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Global Environmental Systems—A Spatial Framework for Better Understanding the Changing World

Aleš Hrdina * and Dušan Romportl

Department of Physical Geography and Geoecology, Faculty of Science, Charles University, 12843 Prague, Czech Republic; dusan.romportl@natur.cuni.cz
* Correspondence: ales.hrdina@natur.cuni.cz

Abstract: Purely natural land formations are increasingly rare in today's world, as most areas have been shaped, to varying degrees, by human influence over time. To better understand ongoing changes in the natural environment, we adopted an approach that involves identifying global systems with a significant anthropogenic component. In this study, we developed a new classification of Global Environmental Systems based on over 20 high-resolution datasets, covering abiotic, biotic, and anthropogenic conditions. We created abiotic, biotic, and anthropogenic classifications, each with ten classes. The combinations of these classes result in 169 distinct classes of Global Environmental Systems. This classification provides a suitable spatial framework for monitoring land use dynamics, biodiversity changes, global climate change impacts, and various processes exhibiting complex spatial patterns.

Keywords: global classification; biodiversity hotspots; anthropogenic impact; environmental transformation; Global Environmental Systems

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1. Introduction

The human dominance of ecosystems and natural processes not only deepens the environmental and biodiversity crisis but also worsens the wellbeing of communities and entire societies dependent on natural resources [1]. Addressing these crises must occur within suitable spatial and typological frameworks that enable appropriate measures for regional conditions. Global classifications of biomes considering the level of anthropogenic degradation provide such a suitable spatial typological framework to assess biodiversity status and the degree of threat to it [2]. The quality of the environment and the extent of its degradation by humans are typically assessed by habitat conditions, biodiversity levels, or the provision of ecosystem services. Biodiversity status is then employed as a common measure of the environmental state.

The uneven distribution of biodiversity on Earth is primarily determined by different abiotic conditions [3] and the evolution of biomes, as well as the size, connectivity, and history of specific ecosystems [4]. In recent centuries, human activities have increasingly influenced the distribution of biodiversity, both directly and through various indirect impacts [5,6]. The intensification of anthropogenic pressure in recent decades has led many authors to characterise this period as a new epoch in Earth's evolution—the Anthropocene [7–10]. The Anthropocene is marked by large-scale changes in ecosystems, including their increasing fragmentation [11], threats to biodiversity from biological invasions, and a host of other global challenges. These changes pose significant questions for society on how to effectively address and protect existing biodiversity [6].

Thus, for the effective protection of biodiversity, we require not only knowledge of its spatial distribution but also comprehensive information on the pressures acting upon it and the posing threats [12]. In addition to providing a basic description of the distribution of life conditions on Earth, such as biomes, environmental classification approaches have evolved to incorporate the significant anthropogenic influence [13]. The natural environment has been classified in many different ways in the past. Allee created biome types [14]; Kendeigh later presented different terrestrial and marine biomes [15]; Whittaker presented the classification of biome types [16]; Goodall edited a book on ecosystem types or biomes: terrestrial, underground, and aquatic [17]; Schultz created the classification of eco-zones [18]; Bailey developed a biogeographical classification system of ecoregions [19]; and in 1998, Olson and Dinnerstein came up with biogeographic realms and biomes [20,21]. In recent years, more complex classifications of anthropogenic biomes [6], anthromes [13], land use systems [22], land systems [23], land system archetypes [24], world ecosystems [2] and the IUCN Global Ecosystem Typology [25] have emerged. In this era of a global biodiversity crisis [26], there is a pressing need for a tool to prioritise spatial conservation, which remains the traditional approach for biodiversity conservation.

The aim of this study was to develop a complex classification of Global Environmental Systems (GES) that could be used for a comprehensive assessment of the degree of human influence on the environment in relation to known biodiversity in the context of geographical gradients. This proposal of comprehensive classification more thoroughly captures the wide range of conditions that will be transforming on the Earth in the future—not only in terms of the gradients of natural (especially climatic) factors, but also the intensity and novel spatial differentiation of anthropogenic pressure and the corresponding distribution of biodiversity. This study thus presents a methodological approach for defining Global Environmental Systems, providing their basic characterisation and their use for assessing the urgency of nature and landscape conservation within biodiversity hotspots.

2. Materials and Methods

For the purpose of developing a new global classification and prioritising nature conservation on Earth, we need to classify both the environmental conditions and distribution of biodiversity as well as the degree of anthropogenic degradation. While biodiversity distribution and conservation priorities are well represented, new methodological approaches are needed to assess environmental conditions, including the degree of human impact. The methodological approach therefore consists of two main steps—an assessment of global environmental conditions and a subsequent assessment of biodiversity status within biodiversity hotspots.

The development of the classification of Global Environmental Systems was a long-term process that required several sequential steps. Once the different datasets covering abiotic, biotic, and anthropogenic conditions were selected, the individual analyses could begin. A principal component analysis (PCA) was performed first, followed by multiresolution segmentation. Each segment was filled with values of all abiotic, biotic, and anthropogenic variables; land cover was analysed using a Python script. As the next step, a cluster analysis was performed; both a K-Means cluster analysis and a TwoStep cluster analysis were executed. A synthesis of the resulting abiotic, biotic, and anthropogenic classifications created 169 types of Global Environmental Systems.

2.1. Global Environmental Systems Classification

This classification is complex as it is based on abiotic, biotic, and anthropogenic factors. The first step in the classification process was to obtain suitable abiotic data characterising the Earth's landmass. The climate data come from the WorldClim database [27], where 19 different variables characterising temperature or precipitation were available. The spatial resolution of all data layers is 30 s ($0.93 \times 0.93 = 0.86$ km^2 at the equator). These variables represent seasonality, annual trends, and extreme or limiting environmental factors. From all of these variables, seven not highly correlated variables were selected for further analysis (Table 1).

The annual mean temperature, mean temperature of warmest quarter, mean temperature of coldest quarter, and temperature annual range characterise the temperature conditions; the annual precipitation, precipitation of wettest quarter, and precipitation of driest quarter characterise the precipitation conditions. The altitude data layer comes from the same database [27]; the last two variables (topographic position index and vertical heterogeneity) were derived in ArcGIS (Table 1). Soils and other factors considered were not included because datasets of sufficient resolution and quality were not available at the global level.

Table 1. Abiotic classification factors.

Abiotic Classification Factor	Reference
Annual Mean Temperature (BIO1)	Hijmans et al. (2005) [27]
Temperature Annual Range (BIO7)	Hijmans et al. (2005) [27]
Mean Temperature of Warmest Quarter (BIO10)	Hijmans et al. (2005) [27]
Mean Temperature of Coldest Quarter (BIO11)	Hijmans et al. (2005) [27]
Annual Precipitation (BIO12)	Hijmans et al. (2005) [27]
Precipitation of Wettest Quarter (BIO16)	Hijmans et al. (2005) [27]
Precipitation of Driest Quarter (BIO17)	Hijmans et al. (2005) [27]
Altitude	Hijmans et al. (2005) [27]
Vertical Heterogeneity	Derived from Hijmans et al. (2005) [27]
Topographic Position Index	Derived from Hijmans et al. (2005) [27]

These ten abiotic input rasters were then standardised, and values were reclassified to the range of 0–100 in order to perform a principal component analysis (PCA). This is a procedure that identifies a smaller number of uncorrelated variables called principal components from a large set of data. The analysis is intended to explain the maximum possible amount of variance using the fewest number of principal components. The result of our analysis is a multiband raster with four principal components, which was the most appropriate number of the several variants tested. Once we had the multiband raster, we could run segmentation in eCognition software (eCognition Developer 64), more precisely, the multiresolution segmentation algorithm that was carried out several times. The parameters of the multiresolution segmentation were set as follows—image layer weights L1: 77.4, L2: 12.8, L3: 6.3, L4: 3.4 based on PCA; scale parameter: 100; shape parameter: 0.1; compactness parameter: 0.5. These settings ensured that the number of segments was not too large and that the shape was neither too regular nor irregular. The rough final segmentation layer based on climate and topography gradients consisted of 44,418 segments, which was further reduced to 18,554 segments as all the water areas and segments smaller than 5 km^2 were removed.

As the next step within these spatial units, the mean, maximum, and minimum values of ten abiotic, four biotic, and seven anthropogenic variables were calculated in ArcGIS for each segment out of a total of 18,554 segments. The biotic factors in this study were represented by the terrestrial diversity of plants and vertebrates. The four biotic variables (Table 2) used were the species richness of mammals, birds, and amphibians derived from the Biodiversity Mapping website [28,29]; and plant diversity coming from the work of Kier et al. [30]. All biotic variables mirror natural conditions, long-term evolution, and human impact and management.

Table 2. Biotic classification factors.

Biotic Classification Factor	Reference
Species Richness of Mammals	Jenkins et al. (2013) [28]; Pimm et al. (2014) [29]
Species Richness of Birds	Jenkins et al. (2013) [28]; Pimm et al. (2014) [29]
Species Richness of Amphibians	Jenkins et al. (2013) [28]; Pimm et al. (2014) [29]
Species Richness of Plants	Kier et al. (2005) [30]

Among the variables used for the analysis of the anthropogenic transformation of the environment (Table 3) were livestock density, which is composed of partial densities of cattle, pigs, sheep, goats, and chickens [31]; population density [32]; and accessibility [33]. Global land cover was also analysed within the segments [34]. The total area, number of patches, and percentage of all land cover classes in each segment were calculated using a Python script. Land cover was originally classified in 37 classes and was subsequently generalised into 17 categories (Table 4) that were utilised in the final anthropogenic classification.

Table 3. Anthropogenic classification factors.

Anthropogenic Classification Factor	Reference
Cattle distribution	Robinson et al. (2014) [31]
Pig distribution	Robinson et al. (2014) [31]
Sheep distribution	Robinson et al. (2014) [31]
Goat distribution	Robinson et al. (2014) [31]
Chicken distribution	Robinson et al. (2014) [31]
Population density	CIESIN (2005) [32]
Accessibility	Nelson (2008) [33]
Global land cover	ESA Land Cover (2017) [34]

Table 4. Land cover categories.

GLC Category	Land Cover Classes
GLC1	Cropland, rainfed
	Herbaceous cover
	Tree or shrub cover
	Cropland, irrigated, or post-flooding
GLC2	Mosaic cropland (>50%)/natural vegetation (tree, shrub, herbaceous cover) (<50%)
	Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%)/cropland (<50%)
GLC3	Tree cover, broadleaved, evergreen, closed to open (>15%)
GLC4	Tree cover, broadleaved, deciduous, closed to open (>15%)
	Tree cover, broadleaved, deciduous, closed (>40%)
	Tree cover, broadleaved, deciduous, open (15–40%)
GLC5	Tree cover, needleleaved, evergreen, closed to open (>15%)
	Tree cover, needleleaved, evergreen, closed (>40%)
	Tree cover, needleleaved, evergreen, open (15–40%)
GLC6	Tree cover, needleleaved, deciduous, closed to open (>15%)
	Tree cover, needleleaved, deciduous, closed (>40%)
	Tree cover, needleleaved, deciduous, open (15–40%)
GLC7	Tree cover, mixed leaf type (broadleaved and needleleaved)
GLC8	Mosaic tree and shrub (>50%)/herbaceous cover (<50%)
	Mosaic herbaceous cover (>50%)/tree and shrub (<50%)
GLC9	Shrubland
	Evergreen shrubland
	Deciduous shrubland
GLC10	Grassland
GLC11	Lichens and mosses
GLC12	Sparse vegetation (tree, shrub, herbaceous cover) (<15%)
	Sparse tree (<15%)
	Sparse shrub (<15%)
	Sparse herbaceous cover (<15%)
GLC13	Tree cover, flooded, fresh or brackish water
	Tree cover, flooded, saline water
	Shrub or herbaceous cover, flooded, fresh/saline/brackish water
GLC14	Urban areas
GLC15	Bare areas
	Consolidated bare areas
	Unconsolidated bare areas
GLC16	Water bodies
GLC17	Permanent snow and ice

Once all of this was completed, the values of all continuous variables abiotic, biotic, and anthropogenic had to be standardised with a mean equal to 0 and standard deviation equal to 1 in order to run a cluster analysis in IBM SPSS software (IBM SPSS Statistics 25 and 27) [35]. Different types of classifications were executed for abiotic and biotic data and for anthropogenic data, respectively. In the case of the cluster analyses of abiotic and biotic data, the K-Means cluster analysis was performed (with a setting of a maximum of 100 iterations). In the case of anthropogenic data, where both continuous (population density, livestock density, accessibility) and categorical variables (land cover) are present, the TwoStep cluster analysis was executed. The classification process was performed many times with different settings for the number of clusters; finally, the number of ten clusters was set for all particular classifications: abiotic, biotic, and anthropogenic. A synthesis of the partial results was then performed; the abiotic and biotic classifications were combined in ArcGIS, and potentially, they could have created 100 natural (abiotic + biotic) classes. But the result was actually the creation of 59 classes. Classes with distinctly similar biotic characteristics that belonged to the same abiotic class were merged, which led to a reduction in the number of classes to a final 30 natural classes. The natural classes were then combined with the anthropogenic classification. Of the 300 possible combinations, 169 types of Global Environmental Systems were created. That was the final result of this complex classification process.

2.2. Biodiversity Hotspots Evaluation

Global Environmental Systems not only reflect the conditions and gradients of inanimate and living nature, but also human activities. Biodiversity hotspots are the areas where immense natural wealth and significant human influence and loss of natural habitat intersect most strongly. The proportion of each abiotic, biotic, anthropogenic, and natural class was calculated using ArcGIS (ArcGIS 10.6–10.8) for all 36 hotspots, as was the representation of each Global Environmental System. The data were then further processed in Excel. The global significance of each biodiversity hotspot was based on the work of Myers et al. [36] and Hrdina and Romportl [37].

3. Results

3.1. Global Environmental Systems Classification

The global classification consists of three sub-typologies based on separate analyses of abiotic conditions, biodiversity gradients of selected taxonomic groups, and the magnitude of anthropogenic dominance. The integration of these sub-classifications then led to a comprehensive classification of Global Environmental Systems.

3.1.1. Abiotic Classification

The abiotic classification is the fundamental classification that forms the basic framework for the subsequent classification of Global Environmental Systems. It consists of ten classes. A clear gradient from the poles to the equator can be observed for these abiotic classes (Figure 1), ranging from Class 1 being the coldest to Class 10 being the warmest one. Classes 1, 2, 4, and 6 are completely absent in the Southern Hemisphere. But there is one major exception: Class 3. It is an azonal class, covering the area of the highest mountain systems in both North and South America, Africa, Europe, and Asia. The different classes of abiotic classification are basically characterised as follows. The full details of each class can be found in Table 5.

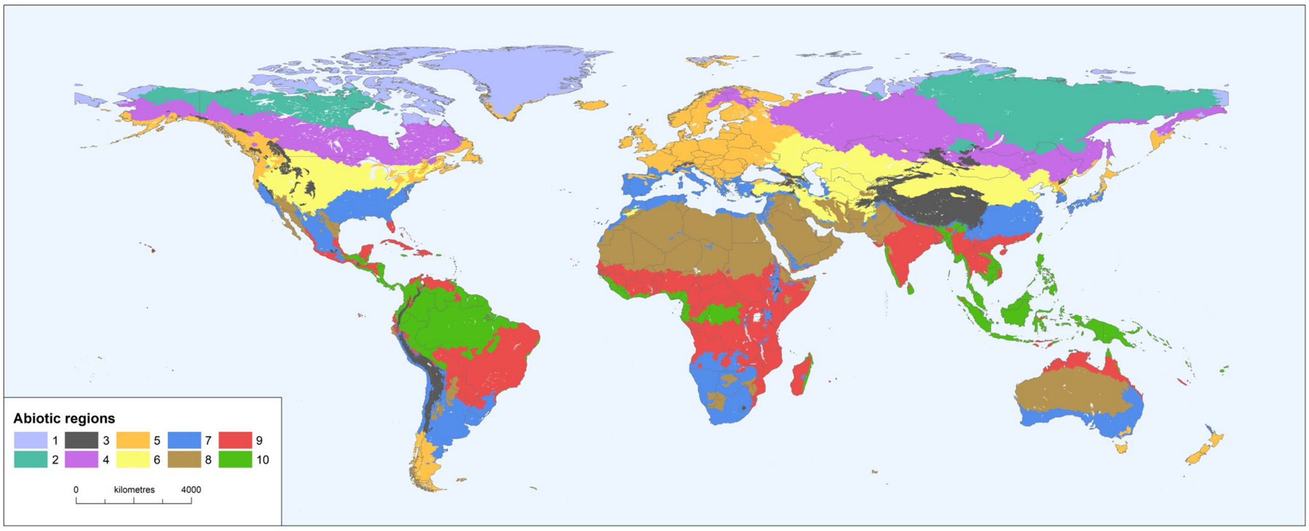

Figure 1. Abiotic classification (Table 5).

Table 5. Characteristics of abiotic classes.

Class	Annual Mean Temperature	Mean Temperature of Warmest Quarter	Mean Temperature of Coldest Quarter	Temperature Annual Range	Annual Precipitation	Precipitation of Wettest Quarter	Precipitation of Driest Quarter	Altitude	Vertical Heterogeneity	TPI	Number of Segments	Area [%]
Class 1	−16.03	−0.32	−29.35	38.25	438.19	152.16	80.25	953.26	34.54	−0.57	2372	3.38
Class 2	−11.20	10.11	−32.25	56.71	327.49	156.00	32.94	452.47	49.64	0.27	1683	7.11
Class 3	0.42	9.55	−9.34	34.47	452.19	230.06	34.75	3578.57	191.79	10.88	910	4.42
Class 4	−1.66	14.32	−18.59	47.20	513.37	217.07	64.89	402.25	32.42	−0.20	1834	10.98
Class 5	5.01	14.18	−4.20	28.86	852.86	294.99	144.33	399.59	68.53	−0.56	2871	7.08
Class 6	8.57	21.80	−5.52	43.01	366.51	154.99	40.97	843.89	38.59	−1.00	1275	9.86
Class 7	16.62	23.25	9.50	28.05	769.04	328.89	84.76	701.99	56.96	−0.90	1910	12.70
Class 8	24.10	30.96	16.20	31.44	169.58	102.84	7.87	430.52	15.74	−0.48	1351	16.84
Class 9	24.44	26.74	21.73	19.33	1161.19	608.32	47.04	512.42	37.08	−0.62	1989	17.73
Class 10	25.39	26.22	24.36	12.62	2 461.61	998.86	268.13	283.97	47.76	−1.20	2359	9.91

- Class 1—Freezing arctic region

This class covers 3.38% of the land area, mainly in the Arctic. It is located in northern Alaska, Canada, and Russia in Kamchatka and Chukotka and covers most of Greenland and the islands in the Arctic Ocean. This region is characterised by very low temperatures, with an annual mean temperature of −16.03 °C. Even during the warmest quarter of the year, the mean temperature is negative (−0.32 °C); during the coldest quarter, the mean temperature in this region is −29.35 °C. Annual precipitation is 438 mm, and the difference in precipitation between the wettest and driest quarter of the year is the smallest among all abiotic classes. The region extends from sea level to an altitude of over 4700 m; the average altitude is about 950 m, and the area is not very vertically heterogeneous.

- Class 2—Cold northern region with a significant temperature annual range

Class 2 is located mainly in the subarctic zone; it also extends into the Arctic and temperate zones and covers 7.11% of the landmass of northern Alaska and Canada, north-eastern Russia, and the Sayan Mountains. The annual mean temperature of the region is −11.2 °C. The temperature annual range is very high, ranging between 38.8 °C and 72.5 °C. Temperatures are extremely low during the coldest quarter of the year, averaging below −32 °C. The annual precipitation is only 327 mm, and the average altitude of the area is approximately 450 m above sea level.

