the START activities in Europe, and in order to obtain the cooperation of all the relevant European countries, a workshop was held in

Amsterdam, The Netherlands on June 7 and 8 where the aims and activities of a European START initiative EUROSTART were discussed.

The functions and objectives of EUROSTART are the same as the overall aims of the START network, in short: research, training, monitoring, integration and synthesis, and communication with decisionmakers. They are described in IGBP report 15 of 1991.

Overall coodination will be accomplished by establishing an international IGBP START office, which in turn will be guided by the START standing committee. In March 1994 the chairman of the IGBP Committees will meet in Bonn to discuss a.o. the progress in establishing the network.

The functions and objectives of EUROSTART research should include:

— to build on existing project networks, and to expand them into Central and Eastern Europe,

— to add an interdisciplinary and multithematic network to:

— identify cross-cutting issues;

— enhance exchange of information (notably East-West);

— identify knowledge gaps;

— formulate and stimulate cross-cutting collaborative research;

— to serve as a European point for interaction with scientific networks concerning global change outside Europe,

— to set priorities for the agenda of research into global change in a European context, to support national and international programmes, including ENRICH, e.g. by developing new research projects fitting in IGBP core projects, and

— to ensure a permanent role for the IGBP committees in developing and implementing research into global change in Europe

The EUROSTART Network could:

— be built on both existing and new networks of research cooperation, of which one is the Biosphere Reserve Network of UNESCO,

— give priority to the creation of small networks to address specific IGBP, WCRP and/or HDP questions,

— for regional research sites, cooperate with the network of Biosphere Reserve of UNESCO's Man and the Biosphere Programme (MAB) and other existing networks of sites,

— review the relevance of START principles and criteria in a European context,

— develop a European START initiative in relation to identified needs and available structures.

Europe has distinctive characteristics with respect to global change. It has a high concentration, and long history, of research and data collecting and well-developed mechanisms of coordination and collaboration. There are particular problems in the European region which relate to global change, there is a rapid expansion in East-West connections with developing opportunities, and potential interactions with Africa are important.

THE MAB BIOSPHERE RESERVE CONCEPT

According to UNESCO Task Force 1974, Practical Guide to MAB, Chapter 5, 1987 the charecteristics of the Biosphere Reserves of the Man and the Biosphere programme of UNESCO are:

1) that biosphere reserves will be protected areas of land and coastal environments. Together they will constitute a world-wide network linked by international understanding on purposes, standards and the exchange of scientific information;

2) that the network of BR's will include significant examples of biomes throughout the world;

3) that each BR will include one or more of the following categories:

— representative examples of natural biomes;

— unique communities or areas with unusual natural features of exceptional interest. It is recognized that representative areas may also contain unique features, e.g. one population of a globally rare species; their representativeness and uniqueness may both be characteristics of an area;

— examples of harmonious landscapes resulting from traditional patterns of land-use;

— examples of modified or degraded ecosystems capable of begin restored to more natural conditions;

4) that each BR will generally have a non-manipulative core area, in combination with areas in which baseline measurements, experimental and manipulative research, education and training can be carried out. Where these areas are not contiguous they can be associated in a cluster;

5) that each BR should be large enough to be an effective conservation unit, and to accommodate different uses without conflict;

6) that BR's should provide opportunities for ecological research, education and training. They will have particular value as benchmarks or standards for measurement of long-term changes in the biosphere as a whole. Their existence may be vital to other projects in the MAB programme;

7) that a BR must have adequate long-term legal protection;

8) that in some cases BR's will coincide with, or incorporate, existing or proposed areas, such as National Parks, sanctuaries or nature reserves.

The BR's have six special features. Because they are again closely related to the START aims. they are mentioned here too:

a) the emphasis in selection is on representative samples of major ecosystems rather than on those that are exceptional,

b) they form an international network in which the international character is ensured by an exchange of information and personnel through MAB committees, MAB technical notes, and the World Conservation Monitoring Centre,

c) they provide for manipulative research in portions of the reserves,

d) they combine conservation, research, education and training as major objectives,

e) they play an integrative role with the local populations, whose social and economic activities comprise a significant management input, and

f) they focus their efforts on the relationship between man and the biosphere.

