GLOBAL MOUNTAIN BIODIVERSITY ASSESSMENT

First international conference on Mountain Biodiversity

7.-10. September 2000 in Rigi-Kaltbad, Switzerland

ABSTRACTS

FRIDAY, 8 SEPTEMBER 2000

OPENING OF THE CONFERENCE

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"National Action Plans for Mountain Biodiversity Conservation and Research"

The Convention on Biological Diversity (CBD) is one of the most important international legal instruments for the conservation of biodiversity and sustainable use of its components. In the distribution of financial resources to further the objectives of the Convention, special considerations are to be given to the special situation of developing countries, including those that are environmentally most vulnerable, such as those with mountainous areas. According to the Decision II/17 of the Conference of the Parties of the CBD, all the Parties agreed to prepare assessments of their national biodiversity, set priorities for action, and report to subsequent meetings of the COP. These overviews, often based on national scientific consensus, are contained in the National Biodiversity Strategies and Action Plans (NBSAPs). A number of projects have been supported by the GEF, the financial arm of the Convention, under its 'Mountain Ecosystem' biodiversity focal area. The results of these projects are also reported in the NBSAPs. My paper will examine NBSAP of selected mountainous countries to answer the following questions:What is the status of mountain biodiversity? Where it is and why? What are the threats to mountain biodiversity loss? How significant is climate change and land use issues perceived in NBSAPs as factors contributing to biodiversity loss? What are the gaps in knowledge? Particular attention will be paid to uppermost forests, the treeline ecotone and the alpine zone. What are the scientific methods and social processes involved in assessing/inventorying mountain biodiversity? What are the priorities for action outlined in the NBSAPs? What are the key policy issues? Conclusion: This paper will address the key issues of the conference from a policy-analyst's point of view. This would help in bridging the gap between the scientists and policy makers, and thus have direct bearing on the final outcome of the workshop "How do we proceed with GMBA network from where we stand".

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"How effective is protected area management?"

Protected areas are widely regarded as one of the most important mechanisms for conserving biodiversity, but surprisingly little thought has been given to the question of whether or not protected areas do in fact conserve biodiversity. Where this question has been addressed, the answers are not always encouraging. For instance, Canada has recently acknowledged that most of its national parks are suffering from serious environmental deterioration as a result of mismanagement, overuse and encroaching development. The conclusion of a two volume report by a task force which spent a year reviewing the status of Canadian protected areas was: "We have come to recognize that Canada's wild places are not endless and that even our protected areas are not safe from undesirable change." This paper argues that there are at least five prerequisites for effective protected area management and examines how each of these can be addressed.

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"Mountain biodiversity: ecological safety, food source, treasure"

Mountain biota are rich in organisms for a number of reasons. Imagine a nutcracker at treeline finding the weather a bit uncomfortable... within 10 minutes this clever bird can move from the 'arctic' to the 'boreal forest' or even to the temperate forest climate. Mountains represent an enormous compression of life zones, otherwise ranging over large latitudinal distances. In the humid tropics all

climatic life zones of the globe may occur within a 10-20 km horizontal distance. This is one of the reasons why mountains are the biodiversity hotspots of earth. Other reasons are the rich topographic structure of steep terrain, which creates innumerable microhabitats for life. In this introductory lecture, I will present an overview of the global mountain species richness, and will discuss its significance for slope stability. Slope stability depends in plants, their roots and on animals "managing" vegetation. The richer the spectrum of plant anchors, the more secure slopes will be under extreme events. Upslope safety of slopes guarantees downslope safety, a cross continental linkage in mountain dependency of society. In many parts of the world, mountains have been used in a sustainable way for agriculture over millennia. In fact, this traditional land use has created anthropogenic precious ecosystems with outstanding biodiversity. The stability of these systems will depend on future management. It is often overlooked that mountain rangeland can provide a substantial amount of healthy and clean food, and its production contributes to the sustained inhabitation of some areas. These human shaped landscapes with their rich biological and man-made inventories represent a cultural heritage, which deserves to be protected and maintained. Mountain biodiversity, besides its widely appreciated conservational value as such, has more to offer than just a rich bowel of, often rare, species. It safeguards life in large parts of the globe, and in one way or the other, 40 % of mankind are dependent on the functioning on these high elevation biota. GMBA is an international initiative to foster these ideas and produce hard facts to support them.

SESSION 1: HOW MUCH MOUNTAIN BIODIVERSITY IS THERE?

CHAIR: CHRISTIAN KÖRNER, SWITZERLAND

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"Some Drivers of Diversity in the southern South American Andean alpine."

The youthful southern Andes bear a species-rich and taxonomically diverse alpine flora. A first estimate for the western slopes of the Andes in Chile from 25º-55º S, suggests that above treeline or equivalent vegetation belts house a sizable proportion of all plant species on continental Chile. Understanding diversity patterns in the alpine ultimately requires knowledge of evolutionary processes producing diversity per se and of ecological processes maintaining it. Steep elevational gradients and contrasting climatic conditions on polar and equatorial slopes are postulated to be critical drivers of population differentiation at a local scale in the southern Andes. Dramatic elevational shifts in pollination mechanisms occur in the alpine, and shifts in pollinator assemblages on opposite facing slopes, along with decoupling of flowering times can determine reduced gene exchange between individuals separated by short physical distances. Elevational changes in pollinator assemblages in the Andes are paralleled by changes in plant breeding system. Contrary to conventual wisdom, although environmental conditions can place strong restrictions on pollinator activity, over one well studied alpine gradient, the frequency of outcrossing breeding systems increases with elevation on account of life-form constraints on plant breeding system associated with adult longevity. In the Patagonian Andes, sexually dimorphic can be relatively more common on recently deglaciated surfaces with low nitrogen content. These observations lead to the hypothesis that many of the first colonizers of the emerging alpine belt in the southern Andes would have been well adapted for the generation of high levels of genetic variability. Coupled with upward migration onto increasingly isolated peaks, the last scenario would open the possibility of rapid differentiation and speciation in the alpine belt, and might go a long way in explaining why the southern Andean alpine flora is so diverse in terms of species richess and floral morphology. The southern Andes stand apart from the New Zealand alpine in their greater diversity of flower colours. Detailed comparisons of the reproductive biology of the alpine floras of the north and southern hemisphere are badly needed in order to detect similarities and differences and for building a global picture of biodiversity drivers in the alpine habit.

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„Species richness and endemism of upper montane forests in the Bolivian Andes and their relationship to natural and human-induced disturbance“

Little is still known about the distribution of plant species richness and endemism in tropical montane forests, and of the ecological and historicalfactors determining these distributions. Between 1995 and 1998, I studied 65 sites in the Bolivian Andes, extending from the lowlands to timberline, gathering semiquantitative data in 1150 vegetation plots for the following botanical indicator groups: Acanthaceae, Araceae, Bromeliaceae, Melastomataceae, Palmae, and Pteridophyta. In the present analysis, I focus on humid montane forests above 3000 m elevation. Natural timberline elevation in the study region is at 3800-4200 m, but human activities have lowered it to 3300-3600 m, destroying over 95% of the original forest coverabove 3500 m. Along full elevational transects in humid areas, vascular plant alpha diversity declines roughly linearly from a peak at around 1500m, but shows a hump at the forest-grasland ecotone, where open habitats are more species-rich than adjacent forests. Alpha diversity varies regionally at least fourfold, mainly in relation to humidity. Forest plant endemism and gamma diversity (i.e., geographical turnover of species composition) peak at about 3500 m, i.e., in a highly disturbed zone. Endemism varies regionally by up to a factor of 17, but the resulting patterns are group-specific and cannot be explained by one or a few general mechanisms. Along gradients of natural forest succession and of human disturbance, species richness peaks in mature, undisturbed forests. Endemism, however, showes maximum values at mid-stages of succession and inmoderately anthropogenically disturbed forests, suggesting a relationship of forest disturbance to plant species range size and implying that a certain level of forest use is compatible with the conservation of endemic plant taxa.

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"New Zealand alpine vegetation, plant distribution, life forms and environments: Tropical high mountain and subantarctic affinities"

A recent comprehensive study on New Zealand's Southern Alps confirms that the c.1000m between climatic treeline and the nival zone divides about equally into a well-covered tall-tussock dominated low-alpine zone and a dwarfed sparsely vegetated high- alpine zone. Caespitose Hemicryptophytes are commonest in our alpine flora except in the upper high-alpine zone where mat forms dominate. Large-leaved, mostly evergreen, forbs (megaphylls) among tall tussocks, characterise the low-alpine zone in perhumid regions, reminiscent of the subantarctic islands and tropical high mountains. In our New Zealand study, richness peaked within 200- 300m of treeline and declined at c.1.8 species per 100m increase in elevation ; an upper limit at c. 2180m (warmest month isotherm c. 4.3deg.C) is indicated. New Zealand alpine vegetation features slow biomass turnover, low root/shoot ratios and negligible over- winter reserves, reflecting the relatively moderate, extended but variable growing season. Close affinities with the vegetation and ecological features of tropical high mountain and subantarctic regions are probably associated with their perhumid non-seasonal environments. All these features contrast with the temperate continental mountains which render close comparisons with them invalid.

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„Species distribution within and between alpine islands in Tasmania and mainland Australia“

Since the height of the Last Glacial the alpine vegetation that covered most of the present land area of Tasmania, and a large contiguous area of the southeastern Australian highlands, has contracted to a large number of small alpine islands. Local endemic vascular plants are concentrated in the environmental extremities of alpine vegetation, the far southwest of Tasmania and the Snowy Mountains,

with a secondary concentration on the Central Plateau of Tasmania, which contains the largest area of contiguous alpine vegetation in Australia. This pattern of distribution suggests a refugial status, rather than the results of recent speciation. The major influences on the distribution of alpine species in Australia appear to be climatic and edaphic, with most of the variation in floristic composition being within Tasmania, where there is a strong southwest to northeast gradient associated with variation in precipitation and soil nutrient conditions. There is less systematic variation within the mainland mountains although the geographic extremes, Baw Baw and the Snowy Mountains are also the floristic extremes.

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„The composition of plant communities and biodiversity of mountain ecotones in Tibet“

A transect in hinterland (32°42.04°N - 36°26.97°N, 98°49.05°- 100°54.62°) of Tibet plateau was selected to investigate the influence of climate changes on plant community composition and biodiversity. The annual average temperature and precipitation varied from 2.5 C to -5 C, from 655mm to 240mm respectively. The data from 61 plots and 141 samples were employed to evaluate the influence of climate condition to plant biodiversity. The distribution of vegetations from southeast to northwest of the transect are forest, alpine shrub, alpine meadow, alpine steppe and alpine desert. The mean plant richness of the ecotones decreases from alpine shrub-meadow (28.3 species) > alpine forestry-shrub (27.6 species) > alpine meadow-steppe (18.32 species) > alpine steppe-desert (11species). However, the biodiversity index decreases from alpine forestry-shrub 6.44> alpine shrub-meadow 5.82> alpine meadow-steppe 3.66> alpine steppe-desert 2.84. The results indicated that the plant richness and biodiversity index were decreased with increasing latitude and altitude. The plant richness and biodiversity index were tightly associated with the average annual temperature and precipitation. These results suggest that climate change could have substantial influence on plant biodivesity in this region.

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"Hot spot versus extinction - The biodiversity of the Tibetan Plateau"

Tibet, the largest and highest plateau on earth, provides an ideal example for studies in biodiversity. In addition to its vast extension, the plateau shows a high variation of surface structures and elevation, and a suit of life- conditions including all sorts of extremes. The diversity centre of SW China (Yunnan, adjacent SE Tibet and E Himalaya), is a prominent "hot spot", considered to represent the highest extratropical phytodiversity. Highly structured, S-N oriented mountain chains, connecting tropical SE Asia to the temperate Holarctic, and a relative continuity of favourable conditions, probably existing almost throughout angiosperm history, contributed to the present species-richness in this area. In contrast, the dry-cold high plateau of NW Tibet (Changtang, E Karakorum), with few W-E running ridges and valleys, and the adjacent arid lowlands of Central Asia, are extremely low in biological diversity. The mountain systems surrounding the plateau, notably the Himalayas and the E rim of the Tibetan plateau, are important areas of differentiation of the holarctic flora. Kunlun Shan, Karakorum, and the mountain ranges radiating from the Pamir knot, provide further migration routes and stepping stones for the evolution and dispersal of the Eurasiatic alpine flora.

SESSION 1, CONT'D: HOW MUCH MOUNTAIN BIODIVERSITY IS THERE?

CHAIR: WILLIAM D. BOWMAN, U.S.A.

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"European montane forest biodiversity in a global perspective"

The mountains of the world are biodiversity hot spots, absolutely, as well as relative to the surrounding lowlands. Mountain forests substantially contribute to this diversity. For example, the elevation zone between 2400-3000m in the Ecuadorian Andes, which corresponds to the tropical cloud forest region, contains 3411 vascular plant species in an area of 17000 km2. This is 300 species more than was encountered in 70000 km2 of lowland Ecuadorian Amazonas. The total high andean moss diversity for the five tropical Andean countries (Venezuela, Colombia, Ecuador, Peru, Bolivia) is estimated to be 7.5 times richer than in the entire Amazonas basin. About half of the habitats of endemic birds identified by the ‚Bird Life's Biodiversity Project' are situated in mountain regions, most of them in tropical cloud forests. Most of the endemic small mammals of Bolivia live in the mountain rain forests. A major cause for this high organismic diversity is high habitat diversity of mountain regions, which is related to relief and variable elevation. Floristic richness of forests in the Alps may exceed the number of 150 plant species associations according to the Central European plant community classification. Furthermore, mountains have always acted as "evolutionary engines", species have become separated when migrating across mountains, mountains acted as refugias for lowland species when these became drier. Tree and shrub species richness of forest community types, i.e. alpha-diversity, is at about 200 in tropical submontane mountains, but very low in temperate regions (less than 15). The total vascular plant species diversity of mountain forests may be less different. Alpha-diversity decreases for vascular plants with elevation but increases for mosses. The decline in vascular plants is not necessarily linear.

