

Lecture 4

The Köppen Classification of Climates



The climatic classifications of the greatest agricultural value are those based on the interactions of temperature and precipitation.



The most widely known and used system was devised by the Austrian geographer Wladimir Köppen.

It is based on temperature, precipitation, seasonal characteristics, and the fact that natural vegetation is the best available expression of the climate of a region.

A distinctive feature of the Köppen system is its use of symbolic terms to designate climatic types.

The various climates are described by a code consisting of letters, each of which has a precise meaning.

Köppen identified five basic climates:

A = Tropical rainy

B = Dry

C = Humid, mild-winter temperate

D = Humid, severe-winter temperate

E = Polar

Each basic climate is subdivided to describe different subclimates, denoted by a combination of capital and small letters.

The capital letters *S* (steppe) and *W* (desert) subdivide the *B*, or dry, climates.

Similarly *T* (tundra) and *F* (icecap) subdivide the *E*, or polar, climates. Small letters further differentiate climates.

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Critics have expressed the opinion that the Köppen classification is based on too few kinds of data, and that boundaries between the various climatic regions are too arbitrary.

But in spite of these objections this system has gained widespread recognition and use.

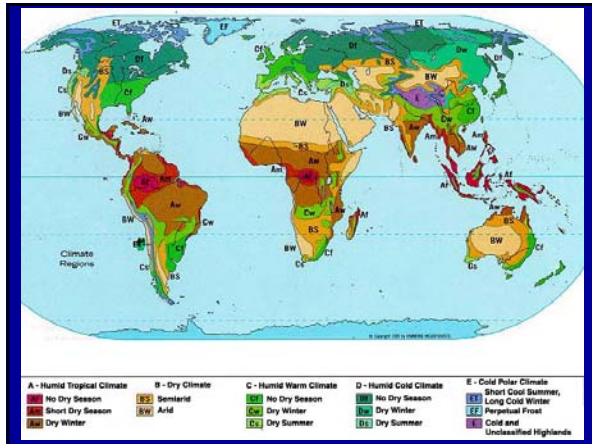
Its simplicity and general adherence to vegetational zones has made it the basis for many revisions and other classifications.

Subclimatic Types

- a* = Warmest month above 22°C (71.6°F) *C, D*
- b* = Warmest month below 22°C (71.6°F) *C, D*
- c* = Warmest month below 22°C (71.6°F);
less than 4 months below 10°C (50°F) *C, D*
- d* = Coldest month below 38°C (-36.4°F) *D*
- f* = No distinct dry season *A, C, D*
- h* = Hot; average annual temperature above 18°C
(64.4°F) *B*
- k* = Cold; average annual temperature below 18°C
(64.4°F) *B*
- m* = Monsoon (short dry season) *A*
- n* = Frequent fog *B*
- s* = Dry season in summer *C*
- w* = Dry season in winter *A, C, D*

Symbol	Major climate	Chief characteristic	Sublimates (incomplete)
<i>A</i>	Tropical rainy	Coolest month above 18°C (64.4°F)	<i>Af</i> , tropical rainforest <i>Am</i> , monsoon rainforest <i>Aw</i> , tropical savannah
<i>B</i>	Dry	Evaporation exceeds precipitation	<i>BS</i> , steppe <i>BSh</i> , tropical and subtropical steppe <i>BSk</i> , middle latitude steppe <i>BW</i> , desert <i>BWh</i> , tropical and subtropical desert
<i>C</i>	Humid, mild-winter temperate	Coldest month between 18°C (64.4°F) and 0°C (32°F)	<i>Cs</i> , Mediterranean (dry-summer subtropical) <i>Csa</i> , hot-summer Mediterranean <i>Csb</i> , cool-summer Mediterranean <i>Ca</i> , humid subtropical (warm summer) <i>Caw</i> , with dry winter <i>Caf</i> , with no dry season <i>Cb</i> , <i>Cc</i> , marine west coast (cool summer)
<i>D</i>	Humid, severe-winter temperate	Coldest month below 0°C (32°F); warmest above 10°C (50°F)	<i>Da</i> , humid continental, warm summer <i>Daw</i> , with dry winter <i>Daf</i> , with no dry season <i>Db</i> , humid continental, cool summer <i>Dc</i> , <i>Dd</i> , subarctic
<i>E</i>	Polar	Warmest month below 10°C (50°F)	<i>ET</i> , tundra <i>EF</i> , icecap