EUROPEAN COMMISSION: ENRICH

Besides the Biosphere Reserve Network and the START initiative, in Europe the European Commission, Directorate-General XII (Science) took the idea for a European Network for Research in Global Change (ENRICH), which aims at: 1) coordination within Western Europe (EC and EFTA), taking into account existing activities and the need for CEC programmes to support the development of public policy objectives, 2) collaboration with research into global change in Central and Eastern Europe, 3) assisting research programmes on global change and infrastructures in developing countries, especially in Africa, taking into account the work of the EC activities in the region and using existing support mechanisms and 4) interactions with intergovernmental bodies such as the inter-American Institute for global change research, ENRICH is a top-down approach, where policy makers select priorities after discussion with scientists, national authorities, etc.

During the June 1993 workshop of EUROSTART recommendations were made to facilitate the development of START: an IGBP standing committee for START was to be appointed, the START initiative should be stimulated and nurtured, and specific RRN's should be designated.

It was recommended that each country should discuss its planning of a national START contribution and its contribution to the START network. A workshop could define scientific priorities, and establish a regional committee. This committee defines the initial project framework on the basis of priorities from the workshop, and addresses funding needs. The committee should also aim to identify key institutions in each nation for each project. Consequently, the committee agrees on guidelines for the acceptance of regional research centres, and finally helps to develop detailed projects with scientific advisory panel(s).

It has been suggested that the functions and objectives of EUROSTART research should include the facts that they are built on existing project networks, that they should add an interdisciplinary and multithematic network, that they should serve as a European focal point, that they should set priorities for the agenda of research into global change in a European context and that they should ensure a permanent role of IGBP-committee functions and objectives for EUROSTART.

One of the possibilities for speeding up the EUROSTART initiative is with a European START scoping study. The terms of reference of such a study could be: to review the extent of research into global change, to identify the major requirements for Europe START, to describe the draft mission statement of the EUROSTART initiative, to set mechanisms for implementation, to enhance links between East and West Europe and with Africa, to consult with relevant communities and organizations, and to prepare a larger conference on the feasibility and goals of EUROSTART, which could act also as the formal start of the initiative.

MAB/UNESCO	START/IGBP
BRS	RRS
	RRC
BRN	RRN

BRS = Biosphere Reserve Sites
BRN = Biosphere Reserve Network

RRS = an affiliated Regional Research Site + research institutions and stations:
RRC = the Regional Research Centre
RRN = a Regional Research Network = RRC + $\sum$ RRN
START = System for Analysis, Research and Training = $\sum$ RRN

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THE TATRA MOUNTAINS — NATURE WORLD HERITAGE

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Abstract. The Tatras constitute the highest massif within the whole Carpathian Range. Great climatic diversity, a wide range of altitudes, and varied geological formations and relief have resulted in an exceptional richness of flora and fauna. The Tatras are the center of occurrence of high-mountain flora in this part of Europe as well as the northermost centre of endemism. Although protected as a National Park, the Tatra Mountains, have been severely degraded and transformed by both historical and contemporary anthropogenic pressures. The Tatra Mountains from a fragment of European nature of unparallelled value which undoubtedly deserves to be considered an element of World Heritage.

Key words: The Tatra Mts, nature threats and protection.

As a natural landscape entity the Tatra Mountains are undoubtedly a unique formation. This true high-mountain massif (Fig. 1) has a unique landscape and aesthetic climate which fascinates everyone who has set eyes on it.

The uniqueness and attractiveness of the Tatras results, among other things, from the fact that nowhere else in the world among mountains of the Alpine system, do we find an area so tiny (one third of the area of Warsaw) and so relatively low (the highest peak is 2663 m a.s.l.) which shows the typical features of an alpine massif.

The tremendous differentiation of nature is connected with high climatic diversity, a wide range of altitude, varied geological formations and relief. These have given rise to an exceptionally rich flora and fauna, with a total of about 10 000 species.

The Tatra Mts situated in the centre of the Western Carpathians are the highest mountain massif within the whole Range — and are the only truly high-mountain area in the whole Western Carpathians.

The Tatras are simultaneously the highest mountain massif between the Alps and the Caucasus as well as between Scandinavia and the Balkan peninsula. They have all the vegetation belts from the lower montane belt to the subnival belt unique to the Carpathians as a whole. This is the only area in the Carpathians which has preserved a typical postglacial relief, with hanging valleys, glacial cirques and numerous high-mountain oligotrophic lakes (Kotarba 1992) (Fig. 2).

The natural value of these mountains is inceased by nearly 1000 caves, of which the largest are about 1000 m deep and have over 10 km of passageways.

