THE WORLD'S LANDSCAPES SYSTEM AND ITS CHANGE*

With 4 figures (as supplements II and III) and 5 tables

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Zusammenfassung: Das Landschaftssystem der Erde und seine Veränderung

Die Karte der Landschaftsgürtel und der zonalen Landschaftsgliederung der Erde (LUKASHOVA 1988) wurde von den Autoren als Grundlage für die Ausweisung der wichtigsten landschaftlichen Strukturelemente der Erde verwendet. Das Landschaftssystem der Erde wird demnach von 13 Landschaftsgürteln, 37 Landschaftszonen, 96 zonalen Landschaftstypen und 61 vertikalen Spektren gebildet. Es dokumentiert den Entwicklungsstand kurz vor dem Einsetzen von massiven anthropogenen Einflüssen. Unter Verwendung dieser Karte wurde ein Modell der planetarischen Zonalität entworfen und zwar als Idealkontinent mit der Ausdehnung der Landfläche, den Grenzen der Landschaftsgürtel und der Lokalisierung der zonalen Landschaftstypen. Dieses Modell eignet sich sehr gut für die Darstellung globaler Umweltveränderungen. Ein Vergleich mit der gegenwärtigen Situation zeigt, daß sich alle größeren globalen Umweltprobleme, die mit landschaftlichen Veränderungen verbunden sind, darstellen und für den Idealkontinent auch quantifizieren lassen. Von den 96 Landschaftstypen der Welt sind etwa 40 durch anthropogene Einflüsse verändert oder ganz verschwunden. Mit Hilfe des Idealkontinents kann weiterhin gezeigt werden, daß die bedeutendsten anthropogen bedingten Veränderungen dort auftreten, wo die natürliche Diversität der Landschaften am größten ist.

Summary: A 1:15,000,000 map of 'Geographic Belts and Zonal Types of the Landscapes in the World' (LUKASHOVA 1988) was used by the authors to look into the principal features of the world landscape structure. The world landscapes system contains 13 geographic belts, 37 landscape zones, 96 zonal types of landscapes and 61 altitudinal spectra. It represents the time in the Earth's evolution just before the beginning of massive anthropogenic pressure. On the basis of the map, a planetary model of the geographical zonality was built as a generalised continent representing the distribution of land, the boundaries of the geographic belts and the position and areas of the zonal types of landscapes. This model is a useful reference point to observe and assess the global environmental change. A comparison with the present-day situation has demonstrated that all major global change problems associated with the landscape issues can be clearly seen and measured, using the generalised continent as a tool. Out of 96 zonal types of landscapes in the world, about 40 are modified or disappeared due to the anthropogenic pressure. It is also seen on the generalised continent that the major man-made changes are where the natural diversity of landscapes is the highest.

A series of maps for university education

New original maps of the world of a large size are not made available frequently. Perhaps, the largest collection of special maps ever produced has been made over the last 20 or so years at the Faculty of Geography, Moscow State University, Russia. A large and long-term project was designed and implemented with the objective to produce a set of wall-chart maps for university education. Eight world maps have been produced by 1988: namely the maps of Relief, Soils, Climatic Belts and Zones, Orographic, Recent Tectonics, Geographical Belts and Zonal Types of Landscapes, Present-Day Landscapes, and Land Use. The scale and projection was made uniform: 1:15,000,000 in a polyconic projection, specially developed in the USSR for the wall-chart world maps. About 30 special maps of the USSR and, later, Russia have also been produced, mostly of the scale of 1:4,000,000. The text of the legend and the geographic names on almost all of the maps are in Russian. Perhaps, it is one of the reasons why this series of maps, although it is of a fundamental geographic value, was never properly presented to the world community.

The map of 'Geographical Belts and Zonal Types of the Landscapes in the World': the main technical features

One map in the series is 'Geographical Belts and Zonal Types of the Landscapes in the World' (LUKASHOVA 1988). This major piece of the geographic and cartographic science was not documented, reviewed or analysed neither in the Russian, nor in the Western literature. Though more than 10 years passed

* Dedicated to CARL TROLL on the occasion of his 100th birthday

since the publication of the map, and the institutional memory of it is getting more and more weak, one can consider the map still as an up-to-date product. The objective of this paper is to review and discuss the main features of the landscapes structure of the world using both the map itself and the generalised continent built on the basis of that same map.

The map of 'Geographical Belts and Zonal Types of the Landscapes in the World' has been compiled at the Department of World Physical Geography and Geo-ecology, Faculty of Geography, Moscow State University. The Scientific Editor is E. N. LUKASHOVA. The authors are 13 experts in geography of different large regions of the Earth or the continents. In their work on the map, the members of the group have been following the legend and the methodology that had been developed and agreed upon prior to the compilation of the map. A cartographic and written information on the different components of Physical Geography (Climatology, Vegetation, Geomorphology, Pedology, etc.) has been collected and served as the source of basic knowledge. Satellite images have been used to fill information gaps and to evaluate data reliability. Each expert compiled a section of the map for his own region, based on his own knowledge of it, including the knowledge in the field. The next step was to align the contours emerging from the neighbouring sections developed by the different authors. Eventually, a map reflecting the collective knowledge of landscape distribution in the world has been built up. It was done by a traditional "hand-drawing" method. Later on, the map was digitized.

The projection used for the preparation of the map is known in Russia as the 1954 TsNIIGAiK polyconic projection. It was designed for wall-chart maps by the USSR Central Research Institute for Geodesy, Remote Sensing and Cartography (TsNIIGAiK). A full mathematical description of the projection can be found in GINSBURG and SALMANOVA (1957; also see KHALUGIN 1988).

The basic characteristics of this projection are as follows:

- The middle meridian (5°E) is not shown;
- The zero meridian is visually perceived as a straight line;
- The map grid is symmetric around the equator and the middle meridian;
- Angular distortions (ω) do not exceed 30° for most of the land areas (excluding the repeated parts of the continents in the corners of the map);
- The area scale (ρ) predominantly varies from 0.83 (in the centre) to 1.5 (around 60° N and S). For the polar regions ρ equals or exceeds 3.0.

Table 1: Areas of the geographical belts
Fläche der Landschaftsgürtel

Geographical belt	Area, million sq. Km	Area, %
Equatorial	6.4	4.3
Northern Sub-equatorial	10.3	6.9
Southern Sub-equatorial	9.3	6.3
Northern Tropical	20.9	14.1
Southern Tropical	8.2	5.5
Northern Sub-tropicall	6.1	10.8
Southern Sub-tropical	5.5	3.7
Northern Temperate	36.8	24.7
Southern Temperate	2.0	1.3
Subarctic	13.5	9.0
Subantarctic	0.0	0.0
Arctic	6.0	4.0
Antarctic	14.0	9.4
Total	139.0	100.0

Since the map is a major cartographic source of knowledge about the world, it deemed us necessary to make a few basic measurements. The goal was set to measure the areas of the main units of the Earth's land, such as the areas of the geographical belts and zones, major biomes, mountains and plains. Due regard to the projection's distortions was paid by means of a special software developed at the Department of Cartography, Moscow State University.