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„How many vascular plant species are there in the Swiss Alpine regions, and where, and why?“

Within the framework of a nation-wide floristic inventory, vascular plant species have been collected nationwide in contiguous mapping areas. In a first step, species richness was analyzed in areas above timberline (n=196), ranging from 1 to 135 km2 in size and from 1700 up to 4600 m a.s.l. Number of species was related to area by rarefaction. In order to explain the richness pattern across the Swiss Alps, a multitude of environmental variables was attributed to the mapping areas, particularly area, substrate and climate properties. Correlation and regression techniques were used to define the most important determinants of regional species richness. Substrate, area and continentality turned out to be of special importance. Collecting quality was taken into account and turned out to be important, as well. In a second step, differences in the regional species composition were analyzed on the basis of both, beta-diversity and usualness/unusualness (frequent and rare species) of the regional flora. Mapping areas with a high number of unusual species didn't correspond with the most diverse mapping areas.

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"Plant Biodiversity as a tool for ecotone definition: the subalpine-alpine transition in the main European mountain ranges“

In plant ecology, the concept of biodiversity varies depending on objectives. Curiously, till now, few scientific researches have attempted to analyze its various components on different spatial scales and in different biogeographical situations. Now, biodiversity, in its multiple facets, may allow us to accurately

characterize more or less wide ecological transitions zones or ecotones. An ecotone juxtaposes constituent elements (plant species and plant associations) of the two adjacent systems, thus involving a maximum of biodiversity. With this perspective, this contribution has in view to tackle the study of the often complex limit between the subalpine and alpine vegetation belts in the largest mountain ranges of the boreal hemisphere. This aim can be achieved by systematically combining the physiognomic, climatic, ecophysiologic, floristic and biocenotic approaches as criteria of biogeographic identification of the high mountain vegetation and of its interface with the vegetation of the lower altitudes. Among other scientific topics, the significance of the mosaic structure of this ecotone, the diversity in ligneous species (trees and shrubby trees) forming the timberline, the floristic composition, the biocenotic diversity and more particularly the coexistence of various herbaceous groups transgressing from the two contiguous vegetation belts will be stated on the scale of the holarctic mountains.

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"Mountain biodiversity in the Caucasus"

Upper montane zone, treeline ecotones and alpine regions in the Caucasus are very rich in total species and show high endemism. High biodiversity resulted from contrasting climate, different geological origin of landscapes and occurrence of rugged relief determining the geographical and ecological isolation of plant species and ecosystems. Total number of plant species at alpine elevations in the Caucasus exceed 1000. The number of angiosperm species per one square meter is highest in alpine meadows. Disturbances are frequent at treeline ecotones of the Caucasus due to anthropogenic degradation. Sheep pastures show a massive reduction in canopy height, LAI and biomass in comparison to the adjacent non-grazed meadows. High endemism occurs in subalpine high grassland and meadow communities of the entire Great Caucasus. Tertiary termophilous vegetation, with many local endemic species, is preserved in the upper montane and treeline ecotones of Western Caucasus. The Central Great Caucasus flora is outstanding for its high communities diversity due to relief, and includes xerophilic as well as mesophilic vegetation. Hemi-xerophilic and xerophilic mountain plant communities predominate in Eastern Great Caucasus and Minor Caucasus.

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"Basic quantitative data in support of a geographical model of mountain florogenesis in Central Asia"

The very heterogenous vertical distribution of the floral diversity and floral quality in Central Asian mountains and adjacent regions has many reasons, e.g.: tectonic dynamics, character of orogenesis, ancestral flora of adjacent plains, chorology of mountain systems in connection with orography and geomorphology, climatic altitudinal belts and effects of exposure in arid and humid bioclimates, formation of forest belts, floristic drainage, chronology and dynamics of glaciations during pleistocene as well as of recent cover by glaciers. The dynamics of florogenesis in relation to orogenesis is illustrated by 2 -3 schematic models with rather different floristic composition reflecting vertically and regionally differing life conditions. These models permit projections of the possible future development of the flora.

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"Diversity of higher plants in the himalayan mountains, a quantitative approach."

The flora of the Himalayas, about 13000 species of higher plant species, from eastern Afghanistan to northern Myanmar have been computerised under TEXTO software. Each species is characterised by a) its horizontal distribution in the 16 biogeographical domaines of the Himalayas, b) its altitudinal distribution

in the 11 levels of vegetation, c) its origin in terms of 16 floristic elements of the world contributing to the Himalayan flora. In addition the database includes for each taxon, the family and the author's name. It is easy to extract from the database any quantitative or qualitative information concerning the biodiversity of any biogeographical domaine or of any elevational level of vegetation and to check the similarities between domaines or between levels and to cross the data concerning the origin, and distributions of the plants.

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"Assessing causes and quantities of Andean Biodiversity – a predicitive approach on the basis of spatial data and geodiversity indicators"

The assessment of biodiversity and furthermore the monitoring of biodiversity losses on the basis of field survey alone, is a difficult and timeconsuming concept to close knowledge gaps on a continental or global scale. Especially for remoted and bad accessible tropical and subtropical high mountains, a lack of basic information on biodiversity patterns is evident. The approach proposed here, tries to fill up knowledge gaps using field records and geospatial data in order to provide a holistic view of mountain biodiversity by means of predicitive modelling. On the basis of continental GI-Systems, built up in the frame of the global BIO-GIS initiative, global climatic data (precipitation, temperature, vapour pressure) have been incorporated and downscaled using a distributed multiple regression approach in order to cover the need of high resolution plant physiological relevant information. Furthermore an algorithm has been developed to derive scale independent geodiversity measures which indicate the strong spatial heterogenity of mountain environments. Because the topographical diversity of mountains varies remarkably the growth and live conditions of plants, and increases overall biodiversity in comparison to mountain forelands, a modelling approach has to consider for the spatial heterogenity and patchiness of of the mountain landscape.The GIS includes furthermore a new satellite derived vegetation map of South America representing 185 vegetation units, multitemporal NOAA-AVHRR-NDVI data, infrastructure, settlements and a DEM. Numerous phytodiversity records collected over whole South America have been integrated into the GIS. A database, which was used for mapping global species richness of vascular plants (Barthlott et al. 1996, 1999), comprises metadata on vascular plant diversity for more than 350 geographical units in the Neotropics. Additionally a database of published species lists from 300 tree species inventories in the Neotropics had been integrated. Distributed multiple regression analysis was used to predict Andean phytodiversity on the basis of growth relevant abiotic factors, geodiversity indicators, a satellite derived vegetation map and multitemporal vegetation indices from NOAA-AVHRR-data.

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“Patterns in species richness of European alpine areas“

Multi-scale patterns in plant species richness of European alpine areas were analysed. The analyses were based on species richness values for exposed, snow-protected and snowbed communities and estimated sizes of species pools of the mountain areas. The number of vascular plants declines towards north, whereas bryophytes and macrolichens show a reversed pattern. There is no relationship between vascular plant richness and the size of mountain area. Vascular plant richness is greater on calcareous than siliceous soil substrates, particularly in the mountains of northern Europe. The relationship between local and regional species diversity shows patterns differing among community types. Most communities on siliceous soil substrates show saturating relationship, snow-protected communities on calcareous soils conform to the proportional sampling model while snowbed communities on calcareous soil substrates the local species richness does not seem to be related to the size of regional species pool.

SESSION 2: FUNCTIONAL ASPECTS OF MOUNTAIN BIODIVERSITY

CHAIR: MARY T. KALIN ARROYO, CHILE

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"Causes and Consequences of Vascular Plant Diversity in the Rocky Mountain Alpine"

The Rocky Mountain Cordillera stretches nearly continuously for 4800 km (or between 32º and 68º degrees N. latitude). Although historically the alpine of the Rockies may have formed a nearly continuous band, there are now several disjunctions, influencing the diversity of several taxa. Species richness of vascular plants varies from approximately 150 to 300, influenced by the size of the alpine area and proximity to other alpine areas. A large proportion of species are derived from the Holarctic flora, with additional contributions from more local floras. Floristic similarity among mountain ranges is related to the distance separating them, with dissimilarity increasing as a result of geographic isolation. Although species composition varies, community types show a high degree of similarity among the different ranges, influenced primarily by the uneven distribution of snow across the alpine landscape. At Niwot Ridge in the Southern Rockies, diversity is related to soil resource availability and production, with the highest diversity at low to intermediate availability of nutrients and aboveground production. The alpine flora of the Rocky Mountains includes a wide diversity of functional types. Several alpine species have a large influence on ecosystem processes, including primary production and N biogeochemistry. Environmental change in the Rocky Mountain alpine may be greatly influenced by changes in the abundance of different functional types and their subsequent influence on ecosystem properties

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"Causes of floral diversity in the subalpine/alpine zones of the Rocky Mountains, SW Alberta."

The Rocky Mountains of Alberta experience increasing numbers of Chinooks from north to south, and this results in an ecotone from boreal forest north of Banff to montane forest south of the Crowsnest Pass. The adjacent alpine-tundra exhibits a similar change in species composition (similar to what?). Alpine meadows only occur where there is more than 2m of snow cover in winter. On-going long-term monitoring of air and ground temperatures in a NW-SE transect indicates that permafrost is absent under alpine meadows but is ubiquitous beneath the alpine tundra. Mean annual air temperatures have dropped 0.6-1.6 degrees C during the last 20 years while precipitation is much less than during the last Neoglacial maximum (can you be more precise?). Alpine soils in the south are dry except during snowmelt,whereas those in the north are generally moist for most of the growing season. Alpine species distribution reflects this independently of temperature. They include amphi-Atlantic, pan-Arctic, Beringian, North American arctic, Californian alpine and local endemic species. The forest species reflect the ecotone from boreal forest to montane forest. Unglaciated areas (you mean formerly?) exhibit an exceptionally diverse flora as do avalanche tracks.

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„The diversity of leaf traits of alpine herbs and shrubs - a latitudinal perspective"

It is assumed that plant species richness increases with decreasing latitude. Here I examine whether functional traits of leaves of alpine herbaceous and woody plants also follow this pattern. Based on published data from the Northern hemisphere, spanning a latitudinal range of 79° latitude for herbs and 68° latitude for shrubs, I examined interspecific and latitudinal variation on leaf lifespan, foliar nitrogen and leaf mass per unit area (LMA). In herbaceous plants mean leaf lifespan decreases linearly with

increasing latitude, concurrently the coefficient of variation decreases from 38 to 7%. This latitudinal decrease in variability was also observed for foliar nitrogen concentration and LMA. The result indicates a maximum diversity of leaf morphotypes in high elevation tropical environments. These trends were less evident in alpine shrub species and tended to be obscured by leaf habit. I will discuss possible mechanisms that explain observed latitudinal patterns of leaf traits, including carbon gain, plant architecture, the duration of the growing season and biogeography.

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„Intraspecific genetic diversity in alpine plants“

Recent studies have shown the importance of species diversity for the stability and productivity of ecosystems. Very often when biodiversity is assessed, only this level is taken into account. However, the typological view of the species ommits a large part of the diversity: species are composed of very diverse individuals (that are sometimes grouped into subspecies). Within-species and even within-population diversity is crucial for the maintenance and adaptability of populations to environmental change, and for the evolution of the species. It has thus important consequences in the maintenance of species communities and must also be taken into account in "biodiversity" estimates. I will present here a partial review of literature data on intraspecific genetic diversity in plants from mountain regions. Few studies have been performed on "true" alpine species (in the sense of "above-treeline vegetation"). I have thus extended the data to alpine and lower-elevation dwelling species. Moreover, in most of the cases, the problem addressed is not the estimation of intra-specific diversity. The data are thus probably biaised : several studies were performed on rare or endangered species where habitat fragmentation poses a threat, others were performed to study the phylogeography of species, with a very limited within population samples (leading to an underestimate of within-population diversity), a third category of papers address clonal plants that are frequent in mountane areas. There is no general pattern for alpine or mountane species diversity. Some species are very variable (with levels comparable to common lowland species), whereas others show no within-population variability and very limited among-population diversity. Surprisingly, clonal plants can exhibit both patterns, sometimes even within a single species in different regions. The genetic among-population differenciation depends a lot on the species type ranging from weak to very strong among adjascent populations differenciation: for example alpine birch or poplar show the same pattern as most trees i.e. very high within-population diversity and low among-population diversity.

SATURDAY, 9 SEPTEMBER 2000

SESSION 3: MOUNTAIN "HETEROTROPHIC" DIVERSITY: FROM BACTERIA TO HUMANS

CHAIR: MARY T. KALIN ARROYO, CHILE

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"The traditional inventory of fauna: help or hindrance in the assessment of mountain biodiversity?"

In the past, cataloguing was a central activity in zoology, which resulted in large museum collections and a huge bibliography. After decades of decline, the present urgency of biodiversity assessment should be highlighting this database. In reality, there is only a fuzzy relationship between faunal inventories and the present needs of biodiversity assessment, which looks at general patterns, trends of change, and the role of functional groups. Traditional inventories are unable to satisfy these requests, because most existing data are not available in a useful form. Knowledge is good for some taxa and geographical areas, but a generalised format of information is missing: data are of unequal quality and often buried in obscure journals and languages, with many gaps. Museum collections are often unusable because they lack computerised files and data collection standards. Mountain characteristics

complicate further these issues, since ecology, biogeography, and land-use interact in reduced spaces, and fauna records often refer to undefined areas. Taxonomists could help alleviate this situation, but they should change their working philosophy, enter the arena of modern science and translate traditional inventories into usable tools. Computerised checklists and species cartography projects could restore the existing data to end users, and adapt this invaluable heritage to the science market.

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"Primary microbial succession and biochemical processes in soils of different glacier forefronts."

The aim of this study is to investigate the soil formation processes including soil chemical, physical and microbiological properties of a glacier fore-front in the Alps. Along two chronosequences on acid and calcerous parent material we especially follow the primary succession of the microbial community (PLFA,s) and its biochemical processes during soil formation over a period of 150 years. Additionally, the response of the metabolic activity to temperature is investigated to predict the effect of climate warming on cold-adapted microorgansims.