Fig. 1. Upper forest limit, subalpine and alpine belts in the Tatra Mts (Photo K. Holeksa)

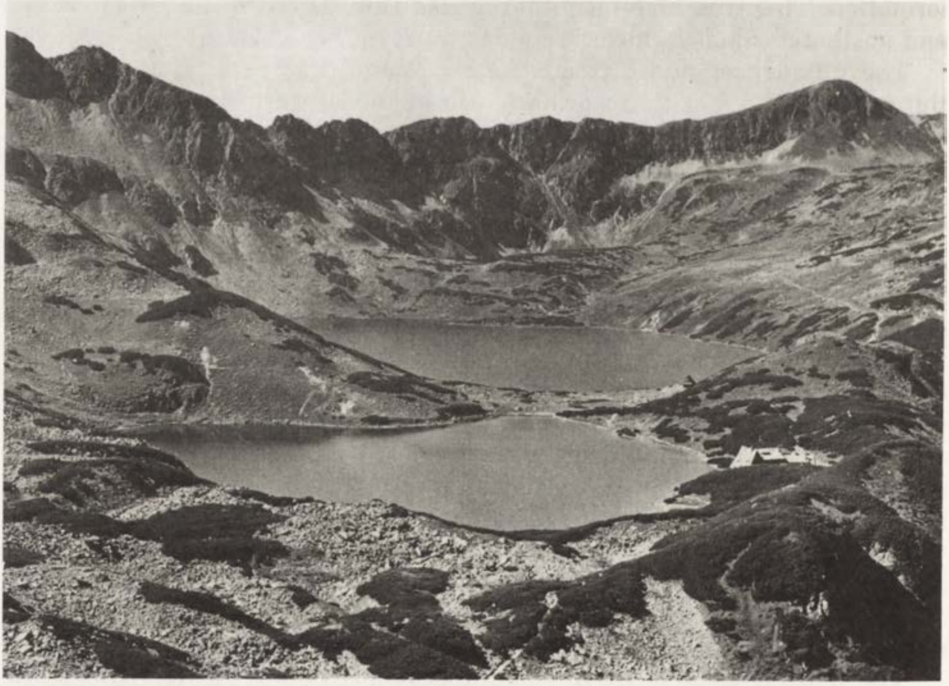

Fig. 2. Postglacial relief and lakes in the Tatra Mts (Photo M. Zbik)

The Tatras are the only area in the Carpathians with permanent snow patches.

The Tatras are also the centre of occurrence of high-mountain flora in this part of Europe, as well as in the whole of the West Carpathians (Pawłowski 1972). Of nearly 500 mountain species in the vascular flora known from Poland, more than 90% occur in the Tatras and nearly 50% (about 250 species), including stone pine and edelweiss are resticted to them as far as Poland or even the whole of the Carpathians are concerned (Mirek and Piękoś-Mirkowa 1992 a, c). There is an analogous situation in the case of the fauna. Only here can alpine marmot and chamois be met with in Poland. The Tatras are simultaneously the northernmost centre of endemism connected with mountains of the alpine system (Hendrych 1980).

The Tatras are also the centre of West Carpathian endemism as well as the centre of endemism in Poland (Pawłowski 1970, 1972, Matuszkiewicz 1991, Mirek and Piękoś-Mirkowa 1992 a, b, c). It should be mentioned, however, that there is also other, sad side of the Tatras present existence: the tremendous destruction they have suffered and threats they face. The Tatra Mountains, believed by both Poles and foreigners to be in an almost primeval state, have in fact been transformed to a high degree; they are, severely degraded and are classified amongst the most endangered areas in Poland. This is due to both historical and contemporary anthropogenic pressure (Piękoś-Mirkowa and Mirek 1982, Mirek 1992). In the eighteenth and nineteenth centuries mining and metallurgical work devastated the landscape. Sheep grazing and exploitation of forests were also intensive at that time and the former activity continued until the 1950s. Today, the most dangerous threats are long-distance air pollution and the constantly increasing pressure of various forms of tourism and recreation, as well as the urbanization isolating the Tatra Mts from the surrounding mountain ranges.

The number of tourists visiting the Tatra Mts annually has increased from a few thousand at the beginning of the century to 3 millions in the last two decades (Mirek 1992).