- Class 3—Region of the highest mountains

An azonal class, which occupies 4.42% of the landmass and covers the highest mountain ranges in the world, such as the American Cordillera, the Drakensberg, the mountains of East Africa, the Sierra Nevada, the Pyrenees, the Alps, the Caucasus, the Taurus Mountains, and the mountain systems of Central Asia and North Korea. This mountain class stretches to the highest peaks of the Himalayas; the average altitude is 3579 m above sea level, and it is the most vertically heterogeneous region by a lot. The annual mean temperature is just 0.42 °C, and the annual precipitation is 452 mm. In this region, we can observe large differences between the minimum and maximum values of individual indicators.

- Class 4—Colder temperate zone of the Northern Hemisphere

A wide belt from Alaska to eastern Canada; Lapland; a vast area from the White Sea through Kazakhstan, Mongolia and China to Sakhalin; a belt along the Sea of Japan; the Sea of Okhotsk; and the Bering Sea, covering a large area (10.98%). The last class where the annual mean temperature is negative (−1.66 °C). The temperature annual range in this region is very high (47.2 °C), and the annual precipitation is 513 mm. The territory of this class has an average altitude of 402 m, and is the second flattest of all classes.

- Class 5—Humid temperate region

Class 5 can be found predominantly in the temperate zone of both hemispheres and occupies 7.08% of the land area in the Aleutian Islands, a wide belt from Alaska to California, eastern US/Canada, Patagonia, the Falkland Islands, the southern coast of Greenland, Iceland, Svalbard, most of Europe (except parts of southern Europe and Lapland), Koreas, Honshu, Hokkaido, southern Kamchatka, southeastern Australia, Tasmania and, finally, New Zealand. The annual mean temperature is 5.01 °C, and the annual precipitation is relatively high (853 mm), as is the precipitation of the driest quarter (144 mm). The average altitude is just under 400 m, but the region is the second most vertically heterogeneous.

- Class 6—Warmer and drier temperate zone of the Northern Hemisphere

This class occupies almost a tenth of the land mass (9.86%) in the Northern Hemisphere only and includes the south of Canada, the interior of the United States, the north of Mexico, Morocco, a vast territory from Ukraine and Turkey to the Sea of Japan, and from Russia and Kazakhstan to Iran and Pakistan. This region has an annual mean temperature of 8.57 °C, and the mean temperature of the warmest quarter is significantly higher (21.8 °C) than in the previous two adjacent classes. The temperature annual range is high (43.01 °C), the annual precipitation is low (366.5 mm), and this region lies at quite a high altitude (844 m).

- Class 7—Subtropics of both hemispheres

Class 7 is the third largest of all abiotic classes (12.7%) and is placed in the southwestern and southeastern United States, in the interior of Mexico, in a belt from Ecuador to Chile; in Bolivia, Argentina, Uruguay, and southern Brazil; in southern Africa; in the East African Rift region, in Madagascar, in the mountainous regions of the Sahara; in the Mediterranean, around the Black and Caspian Seas; in Saudi Arabia and Yemen, in a narrow disjointed belt of Turkey–Iraq–Iran; from Afghanistan to eastern China; in South Korea; on the islands of Honshu, Kyushu and Shikoku; and in southern Australia and northern New Zealand. The annual mean temperature is much higher (16.62 °C) than in the previous Class 6; especially, the mean temperature of the coldest quarter differs by a lot: 9.5 °C vs. −5.52 °C. The temperature annual range is only 28.05 °C, the annual precipitation is 769 mm, the average altitude is 702 m, and this region has the third highest vertical heterogeneity.

- Class 8—Deserts and semi-deserts of the tropics

This class is very extensive (16.84%) and can be found in desert and semi-desert areas of the world: the southern United States, northern Mexico, Peru, Bolivia–Paraguay–Argentina, Namibia–South Africa–Botswana, Zimbabwe–Mozambique, a large territory from the Western Sahara to India, and western and interior Australia. The annual mean temperature of this distinctive region is high (24.1 °C), and the mean temperature of the warmest quarter is almost 31 °C on average, being up to 38.3 °C in some places. The annual precipitation is extremely low (170 mm), and the precipitation of the driest quarter is just under 8 mm. The whole region is very flat.

- Class 9—Extensive subequatorial region with a drier period

Class 9 occupies 17.73% of the Earth's landmass, making it the most extensive class. The area of occurrence is: Hawaii, an area from Mexico to Nicaragua, Florida, Cuba, Hispaniola, the Bahamas, part of the Lesser Antilles, a discontinuous arc from Guyana to Peru, the Galápagos Islands, Bolivia, Brazil, Paraguay, Argentina, most of Africa between Cape Verde–Eritrea and Angola–Mozambique, Eswatini, eastern South Africa, Madagascar, Réunion, Yemen, Sri Lanka, the peninsulas of India and Farther India, southern China, Hainan, Taiwan, Sumatra, Sulawesi, Sumba, Flores, Timor, Wetar, northern and north-eastern Australia, New Caledonia, and Vanuatu. High temperature, low temperature amplitude, or high precipitation are typical for this region; the mean annual temperature is 24.44 °C, the temperature annual range is 19.33 °C, and the annual precipitation is 1161 mm, but the precipitation of the driest quarter is only 47 mm.

- Class 10—Warm and humid equatorial region

The last abiotic class lies in the equatorial zone and covers 9.91% of the land area. Class 10 is typical of Hawaii, a vast territory from Mexico to Bolivia–Brazil, Jamaica, Puerto Rico, the Lesser Antilles, a coastal belt from Guinea-Bissau to Ghana and from Ghana to Gabon, Congo, the Democratic Republic of the Congo, Madagascar, the Comoros, the Seychelles, Mauritius, the west coast of India, Sri Lanka, Nepal, from Bhutan to Singapore, Farther India, the Sunda Islands, the Moluccas, the Philippines, Taiwan, New Guinea, northern Australia, and Oceania. The annual mean temperature is the highest (25.39 °C), as well as the mean temperature of the coldest quarter (24.36 °C). The temperature annual range is the lowest (12.62 °C), and the annual precipitation is the highest (2462 mm), in places over 11,000 mm. The precipitation of the wettest quarter is around 1000 mm, in places over 8000 mm, and the precipitation of the driest quarter is 268 mm, in places around 2500 mm. The altitude is only 284 m above sea level.

3.1.2. Biotic Classification

The biotic classification also consists of ten classes. The distribution of biotic classes corresponds to the idea of the distribution of biodiversity on the planet (Figure 2). Classes 6 and 1 are the richest. They are found in the equatorial regions of Africa, America, and Southeast Asia. Classes 7 and 2, on the other hand, are the poorest in terms of both fauna and flora biodiversity, and both are very extensive. Class 7 can be found in areas of cold and warm deserts and in high-latitude areas. Class 2 is located next to Class 7. In contrast to the abiotic classification, all biotic classes are represented in both hemispheres. All classes are ordered according to the gradient of species richness of fauna and flora, from the most species-poor to the most species-rich. The different classes of biotic classification are basically characterised as follows. The full details of each class can be found in Table 6.

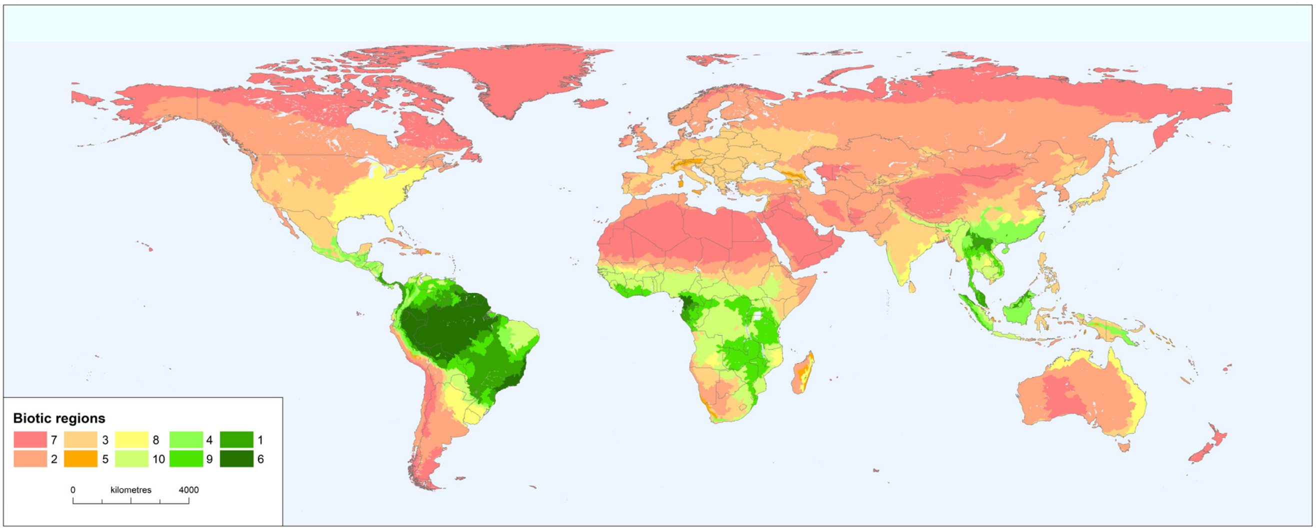

Figure 2. Biotic classification (Table 6).

Table 6. Characteristics of biotic classes.

Class	Mammal Species	Bird Species	Amphibian Species	Plant Species	Number of Segments	Area [%]
Class 7	18.53	52.55	1.64	588.36	7696	23.50
Class 2	37.65	151.95	4.79	1283.91	5257	32.61
Class 3	57.91	214.89	10.28	2389.73	1894	14.59
Class 5	38.83	145.15	8.10	4532.68	743	0.52
Class 8	50.04	215.30	25.31	2259.29	555	4.76
Class 10	99.04	326.78	23.94	2455.29	889	8.85
Class 4	104.62	318.49	20.09	5866.97	445	2.95
Class 9	133.74	402.61	38.12	3123.06	497	5.10
Class 1	139.30	418.29	45.27	6263.24	329	3.31
Class 6	167.87	492.19	84.07	6168.79	249	3.81

- Class 7—Region with the lowest species richness

This is the poorest class in all monitored biodiversity indicators. It is very extensive (23.5%), located in: a belt from Alaska, through northern Canada, Greenland, Iceland, Ireland, Scotland, northern Scandinavia, Russia to Chukotka, the Bahamas, the Lesser Antilles, the Azores, the Canary Islands, Cape Verde, the Mascarene Islands, the Comoros, Oceania, from Peru through Patagonia to Tierra del Fuego and the Falklands, a discontinuous desert belt from the Sahara through the Arabian Peninsula to the Gobi, Australia, and New Zealand.

- Class 2

The most extensive biotic class of all, occupying 32.61% of the land area: the USA incl. Alaska, Canada, the Baja California peninsula, the Greater Antilles, a belt from Peru to the south of Chile and Argentina, northern Africa, a belt from Mali to the Horn of Africa, an area from Angola to South Africa, Madagascar, a belt from the Iberian Peninsula, through the British Isles, Scandinavia to the east of Russia and from Greece through Central Asia, Korea, to Hokkaido; Australia, Tasmania, New Caledonia, the Lesser Sunda Islands, and the Moluccas. It is the second poorest class, but the diversity of mammals, birds, amphibians, and plants is 2–3 times greater than the previous class.

- Class 3

Class 3 is still one of the poorer classes in the classification, although the diversity of fauna and flora is roughly average from a global perspective. It is the third largest class (14.59%) of the biotic classification, typical of the western United States; Mexico; a narrow strip from Ecuador to Argentina; a belt from Senegal to Eritrea and on to Kenya;

from Angola to South Africa incl. Lesotho; western, southern, central, and eastern Europe; Turkey; the Caucasus region; parts of Central Asia; a belt from Pakistan to Japan; India–Bangladesh–Sri Lanka; the Philippines; Sulawesi; Bali; Lombok; Flores; Papua New Guinea; and a small part of Australia.

- Class 5

This biotic class is definitely the smallest of all, occupying only 0.52% of the world's land area, and it is highly specific as the species richness of fauna is quite below average; meanwhile, the species richness of flora is very high at over 4500 species and locally up to 10,000 species. Class 5 is typical of the Dominican Republic, Peru, Namibia–South Africa, Madagascar, the Alps, Ibiza, Sardinia, Sicily, the Caucasus, Lebanon–Syria, Indonesia, the Solomon Islands, and New Caledonia.

- Class 8

Class 8 can be found in the southeastern USA, Paraguay, Argentina, Uruguay, Brazil, Burkina Faso, Mali, Angola, Mozambique, Madagascar, on the east coast of India, in Thailand, Laos, China, Taiwan, Honshu, and on the north and east coasts of Australia over a total area of 4.76%. This region has an above-average amphibian diversity (25 species, max. 93 species), while other indicators are quite average.

- Class 10

The fourth largest biotic class (8.85%), typical of an area from Mexico to Costa Rica; Panama; from Ecuador to Trinidad; from Peru to Brazil; northeastern Brazil; the territory south of the Senegal–Ethiopia line to South Africa; the west coast of India; a belt from India through Nepal, Bhutan, and Myanmar to China; Farther India; Sumatra; and Java. This is the first biotic class having above average values for all indicators. The species richness of birds is the fourth highest, with an average of 327 bird species and a max. of 578 bird species.

- Class 4

The second smallest class (2.95%) situated in a belt from Mexico to Bolivia, in Paraguay, Argentina, Brazil, in the Western Cape, from Myanmar to southern China, and in Sumatra, Borneo, and Papua New Guinea. This region hosts 105 species of mammals (max. 197 species) and 5867 species of plants, with a maximum of around 10,000 species.

- Class 9

Class 9 is very rich in fauna species; the plant diversity is not so substantial (3123 species). The sites with the highest number of mammal (217) and bird (666) species are within this class. It is located from Colombia to Guyana, in Peru, Bolivia, and Brazil, from Sierra Leone to Ghana, from Nigeria to the Democratic Republic of the Congo, from South Sudan to South Africa, in Farther India, and Sumatra. This class is located right here on 5.1% of the landmass.

- Class 1

Together with Class 6, the two most species-rich classes. Class 1 is the second richest in mammal (139 species), bird (418 species), and amphibian (45 species) diversity and the richest in plant diversity (6263 species). It occupies 3.31% of the land area in a belt from Nicaragua to Ecuador; from Guyana to Peru; in Peru–Bolivia, and Brazil–Paraguay–Argentina; from Congo through Gabon, Equatorial Guinea to Cameroon; in Madagascar; from Myanmar through China, Vietnam, and Laos to Thailand; and in the Malay Peninsula, Borneo, and Sumatra.

- Class 6—Region with the highest species richness

Class 6 is the territory with the highest biodiversity in the world. It has a land area of 3.81% in only three areas in South America and Africa: the Amazon rainforest, the Atlantic Forest, and Cameroon, Equatorial Guinea, and Gabon. Class 6 is the richest in mammal

(168 species), bird (492 species), and amphibian (84 species) diversity, and it is the second richest in plant diversity (6169 species).

3.1.3. Anthropogenic Classification

The anthropogenic classification consists of ten classes too but does not create such a clear and obvious pattern. The distribution of individual classes is much more heterogeneous, and classes do not form such large and homogeneous units (Figure 3). All classes are ordered according to the anthropogenic gradient, from the most remote with little anthropogenic impact to the most easily accessible with significant anthropogenic impact. The different classes of anthropogenic classification are basically characterised as follows. The full details of each class can be found in Table 7.

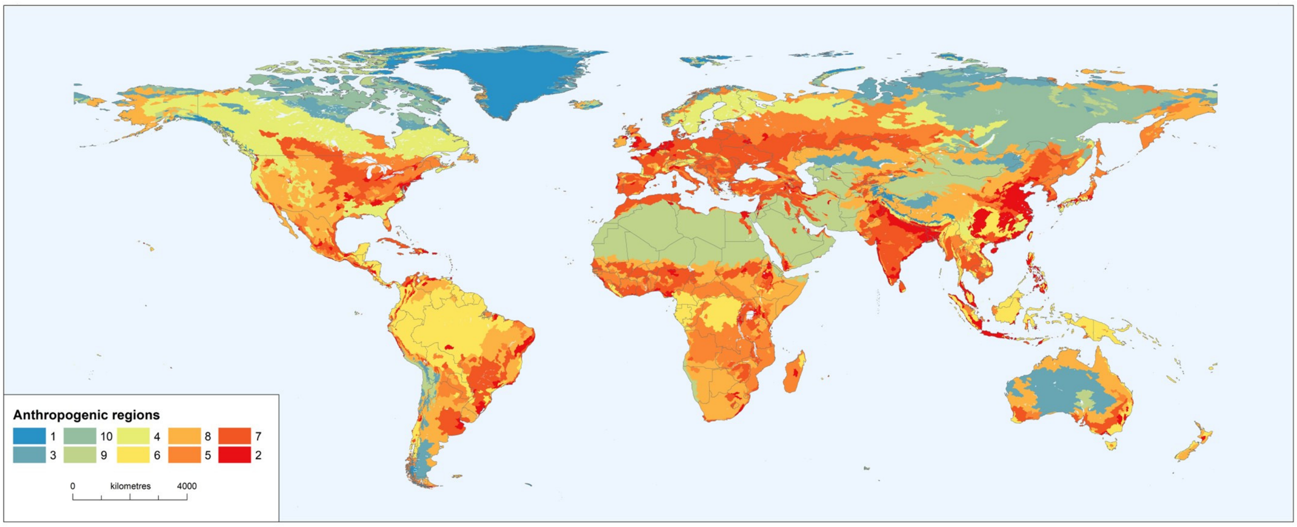

Figure 3. Anthropogenic classification (Table 7).

Table 7. Characteristics of anthropogenic classes.

Class	Livestock Density	Accessibility	Human Density	Predominant Land Cover	Number of Segments	Area [%]
Class 1	1.50	9764.58	2.45	GLC 17	689	1.98
Class 3	4.46	2840.49	0.48	GLC 12	1989	6.17
Class 10	0.72	2394.74	0.51	GLC 6, 11	1525	5.82
Class 9	16.50	1527.45	6.01	GLC 15	1771	14.25
Class 4	12.70	1039.64	10.20	GLC 5	2300	8.19
Class 6	26.26	1257.76	21.41	GLC 3	2330	11.19
Class 8	30.84	831.99	12.38	GLC 9, 10	2981	19.94
Class 5	22.18	562.35	24.42	GLC 4, 7, 8, 13	2175	12.31
Class 7	99.31	175.45	94.92	GLC 1	1907	15.88
Class 2	353.54	156.15	462.43	GLC 1, 2	887	4.26

- Class 1—Highly remote areas with very little anthropogenic impact

The first class of the anthropogenic classification occupies the smallest area (1.98%) with an extremely low accessibility and can be found only at very high latitudes or altitudes: Alaska, northern Canada, Greenland, Iceland, the Arctic Ocean islands, the mountains of Central Asia, Patagonia, and the small islands of the southernmost waters of the World Ocean. The completely dominant land cover class is permanent snow and ice. It is no surprise that the densities of both population and livestock are very low.

- Class 3

Another class with a very low accessibility, low livestock density, and even the lowest human density (0.48 people/km^2). This class is typical of Alaska, northern Canada, the coast of Greenland, Iceland, north of Scandinavia, Russia, the Arctic Ocean islands, Central Asia, Tibet, Mongolia, the Andes, Patagonia, and Australia. The completely predominant land cover class is sparse (<15%) vegetation (tree, shrub, herbaceous cover), sparse tree, sparse shrub, and sparse herbaceous cover. It is rather a smaller class (6.17%).

- Class 10

Class 10, like the previous one, has very low values of population and livestock density and accessibility. It covers a similar land area (5.82%) in northern Alaska and Canada and eastern Siberia. There are two main land cover types in the area: tree cover, needleleaved, deciduous, closed to open (>15%); tree cover, needleleaved, deciduous, closed (>40%); tree cover, needleleaved, deciduous, open (15–40%); and lichens and mosses.

- Class 9

The area of this class is much larger (14.25%), and it occurs in Chukotka, Alaska, in the northern part of the Canadian Archipelago, Iceland, Svalbard, the Arctic Ocean islands, in a belt from Peru through Bolivia to Chile and Argentina, in Namibia and Angola, in a desert region from the Western Sahara to Mongolia, and in central Australia. Bare areas, consolidated bare areas, and unconsolidated bare areas are the dominant land cover type of this large region. Human density (6.01 people/km^2), livestock density, and accessibility are higher than previous classes.