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"Diversity in primary succession: The chronosequence of a glacier foreland"

Generally it is assumed that diversity increases with ongoing primary succession, often with a slow-down of succession progress in older stages. According to the intermediate disturbance hypothesis, diversity might again decrease as the development settles into stable mature communities. This study of the 150-year chronosequence of a glacier foreland succession focused on the epigean fauna sampled by pitfall traps and investigated the relationships between faunal and floral development. (1) Animal diversity is high even at the youngest sites and remains constant over the first 70 years. Communities develop rapidly with a high species turnover. (2) Diversities at the older sites (70 - 150 years) are slightly higher, but species turn-over has almost come to a standstill. (3) The highly divers pioneer communities on the barren moraines consist almost entirely of carnivorous species. It remains unclear whether these can be sustained by local productivity, possibly based on algae, or whether they have to rely on allochtonous wind-blown input. Herbivorous guilds arrive after 30 years with the onset of vegetation development. (4) Different taxonomic groups show markedly different diversity patterns. Local diversities are governed by specific habitat preferences and the small-scale spatial structure of the habitat. (5) In contrast to animals, plant diversities increase steadily with age. Local variability is high in young sites, and also for plants, species turn-over slows down after 70 years. (6) Neither plants nor animals as a whole have a hump-shaped diversity development as predicted by intermediate disturbance, but it is present for some specific faunal guilds.

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"Status and trends in diversity of alpine vertebrates in the Columbia River Basin"

Overview of trend in diversity and abundance of terrestrial vertebrates from historical (1800s) conditions to present and future (100 yr from now) under proposed land management actions in the Columbia River Basin or Oregon, Washington, Idaho, Montana - Special focus on centers of endemism, habitat specialists, and functional roles of species in alpine habitats - Disturbance processes that affect species distributions and abundance - Threats to species persistence, including change in habitat conditions and other major drivers of change - Narratives of change in specific taxa, including wide-ranging carnivores and narrow endemics.

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"Endemic butterflies and moths of the Alps - an overview"

The endemic butterflies and moths (Lepidoptera) of the Alps are reviewed and their importance for conservation is discussed. A total of 225 species, belonging to 32 families, are identified as endemics. About one third of these faunal elements has been described during the last 20 years. 4 species are still undescribed at the moment. A tentative biogeographical analysis proves the importance of the south-eastern and south-western Alps and the inner Alps as areas of endemism. A main part of the endemic fauna belongs to orophilous elements with restriction to rock formation and related habitats. This is also reflected by the high percentage of species feeding on lichens, moss and spermatophytes such as Saxifragaceae and Caryophyllaceae. Accordingly most of the alpic endemics are restricted to the montane, subalpine and alpine zone, whereas only a few species occur in the nival and colline zone.

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„Arachnid diversity of the Dolomites and of the Central Alps (Italy, Austria, Switzerland)“

The aim of this study is to determinate spider and harvestmen diversity in woodlands just below the timberline, in alpine grassland, scree and nival zone of the Dolomites. Comparable data are available from the the Central Alps, i.e. Zillertal Mountains (Italy), Brenner Mountains (Italy and Austria), Obergurgl and Grossglockner (Austria) and Munt La Schera (Switzerland). The Dolomites are situated in the south-eastern part of the Alps (Italy), delimited in the south by the plain of the river Po, in the west, east and north by the rivers Adige, Piave and Rienza respectively. The Central Alps comprise the main chain of the Alps. In forests near to the timberline in the Dolomites, spiders species numbers ranged from 19 to 41, in Central Alps from 23 to 46. The high Shannon-Weaver diversity (3.1 to 4.2 in the Dolomites, 3.1 to 4.0 in Central Alps) at the timberline is caused by the "mixed fauna" of forest and grassland species. These habitats are generally dominated by linyphiid spiders (up to 85% of specimens). Community composition in alpine grassland was markedly different with up to 80% of the spider specimens belonging to the family Lycosidae. Diversity values were lower than in forest habitats (H=2.7 to 3.9). Nevertheless species numbers are high (up to 47 species). Screes are generally characterized by lower numbers of individuals and species (S=10 to 19 in the Dolomites, S=8 to 18 in the Central Alps). In the southern Dolomites few species indicate minor impact of ice-age and give evidence for peripheral isolation. The nival fauna of the Dolomites demonstrates isolation effects and speciation on nunataks during ice-age.

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"Human dimensions of global mountain diversity"

The human dimensions of biodiversity combine ecological, evolutionary, and social sciences perspectives. This presentation focuses on human populations indigenous to high-altitude mountain ecosystems, such as Tibetan, Andean, and East African highlanders, and the importance of understanding their ecology, culture and biology in order to build models for continuous sustainable use of high mountain habitats. Human activities are commonly viewed as threats to biodiversity and habitats. However, another perspective reasons that populations with millennia of residence in their environment have developed knowledge and practices that have resulted in sustainable use of their environments. A case study of Tibetan pastoral nomads illustrates one situation where traditional knowledge has resulted in long-term residence without environmental degradation. Another human dimension of biodiversity is the diversity of the human species itself. Human populations evolve and adapt to their mountain environments. Indigenous populations are biologically well-adapted as measured by the ability to perform physical work and reproduce successfully under high-altitude hypoxia. In contrast, low-altitude natives who migrate to high altitudes suffer an immediate reduction in the ability to perform physical work and

never recover their sea level work capacity. Understanding how high-altitude natives adapt is vital to understanding the future human habitation of these environments. Case studies of indigenous Tibetan, Andean and Ethiopian populations illustrate different physiological patterns of adaptation to high-altitude hypoxia and raise the possibility that other colonizing species may also vary from one mountain habitat to another. In summary, understanding human cultural and biological diversity greatly enhances scientific understanding of biodiversity in mountain habitats.

SESSION 4: CLIMATIC CHANGES AND MOUNTAIN BIODIVERSITY

CHAIR: GEORG GRABHERR, AUSTRIA

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"Is global warming a true danger to alpine plants? Results from revisitations and modelling experiments"

It was hypothesised that the upward movement of the alpine flora - evidenced by monitoring and revisitation studies - should lead to extinction threats, where species of the uppermost belts will lack proper escape routes. We query this hypothesis for the Alps using monitoring results, migration models, and fine-scaled microclimatic measurements from the alpine and nival belt. In the first phase of the recent climate warming, i.e. during the last 100-150 years, no pronounced extinction phenomena could be observed. While the species pool of many summits within the nival belt was enriched with alpine elements, the nival flora could still persist there. But from modelling studies we can learn that with an ongoing warming - in the range of 2-4 K - the distribution of many nival species will likely be restricted to specific habitats limited in space, even on high mountains of the Alps. This will foremost be an effect of snowcover changes. As recent microclimatic measurements show, the length of snowcover is an almost perfect descriptor to distinguish the "alpine" from the "nival" species pool. Only where long snowcover suppresses the growth of alpine species, the nival flora will persist. Diminished snowcover has to be seen as the real threat for the nival belt, especially for endemics, e.g. Draba ladina.

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"Taking the pulse of mountains: ecosystem responses to climate change in three North American mountain ranges."

An integrated program of ecosystem modeling and extensive field studies in the Northern Rocky and Olympic Mountains of the U.S.A. has quantified many of the ecological processes affected by climatic variability and disturbance such as land-use. Models have successfully estimated snow distribution, annual watershed discharge, and stream temperature variation based on seven years of monitoring. Biodiversity changes at treeline, the invasion of high-elevation meadows and altered life form responses to 100 years of warming have been documented. Spatially-explicit long-term responses to forest fires and insect outbreaks have been coupled with various climatic scenarios to examine potential future conditions in these mountains. This modeling indicates that reduced net primary productivity and biodiversity can be expected with altered disturbance patterns in dry, east-side forest ecosystems in the Rocky and Olympic Mountains under climatic warming. A transect of mountain bioregions from the Pacific Coast to the Rocky Mountains includes additional mountain systems and is determining how future climatic variability will affect mountain biodiversity and regional-scale ecosystem dynamics.

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„Climate change, treeline dynamics and potential scenarios of highland biodiversity in the South Ural Mountains“

The comparison of contemporary vegetation with the images of vegetation fixed on old landscape photos showed that vigorous trees regeneration and their establishment on sites, which were covered earlier with meadow and tundra communities, have occured during the last 70 years within the forest-tundra ecotone of the South Urals (Taganai Ridge and Iremel Massif). Upper limits of open and closed forests displaced upward up to 60-80 m of altitudinal and up to 600-900 m of horizontal gradients on gentle slopes and up to 20-40 m of altitudinal and 100-300 m of horizontal gradients on steep slopes. That has affected strongly on biodiversity and the total area covered by typical mountain tundra communities and on the composition and structure of communities located within and near by forest-tundra ecotone. By preliminary estimations the total tundra area have been decreased on 10-30% over last century, when the average surface temperatures have risen by about 0,7 - 0,8∞C. If temperature will increase by 1,5-3ºC in the South Urals, we expect complete disappearance of mountain tundra on 7 out of 16 sites, where they have still remained, and decrease total tundra area on 40-70%. In this case, mountain tundra communities will remain on tops of the highest summits and will be present by several types with dominance of lithophytous species. We intend to continue investigation in this field on other parts of the Urals and organise the monitoring of climatic changes effects on composition, structure and dynamics of natural mountain ecosystems on permanent altitudinal transects using different methods and approaches

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„Potential scenarios for biodiversity in the Snowy Mountains in relation to climate change.“

Simulated global warming models predict dramatic declines in snow cover for alpine and subalpine areas of mainland Australia. Potential impacts of increased temperature, decreased precipitation and snow duration on twelveplant communities and four vertebrate groups are evaluated for the largest alpine area in Australia. Data on the ecological requirements, and responses to past disturbances were utilised for predicting plant responses. Snow-dependent herbfields and feldmark are likely to decline while heath communities may become more widespread. The response to a 30% reduction in snow cover over three decades is examined for the fauna. Snow is important in protecting endemic fauna from winter cold and at the same time limiting invasion by generalist animals. However, in three decades there has been a decline in some endemic faunal groups, an altitudinal shift in distribution in others and earlier spring arrival of migratory species. Increasing diversity and abundance of alien plant and animal species within the alpine is likely to continue and may be amplified by climate change.

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„Long term hydrological, vegetation and faunal monitoring in the Cumbres Calchaquíes mountains, Argentina“

Long-term monitoring was initiated in a 10 km2 area around 4250 m in 1977. The area is located in the Cumbres Calchaquíes mountains and is spatially nested into a 147 km2 area from 4000 to 4650 m, which was extensively surveyed to extend the validity of the results. In turn, this is nested into the NW Argentina mountain complex including Andes, Puna and Pampean mountains, in which point surveys were performed. The present monitoring is also temporally nested within over 90 years of scientific collecting and observations in the area and the post-glacial history recorded in sediments and geomorphology. The area is not accessible by road and has no present day inhabitants but was occupied in pre-Colombian times. Human disturbance is relatively low, including occasional grass fires, sparse cattle and donkey grazing, and game hunting. Lake levels in the last 30 years have peaked in 1972 at levels achieved at least three times in the first half of the 20th century, and have progressively declined

since then. As a result of reduced precipitation, major changes in the composition of vegetation and fauna have occurred in and around lakes, peat bogs and springs. Elsewhere, species composition is changing more slowly. At least four plant species have disappeared in the last 50 years. Measurement of individual plants is providing information on population dynamics, fluctuation of growth rates and longevity. Small rosettes (e.g. Nototriche caesia, Lepidium meyenii) reach 10-50 years of age, giant candelabra cacti (Trichocereus pasacana) reach over 150 and yareta (Azorella compacta) cushion plants exceed 1000 years. Clonal circle building grasses may have been present since the last glaciation. Such long-living plants can be used as "observers" of the changes occurring around them.

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"Potential scenarios of plant diversity in South African mountain ranges related to climate change."

Mountain ranges in South Africa extend in a wide arc from the Cape Fold Mountains in the west and southwest, eastwards to the Drakensberg and beyond. These mountains form a boundary between the lowlands to the south and east, the moist seaward side, and the more arid high inland plateau. The climate in the northwest is arid, with rainfall in summer, whereas in the southwest rain occurs mainly in winter; the climate is temperate and mediterranean in character. A transitional zone between the winter and summer rainfall regions is found in the south but in the east the climate is more humid with summer rainfall. The Cape Floristic Region that includes the Cape Fold Mountains is one of the world's 'hotspots' of plant diversity. About 68% of the 8550 plant species in this region are endemic and a large proportion of the species is confined to the mountains. With predicted higher temperature prevalence, longer summers with greater incidence of drought would be expected. This would lead to increased incidence of fires that would threaten the fynbos (macchia-like) plant communities in many moist highland and marginal arid localities. Substantial plant species replacements are possible. The Drakensberg range is unusual in being dominated by C4 grasslands. This is not in line with the current understanding of temperature: C4 grass relationships. This pattern is probably the result of C4-dominance with lower atmospheric CO2 levels during glacial times. Frequent fires and high plant nutrient use efficiencies have probably allowed the C4 grasses to reduce soil nutrient levels to a point that excludes C3 species. An increase in fire frequency with climate warming will probably allow C4 grasslands to continue dominating this region into the future, notwithstanding increasing levels of CO2.

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"A conceptual two-dimensional model for responses of mountain plant diversity to changes in climate"

The impact model described below is based on known patterns of the altitudinal ranges of mountain vascular plants, as well as their macroclimatic limitations in the same area. The field information is collected along a coast-inland transect in Central Norway, in which the humidity gradient is extremely steep, from the coastal maximum of 2000 mm annual precipitation, to less than 300 mm in the dry end of the gradient. The January mean T varies from +1.5K at the coast, to –10K at the watershed (Dovrefjell). The conceptual model is a simple correlative model based on the 'limiting climatic factor approach'. The three limiting variables used are the same as in Tuhkanen's cube model: 1. Energy ('summer temperature', accumulated temperature), 2. oceanity/continentality) and 3. humidity/aridity. The altitudinal patterns are circumscribed by purely thermic, hygric or by mixed thermic/hygric climatic characteristics. The evidence on the distribution patterns of species can be grouped into three series, each showing a gradient in the above-mentioned limiting factors: 1. Species with lower (or upper) limits are well correlated with thermal limits, 2. Species with western or eastern limits that are well correlated with some humidity figure, and 3. Species with western or eastern limits that are well correlated with some oceanity figure. Preliminary and semi-quantitative results show that some restricted, continental species ('centric' vascular plants) in the Scandes might come under threat due to a future climate change. Such a change can be explained by a combination of displacement of winter thermic isolines eastwards (more oceanic climate) and competition. A refined and quantitative impact model of climate change has to take into consideration

the effects of secondary changes such as snow cover, slope processes (solifluction etc), soil changes (peat decay or peat accumulation?) and cryo-turbation.

