MOUNTAINS

Jeník J.
Charles University, Praha, Czech Republic

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Contents

Summary

The natural status of the highlands is controlled by the interaction of altitude, latitude, continentality, and topography. The multiplicity of combinations of these physical factors is enhanced by the diversity of plant and animal populations, which themselves create new habitats, develop specialized ecosystems, and affect the position of geoecological boundaries in four mountain domains distinguished over Earth's continents: the humid tropical, humid temperate, arid, and polar domains. Altitudinal belts, biotope, and ecosystem types are best identified and surveyed using the distribution of plant growth forms and communities. The treeline is the most expressive geoecological boundary, dividing the contrasting environments of wooded areas and treeless alpine tundra. The isolation of patches of alpine tundra and the heterogeneity of their interior conditions affect the genetic mobility of plant and animal species and stimulate microevolutionary processes. The exploitable resources of the mountains serve both the local populations and the population of plains, which make them equally

responsible for conservation and sustainable development. **See *Mountain Management, Tundra***.

1. Introduction

The English word mountains, and its nearest equivalents in many languages, refers to a variety of topographic elevations rising considerably above the surrounding landscape. A sizeable landform is always assumed, yet its actual dimensions are only approximately outlined in linear, square, or cubic measures. Absolute altitude above sea level is very important, but the respective situation on Earth's surface, indicated by geographical latitude and distance from oceans, is also decisive. It is the relative height of the hillslopes and their situation within the broad landscape topography that make mountainous shapes sufficiently distinct. A variety of different eminencies are expressed in all languages by a series of related terms, for which the possible English equivalents are hills, uplands, highlands, and mountains.

The general physiognomy of mountains varies a lot. They include typical chains and ridges of elevated massifs, but also single mounts emerging from the surrounding plain and facing all cardinal points. A huge escarpment dividing two landscapes in the manner of a step can also generate a similar environmental complexity. Experts in mountain geoecology and geography—Carl Troll, Bruno Messerli, and Jack Ives—also include high plateaus, such as Altiplano of the Andes, the Tibetan Plateau, and the eastern Pamirs, where life is constrained by physical and biotic factors much as it is in highlands emerging from plains. Moreover, even slightly undulating landscapes with low elevation yet high latitude can be accepted as polar mountains, for example, the landscapes of northernmost Canada, Alaska, and Norway, where the alpine treeline meets the polar treeline. **See *Polar Regions***.

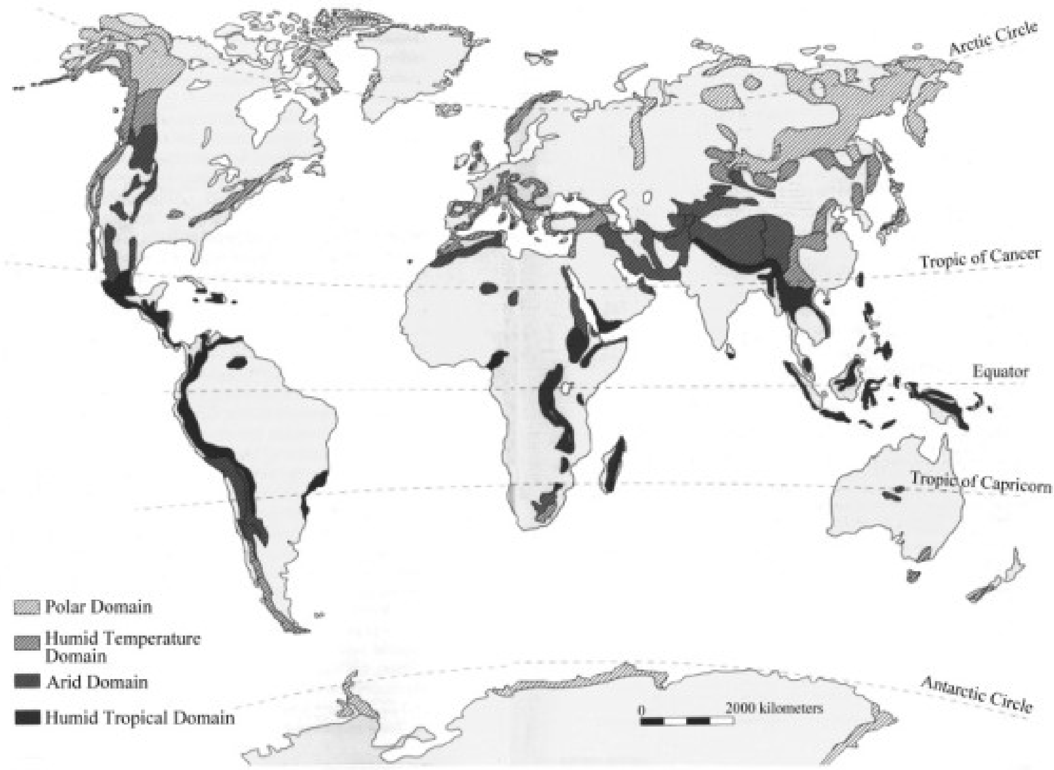

Figure 1. Mountain domains and ecoregions of Earth
(Adapted from Denniston D. (1995). *High Priorities: Conserving Mountain Ecosystems and Cultures*, 80 pp. Washington, DC: Worldwatch Institute.)