The Tatra Mts are located in the vicinity of the “Black Triangle”, one of the most polluted areas in Europe, which is formed by the industrial centres of the Czech Republic, Southern Germany and South-West Poland. This is well seen on the map of sulphur dioxide concentrations of Europe and Poland. The same pattern can be observed with regard to heavy metal pollution (Grodzińska 1990). Mineral dust and radioactive radium fall-out in the Tatras has also shown a distinct and rapid growth in the last 100 years (Jaworowski 1978).

Direct human impact and indirect changes in the abiotic environment have caused severe changes in the flora and fauna:

— In the lower montane belt secondary spruce monocultures have replaced native, mixed beech-fir forest in nearly 80% of the area.

— In the upper montane belt, only about 25% of the forest area has preserved its primeval or natural character.

— Previous human impact has resulted in the lowering of the upper forest border by 100-200 m along over two-thirds of its length (Piękoś-Mirkowa 1981, 1986).

— Due to air and soil pollution, the Tatra forests are today at the second stage of degeneration. The first stage saw sensitive lichens, such as representatives of the genus *Usnea*, became extinct, and the second stage, is now witnessing the rapid dieback of fir and spruce stands.

— Over 90% of the 34 sites of the Apollo butterfly *Parnassius apollo* known from the Tatra National Park until the 1950s, have now been deserted by the species (Dąbrowski 1980).

— Over 10% of the Tatra vascular plant flora is made up of non-native newcomers including many American and Asiatic species which are very well established in the National Park (Mirek and Piękoś-Mirkowa 1984).

— Entire groups of plants, like lichens, are seriously endangered by air pollution. Many species have died out completely, others are clearly regressing or showing lowered vitality, deformations, parasite attack and the loss of the ability to propagate (Kiszka and Mulenko 1980).

— Every third spruce in the lower montane belt is under attack from root bracket fungus and honey fungus; spruce trees in the upper montane belt area in a similar state (Krzan 1985).

— Great changes have also been observed in aquatic ecosystems, especially in the most interesting oligotrophic alpine lakes above the timberline. Increased eutrophication and the introduction of both native and American fishs species has produced significant changes in plankton communities (Gliwicz 1985).

— The increasing acidification of small oligotrophic lakes particularly in early spring has resulted in dramatic changes in their fauna, including the mass death of fish.

— In the early 1960s, heavy metal pollution and acidification were the most probable cause of the extinction of the relic crustacean *Branchinecta paludosa* (Dyduch-Falniowska and Smagowicz 1980).

— Water intakes for Zakopane have been constructed on the majority of the main streams in the Tatra National Park.

— Urbanization of the area adjacent to the Tatra National Park has resulted in the almost total destruction of its natural buffer zone and ecological corridors and has caused the Tatras to become an isolated ecological island.

— Quite recently, local authorities and business groups have attempted to change the protective status of two Park areas with the aim of intensifying their commercial use; similar pressure now concerns ski investments in the Park. All these are only examples.

The unique value of the Tatra Mountains, mentioned earlier, has led to the Polish and Slovakian parts being recognized as the most valuable areas of the two countries and taken under protection in the form of National Parks and transborder MAB Biosphere Reserve.

However, that which lays in the area of Poland or Slovakia, does not belong only to the Polish or Slovakian nations. None of us, irrespective of our places of residence, should be insensible to the fate of the Tatras. Similarly, no one in Poland can be insensible to the fate of the wonderful world of the African Serengeti or of fantastic Venetian monuments. In this day and age of the uniting of a Europe perceived as a natural and cultural entity, the unique qualities of the Tatras and their nature show their supranational value clearly.

To express its care for the greatest natural and cultural values of our planet the international community gives them the name World Heritage sites. In Poland this name has already been given to Wawel Castle, the salt mine in Wieliczka, Old Town of Warsaw, Białowieża Primeval Forest and Auschwitz Camp.

The Tatra Mountains are a fragment of European nature of unparalleled value and undoubtedly deserve this name; *all the more so as they* are very seriously threatened. People of science, and particularly naturalists, are best predestined to speak for this.