- Class 4

This class covers 8.19% of the land area in the United States and Canada, in parts of Europe, in Scandinavia, in Russia, in a continuous belt from Afghanistan to China, and in southeastern China and Japan. Class 4 has one dominant land cover type: tree cover, needleleaved, evergreen, closed to open (>15%); tree cover, needleleaved, evergreen, closed (>40%); and tree cover, needleleaved, evergreen, open (15–40%), and it has similar human and livestock density to Class 9 and better accessibility.

- Class 6

Oceania, Hawaii, Central America, the Caribbean, Amazonia, Paraguay, the coast of Brazil, central Chile, central Africa, Madagascar, Farther India, the Malay Archipelago, the southeastern coast of Australia, Tasmania, and New Zealand are covered with Class 6, with an area of 11.19%. The predominant land cover type is tree cover, broadleaved, evergreen, closed to open (>15%). Human and livestock density is roughly double that of the previous class; accessibility is quite average.

- Class 8

This class occupies almost a fifth of the land mass (19.94%) and includes Alaska, the western half of the USA, Newfoundland, Mexico, a belt from Guyana to Argentina, Uruguay, eastern Brazil, the Sahel, the Horn of Africa, southern Africa, Iceland, the British Isles, the Alps, the Pyrenees, the French Central Highlands, Central Asia, eastern Russia, Australia, and New Zealand. Human density is 12.38 people/km^2, livestock density is the third highest (30.84 livestock units/km^2), and this region has better than average accessibility. The region is dominated by two land cover classes: shrubland, evergreen shrubland, and deciduous shrubland; and grassland.

- Class 5

The typical land cover type of this class with an area of 12.31% is primarily tree cover, broadleaved, deciduous, closed to open (>15%); tree cover, broadleaved, deciduous, closed (>40%); and tree cover, broadleaved, deciduous, open (15–40%). This is followed by tree cover, mixed leaf type (broadleaved and needleleaved); mosaic tree and shrub (>50%)/herbaceous cover (<50%); and mosaic herbaceous cover (>50%)/tree and shrub (<50%). Lastly, this is followed by tree cover, flooded, fresh or brackish water; tree cover, flooded, saline water; and shrub or herbaceous cover, flooded, fresh/saline/brackish water. Class 5 is typical of southeastern Canada, the eastern USA, an area from Mexico to Nicaragua, Brazil, Bolivia, Paraguay, Argentina, southern Chile, much of Africa south of the Sahel, Madagascar, Europe, western and central Russia, Turkey, the Caucasus, the peninsulas of India and Farther India, and an area from China to Kamchatka. This class has the third highest human density (24.42 people/km^2), and the region is the third most accessible too.

- Class 7

The second largest (15.88%) and the second most anthropogenically impacted region with very good accessibility. Human density is 94.92 people/km^2, and livestock density is 99.31 livestock units/km^2. The location of this class is southern Canada, central USA, Cuba, Colombia, Brazil, Argentina, a belt from Senegal to Ethiopia and from Sierra Leone to Nigeria, much of Europe except for mountainous areas and northern Europe up to Iran and Kazakhstan, the peninsulas of India and Farther India, eastern China, the Korean Peninsula, and southwestern and southeastern Australia. Cropland, rainfed; herbaceous cover; tree or shrub cover; and cropland, irrigated or post-flooding type of land cover dominates here.

- Class 2—Easily accessible areas with significant anthropogenic impact

And finally, there is Class 2, which is by far the most anthropogenically exploited. Class 2 is located in areas (4.26%) with significant livestock farming (353.54 livestock units/km^2), human density (462.43 people/km^2), and the highest accessibility from all anthropogenic classes, such as India, eastern China, Indonesia, Malaysia, Japan, the Philippines, Benelux, England, etc. There are two main land cover types: cropland, rainfed; herbaceous cover; tree or shrub cover; cropland, irrigated or post-flooding. Andmosaic cropland (>50%)/natural vegetation (tree, shrub, herbaceous cover) (<50%); and mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%)/cropland (<50%).

3.1.4. Classification of Natural Conditions

This natural classification (Figure 4, Table 8) is the penultimate step in the creation of Global Environmental Systems. It is a combination of abiotic and biotic classification, having 30 classes out of 100 theoretically possible classes (10 abiotic classes × 10 biotic classes) (Figure 5). The letters 'A' to 'J' indicate affiliation with one of the ten abiotic classes (1 to 10), which are further subdivided into one to five classes and the letters 'a' to 'e' distinguish individual biotic classes or groups of classes.

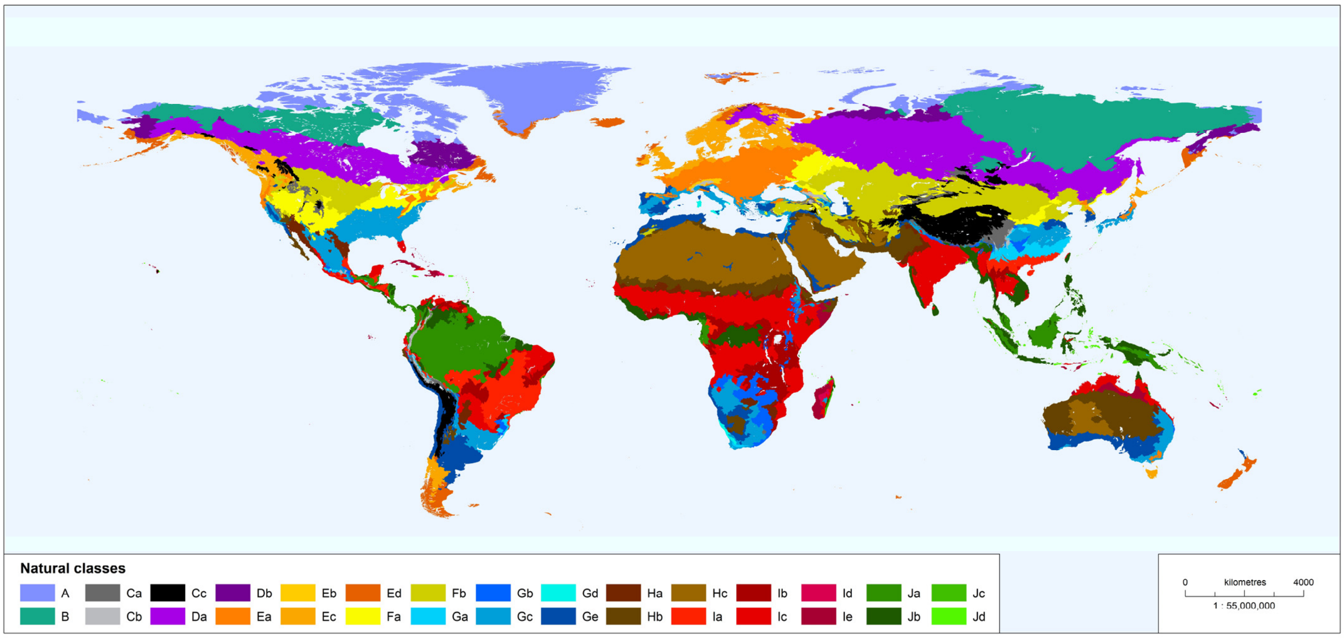

Figure 4. Classification of natural (abiotic + biotic) conditions (Table 8).

Table 8. Characteristics of 30 natural classes.

Class	Abio + Bio Codes	Mammal Species	Bird Species	Amphibian Species	Plant Species	Annual Mean Temp.	Mean Temp. of Warmest Quarter	Mean Temp. of Coldest Quarter	Temp. Annual Range	Annual Precipit.	Precipit. of Wettest Quarter	Precipit. of Driest Quarter	Altitude	Vertical Hetero-gen.	TPI	Number of Seg-ments	Area [km^2]	Area [%]
A	17	7.67	24.02	1.00	212.87	−16.03	−0.32	−29.35	38.25	438.19	152.16	80.25	953.26	34.54	−0.57	2372	4,509,843	3.38
B	22; 27	28.05	102.73	1.75	899.57	−11.20	10.11	−32.25	56.71	327.49	156.00	32.94	452.47	49.64	0.27	1683	9,484,710	7.11
Ca	33; 39; 310	69.20	218.01	6.72	2530.86	2.79	11.48	−6.59	33.62	662.50	323.07	48.75	3054.23	230.28	15.43	258	1,418,906	1.06
Cb	34; 35	99.36	258.30	9.09	5066.13	8.29	12.51	3.66	21.68	1063.16	440.86	118.46	2624.64	277.28	23.06	71	412,479	0.31
Cc	32; 37	33.58	108.34	2.69	1219.14	−1.13	8.60	−11.51	35.96	322.12	178.07	22.08	3849.76	170.44	8.17	581	4,065,325	3.05
Da	42; 43	41.75	156.67	4.17	1178.75	−0.98	15.11	−18.22	47.92	507.03	218.48	61.34	426.78	32.43	−0.21	1324	12,605,613	9.45
Db	47	26.28	71.63	1.78	779.29	−5.35	10.07	−20.55	43.35	547.46	209.53	83.97	270.42	32.37	−0.19	510	2,039,862	1.53
Ea	53; 58	55.25	168.33	12.81	2384.78	7.77	17.65	−2.59	31.15	742.50	260.04	127.21	351.21	46.46	0.41	330	3,763,862	2.82
Eb	55	64.86	124.97	8.67	4954.88	3.97	12.04	−4.26	26.37	1293.17	428.19	240.51	1448.17	282.17	12.38	12	76,258	0.06
Ec	52	37.66	144.55	5.80	1328.05	4.28	13.71	−5.03	29.60	860.33	309.84	133.39	436.98	75.86	−1.25	1112	3,682,350	2.76
Ed	57	15.78	83.32	1.59	699.19	1.97	9.61	−5.26	23.96	1000.53	319.51	188.11	376.70	83.66	−1.23	1417	1,925,294	1.44
Fa	63; 65; 68	54.95	169.48	10.36	2434.61	8.64	20.54	−3.69	39.51	546.63	202.95	79.14	864.85	48.67	−1.66	363	3,574,425	2.68
Fb	62; 67	39.16	127.99	4.87	1316.03	8.54	22.27	−6.21	44.31	299.38	137.12	26.75	836.08	34.84	−0.76	912	9,578,430	7.18
Ga	71; 74	92.89	320.21	25.04	5549.39	16.74	23.22	9.31	25.45	1338.01	631.40	115.74	1036.77	144.71	−0.85	118	1,165,589	0.87
Gb	79; 710	102.79	375.48	27.17	2567.00	18.36	21.77	13.76	24.09	969.28	517.81	45.14	1320.54	71.82	1.06	179	2,010,233	1.51
Gc	73; 78	54.90	213.17	18.08	2519.75	16.53	23.83	8.68	29.43	907.35	357.07	121.03	609.92	50.58	−1.09	727	7,860,848	5.89
Gd	75	39.75	144.93	5.21	4012.36	16.01	21.72	10.46	22.89	396.39	170.78	30.65	429.48	67.69	−1.51	133	138,350	0.10
Ge	72; 77	31.52	148.88	6.03	1399.42	16.20	22.98	9.29	28.06	421.72	178.53	43.80	575.65	44.10	−1.26	753	5,764,459	4.32
Ha	83; 88; 89; 810	62.40	257.47	12.99	1840.49	24.17	29.56	18.11	28.52	466.29	294.99	16.86	403.35	16.80	−0.81	126	2,102,486	1.58
Hb	82; 85	31.85	156.01	5.25	1091.61	24.00	30.38	16.64	30.29	256.02	155.47	13.53	380.83	18.16	−0.79	490	7,978,945	5.98
Hc	87	17.53	39.24	1.99	717.06	24.15	31.57	15.60	32.67	64.23	36.77	2.73	467.00	14.00	−0.23	735	12,376,256	9.28
Ia	91; 94; 96	126.57	398.28	44.46	5994.01	22.89	25.01	20.04	18.30	1466.89	695.36	84.47	526.65	57.34	−0.52	333	4,309,194	3.23
Ib	99	131.97	401.53	38.73	3023.79	23.21	24.79	21.02	17.56	1215.67	583.30	60.71	718.05	41.37	−0.12	293	4,415,565	3.31
Ic	93; 98; 910	82.73	298.41	20.42	2223.11	25.28	27.85	22.49	20.23	1070.63	596.22	31.63	459.49	29.11	−0.75	933	13,610,003	10.20
Id	95	16.19	114.51	8.12	3373.74	22.30	24.18	19.47	18.09	1500.12	848.84	66.87	734.05	70.25	−1.62	52	109,879	0.08
Ie	92; 97	27.62	150.45	8.44	1860.00	25.32	27.74	22.09	19.45	845.31	497.62	33.51	293.72	34.80	−1.14	378	1,200,975	0.90
Ja	101; 104; 106	155.21	445.71	62.90	6305.01	25.45	26.05	24.71	12.27	2523.94	959.40	307.22	276.06	42.57	−0.98	528	7,694,919	5.77
Jb	103; 108; 109; 1010	101.18	330.94	25.59	3193.89	25.33	26.50	23.89	13.32	2366.40	1061.40	202.18	301.04	52.46	−1.30	576	5,038,325	3.78
Jc	105	22.52	157.76	12.96	5045.96	24.85	25.90	23.48	10.84	2645.76	996.66	413.20	252.65	72.07	−3.29	512	196,530	0.15
Jd	102; 107	20.96	153.28	5.81	1767.20	25.16	26.11	23.86	10.60	2351.87	948.10	290.21	214.28	86.80	−3.94	743	282,883	0.21

Temp. = Temperature; Precipit. = Precipitation; Heterogen. = Heterogeneity; TPI = Topographic Position Index.

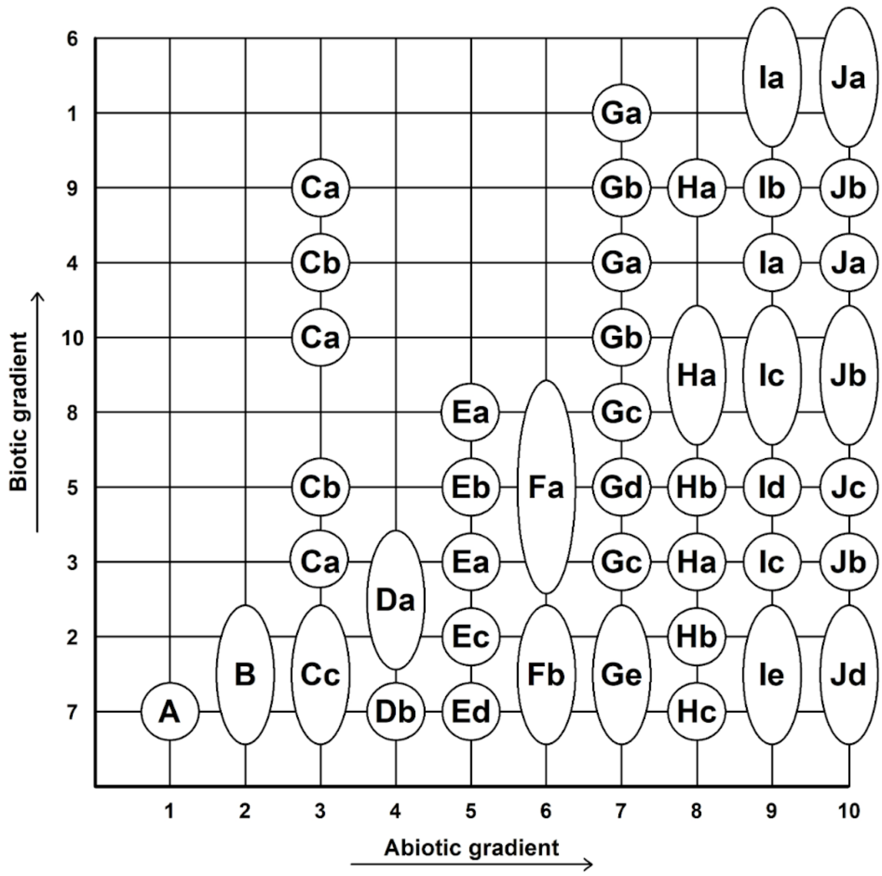

Figure 5. Synthetic diagram of the combination of natural conditions (Tables 5, 6 and 8).

On one side of the classification is Class A, which represents the freezing arctic region with the lowest species richness. Class B is located in the northern part of America and northeastern Asia. It is a cold world that is extensive, with the greatest temperature annual range and low biodiversity. Class C lies in the highest mountains. This class is divided into three classes: Ca, Cb, and Cc. Class Cb lies at the lowest altitude, has the highest annual mean temperature, the highest precipitation, and the highest species richness of mammals, birds, amphibians, and plants. Class Cc, on the other hand, lies at the absolute highest altitude and has the lowest annual mean temperature, the lowest precipitation, and the lowest species richness of fauna and flora. And finally, there is Class Ca, with all values being somewhere in between. Class D can be found in the temperate zone of the Northern Hemisphere, and it is divided into two classes: Da, and Db. In both classes, there is an annual mean temperature of below zero, with Class Db being colder. The temperature annual range is very high, the annual precipitation is below average, and the altitude is low, especially in Class Db. Both classes show low biodiversity, with Class Db being the poorer one. Class E includes four classes: Ea, Eb, Ec, and Ed, which lie in the humid temperate zone. The annual mean temperature is below average but is above zero in all classes. Classes Ea, Ec, and Ed lie at a low altitude. Class Eb is the smallest and is typical of the Alps; it has an above average annual precipitation and a high number of mammal species and especially plant species. Class Ea shows an average biodiversity, Class Ec a below average species richness, and Class Ed is very species-poor. Class F is typical mainly of the temperate zone too, but it is located in the warmer and drier area. This class is divided into two classes, both of which are found only in the Northern Hemisphere. Especially Class Fb lacks significant precipitation; therefore, the biodiversity is rather below average. In the subtropics of both the Northern and Southern Hemispheres, there are five G classes. The annual mean temperature of Class Ga, as in the Gc–Ge regions, is over 16 °C. Class Gb is warmer, with an annual mean temperature of over 18 °C. Classes Ga and Gb lie at a higher altitude of over 1000 m, and they are generously endowed with precipitation and being species-rich, while classes Gd and Ge lie at a lower altitude and are relatively poor in rainfall and biodiversity; however, Class Gd is very rich in plant diversity. Class H covers deserts and semi-deserts of the tropics in three classes, Ha–Hc. The annual mean temperature is over 24 °C, the mean temperature of the warmest quarter is around 30 °C, and the precipitation is extremely low, especially in classes Hb and Hc, with most of the precipitation occurring during the wettest quarter and less than 5% occurring during the driest quarter. The area is at a low altitude and the terrain is very flat. Class Ha is the smallest of these three classes and has a higher diversity of mammals and birds. Class Hb is species-poor, and the extensive Class Hc is very species-poor. The subequatorial region with a drier period is described by Class I, further subdivided into five classes, Ia–Ie. The annual mean temperature is high, the temperature annual range is low, and the precipitation is above average but only 3 to 6% falls during the driest quarter. Classes Ia and Ib are extremely species-rich, and Classes Id and Ie have below average faunal species richness, but Class Id is rich in plant species due to high rainfall. And finally, on the other side of the classification is Class J, characterising the warm and humid equatorial region, subdivided into four classes Ja–Jd. The annual mean temperature is around 25 °C in all classes, the temperature annual range is extremely low, and the precipitation is very high at over 2300 mm, with plenty even in the driest quarter. The altitude is very low. Class Ja is the richest of all thirty classes in the diversity of mammals, birds, amphibians, and plants, Class Jb is also above average rich in fauna and flora. Classes Jc and Jd do not have a very diverse fauna, but there are over 5000 species of plants in Class Jc.

- Class A

This class is a combination of abiotic Class 1 as a whole and a part of biotic Class 7, which makes this area the coldest one with the lowest biodiversity. In this arctic region, there can be found on average 8 species of mammals, 24 species of birds, or 213 species of plants.