The concept of the map 'Geographical Belts and Zonal Types of the Landscapes of the World' is based on the global hierarchy of geographic units representing several taxonomic levels of the landscape differentiation. The highest taxonomic level is a *geographical belt* (RYABCHIKOV 1988). Each belt is determined by the prevailing planetary air mass. It may predominantly stay there over the whole of a year or over the warmer half of the year. A prevalence of the Tropical air mass over certain territory during a year puts it as a Tropical Belt, while the prevalence of a Tropical air mass in summer and Temperate air mass in winter gives the territory the name of Subtropical. In the first case, the names of the belts are Equatorial, North and South Tropical, North and South Temperate, Arctic and Antarctic. In the second case, the names of the belts are North and South Subequatorial, North and South Subtropical, Subarctic and Subantarctic. In total, there are 13 geographical belts (Table 1).

Macro-climatically, each belt is relatively homogenous and is characterised by certain specific features of the hydrometeorological regime, which is the determining factor for a number of other phenomena in the belt, such as vegetation, biogeochemical processes, genetic types of soils, distinctive values of the biomass

Table 2: Legend for the Temperate Belt

Legende für den "Temperate Belt"

Sectors Zone or subzone	Maritime	Transitional	Continental	Extra-continental	Altitudinal spectra of mountainous landscapes
Maritime meadows	12				6
Open woodlands	13				7
Taiga	14	15	16	17	8
					9
					10
					11
Mixed forests	18	21	22		12
	19				13
	20				14
Broadleaved forests	23	24			15
		25			16
Forest-steppes		26	29	30	17
		27			18
		28			19
Steppes		31	34	37	20
		32	35		21
		33	36		22
Semideserts			38	40	23
			39		24
			41		25
Deserts			42	43	26
				44	

and the primary biological productivity, etc. Each belt is characterised, therefore, by a suite of natural processes which gives a reason to attach to the belt's name the adjective "geographical" rather than "climatic".

Almost half (49.6%) of the world land mass is concentrated in the Northern Hemisphere in the Tropical, Sub-tropical and Temperate Belts. Also, from another point of view, more than half (51.6%) of the land is situated in the Equatorial, Sub-equatorial, Tropical and Sub-tropical Belts. It is apparent that the former figure is linked to the distribution of land and sea on the world surface, while the latter is formed mainly due to the sphere-like shape of the Earth. This latter conclusion stresses, from the morphometric point of view, the decisive weight of the tropical areas in many world phenomena.

Within the belts, the main factor of the landscape differentiation is the continentality of climate, that is the position of landscapes in relation to the fluxes of atmospheric moisture. It places a territory into the respective sectors. In the Temperate Belt there are the Maritime, Transitional, Continental or Extracontinental Sectors (Tab. 2). The sectors are not explicitly reflected on the map, but are rather clearly seen through the sets of landscapes of a different degree of continentality.

The other major units of the terrestrial ecosystems' differentiation are the *geographical (natural landscapes) zones*. While the sectors reflect the degree of continentality of the territory in question, the zones represent the areas, characterised by a ratio between the heat and water balances and reflected in the major types of vegetation. For instance, in the Tropical Belt there are the zones of deserts, semideserts, steppes, open forest-bush-savannah, and forests. The most optimal one from the point of view of water availability is a transitional area between the forest and savannah zones. The zones are distinguished first of all by the predominant type of vegetation. For instance, out of 37 zones depicted on the map, there are the zone of coniferous boreal forests (taiga), the zone of steppes, the zone of evergreen rain forests, etc. Specific values of the radiation balance, the co-relation between the energy and water balances, specific types of soils, predominant impacts of exogenous geomorphic processes, etc., are attributed to the zones.

The geographic zones consist of *the zonal types of landscapes*. The latter are the typical, territorially repeated

Table 3: Numbers of the taxonomic units as shown on the map of Geographical Belts (the North and South combined) and Zonal Types of the Landscape in the World

Anzahl taxonomischer Einheiten in der Karte der Landschaftsgürtel und zonalen Landschaftstypen der Erde

Belt	Zone	Sector	Zonal types of landscapes	Altidudinal spectra of landscapes
Polar	2	1	3	1
Subpolar	2	4	8	4
Temperate	10	4	33	21
Sub-tropical	11	5	26	18
Tropical	6	4	12	10
Sub-equatorial	4	2	11	6
Equatorial	2	2	3	1
Total	37	–	96	61

landscapes within a geographic (landscape) zone. In the legend, they are put in a matrix, where the X-axis is the sector of continentality, while the Y-axis indicates the zone of the optimal availability of water (Tab. 2). The main indicators on the map at the level of the zonal type of landscape are vegetation and soil types.

Table 2 gives an example of the legend for the largest and the most complicated Temperate Belts (the Northern and Southern combined). The numbers inside the matrix represent the zonal types of landscapes depicted on the map. Their names are given in Appendix I. An absolute majority of the landscapes in the world are of the zonal character from the point of view of such geographical components such as vegetation, climate, water regime, exogenous geomorphic processes, specific features of the biogeochemical cycles, specific types of soils, etc. In total, 96 zonal types of landscapes have been singled out on the plain territories in the world and represented on the map in question. The list of the zonal types of landscapes is provided in Appendix I.

The map 'Geographical Belts and Zonal Types of the Landscapes in the World' explicitly shows two taxonomic levels of the terrestrial landscape differentiation: the *belts* and the *zonal types of the landscapes*, and implicitly through the legend, the other two: the *sectors and the zones*. Each zonal type of landscape is put in relation to the sector (representing thermal factors) and the zone (representing hydric factors). On plains, the zonal types of landscapes are of the lowest hierarchical level and they predetermine the whole aspect of the map.

Mountains bring in much more complicated landscape pictures as compared with plains. The map of 'Geographical Belts and Zonal Types of the Landscapes in the World' shows in addition, for mountainous areas, typical *altitudinal spectra of landscape*. They are briefly listed in Appendix II. To a large extent, their type depends on the location of the mountain system within the geographical belt, sector and zone. In total, 61 altitudinal spectra are depicted. However, in cases of plateaus, such as Tibet, where the vertical zonality is not clearly seen due to the relatively small amplitudes of the relief, the map does not show those territories as mountains. It has created some methodological difficulties in the process of analysing the map.