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SELECTED EURO-MAB DOCUMENTS

IUCN*
ACTION PLAN FOR PROTECTED AREAS IN EUROPE

A Progress Report, August 1993

The plan is being prepared by
The IUCN Commission on National Parks and Protected Areas (CNPPA)
as a component of the IUCN European Programme

In association with
The Federation of Nature and National Parks of Europe (FNNPE)
The World Wilde Fund for Nature (WWF),
and The World Conservation Monitoring Centre (WCMC)

With support from
The Swedish Environmental Protection Agency
and The Government of the Netherlands

As a contribution to the evolving Environmental Programme for Europe, being prepared on behalf of the Environment Ministers of Europe

THE ACTION PLAN AND ITS 2ND DRAFT

The proposal for an Action Plan on Protected Areas in Europe arose from the Caracas Action Plan, prepared at the IVth World Congress on National Parks and Protected Areas (Caracas, 1992). The Caracas Action Plan calls for the development of regional action plans to act as the bridge between the global aims of the Caracas Congress and action at the national level. The European Plan also builds upon the review of protected areas prepared for the Caracas Congress and to which many experts and institutions across Europe had contributed.

The aim of the Action Plan is to ensure an adequate, effective and well-managed network of protected areas in Europe. It is not a plan for IUCN but a plan prepared by protected area experts through the IUCN system, for implementation by all appropriate agencies throughout Europe.

The process by which the European Action Plan is being prepared is designed to encourage as high a degree of participation as possible. A small "blue booklet" was published in January 1993, and send to members of IUCN, CNPPA and FNNPE, inviting their collaboration and contribution.

Based upon a very encouraging response (more than 120 substantive contributions), the first draft was prepared by project coordinator Hugh Synge under the guidance of a Steering Group involving the sponsoring organizations. This 90-pp draft was distributed to all contributors in May and reviewed

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* IUCN — International Union for Conservation of Nature and Natural Resources.

at a CNPPA meeting in Nyköping, Sweden (7-11 June 1993), which included delegates from UNESCO-MAB and also included a seminar on the Baltic.

Five working groups were established at Nyköping to consider the draft and many very helpful proposal came forward for strengthening it. These are now being incorporated in the preparation of a second draft, which will be available in time for the conference being organized by the Governments of the Netherlands and Hungary on the development of a European Ecological Network (Maastricht, November 1993).

The new draft will be a substantial advance on the first draft. In particular it will:

— Place the plan more firmly in the global context and also relate it to the many other environmental initiatives underway in Europe;

— Expand the treatment of protected areas in relation to sectors like agriculture, forestry, tourism, transport and industry;

— Focus on the opportunities for conservation as well as the threats and the difficulties;

— Strengthen the marine element;

— Introduce fuller — but not necessarily longer — texts on protected areas management, information needs and public support.

It is intended, too, that the action points will now each be in one of three forms:

— Recommendations — advice to Governments and others on the action needed to improve the status of protected areas;

— Endorsements — support from the plan for important initiatives already underway in relation to conservation generally in Europe, e.g. EURO-MAB;

— Priority Projects — about 20 high profile, international projects designed to greatly enhance the prospects for protected areas in Europe. It is intended that they would be carried out by the partners to the plan.

Looking beyond the Maastricht meeting, the second draft will be tabled at the IUCN General Assembly (Buenos Aires, January 1994), and the IUCN members invited to agree a supportive recommendation on it. The plan will then be worked up for publication in its final form during the first half of 1994, and launched in as many European countries as possible.

CONTENTS

Because of the timetable, it is not possible to present a draft of the full plan to the EURO-MAB meeting in September. The first draft is already history, and the second draft is not yet ready. Below is a working version of the contents of the second draft; various sections may change during the course of preparation.

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Introduction

Part I: Placing Europe's Protected Areas in their Wider Context
1. Protected Areas: The Global and Regional Contexts

1.1 The Lessons of Rio
1.2 The Lessons of Caracas
1.3 European Strategic Environmental Initiatives
2. Protected Areas and Environmental Planning and Management
2.1 Protected Areas and National Planning for Sustainable Development
2.2 Protected Areas and Land-Use Planning
2.3 Protected Areas and the Management of the Marine Environment
2.4 Protected Areas and Pollution Control
3. Protected Areas and the Key Sectors of Public Policy
3.1 Introduction
3.2 Agriculture
3.3 Forestry
3.4 Tourism
3.5 Transport
3.6 Energy and Industry

Part II: Addressing Priorities at the European, Sub-regional and National Levels
4. A Europe-wide approach to protected areas
4.1 Developing and implementing the EECONET concept
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5. Priority terrestrial and marine sub-regions
5.1 Central and Eastern Europe
5.2 Southern Europe and the Mediterranean Sea
5.3 The Baltic
5.4 The North-East Atlantic
5.5 The Arctic
6. The needs of particular countries
6.1 Countries in great economic and social difficulties
6.2 Countries suffering form armed conflict
6.3 Countries where political support needs reinforcement
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6.5 Countries needing an improved coverage of protected areas