- Class B

Class B combines abiotic Class 2 with parts of biotic Class 2 and 7. Biodiversity is low, with an average of 28 mammal species, 103 bird species, or 900 plant species. All other classes from 'C' to 'J' are further divided into two, three, four, or five classes.

- Class Ca

The mountain region, occupying 1.06% of the landmass, is found on all continents except Australia and Oceania, represented in the American Cordillera, eastern Africa, Lesotho, Sierra Nevada and the Pyrenees, the Caucasus, the Taurus Mountains, and the mountain systems of Central Asia and North Korea. The annual mean temperature across the region ranges from −21.4 °C to +23.6 °C, with an average annual precipitation of about 660 mm. The region hosts an average of 69 mammal species, 218 bird species, and over 2500 plant species. There are also sites with more than 650 bird species (Africa) and 6500 plant species (South America).

- Class Cb

Also a mountainous region, it occupies a smaller share of the world (0.31%) in Central and South America and Eurasia (Mexico, Guatemala, the Andes from Colombia to Peru, the Alps, the Caucasus, and southwestern China). It extends a little lower at an average altitude of about 2600 m above sea level, peaking at over 5.5 km. The territory has a very rugged character. The average temperature here is 5.5 °C higher at 8.3 °C. In particular, the coldest quarter is significantly warmer (+3.7 °C) compared with class Ca (−6.6 °C) and Cc (−11.5 °C). The annual precipitation is higher, with 1063 mm falling. Biodiversity indicators also show higher numbers, with an average of 99 mammal species, 258 bird species, and over 5000 plant species inhabiting the region, with a local maximum of 8500 plant species.

- Class Cc

Another of the high mountain regions. It occurs in North and South America and Asia, extending to the peaks of the Himalayas, the largest in area (3.05%). The highest placed class at an average altitude of 3850 m above sea level. The climate is cool, with an annual mean temperature of −1.1 °C and annual precipitation of 322 mm. The biodiversity of fauna and flora is below average, as there are 34 species of mammals, 108 species of birds, and 1219 species of plants.

- Class Da

A wide belt from Alaska to eastern Canada, Lapland, a vast area from the White Sea through Kazakhstan, Mongolia and China to Sakhalin, and a belt along the Sea of Okhotsk. It is the second largest region of all (9.45%) and lies in the subarctic and temperate zone of the Northern Hemisphere. The annual mean temperature is negative, namely −0.98 °C. The region has a high temperature annual range of almost 48 °C, with some places being even over 62 °C. The mean temperature of the warmest quarter is over +15 °C, while during the coldest quarter it is below −18 °C. The annual precipitation is below average at 507 mm. The area is situated at an average altitude of 427 m above sea level, and the vertical heterogeneity is low. The diversity of fauna and flora is slightly below average.

- Class Db

The region occupies a much smaller area (1.53%) in the subarctic and temperate zone of western Alaska, eastern Canada, northern Scandinavia, northern Russia from the Pechora Sea to the Yenisei, Mongolia, Kamchatka, and the Bering Sea belt. It is located in a cooler area with an annual mean temperature of −5.35 °C, and it is slightly richer in precipitation (547 mm/year). The territory is not very rugged, and it lies at a low altitude of 270 m above sea level. Biodiversity is rather low, with an average of only 26 mammal species, 72 bird species, and 779 plant species. Even the most species-rich sites here are below the normal average.

- Class Ea

The region has most of its land area (2.82%) in the temperate zone, with a small part of the area extending into the subtropics, located in the west and east of the USA, Europe from Spain to Russia, North Korea, Honshu, and southeastern Australia. In most indicators, the defined territory appears very average. The number of species of mammals (55), birds (168), amphibians (13), and plants (2385) is slightly below average. The average annual temperature is 7.77 °C; a total of 743 mm of rainfall can be measured per year, and 127 mm falls during the driest quarter. The area is moderately rugged and lies at an average altitude of around 350 m above sea level.

- Class Eb

A very small region in the Alps, it occupies only 0.06% of the land area. It has higher species richness of mammals (65 species) and especially plants (4955 species). It is a very rugged area, lying at a higher altitude of 1448 m above sea level, which corresponds to a lower annual mean temperature (3.97 °C) and higher annual precipitation (1293 mm).

- Class Ec

A belt from Alaska to the north of the USA, then eastern USA/Canada; Patagonia; a wide belt from northern Spain, along the English Channel, the North Sea, and the Baltic Sea; the British Isles; Jutland; Scandinavia; from Estonia to Russia; Korea; Hokkaido; Sakhalin; the Kuril Islands; and Tasmania. The region occupies the entire width of the temperate zone of the Northern and Southern Hemisphere and the nearest adjacent subtropics with a proportion of 2.76%. It lies at an altitude of 437 m above sea level. The annual precipitation is around 860 mm, with higher totals on the windward side of the coasts of North and South America and Scandinavia, and the annual mean temperature is 4.28 °C. Biodiversity here is below average.

- Class Ed

Class Ed can be found in Alaska, the Aleutian Islands, Newfoundland, Labrador, Patagonia, the Falkland Islands, the south coast of Greenland, Iceland, Svalbard, the north of the British Isles and Scandinavia, the south of Kamchatka, and New Zealand, and it occupies 1.44% of the land area. The area has an altitude of about 375 m above sea level. It is the coldest area of abiotic Class E, with an annual mean temperature of less than 2 °C and in some segments almost −9 °C. Annual precipitation is 1000 mm, but the windward side of the South Island of New Zealand and Patagonia has rainfall of 5900 and 6700 mm/year, respectively. Biodiversity of flora and fauna is very low.

- Class Fa

The temperate latitudes and subtropics of North America and Eurasia, with a share of 2.68% (southern Canada, the interior of the United States, northern Mexico, a territory from Turkey through Transcaucasia to southwestern Russia, Central Asia, China, and a strip of land by the Sea of Japan). The region has an annual mean temperature of 8.64 °C, a temperature annual range of almost 40 °C, an annual precipitation of 547 mm, and an altitude of 865 m above sea level. The diversity of the fauna is slightly below average; the flora is richer with an average of 2435 plant species, but there are up to 5000 in places.

- Class Fb

A large region (7.18%) of the Northern Hemisphere also in the temperate latitudes and subtropics. Class Fb is located in southern Canada, the interior of the USA, Morocco, a vast territory from Turkey to North Korea, and from Russia and Kazakhstan to Iran and Pakistan. There is a very similar annual mean temperature (8.54 °C) and an even higher temperature annual range of over 44 °C. Annual precipitation in the region is less than 300 mm, with only 9% of the total falling during the driest quarter. The area lies at an altitude of 836 m above sea level, but there are also sites above 5000 m. The diversity of fauna and flora is lower and rather below average.

- Class Ga

One of the smaller regions (0.87%); it lies between the subtropical and subequatorial zones in Central (Mexico) and South America (a discontinuous belt from Ecuador to Bolivia, south of Brazil), south of South Africa, and especially eastern Asia (Myanmar, China). This class has an altitude of 1037 m above sea level and high ruggedness. The annual mean temperature, as in the Gc–Ge regions, is over 16 °C. Annual precipitation is high at 1338 mm. The biodiversity of the region's fauna is high, and flora has an average of 5549 plant species and, in some places, 9000 species.

- Class Gb

A region with a proportion of 1.51% occupying similar locations that are only higher (1321 m above sea level, maximum around 5500 m), in America (Mexico, Venezuela, Bolivia, Argentina, southern Brazil) and Asia (India, Nepal, Bhutan, Myanmar, and China) and most abundant in Africa (southern Africa, the East African Rift). The annual mean temperature of 18.36 °C is higher than in the other four regions. The annual precipitation is 969 mm, more than half of which falls during the wettest quarter of the year, while only 5% falls during the driest quarter. The biodiversity of the fauna is even higher, with an average of 103 mammal species, 375 bird species, and 27 amphibian species. The flora, on the other hand, is not so rich; the region hosts 2567 plant species.

- Class Gc

A region occupying 5.89% with significant latitudinal banding. The core is in the subtropics of the Northern Hemisphere and around the Tropic of Capricorn: the southwestern and southeastern USA; the interior of Mexico; Bolivia; Argentina; Uruguay; southern Brazil; southern Africa; Madagascar; Ethiopia; Eritrea; the Mediterranean; the Black and Caspian Sea area; a discontinuous belt from Pakistan to eastern China; Honshu; Kyushu;

Shikoku; and the southern and southeastern part of Australia. On average, this is a lower lying area around 610 m above sea level. The annual rainfall is 907 mm, which is more regularly distributed throughout the year. Diversity of fauna is still above average but is considerably lower; this class has a similar number of plant species (2520) as the Gb region.

- Class Gd

Class Gd is a very small region (0.10%) occurring in the subtropics of the Mediterranean (Sardinia, Sicily, Malta, Lebanon, etc.), South Africa, Namibia, and Japan. It is very similar in temperature and poorer in rainfall (396 mm/year). It lies at the lowest altitude within class G, around 429 m above sea level. The diversity of mammals, birds, and amphibians is below average, but the flora is very rich, with the area hosting 4012 plant species on average. The region lies in the biodiversity hotspots of the Mediterranean, Cape Floristic Region, Succulent Karoo, or Japan.

- Class Ge

One of the larger-than-average regions (4.32%) found on all continents at an altitude of 576 m above sea level on average. Its distribution is strikingly reminiscent of the Mediterranean vegetation type, found in the southwestern USA, a belt from Peru to Chile, Bolivia, Argentina, from Angola to South Africa, in the mountainous areas of Sahara, the Mediterranean, the Caspian Sea area, Saudi Arabia, Yemen, a narrow discontinuous belt of Turkey–Iraq–Iran, Afghanistan–Pakistan, eastern China, South Korea, Honshu, in a southern part of Australia, and northern New Zealand. The average annual precipitation is 422 mm. The diversity of fauna is similar to that of the Gd region, but here, the diversity of plant species is below average.

- Class Ha

The region occupies 1.58% of the land area in the southern USA and northern Mexico; Bolivia; Paraguay; Argentina; Botswana; Zimbabwe; South Africa; Mozambique; in a discontinuous belt from Senegal to Ethiopia; Pakistan; India; and eastern Australia. It lies at an altitude of 403 m above sea level, and the surface is not very rugged. The annual mean temperature in all three regions is around 24 °C, with the highest rainfall in the area of this class (466 mm/year). As in the Hb and Hc regions, only about 4–5% of the rainfall falls in the driest quarter. Mammal and bird diversity is above average, while amphibian and plant diversity is slightly below average.

- Class Hb

This region has a larger share of 5.98% and is typical of the southwestern USA, Baja California peninsula, Argentina, Namibia, South Africa, Botswana, a continuous belt from Mauritania to Sudan, the area around the Red Sea and the Gulf of Aden, Morocco, Algeria, Tunisia, Libya, Egypt, from Syria to India, and the west and interior of Australia. It is situated at an altitude of 381 m above sea level on average and is not very vertically heterogeneous too. It extends up to an altitude of about 420 m below the world ocean level. The annual precipitation is only 256 mm. Biodiversity here is lower than in Ha and is overall below average.

- Class Hc

A very extensive area (9.28%) of the tropics and subtropics from the Western Sahara to the Arabian Peninsula, Iran, Afghanistan, Pakistan, and inland Australia. The least vertically heterogeneous region of all, it lies at an altitude of 467 m above sea level. The temperature is very similar, with only a slightly higher temperature annual range. It is a very dry area with an average of only 64 mm of rainfall per year, with less than 3 mm in the driest quarter. It has the second poorest fauna and the third poorest flora, averaging only 18 species of mammals, 39 species of birds, 2 species of amphibians, and 717 species of plants.

- Class Ia

A tropical region with an area share of 3.23%, it is most represented in Central (from Mexico to Nicaragua) and South America (a discontinuous arc from Guyana to Peru, Bolivia, Brazil, Paraguay, Argentina), and then from Cameroon to Gabon, from Myanmar to southern China, and Hainan. This region, situated at an altitude of around 527 m above sea level, has an annual mean temperature of 22.89 °C and an annual precipitation of 1467 mm, with a temperature annual range only ranging between 8 and 28 °C. Very rich fauna and flora, on average 127 mammal species, 398 bird species, 44 amphibian species (max. 135), and 5994 plant species (max. 9000).

- Class Ib

The region occupies 3.31% of the world's land area, much of which is in Africa (Ivory Coast, Ghana, central and eastern Africa), South America (Venezuela, Peru, Bolivia, Brazil) and Farther India at an altitude around 718 m above sea level. It is very similar in temperature and slightly poorer in precipitation (1216 mm/year). The fauna is also very rich, on average having 132 species of mammals, 402 species of birds (max. 666), 39 species of amphibians, and the flora is only about half as rich, on average having 3024 species of plants growing in the region.

- Class Ic

A very large region (10.20%), typical especially of the subequatorial belt; it can be found everywhere except Europe: from Mexico to Nicaragua, Florida, Cuba, from Venezuela to Ecuador, Bolivia, Brazil, Paraguay, Argentina, a continuous belt from Senegal to Somalia, central and eastern Africa, Madagascar, Sri Lanka, the peninsulas of India and Farther India, Taiwan, Sumatra, Sulawesi, Flores, and northern and northeastern Australia. It is located at an altitude of 459 m above sea level and is not very rugged. The annual mean temperature is higher at 25.28 °C. The annual rainfall is 1071 mm but is only 3% during the driest quarter. For this reason, the region hosts on average 'only' 2223 plant species. The diversity of fauna is also lower here but is still well above average.

- Class Id

The area of this class is very small (0.08%), and it is located, e.g., in the Dominican Republic, Madagascar, or New Caledonia at an altitude from sea level to about 1800 metres above sea level. The annual mean temperature is 22.3 °C and rainfall is 1500 mm/year. The diversity of fauna is very low within Class I and is also rather below average overall. On the contrary, 3374 plant species can be found in this small class.

- Class Ie

One of the smaller regions (0.90%) comprising many islands of the tropical and subequatorial belt (Hawaii, Cuba, western Hispaniola, the Bahamas, a part of the Lesser Antilles, the Galápagos Islands, Reunion, Sumba, Timor, Wetar, New Caledonia, Vanuatu. . .), plus Madagascar, the Horn of Africa and surroundings, southern Florida, Peru, and the northern part of Australia. It lies at a low altitude of 294 m above sea level but extends to the summit of Maui. The annual mean temperature is 25.32 °C, and the annual precipitation is lower at only 845 mm. Compared with Class Id, the fauna is slightly richer, but the flora poorer, with 1860 plant species on average.

- Class Ja

Class Ja, with a share of 5.77% of the land mass, is mainly located in the equatorial belt in Americas, and especially in Amazonia (from Mexico to Bolivia and Brazil), Africa (from Cameroon to Gabon) and southeastern Asia (the Malay Peninsula, Borneo, Sumatra, New Guinea). The Ja–Jd regions all have a high annual mean temperature of 24.9 to 25.5 °C, a very low temperature annual range of 10.6 to 13.3 °C, similar precipitation totals of 2350 to 2650 mm/year, and a similarly low altitude of 214 to 301 m above sea level on average. In some areas, however, the annual precipitation can exceed 11,300 mm. The diversity of flora and fauna is the highest of any region. On average, there are 155 mammal species, 446 bird species, 63 amphibian species (max. 135), and 6305 plant species (max. 10,000).

- Class Jb

The region is slightly smaller in area (3.78%) and has a significantly smaller presence in the Americas (coastal areas of Central America, from Peru to Guyana, Brazil, Trinidad), while it occupies a significant area in Africa (a coastal belt from Guinea-Bissau to Ghana and from Benin to Cameroon, Gabon, Congo, the Democratic Republic of the Congo, and Madagascar), southern and southeastern Asia (a west coast of India, Sri Lanka, Nepal, from Bhutan to Malaysia, Farther India, the Sunda Islands, the Moluccas, the Philippines, Taiwan, New Guinea), and northern Australia (the Cape York Peninsula). The maximum annual precipitation exceeds 11,400 mm. There is a greater difference between the wettest and the driest quarters. Biodiversity is lower, at about two-thirds for fauna and one-half for flora, but it is still well above average.

- Class Jc

One of the smallest regions (0.15%) which, apart from the east of Madagascar, comprises mainly small islands and islets (smaller islands of the Malay Archipelago, or the Solomon Islands). The diversity of the fauna is slightly below average, but the flora is very rich, with 5046 plant species on average and a maximum of about 10,000 species.

- Class Jd

This is also a very small region (0.21%) that spreads over tropical islands and archipelagos (Jamaica, Puerto Rico, the Lesser Antilles, São Tomé and Príncipe, Madagascar, the Comoros, the Seychelles, Mauritius, the Maldives, the Andaman and Nicobar Islands, small islands of the Malay Archipelago, and Oceania). It has the lowest temperature annual range of 10.6 °C and an altitude of 214 m above sea level. The diversity of the fauna is slightly lower, and the diversity of the flora is significantly lower, with a below average 1767 plant species.

3.1.5. GES Classification

Global Environmental Systems are the final result of the classification process. The classification of natural conditions (30 classes) was combined with the anthropogenic classification (10 classes), resulting in 169 unique Global Environmental Systems out of 300 possible (Figures 6 and 7). Each GES has its own code assigned. The code consists of one or two letters ('A' to 'J', and 'a' to 'e') and a number (1 to 10), e.g., A9, Hc7, or Db10. The letters in the title indicate abiotic + biotic affiliation, and the number indicates affiliation to the anthropogenic class.

A Global Environmental System with the designation Hc9 is the most widespread in the world, occupying 8.32% of the world's land area from the Western Sahara to the Arabian Peninsula, Iran, Afghanistan, and Pakistan. It is a region of bare areas with high temperature, the lowest precipitation, and low vertical heterogeneity, human impact, and biodiversity. Class Ja6 occupies 5.3% of the world in the equatorial region of America, Africa, and Asia. The dominant land cover is broadleaved, evergreen forest with the highest diversity of mammals, birds, and amphibians and the third highest diversity of flora. This region is typical of high temperature and precipitation and has a low temperature annual range. The third largest GES is B10 (4.41%) in Alaska, Canada, and Russia. It is a very cold region of needleleaved, deciduous forest with the second highest temperature annual range, low biodiversity, and human impact. Global Environmental Systems Ic5 and Da4 cover over 3%; Ic8, Ic7, Da5, Fb9, Fb8, Gc8, and Hb8 cover over 2%. In contrast, classes Gd2 and Hc2 cover only about 0.001% of the Earth's landmass.

The full details of each of the 169 GES classes can be found in Appendix A; the Global Environmental Systems classification is openly available in the Science Data Bank [38].