In total, the map distinguishes 96 zonal types of landscapes and 61 types of altitudinal spectra, with the following distribution in the world as defined in Table 3.

The next two levels in the classification and mapping of landscapes are called *classes* and *subclasses*. They are defined through their physiography and relief. Two major classes of landscapes are distinguished: plains and mountains. The basic characteristics for the division into classes are the first-order morphostructures (elements of the megarelief). The subclasses are distinguished through more detailed characteristics of the relief: 1 – lowlands, 2 – elevated plains, 3 – high plains, 4 – low mountains, 5 – medium mountains, 6 – high mountains, 7 – plateaus. They are shown on the map by different shading.

Obviously, the landscape's subclass is of the lowest level for the global mapping of the natural landscape units. The map 'Geographic Belts and Zonal Types of Landscapes in the World' explicitly represents, therefore, a four-level system for mountainous regions: geographical belt – zonal type of landscape – class – subclass and a two-level system for the plains: geographical belt – zonal type of landscapes.

Besides, few landscapes are shown as intrazonal ones. They are marshes, solonchaks, mangrove coasts, halophyte and psammophyte coastal systems, large river valleys, and mountain glaciers. Among azonal areas are such areas as sands, hammadas, loess, lava covers, limestone, coral reefs, and shelf glaciers.

For technical reasons, it is not possible to print a wall-chart map of the world in a journal of usual size. As an illustration, a section of the map covering the main part of Southern and Central Asia is given in Figure 1 (Suppl. II). On the map, one can see the taxonomic levels of the landscapes differentiation mentioned in this text, as well as many other details. The list of the belts, zones and zonal types of landscapes is also given in Appendix I, and the list of the altitudinal spectra in Appendix II. Unfortunately, the legend as a whole is also too large to be represented here, and only an example for the Temperate Belt is represented in Table 2.

The map of 'Geographical Belts and Zonal Types of the Landscapes in the World': some measurements and discussion

Measurements of the main units of the Earth's land have been made, and the results are represented in Tables 1, 3–5. The largest zonal types of landscapes are: taiga (10.6 million sq. km), polar deserts (6.7 million sq. km), equatorial moist forests (6.6 million sq. km) and tropical deserts (4.0 million sq. km). Two observations can be made based on these figures:

– It is possible that the homogenous, even monotonous, and sparsely populated landscapes are just less studied and less understood in terms of their further subdivision. Major types of vegetation serve on the map as the main indicator for the zonal types of landscapes. But in case of the polar and tropical deserts the vegetation types cannot be used as the main indicator. As well as the largest zonal types of landscapes associated with the boreal (taiga) and the equatorial moist forests (hylaea) can, perhaps, be subdivided, but on the basis of some other indicators. To find out in more detail the spatial differentiation of the homogeneous landscapes, one may need techniques of higher resolution related to climatic and ecologic criteria. Then, perhaps, more landscapes at the same hierarchical rank, as in other areas of the world, would be found. In other words, in our global map the incomplete knowledge of seemingly very well studied subjects was unconsciously reflected.

– The largest types of landscapes in the world are sparsely populated, if at all. Clearly, the conditions of human life in those four zones seem to be the most difficult in the world.

One can see that the highest landscape diversity is characteristic of the temperate and sub-tropical belts. The zonal types of landscapes are more fully represented in the Northern Hemisphere where the land area is larger. For instance, in the Southern Temperate Belt there are three zones and five zonal types of landscapes, while in the northern Hemisphere the corresponding numbers are nine and thirty-three respectively. The global distribution of the major biomes and the number of the zonal types of landscapes in each biome is shown in Table 4. Forests, open woods and bush cover 56% of the world's territory, while treeless areas are 44% of the land. The landscape diversity is the highest in the forest and wood biomes, as well as in grasslands. By definition applied to the map in question, mountains are the areas with distinct vertical zones. On the basis of this definition, the mountains occupy about 22% of the total land area, and the plains, 78%.

Table 4: Data on the main biomes of the world

Angaben zu den wichtigsten Biomen der Erde

Biome	Area, %	The number of zonal types of landscapes
Forests and woods	36	47
Deserts and semideserts	35	11
Open woods and bush	20	18
Grasslands	9	20
Total	100	96

The map of 'Geographic Belts and Zonal Types of the Landscapes in the World' is a solid product of the collective knowledge of the Earth. It is mostly based, in a qualitative way, on analyses of climate and vegetation. The map relates to the recent past when the anthropogenic influence on landscapes was not yet noticeable at the global level, and the climate was already more or less comparable to the present one, to such an extent that the vegetation types could not change due to the difference in climate between the present time and the time for which the map was designed. One can say that the map demonstrates the distribution of landscapes yet untouched by man, or so-called potential landscapes. What situation or a moment in time does it represent? It is not a trivial question. The map reflects the geographic zones and the zonal types of landscapes in the period of time after the last major changes of their position due to the natural factors. In other words, it reflects the situation after such events as recolonisation by vegetation of the formerly ice-covered land in north-western Europe and North America, as well as the end of the relatively wet Atlantic period in northern Africa. Therefore, it is not a moment in time, but rather a period which could be associated approximately with mid-Holocene.

It means that the map represents the situation as it was before the massive man-made pressure on landscapes has started. One can state, therefore, that the map in question might serve as a reference point for the assessment of the current global change.

The generalised continent

The next objective in the map's analyses was to build a version of the generalised continent which is a model of the most general laws in the world-wide distribution of various geographic phenomena. The models of the generalised continent are used to analyse the distribution of the geographically determined, world-wide features, such as the types of climate, vegetation or landscapes. Such an approach was introduced both by the German and Russian schools of geography. Apparently, the first generalised continent describing the climate types was proposed in 1910 by the German and Russian geographer and climatologist VLADIMIR PETROVICH KOEPPEN (1923). Later, there was another model of the generalised continent built in Germany by TROLL (1948; also see: SCHMIDT 1969, 378; WALTER 1962, 48). In the Russian literature the latest ones were made by RYABCHIKOV (1988) and by ISACHENKO and SHLYAPNIKOV (1989).

The above mentioned approaches suggest that all the land of the world is assembled into one relatively flat continent surrounded by the World Ocean. The configuration of it corresponds to the global distribution of land by latitude and the insides of the continent represent a generalised landscape structure. This model would then represent in the Northern Hemisphere the average of North America, Eurasia and North Africa, while in the Southern Hemisphere it is somehow an average of South America, South Africa and Australia. This combination is called a generalised continent.