Part III: Strengthening the Planning and Management of Europe's Protected Areas
7. The legal framework
7.1 Improving national law
7.2 Implementing the Birds Directive and the Habitats Directive (EC Member States)
7.3 Adhering to global conventions
7.4 Adhering to and improving regional conventions
7.5 Developing a Conservation for the Conservation of Rural Landscapes of Europe
8. Protected area management
8.1 Raising the standard of protection of Category II national parks

8.2 Improving the management of Category IV nature reserves
8.3 Improving the management of Category V protected landscapes
8.4 Developing new approaches to protected areas management
8.5 The special case of transfrontier protected areas
8.6 Identifying and publicizing high profile demonstration projects
9. Training
9.1 Action at the national level
9.2 Action at international level
10. Information and monitoring
10.1 Information
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Part IV: Creating the Climate for Success
11. Public Support for Protected Areas (Chapter being reconstructed)
12. International cooperation to implement the Action Plan
12.1 Ensuring that protected areas figure prominently in international cooperation
12.2 Providing adequate funds for protected areas
12.3 The use of development aid
12.4 Institutional responsibilities to implement the Action Plan
12.5 Convening a Regional Congress

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WORKING GROUP ON HIGH MOUNTAIN ECOSYSTEMS

Some members of this working group suggested ideas around which future MAB mountain studies could crystallize. These are:

(a) Interrelationships between resource development (e.g. mining), environmental protection, aspirations of local/indigenous people and climate change. This topic would include socio-economic and socio-cultural factors in the light of changing environmental conditions.

(b) The study of ecotones in mountain environments (e.g. timberline, snowline zones), their role for species speciation and biological diversity, and the impact of climate change and environmental pollution on the ecotone zonation. Associated with this broad topic could be the study of varying precipitation regimes subject to climate change and their impacts on mountain water budgets (e.g. floods, landslides in risk prone human settlement areas). Such activities should be linked to the activities of the Northern Sciences Network.

(c) The establishment of species inventories of a wide range of life-forms in mountain biosphere reserves which would tie in with the BRIM initiative and which would provide valuable data for long-term ecological monitoring as part of the Global Terrestrial Observing System (GTOS).

Appendix 3

RECOMMENDATIONS FROM MANAGERS OF BIOSPHERE RESERVES IN THE CIRCUMPOLAR AREA

During the discussions at EURO-MAB IV on the need to involve the public in a substantial way if Biosphere Reserves were to play an important role in defining and demonstrating various ways for improving the long-term relationship between humans and the environment, it became evident that some of the findings and recommendations from the 1992 Workshop of Managers of Circumpolar Biosphere Reserves were pertinent. At the request of the Chairman of the EURO-MAB IV Session, these recommendations, and a note on the discussions that led to them, are here brought to the attention of EURO-MAB.

The Circumpolar Biosphere Reserves Managers' Workshop, held in Anchorage, Alaska 14-17 September 1992, is noted in the report of the Northern Sciences Network working group to EURO-MAB IV. It is reported in more detail in MAB NSN Newsletter No. 12, where the recommendations arising from the Workshop are printed. The recommendations are also attached herewith, for information of EURO-MAB.

The managers of Biosphere Reserves in the circumpolar area clearly felt that, as managers, they needed to take a more active role in developing and promoting the concept of Biosphere Reserves and communicating it to the public. All of them agreed that they needed to know more about MAB, and not be just expected to manage and protect a piece of territory called a Biosphere Reserve. Many pointed out that their authority and formal responsibility was defined with respect to core areas only, and that although the transition zone may be drawn on a map, it was not clear what the manager's responsibility for it was, or who was looking after it or what means were available to make things happen differently in a transition zone from what otherwise would happen if the Biosphere Reserve was not there at all. Who was collecting information from the transition zone or the buffer zone, and for what purpose; and did the people and enterprises in these zones know it?

Many managers and other MAB people at the workshop felt that the transition zone was the most critical and distinctive part of a Biosphere Reserve and should, from the MAB point of view, be an important focus of attention of a Biosphere Reserve Manager. The core area had legal protection and a recognized "nature" value, especially if it was a National Park or equivalent, and would be managed anyway. But not one of the managers at the workshop felt that their National Committees were giving them adequate MAB policy support, guidance, or information with regard to the relationships between the core area and the transition zone.