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„Climate Simulations of Recent Changes in the Monteverde Cloud Bank: Potential Cause of Frog Extinctions“

We examine the postulate that recent increases in the number of dry days during the dry season at the Monteverde Cloud Forest (1500m) are caused by a rising cloud bank (Pounds et al 1999). This increase in dry days has been postulated to be responsible for the extinciton of many frog species. Using a regional area model, RAMS, we simulate the climate over Monteverde, Costa Rica, for the dry season month of January for 10 years, 1979-1988, at the end of which the largest extinction spike occurred. We then compare various cloudiness parameters in the model with the observed number of dry days in the dry season for each of these 10 years. Preliminary results show that the cloudiness indicators decrease as the number of observed dry days increases. This suggests that regional climate models may be capable of reproducing responses to the changing hydrological cycle in mountainous regions.

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"Are there climate induced changes in mountain biodiversity in the UK Environmental Change Network?"

ECN is the UK's long-term monitoring and research initiative, which includes three mountain sites. In addition to collecting data that will eventually lead to definitive statements on the impacts of climate change on biodiversity, ECN contributes to a range of shorter term observational and experimental studies. This paper synthesises these studies, examples from three trophic levels being given below. Soil Fauna. Soil monoliths were transplanted from a mountain summit to lower altitude, simulating an annual temperature increase of 2.5 oC. Responses included, migration, dormancy, extinction and increasing numbers of more tolerant species. Vegetation: Areas were resurveyed that were first surveyed in 1971. Of the more abundant spermatophytes in a nodum that included mountain species, 5 species were new to the nodum or increased significantly while 9 species decreased significantly in abundance or were lost. Evidence points to climate change as the cause so manipulative trials have been established to examine the impact of climate on the population dynamics of the species. Insects: A 37 year population record for the xylem feeding Neophilaenus lineatus from a mountain location was analysed. Air temperature explained 75% of the annual change and a 1 oC rise would increase the population density by 50%. A challenge for the future is to develop a better understanding of food web structures. This would allow climate induced changes in biodiversity at one trophic level to be factored as an impact on the next trophic level.

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"Potential scenarios on mountain biodiversity in the Eastern Carpathians related to climate change"

Is the diversity of alpine plants affected by climatic change, and in which mode? Two high altitude meteorological stations, namely the Omul (2,500 m a.s.l.) from the Bucegi Mts and the Iezeru (1,780 m a.s.l.) from the Rodnei Mts provide representative data for the South-Eastern Carpathians in the last 70 years (1928-1998). Three 30 year's climatic cycles can be distinguished for the whole observed period, with a general tendency of slight increase (with 0.5-0.7oC) of air temperature and a slight decrease (200-300 mm) of rainfall. The calculated rainfall trend curve has an opposite trend as compared with the temperature curve, proving a temperate continental type of climate. This slight climate change, with a tendency of warmness and dryness, affect mostly the patchy humid and cold biotopes, such as snow deposits, bogs and alpine springs. A process of continuous fragmentation and reduction of the area of

these biotopes makes them improper to support the orophytic plant species. Our observations show a decline of several endemic, arctic-alpine species and even their dissapearance, such as Saussurea porcii Deg.

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„Biodiversity in mountain medicinal plants and possible impacts of climatic change“

Globalization, economic liberalization and coming in of intellectual property rights open up new opportunities as well as challenges to the mountain people in using mountain specific natural resources. People in mountains need to thing about their place in such a changing scenario and to use these resources to their advantage by way of marketing their traditions in a sustainable manner. As per available records, ethnomedical use of plants has been a tradition in Asian mountains since 4500-1600 B.C. Survey of the available literature reveals that about 2,500 species from Indian sub continent are in local medicinal use or commerce / trade, especially by pharmaceutical industries. Out of these 1748 is from Indian Himalayan region. Further analysis of the available data indicates that about 44 percent of these plants are from sub-alpine and alpine zones. These are also the species with high economic returns in the market. Probably because the noble molecules of commercial and medical value are synthesized more under higher stressed conditions. Since the Himalaya provides unique conditions due to superimposition of temperate climatic conditions in the tropics, probably intraspecific variations and the variability in secondary metabolites would be of wider range in plants growing in this area. Study of vegetation pattern at ten years intervals in completely protected area in Tungnath (alpine area) by Nautiyal and his associates indicates that overall species richness has increased during the last ten years. Late emerging species are increasing at a faster rate than early emerging species. However, some of the species that were recorded in 1988 are being replaced by the new species. The fact that late emerging species are increasing at a faster rate indicates that probably micro-temperature changes are taking place. Similarly, a considerable increase in ferns is indicative of the fact that soil moisture is increasing in these areas. If such a scenario continues, medicinal herbs with low temperature requirements for induction of reproductive phase would be affected adversely and the diversity would be affected by predicted global climatic changes. Therefore, specific studies on ethnomedicinal plants of these areas need special attention.

GLORIA WORKSHOP

PAULI, HARALD; GOTTFRIED MICHAEL; REITER, KARL; GRABHERR, GEORG
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"GLORIA, a global observation research initiative in alpine environments"

A comparison of historical records from high summits of the Alps with recent investigations provided evidence that vascular plant species richness has increased remarkably (see Grabherr et al. 1994, Nature, Vol. 369:448). This upward shift of alpine plants is most likely a response to the ongoing climate warming since the 19 th century. With respect to this finding, GLORIA aims to establish an international observation network to detect climate change-induced effects on alpine ecosystems (i. e. from the low-temperature determined tree line upwards). It is a contribution to GTOS (Global Terrestrial Observing System) and to the IGBP Mountain Research Initiative. A feasibility study towards the world wide implementation of the network, launched by the Austrian Ministry of Science, confirmed the urgent need for such a research initiative. High mountain environments are particularly appropriate for a global comparison of climate-induced effects on ecosystems, due to their presence in all major life zones on earth and due to their high vulnerability to climatic changes. Moreover, most high mountain regions show natural habitats - therefore, "masking effects" from human land use are minimised. The presentation gives 1) an overview about the potential Target Regions distributed from polar to tropical latitudes, 2) an outline on the current status of GLORIA, and 3) shows the method, sampling design and first results of the "Multi Summit-Approach" which is proposed to establish the standardised observation plots in each Target

Region. This approach can provide a particularly cost-and time-effective method for a comparative monitoring of alpine species and vegetation patterns along the altitudinal gradient within each Target Region and along the latitudinal and longitudinal gradients among the different Target Regions. Results from two "Multi Summit"-testregions (NE-Limestone Alps and Sierra Nevada of Spain) showed that relative numbers of rare endemic plant species increase with altitude. Species exclusively found in Sierra Nevada make up to 90 % of species richness and up to 88 % of vegetation cover at the high mountain peaks. Hence, climate warming-induced extinctions of species may become true when wider spread plants from lower altitudes respond with enhanced upward migration. The presentation is the introduction for the following GLORIA-work shop to discuss the method and the options to realise the observation network.

SUNDAY, 10 SEPTEMBER 2000

SESSION 5: LAND USE AND MOUNTAIN BIODIVERSITY

CHAIR: BRUNO MESSERLI, SWITZERLAND

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"Management of forage resources to enhance conservation and use of natural resources for sustainable improvement of crop-livestock systems in tropical highlands"

Repeated famine, malnutrition, natural disasters, mass human displacement and trans-boundary conflicts are recurrent human tragedies in the east African Highlands/mountain areas. Unbridled population growths, declining productivity, land degradation and abject poverty are contributing factors, and under this situation, short term gains override the need for safeguarding the natural resources for the benefit of the posterity. Biodiversity is a rightful heritage and a regenerating asset for all. Nonetheless, safeguarding biodiversity per se will be less important when there is a compelling human survival need. How to supply for the immediate human needs as well as protect the biodiversity for the future? This is the major challenge for the region. The East African highlands/mountain region is regarded as the center of endemism for many plants and animals, and historically, their altitudinal and temporal distribution have oscillated with the changing climate, which is evident from pollen studies. But over the last few centuries, dramatic human-induced changes in the landscape from cultivation, fuel-wood collection and grazing animals have left pristine vegetation only in the inaccessible or sacred sites. Restoring the pristine vegetation may be desirable for the hard-core conservationists, but it is neither practicable nor a necessity in an environment of poverty. Increasing the utility of what is available may be a better strategy for guaranteeing sustainable livelihood and preventing further biodiversity erosion or regaining its losses. Preliminary monitoring of changes in the common grasslands of a selected watershed in Ethiopia under varying grazing pressures is providing an understanding of the dynamics of the vegetation cover and species composition in their current states, and the factors that are preventing them from reverting to their "original" states of the protected "sacred patches" in the neighbourhood. Forages in their mixed states have multiple uses as livestock feed, raw material for human shelter and making marketable items and soil protective cover. Use and conservation of grassland biodiversity should recognize these values to serve the people dependent on them. It appears that human interference can transform a pristine state to varying states of grasslands depending on the social and market forces exerted on it. Studies are therefore proposed for international support to compare, applying GIS tools, the land-use induced forage biodiversity formations in similar altitude gradients across African, Andean and HKH and develop strategies in consultation with the user-communities for their optimum benefit and to protect the landscape that provide for the livelihoods of today as well as the future.

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"Human and livestock impacts on the Khumbu (Mt. Everest) alpine zone"

Few quantitative studies related to human and livestock impacts on the fragile alpine landscapes (4000-5000 m) of the Sagarmatha (Mt. Everest) National Park, Khumbu, Nepal have been conducted. The evidence nevertheless suggests that large areas within the parks, alpine zone are experiencing adverse impacts related to shrub juniper removal, alpine turf mining, and soil loss. In Dingboche (4,412 m), the present study linked the rapidly eroding south-facing slopes with the accelerated harvesting of juniper shrub species for fuelwood (usually for high altitude tourist lodges), the mining of alpine turf for lodge and wall construction, and overgrazing by livestock. Although some of these processes have been on-going for at least several hundred years, the 1995 replication of landscape photographs from the 1962 Austrian photogrammetric expeditions clearly showed a significant loss of shrub juniper groundcover during the 33 year interval. Field work also demonstrated that the Dingboche region experienced much higher rates of soil loss (>30 t/ha/yr) than the more publicized forests and grasslands of lower altitudes (<1 t/ha/yr). More work is indicated in order to adequately understand the (a) types of impacts on the alpine, (b) their historic and contemporary causes, (c) the areal extent within the park, and (d) prospective solutions for the rehabilitation and/or the prevention of further alpine degradation."

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"Andean Cloud Forest Tree-Lines: naturalness, agriculture and the human dimension"

The paradigm of natural tree-line existence in the equatorial Andes is challenged hereby with an alternate hypothesis that incorporates the human dimension. By the exemplification of direct (i.e., agricultural practices, grazing native and exotic herbivores, and burning regime) and indirect evidence in support of anthropic origins (i.e, paleoecological data and biogeography, archaeological artifacts, ancient irrigation channels and trade routes, historical records, local toponimy, and fisheries), we argue that two Andean tree-lines be redefined within the extensification of grassland for grazing in the upper limit, and the intensification of the agricultural frontier, fuelwood gathering, and timber extraction in the lower limit. Management plans and overall conservation strategies of the cloud forest in tropical mountains should change in relation to this new standpoint, and incorporate a proactive, more assertive approach towards restoration of Andean forests with highland pasture conversion to favor landscape ecodiversity in the tropical mountain ecoregions.

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"Effects of long fallow agriculture on plant diversity in the high tropical andes: a landscape analysis"

In the páramo ecological belt of the Venezuelan Andes (3000 to 3800 m asl), potatoes and cereals are produced using a long fallow agricultural system. The objective of this study is to evaluate the effects of the agricultural management on the plant diversity at landscape level and the possible impacts of the shortening of the fallow time, which is a currently observed trend. In the Páramo de Gavidia, a small glacial valley, where 18 peasant farms exist, all the fields (more than 1000) were mapped and the information of the fallow time of each field was collected. To analyse the plant community structure and diversity along the succession, a sample of 36 fields with different ages (1 to 9 years, four replicates per year) and four never cultivated areas were selected. The vegetation data combined with the fallow time map enables the calculation of the total diversity of the valley under the current management system. The result is compared to the natural ecosystem diversity. Scenarios simulating the increase or reduction of the fallow time were also explored. This approach permits to determine the optimal intensity of land use to achieve a high biological diversity.

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„Assessing the effects of land use on Himalayan river biodiversity“

In the largest survey of its type ever undertaken, spread across 1000 km and an altitudinal range of 4000m in the Indian and Nepali Himalaya, we assessed the occurrence of river birds, aquatic invertebrates and habitat structure along 180 streams. We used multivariate techniques to assess whether river biodiversity was affected by the presence of extensive terracing in each catchment. Terraced catchments ( ) were at significantly lower altitudes than other catchment types ( ), and 75% of terraced sites were below 1830m. After accounting for altitudinal effects on streams habitats, there were highly significant differences in habitat character between streams from terraced catchment and others. The total abundance of aquatic invertebrate was greater where there was extensive terracing (501.2 [sd=1.07] vs 691.8 [sd=1.15]. By contrast, river bird distribution was best explained by altitude, and secondarily by habitat structure. Out the 7 species modelled, the distribution of all but one species (Brown Dipper) reflected the effects of altitude. The occurrence of four species increased logistically as altitude declined; the others showed an unimodal altitudinal distribution. Only one species, the Grey Wagtail, was significantly affected by the presence of terracing. This study provides important leads in assessing the effects of land use on Himalaya river biodiversity, but as with many large scale problems in river ecology, the conclusions rely on an assumption that spatial pattern and correlative data represent cause-effect links.