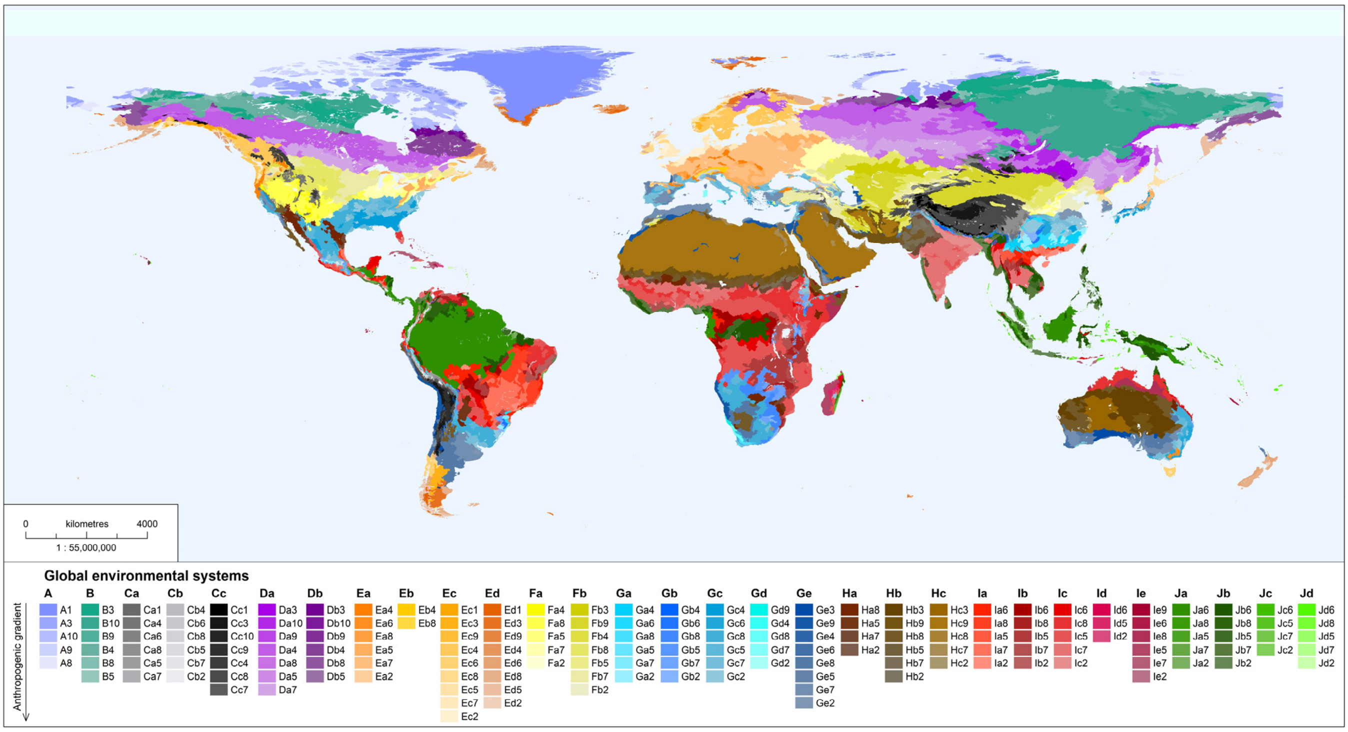

Figure 6. Global Environmental Systems (Tables 7 and 8).

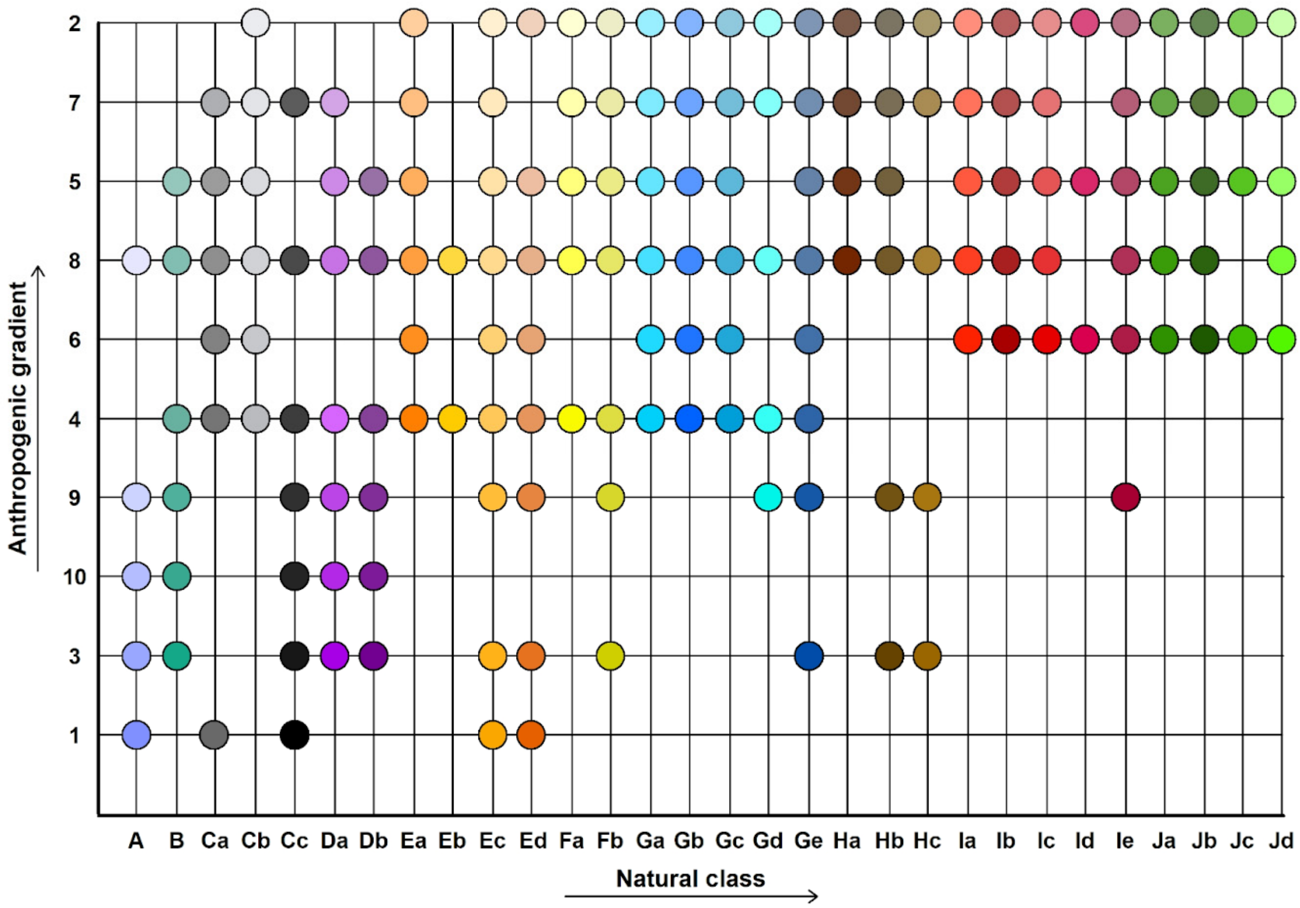

Figure 7. Synthetic diagram of the combination of natural conditions and anthropogenic gradient (Tables 7 and 8).

3.2. Biodiversity Conservation Prioritisation—Biodiversity Hotspots Concept

Biodiversity hotspots are those areas where the highest concentrations of endemic species can be found. At the same time, however, these are areas that are facing enormous loss of natural habitat. The concept of terrestrial biodiversity hotspots, very important areas for biological conservation, was first introduced by the British ecologist Norman Myers [39] and adopted by Conservation International a year later [40]. Biodiversity hotspots must meet two strict criteria: every hotspot must contain at least 1500 endemic vascular plant species and must have lost at least 70 percent of its primary native vegetation. There are currently 36 biodiversity hotspots on Earth, the last one having been established in 2016. Biodiversity hotspots cover 2.4% of the Earth's land area and harbour about 50% of endemic plant species and 42% of endemic terrestrial vertebrate species [41].

Thus, it is no great surprise that abiotic classes 1: freezing arctic region; 2: cold northern region with a significant temperature annual range; and 4: colder temperate zone of the Northern Hemisphere are not present in the biodiversity hotspots. Many hotspots are located partially or completely in the mountains, so Class 3: region of the highest mountains covers more than 9% of the total area of hotspots (Table 9). Two other temperate regions, Class 5: humid temperate region; and 6: Warmer and drier temperate zone of the Northern Hemisphere, cover 3.37% and 5.66%, respectively. Class 8: deserts and semi-deserts of the tropics is found in 4.81% of the hotspot area. The most suitable conditions for the existence of biodiversity hotspots have Class 7: subtropics of both hemispheres; 9: extensive subequatorial region with a drier period; and 10: warm and humid equatorial region. These classes occupy 24.10%, 33.39%, and 19.51% of the area of biodiversity hotspots, respectively.

Table 9. Abiotic classes within biodiversity hotspots.

Abiotic Class	Class Area in Hotspots [%]	Global Class Area [%]	Representation in Hotspots [%]
1	0.00	3.38	0.00
2	0.00	7.11	0.00
3	9.16	4.42	38.66
4	0.00	10.98	0.00
5	3.37	7.08	8.87
6	5.66	9.86	10.71
7	24.10	12.70	35.38
8	4.81	16.84	5.32
9	33.39	17.73	35.11
10	19.51	9.91	36.71

The abiotic classes of the Arctic and temperate zones (1, 2, 4, to 6) account for 38.41% of the world's land area but only 9.03% of the area of biodiversity hotspots. An azonal mountain Class 3 covers 4.42% of the Earth's landmass but 9.16% of the hotspots area. This means that almost 40% of the area of this class lies in hotspot territory (Figure 8). The abiotic classes of the subtropic and tropic zones (7 to 10) account for 57.18% of the world's land area but 81.80% of the area of biodiversity hotspots. And without the inhospitable desert Class 8, it is 40.34% globally and 77% within hotspots. These three classes have over 35% of their area in hotspots, while Class 8 has only 5.32% (Figure 8).

Biotic Class 7: region with the lowest species richness is very extensive, but only around 3% of its total area is in hotspots (Table 10, Figure 9). This class is found in only 4.21% of the hotspots area, which is the third lowest share. Class 2 is the largest globally and in hotspots, where it occupies 22.30% of the area. However, this is only 12.75% of the global class area. Class 3 has a richer fauna and flora and is thus the first with a larger proportion in the hotspots than at the global level. This is true for all subsequent classes except the richest one: Class 6. Class 3 occurs in almost one-fifth of the hotspot area. Class 5 is very specific with a low diversity of fauna but very high diversity of flora. This class is very small, so it covers only

2% of the area in the hotspots. However, this is almost 75% of the global area of this unique class. Class 8 covers 6.25% of hotspots area, and the slightly richer Class 10 covers 13.34%. The next class is Class 4, which does not differ much from the previous one in diversity of fauna but has a very rich flora. It accounts for 10.51% of the area of hotspots. The class with the third highest faunal biodiversity, but no exceptional flora, is Class 9, covering 7.65% of the hotspots territory. Class 1 again shows a slightly higher diversity of fauna than the previous class, the second highest, but the diversity of flora is twice as high and is the highest overall. Class 1 is abundant in biodiversity hotspots. Classes 3, 8, 10, and 9 have progressively higher species richness, but the diversity of flora is only slightly above average in all of them. They all have a very similar representation in hotspots, ranging from 24.47% to 28.11% of the total class area. Classes 4 and 1 both show very rich flora, and both are abundant in hotspots at 66.43% and 69.22%, respectively. The same pattern works for Class 5, which even shows a representation of 74.92%. Classes with high floral diversity are concentrated in biodiversity hotspots areas. Class 6 is the richest class, but it occupies only 1.39% of hotspots. Here in the biodiversity hotspots, it is a smaller proportion than at the global level (3.81%). This is due to the fact that most of the species-richest Class 6 is fortunately located in wilderness areas such as Amazonia or the Congo Forests of Central Africa and not in the anthropogenically heavily impacted biodiversity hotspots.

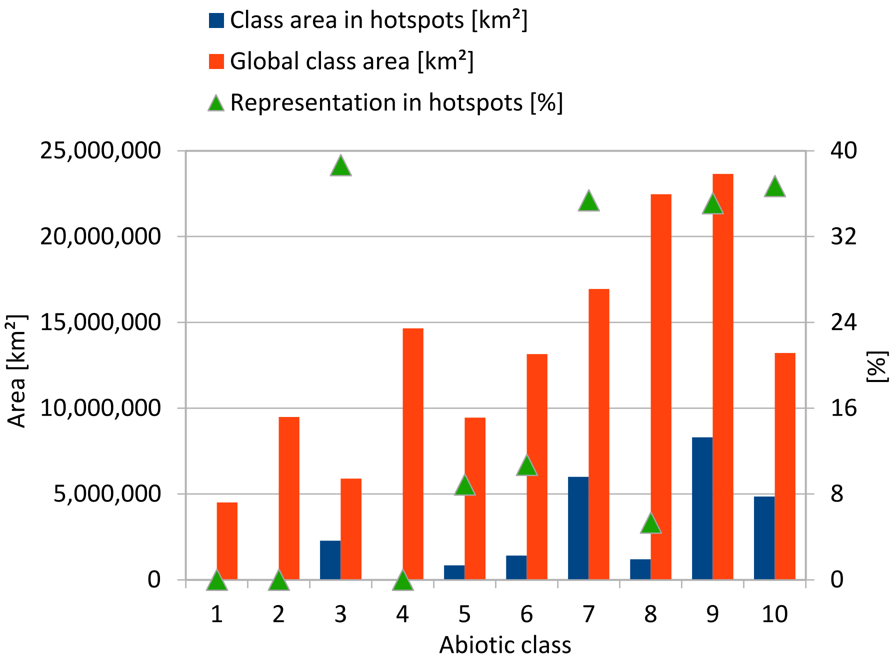

Figure 8. Abiotic classes within biodiversity hotspots.

Table 10. Biotic classes within biodiversity hotspots.

Biotic Class	Class Area in Hotspots [%]	Global Class Area [%]	Representation in Hotspots [%]
7	4.21	23.50	3.34
2	22.30	32.61	12.75
3	19.98	14.59	25.54
5	2.09	0.52	74.92
8	6.25	4.76	24.47
10	13.34	8.85	28.11
4	10.51	2.95	66.43
9	7.65	5.10	27.96
1	12.29	3.31	69.22
6	1.39	3.81	6.81

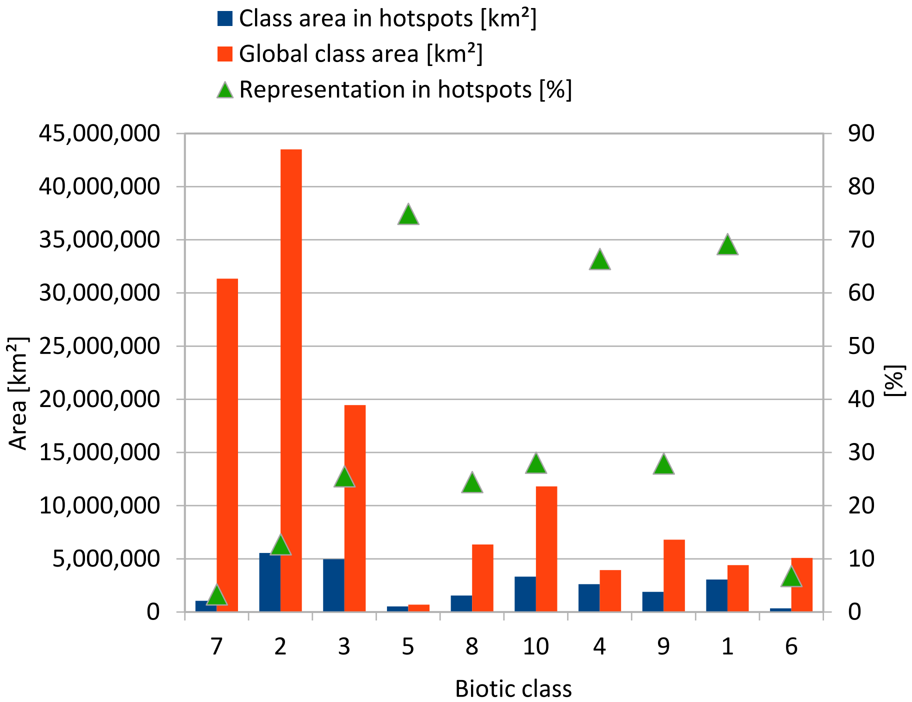

Figure 9. Biotic classes within biodiversity hotspots.

From 30 combined natural classes, 26 are present in the hotspots. Classes A, B, Da, and Db are missing. Four classes cover more than 10% of the total hotspot area. Class Ia, characterised as an extensive subequatorial region with a drier period with very high biodiversity, occupies the largest share with 14.12%. Class Gc, a region of moderately species-rich subtropics, covers 12.02%. Class Ic is also an extensive subequatorial region with a drier period, this time with slightly above average biodiversity. This class covers 11.47% of the hotspots area. And finally, Class Jb, a warm and humid equatorial region with well above average biodiversity, covers 10.31%. Classes Ja and Ge are next with a share of over 7.5%, then classes Cc, Fb, and Ib with a share of over 4%, and so on up to class Id (0.44%, i.e., 109,082 km^2). And finally, Class Eb is by far the least represented with only 11 km^2.

Anthropogenic Class 1 does not occupy a large share globally (1.98%) and even less in biodiversity hotspots (0.92%), being found mostly in Asian mountain hotspots with permanent snow and ice. Only 2.91% of the Class 3 global area lies in hotspots (Table 11, Figure 10), where sparse vegetation land cover class covers 0.96% of the total hotspot area. Class 10, characterised by very low human and livestock density and needle leaved, deciduous tree cover and lichens and mosses, is not present in the biodiversity hotspots area at all. Class 9, characterised by different bare areas, occupies the third largest area globally but only 4.44% in the hotspots. Another class with a relatively small representation in biodiversity hotspots is Class 4 (4.85%), dominated by tree cover, needle leaved, evergreen. Class 6, on the other hand, accounts for 19.6% of the hotspots area, which is the third highest share. Almost one-third of this class is in hotspots. Human and livestock density is already a bit higher in this region, and the typical land cover is tree cover, broadleaved, evergreen. Class 8 is the second most represented in the hotspots territory (20.75%). It is the area of shrublands and grasslands. Another important class is Class 5 (11.51%), which has the third highest human density and accessibility, and broadleaved, deciduous, or mixed leaf type tree cover, mosaic tree and shrub/herbaceous cover, or flooded tree/shrub/herbaceous cover. The last two classes are Class 7 and Class 2, both with more than 34% of their total global area being located in biodiversity hotspots. Class 7 has the second highest values of all anthropogenic indicators; it is typical of cropland land cover and occupies 28.99% of the hotspots area. Class 2 has the highest values of all anthropogenic indicators; it is typical of cropland land cover or mosaic cropland/natural vegetation and occupies 7.98% of the hotspots area.

Table 11. Anthropogenic classes within biodiversity hotspots.

Anthropogenic Class	Class Area in Hotspots [%]	Global Class Area [%]	Representation in Hotspots [%]
1	0.92	1.98	8.66
3	0.96	6.17	2.91
10	0.00	5.82	0.00
9	4.44	14.25	5.81
4	4.85	8.19	11.03
6	19.60	11.19	32.67
8	20.75	19.94	19.40
5	11.51	12.31	17.43
7	28.99	15.88	34.04
2	7.98	4.26	34.95

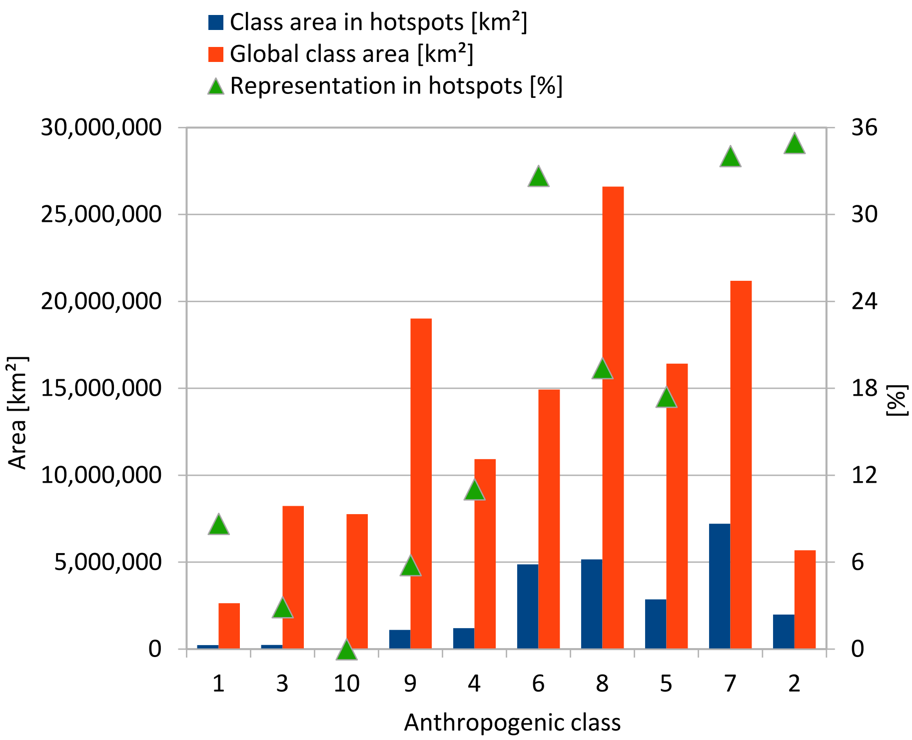

Figure 10. Anthropogenic classes within biodiversity hotspots.