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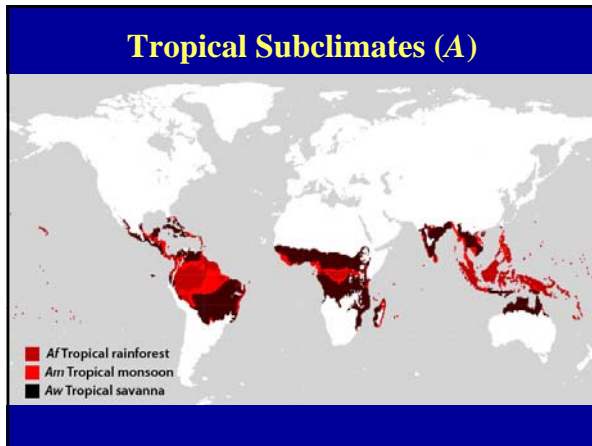
Tropical Rainy Climates (A)

Tropical rainy climates are characterized by the absence of winter; there is no month with an average temperature less than 18°C (64.4°F). This type of climate prevails over about 36% of the total surface of the earth and over about 20% of its land surface. Rainfall is usually abundant, seldom less than 75 cm (about 30 in) per year. The principal climatic types in the humid tropics are distinguished by the amount and distribution of rainfall.

Tropical Subclimates

Af Tropical Rainforest
Am Monsoon Rainforest
Aw Tropical Savanna

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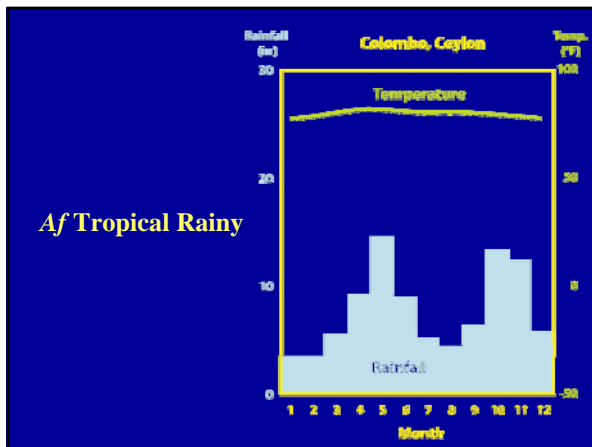
Tropical Rainforest (Af)

Tropical rainforest is found in parts of Africa, Central America, Brazil, Madagascar, the Philippines, and elsewhere.

Its climate is characterized by uniformly high temperatures and heavy, more or less uniformly distributed precipitation.

Even though temperatures may be more moderate than those in higher latitudes, the high humidity makes the heat oppressive.

Violent thunderstorms occur daily at the same hour and with clocklike precision during certain parts of the year.



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Plants that grow in tropical rainforests are called megatherms, and they require continuous high temperatures with abundant precipitation.

The vegetation of tropical rainforests is vigorous and luxuriant.

The number of plant species is large.

The trees are tall and broad leaved, held together as a unit by vines and lianas.

During World War II, when campsites were cleared in the midst of tropical rainforests, a few trees were nearly always left for shade, but this practice was discontinued because high winds blew many of the unsupported trees down.

Soils of the rainforest are deeply weathered because high temperatures intensify chemical action.

When cultivated they are quickly exhausted unless heavily fertilized.

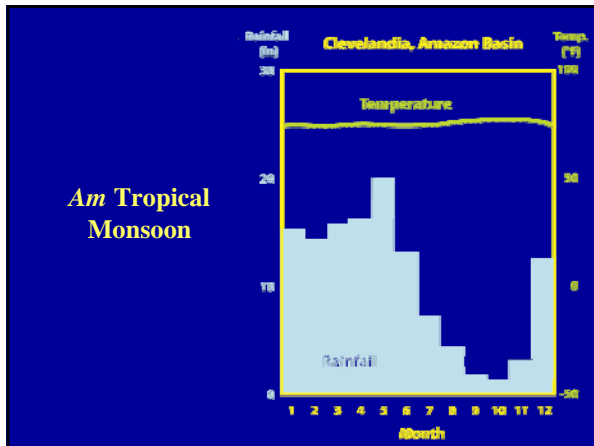
Rainforest soils may also lose their porosity under cultivation, in which case poor aeration becomes a problem.