Numerous combinations of altitude and latitudes, differences in georelief, and diversity of physical–chemical factors are amplified by a diversity of plant and animal species and multiple ecosystems; this variety requires identification of corresponding mapping units in fine-scale ecological surveying. With the risk of oversimplification, the variety of Earth’s mountains can be classified within four mountain domains—humid tropical domain, humid temperate domain, arid domain, and polar domain—which are further divided into 15 coarse-scale mountain ecoregions(Figure 1). In a global survey of biomes used by UNESCO, mountains are identified as mixed mountain and highland systems with complex zonation. The principal division of the geobiosphere applied by many geographers and ecologists identifies all highlands as "orobiomes" situated within the matrix of nine worldwide zonobiomes.

2. Physical Environment

2.1. Rocks and Landforms

In a simplified view, highlands are a product of endogenic and exogenic geological processes causing the uplift and denudation of Earth’s surface. Current observations confirm that beside the incessant erosion, in many mountains a considerable rate of uplift also takes place. Effects of the powerful physical force of gravity are maintained or enhanced in numerous slope processes and remain active in sculpting the georelief. Physical and chemical features of rocks and their weathering affect the geochemical cycling, water regime, and flow of incident solar radiation, and thus act as the primary control of all biotic events and ecosystem functioning.

The fundamental role played by geological formations and by the chemical characteristics of rock-forming minerals is evident in all mountain ecoregions. A portion of mountains consists of relatively soft rocks of sedimentary origin, such as some sandstones or shale, which weather quickly and produce rounded landforms with a smooth surface and gentle slopes. Other mountains are composed of hard volcanic or metamorphosed rocks, such as granite or gneiss, which disintegrate slowly and create a rugged surface with precipitous hillsides. Ecologically spectacular mountains consist of carbonate rocks (limestone, dolomite) whose heterogeneous layers weather selectively, drain water underground and tend to create rugged relief with contrasting habitats for life.

The texture and mineral composition of the outcropping rocks affect the landforms and soil-forming processes, which ultimately influence the establishment of particular plant and animal populations and the succession of entire ecosystems. A distinction between silica-rich rocks and carbonate rocks is an elementary step in the geoecological classification of mountains. Primitive soils lacking any layering, such as lithosols, and many soil types with distinct pedogenetic layering are identified in all mountain ecoregions. According to recent soil taxonomy they include numerous types of entisols, inceptisols, spodosols, alfisols, ultisols, and even histosols.

The age and duration of the mountain-building process are clearly reflected in the physiognomy of mountain systems. Ancient Paleozoic ranges, such as the Appalachian Mountains in North America or the Hercynian Mountains in Europe, display soil-mantled slopes and grassy flat summits which are partly remainders of the early Tertiary plains, beside precipitous landforms sculpted by nivation and glacial erosion in the posterior glacial ages. Young ranges lifted in the Tertiary, such as the Alps or Himalayas, show prevailingly intensely cut relief and contain a mosaic of outcropping rocks, lichen deserts, scree, and moraines. Even in the humid tropical domain, glacigenic and cryogenic processes are continually active in sculpturing steep flanks of the troughs, maintenance of precipitous rock faces in corries, and accumulation of scree and moraines in valleys.

In the middle and high latitudes, where south- and north-facing slopes receive contrasting doses of solar radiation, the slope inclination and its orientation towards cardinal points are decisive topographic factors in the development of ecosystems with different requirements for temperature and moisture. North- and south-facing slopes may harbor ecosystems with contrasting affinity to either boreal or mediterranean landscape, respectively. In narrow valleys and deep gorges, the horizon screening may cause an extreme deficit in light and heat supply and thus create the conditions for an extremely cold-adapted ecosystem. **See *Glacial and Periglacial Processes***.