Biodiversity hotspots are areas with significant fauna and flora but also intense human impact. Anthropogenic classes with lower human impact (1, 3, 10, 9, and 4) cover only 11.17% of biodiversity hotspots while anthropogenic classes with higher human impact (6, 8, 5, 7, and 2) cover 88.83% of the area of biodiversity hotspots, and globally, the ratio is 36.41% to 63.58%. This shows that valuable hotspot areas are more threatened by different types of human activity than the rest of the world.

Biodiversity hotspots can be classified to identify the most significant hotspots. The analysis of hotspots' importance by Myers et al. [36] was driven by two criteria: species endemism and the degree of threat, and it considered five factors: numbers of endemics and endemic/species ratios for plants and vertebrates and habitat loss. Hotspots, which appeared the most often in the top ten listings for each factor, were the most important. The analysis by Hrdina and Romportl [37] considered thirteen factors: the numbers of endemics and endemic/species ratios for plants, mammals, birds, amphibians, reptiles and freshwater fish, and habitat loss. For the purposes of qualitative comparison, the rankings of each factor were compiled and the top twelve listings for each factor were considered. Biodiversity hotspots, appearing for all thirteen factors in the top twelve listings, are the most important.

From articles by Myers et al. [36] and Hrdina and Romportl [37], it is clear that these six biodiversity hotspots are clearly the most significant: Madagascar and the Indian Ocean Islands, Sundaland, the Philippines, the Caribbean Islands, Indo-Burma, and Atlantic Forest. Five of them contain only anthropogenic classes with higher human impact (2, 7, 5, 8, or 6); only in Indo-Burma is 2.62% of this hotspot occupied by anthropogenic Class 4, which is nevertheless the class with the sixth highest human impact. A closer look at individual biodiversity hotspots shows that the most important ones face a great anthropogenic impact.

Out of a total of 169 Global Environmental Systems, 134 are located in hotspots. The most widespread GESs in hotspots is an equatorial Class Ja6 with the highest species richness of amphibians, birds, and mammals and the third highest number of plants, with predominant tree cover, broadleaved, evergreen, which covers 5.62% of the total area of biodiversity hotspots. Over 5% of the area is also occupied by tropical Class Ia7 (5.39%), which is also very rich in species but is under much greater human pressure. Then, there are three classes over 4%: Ge7, Ia8, and Jb6; three classes over 3%: Gc7, Ic8, and Ic7; seven classes over 2%: Gc4, Jb7, Ic5, Ia6, Fb7, Gc8, and Jb2; and ten classes over 1%: Cc8, Ic6, Ca8, Gc2, Ib7, Gc5, Ie5, Hb9, Ja2, and Ib5. The remaining 109 GESs occupy less than 1% of the area. The most unique GES is Hb5 with an area of only 5.7 km^2. All five A classes, six B classes, seven Da classes, and six Db classes are not located in hotspots. Furthermore, there are no GESs Cc10, Ea6, Eb4, Ec1, Ec9, Ed4, Ed9, Fb3, Fb4, Hc2, and Hc3 in biodiversity hotspots.

The presented combination of both spatial concepts of environmental quality assessment and the level of its human degradation across abiotic gradients gives us information about the areal distribution, the level of vulnerability, and the priority of the natural protection of specific regions of our planet.

4. Discussion

Several different classifications have emerged over the years. In 2008, Ellis and Ramankutty [6] published the classification of anthropogenic biomes, followed by Ellis' anthromes in 2010 [13]. In 2012, Letourneau et al. [22] presented the classification of land-use systems and Van Asselen and Verburg [23] the classification of land systems. A year later, Václavík et al. [24] came up with the classification of land system archetypes. In 2020, the classifications of world ecosystems [2] and the IUCN Global Ecosystem Typology [25] were released.

Anthropogenic biomes and anthromes are based on the global data of population, land use, and land cover, not using biotic or abiotic factors. Land-use systems are characterised by land cover, land use, and population data too, plus livestock density and accessibility. Land cover, livestock, and agricultural intensity data were used for the classification of land systems, with land use intensity being a crucial characteristic, while population density was not used as a classification criterion at all. Land system archetypes are based on 32 indicators that are socioeconomic, but also biotic and abiotic. All five classifications have a resolution of 5 arc minutes. The classification of GESs has a resolution of 30 s, as does the IUCN Global Ecosystem Typology. The finest resolution of 8 arc seconds has the classification of world ecosystems that is based on global moisture domains, global temperature domains, global landforms, and finally global vegetation and land use. In this classification, no socioeconomic data were used. GES classification uses 22 variables characterising abiotic, biotic, and anthropogenic conditions.

The authors of anthropogenic biomes, anthromes, land-use systems, and land systems classifications all applied top-down approaches based on expert's rules or a priori classification; Václavík et al. [24] used a bottom-up approach for the classification of land system archetypes, while Keith et al. [25] used the combination of both bottom-up and top-down approaches for the IUCN Global Ecosystem Typology. It was created as a hierarchical classification, where functional variation among ecosystems is represented in the upper three levels developed from the top-down approach, while compositional variation is represented in the lower three levels. Sayre et al. [2] used the structural approach. The map of world ecosystems was derived from the objective development and integration of different global natural elements.

The classification of Global Environmental Systems consists of ten abiotic classes at the upper level. A total of 10 biotic classes are added at the middle hierarchical level, resulting in 30 natural classes. And finally, at the bottom level, ten anthropogenic classes enter the classification. There are 169 different GESs at this level of classification. It is the most similar to the IUCN Global Ecosystem Typology that consists of 5 global realms, 25 biomes, and then 108 ecosystem functional groups, etc. Anthropogenic biomes, anthromes, land-use systems, and land systems all have a very similar structure. These classifications are grouped into six or eight categories in the case of land systems. Each category is further divided into individual classes; in total, there are 21, 19, 24, and 30 classes, respectively. Land system archetypes and world ecosystems have a different structure, and they also differ from each other; there are 12 and 431 classes, respectively, which are not further divided.

5. Conclusions

The new classification of Global Environmental Systems is a high-resolution spatial delineation of many different combinations of partial abiotic and biotic classifications based on gradients of inanimate and living nature and anthropogenic classification reflecting the degree of human impact. A total of 169 GESs were identified and mapped. The proposed procedure of defining Global Environmental Systems outperforms previously developed classifications mainly by the complexity of the input data and their thematic and spatial resolution.

The Global Environmental Systems presented in this article can serve in many ways to better understand the changing world, human pressure on the natural sphere, interactions between humans and the natural environment, etc., not just at the global level, which would help to find common patterns across continents where similar actions can be taken or to help with conservation activities.

The use of delineated GESs can be applied as a typological spatial framework for assessing global environmental processes, whether they be climate change impacts, land use/land cover changes, ecosystem service dynamics, or changes in biodiversity distribution. Similarly, GESs can be used to monitor these processes; the changes in the defined GESs will indicate changes in the whole complex of environmental conditions.

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Abbreviations

GES	Global Environmental System
Temp.	Temperature
Precip.	Precipitation
Heterogen.	Heterogeneity
TPI	Topographic Position Index
GLC	Global land cover

Appendix A

Table A1. GES of the freezing arctic region.

GES	Mammal Species	Bird Species	Amphibian Species	Plant Species	Annual Mean Temp.	Mean Temp. of Warmest Quarter	Mean Temp. of Coldest Quarter	Temp. Annual Range	Annual Precip.	Precip. of Wettest Quarter	Precip. of Driest Quarter	Altitude	Vertical Heterogen.	TPI	Livestock	Human Density	Accessibility	Prevailing GLC Class	Prevailing GLC Class [%]	Area [km^2]	Area [%]
A1	3.26	9.59	0.00	34.88	−18.27	−3.66	−30.14	34.74	656.36	209.43	132.29	1699.82	25.78	1.25	0.61	0.01	10,750.06	17	79.76	1,996,435	1.497
A3	11.04	33.45	1.00	393.10	−13.44	2.68	−27.43	40.21	263.57	104.23	39.65	272.70	41.47	−2.36	0.61	0.04	4832.39	12	43.29	1,036,034	0.777
A8	17.82	53.11	1.00	606.19	−9.44	5.15	−22.61	38.17	295.32	122.30	41.41	238.19	49.03	0.57	0.07	0.17	3348.53	16	27.17	194,643	0.146
A9	8.48	25.53	1.00	287.08	−17.37	1.29	−32.80	43.56	156.29	70.79	19.49	278.67	57.88	−3.91	8.40	0.02	6834.79	15	57.65	433,748	0.325
A10	11.23	33.74	1.00	393.89	−12.96	3.64	−28.34	42.56	241.10	107.73	27.53	221.16	31.12	−1.40	1.54	0.03	4464.17	11	51.85	848,981	0.636

Table A2. GES of the cold northern region with a significant temperature annual range.

GES	Mammal Species	Bird Species	Amphibian Species	Plant Species	Annual Mean Temp.	Mean Temp. of Warmest Quarter	Mean Temp. of Coldest Quarter	Temp. Annual Range	Annual Precip.	Precip. of Wettest Quarter	Precip. of Driest Quarter	Altitude	Vertical Heterogen.	TPI	Livestock	Human Density	Accessibility	Prevailing GLC Class	Prevailing GLC Class [%]	Area [km^2]	Area [%]
B3	20.42	57.86	1.06	644.34	−12.79	7.38	−31.38	52.34	289.02	127.43	36.14	351.20	39.74	1.01	0.38	0.24	2888.07	12	42.80	1,408,694	1.056
B4	33.23	104.94	1.31	748.01	−7.38	11.76	−26.64	52.71	319.96	140.65	39.31	447.70	36.98	−0.21	0.25	0.17	2076.56	5	54.60	1,113,844	0.835
B5	27.41	93.58	1.67	808.22	−11.16	9.28	−30.25	52.80	297.21	136.14	31.36	237.26	36.17	−0.01	0.18	0.29	3026.34	16	22.71	172,523	0.129
B8	26.24	81.15	1.23	746.80	−11.91	8.40	−30.34	51.99	267.20	123.93	30.94	357.14	52.63	0.24	0.57	0.32	2692.03	10	22.66	680,358	0.510
B9	24.00	89.94	1.84	562.32	−17.91	6.50	−41.95	62.45	360.90	187.52	34.10	1179.17	146.55	11.18	0.06	0.11	2366.08	15	45.27	232,831	0.175
B10	29.29	116.32	1.95	1042.45	−11.05	11.03	−33.45	59.27	348.02	170.99	31.06	470.98	50.69	−0.33	0.40	0.36	2187.36	6	47.46	5,876,459	4.405

Table A3. GES of the region of the highest mountains.

GES	Mammal Species	Bird Species	Amphibian Species	Plant Species	Annual Mean Temp.	Mean Temp. of Warmest Quarter	Mean Temp. of Coldest Quarter	Temp. Annual Range	Annual Precip.	Precip. of Wettest Quarter	Precip. of Driest Quarter	Altitude	Vertical Heterogen.	TPI	Livestock	Human Density	Accessibility	Prevailing GLC Class	Prevailing GLC Class [%]	Area [km^2]	Area [%]
Ca1	49.00	192.24	2.97	2649.14	−3.72	7.07	−16.24	37.07	424.67	242.29	16.45	3946.36	317.47	52.00	14.73	10.49	1830.47	10	41.80	67,562	0.051
Ca4	73.49	226.92	7.88	2154.52	3.81	12.74	−5.15	34.11	691.69	317.74	67.02	2702.22	230.08	5.57	24.97	16.15	703.81	5	59.88	472,816	0.354
Ca5	57.71	168.43	8.33	3059.30	4.50	15.68	−7.51	37.54	726.65	353.08	61.08	1785.93	175.91	16.23	27.39	57.47	397.96	4	31.42	79,636	0.060
Ca6	123.87	345.74	14.61	3383.47	12.25	13.07	11.08	16.22	1211.71	495.85	114.75	2979.21	279.95	30.26	87.47	61.79	587.94	3	50.51	44,836	0.034
Ca7	77.39	225.12	6.81	2884.77	8.28	11.47	4.58	22.89	836.58	412.91	51.24	3270.84	170.09	16.53	152.47	81.39	412.18	10	31.24	82,034	0.061
Ca8	64.91	210.79	5.17	2638.18	1.40	10.43	−8.68	34.52	609.44	312.53	33.49	3354.21	231.78	17.72	44.30	19.64	1080.85	10	49.80	672,024	0.504
Cb2	137.23	314.70	11.15	5440.77	12.09	12.56	11.41	12.97	1061.48	397.48	117.58	2876.92	192.66	16.64	282.93	272.44	211.25	3	32.57	32,165	0.024
Cb4	98.46	286.90	14.69	4854.33	7.74	14.59	0.08	26.85	1007.56	536.07	42.40	2627.10	329.60	15.77	126.86	68.69	835.53	5	56.61	69,170	0.052
Cb5	61.74	166.92	6.59	4923.74	6.22	14.46	−2.21	28.24	1040.50	345.51	175.71	1431.15	281.80	−14.84	24.99	63.39	292.02	4	50.21	31,775	0.024
Cb6	129.69	329.85	8.83	5303.33	12.08	12.60	11.27	14.15	1251.91	464.16	162.43	2982.04	284.19	40.28	68.84	65.15	703.01	3	64.52	129,668	0.097
Cb7	89.08	233.18	10.20	5285.01	11.81	13.87	9.23	20.68	1010.27	497.72	68.67	2789.93	209.96	4.10	112.14	147.84	261.19	3	24.36	53,721	0.040
Cb8	64.33	165.84	4.90	4809.59	2.80	9.74	−4.50	26.62	933.67	373.01	124.78	2526.61	286.90	33.41	48.31	29.19	346.41	10	36.28	95,979	0.072
Cc1	38.90	135.31	3.05	1030.14	−4.79	5.69	−15.68	35.48	413.71	199.86	41.23	4489.00	318.80	48.04	7.53	14.88	2802.43	10	37.93	318,956	0.239
Cc3	24.02	73.84	2.29	937.71	−1.35	6.93	−10.05	33.41	205.28	135.67	8.15	4349.47	113.73	4.64	9.36	2.12	8517.38	12	32.70	582,002	0.436
Cc4	54.19	168.41	4.47	1412.35	0.37	10.42	−9.58	35.36	633.65	223.21	111.44	2049.21	231.83	13.66	4.40	2.22	696.70	5	55.95	266,018	0.199
Cc7	51.86	137.67	4.13	1737.88	6.53	13.20	−0.88	30.15	568.15	284.47	26.21	3103.58	168.56	12.59	105.70	61.76	302.06	10	31.33	85,383	0.064
Cc8	33.20	109.87	2.27	1353.13	−1.33	8.64	−12.03	36.44	334.42	199.58	14.00	3985.47	169.72	3.95	30.91	9.12	1734.94	10	62.59	2,205,694	1.654
Cc9	28.18	82.62	2.16	911.57	0.63	10.04	−9.76	36.66	109.37	73.49	3.90	3754.81	107.96	1.06	13.53	2.02	2587.65	15	61.65	570,074	0.427
Cc10	53.73	225.46	2.04	1099.37	−8.08	9.28	−27.62	52.38	456.29	281.07	20.27	2021.12	160.85	6.46	6.20	1.16	1065.08	6	39.05	37,197	0.028

Table A4. GES of the colder temperate zone of the Northern Hemisphere.

GES	Mammal Species	Bird Species	Amphibian Species	Plant Species	Annual Mean Temp.	Mean Temp. of Warmest Quarter	Mean Temp. of Coldest Quarter	Temp. Annual Range	Annual Precip.	Precip. of Wettest Quarter	Precip. of Driest Quarter	Altitude	Vertical Heterogen.	TPI	Livestock	Human Density	Accessibility	Prevailing GLC Class	Prevailing GLC Class [%]	Area [km^2]	Area [%]
Da3	36.14	117.38	1.52	1165.19	−0.18	17.19	−19.08	51.83	260.08	168.81	11.75	1012.27	29.55	0.44	32.54	1.53	611.35	12	64.42	360,767	0.270
Da4	37.84	134.34	3.27	1003.76	−2.29	13.57	−19.12	47.47	531.79	211.09	72.87	405.21	34.43	−0.22	0.58	1.11	1073.21	5	58.34	4,429,238	3.320
Da5	43.30	167.23	5.81	1271.79	−0.09	15.68	−16.89	46.65	587.72	242.74	72.75	239.97	22.22	−0.07	7.92	11.33	639.27	4	27.71	3,556,810	2.666
Da7	46.89	183.11	5.37	1500.28	2.12	18.04	−15.39	48.02	443.81	210.18	47.18	318.36	13.49	−0.11	41.60	39.41	223.12	1	60.76	2,002,789	1.501
Da8	43.88	166.71	2.49	1216.93	−0.32	16.41	−18.55	49.82	338.92	181.59	30.18	831.58	47.44	−0.94	23.51	6.84	546.08	10	43.69	1,157,900	0.868
Da9	40.38	146.20	1.23	688.30	−3.47	12.58	−20.64	48.31	273.98	143.01	29.53	1488.84	115.45	1.86	13.94	0.67	1101.29	15	57.06	183,572	0.138
Da10	43.23	170.62	2.75	1159.75	−4.23	13.49	−23.21	51.45	505.25	252.77	41.82	626.48	67.33	−0.61	1.90	2.33	1161.77	6	51.33	914,537	0.686
Db3	21.82	55.92	1.26	639.91	−6.94	8.77	−22.39	43.61	467.73	181.04	69.80	191.21	22.82	0.57	1.79	0.48	2301.09	12	37.52	327,037	0.245
Db4	29.19	64.62	2.40	946.75	−4.37	10.66	−20.61	45.06	731.55	268.78	117.45	382.72	26.54	0.07	0.03	0.12	1891.61	5	58.84	817,812	0.613
Db5	24.66	102.27	1.18	687.65	−4.82	10.25	−19.12	41.01	549.58	197.49	79.85	195.35	42.24	−2.69	0.34	0.51	1625.89	13	23.46	128,460	0.096
Db8	24.94	81.25	1.17	712.62	−5.64	9.83	−19.58	41.33	428.15	174.35	63.37	204.23	43.32	−0.40	0.54	0.48	2324.14	9	34.70	638,607	0.479
Db9	35.40	85.84	1.00	711.33	1.90	19.34	−17.31	51.80	183.90	128.74	4.59	1036.98	17.31	−0.37	24.11	0.68	433.18	15	46.63	35,221	0.026
Db10	24.34	74.89	1.61	699.71	−6.90	9.91	−23.07	45.77	475.69	180.85	70.91	145.62	20.35	−0.02	1.37	0.78	1740.23	11	48.32	92,727	0.070

Table A5. GES of the humid temperate region.