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„Plant species richness of montane and subalpine forest communities in the Swiss Alps: the importance of disturbance“

Differences in vascular plant species richness along the altitudinal gradient in Swiss montane and subalpine forest communities have been investigated. On the basis of a nationwide systematic sampling (4 x 4 km), data on plant species richness were collected in sampling plots with different subplot sizes (30, 200, 500 m2). Being part of the Swiss National forest inventory, the plots are attributed by a multitude of measeured forest variables. In the presented analysis, we used a subset of 388 plots laying in the alpine space (prealps, alps, southern alps) and ranging from 280 up to 2215 m a.s.l.. Species richness of trees, shrubs and characteristic forest plants decreases with increasing plot altitudes. The result can be explained with decreasing productivity towards higher elevations. In contrast, total plant species richness in these plots tends to increase towards the timberline. We used multiple regression techniques to find the most important variables: tree cover (light), forest management (type of disturbance), and substrate (water and nutrients). With increasing altitude, forest and agro-forest-management predominantly influences the forest structure and, in consequence, light conditions. Species richness towards the timberline is basically higher because of the increasingly opened forest habitats which in turn is mirrored by the ratio of forest and grassland species.

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"Does the abandonment of alpine grasslands induce changes in the composition of the vegetation and in plant species richness?"

Already in the foreseeable future it will no longer be possible to finance the traditional systems of agriculture currently applied in the Alps. It is a fear that the change in agricultural use might cause a decrease in the diversity of alpine grasslands. We tested the truth of this fear by analysing data from the Swiss National Park. The Swiss National Park offers unique data on the long-term development of the vegetation (since 1917) under different grazing regimes: (1) cessation of agricultural management in 1914; (2) triplication of the number of wild ungulates between 1920 and today. Permanent plots were

established in three alpine grassland communities and in one tall-herb stand above the tree-line at altitudes between 2160 and 2470 m a.s.l.. In the past eighty years, no significant changes in the composition of the vegetation in the three grassland communities could be detected. Furthermore, no obvious change in plant species richness was observed. Biotic impacts of intermediate intensity, such as grazing by cattle or wild ungulates, may not influence greatly the composition or species richness of alpine grasslands. In contrast, impacts of extremely high intensity may induce a degradation of alpine grasslands. Locally, cattle and sheep at resting-places in the vicinity of stables create such places of very high impact. Under such circumstances tall-herb communities may replace grassland communities. The cessation of the agricultural management in 1914 initiated a process of secondary succession in such tall-herb communities. During the first stage of this long-term process, the dominant tall-herb Aconitum compactum was partly replaced by the tall-grass Deschampsia caespitosa. This was accompanied by a remarkable increase in plant species richness. In the contrast to the man induced tall-herb community, alpine grasslands are stable and maintained independent of intermediate disturbances by both wild ungulates and cattle. It might be the climate conditions that maintain these grasslands.

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"Effect of extensive grazing on the species-rich vegetation of traditionally mown subalpine meadows"

We studied subalpine meadows which traditionally have been mown (once?) every other year. Because of their richness in plant species and especially forbs they are particularly valuable among the grasslands in Central Europe. Recently, many formerly mown meadows have been fertilized, abandoned, or grazed (largely by dry cows). Both fertilization and abandonment reduce species richness and vulgarize species composition. Near Davos (Switzerland) we studied the vegetation of 17 subalpine meadows which are either still mown or grazed by dry cows. We compared 19 vegetation records of 10 traditionally used parcels with 21 vegetation records of 11 parcels grazed for between 3 and 50 years. Mean biomass > 3cm above ground was 291 gm-2. Per 4 x 4 m plot on average we recorded 51.1 plant species, a Shannon-index of 2.81, and an evenness of 0.72. Per parcel, i.e. per two plots, we recorded 68.3 plant species, a Shannon-index of 3.06, and an evenness of 0.73. Productivity and number of species of grazed and mown sites were similar. However, among grazed sites, Shannon-index and evenness declined with increasing time since conversion to grazing, suggesting a slow but steady progression of vegetation change which may eventually result in the loss of species. Ground cover by forbs was higher in mown (35.5%) than in grazed sites (26.7%). The longer the time since conversion to grazing the higher the cover by graminoid species was (+15.2% in 50 years) and the lower the cover by forbs (-19.3% in 50 years). Compared with less intensely grazed sites, more intensely grazed sites had a lower cover of dwarf shrubs and higher cover of legume species, which may be attributed to direct damage and to phosphorous fertilization by grazing cows, respectively. Compared with fertilization or abandonment, extensive grazing appears to have the least severe consequences for species diversity and composition of this characteristic vegetation type. However, because even extensive grazing changes vegetation composition and diminishes forb richness it negatively affects vegetation quality. Therefore, wherever possible, mowing should be maintained, and grazed sites should be re-converted to mowing.

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"Understanding Local Uses of Upland Forest in Shi Men Tai Nature Reserve in Yingde, Guangdong Province, P. R. China"

The protected areas as a mode of land uses are considered to be one of the most effective means for saving mountain biodiversity in situ. Yet the designation of mountain forests as a protected area usually leads to conflicts with local residents who live within or adjacent to the forest for a long time since their livelihoods heavily depend on the forest resources. It is now generally accepted that the assessment and survey on local uses of forest resources is a key step to address and understand local residents' material, cultural and social needs of mountain forests before policymakers or reserve agencies could

adopt workable measures to win their supports and cooperation. This paper presents data from a case study of human forest interaction in mountain villages within and adjacent to Shi Men Tai nature reserve in Yingde, Guangdong province, P. R. China. Questionnaire survey and face to face interview data were applied to examine the local use of forest plants and wildlife, qualitatively and quantitatively. The above results were also compared with historical local uses of forest resources in Imperial China, described in detail in the Yingde di fang zhi (district history). The paper would seek to answer this question, "under what social, economic and ecological conditions, mountain plants and wildlife was protected, managed and maintained, in the face of widespread conversions, clearances and exploitations in South China?".

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"Andean traditional agriculture: a system which enhances biodiversity"

The development of Andean native agricultural sytems over the last four millenia was the result of a complex process of adaptation to the extremely varied, fractioned, unstable and unpredictable tropical mountain ecosystem of the Andes. The basic pattern of Andean traditional subsistence systems is one of not just adapting to the extreme diversity of the landscape and adjusting to unpredictability of the weather, but, paradoxically, taking advantage of this "undesirable" features. In this paper we examine the basic subsistence patterns based on a combination of vertically diversified horticulture and Andean camelid grazing. Due to the tropical conditions of the central Andes this pattern fluctuates from dry to rainy season and rural communities device numerous strategies to cope with constrains on one side, and to take advantage of biodiversity in the other. Furthermore, the paper shows how the traditional subsistence patterns sometimes presses towards increased biodiversity as exemplified by the diversification of cultivars and varieties of all native crops.

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"The endemic plant species of Prahova's superior basin"

The Prahova's Superior Basin is included between eastern Bucegi Mountain and western Baiului Mountain. The Bucegi and the Baiului Mountains are parts from Meridional Carpathian (that are integrated in Carpathian chain - which 54% represent Romanian Carpathian). These mountains are composed of Jurassic limestone, conglomerates of Bucegi and gritstone of mica. The annual averages of air temperature is depending on altitude and location (between 500 m and 2000 m altitude). The endemic plants play a major part in biodiversity studies not only in a restricted area (like Prahova's Superior Basin) but in a larger area (like the Carpathian Mountains). As a result of the position in the contact area of these two mountains (Bucegi and Baiului) the flora is richer than to be expected (963 taxa in 87 families on 270 km2 only). From these, five species (Thesium kernerianum, Hesperis oblongifolia, Saxifraga demissa, Astragalus australis ssp. bucegiensis, and Poa molinerii ssp. gracialis) are endemic to Bucegi. The large biodiversity of this territory is determined by ecological various factors like the relief, the geological substrate, the temperature, the precipitations. The calcareous substrate represents an important ecological factor because it favors the appearance of endemic species in this territory (Dianthus spiculifolius, Erisimum transsilvanicum, Gypsophylla petraea). In the studied area are all the four belts of vegetation: the superior montane belt - which are a lot of endemic species, like Dentaria glandulosa, Hieracium transsilvanicum, Ranunculus carpaticus, Pulmonaria rubra, the subalpine belt - with the endemic species like Silene dubia, Centaurea kotschyana, Heracleum palmatum, the inferior alpine belt - with Dianthus tenuifolius, Bromus barcensis var. bucegiense, Geranium coerulatum var. caroli-principis, Thesium kernerianum, Draba compacta, Draba haynaldii, the superior alpine belt - where are the endemic species Cerastium arvense ssp. calcicolum, Oxytropis jacquini ssp. carpatica, Poa granitica. In the Romanian Carpathians, 45 endemic species have been found (42% of a 110 known total for Romania). The endemic species are characteristic of the studied area and represent 0.52% of total species of the Prahova's Superior Basin."

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"Diversity and disturbance in an alpine grassland"

The alpine sedge mat in the Glatzbach area (Hohe Tauern, Austria) is characterised by long-term stability. The keystone competitive species Carex curvula exerts enormous competitive pressure on other species in undisturbed parts of the sedge mat. Other vascular plants are unable to establish themselves when the Carex population is well developed. The endogenous vegetation dynamics represent mosaic cycle or carousel dynamics (van der Maarel & Sykes 1993). These dense mats can only be destroyed mechanically by frost dynamics. Cryoturbation creates patchy disturbance. Distinctive vegetation zonation is formed resulting in concentric patterns of decreasing intensity of disturbance. The majority of species is abundant (?) or even completely restricted to these disturbed areas. The disturbance regime creates a diversified community series (Cryptogam aspect, Luzula aspect, first Primula aspect, second Primula aspect), which develops after a climax-like transitional phase into a herbal stage with Carex curvula (≥herbal climax"). This stage probably alternates cyclically with a poor ≥absolute climax" and a stage with additional abundance of Oreochloa disticha (≥grass climax").

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"Holocene oscillations of the Alpine timberline ecotone and global warming"

Climate, particularly the summer temperatures, the growing season length and the microclimate of the site are the main factors which control the position of the alpine and polar tree limits. Not only average temperatures but also climatic extremities have a strong impact on the growth of trees, although the trees at the tree limit are mostly adapted to severe and changing environmental conditions. In order to estimate a possible future impact on the alpine timberline ecotone (Kampfzone) due to climate change (global warming), it is necessary to investigate its present and past situation. The first step includes fieldwork and GIS aided modelling of the structure and the climate dynamics of the present timberline ecotones using vegetational, dendrochronological and physical geographic parameters for 2–3 small model areas within

two selected test regions in the Swiss Alps (vegetation patterns, seed dispersal, present potential forest- and tree limit, tree ages of stunted tree zones and regeneration areas, abiotic boundary conditions of the sites (geomorphology, altitude above sea level, potential direct solar radiation, local thermic conditions and snow cover). In a second step, the vegetational data will be used together with the palyno data (pollen records, plant macrofossils) for modelling the past in different time scales, i.e. mainly former (historical) alpine tree limit and phytobiodiversity dynamics (past situation). In a third step, different climate scenarios focusing the future will be tested with the help of vegetational, dendrochronological and physical geographic parameters of the small model areas within the test regions. The different models for the present, past and future will be established using GIS. The combination of vegetational, dendrochronological and physical geographic parameters concerning the modelling of the Swiss alpine timberline ecotones envisaging different climate scenarios is the main approach.

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"Epiphyte diversity in a tropical mountain ecosystems – the example of Estación Científica San Francisco, Southern Ecuador"

Estación Científica San Francisco (ECSF) is located in Southern Ecuador, at the Northern limit of Podocarpus National Park. The research area of ECSF, includes about 1000 hectares of primary tropical mountain forest, as well as small Yalca areas, at altitudes from 1800-3200 m, which allows a complete transect of the different tropical montane forest types on the Eastern side of the Andes.One of the main characteristics of tropical mountain forests is the incredible diversity and abundance of epiphytes, which are not only prominent structural elements, but have also high importance for the hydrological regime of the forests. The altitudinal distribution of epiphytes and the change of epiphyte diversity in relation to the level of disturbance were investigated. In the lower part of ECSF, between 1800-2250 m altitude, more than 200 species of epiphytes, belonging to 19 families and 35 genera were collected. This is one of the highest epiphyte diversities found worldwide. The largest group of species belongs to the Monocotyledones (52%), and orchids alone account for 38% of the whole epifitic species encountered. The highest diversity was found at altitudes around 2050m, with a peak of more than 100 epiphyte species in a single tree.

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"Species diversity of beech forest in subtropical mountains of China"

How much biodiversity is there in Chinese mountain beech forests (subtropical evergreen zone) and what are important factors that influence it? Beeches are absent from temperate China due to the continental climate. However, they form mixed forests that disjunctly occur in the subtropical montane zones at altitudes from 700 to 2500 m asl., within the latitudes from 22.3 to 34.3 degrees N and longitudes from 101 to 121.5 degrees E. To characterize the species diversity of these forests and its relationship with climatic factors such as temperature, precipitation and climatic disturbances, plots (each around 2000 m2) were sampled from ten old-growth beech forests at eight locations that are widely separated. Climate data were from nearby weather stations and were extrapolated to the forest sites sampled. The results show that among the Northern Hemisphere beech forests, species diversity was the highest for the southern Chinese beech forests, mixed with evergreen broad-leaved trees, which is even comparable to those for some tropical rain forests. The species diversity was primarily affected by temperature, and was correlated positively with windstorm and heavy rain frequency and negatively with frost frequency. Ice storms negatively affected the evergreen trees. The high biodiversity of Chinese beech forests could also be due to the floristic history of southern China that was barely impacted by glaciations. These forests, however, are under a great pressure of deforestation, and their beech dominance may be replaced by the evergreen co-dominants if the climate becomes warmer.

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"Agrodiversity in the highlands of central Mexico. Is it being maintained or is it being lost?"