Monsoon Rainforest (*Am*)

The monsoon rainforest is characterized by a long season of fairly evenly distributed rainfall, which supports rainforest vegetation, a period of intense rainfall, and a short dry season.

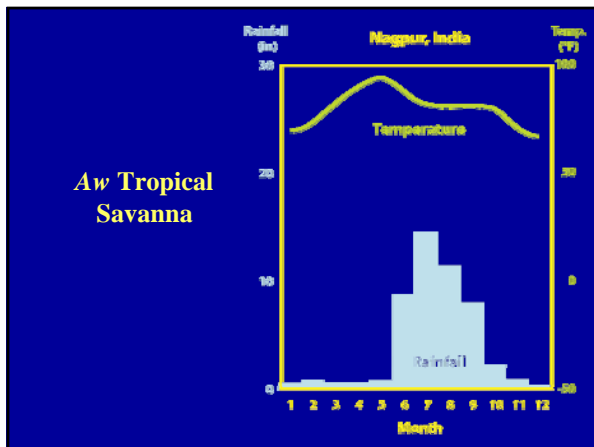
The classic monsoon climate is found in India, Indochina, Burma, and the eastern Amazon valley.

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Tropical Savanna (Aw)

The climate of tropical savannas is transitional between dry climates and those of tropical rainforests. There is less yearly rainfall than in rainforests and it is less evenly distributed throughout the year. Temperatures are much like those of the rainforest climate (Af), but yearly ranges are greater. There are distinct cool dry and hot wet seasons. Savanna climates are found in South America, Africa, and Australia.



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The natural vegetation of tropical savannas consists typically of tall, coarse grass punctuated with clumps of trees, giving a park like appearance.

Bunch grass, which may reach heights of 12', predominates.

The trees are always widely spaced and are leafless during the dry season.

Savanna soils are lateritic.

They are low in organic matter, poor in fertility, but porous and easily cultivated.

In dry savanna regions, the soils resemble prairie soils.

Classical Tropical Crops

Tropical Rainy

Cacao, rubber, oilpalm, banana & plantain

Tropical Monsoon

Rice, coconut

Tropical Savanna

Sugarcane, coffee, citrus

Dry Climates (*B*)

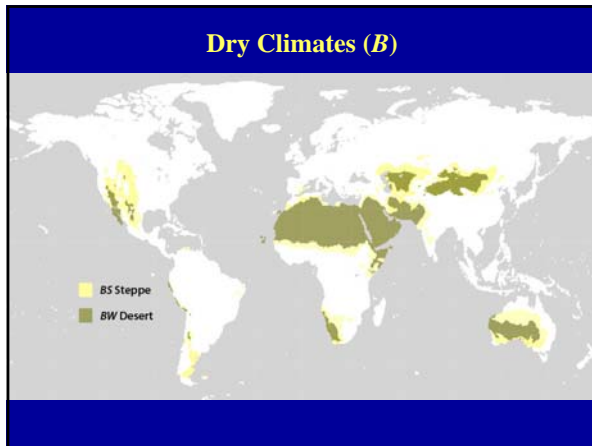
The main features of dry climates are low humidity, scanty and unreliable rainfall, intense radiation, and violent winds.

Desert (*BW*) and steppe (*BS*) are the principal subtypes.

Potential evapotranspiration (transpiration and evaporation from land and water surfaces) exceeds precipitation in dry climates.

In general, the drier the climate, the more uncertain the rainfall.

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Since dryness is defined as a function of potential evapotranspiration, it is difficult to associate a particular temperature with dryness.

For example, Paris has a cool marine climate but receives only about 58 cm (23 in) of rainfall per year; it is in the midst of forest vegetation typical of humid climates.

In the United States temperatures are much higher in areas with such low rainfall, and no forests grow in regions with less than 64 cm (about 25 in) of precipitation per year.