To outline the generalised continent, the terrestrial parts of the world were approximated by trapezia of 10° by latitude and longitude. The projection's distortions were taken into account and made constant for each trapezium. The areas of the zonal types of landscapes, the zones, biomes, geographical belts, etc., were calculated for each trapezium at the Department of Cartography, Moscow State University. Then the boundaries of the zonal types of landscapes were drawn considering their geometric features combining automatic and manual procedures.

This global model of landscape distribution is a reasonable representation of the most general geographic features of the world. The resulting generalised continent is presented in Figure 2 (Suppl. III). In the process of design the main methodological difficulty was linked to the treatment of mountains, including the high plateaux. Every attempt has been made to draw the potential zonal types of landscapes as they should had been if the mountains on that same place would not have existed. The distribution of mountains by the geographical belts is shown in Table 5.

Table 5: Distribution of mountains by the geographical belts of the world (The Northern and the Southern Belts are combined)

Anteil der Gebirge in den Landschaftsgürteln der Erde

Geographic belt	Total area, %	Area of mountains, %
Equatorial	4.3	8.9
Sub-equatorial	13.2	12.9
Tropical	19.6	28.3
Sub-tropical	14.5	33.1
Temperate	26.0	26.4
Subpolar	9.0	27.8
Polar	13.4	3.0
Total	100.0	22.2

The average distribution of mountains in the world on the generalised continent is represented in Figure 3 (Suppl. III). The measurements of areas of the mountain landscapes have been made, and the data are taken into account and included into the tables demonstrated above. The average distribution of mountains in the world, as presented in Figure 3 (Suppl. III), clearly shows the existence of one latitudinal mountain system and two meridional ones. Perhaps, they can be called supersystems as they reflect the most general features of the Earth's relief.

Among the zones and zonal types of landscapes, area with sub-tropical and temperate moist evergreen forests, or hemihylaea[1] is characterized by the highest percentage of mountains (79% of the total area of the zone), while within the zone of equatorial moist evergreen forest, or hylaea[2], only 3% of its area could be considered as mountainous, as well as within the zones of polar and tropical deserts where mountains occupy 3% and 7% respectively. The hemihylaeas are formed in place of hylaeas where mountains "distort" the picture of a lowland rain equatorial forest, that is where the air temperatures are somewhat lower than those near the sea level.

The problem related to mountains had also brought a problem of a methodological impossibility to use an algorithm describing the distribution of the zonal types of landscapes. Instead, one had to combine a mathe-

[1] Hemihylaea is a rain forest situated in sub-equatorial and temperate belts.

[2] Hylaea is an Equatorial rain forest. It seems that the term was introduced by A. v. Humboldt.

matical approach in measuring the areas with the geographic knowledge and intuition when putting the contours of the zonal types of landscapes on the hypothetical continent and analysing it. Intrazonal elements such as large river valleys and mangrove coasts were also a problem but these two types of landscapes occupy relatively small areas.

The distribution of the contours of zonal types of landscapes on the generalised continent represents the potential situation as it was before the massive human influence began. Therefore if we would compare the contours on the generalised continent with the contours as they are at the present time, we could assess some fundamental global change patterns. Moreover, the method of assessment would be quite independent from any other methods.

Such research has been made, and the changes on the generalised continent corresponding to the present day situation as compared with the pre-anthropogenic time are shown in Figure 4 (Suppl. III). The black lines delineate the position of geographical belts. The boundaries of geographical zones currently affected by human activity are shown by the red lines. The zonal types of landscapes considerably transformed by man are shaded in red.

The most pronounced features of the global change resulting from the comparison of Figures 2 and 4 (Suppl. III) are as follows:

– The geographic belts have not altered as the Earth's climate did not change so profoundly.

– The affected boundaries of the geographic zones represent in most cases very well known global environmental problems such as the deforestation in the Equatorial, Sub-equatorial, Tropical, Sub-tropical and Temperate Belts and the desertification in the Tropical and the neighbouring belts.

– Quite a number of the potential zonal types of landscapes have been fundamentally transformed or even completely wiped out by man. Out of 96 zonal types of landscapes singled out on the map, about 40 types are modified or have disappeared. It is one more world-wide indicator of the degree of global change!

– In this way, such landscapes as all kinds of forests in both western sectors of the sub-tropical and temperate belts and eastern sector of the predominantly subtropical belt disappeared or are deeply transformed. The continental sectors of the temperate belt containing natural grasslands such as steppes and prairies have been transformed, mostly by agriculture and livestock raising. Savannahs and other tropical open or semi-open landscapes have been transformed as well. The boundaries of the geographical zones shown in red in Figure 4 (Suppl. III) represent the ecotones affected by the human activity such as land use transformation, desertification or change in the state of forests. Hence, those ecotones are not stable.

– The most pronounced anthropogenic changes in landscapes have occurred in the areas where the natural diversity of landscapes was the highest. This conclusion does not seem to be trivial and requires more deliberation.

Concluding, one can say that the generalised continent is considered to be a useful model to look into the global change at the planetary level.

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Appendix I

GEOGRAPHICAL BELTS AND ZONAL TYPES OF LANDSCAPES

POLAR BELTS

Polar Deserts

1. Ice deserts (continental and shelf glaciers)
2. Stony deserts

Arctic Tundras

3. Arctic tundras on permafrost arctic soils

SUBPOLAR BELTS

Tundras

4. Meadow-moss tundras on peat sod soils
5. Dwarf-shrub-moss-grass tundras on tundra, gley and tundra-sod soils
6. Moss-lichen tundras on tundra gley soils and podburs
7. Moss-dwarf-shrub and shrub tundras on peaty podzolized tundra soils and podburs

Forest Tundras and Open Woodlands

8. Meadow-shrub and small-leaved forest tundras and open woodlands on raw-humic sod soils
9. Dark coniferous and shrub forest tundras and open woodlands on gley ferric humic podzols and podburs
10. Dark and light coniferous forest-tundras and open woodlands on ferric humic podzols and podburs
11. Light coniferous forest tundras and open woodlands on ferric humid podzols and podburs

TEMPERATE BELTS (BOREAL SUBBELTS)

Maritime Meadows

12. Shrub-forb-grass meadows on peat sod soils

Open Woodlands

13. Small-leafed tall-grass-meadow open woodlands on sod soils and podburs

Taiga

14. Dark coniferous humid taiga on illuvial humid ferric podzols and podburs
15. Light and dark coniferous moderately humid taiga on illuvial humid ferric podzols (northern taiga), podzols and ferric podzols (medium taiga), sod-podzolic soils and humid ferric podzols (southern taiga)
16. Dark and light coniferous moderately humid taiga on humid ferric podzols and podburs (northern taiga), raw-humid podzols and straw-yellow soils (medium taiga), sod-podzolic soils (southern taiga)
17. Light coniferous taiga on cryomorphic taiga and straw-yellow soils (medium taiga), sod-podzolic soils (southern taiga)