The study is carried out in the municipality of San Felipe del Progreso (SFP), Mexico and belongs to a UNU/PLEC project. SFP is located between 19°21' and 19° 47' latitude and at the 99'52'02" and 100°16' 26" longitude, inhabitated by Mazahua people. The altitude of the community is almost 3 000 m. Agriculture is carried out in two areas: i) a produtive one (several crops are cultivated, including maize) and ii) one for self consumption (milpa). Productive crop land is far from home, maize is cultivated as a cashcrop. Milpa is grown for local (family) consumption and represents a sustainable cropping model: it provides a variety of goods (70 cultivers) for self consumption and is cultivated using organic inputs and weeds are used as well. This study identifies the crucial elements to manage and use biodiversity in both agrosystems. Social and environmental conditions determine the biodiversity used. For example in the late 19th century and early 19th century barley and wheat were sown in SFP introduced by the Spanish. Once land was given to local farmers after the Revolution barley had been replaced by maize. Oats was not cultivated until 1960. Diversity of crops has not been lost, but some species and cultivers were replaced by others. Regarding wild species, some have been lost due to changes in land management. Campesino agriculture in Mexico has been marginalized, to face globalization. Alternatives have to emerge from local resources (i.e. blue maize with increasing demand), but conserving or even increasing biodiversity (enhace local resources) should be attempted

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"HKH Ecoregion: a key node of biodiversity conservation“

HKH means Hindu Kush – Himalayas the working area of the International Centre for Integrated Mountain Development (ICIMOD), who emphases this working area the ECOREGION. This region includes the Hindu Kush - Himalayan areas of eight host member countries: Afghanistan, Chittagong District of Bangladesh, Bhutan, Qinghai-Xizang Plateau and Hengduan Mountain of China, the north mountain area of India, Nepal, the north part of Myanmar and Pakistan. This ecoregion situated in the largest mountain systems of our planet and forms a complex of special ecosystems. Qinghai-Xizang Plateau is also known as the third polar of the Earth. There is colorful physical geographic nature, extremely differentiated ecosystems, and rich biota with their diversified genetics. This young dynamic ecoregion has been experienced great change in the past 100 million years with its great evolution of geology, geomorphology, climate, vegetation and fauna. In geological history HKH was the important refugee camps of many species. Later HKH also has become a new place for these species evolution. Now it is sensitive to the global change. The ecoregion is accommodated its diversified culture which is supported strongly by it's diversified ecosystems. In one word HKH is one of the important nodes of the world in many aspects of nature and society, religion, economy and culture. Due to the remoteness, inaccessibility and hard environment, HKH is a backward region under the impact of globalization. It is necessary to attach more attention to HKH ecoregion as it has great significance of global context, so as the study of its nature, its biodiversity. This paper will introduce the advance biodiversity study in HKH ecoregion, its biota realms, ecosystems, flora and fauna and related impact of human activities.

Key Word: HKH Ecoregion, The third polar, New animal geographical area

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"Man induced diversity of higher plants in the mountains of Central Nepal"

The Flora of higher plants of Central Nepal includes about 4500 taxa. All these plants have been computerised under TEXTO software. Each species is characterised by a) its horizontal distribution in the 16 biogeographical domaines of the Himalayas, b) its altitudinal distribution in the 11 levels of vegetation, c) its origin in terms of 16 floristic elements of the world contributing to the himalayan Flora, d) its habitat (more than 50 habitat types). As these habitats refer to the physionomy of vegetation (dense forest, clear

forest, open forest, shrubland, meadows, cultivated area, barren land...), they give some informations not only on the effect of land use on biodiversity, but also on how different forms of land use affect biodiversity. It is easy to extract from the database any quantitative or qualitative information concerning man induced changes in diversity of higher plants in each level of vegetation of Central Nepal.

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"Facilitation and competition in mediterranean high mountain vegetation (Sistema Central, Spain)"

Direct positive interactions are generally accepted as important processes in communities. They appear to be most common in environments with relatively high physical disturbance, stress or predation, where associated species can increase the growth and survival of other species unable to survive in isolation. We have checked facilitation and competition effects in the high vegetation of Sierra de Guadarrama (Sistema Central, Spain). This type of vegetation occurs between 2000-2430 masl, in the so called cryo-oro-Mediterranean belt, usually, as isolated patches dominated by flat cushion plants like Minuartia recurva, Jasione crispa subsp. centralis, Armeria caespitosa, Saxifraga willkommiana, etc. We have evaluated patterns of plant species co-occurrence and species affinity for patches with and without those cushion plants and also patch species richness. For that purpose, we have mapped and recorded species composition of patches. Successional changes have also been checked across total species richness and size of patches. Patches dominated by different cushion plants did not differ substantially in species composition, although species affinities for patches is different, depending on number of species. Herbaceous species appear to act as late colonizers, mostly restricted to species-rich patches. Flat cushion plants can be considered "nurse plants", they can modify micro-environmental conditions and allow establishment and survival of associated species

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"Bird Diversity of Russian South-Eastern Altai"

The study area is situated in the Kosh-Agach district of the Republic of Altai of Russia (49° northern latitude, 89° eastern longitude, and 1600-3500 m altitude). The bird censuses were performed in 57 habitats during the summer 1984-1990 and 1997-1998. The birds were counted on permanent routes without limitation of the transect width. The total length of basic census routes was 1465 km and additional transects for counting scarce birds were 1350 km in length. In these expeditions 198 bird species were recorded. The majority of the bird communities was composed of transpalaearctic species (27%), and of species of Mongolian and European (18% each), as well as Siberian (16%) types of avian fauna. Representatives of Tibetan (7%), Chinese (4%), Mediterranean (3%) and Arctic (2%) types were less numerous. Species richness and diversity is greatest in forest habitats and minimal in nival, semidesert and settlement landscapes. The proportion of individuals subsisting on the ground was 67%, far less than in crowns (13%) or shrubs (12%).The composition of summer bird communities was largely associated with complexity of habitat structure (40% of variance of the matrix of similarity coefficients eliminated by qualitative linear approximation), which depended on forest presence (21%), presence of shrubs (12%) and degree of relief fragmentation (10%). Other significant factors were altitudinal zonation of vegetation (21%) conditioned by absolute height (8%), and further wettness (8%), pasturing (8%), presence of surface water (7%) and settlement (2%).

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"Climate Change: Possible Effects on Mountain Biodiversity in New Zealand"

New Zealand is unique in being the worlds most isolated, ancient and topographically diverse continental island groups. Its alpine region is believed to be relatively recent (~2 million years old), yet it is populated by a high diversity of mostly endemic (~93%) vascular plants (~600 species) and invertebrates. Many alpine plants can exist below treeline in a variety of open environments.Several thousand permanent plots have been established in grassland areas since 1900, including permanent photo points, herbivore exclosures, altitudinally stratified vegetation transects and regular faunal monitoring. The responsibility for continued monitoring of these plots has become unclear after the 1992 restructuring of research. Human disturbance in the last millennium has been profound. In particular, forest destruction has allowed alpine and subalpine plants to extend their ranges significantly, while high-alpine plants have probably extended into low-alpine tussock grasslands opened by burning and grazing in the drier rainshadow regions. Such changes may override potential present climate change signals. As a complement to direct observations, we have modelled the species-area relations for New Zealand's total vascular flora. This flora is presently below equilibrium for its size, which suggests that the number of species may rise from the present ~2450 to ~5000 composed of mostly exotics, regardless of climate change. Assuming a 2 C temperature rise, alpine areas will reduce by close to 50%, which could lead to 60-150 species reaching critically low population levels. However, this could be modified to some degree by downward extension through forest destruction and/or the upward invasion of exotics.

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"Features of phytodiversity in high mountains: the influence of disturbance regimes"

High mountains are considered as ""hot spots"" of biodiversity due to their geographically compressed variety of geomorphological, petrographical and climatic conditions. As dynamic ecological factors natural disturbances significantly contribute to spatial heterogeneity and biotic diversity (not necessarily species richness) in all high mountain regions. However, features of phytodiversity as well as kind and impact of disturbances vary along environmental gradients and latitudinal zones as a function of variation in absolute properties like growth rate, climatic conditions and shape of the physical template. In this conceptual contribution an overview of the correlation between ecozone-specific disturbance regimes and features of phytodiversity is presented. Within a particular ecozones each altitudinal belt exhibits various kinds and intensities of mechanical impact. Due to the greater number of elevational belts in tropical high mountains more and qualitatively different disturbance regimes have to be expected there than in subpolar mountain ranges. This coincides with the general phenomenon of increased phytodiversity towards the equator. The spatio-temporal dimensions of disturbance as well as the number of secondary successional stages differ among high mountains situated in various ecozones. This context is elucidated referring to three examples: Brooks Range (Alaska) for a subpolar mountain range with high impact of cryoturbation and flooding; Sierra Nevada (California) in a mediterranean region with droughts, wildfire and insect pests as main triggers for patch dynamics; Cordillera San Francisco (Ecuador) in the tropics influenced by landslides and El Niño-events.

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“Changes in the vegetation composition due to a different length of the snow-covered period”

The potential impact of earlier snow melt on high alpine vegetation is investigated in 30 species in controlled environments. We hypothesize that earlier snow melt will affect species, depending on their photoperiod sensitivity, i.e. earlier snow melt will favor specie which are not sensitive to photoperiod. This will change the species composition. Our Null-hypothesis is that alpine species are not photoperiod sensitive with respect to the onset of growth and flowering, but their phenology is exclusively driven by temperature. Test species were excavated between 2600 and 3200 m.a.s.l. at Schrankkogl (Austria). After simulating artificial autumn and a dark winter environment at sub-zero temperature plants were released to photoperiods between 12 and 16 hours at two temperature regimes. Grown in little microcosms on

natural substrate and in a simulated early summer climate, several plant species exhibited very pronounced photoperiod sensitivity (for instance Oxyria digyna, Tanacetum alpinum) while others did not. In combination with a snow cover model these data will permit projections as to the fate of high alpine plant diversity under climate change scenarios. Our Null-hypothesis is rejected. We conclude that high elevation plants will exhibit different responses to climate warming depending on their photoperiod sensitivity, which needs to be known for realistic predictions.

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"Biodiversity in alpine pastures in relation to cattle, an unpalatable weed and soil nutrients"

Most species-rich upper montane grasslands below the tree line have been maintained through centuries of continuous grazing by domestic cattle. Usually, a small number of species in these systems are unpalatable to cattle and control by farmers is required to keep their abundance within limits. As labour costs rise, weed control declines which may threaten the existence of alpine pastures. Veratrum album (Liliales, Melanthiaceae) is a tall (sub)alpine weed that is toxic to livestock and reproduces both through seeds and through fragmentation of the long-lived vertical rhizomes. We aimed to investigate (1) whether the presence and abundance of V. album is correlated with the botanical diversity of alpine pastures and (2) whether grazing promotes the abundance of V. album by enhancing its clonal growth rate. The abundance of V. album was negatively correlated with species richness at a small scale (ca. 1 m2), but not at the field scale. At the field scale, species richness was correlated with a combination of P (negatively) and N (positively) content of the soil. V. album populations in pastures had a significantly more clumped spatial shoot distribution than populations in hay meadows (which served as controls). As this abstract is written, RAPD-analyses are performed to identify genotypes within four pasture and four hay meadow populations to determine whether aggregation is the result of clonal growth of V. album. Our results indicate that the composition of species rich mountain grasslands is the result of a complex interplay of grazers, the palatability of species and abiotic factors. A cost effective conservation requires insight in the effects grazers have on the population dynamics of the most dominant plant species.

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“Graded management intensity of grassland systems for enhancing floristical diversity”

The objective of our research is to maintain and enhance richness of wildlife species, land-scape diversity and economic competitiveness of grassland-ruminant systems. This may be accomplished by a diversified, graded management intensity of pastures and meadows (Dietl, 1990), resulting in a network of intensively and extensively used grassland and other semi-natural habitats. Botanical diversity is thus increased on both a habitat and landscape level. In intensively farmed regions it may be necessary to reestablish species-rich grassland types and adjust management intensity to the site conditions and species’ requirements.

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"Vegetation pattern and plant diversity of man‘ influenced habitat of Czech-Polish border in Giant Mts., Sudetes"

The Czech-Polish border in Giant Mts. was closed zone, controlled by military troops till 1989. On the long stretches of the border vegetation cover and topsoil were totally degraded as a result of regular harrow. This artificial landscape structure is running along the main ridge from 900 up to 1500 m. a.s.l. and crosses different vegetation types in Picea abies mountain forest, krumholz, tall grasslands, mires and subalpine short grass. Present streak,s vegetation is in different stages of succession which started after cessation of mechanical disturbances in the beginning of 60,s. The direction and rate of revegetation depends on disturbances and is affected by neighbouring vegetation types. Surprisingly some rare plant species are frequent in this man, created habitat. Their distribution and vegetation pattern were studied in relation to factors affecting succession process.

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"Vegetation dynamics after forest clearing in the mountain and subalpine zone of southwest China"

China is biologically very rich with approximately 30'000 species of higher plants, including about 7000 tree species. Fifteen-thousand species occur in tropical and subtropical regions (Mark Collins et al. 1991). In the province of Sichuan (southwest China), there are over 10000 species of higher plants, of which over 3190 woody plants (ligneous plants) and over 3100 angiosperms (Yang, Q., 1990). Because of forest practice (i.e. clear-cutting), the environmental conditions, such as temperature, water, and light will change (Sichuan Academy of Forestry, 1984; Li, M. 1998a/b; Li, M., 1999). Some plants, which grow under a forest canopy, may disappear if they do not adapt to the changed conditions. Forthermore, some new plants may invade just because of those changes. The study area is between 2700 and 4000 m a.s.l. in west Sichuan. The timberline lies at about 4000 - 4300 m a.s.l. in this area. The results of our analysis show that the change of vegetation is not the same at different altitudes and in different forest communities. Under forest canopies, the dominant species are shade-tolerant plants, such as species of Ribes, Lonicera, Sorbus, Primula, Pyrola, Actinothuidium, Hylocomium etc. After the clear-cutting of forest stand, the dominant species are heliophilous plants, such as Alamagrostis, Anaphalis, Artemisia, Rubus etc (Li, M. 1999). The species number under forest canopies does not indicate a regular change with the increasing elevation in different forest communities (Fig. 1). This may mainly be related to site condition and crown density. But, the species number is increasing consistently with rising elevation within the Abies-belt (Abies-belt, from 2700 to 3600 m elevation) (Fig. 2). This change may largely result from increasing light condition under forest canopies, because the crown density of Abies-stands decreases with the increasing elevation till near the timberline (from 0.8 – 0.9 at 2700 – 3000 m altitude to 0.3 – 0.4 at timberline). Therefore, we suppose that the species number will in fact increase after clear-cutting until the area is completely recovered with forsts, and species number will deline again.