GES	Mammal Species	Bird Species	Amphibian Species	Plant Species	Annual Mean Temp.	Mean Temp. of Warmest Quarter	Mean Temp. of Coldest Quarter	Temp. Annual Range	Annual Precip.	Precip. of Wettest Quarter	Precip. of Driest Quarter	Altitude	Vertical Heterogen.	TPI	Livestock	Human Density	Accessibility	Prevailing GLC Class	Prevailing GLC Class [%]	Area [km^2]	Area [%]
Ea2	50.74	179.85	14.26	1946.56	6.91	18.08	−4.74	34.00	797.83	257.06	153.24	161.38	17.15	−0.53	36.64	398.24	84.15	4	21.22	81,067	0.061
Ea4	61.30	162.67	11.54	2308.41	7.32	15.64	−0.93	28.87	988.28	399.90	121.34	877.81	137.15	2.61	50.93	44.76	219.52	5	57.51	324,539	0.243
Ea5	55.00	166.23	13.48	2372.11	6.66	17.33	−4.50	33.44	857.56	295.82	148.05	520.75	75.41	2.49	38.03	59.42	170.23	4	42.36	978,211	0.733
Ea6	37.40	240.83	15.81	2097.60	10.09	15.84	4.23	24.64	1104.73	348.65	195.34	897.67	111.39	10.18	36.00	3.01	321.74	3	70.44	49,316	0.037
Ea7	54.90	169.35	12.54	2393.59	8.26	18.15	−2.21	30.77	642.83	223.54	113.83	194.98	20.13	−0.62	85.31	104.75	93.16	1	55.69	2,230,541	1.672
Ea8	58.56	139.38	13.50	3033.47	8.61	16.01	1.11	24.90	964.55	284.85	202.35	606.52	88.60	−6.17	97.51	105.23	104.14	10	35.42	100,188	0.075
Eb4	63.96	125.91	9.74	4942.47	4.96	13.31	−3.72	27.62	1168.86	414.71	198.22	1197.98	252.99	−4.21	61.27	72.08	169.90	5	39.42	56,709	0.043
Eb8	67.45	122.26	5.59	4990.91	1.04	8.28	−5.88	22.69	1661.71	468.15	365.87	2189.90	368.68	61.55	22.19	24.54	312.98	10	36.10	19,548	0.015
Ec1	37.18	122.11	2.54	610.61	−1.52	8.15	−10.58	30.29	1156.78	401.70	193.50	1176.79	237.54	10.57	9.15	0.23	2084.14	17	51.81	87,959	0.066
Ec2	39.70	143.19	9.99	1770.29	9.26	15.76	2.86	21.00	865.07	269.72	164.15	92.21	24.80	−0.98	421.41	406.75	56.91	1	25.56	221,897	0.166
Ec3	27.01	109.33	1.93	1102.64	5.40	12.03	−1.18	24.62	583.67	205.18	93.31	935.92	96.11	4.37	18.29	1.22	501.71	12	49.87	253,794	0.190
Ec4	39.00	143.70	4.73	1300.71	2.81	13.01	−7.18	31.54	830.74	304.37	123.42	480.91	81.79	−2.81	8.15	11.54	434.72	5	59.12	1,596,919	1.197
Ec5	40.30	166.50	7.34	1426.47	3.82	15.16	−7.75	33.88	899.46	318.41	142.56	261.16	51.71	−1.01	20.83	27.27	282.01	4	25.14	773,736	0.580
Ec6	25.54	131.10	6.57	910.65	9.55	13.80	5.43	19.24	1550.69	642.86	194.48	529.53	134.86	−3.45	24.09	14.03	398.02	3	50.56	177,777	0.133
Ec7	39.91	152.23	9.10	1558.10	8.34	16.12	0.64	24.88	774.72	266.90	129.84	135.93	21.09	−1.09	160.91	158.81	88.33	1	45.09	341,468	0.256
Ec8	35.73	126.63	4.07	1376.52	6.76	13.79	0.22	23.96	800.34	282.59	133.63	465.98	83.88	−1.32	117.24	40.94	309.16	10	26.68	196,787	0.148
Ec9	34.08	109.83	1.52	727.82	−2.61	8.04	−12.02	31.23	815.88	293.97	128.86	1099.38	252.04	6.51	3.28	0.55	1410.79	15	39.66	32,012	0.024
Ed1	8.92	48.10	1.18	232.13	−3.38	3.73	−9.46	20.64	1100.01	324.92	221.88	781.68	106.37	2.80	6.44	0.26	2614.52	17	51.49	168,708	0.126
Ed2	2.49	68.06	2.05	970.44	9.12	13.19	4.90	17.71	1234.22	360.51	255.12	440.78	92.68	0.67	481.47	18.31	377.77	16	26.37	18,717	0.014
Ed3	18.04	83.57	1.05	887.95	2.79	9.84	−3.99	23.45	575.83	182.66	107.04	442.75	75.12	−2.40	24.12	1.21	1057.72	12	36.04	309,080	0.232
Ed4	20.85	93.93	1.76	928.11	1.39	10.93	−8.10	29.41	1320.21	445.93	227.33	258.08	61.80	−1.26	3.89	4.08	1232.73	5	53.46	202,841	0.152
Ed5	17.69	108.90	1.66	597.09	2.10	9.46	−5.08	22.83	1300.85	407.85	250.40	332.84	115.36	−3.22	7.05	2.33	998.39	16	30.86	340,044	0.255
Ed6	5.18	80.42	5.56	966.07	9.12	13.44	4.59	18.61	2270.23	695.90	455.37	548.66	191.81	−2.55	48.32	4.62	676.54	3	43.67	112,068	0.084
Ed8	17.03	81.59	1.32	767.14	3.07	11.29	−4.70	25.61	820.10	273.44	149.69	251.12	59.72	−0.67	40.69	4.64	1212.49	16	25.71	712,265	0.534
Ed9	4.27	32.24	1.00	268.58	−2.55	4.45	−8.30	19.49	725.53	217.57	134.83	371.12	79.41	−3.12	23.42	0.44	1606.18	15	37.68	61,571	0.046

Table A6. GES of the warmer and drier temperate zone of the Northern Hemisphere.

GES	Mammal Species	Bird Species	Amphibian Species	Plant Species	Annual Mean Temp.	Mean Temp. of Warmest Quarter	Mean Temp. of Coldest Quarter	Temp. Annual Range	Annual Precip.	Precip. of Wettest Quarter	Precip. of Driest Quarter	Altitude	Vertical Heterogen.	TPI	Livestock	Human Density	Accessibility	Prevailing GLC Class	Prevailing GLC Class [%]	Area [km^2]	Area [%]
Fa2	48.75	159.76	10.93	2540.35	10.35	22.48	−2.87	39.34	693.28	295.34	83.38	524.91	47.72	−5.10	241.69	376.91	131.84	1	45.88	204,408	0.153
Fa4	69.24	176.75	8.91	2103.50	7.06	17.25	−2.79	38.88	456.85	176.12	65.39	2023.44	95.23	−0.76	3.44	3.66	301.01	5	56.99	221,485	0.166
Fa5	52.29	169.35	15.39	2295.23	7.95	19.61	−4.71	38.44	836.35	312.22	123.28	604.23	70.18	−0.62	51.37	69.14	237.36	4	37.05	492,641	0.369
Fa7	49.36	174.35	10.51	2444.29	7.74	20.72	−5.97	39.38	604.57	206.67	96.97	323.68	25.55	−0.93	52.50	62.50	139.60	1	57.62	1,359,413	1.019
Fa8	60.34	164.71	8.39	2516.87	9.98	20.94	−0.85	40.22	355.52	145.52	42.13	1471.95	60.12	−2.56	22.95	12.28	291.01	9	48.24	1,296,477	0.972
Fb2	33.87	149.42	7.65	2558.11	11.47	24.30	−2.73	40.04	569.30	373.34	20.16	332.77	31.26	−0.67	764.06	535.96	140.41	1	43.52	372,378	0.279
Fb3	34.32	124.20	1.50	795.22	6.89	23.33	−10.51	48.45	176.42	55.58	31.20	222.28	8.38	0.02	5.63	1.68	484.74	12	65.51	547,528	0.410
Fb4	61.05	177.65	5.84	1446.66	5.35	15.61	−4.52	37.41	491.07	187.42	71.36	1387.34	112.04	−4.06	5.19	3.48	279.43	5	52.58	107,680	0.081
Fb5	46.22	160.71	11.96	1547.32	5.63	17.98	−7.94	40.87	794.63	264.92	125.61	659.25	56.93	2.16	29.17	25.57	247.10	4	23.79	218,889	0.164
Fb7	45.08	150.59	6.83	1811.58	9.07	21.62	−4.45	41.55	522.11	229.17	41.31	786.01	45.18	−0.42	99.49	67.81	184.14	1	49.63	1,921,340	1.440
Fb8	42.11	143.95	4.39	1480.73	7.20	20.99	−7.38	44.43	311.32	140.98	31.18	916.83	36.50	−1.11	38.95	18.53	350.60	10	45.93	3,059,132	2.293
Fb9	33.28	95.00	1.42	815.63	9.82	23.99	−5.62	45.96	112.56	59.51	5.70	945.31	28.26	−0.85	26.38	10.38	773.18	15	76.64	3,351,483	2.512

Table A7. GES of the subtropics of both hemispheres.

GES	Mammal Species	Bird Species	Amphibian Species	Plant Species	Annual Mean Temp.	Mean Temp. of Warmest Quarter	Mean Temp. of Coldest Quarter	Temp. Annual Range	Annual Precip.	Precip. of Wettest Quarter	Precip. of Driest Quarter	Altitude	Vertical Heterogen.	TPI	Livestock	Human Density	Accessibility	Prevailing GLC Class	Prevailing GLC Class [%]	Area [km^2]	Area [%]
Ga2	82.29	298.85	23.04	5518.52	16.53	23.85	8.18	26.38	1324.80	607.57	127.05	954.30	104.96	−4.62	270.93	272.51	214.05	2	31.67	316,188	0.237
Ga4	96.53	342.55	26.39	5856.51	16.64	23.36	8.87	25.98	1433.10	702.93	107.65	1163.46	170.78	1.58	145.96	140.79	312.69	5	36.17	275,991	0.207
Ga5	121.73	379.86	18.31	5548.86	18.13	20.87	14.29	22.22	1370.70	776.98	42.93	1539.37	187.02	3.79	54.54	41.90	298.65	7	43.13	35,002	0.026
Ga6	96.95	317.48	25.91	5464.58	16.86	23.49	9.25	25.45	1372.91	650.64	111.21	999.83	166.57	−0.90	160.99	118.00	490.47	3	53.39	419,638	0.315
Ga7	98.04	345.74	32.23	5069.31	17.64	21.57	13.23	21.69	1292.08	543.61	172.73	1028.42	84.27	−2.02	162.83	113.24	138.98	1	22.58	83,565	0.063
Ga8	70.14	249.20	11.75	5547.06	14.73	19.50	9.75	24.73	443.16	160.32	70.18	781.42	142.17	11.95	35.52	10.67	272.69	9	80.83	35,205	0.026
Gb2	98.54	347.58	22.67	3000.23	16.48	21.33	10.84	23.05	1070.25	508.66	79.21	1239.56	88.67	2.74	234.19	246.83	259.59	1	28.22	195,333	0.146
Gb4	91.24	394.08	11.90	2553.60	14.48	19.81	7.72	24.21	1548.11	964.60	65.17	1979.75	322.79	−18.06	97.27	89.89	608.94	5	46.59	67,823	0.051
Gb5	105.40	368.98	33.60	2581.95	19.77	22.46	15.69	25.27	990.05	591.06	8.98	1257.21	45.86	0.38	22.60	23.42	590.76	4	54.15	580,438	0.435
Gb6	96.13	362.33	22.78	3638.61	16.05	21.38	9.86	23.02	1510.31	705.38	121.60	1333.20	183.59	−1.29	104.60	78.58	471.81	3	49.83	150,260	0.113
Gb7	113.23	406.88	27.94	2698.63	17.78	20.34	14.37	21.55	1023.36	500.41	76.30	1516.09	64.02	5.72	117.91	90.27	244.13	1	41.24	479,632	0.360
Gb8	95.51	365.94	24.29	1975.96	19.25	22.82	14.22	25.74	631.26	346.65	18.70	1156.00	34.10	0.31	38.12	30.19	520.39	9	44.92	536,747	0.402
Gc2	52.12	215.02	16.99	2900.92	15.99	24.53	7.02	29.41	1113.74	464.23	136.41	382.57	47.00	−2.28	361.37	461.77	151.94	1	34.27	1,160,904	0.870
Gc4	48.23	188.94	27.42	2686.56	16.52	24.85	7.64	30.84	1373.24	492.87	216.97	407.68	57.72	0.04	99.75	50.14	170.16	5	49.14	867,248	0.650
Gc5	56.79	205.30	20.29	2598.81	15.55	23.24	7.16	30.80	960.50	372.41	138.16	679.18	70.27	−1.19	44.98	39.61	331.74	4	32.82	983,261	0.737
Gc6	60.24	251.50	21.35	3290.71	14.54	21.28	7.36	25.58	1101.90	435.93	123.43	660.65	125.84	−2.42	113.00	70.16	343.20	3	54.86	291,981	0.219
Gc7	49.50	192.95	15.50	2589.39	15.17	23.13	7.03	29.08	871.30	319.94	125.96	399.32	46.35	−2.83	125.79	104.53	148.11	1	40.24	1,686,632	1.264
Gc8	60.02	230.38	16.12	2153.62	18.18	24.14	11.44	29.13	657.33	279.16	74.80	873.83	37.56	0.34	41.39	13.72	339.94	9	36.85	2,870,822	2.152
Gd2	14.67	136.07	3.62	4087.50	17.65	26.14	9.28	24.94	1096.32	421.86	119.91	51.09	44.24	−1.48	242.82	1368.96	113.61	1	30.10	1405	0.001
Gd4	10.05	117.13	6.75	3138.46	15.36	24.15	6.88	26.59	1702.86	679.78	214.60	122.33	84.29	−5.79	32.30	92.56	223.54	5	37.37	4401	0.003
Gd7	31.57	118.87	4.68	3339.61	15.12	22.51	8.47	23.60	602.19	260.55	37.91	437.93	91.11	−1.17	126.71	152.25	100.09	1	31.97	56,800	0.043
Gd8	57.84	184.39	6.66	4907.59	17.37	21.92	12.46	24.57	161.24	73.20	14.41	428.35	54.03	−2.12	16.58	3.88	500.19	9	43.20	50,160	0.038
Gd9	28.85	130.50	3.37	3960.85	15.54	18.63	12.16	16.92	67.25	31.72	5.30	490.31	34.67	−0.31	25.42	1.00	1017.57	15	55.28	25,585	0.019
Ge2	32.32	154.36	8.26	2206.26	14.98	24.38	5.11	31.22	813.92	390.80	81.32	275.22	41.51	−3.76	592.11	557.53	135.57	1	36.13	339,197	0.254
Ge3	16.56	98.65	2.10	730.21	16.64	21.72	11.09	25.83	202.83	75.12	33.53	579.61	41.49	−3.13	5.80	1.91	887.51	12	56.52	344,904	0.259
Ge4	41.55	164.10	10.39	1865.34	13.59	21.87	5.43	26.98	1280.22	443.46	222.30	407.54	99.80	−11.95	91.39	114.91	149.51	5	33.63	30,836	0.023
Ge5	29.23	137.99	7.56	2161.00	14.86	21.28	8.49	25.47	671.58	274.36	72.36	496.23	62.29	0.26	64.30	29.25	539.32	4	24.63	204,628	0.153

Table A7. *Cont.*

GES	Mammal Species	Bird Species	Amphibian Species	Plant Species	Annual Mean Temp.	Mean Temp. of Warmest Quarter	Mean Temp. of Coldest Quarter	Temp. Annual Range	Annual Precip.	Precip. of Wettest Quarter	Precip. of Driest Quarter	Altitude	Vertical Heterogen.	TPI	Livestock	Human Density	Accessibility	Prevailing GLC Class	Prevailing GLC Class [%]	Area [km^2]	Area [%]
Ge6	23.17	162.40	7.24	1971.56	14.50	19.61	9.83	22.73	936.45	508.24	50.82	200.41	38.12	−0.25	52.10	29.14	191.55	3	37.01	77,663	0.058
Ge7	33.98	169.84	7.25	1726.95	15.66	23.20	8.35	28.89	556.15	224.90	55.35	459.61	44.78	−1.43	100.12	70.17	185.64	1	46.25	2,085,008	1.563
Ge8	33.13	161.11	5.14	1031.52	16.44	22.79	9.73	28.91	310.54	130.41	36.18	666.52	35.58	−0.71	22.05	7.40	431.26	9	34.30	1,794,058	1.345
Ge9	28.89	93.27	3.15	1025.28	18.00	23.56	12.03	24.89	95.72	51.05	4.18	862.58	56.47	−0.27	33.85	12.76	438.20	15	81.52	888,165	0.666

Table A8. GES of the deserts and semi-deserts of the tropics.

GES	Mammal Species	Bird Species	Amphibian Species	Plant Species	Annual Mean Temp.	Mean Temp. of Warmest Quarter	Mean Temp. of Coldest Quarter	Temp. Annual Range	Annual Precip.	Precip. of Wettest Quarter	Precip. of Driest Quarter	Altitude	Vertical Heterogen.	TPI	Livestock	Human Density	Accessibility	Prevailing GLC Class	Prevailing GLC Class [%]	Area [km^2]	Area [%]
Ha2	49.37	278.97	8.41	1483.55	25.27	32.12	16.84	32.15	609.37	472.27	20.29	256.43	4.17	−0.27	231.40	680.74	96.97	1	70.74	103,401	0.078
Ha5	69.78	278.58	24.95	1304.37	23.11	27.74	17.69	25.87	594.35	312.05	21.30	253.74	9.71	−0.37	21.78	5.16	474.53	4	48.17	234,192	0.176
Ha7	59.57	272.12	10.47	1674.41	25.82	30.72	20.35	28.16	503.46	363.92	11.93	345.32	12.17	−0.39	117.04	104.94	186.88	1	56.50	733,896	0.550
Ha8	64.04	240.09	12.53	2112.68	23.15	28.91	16.78	28.99	396.89	225.21	18.92	492.50	22.90	−1.26	29.26	15.12	371.21	9	60.06	1,030,996	0.773
Hb2	36.04	170.72	4.52	1003.53	22.44	30.53	13.00	33.48	183.06	110.49	9.40	214.81	16.51	−3.23	318.60	618.00	141.21	15	40.51	168,294	0.126
Hb3	23.82	149.77	6.54	889.13	23.44	29.82	15.90	30.22	322.32	173.46	24.72	268.74	7.75	−0.03	3.17	0.08	1155.88	12	69.32	2,068,237	1.550
Hb5	45.13	237.16	5.49	784.11	27.06	32.81	19.23	33.62	318.83	279.26	3.03	30.96	7.72	−0.03	150.21	55.86	415.23	13	44.73	36,542	0.027
Hb7	38.37	183.76	4.86	1187.51	24.44	31.73	16.06	32.58	271.80	186.90	5.76	285.11	15.71	−1.37	146.57	130.75	191.49	1	41.10	927,982	0.696
Hb8	35.00	168.82	5.92	1205.42	23.96	29.69	17.42	29.25	285.95	177.36	13.69	451.44	18.87	−0.59	27.69	10.68	583.15	9	29.75	2,722,237	2.041
Hb9	32.25	130.16	3.17	1113.83	24.47	31.15	16.90	30.33	148.35	95.95	6.24	465.24	29.13	−1.34	37.04	13.55	633.63	15	76.60	2,055,653	1.541
Hc2	7.27	57.71	1.00	350.00	25.65	34.44	15.72	31.21	107.30	64.32	0.00	7.47	4.42	−0.29	124.85	523.22	177.11	14	49.32	1589	0.001
Hc3	20.73	98.83	3.09	511.98	22.37	28.98	14.60	31.12	220.17	98.80	23.34	383.12	8.54	−0.01	2.52	0.02	1877.19	12	70.33	998,147	0.748
Hc7	24.14	82.73	2.15	733.62	24.03	31.02	15.89	29.87	78.90	47.16	0.64	187.17	20.06	−1.54	80.62	85.19	234.95	15	68.23	233,537	0.175
Hc8	24.18	99.64	3.76	626.32	21.77	28.02	14.94	27.58	167.79	74.02	17.07	622.65	67.51	3.69	30.80	13.44	727.11	9	33.34	49,709	0.037
Hc9	17.08	32.69	1.67	735.77	24.33	31.83	15.69	32.89	49.31	30.75	0.84	479.97	14.13	−0.24	9.67	4.21	1166.68	15	92.95	11,093,274	8.316

Table A9. GES of the extensive subequatorial region with a drier period.