TEMPERATE BELTS (SUBBOREAL SUBBELTS)

Forests

18. Mixed coniferous- deciduous extra humid forests (including hemihylea) on acid brown soils and podzols
19. Mixed broad-leafed-coniferous humid forests on ferric podzols and sod-podzolic soils
20. Mixed coniferous-broad-leafed humid forests on brown soils and sod-podzolic soils
21. Mixed coniferous-broad-leafed moderately humid forests on sod-podzolic soils
22. Mixed coniferous-small-leafed forests on sod-podzolic soils and grey forest soils
23. Broad-leaved humid forests on sod-podzolic soils and typical brown soils
24. Broad-leaved moderately humid forests on sod-podzolic soils, grey forest and acid brown soils
25. Broad-leaved moderately humid woodlands with admixture of coniferous on solonetzic meadow soils

Forest-Steppes

26. Coniferous-small-leafed forest-steppes on podzolized and leached chernozems and acid brown soils
27. Broad-leaved forest-steppes including prairies on meadow-chernozem and chernozem-like soils
28. Broad-leaved forest-steppes on grey forest soils, leached and typical chernozems
29. Coniferous-deciduous forest-steppes on grey forest soils, chernozem-like and chernozemic soils
30. Small-leafed-coniferous forest-steppes on chernozems and dark chestnut soils

Steppes

31. Forb-grass steppes on ordinary and southern chernozems
32. Grass steppes on ordinary and southern chernozems
33. Sod-grass-dwarf-shrub steppes on chestnut soils
34. Forb-grass steppes on meadow-chernozemic and chernozemic soils, often solonetzic
35. Grass steppes on ordinary and southern chernozems, dark chestnut soils including solonetzic
36. Sod-grass-dwarf-shrub steppes on chestnut soils, solonetzic soils and Solent
37. Dwarf semi-shrub-grass steppes on chestnut and light chestnut soils

Semideserts

38. Grass-dwarf-shrub semideserts on light chestnut and brown semidesertic soils, mainly solonetzic
39. Shrub and dwarf-shrub semideserts on light chestnut and brown semidesertic soils
40. Dwarf-shrub and dwarf semi-shrub semideserts on brown semidesertic and grey-brown soils

Semideserts and Deserts

41. Shrub and dwarf-shrub semideserts and deserts on brown semidesertic and grey-brown soils

Deserts
42. Shrub deserts on desert soils
43. Shrub and dwarf semi-shrub deserts on desert soils
44. Almost without vegetation

SUB-TROPICAL BELTS

Forests
45. Mixed evergreen extra humid coniferous-broad-leafed forests (hemihylea) on acid brown soils
46. Mixed semi-evergreen seasonally humid coniferous-broad-leafed forests on cinnamonic and brown soils
47. Mixed humid broad-leafed-coniferous evergreen humid forests on podzolized krasnozems and zheltozems
48. Mixed semi-evergreen seasonally humid coniferous-broad-leafed forests on zheltozems and krasnozems
49. Mixed evergreen humid coniferous-broad-leafed forests on krasnozems and zheltozems
50. Mixed semi-evergreen humid coniferous-broad-leafed forests on krasnozems and zheltozems
51. Deciduous semi-evergreen humid forests on krasnozems and zheltozems
52. Deciduous semi-evergreen humid woodlands on krasnozems and zheltozems
53. Coniferous dry open woodlands on cinnamonic soils
54. Coniferous moderately humid open woodlands on cinnamonic soils

Mediterranean Hardleaf Evergreen Forests, Open Woodlands and Shrubs
55. Mediterranean hardleaf evergreen forests and shrubs on cinnamonic or red-cinnamonic soils
56. Mediterranean hardleaf evergreen open woodlands and shrubs on cinnamonic soils

Semideserts
57. Shrub and dwarf-shrub semideserts on grey-cinnamonic soils
58. Dwarf-shrub semideserts on grey-cinnamonic soils and serozems

Semideserts and Deserts
59. Succulent semideserts and deserts on red-brown and brown semidesertic soils

Deserts
60. Open woodland and shrub deserts on sands and primitive soils
61. Shrub and dwarf semi-shrub (including succulent and ephemer) deserts on red-brown, grey-brown soils and serozems
62. Grass-dwarf-shrub cold deserts on primitive soils

Open Woodlands and Shrubs

63. Seasonally dry (in summer) shrubs on grey-cinnamonic soils
64. Seasonally dry (in winter) shrubs on cinnamonic soils

Steppes
65. Shrub- and dwarf-shrub-grass steppes on grey-cinnamonic soils
66. Cold meadow steppes of inner plateaux on meadow-steppe soils
67. Grass-shrub steppes on grey-cinnamonic soils
68. Meadow steppes on chernozem-like and reddish-black soils

Prairies
69. Seasonally humid prairies on cinnamonic and reddish-black soils
70. Humid prairies on chernozem-like soils

TROPICAL BELTS

Deserts
71. Ephemer-bulbous-succulent deserts with high relative air humidity
72. Deserts almost without vegetation
73. Grass and dwarf-shrub-grass deserts on primitive soils and sands
74. Shrub and dwarf-shrub deserts on primitive soils and sands, including those of cold high plateaux, red-brown and grey-cinnamonic soils

Semideserts
75. Grass-shrub-succulent semideserts with high relative air humidity on red-brown and brown soils
76. Grass-shrub semideserts on reddish-brown soils and semidesert soils of cold high plateaux

Steppes
77. Shrub steppes on meadow-steppe soils of cold high plateaux

Open Woodlands, Shrubs and Savannahs
78. Deserted savannahs and open woodlands on reddish- and red-brown soils
79. Xerophyte open woodlands and shrubs on red-cinnamonic and red-brown soils
80. Evergreen open woodlands and shrubs on red and red-cinnamonic soils

Forests
81. Semi-evergreen seasonally humid forests on red and red-yellow ferrallitic soils
82. Evergreen humid forests on red-yellow ferrallitic soils

SUB-EQUATORIAL BELTS

Forests
83. Evergreen humid forests on red-yellow ferrallitic soils
84. Evergreen moderately humid forests on red-yellow ferrallitic soils
85. Evergreen semi-dry forests and shrubs on red and red-brown soils
86. Semi-evergreen humid forests on red-yellow and red soils
87. Semi-evergreen moderately humid forests on red soils

88. Deciduous moderately humid forests on red soils
89. Deciduous dry forests on red and red-cinnamonic soils

Savannahs and Open Woodlands

90. Humid evergreen open woodlands on red soils
91. Humid tall grass savannahs and open woodlands on red and red-cinnamonic soils
92. Moderately humid open woodlands and low-tree (typical) savannahs on red, red-cinnamonic and red-brown soils
93. Deserted savannahs, open woodlands and shrubs on reddish- and red-brown soils