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Steppe (BS)

Steppe climates are semiarid, intermediate between tropical savanna and desert.

Where rainfall is greatest, short grasses prevail; elsewhere, bunch grasses dominate the vegetation.

The steppes of the South Africa veldt (grassland in which there may also be scattered shrubs) once supported vast herds of wild animals.

Native animals may produce more meat for human consumption than the beef cattle that have been introduced.

Steppe soils are dark in color and have no well developed structure.

Those of tropical regions are generally less well developed than those of higher latitudes.

Although cultivation is easy, there is not enough rainfall to support a well developed agriculture unless irrigation is provided.

Desert (BW)

Annual rainfall in most deserts is usually less than 13 cm (about 5 in).

In Cairo, rainfall averages less than 5 cm (2 in), whereas in some parts of the world, such as Calama, Chile, there is little evidence to show that rain has ever fallen.

When rain does fall in desert climates, it is likely to create local torrential floods. Drowning is a frequent cause of death in desert climates.

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Desert vegetation is notable by its scarcity.

When present, it is highly seasonal in character, bursting out after rainfall and rapidly completing its life cycle or yearly growth (if perennial) in a period of about a month, before available soil moisture is depleted.

Wide spacing is characteristic of desert vegetation, with bare soil between shrubs and bunch grasses.

Deserts of the middle latitudes tend to be cooler than those of lower latitudes, and frequently have a partial plant cover.

The meager vegetation has slight value as food for livestock, but has been exploited for this purpose in practically every part of the world.

In contrast to the highly leached soils of wet climates, desert soils are often highly fertile and may become productive when irrigated, but they require careful management.

They are highly variable, however, and tend to be alkaline.

The accumulation of salts (salinity) is a recurrent problem.

Humid, Mild Winter Temperate Climates (C)

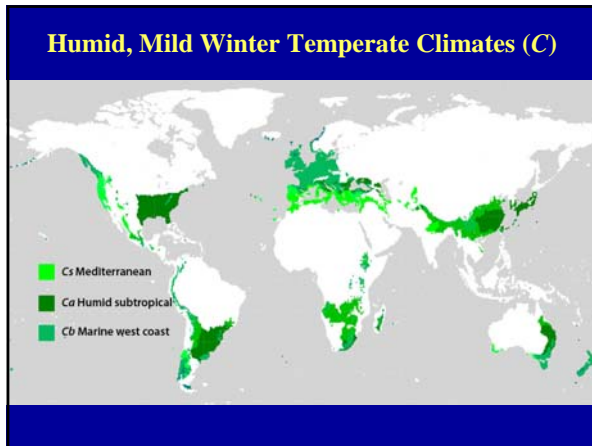
Humid, mild winter climates are characterized by seasonal variations in temperature.

Plant dormancy is usually caused by cold rather than drought.

Weather conditions in C climates are likely to be changeable, owing to conflicting masses of air from tropical and polar sources.

Cyclonic storms are frequent.

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Regions with C climates produce a wide variety of crops, including forage grasses, olives, cotton, grapes, tobacco, cereal grains, and vegetables.

There are three principal climatic subtypes:

- Cs = Dry summer subtropical, or Mediterranean
- Ca = Humid subtropical
- Cb = Marine west coast

Dry Summer Subtropical (Cs)

Commonly referred to as Mediterranean climates.

Dry summer subtropical climates are characterized by hot, dry summers, mild winters with rainfall, and brilliant sunshine throughout the year.

They are found on the borders of the Mediterranean Sea, in central Chile, in South Africa, in southern Australia, and in central and coastal California.

Because of their delightfully mild winters and bright sunny weather, these are among the best-known climates, even though they are found in only 2% of the world's land area.

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Average winter temperatures are typically 4.5–10°C (40–50°F) and average summer temperatures are 21–27°C (70–80°F).

Rainfall averages 38–64 cm (15–25 in), less than enough to support a forest vegetation of large trees with a closed canopy.

The effective precipitation is high, since the bulk of the rain comes in the winter.

Summers are generally hot and dry.

Soils are varied because of the diversity of parent materials.

In the Mediterranean region a distinctive soil, known as terra rosa (red soil), has developed on the hard limestone bed rock.