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"Permanent photographic points for following vegetation trends; a 29-year record from Mt Aspiring National Park, New Zealand"

A vegetation survey of the extensive (287 200ha), generally mountainous and remote Mt Aspiring National Park in 1968-69 coincided with a drastic reduction in the uncontrolled feral red deer populations through commercial hunting using helicopters. The generally depleted vegetation was monitored with 88 permanent photographic points established in 1970-71 to represent the wide range of vegetation zones (lowland to high-alpine) and types (forests, shrublands, tussock grasslands, fellfields, snowbanks). They were marked on site (metal stakes) and on aerial photographs. Precise photographs and descriptions of local plant cover, using ranked values for species, with notes on any animal sign, were recorded. Sites have been remonitored four times up to 1999. Fourteen have been lost to date, mainly through snow removal of markers, but sufficient remain to provide a reliable record of trends. Vegetation condition has generally improved as animal numbers have remained very low. Numerous bluffs have provided refuges and seed sources for palatable species. Responses have varied with community type: subalpine scrub and low-alpine snow tussockland communities show the greatest recovery (they may now be close to their pre-disturbed state in many areas); forests have generally improved but high-alpine communities show little change. This monitoring information is valuable for park management and interpretation and, despite its high cost (c. NZ $10000), should be continued at about decade intervals while threats of exotic ungulates (and some aggressive exotic plants, e.g. Hieracium lepidulum) persist.

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“Phytophagous insects as biosensors in mountain ecosystems and role of population biology in this research.”

Traditionally, biodiversity is investigated and implied on the species level and usually is limited by it. However, biodiversity manifest itself also on the population level and the most common example here is polymorphism. It is ecologically selected variability, which main function is the most complete and effective use of environmental heterogeneity. Whether species track environmental changes is best evidenced by population structure. Especially sensitive are such population characters as composition of morphs and its changes in space and time, fluctuating asymmetry, ets. And population sexual dimorphism, which we precisely evaluated for the first time in leaf beetles, proved to be a complex sensor of population changes under succession. It is known that herbivorous insects associated with common boreal and alpine plants may act as more sensitive biosensors of climate change than their host plants. Among them leaf beetles (Coleoptera, Chrysomelidae), which have high abundances and are one of dominating groups in alpine meadows and mountain tundras. There are several good objects. For example, Chrysomela lapponica L. may be very numerous on willows and was investigated in Altai - Sayan mts., the Urals and Tien-Shan. Gonioctena arctica (Mannh.) (=affinis (Gyll.) has specific composition of morphs in every investigated point and relict populations of the South Urals differ greatly from all others. Both species inhabit the majority of Northern Eurasia and have isolated populations in the mountains distant southward. Their exact populations are highly polymorphic. They are convenient for comparison in lowland and mountains and on different mountain ranges. Oreina basilea Gebl. in the mountains of South Siberia from the foothills to mountain tundra has good trends of body colour change along altitudinal transects. It is polymorphic only on the hights above 1500 m. and has specific differences in Altai, East and West Sayan mts., Tuva and Transbaical ranges. In conclusion we can say, that high abundances of leaf beetles and other herbivorous insects and elaborated complex of research methods in their populations turn them into one of the key objects of climate change monitoring.

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"Andean plant biodiversity Patterns and Causes"

The spatial patterns of Andean plant diversity are analysed on the basis of different databases and Geographical Information Systems. The first database, which was used for our map of global species richness of vascular plants (Barthlott et al. 1996, 1999), comprises metadata on vascular plant diversity for more than 350 geographical units in the Neotropics. The maps based on these data identify especially the slopes of the northern and central Andes as centres of high phytodiversity on a landscape level. Multiple regression analyses show strong correlation between species richness data with datasets of abiotic parameters in GIS. As one important basis for these analyses we computed the first map of South American geodiversity, the spatial heterogeneity of the abiotic parameters. The centres of high phytodiversity on a landscape level coincide with the centres of highest geodiversity (tropical Andes, especially the eastern slopes, Venezuelean Coastal Cordillera, Guayana Highlands, SE Brazil). On the other hand, we analysed a database of published species lists from almost 300 tree species inventories in the Neotropics. In these small-scale inventories, where the heterogeneity on the landscape level has no direct effect, we find highest species numbers for most groups of plants in the humid lowland forests. Diversity of trees in small-scale inventories is rapidly decreasing with increasing altitude. Within the Andean subset of this database (>50 inventories above 2000 m a.s.l., c. 30 between 1000 and 2000 m a.s.l.), the floristic composition on family and genus level is highly predictable on the basis of only a few environmental parameters with altitude being the most important indicator. The species per genus ratio for trees in our database as well as, e.g., in the Peru Checklist, is decreasing with increasing altitude, indicating that there has been no extensive radiation within most of the tree taxa after the uplift of the Andes. This is in contrast with epiphytes and shrubs, for which highest species per genus ratios can be found in upper Andean forest and the subpáramo respectively. These high Andean habitats seem to be important areas of speciation for these taxa. Comparing the patterns of alpha diversity (highest in lowlands) and gamma diversity (highest in the Andes) in the Neotropics, the extreme scale dependence of the results becomes obvious. Measures of geodiversity, the diversity of abiotic parameters, seem to explain much of this effect.

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"Data requirement for monitoring trampling impact on vegetation change"

We use two case studies made in the Cairngorms, Scotland to generalise the importance of experimental design in detecting statistically significant changes in biodiversity monitoring studies. We compare the efficiency of using cover estimates of all species present with that of using indicators of trampling damage. The optimal sampling design for detecting change was based on a model of variance, constructed from field trial data. Variance for different methods, between observers, within-observer, between-quadrats and between-habitats were estimated. Error structures for the observer variances approximated to a binomial model; the between-quadrat variance was larger than observer variance and approximated to a modified binomial model. This implies that more samples are needed to detect change in species with a mean cover of 50% than at the other levels of cover. The comparisons suggested that about 8-10 times more samples would be required for using non-permanent quadrats as opposed to permanent ones. The total number of quadrats required using species cover estimates was similar to that for estimating the cover of indicators and lower than that required for frequency. Paths are the centres of trampling damage. A study quantified the frequency and percentage cover of trampling indicators along 30-m transects running from footpaths into vegetation. Canonical correspondence analysis showed that > 60% of the variation in the cover of indicators was attributable to distance from path centres. A modelling exercise attempted to model the nature of variation in the data that will be obtained by repeated estimation of cover of various trampling indicators in the monitoring of trampling damage around footpaths. It was found that whilst a multivariate approach with re-randomised quadrats can distinguish relatively intact vegetation from path centres, it does not provide a good indication of intermediate levels of trampling, and cannot therefore be used to monitor changes in path width or changes in path intensity.

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"Tropical montane biodiversity: using GIS to link climate, vegetatation and habitat"

In order to effectively manage protected tropical montane areas for species and habitat conservation, the following questions must be addressed: what habitat variation exists within an area, how are animals using the available habitat, and what are the factors controlling seasonal altitudinal migration of wildlife? A vegetation classification based on bioclimatic modelling is used to map forest type and structure across a 'hotspot' area of tropical montane forest along the slopes of the eastern andes in Bolivia. By linking this with a database of arboreal species and their fruiting phenology, food availability for frugivorous mammals and other habitat factors can be modelled spatially. Food is likely to be a major determinant of wildlife distribution, abundance and seasonal movements. The potential uses or threats provided by the surrounding area must also be considered as protected areas do not exist in isolation. By combining the information in a GIS, seasonal habitat suitability for wildlife may be modelled across the park to determine the most valuable areas for supporting biodiversity. A number of distinct climatic regimes and forest types exist over the elevational gradient, which ranges from 250 m to over 4000 m. Preliminary observations indicate that seasonal fruiting patterns vary with elevation, but that fruit availability may not be a limiting factor in the 'dry' season.

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Land-use and biodiversity changes in slovakian part of eastern carpathians

How have the land-use changes in recent 60 years influenced the species, ecosystems and landscape diversity in the uppermost part of the Eastern Carpathians. Due to different administrative, demographic and technical reasons, the area of the eastermost part of Slovakia became practically unpopulated. The characteristical meadows and extensive pastures "poloniny" situated above the tree line are now abandoned, unmanaged. This caused significant changes in species composition with the trend to simplification of phytocoenoses. In lower parts, the initial forest starts to overgrow the meadows and "poloniny" pastures. Examples of forms of biodiversity changes. The evaluation is based on 15 up to 22

year time series of observation. Extinction or endangering of numerous taxa and phytoceonoses is the result. Many of the phytocoenoses described in literature can not be found anymore, some of them are protected and maintained on small acreage spot by simulating managerial practices." In the "poloniny" meadows, situated above 1000 m a.s.l. the threatened communities are Nardo-Agrostion tenuis Sillinger 1933 Campanulo abietinae-Nardetum (Palczinski 1962) Hadac et al. 1988 Betonico-Agrostietum tenuis Blazkova 1991 Very rare communities became Calamagrostion arundinacae (Luquet 1926) Jenik 1961 Gentiano asclepiadee-Acetosetum carpaticae Hadac et al. 1988 Hyperico-Luzuletum luzuloides Hadac et al. 1988 Also some species, which can be found only on this "poloniny" meadows are threatened by overgrowing by trees (Viola dacica, Campanula abietina, Melampyrum herbichii, Senecio papposus, Tithymalus sojakii, Dianthus compactus etc.) In the lower elevations endengered communities are Carici flavae-Eriophoretum latifolii Soo 1944 Caricetum goodenowii Braun 1915 Cirsietum rivularis Nowinski 1927 Origano-Brachypodietum pinnati Medw.-Kornas et Kornas 1962 Prunello laciniatae-Dorycnietum herbacei Hadac mscr.

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"Biodiversity of the Darjeeling Himalayas- challenges and opportunities"

The Himalaya forms an important component of the global mountain system. Much of this spectacular and rugged mountain range is biologically under-explored, thus leading to the gaps in the biological understanding of the Himalayas. The paper focusses on the Darjeeling Himalaya - the lesser known component of the Eastern Himalaya. Darjeeling has 42% of its land under forest cover, with as many as 131 species of recorded mammals including the red panda, Himalayan black bear, clouded leopard, tiger, Himalayan thar, goral, gaur and the pangolin. Early records list as many as 550 bird species. 144 dictyledenous species of Darjeeling are endemic to the Eastern Himalaya and 29 species are endemic to Darjeeling. 28 species of Rhododendron, 322 orchid spp (including 53 rare and endangered) are present in Darjeeling. At least 125 fish and 51 reptiles were recorded from this place. Darjeeling is often seen as equivalent to the Sikkim Himalaya, so that Darjeeling itself has received little attention with request to biodiversity conservation. Poor communication and lack of international exposure have further obscured Darjeeling in the Eastern Himalayas. Conservation attention to Darjeeling is important because Darjeeling 's population density is high (413/km2) and is growing rapidly. The paper further discusses in general the socio-politico-economic problems of the area, which have an impact on the biodiversity of the region. Very few studies have been carried out so far in order to have indepth understanding of the conservation issues of the region and is therefore the need of the hour.

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"Features of phytodiversity in high mountains: the influence of airstreams and hygrothermic conditions"

The degree of species numbers in high mountains depends on different factors: mass elevation, orographic heterogeneity, location within a floristic region and climate zone, frequency and natural disturbance regimes (compare abstract Jentsch/Richter) , as well as the position of the mountain chain against advective airstreams. While these factors are considered as the main triggers driving community diversity at the regional level, additional stand conditions and processes play an important role for the degree of ß-turnover, considering the change in species number with altitude at a meso-level and of species-diversity at a micro-level. After analysing different effects caused by mass elevation (???), the main part of the poster focuses on the importance of different wind directions. A distinction (of what?) is presented by the comparison of a species-poor type (of what???) given by convective currents and a species-rich type given by obvious climatic differences between windward and leeward exposures. Intermediate types result in intermediate numbers of species. It must be emphasized that the extent of advective airstreams form an important, but only one of the decessive triggers concerning the degree of g-diversity of a high mountain range.

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"Rare species as bio-monitor of climatic changes in high mountain areas."

In alpine areas of temperate latitudes, the most significant influence of climate changes on flora and vegetation are not due to the mean air temperature change itself but to the influence of climate at the micro-scale level, as a combination of amounts and patterns of snowfall, wind and cloudiness, all affecting the length of the growing period. But then, which are the most useful bio-monitors to detect climatic changes? Can rare species be considered good bio-indicators? Probably yes, for locally abundant taxa growing over a large range but restricted to a specific habitat. In the N-Apennines (Italy), above the timberline, we have started in 1999 observations of some arctic-alpine or European orophytic species, locally rare for phytogeographical reasons (border of the range) but also because strictly linked to peculiar micro-thermal habitats, such as snow-beds, ridges and wet meadows. They are expected to be sensitive bio-monitors of climatic changes at the micro-scale. The monitoring is achieved by means of annual counts of the number of individuals and by measurements of local population viability within permanent plots. Data collected in 1999 and 2000 and climate conditions are shown and discussed. For Salix herbacea L. and Juncus jacquinii L. data recorded were compared with those collected in some control plots from the Alps (the center of their range). This comparison showed a lower viability (number of stalks and infructescences) for the N-Apennine populations compared to the ones from the Alps. Therefore the former seem to be under a considerable environmental stress (longer snow-free period?) likely to make them sensitive to climate changes at the micro-scale.

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“Vegetation monitoring on a small-scale restoration site in the alpine belt: Pilatus Kulm, Switzerland”

The success of vegetation restoration of a site (ca. 300 m2) on Pilatus Kulm (2050 m a. s. l., Obwalden, Switzerland), located in the alpine belt was monitored between 1990 and 1998. Severe damage to the vegetation cover had occurred during construction of a sewer pipeline from Pilatus Kulm down to the valley and establishment of military installations. In the first stage, plant recolonization was induced by planting different seedlings of herbs. In the second stage, seeds of alpine grass species were used to achieve a more dense pioneer vegetation cover. A vegetation study made at different plots revealed that over 80 % of transplants survived the four-year period (1990 -1994). On the whole, the plant cover increased up to 40 % on the slope and up to 80 % on tilted borders within the four years period. With the introduction of seedlings in 1994, along with favorable circumstances, the establishment of the vegetation has been accelerated, resulting in an area which is now covered by dense herbaceous vegetation. In 1998, the control plots showed a plant cover of 60 % on the slope and up to 95 % on tilted borders. During the eight year monitoring period, considerable fluctuations of species could be observed.

