# Explanatory Supplement to Ecoregions Map of the Continents

*by*

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This explanatory note is intended to accompany the map included in this issue.** The map is on a scale of 1:30,000,000 (1 cm = 300 km) and shows regional-scale 'ecosystem' units, or *ecoregions*, differentiated according to a scheme modified from J.M. Crowley (1967), and using climate and vegetation as indicators of the extent of each unit. The units are similar in concept to 'ecobiomes' as proposed by Polunin (1984). The map was developed following a proposal by Bailey & Hogg (1986) to supplement the Udvardy (1975) system of biogeographical provinces with a treatment of higher resolution. Three levels or categories of this hierarchy are shown. Of these the broadest, *domains*, and within them *divisions*, are based largely on the broad ecological climate zones following the Köppen system as modified by Trewartha (1968), and summarized in our Tables I and II. Climate is emphasized at the broadest levels because of its overriding effect on the composition and productivity of ecosystems etc. from region to region.†

TABLE I

*Regional Climates, Based on the Köppen System of Classification, as Modified by Trewartha (1968).*

| *Köppen group and types* | *Ecoregion equivalents* |
|---|---|
| *A—Tropical humid climates* | *Humid tropical domain* |
| Tropical wet (Ar) | Rain-forest division |
| Tropical wet–dry (Aw) | Savanna division |
| *B—Dry climates* | *Dry domain* |
| Tropical/subtropical semi-arid (BSh) | Tropical/subtropical steppe division |
| Tropical/subtropical arid (BWh) | Tropical/subtropical desert division |
| Temperate semi-arid (BSk) | Temperate steppe division |
| Temperate arid (BWk) | Temperate desert division |
| *C—Subtropical climates* | *Humid temperate domain* |
| Subtropical dry summer (Cs) | Mediterranean division |
| Humid subtropical (Cf) | Subtropical division |
| | Prairie division * |
| *D—Temperate climates* | |
| Temperate oceanic (Do) | Marine division |
| Temperate continental, warm summer (Dca) | Hot continental division |
| | Prairie division * |
| Temperate continental, cool summer (Dcb) | Warm continental division |
| | Prairie division * |
| *E—Boreal climates* | *Polar domain* |
| Subarctic (E) | Subarctic division |
| *F—Polar climates* | |
| Tundra (Ft) | Tundra division |
| Icecap (Fi) | |

* W. Köppen did not recognize the prairie as a distinct climatic type. The ecoregion classification system represents it at the dry side of the Cf, Dca, and Dcb, types.

TABLE II

*Definitions and Boundaries of the Köppen System.*

| | |
|---|---|
| Ar | all months above 18 °C (64 °F) and no dry season. |
| Aw | all months above 18 °C and 2 months dry in the winter. |
| BSh | Evaporation exceeds precipitation and all months over 0 °C (32 °F). |
| BWh | one-half the precipitation of the BSh and all months over 0 °C. |
| BSk | same as BSh but with at least 1 month colder than 0 °C. |
| BWk | same as BWh but with at least 1 month colder than 0 °C. |
| Cs | 8 months 10 °C (50 °F) or more, summer dry. |
| Cf | 8 months over 10 °C, no dry season. |
| Do | 8 months over 10 °C, warmest month below 22 °C (72 °F). |
| Dca | 4 to 8 months over 10 °C, warmest month above 22 °C. |
| Dcb | 4 to 8 months over 10 °C, warmest month below 22 °C. |
| E | one warmest month 10 °C or above. |
| Ft | all months below 10 °C. |
| Fi | all months below 0 °C. |

A/C boundary = Equatorial limits of frost; in marine locations the isotherm of 18 °C for coolest month.
C/D boundary = 8 months 10 °C.
D/E boundary = 4 months 10 °C.
E/F boundary = 10 °C for warmest month.
B/A, B/C, B/D, B/E boundary = Evaporation equals precipitation.

It should be emphasized that, in this exploratory treatment, no attempt is made to include the marine ecoregions which together occupy some 70% of the Earth's surface—the reference in the title of this paper to 'the Continents' being to their terrestrial components only. On land we distinguish the following domains, interpreting the climatic levels of mountains as altitudinal variations of the climatic zone concerned:

*The Polar Domain*

This is where frost action has primary importance in determining plant development and soil formation. This

** Unfolded copies of the map are available from the Author.

† The delineation of ecoregions should properly be based upon the distinctiveness and distribution of various ecological associations. Unfortunately, available data on the associations of the Earth that include both plants and animals are inadequate for this purpose. The 'ecosystem' regionalization presented here is based to a large extent on macro-features of the climate and vegetation. Animals are dependent directly or indirectly upon plants for food, and often also for shelter and breeding places. Even where plants do not control the distribution of animals, they often indicate the characters of climate and soil upon which animals are dependent.