Soils tend to be easily leached when cultivated.

Soils in humid regions with abundant vegetation tend to be poor, whereas those in regions with less rainfall are often very fertile.

At both extremes of precipitation, productivity of crop plants may be poor.

Vegetation in this climate is variable and falls into complex patterns.

No single type dominates, although trees are always present except in local areas where soil type or fire is the dominant ecological factor.

Glades and open woodland constitute the tree vegetation.

Shrubs and trees are usually dwarfed and have small, thick, glossy leaves that prevent excessive transpiration.

The cork oak (*Quercus suber*) is characteristic, as is the olive.

With irrigation, it is possible to grow an extremely wide variety of crop plants.

The fruit crops of Cs climates include citrus, fig, date, apricot, olive, grape, and plum.

The dry heat of summer is ideal for fruit drying; the fruit is merely laid out in the sun.

California vegetables grown under irrigation are shipped throughout the United States and Canada because of their high quality and winter availability.

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Humid Subtropical (*Ca*)

This is the climate of the US South.

Humid subtropical climates have abundant precipitation, which may be concentrated in the summer, and are usually found on the eastern sides of continents.

Every continent has regions dominated by this type of climate, which has a high potential for the production of agricultural products.

There is nearly always enough precipitation to support crops that mature in late summer or in early fall.

Summer temperatures average from 24–26.5°C (75–80°F), and winter temperatures average from 4.5–13°C (40–55°F).

There is a wide difference between day and night temperatures, sometimes as much as 20°C (36°F).

Precipitation ranges from 75–165 cm (30–65 in) per year.

There is abundant snow, but in lower latitudes it may remain on the ground for no more than a day.

Violent typhoons sometimes occur near land masses, and late summer rains and hailstorms may destroy nearly ripened crops.

Marine West Coast (*Cb* and *Cc*)

Marine west coast climates are usually found in relatively narrow strips along the west coasts of continents in the middle latitudes.

Characteristic air masses move in from the oceans, resulting in cool summers and moderate winters.

Mean summer temperatures are seldom higher than 20°C (68°F).

Mean winter temperatures are above freezing, although killing frosts are not unusual.

Frequently the transition from a marine climate to a severely cold one (as in Scandinavia) or from a marine climate to a very dry one (as in California) may take place within a mile or two.

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In some places there is as much as 380 cm (150 in) of precipitation per year but in others no more than 50 cm (20 in), which nevertheless may be adequate for crop growth because of cool temperatures.

Snow is usually abundant only at high elevations.

Always accompanying the precipitation is a high degree of cloudiness.

Fog and mist are common, and the sun may not be seen for several weeks.

Soils are quite variable and generally deep, for the most part they are capable of good agricultural production.

Evergreen forests are predominant in some areas, deciduous forests in others.

In North America, gigantic redwoods that grow to more than 3 m (10') in diameter occupy the foggy western slopes of California's coastal ranges.

In Chile, the forests are of broad leaved evergreen trees.

Evergreen shrubs, such as heather, gorse, and juniper, take the place of trees in areas that have been subjected to severe glacial scouring, as in Wales and Scotland.

In Europe, the dominant trees are deciduous.

These are rich climates for such cool season crops as apple, pear, strawberry, peas, and lettuce, but too cool for growing many warm season crops outdoors, with the result that greenhouses are used in Holland and England to grow such crops as tomato and cucumber.

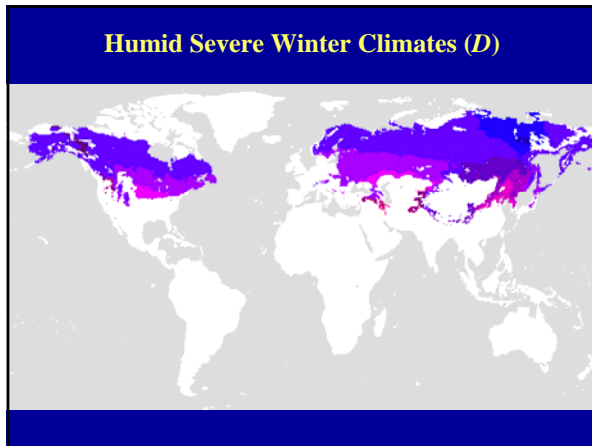
Humid, Severe Winter Temperate Climates (*D*)

There are two main subdivisions of *D* climates that are of agricultural importance, both distinguished by cold, snowy winters and wide annual ranges in temperature.