EQUATORIAL BELT

Evergreen Forests

94. Evergreen rain forests (hylea) on yellow ferrallitic, often gleyed, soils
95. Evergreen rain forests (hylea) on red-yellow ferrallitic soils
96. Evergreen forests with admixture of deciduous species on yellow-red ferrallitic soils with a short relatively dry period

Appendix II

TYPES OF ALTITUDINAL LANDSCAPE SPECTRA (MEDIUM AND HIGH MOUNTAINS)

POLAR BELTS

1. Polar desert

SUBPOLAR BELTS

2. Tundra – polar desert
3. Shrub – polar desert
4. Shrub – tundra
5. Woodland – tundra

TEMPERATE BELTS (BOREAL BELTS)

6. Meadow – tundra
7. Forest-meadow – meadow-tundra
8. Woodland – tundra
9. Humid taiga – tundra
10. Taiga – meadow-tundra
11. Taiga – tundra

TEMPERATE BELTS (SUBBOREAL BELTS)

12. Coniferous forest – tundra
13. Mixed forest – coniferous forest – tundra
14. Mixed forest – coniferous forest – shrub – meadow
15. Mixed forest – coniferous forest – meadow
16. Mixed forest – coniferous forest – alpine meadow
17. Hemihylea (mixed evergreen-deciduous-coniferous forest) – meadow
18. Broad-leaved forest – coniferous forest – alpine meadow
19. Forest steppe – coniferous forest – meadow-tundra or alpine meadow
20. Steppe – coniferous forest – tundra
21. Steppe – coniferous forest – alpine meadow
22. Steppe – mixed forest – meadow
23. Steppe – coniferous forest – alpine meadow or meadow-steppe
24. Semidesert – coniferous forest – alpine meadow or steppe- meadow
25. Semidesert – woodland – xerophyte meadow
26. Semidesert – steppe-desert

SUB-TROPICAL BELTS

27. Evergreen forest – coniferous forest – shrub-meadow
28. Hemihylea – alpine meadow
29. Evergreen forest – mixed forest – meadow
30. Evergreen-deciduous forest – meadow
31. Evergreen-deciduous-coniferous forest – alpine meadow or meadow
32. Mixed forest – coniferous forest – alpine meadow
33. Shrub – broad-leaved forest – meadow or steppe
34. Hard-leafed forest – mixed forest – alpine meadow
35. Hard-leafed forest – mixed forest – coniferous forest – steppe or meadow
36. Hard-leafed forest – shrub – steppe
37. Steppe – mixed forest – alpine meadow or meadow
38. Steppe (semidesert) – coniferous forest – alpine meadow or steppe
39. Woodland – steppe – meadow
40. Shrub – woodland – mountainous xerophyte or steppe
41. Semidesert or desert – shrub – woodland – steppe or meadow
42. Semidesert – steppe – meadow
43. Semidesert – desert – semidesert
44. Desert – semidesert – desert

TROPICAL BELTS

45. Desert – lomas – desert
46. Desert – desert
47. Desert – semidesert
48. Desert or semidesert – woodland – semidesert
49. Steppe – desert or desert – steppe
50. Woodland – steppe or mountainous xerophyte
51. Steppe – mountainous xerophyte – meadow
52. Woodland – mixed evergreen-deciduous forest – coniferous forest – steppe or meadow
53. Mixed evergreen-deciduous forest – coniferous forest – meadow
54. Evergreen forest – mixed evergreen-deciduous forest – coniferous forest – meadow or alpine meadow

SUB-EQUATORIAL BELTS

55. Evergreen forest – paramos
56. Evergreen forest – meadow
57. Mixed forest – meadow
58. Semi-evergreen forest – meadow
59. Savannah – forest – paramos or meadow
60. Woodland – forest – steppe