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domain is divided on the basis of plant development into (a) a tundra zone (division) where the average daily air temperatures in all months are below 10°C (50°F), and (b) a subarctic tayga zone (division) where the average air temperatures in as many as three months of the year may be warmer than 10°C.

*The Humid Temperate Domain*

This comprises the humid mid-latitude forests of broad-leafed and coniferous trees†. The variable importance of winter frost largely determines the divisions: (a) a warm continental zone (division) that has very cold winters but warm summers; (b) a hot continental zone (division) that has cold winters but hot summers; (c) a subtropical zone (division) having mild winters and hot summers; (d) a marine (maritime) zone (division) that has mild winters, cool summers, and a minor role played by frost; (e) a prairie transition zone (division) that has a sub-humid climate; and (f) a Mediterranean-type zone (division) with dry summers and mild winters.

*The Dry Domain*

This comprises the arid and semi-arid regions of middle and adjacent latitudes, and has discontinuous vegetation of steppe, xerophytic bush, and desert, types, with only intermittent and local runoff. It is subdivided into divisions according to: (a) the amount of water deficit, determining whether it is semi-arid steppe or arid desert; and (b) the winter temperatures, which have an important influence on biological and physical processes and the duration of any snow-cover. This temperature factor is the basis of distinction between temperate and tropical/subtropical dry regions.

*The Humid Tropical Domain*

This is characterized by persistently high moisture- and temperature-levels and perennial streamflows. It is divided into (a) the savannas or alternating wet-and-dry tropics, and (b) the rain-forest or wet tropics, on the basis of the seasonality of rainfall, total annual rainfall, and density of plant cover.

In the manner of its division of the primary domains into secondary divisions, each of the above divisions is further subdivided, on the basis of macro-features of the vegetation, into *provinces*. These subdivisions, expressing also more refined climatic differences than the domains and divisions, are adapted from a world map of natural landscape types (Gerasimov, 1964), at a scale of 1:80.000,000. The total number of differentiated province types represented on the present map is 86 (within 12 'divisions' and the above 4 domains).

*Ecoregions* are composed of smaller ecosystems or, more often, complexes of ecosystems, called *sites*, that recur throughout the region. By observing the behaviour of the different kinds of systems within a region, it is possible to predict the approximate behaviour of an unvisited one. Ecoregions are useful to land managers in two ways. First, a map of them suggests the area to which the knowledge gained in studying an ecosystem or wider econ's behaviour may be applied. Second, they provide a geographical framework for identifying other, similar areas from which similar responses may be expected and to which similar management policies may be applied. This facilitates a regional rather than a site-by-site approach to planning land-use. The need for environmental monitoring and analysis is correspondingly reduced.

The colours on the map show the major climatic zones: the mountains in each zone are shown by pattern. The names of provinces retain the names of the most obvious vegetation indicator: dark needle-leafed forest, broad-leafed forest, etc. As a rule, designations of the geographic situation, climate type, and other characteristics, are added: for example, dark-needle-leafed forest of continental climate. In mountain areas, the altitudinal zonality-type is named for the lower- and upper-elevation (subnival) belts: *e.g.* forest-alpine meadow. It is understood that each type corresponds to a typical sequence of altitudinal belts.

If it is necessary to emphasize the existence of intermediate belts in the structure of similar spectra, the name of the most characteristic intermediate belt is added to hte designation; for example, open woodland-shrubs-desert. In low- and middle-elevation mountains, the zonal spectra are, of course, incomplete. In such cases, the type is designated by the character of the lower belt. More details are presented elsewhere (Bailey, 1983, 1988).

The terms used in describing provinces may not be familiar and so need explanation. These include:

*Broad-leafed*—with leaves other than linear in outline; as opposed to needle-leafed or grass-like (graminoid).

*Dark tayga*—shady tayga forests composed of spruce, fir, or cedar.

*Deciduous*—woody plants, or pertaining to woody plants, that seasonally lose all their leaves and become temporarily bare-stemmed.