Because their controlling climatic forces originate over large land masses, they are frequently called continental climates.

Only in the Northern Hemisphere (North America and Eurasia), are there land masses large enough for their development.

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The climates of Canada and the Russian Federation are typical.

Soils at the northern limits of D climates are podzols with a heavy cover of litter.

They are poor for agricultural purposes, but they support dense stands of conifers.

Soils of the deciduous forests have podzolic characteristics, but generally they are better than those further north.

Grasslands have fertile, dark, prairie soils.

Their general use for agricultural production testifies to their desirability.

The grasses are tall and originally supported large herds of animals.

Today, there are few places where relicts of this vegetation in North America have been preserved.

The forests were originally maple and mixed oak and hickory in the southern parts, with conifers along the northern edges.

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Humid Continental with Warm Summers (*Da*)

Conditions in *Da* climates are excellent for the growth of certain crops.

Mean temperatures may be as much as 30°C (86°F), and highs of 38.5°C (105°F) have been recorded.

There may be as many as 200 frost free days.

The climate of the north-central United States is an excellent example of this type.

Most rainfall occurs in the summer months.

In some years rainfall is sparse, resulting in drought.

Snows are occasionally extremely deep, but winter precipitation does not usually exceed 13 cm (about 5 in), whether it is rain or its equivalent in melted snow.

Snow cover prevents losses of heat from the earth during the winter, with the result that the soil warms faster than might be expected on the basis of air temperature measurements.

Humid Continental with Cool Summers (*Db*)

Regions with the *Db* climate lie to the north of those with the *Da* type, and are primarily wheat production regions.

Although summers are a few degrees cooler than those of the hot summer type, winters are 5–15°C (9–27°F) colder.

The long summer days in higher latitudes compensate to some extent for the colder temperatures.

But in all, the climate is dominated by winter.

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In the parts of Europe subject to this climate, winter temperatures are tempered somewhat by oceanic air masses.

The frost free season may be no longer than 50 days.

Precipitation is highly variable.

There is, however, considerable snow, and the snow cover may last for more than 120 days.

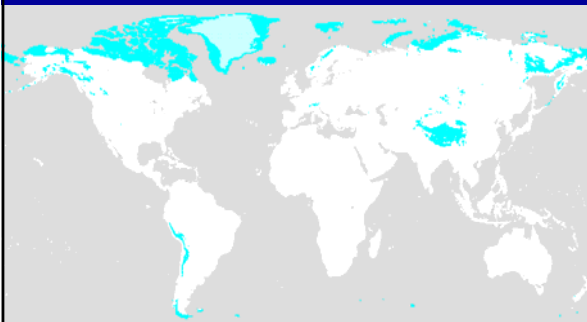
Crops grown in *Db* climates include potato, pea, sweet corn, turnip, carrot, cabbage, and other plants that need only a short growing season.

Polar Climates (*E*)

Polar climates are agriculturally unimportant.

The presence of the sun above the horizon for six months, its absence for an equal period, the bitter cold, and the perpetual snows or icecaps (in *EF* climates) may signal high adventure for those who wish to test their courage, endurance, and skill, but they hold no appeal for the agriculturist.

Polar Climates (*E*)



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Not all polar climates are characterized by permanent snow.

In the warmer tundra (*ET*), which is found over a large area in the Northern Hemisphere, there is a brief growing season and meager vegetative cover, even though the soil may be permanently frozen to a depth of a few inches to a few feet below the surface, a condition called permafrost.

Tundra vegetation is basically of two types: one a carpet of moss and lichens; the other a mixture of mosses, sedges, flowering herbs, and low woody shrubs.

These shrubs (often trees in warmer climes) are dwarfed and stunted, have distorted and crooked stems, and are known as elfinwood, or krummholtz.

The soil in which tundra vegetation grows may be no more than a few centimeters deep, an environmental characteristic shared by plants that grow at high elevations.