EQUATORIAL BELT

61. Hylea – paramos

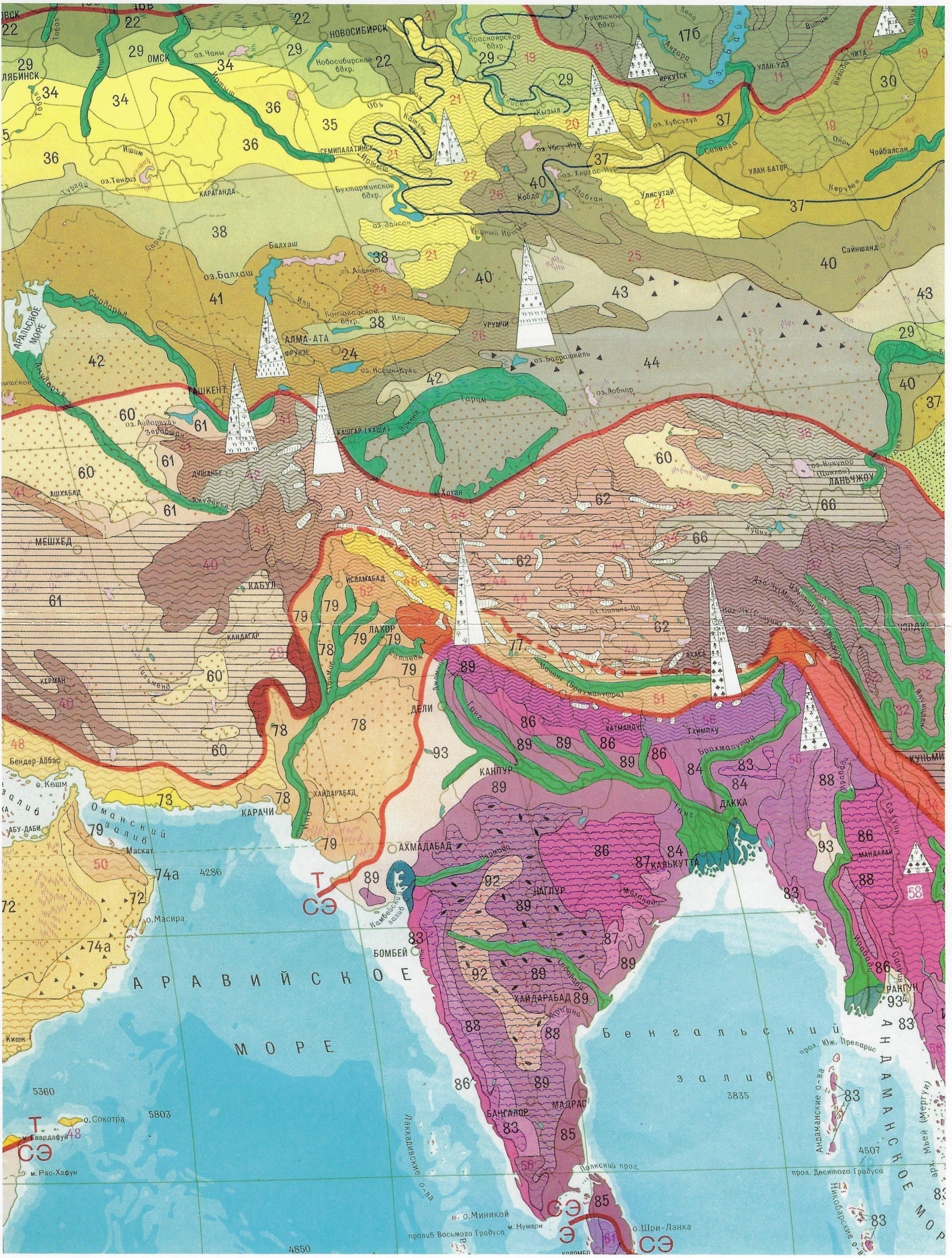

Fig. 1: Section of the map of Geographical Belts and Zonal Types of the Landscapes of the World
Ausschnitt aus der Karte der Geographischen Gürtel und zonalen Landschaftstypen der Erde

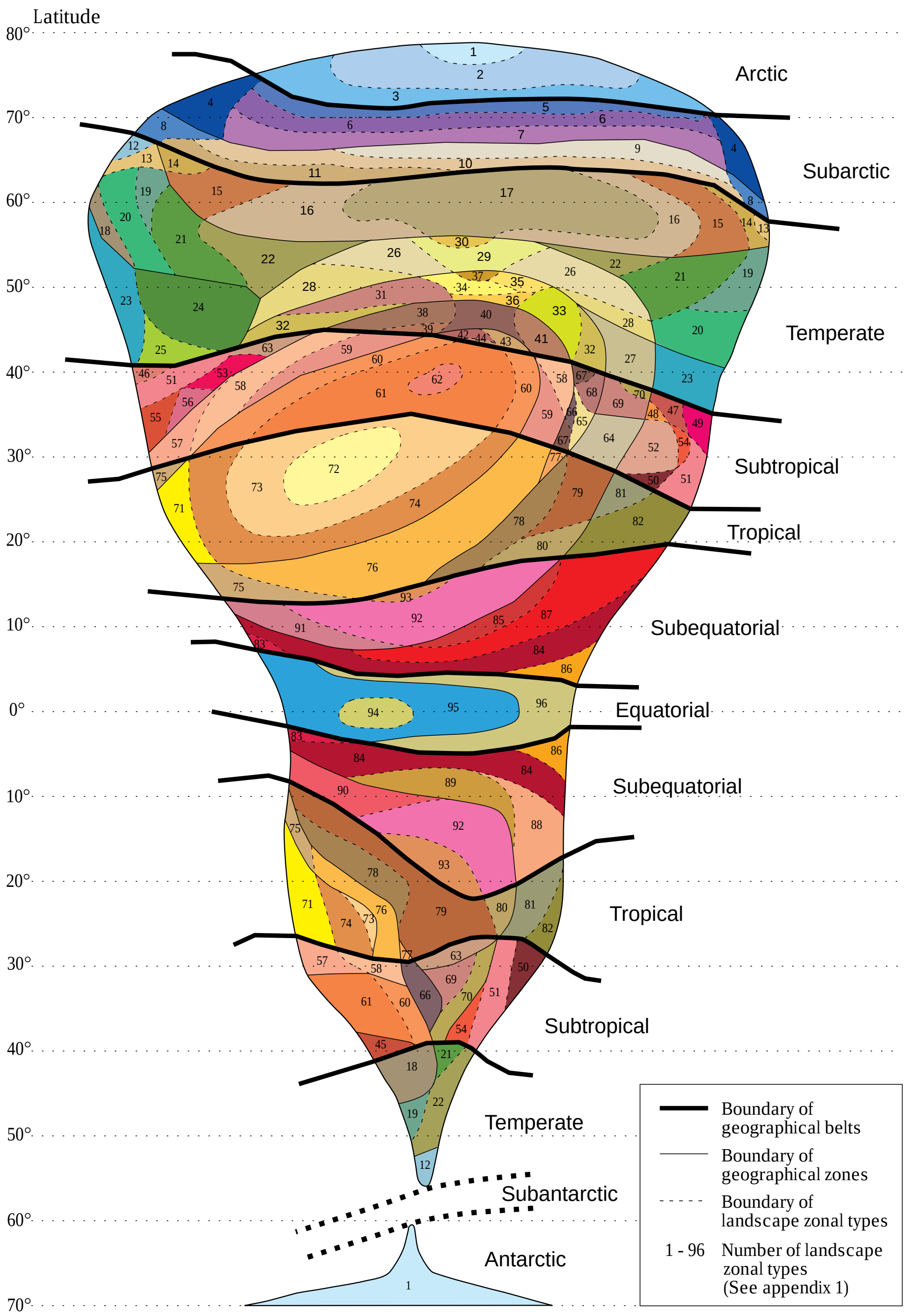

Fig. 2: Geographical belts and the zonal types of landscapes on the hypothetical (ideal) continent
Geographische Gürtel und zonale Landschaftstypen auf dem Idealkontinent