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“The subalpine forest/grassland ecotone of the Andringitra Mountains in Madagascar: A landscape matrix created by fire and herbivores”

In the subalpine forest/grassland ecotone at ~2000m asl., traditional land use through grazing and fire, has over the last 100 years produced an anthropogenic mountain landscape with a complex mosaic of forest patches, ericoid bush and open grasslands, maintaining unique biodiversity, important pasture values and aesthetic beauty. Since work began for the creation of a National Park in 1993, management objectives focused on protection, preservation and scientific research, initially excluding traditional landuse. However, control of grazing herbivores and fire provoked rapid ericoid bush encroachment, pioneered by fire sensitive Philippia cryptoclada. This lead to the challenging question how Protected Area management objectives can be linked with local communities’ traditions and needs to safeguard in

collaborative approaches unique biodiversity, use- and scenic values. Results from floral and faunal inventories declare Andringitra mountains a biodiversity hot spot in Madagascar. The subalpine forest/grassland ecotone is outstanding for Ericaceae, Asteraceae, Poaceae, geophytic Orchidaceae and Succulents. 14 punoid to paramoid vegetation units were identified. Amongst Poaceae, the dominant genus is the palatable Panicum, represented by 13 species with P. andringitrensis, endemic for Andringitra. Convergence phenomena between the genera Panicum, Philippia, Helichrysum and Stoebe highlight similar adaptation strategies to special climatic conditions. To reopen ericoid bush and arrest further encroachment, strategic use of clipping close to the ground and controlled burning are studied as future management tools. Philippia cryptoclada, trichoclada and floribunda react to clipping by extensive resprouting from the base, increasing dramatically the number of stems. Burning kills all Philippia spp. except Ph. trichoclada, which resprouts from the base as seen in the clipping experiment. To assess ecological trends of systemic ecosystem dynamics and resilience, we developed a simple monitoring methodology, using Composite Entomological Traps for sampling epigeal terrestrial invertebrates. Relative insect abundance is grouped into 4 main trophic guilds of phytophages, detritophages, zoophages and parasitoid and then compared in relation to the anthropogenic history of 7 sites along a forest-grassland gradient from east to west. For mountain forests disturbed by fire and cattle, supplementary research in progress studies the re-colonisation patterns by non-flying Micro-mammals (Insectivores and Rodents) as indicators for habit damage, rate of recovery and speed of return to functional habitats. Our investigations have shown, that unique mountain forest/grassland biodiversity, pasture-, and aesthetic values have evolved with and are maintained through moderate anthropogenic disturbance. A holistic, proactive systems approach to park management has thus to consider the shaping role of human culture as an intrinsic part of biodiversity and ecosystem functionality.

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“The Effects of Roads Through Tropical Mountains: Peru's Transoceanic Highway and the Threat to One of Earth's Most Biodiverse Ecosystems."

Mountains, due to their topographic complexity, have tended to be somewhat less vulnerable to economic development and environmental destruction prevalent in lowland areas. However, recent development projects aimed at breaching this isolation now threaten mountain ecosystems around the world. This study examines the Cordillera Carabaya of southern Peru, one of the least-known regions of high-elevation cloud forest, puna grassland and glaciated alpine peaks in the Andes Mountains. An elevational gradient of 5,000m over 50km results in extreme climatic and ecological variations over small horizontal distances. The highest biodiversity on Earth has been recorded in the rainforest immediately adjacent to the Carabaya, reflecting the ecological complexity and sensitivity of this unique region. The Andean cordillera has always presented an insurmountable obstruction to the building of viable roads linking the Amazon and Pacific. Within the present year, however, a major road being built through the Carabaya and adjacent rainforest will first become traversable, imperiling the fragile, complex ecosystems that extend from rainforest to snowline. The Transoceanic Highway represents both the culmination of a decades-long effort by the Peruvian government to access the Amazon and, more recently, an international effort to link Amazon and Pacific Basin markets. I will describe the factors promoting road development, and current and future impacts of this activity. The consequences to both highland and lowland ecosystems are likely to be severe and irreversible. In particular, the road spans a 50 km wide corridor between the Manu and Bahuaja-Sonene national parks, thus effectively bifurcating the world's most biodiverse ecosystem.

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"Encroachment of Complex Ecosystems into High Alpine Zones in Response to Climatic Warming: A Case from the Andes."

Rapid deglaciation and regional warming have been ongoing across the central Andean Cordillera since the termination of the AD 1500-1900 Little Ice Age. We studied ecological responses to these changes in the watershed of a high alpine lake, Laguna Sibinacocha, located at 4,850 in the Cordillera Vilcanota of southern Peru. Visits to the region revealed that much of the terrain between 5,200-5,400m, shown to have been glaciated in air-photo imagery from 1931, is now ice-free and supports an upwardly

expanding floral and faunal ecosystem. The lake has expanded due to increased runoff from melt. High solar uptake results in a relatively warm waters that both support abundant and diverse waterfowl and creates a locally warm microclimate supportive of a biodiverse ecosystem despite the extreme altitudes. Rodent (viscacha) colonies and small reptiles are now found to 5,300m elevation, while vicuna, felids and other mammals routinely cross a 5,400m pass to an adjacent watershed that was blocked by 50-100m of ice in 1931. Lands adjacent to Sibinacocha are presently utilized by Quechua inhabitants in traditional alpaca husbandry. The upward propagation of habitat in response to deglaciation allows wildlife, including such rare and endangered animals such as vicuna, huemul deer and Andean mountain cats, to expand into a domain that lessens competition with domestic animals. Our research suggests that regional/global climate change is causing the uppermost few hundred meters of the alpine zone to increase, providing new habitat and connective routes between once-isolated populations of plants and animals. While this change may provide increased space and refuge from spreading human land use, the effects on once-isolated endemic alpine species has yet to be determined.

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“Sexual and clonal reproduction in alpine plant life: persistence and dispersal as key processes to explain the maintenance of genetic diversity”

Persistence by clonal growth is an obvious characteristic of most alpine plant life. Species from alpine communities are usually long-lived and rely strongly on the reproduction by vegetative growth. However, it remains unclear how the surprisingly high level of genetic variation in extremely long-lived clonal species with usually poor dispersal capacity is maintained. Current theories on the maintenance of genetic diversity have been developed for animal organisms and focus on the effects of spatial dispersal of mobile organisms with separate sexes, usually referred to as metapopulation theory. In a ongoing project we ask whether and how this dominant theoretical concept also applies to sessile plants which occur in the extreme patchy and fragmented alpine landscape and which possess complex reproductive systems. We use demographic field work, an experimental approach and the newly available molecular tools to answer the following questions: How important is dispersal by seeds and the colonization of new sites in the alpine landscape, how effective does it affect the balance between sexual and asexual reproduction, and how is the spatial genetic structure in alpine clonal species related to the dispersal of pollen and seeds. We present data to show that clonal growth in alpine species is not necessarily correlated with a reduced reproduction by seeds. Preliminary results from a demographic study with the clonal Geum reptans support the hypotheses that the importance of establishment from seeds is sufficient to maintain a high genetic diversity and that in newly created habitats traits favoring a high seed production and dispersal are favored compared to later successional stages. Our results are important to predict the resilience of alpine plants to global warming.

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“Comparative study on diversities of the forest communities of mountain area in Northeast China transect (NECT)"

Nect is a forest-steppe sample with a gradient of precipitation from 120mm to 700mm among the active IGBP-sponsored terrestrial transects in the international arena running along the line of 43.5N and caught between 110 and 132E. It is located in a mid-latitude zone,being 1,600 by 300 km. Two parts of NECT, the southern watersheds of Daxing-anling mountains(SD), and the mountainous forest zone located on the northern slopes of Changbai Mountains and the Zhangguangcai Mountains and the coastal mountains(NE), featuring a temperate timberland of evergreen coniferous forests and broad-leaved deciduous forests, were selected as our study area.4 and 9 sites were selected respectively to analyse their eco-geographical characteristics of plant composition, including life form, water ecotype and floristic element. There are totally 14,7 and 10 types of each. The results shown that the floristic geographical element of SD is apparently richer than that of NE.In SD area,plant are dominated by Panartic, paleoarctic, Eastern paleoarctic, whereas, by East-Asian broadleaved forest element in NE and floristic element of grassland has a certain proportion in SD, but nearly not exist in NE. Furthermore,the percentage of species compositon and important value of different layer of four types, Betula platyphylla, B. dahurica, Quercus mongolica forest and Ulmus macrocarpa woodland was analysed.The former is 58%, 55%, 75% and 61%, but the latter is 2.46%, 93.76%, 83.18% and 91.23% in woody layer of

B.platyphylla forest, which was also found in herbaceous layer and other three sites.Finally,the effects of human activities and floristic distribution area on different communities were discussed.

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"Historical Changes in species composition, abundance and diversity of alpine plant communities in Norway and Finland"

Historical changes in species composition, abundance and diversity of alpine plant communities were analysed by using data sets sampled in 1920's and 1990's from Central Norway and NW Finland. The comparisons were made for seven communities differing in their initial species diversity and habitat conditions. The species composition of plant communities and the abundance of most species have remained unchanged. For some species and species groups marked changes were found. The cover and number lichens had declined in most communities. On mountain heath communities, the cover of some bryophytes had increased. We also found that herbs and grasses had increased in snowbed communities, while some typical snowbed plants had disappeared or decreased in these sites. The data for snowbeds suggests that these communities may exhibit rapid response to changed conditions. The observed changes in species composition and abundance are consistentwith predicted effects of slightly increased reindeer grazing pressure and observed climatic trends.

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"The influence of fire on diversity patterns on Mt. Elgon"

Mt. Elgon (4.321 m a.s.l.) is an isolated mountain of volcanic origin straddling the Kenyan/Ugandan border (0°54'-1°25'N; 34°14'-34°45'E), which was deglaciated about 12.000 years BP. In the presented study, the small mammal fauna and the flora were studied on Mt. Elgon at altitudes between 2900 and 4300 m a.s.l., with the main focus in the afroalpine grasslands above 3500 m a.s.l. Since recurrent fires are an important but much neglected factor in tropical-alpine ecology, we tried to asses the impact of burning on Mt. Elgon's biodiversity by means of descriptive and experimental methods. Species richness appears to peak at intermediate disturbance levels. Recurrent man-made fires maintain a highly structured and diverse landscape with mosaics of grasslands, rocky outcrop vegetation and ericaceous scrub and forests. The grasslands are a largely secondary result of frequent burning and would be replaced by ericaceous vegetation up to more than 4000 m a.s.l in case burning would be discontinued. About 10 rodent species live in these highly structured grasslands, whereas only 3-4 species utilize dense ericaceous forest. If fire frequency is very high (intervals of few years) these structured grasslands are degraded to poor, homogenous tussock grasslands dominated by few grass species and the rodent fauna drops to 3-4 species, comparable to undisturbed ericaceous forests. Vascular plant species diversity follows a similar pattern.Without fire, i.e. human disturbances, large ungulates would have a high impact on the vegetation structure, leaving a cycle of open, secondary and mature forest patches and therefor enabling the existence of different life-forms next to each other.

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"A Five-Step Approach to the Protection of Mountain Biodiversity Affected by Land Use: The Wedding of Conservation and Culture"

The Western Himalayas is an area of high endemism, with a mix of Palearctic, Ethiopian, and Indo-Malayan taxa affected by the geographic isolation of giant mountain ranges and the greatest glaciation outside of the polar regions. One of the most important habitats for biodiversity in these steep and arid mountains is conifer woodland. Recently these woodlands have been decimated by heavy logging. This destruction is due to a rapid increase in human population, the opening by road of once-isolated areas, and a cultural shift to a cash economy. The loss of these forests threatens biodiversity, soils, watersheds, and the future viability of human cultures and communities. A five-step program was initiated in the mountains of Northern Pakistan that was adapted to maintaining local Muslim culture through the conservation of natural resources. Methods involve educating local villagers about ecological

processes, conservation issues, and sustainable practices; and training them to analyze land use, resources, habitats, and wildlife patterns. These analyses are then used to develop and implement community-based conservation activities and sustainable resource management plans. The methods used in this program have wide-ranging applications for all mountain regions where human cultures and the environment are, or may soon be, under siege.

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“Change of Structure and Biodiversity Along a Restoring Gradient of Artificial Forest in the Eastern Qinghai-Tibet Plateau"

Clearcutting, a commonly used forest management practice in eastern Qinghai-Tibtean Plateau, often results in the drastic degradation of mountain ecosystems. This study examined the community structure and species composition across a chrono-sequence of nine stands that restored artificially following clearcutting and nearby primary forest stand in the upper reaches of Dadu River (31 o 24'N--31 o 33'N, 101 o 48'E--101 o 53', alt. 3560m~3880m, slope-direction with northwest, grade 8~38), The restoring stand ages ranged from 1 to 30 years (2-5-7-10-15-19-30a). Three stages of stand development were identified in terms of structural difference, namely the establishment stage in 1-7a after artificial plantation, the closing stage with between 8-15a and stand self-adjustment stage in 15-30 a. A total of 167 species was found in nine restoring stand and most were sun-liking herbs and shrubs. According to the change of plant population density and IV across the chrono-sequence, they were divided into the invasive species group (75 species), the sensitive species group (12 species) and the tolerant species group (22 species) with different adaptation. Throughout the early stand development following clear-cuts, species diversity development also was identified three stages, viz. the induction stage in 1-10a, high diversity stage in 10-20a, and the adjustment stage after 20a of artificial restoration. The change of community structure and Alpha/Beta index strongly explained the forest microenvironment, resulting from the stand closure , and was a key filter to species composition of the stand and it would be difficult for indigenous species composition unless they were restored artificially. One important finding was that some species from subalpine meadow and scrubs invaded and established in the artificial stand. Implicating the artificial restoration was an effective measure for subalpine biodiversity conservation. No tree species established successfully in the artificial stand except selected trees, Picea asperata and P. balfouriana, although other species existed in surrounding natural forest. This suggested that the present artificial restoration methodology and management need revision in order to promote indigenous tree diversity.