2.2. Mass Movements

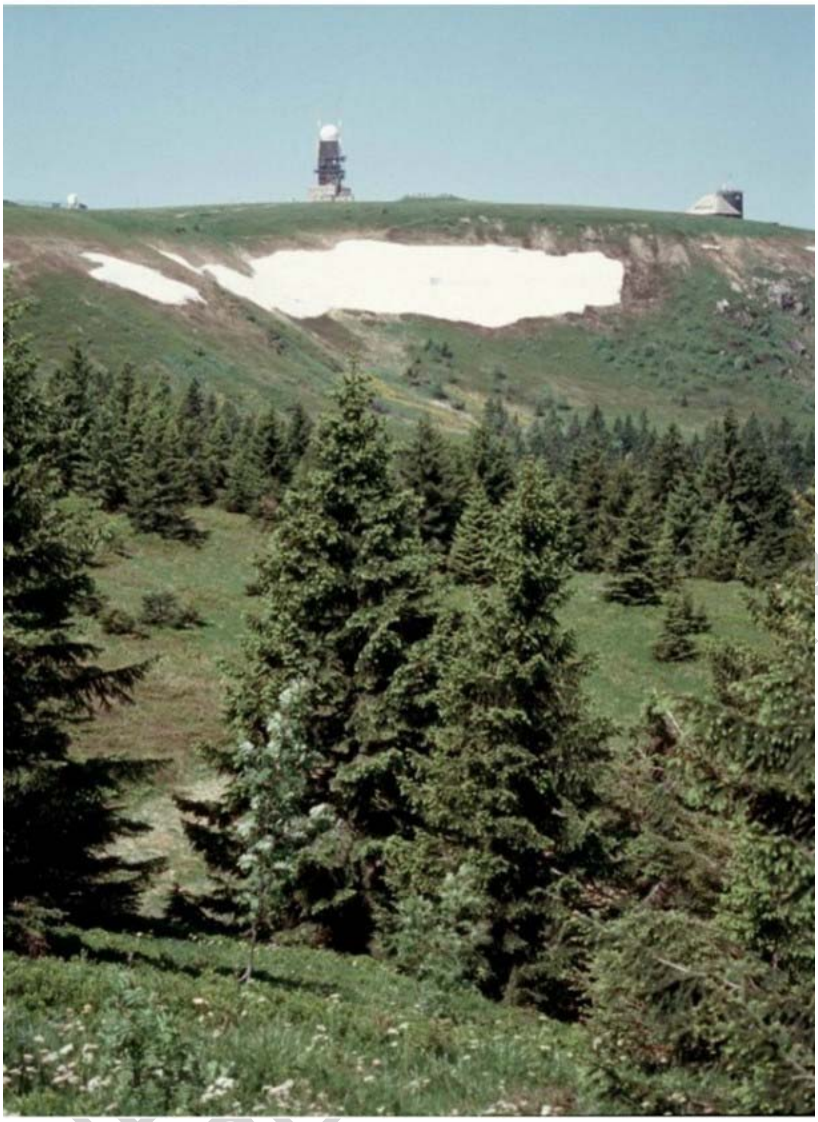

Figure 2. Isolated summit of Feldberg, Black Forest, Germany, showing a stabilized pattern of subalpine ecosystems affected by conservative distribution of snow and avalanche activity

The omnipresent gravitational force, stimulated by various degrees of moisture, causes the fall, slide, and creep of rocks, soil, and snow. These violent mass movements markedly change the relief, disturb current ecosystems, and create new opportunities for diverse life on hillsides and in valley bottoms. Rockfall and rock slide, debris flow, mudflow, solifluction, and gelifluction are widespread, but snow avalanches are a particularly frequent factor in summit areas of the humid temperate domain. Unless generated by human carelessness, avalanches fall either repeatedly on predictable avalanche paths, or unexpectedly on incidental sites after exceptional climatic events. Their failure occurs by two modes: (a) loose-snow avalanches begin near the snow surface after a small amount of cohesionless snow slips out of place and sets into motion an increasing amount of snow, and (b) slab avalanches start with brittle fracturing of cohesive snow that frees blocks which propagate quickly and move down the avalanche track. The disturbing effects of the avalanche depend on the frequency and depth of the moving snow mass. Emergent trees and closed-canopy forests seldom resist such a violent force, and allow the development of shrubby and herbaceous ecosystems with numerous arctic–alpine species. In European mountains, frequented avalanche paths reaching far below the treeline contain relict plant and animal populations associated with the periglacial tundra (Figures 2 and 3). **See *Avalanche***.