All Biosphere Reserve Managers expressed a need for communication between Reserves, and also called for more support and information from their respective National Committees.

Each MAB National Committee participating in the Northern Sciences Network consider the recommendations (attached) and take whatever action is possible, particularly with respect to:

(I) compilation and exchange of research bibliographies and lists of research and monitoring projects in circumpolar Biosphere Reserves (recommendations IA 1, 2, 5);

(II) development of species lists and periodic inventory or monitoring strategies, in co-operation with the Conservation of Arctic Flora and Fauna programme of the Arctic Environmental Protection Strategy AEPS/CAFF (Recommendation 1A 3, 4,);

(III) development of co-operative or joint action between Biosphere Reserves, with special attention to zones of transition (Recommendation 1 A 6, 7);

(IV) support the Northern Sciences Network in development of compatible data systems (Recommendation 1 B 1-3);

(V) creation and encouragement of local programmes of sustainable development, education and training, and citizen action or support groups, led by Biosphere Reserve Managers (Recommendation IC1 1, 2, 5);

(VI) development of management policies or plans for each Biosphere Reserve, including the transition zone, with adequate local participation (Recommendation 1 C 2, 4);

(VII) encouragement and facilitation for Biosphere Reserve Managers to be more directly involved in MAB national and international activities (Recommendation 1 C2 1, 2, 3, 4, 5, 6). It is recommended that MAB National Committees search actively for ways and opportunities through which their Biosphere Reserve managers can play a stronger role in MAB as a whole, and be provided with the means and information to do so;

(VIII) provision of adequate information in local languages about MAB and the international and national Biosphere Reserve programme to managers, and improve direct communication between Biosphere Reserves (Recommendation IIA);

(IX) define clearly the role and function of the manager of each Biosphere Reserve (not just for the core area), and his or her responsibilities with respect to national and international MAB activities (Recommendation IIC 1).

(X) Continue support of the Biosphere Reserve Managers' Working Group and Steering Committee (Recommendation IIC 2);

(XI) Provide MAB training and orientation to new Biosphere Reserve Managers within 6 months of their appointment (Recommendation IIC 3).

RECOMMENDATIONS OF CIRCUMPOLAR BIOSPHERE RESERVE MANAGERS

ANCHORAGE, ALASKA, WORKSHOP 15-17 SEPTEMBER 1992

COOPERATION BETWEEN CIRCUMPOLAR BIOSPHERE RESERVES

A. Recommended Actions in Scientific Monitoring and Free Exchange of Data.

— Exchange research bibliographies among Circumpolar Biosphere Reserves.

— Exchange lists of current and planned research and monitoring activities, for the whole Biosphere Reserve (core, transition, buffer).

— Compile a consolidated fauna and flora species list for circumpolar Biosphere Reserves.

— Develop Integrated monitoring strategies taking into account the monitoring needs of the Arctic Environmental Protection Strategy:

— Describe critical resource management issues.
— Determine items to monitor.
— Determine monitoring protocols.

— Prepare a catalog/atlas providing detailed text on unit descriptions, resource management issues, primary research emphases, and maps for all Circumpolar Biosphere Reserves. Print in appropriate languages for understanding by local citizens. Complete a similar catalog/atlas of research sites/facilities.

— Define joint projects between cooperating Circumpolar Biosphere Reserves through: (a) identification of sister Circumpolar Biosphere Reserves with common problems/themes and (b) preparation of MAB pilot and comparative study proposals.

— Develop a list of research needs that address generic issues common between Circumpolar Biosphere Reserves.

B. Recommended Actions in Compatible Data Systems for Circumpolar Biosphere Reserves

With Guidance from the Circumpolar Biosphere Reserve Steering Committee, The Northern Science Network should:

— Survey computer hardware/software compatibilities within each Circumpolar Biosphere Reserve.

— Survey types of data and methods of storage currently used.

— Make recommendations regarding data transferability between Circumpolar Biosphere Reserves.

C. Recommended Actions in Public Communication and Linkages to Circumpolar Biosphere Reserves

C-1. At the Local Level, Each Biosphere Reserve Manager in the Circumpolar area should:

— Develop a proposal for local sustainable development.

— Develop an education/local participation program. Prepare Biosphere

Reserve information packages for school teachers in northern countries. Train the teachers. Inform local community leaders about the purpose and significance of Biosphere Reserves, and the role of that Reserve in the circumpolar network.