GES	Mammal Species	Bird Species	Amphibian Species	Plant Species	Annual Mean Temp.	Mean Temp. of Warmest Quarter	Mean Temp. of Coldest Quarter	Temp. Annual Range	Annual Precip.	Precip. of Wettest Quarter	Precip. of Driest Quarter	Altitude	Vertical Heterogen.	TPI	Livestock	Human Density	Accessibility	Prevailing GLC Class	Prevailing GLC Class [%]	Area [km^2]	Area [%]
Ia2	96.33	378.62	42.27	6139.57	21.57	25.83	16.39	20.00	1598.56	752.73	101.97	339.67	62.40	−0.77	295.74	460.08	150.94	1	27.44	316,662	0.237
Ia5	124.21	411.03	29.24	5528.76	22.28	24.59	18.95	21.67	1400.45	738.26	39.24	866.81	114.00	2.19	31.05	27.56	309.20	4	18.10	258,153	0.194
Ia6	133.85	423.40	48.60	5613.74	23.07	25.04	20.49	17.54	1583.20	712.82	114.54	499.18	71.80	−1.71	42.48	29.78	601.82	3	56.52	1,249,758	0.937
Ia7	122.80	397.51	42.96	6261.85	22.43	24.77	19.16	18.70	1439.49	666.00	100.59	527.12	38.84	−0.27	127.62	57.60	170.36	1	47.16	1,364,940	1.023
Ia8	132.13	373.79	45.78	6151.50	23.79	25.13	21.99	17.35	1347.52	685.68	35.94	531.81	49.48	−0.06	41.56	14.80	275.08	9	44.36	1,119,679	0.839
Ib2	138.42	373.47	35.74	2149.77	22.80	24.01	21.12	14.26	963.38	397.87	86.98	661.81	52.37	−0.31	135.02	142.07	153.10	1	46.75	241,265	0.181
Ib5	124.57	411.99	40.70	2967.93	22.71	24.77	19.78	20.60	1141.28	634.39	21.31	849.52	37.52	−0.62	16.09	20.08	515.58	4	51.06	1,533,460	1.150
Ib6	133.09	381.49	41.53	3486.36	23.90	25.00	22.40	15.31	1559.92	639.80	110.40	569.70	44.38	1.32	16.18	15.43	727.53	3	64.18	1,164,776	0.873
Ib7	134.26	410.36	35.07	2777.58	23.00	24.54	21.05	16.23	1100.56	502.26	77.31	756.03	38.41	−1.47	76.10	86.30	231.73	1	50.60	823,943	0.618
Ib8	142.09	411.96	34.83	2966.36	23.57	25.09	21.46	17.24	1019.00	532.72	35.16	643.03	44.84	0.28	33.62	21.22	328.42	9	44.01	652,122	0.489
Ic2	58.67	301.03	14.86	2283.68	25.51	29.95	19.67	24.84	1204.54	782.55	29.92	236.21	22.08	−3.04	358.42	666.48	121.36	1	56.90	805,659	0.604
Ic5	93.31	309.86	25.22	2498.39	24.09	26.01	21.96	18.97	1228.19	625.50	33.59	622.08	36.62	−0.64	28.84	25.03	500.85	4	52.88	4,694,371	3.519
Ic6	94.28	304.14	21.74	2694.37	24.15	25.92	21.83	16.69	1476.35	642.60	108.19	415.92	44.31	−0.16	24.58	24.95	509.10	3	48.02	961,594	0.721
Ic7	76.29	304.21	18.22	1916.64	26.31	29.90	22.74	22.75	1006.31	629.01	22.71	337.53	22.61	−0.78	131.57	153.36	195.06	1	57.50	3,569,682	2.676
Ic8	77.58	275.47	17.22	2029.68	26.07	28.21	23.78	19.20	785.51	467.00	17.63	434.67	23.34	−0.49	37.60	15.47	555.64	9	54.71	3,578,697	2.683

Table A9. *Cont.*

GES	Mammal Species	Bird Species	Amphibian Species	Plant Species	Annual Mean Temp.	Mean Temp. of Warmest Quarter	Mean Temp. of Coldest Quarter	Temp. Annual Range	Annual Precip.	Precip. of Wettest Quarter	Precip. of Driest Quarter	Altitude	Vertical Heterogen.	TPI	Livestock	Human Density	Accessibility	Prevailing GLC Class	Prevailing GLC Class [%]	Area [km^2]	Area [%]
Id2	15.85	136.81	10.03	3578.63	22.84	24.62	20.37	15.75	1547.96	691.34	140.37	571.50	50.12	0.25	231.13	244.26	112.43	16	28.69	31,125	0.023
Id5	13.69	99.45	5.33	3112.23	22.02	23.91	19.02	19.71	1458.30	929.34	19.39	854.68	68.35	−1.49	20.08	19.11	268.38	8	61.85	65,970	0.049
Id6	30.05	138.03	19.60	4284.47	22.37	24.48	19.59	15.37	1600.65	817.56	133.47	505.00	130.07	−6.92	62.27	29.12	489.01	3	45.26	12,785	0.010
Ie2	30.38	162.24	6.19	1275.28	24.54	26.29	22.42	14.38	1036.09	521.27	65.57	509.06	113.12	−3.75	172.73	259.06	339.32	16	24.46	42,342	0.032
Ie5	22.15	122.36	5.95	1776.89	24.73	26.97	21.42	19.84	1077.52	715.17	19.75	282.42	31.79	−1.16	30.64	18.54	311.20	16	33.12	310,121	0.232
Ie6	11.34	123.86	5.57	1938.19	22.29	24.38	19.84	13.93	1404.00	632.29	142.89	450.60	127.38	−1.68	33.92	51.42	485.81	16	35.77	61,751	0.046
Ie7	23.17	182.44	7.91	2417.50	24.83	26.68	22.47	15.72	1381.06	572.94	111.17	178.15	50.97	−1.96	146.02	128.77	172.96	1	33.07	143,918	0.108
Ie8	33.12	162.40	10.35	1823.52	26.22	28.96	22.63	21.25	560.46	375.01	8.54	270.45	14.52	−0.57	24.02	6.07	797.08	9	45.35	600,881	0.450
Ie9	24.48	104.06	4.83	1532.48	23.98	26.48	21.14	17.33	218.43	95.67	25.12	674.35	73.53	−2.74	24.73	8.63	812.28	16	36.42	41,964	0.031

Table A10. GES of the warm and humid equatorial region.

GES	Mammal Species	Bird Species	Amphibian Species	Plant Species	Annual Mean Temp.	Mean Temp. of Warmest Quarter	Mean Temp. of Coldest Quarter	Temp. Annual Range	Annual Precip.	Precip. of Wettest Quarter	Precip. of Driest Quarter	Altitude	Vertical Heterogen.	TPI	Livestock	Human Density	Accessibility	Prevailing GLC Class	Prevailing GLC Class [%]	Area [km^2]	Area [%]
Ja2	133.91	371.95	29.41	6372.64	26.22	26.81	25.53	11.15	2633.33	999.99	359.99	131.89	31.76	−3.68	118.96	178.27	275.16	2	39.17	281,185	0.211
Ja5	120.92	309.37	18.02	6764.52	25.65	26.13	25.04	10.71	2847.62	992.86	430.33	250.55	45.98	−2.03	25.04	50.34	490.35	2	29.71	85,499	0.064
Ja6	157.34	453.43	65.62	6328.00	25.44	26.02	24.69	12.26	2534.65	959.85	310.65	277.11	42.20	−0.73	11.84	7.26	1881.32	3	81.49	7,073,502	5.303
Ja7	138.23	360.77	36.08	5340.49	23.38	24.25	22.41	12.56	2178.36	904.40	200.34	619.99	115.46	−9.15	124.44	175.65	189.14	3	57.53	121,994	0.091
Ja8	123.94	356.24	41.24	5535.52	26.64	27.17	25.98	16.03	1840.29	880.07	35.03	222.23	15.29	−0.45	40.45	5.25	366.37	9	48.82	132,739	0.100
Jb2	79.02	322.14	19.45	3077.58	25.78	27.21	23.92	13.46	2520.09	1264.97	160.76	178.01	55.58	−4.77	314.03	537.93	187.29	2	27.85	697,359	0.523
Jb5	106.22	327.76	31.80	2814.01	25.55	26.68	24.46	13.24	2217.31	1003.41	184.29	290.46	28.00	−0.04	25.17	40.71	728.10	13	27.61	519,187	0.389
Jb6	102.20	325.73	26.03	3503.02	24.74	25.70	23.49	12.76	2414.91	978.56	267.48	402.23	66.99	−0.21	17.99	25.85	991.73	3	60.05	2,656,305	1.991
Jb7	97.34	341.02	24.17	2665.04	26.20	27.82	24.24	14.87	2224.53	1162.95	92.84	137.22	27.65	−2.02	98.29	178.97	222.42	1	42.93	774,340	0.580
Jb8	134.70	366.24	28.11	2865.14	26.53	27.75	25.11	13.88	2240.21	1128.76	76.35	178.63	30.24	−2.73	32.98	12.90	612.93	9	23.51	391,133	0.293
Jc2	19.41	195.68	6.28	4859.43	26.39	27.00	25.57	10.42	2153.21	780.07	274.50	99.33	52.85	−2.75	260.31	150.16	289.46	16	38.86	21,094	0.016
Jc5	24.82	165.98	21.64	5428.07	24.33	26.28	21.93	13.13	2405.52	1037.63	299.33	87.89	38.66	−6.02	19.10	58.14	249.81	13	37.11	67,104	0.050
Jc6	21.92	145.18	8.31	4806.88	24.85	25.40	24.06	9.42	2914.39	1014.03	520.27	397.03	99.05	−1.64	14.00	36.92	1003.93	16	51.30	105,958	0.079
Jc7	10.48	141.17	7.17	4530.77	26.47	27.48	25.15	10.74	2118.50	938.66	224.59	29.19	18.37	−1.40	155.05	261.93	299.11	1	43.32	2374	0.002
Jd2	19.58	174.36	8.10	1265.04	25.42	26.80	23.28	13.22	2312.05	1031.45	223.54	125.66	58.63	−3.55	267.05	465.85	179.78	16	50.31	33,025	0.025
Jd5	26.06	190.42	6.24	2032.04	26.07	27.17	24.43	12.26	2087.34	998.66	177.91	44.22	22.94	−3.24	9.49	15.09	1429.79	13	34.75	33,783	0.025
Jd6	20.48	142.38	5.36	1738.74	24.95	25.73	23.93	9.66	2467.70	933.73	340.40	265.28	106.48	−4.41	21.70	41.95	856.05	16	49.03	190,330	0.143
Jd7	17.13	152.03	6.10	2219.06	24.59	25.99	22.90	11.13	1986.94	833.71	203.66	224.07	77.51	−2.45	123.93	246.39	173.47	1	46.40	19,350	0.015
Jd8	26.94	174.84	2.88	2419.23	27.03	28.41	24.79	14.43	1674.01	1024.72	19.96	40.49	19.58	−0.59	5.73	0.46	655.63	16	29.58	6396	0.005

References

1. Vitousek, P.M.; Mooney, H.A.; Lubchenco, J.; Melillo, J.M. Human domination of earth's ecosystems. *Science* **1997**, *277*, 494–499. [CrossRef]
2. Sayre, R.; Karagulle, D.; Frye, C.; Boucher, T.; Wolff, N.H.; Breyer, S.; Wright, D.; Martin, M.; Butler, K.; Van Graafeiland, K.; et al. An assessment of the representation of ecosystems in global protected areas using new maps of world climate regions and world ecosystems. *Glob. Ecol. Conserv.* **2020**, *21*, e00860. [CrossRef]
3. Bailey, R. *Ecoregions: The Ecosystem Geography of the Oceans and Continents*, 2nd ed.; Springer: Berlin/Heidelberg, Germany, 2014; ISBN 978-1-4939-0523-2.
4. Lomolino, M.V.; Riddle, B.R.; Whittaker, R.J.; Brown, J.H. *Biogeography*, 5th ed.; Sinauer Associates: Sunderland, MA, USA, 2016; ISBN 978-1605354729.
5. Alessa, L.; Chapin, F.S. Anthropogenic biomes: A key contribution to earth-system science. *Trends Ecol. Evol.* **2008**, *23*, 529–531. [CrossRef] [PubMed]
6. Ellis, E.C.; Ramankutty, N. Putting people in the map: Anthropogenic biomes of the world. *Front. Ecol. Environ.* **2008**, *6*, 439–447. [CrossRef]
7. Crutzen, P.J.; Stoermer, E.F. The Anthropocene. *Glob. Chang. Newsl.* **2000**, *41*, 17–18.
8. Crutzen, P.J. Geology of mankind. *Nature* **2002**, *415*, 23. [CrossRef]
9. Steffen, W.; Grinevald, J.; Crutzen, P.; McNeill, J. The Anthropocene: Conceptual and historical perspectives. *Philos. Trans. R. Soc. A* **2011**, *369*, 842–867. [CrossRef] [PubMed]
10. Waters, C.N.; Zalasiewicz, J.; Summerhayes, C.; Barnosky, A.D.; Poirier, C.; Gałuszka, A.; Cearreta, A.; Edgeworth, M.; Ellis, E.C.; Ellis, M.; et al. The Anthropocene is functionally and stratigraphically distinct from the Holocene. *Science* **2016**, *351*, aad2622. [CrossRef]
11. Fahrig, L. Habitat fragmentation: A long and tangled tale. *Glob. Ecol. Biogeogr.* **2019**, *28*, 33–41. [CrossRef]
12. Tilman, D.; Clark, M.; Williams, D.R.; Kimmel, K.; Polasky, S.; Packer, C. Future threats to biodiversity and pathways to their prevention. *Nature* **2017**, *546*, 73–81. [CrossRef]
13. Ellis, E.C.; Klein Goldewijk, K.; Siebert, S.; Lightman, D.; Ramankutty, N. Anthropogenic transformation of the biomes, 1700 to 2000. *Glob. Ecol. Biogeogr.* **2010**, *19*, 589–606. [CrossRef]
14. Allee, W.C.; Park, O.; Emerson, A.E.; Park, T.; Schmidt, K.P. *Principles of Animal Ecology*; Saunders Co.: Philadelphia, PA, USA, 1949.
15. Kendeigh, S.C. *Animal Ecology*; Prentice-Hall: Englewood Cliffs, NJ, USA, 1961.
16. Whittaker, R.H. *Communities and Ecosystems*, 2nd ed.; MacMillan Publishing: New York, NY, USA, 1975.
17. Goodall, D.W. *Ecosystems of the World*; Elsevier: Amsterdam, The Netherlands, 1977–2005.
18. Schultz, J. *Die Ökozonen der Erde*, 1st ed.; Ulmer: Stuttgart, Germany, 1988; 488p.
19. Bailey, R.G. Explanatory Supplement to Ecoregions Map of the Continents. *Environ. Conserv.* **1989**, *16*, 307–309. [CrossRef]
20. Olson, D.M.; Dinerstein, E. The Global 200: A representation approach to conserving the Earth's most biologically valuable ecoregions. *Conserv. Biol.* **1998**, *12*, 502–515. [CrossRef]
21. Olson, D.M.; Dinerstein, E.; Wikramanayake, E.D.; Burgess, N.D.; Powell, G.V.N.; Underwood, E.C.; D'amico, J.A.; Itoua, I.; Strand, H.E.; Morrison, J.C.; et al. Terrestrial ecoregions of the world: A new map of life on Earth. *BioScience* **2001**, *51*, 933–938. [CrossRef]
22. Letourneau, A.; Verburg, P.H.; Stehfest, E. A land-use systems approach to represent land-use dynamics at continental and global scales. *Environ. Model. Softw.* **2012**, *33*, 61–79. [CrossRef]
23. van Asselen, S.; Verburg, P.H. A Land System representation for global assessments and land-use modeling. *Glob. Chang. Biol.* **2012**, *18*, 3125–3148. [CrossRef] [PubMed]
24. Václavík, T.; Lautenbach, S.; Kuemmerle, T.; Seppelt, R. Mapping global land system archetypes. *Glob. Environ. Chang.* **2013**, *23*, 1637–1647. [CrossRef]
25. Keith, D.A.; Ferrer-Paris, J.R.; Nicholson, E.; Kingsford, R.T. (Eds.) *The IUCN Global Ecosystem Typology 2.0: Descriptive Profiles for Biomes and Ecosystem Functional Groups*; IUCN: Gland, Switzerland, 2020.
26. Hoag, H. Confronting the biodiversity crisis. *Nat. Clim. Chang.* **2010**, *1*, 51–54. [CrossRef]
27. Hijmans, R.J.; Cameron, S.E.; Parra, J.L.; Jones, P.G.; Jarvis, A. Very high resolution interpolated climate surfaces for global land areas. *Int. J. Climatol.* **2005**, *25*, 1965–1978. [CrossRef]
28. Jenkins, C.N.; Pimm, S.L.; Joppa, L.N. Global patterns of terrestrial vertebrate diversity and conservation. *Proc. Natl. Acad. Sci. USA* **2013**, *110*, E2602–E2610. [CrossRef]
29. Pimm, S.L.; Jenkins, C.N.; Abell, R.; Brooks, T.M.; Gittleman, J.L.; Joppa, L.N.; Raven, P.H.; Roberts, C.M.; Sexton, J.O. The biodiversity of species and their rates of extinction, distribution, and protection. *Science* **2014**, *344*, 1246752. [CrossRef]
30. Kier, G.; Mutke, J.; Dinerstein, E.; Ricketts, T.H.; Küper, W.; Kreft, H.; Barthlott, W. Global patterns of plant diversity and floristic knowledge. *J. Biogeogr.* **2005**, *32*, 1107–1116. [CrossRef]
31. Robinson, T.P.; Wint, G.W.; Conchedda, G.; Van Boeckel, T.P.; Ercoli, V.; Palamara, E.; Cinardi, G.; D'Aietti, L.; Hay, S.I.; Gilbert, M. Mapping the global distribution of livestock. *PLoS ONE* **2014**, *9*, e96084. [CrossRef]
32. CIESIN. *Gridded Population of the World Version 3 (GPWv3): Population Density Grids*; Socioeconomic Data and Applications Center (SEDAC)/Columbia University/Centro Internacional de Agricultura Tropical (CIAT): Palisades, NY, USA, 2005.

33. Nelson, A. *Estimated Travel Time to the Nearest City of 50,000 or More People in Year 2000*; Global Environment Monitoring Unit—Joint Research Centre of the European Commission: Brussels, Belgium, 2008.
34. ESA (European Space Agency). *Land Cover CCI Product User Guide Version 2.0*; European Space Agency: Paris, France, 2017. Available online: http://maps.elie.ucl.ac.be/CCI/viewer/download/ESACCI-LC-Ph2-PUGv2_2.0.pdf (accessed on 15 October 2018).
35. IBM Corporation. *IBM SPSS Statistics for Windows, Version 27.0*; IBM Corporation: Armonk, NY, USA, 2020.
36. Myers, N.; Mittermeier, R.A.; Mittermeier, C.G.; Da Fonseca, G.A.B.; Kent, J. Biodiversity hotspots for conservation priorities. *Nature* **2000**, *403*, 853–858. [CrossRef]
37. Hrdina, A.; Romportl, D. Evaluating Global Biodiversity Hotspots—Very Rich and Even More Endangered. *J. Landsc. Ecol.* **2017**, *10*, 108–115. [CrossRef]
38. Hrdina, A.; Romportl, D. *Global Environmental Systems. V1.*; Science Data Bank: Beijing, China, 2022. [CrossRef]
39. Myers, N. Threatened biotas: 'Hotspots' in tropical forests. *Environmentalist* **1988**, *8*, 187–208. [CrossRef] [PubMed]
40. Mittermeier, R.A.; Myers, N.; Thomsen, J.B.; Da Fonseca, G.A.B.; Olivieri, S. Biodiversity Hotspots and Major Tropical Wilderness Areas: Approaches to Setting Conservation Priorities. *Conserv. Biol.* **1998**, *12*, 516–520. [CrossRef]
41. CEPF (Critical Ecosystem Partnership Fund). The Biodiversity Hotspots. Available online: https://www.cepf.net/our-work/biodiversity-hotspots/hotspots-defined (accessed on 31 August 2023).