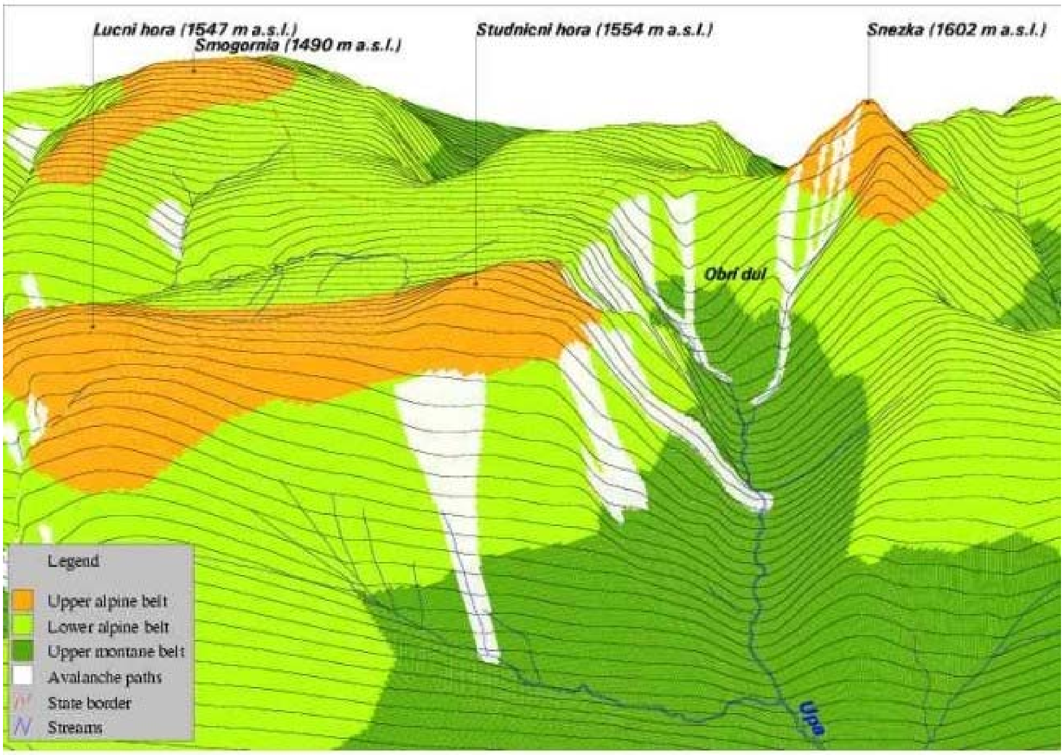

Figure 3. Cross-section of altitudinal belts and stabilized avalanche paths affected by prevailing western winds in the High Sudetes, Czechia. The avalanche paths serve as Postglacial refugia of relict and disjunct populations of plants and animals. (Three dimensional model compiled by J. Štursa and Z. Fajfr)

In all mountain domains, soil erosion and other sorts of hillslope hydrology influence the status of fragile mountain ecosystems. On bare and steep slopes poorly covered by vegetation, both rainsplash erosion and wash processes are effective in geochemical flows of the ecosystems. Along the streams, fluvial processes participate in the transport and deposition of solid and dissolved particles. Runoff varies according to amounts of precipitation, losses through evaporation and transpiration, changes of soil moisture and storage of ground water. In montane forests, the principle difference between wooded and clear-cut patches was demonstrated by means of long-term observations and experiments, such as the Hubbard Brook Project in the White Mountains, USA. Dramatic fluctuation of the stream discharge and floods seasonally or occasionally disturb the ecosystem (and human habitations) in the valleys, including in some parts of the arid domain.

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Biographical Sketch

Jan Jeník was born on January 6, 1929, is married, and has one daughter. He passed undergraduate studies at Czech University of Technology, Prague, 1948–1952, and postgraduate studies at Charles University, Prague, 1952–1956. He was employed mostly as teacher at Charles University, and—after political persecution—as research officer at Czechoslovak Academy of Sciences (1971–1990). He has been a Full Professor in botany since 1990, Emeritus Professor since 1995, and was formerly a Visiting Professor in Afghanistan, Ghana, Tanzania, and Austria. He is an author, co-author, and editor of textbooks in botany and ecology for universities and secondary schools. Presently, he is a Senior Researcher at the Academy of Sciences of the Czech Republic. His major scientific studies were performed in forest, alpine, tropical, and wetland ecosystems. He has been a participant and leader of scientific expeditions in tropical regions (West Africa, East Africa, South America, Cuba, India) and his results have been published in journals and books (about 400 titles in eight languages and 12 countries) and by numerous presentations at conferences (Czechia, USA, Germany, France, Spain, Poland, Great Britain, etc.). For several periods, he was member/vice-Chairman of the UNESCO´s MAB International Coordination Council and a member of the IUCN´s WCPA. He has been president of the Academy Appraisal Commision (Academy of Sciences, Czech Republic), an Honorary Member of the Botanical Society of Scotland, and of the Czech Botanical Society. In 1993, he was awarded the UNESCO Sultan Qaboos Price.