— Develop a cooperative association with private citizen groups outside and/or inside Circumpolar Biosphere Reserves.

— Develop a management policies/plan for each Biosphere Reserve in the Circumpolar area.

— The Circumpolar Biosphere Reserve Steering Committee should develop a questionnaire regarding information transfer needs, citizen outreach issues, typical projects, and what is produced regularly.

Share results with other Circumpolar Biosphere Reserves.

C-2. At Levels External to Circumpolar Biosphere Reserves, Managers should:

— Participate in programmes for manager exchanges under protocols developed by the Circumpolar Biosphere Reserve Managers Steering Committee.

— Submit articles to or perhaps have a special section (or page) in the Northern Sciences Network Newsletter.

— Actively participate in MAB science programs.

— Identify needs for science assistance in arctic Russia. Identify opportunities to focus financial assistance to Russia through Circumpolar Biosphere Reserve management programs.

— Review the International Tundra experiment (ITEX) and other MAB arctic projects and determine if appropriate for their specific Biosphere Reserves to be included in or contribute to the study.

— Use the existing UNESCO-MAB Young Scientist Program (exchange student fellowships) to enhance cooperation between Circumpolar Biosphere reserves. Encourage comparative studies and information exchange through this program.

Appendix 4

SOCIETAL DIMENSIONS OF BIOSPHERE RESERVES

PROPOSED WORKING GROUP

EURO-MAB recommends that the perspective of people as part of the biosphere should be strengthened through the establishment of a Working Group for Societal Dimensions of Biosphere Reserves. This Group will focus on activities in the buffer and transition zones of Biosphere Reserves, recollecting the statement of the MAB ICC in 1993 that Biosphere Reserves should be "models for sustainable development".

It is proposed that the Working Group will consider socio-economic and socio-cultural processes as well as environmental education (ecological learning) in these zones.

It is further proposed that environmental education (ecological learning) programmes should be developed for a range of target groups, e.g. children, adults, local inhabitants and decision-makers, tourists, staff of Biosphere Reserves.

It is suggested that the activities of the Working Group should focus on three groups of people:

1. Local populations:

Acceptance of Biosphere Reserves; participation in decision-making regarding the establishment and maintenance/development of Biosphere Reserves; roles of local officials vs. roles of inhabitants.

Current and future socio-economic status/conditions.

Socio-cultural aspects (e.g. religious or indigenous belief systems traditional activities).

2. Tourists:

Conflicts arising from the fact that Biosphere Reserves are areas of scenic beauty and for recreational activities, as well as areas for research and the protection of natural and semi-natural ecosystems (core/buffer zones) and where local populations live and work (buffer/transition zones).

3. Managers and staff of Biosphere Reserves:

— Issues relating to interactions with local populations and tourists with regard to similar topics as under 1. and 2. above.

EURO-MAB proposes that the first meeting of this Working Group should be held at the latest by September 1994. The objective of the meeting will be to define more precisely the scope of future activities.

The German MAB National Committee will convene the meeting.

Each EURO-MAB National Committee is invited to nominate an expert to attend the meeting. It is further proposed that representatives of other international and intergovernmental programmes concerned with the issues of sustainable development in regions containing protected areas (e.g ISSC Human Dimensions Programme, IGBP/WCRP/ISSC START Programme, World Conservation Union (IUCN) should also be invited to attend this meeting, in order to explore the possibilites of mutual cooperation.

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DECLARATION

Being aware of the unparalleled beauty and natural uniqueness of the Tatra Mountains as well as of various tremendous threats to them and, at the same time, feeling the joint responsibility for the fate of this unique National Park Biosphere Reserve, we appeal to the chief authorities of Poland, local communities, Directors and Scientific Council of the Tatra National Parks, and international organizations (particularly UNESCO and MAB Committee), for taking energetic steps to recognize the Tatras to be World Heritage site and for intensifying actions in support of their protection.

The above Declaration was accepted unanimously by participants of International Symposium EURO-MAB IV in Zakopane, 6-11 sept. 1994; this wersion, on behalf of participants, was signed and submitted to print by Professor Alicja Breymeyer.

CONFERENCE PAPERS 21

A publication of the Institute of Geography and Spatial Organization, Polish Academy of Sciences:

1 — Restructuring of economies and regional development, Warszawa 1988, s. 156
2 — Natural environment of suburban areas as development factor of big cities, Warszawa 1988, s. 184
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