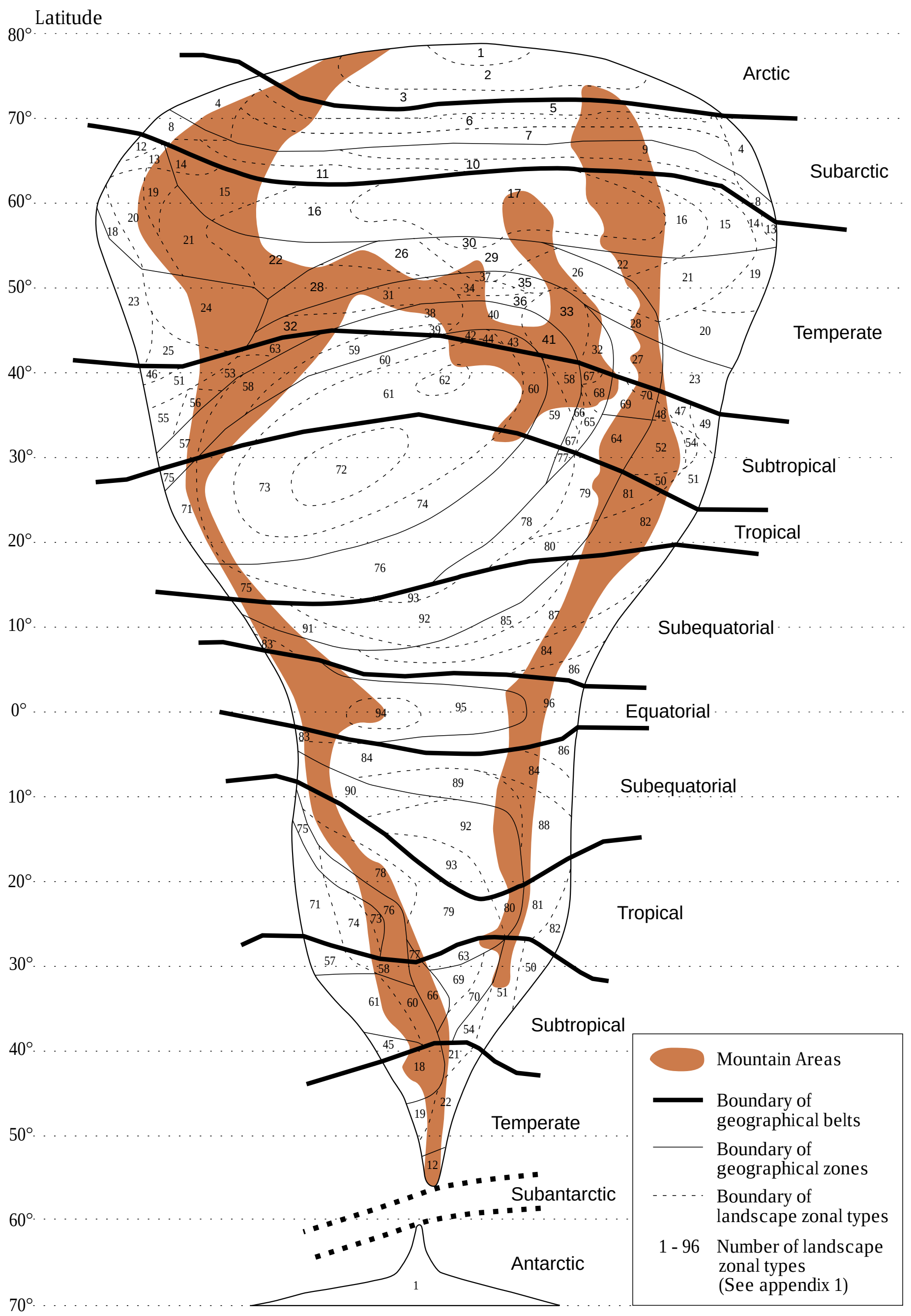

Fig. 3: Spatial distribution of mountains on the hypothetical continent
Räumliche Verteilung der Gebirge auf dem Idealkontinent

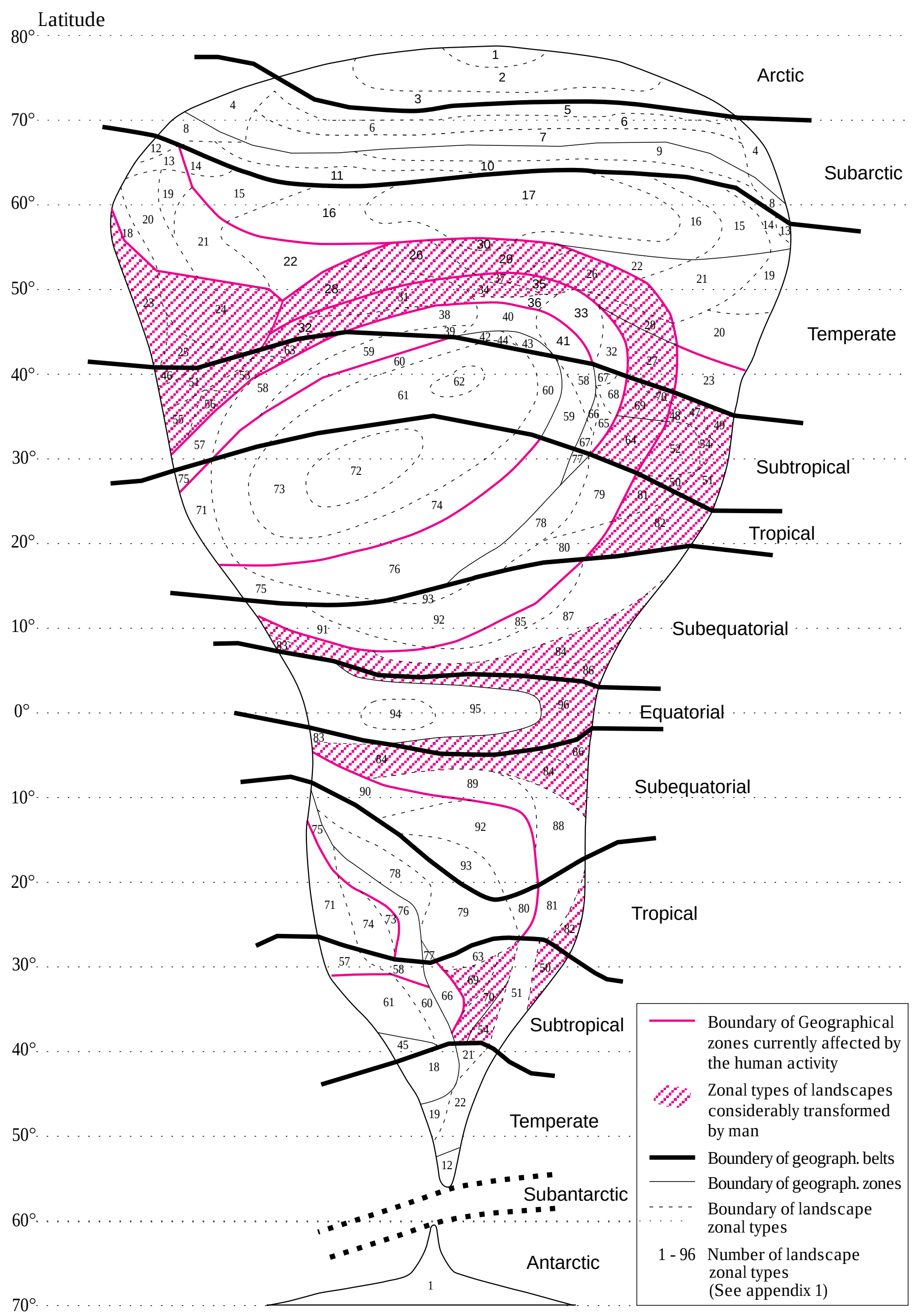

Fig. 4: Global change as seen on the hypothetical continent
Globale Veränderungen dargestellt auf dem Idealkontinent