*Desert*—supporting vegetation of plants so widely spaced, or sparse, that enough of the substratum shows through to give the dominant tone to the landscape.

*Desert-like savanna*—tropical semi-desert with scattered low trees or shrubs.

*Dry savanna or steppe*—with 6–7 arid months in each year.

*Dry steppe*—*see* dry savanna.

*Evergreen*—plants, or pertaining to plants, which remain green in parts the year around, either by retaining at least some of their leaves at all times, or by having green stems which carry on the principal photosynthetic functions.

*Forest*—open or closed vegetation with the principal layer consisting of trees averaging more than 5 m in height.

*Forest-steppe*—intermingling of steppe and groves or strips of trees.

*Grassy savanna*—savanna in which woody plants are entirely lacking.

*Light tayga*—tayga forest composed of larch and pine or spruce.

† A number of compound words used in this paper are written with a hyphen between parts, whereas on the map they may be printed as a single-word variant. The reason for this discrepancy is that the map went into production before the manuscript for this explanatory supplement was edited. Thus what we refer to here as 'broad-leaf' or 'broad-leafed' is printed as 'broadleaf' on the map—Ed.

*Meadow*—closed herbaceous vegetation, commonly in stands of rather limited extent, or at least not usually applied to extensive grasslands.

*Meadow steppe*—the steppe component of the forest-steppe zone.

*Mixed forest*—forest with both needle-leafed and broad-leafed trees.

*Monsoon forest*—drought-deciduous.

*Open vegetation*—vegetation with the plants or tufts mostly discrete rather than touching, but separated on the average by less than their diameter.

*Open woodland* (also called steppe forest and woodland-savanna)—open forest with lower layers also open, having the trees or tufts of vegetation discrete but averaging *less* than their diameter apart.

*Paramo*—the alpine belt in the wet tropics.

*Prairie*—consists of tall grasses, mostly exceeding 1 m in height, comprising the dominant herbs, with subdominant forbs (broad-leafed herbs).

*Savanna*—closed grass or other predominantly herbaceous vegetation with scattered or widely-spaced woody plants usually including some low trees.

*Savanna forest*—the forest component of the savanna.

*Sclerophyll or sclerophyllous*—refers to plants with predominantly hard, stiff or coriaceous (as opposed to orthophyllous) leaves.

*Semi-desert*—(also called *half-desert*) is an area of xerophytic shrubby vegetation with a poorly-developed herbaceous lower layer, *e.g.* sagebrush.

*Semi-shrub* (also called *dwarf-shrub*)—a shrub or woody plant that is less than 0.5 m high.

*Shrub*—a woody plant less than 5 m in height.

*Shrub savanna*—closed grass or other predominantly herbaceous vegetation with scattered or widely-spaced shrubs.

*Small-leafed*—as used here, refers to birch and aspen.

*Steppe* (also called *short-grass prairie*)—open herbaceous vegetation, less than 1 m high, with the tufts or plants discrete, yet sufficiently close together to dominate the landscape.

*Tayga*—a parkland or savanna with needle-leafed (usually evergreen) low trees or shrubs.

*Tundra*—slow-growing, low-formation, mainly closed vegetation of dwarf-shrubs, graminoids, and cryptogams, beyond the subpolar or alpine tree-line.

*Wooded steppe*—open grass, or steppe, with scattered trees.

## Limitations and Warning

This is a *synoptic map* that shows mainly global patterns and must not be relied on for local details. When interpreting the map, one should recognize three limitations. First, strong internal variations can occur within regions where local contrasts (related to elevation, geology, or groundwater) form a complex intraregional mosaic; furthermore, boundaries between regions may be marked by slow gradations rather than abrupt discontinuities. A second limitation is that the boundaries of regions are subject to slow but continuous change, related to long-term alterations in climate and, to a lesser extent, to plant succession. Third, the vegetation conditions indicated by the province names refer to undisturbed plant cover that is known to exit or is assumed to grow if human intervention should be removed. In some regions, *e.g.* the hot continental, little natural plant cover remains, whereas in others, *e.g.* the subarctic, the opposite is widely true. The reader of this map is warned that *deductions as regards local situations should not be made without careful study of local literature and preferably on-the-spot inspection.*

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*Ecoregions of the Continents*
(Coloured folding map inserted overleaf as page 310)