Vegetation Patterns in Relation to Climate, Other Factors, and History

Lecture 2 ESP 30

Why concentrate on vegetation?

- Plants are tightly tied to climate and other abiotic drivers
- Plants are the base of the food chain and hence have a dramatic effect on animals
- People rely heavily on forests, farms and fisheries
- Plants are “niche constructors”
  - The have a big impact on weathering, erosion rates, soil development, and climate
  - They build their own niches and of course the niches of the animals that depend upon them to an appreciable degree

Weaverbird nests
South Africa

Biogeographic Hypotheses

- Adaptation
  - Plants and animals are adapted to their environments
  - Ergo places with similar environments will have similar plants and animals
  - Biome hypothesis is that climates are especially important and that “homoclimates” will have similarly structured ecosystems
- History
  - The various continents and oceans are partly isolated
  - Different lineages will have evolved in different places
  - At least to some extent, the ecosystems of historically unique places will be different due to having historically unique species

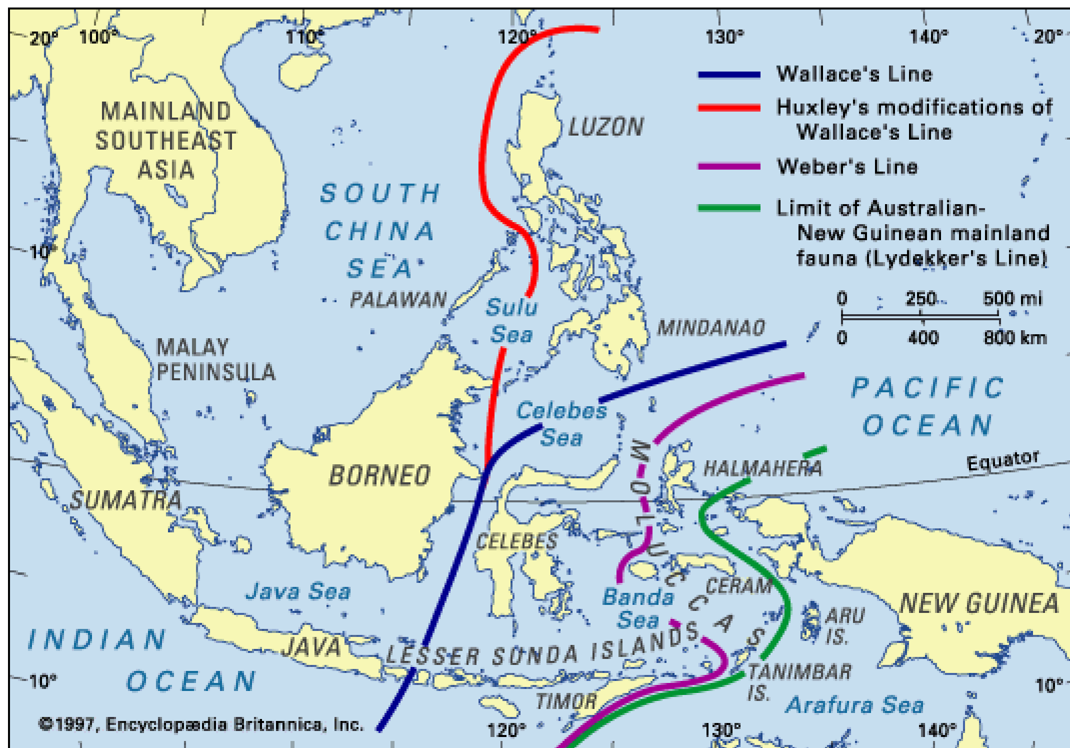
Australian vegetation dominated by Eucalyptus and related woody plants found nowhere else

Australian hunter-gatherers were unusual in that many men tended to have multiple wives

Biogeographic Classification: History

Alfred Russel Wallace. Co-discoverer of natural selection wrote the first treatise on biogeography

New Guinea and Australia are the most isolated continental mass, one of Wallace's signal discoveries. The island biotas between Borneo and Java and New Guinea have various sorts of admixtures leading to several proposals to modify Wallace's line



The plant realms

The realms are attempts to depict the historical patterns. For example, Eucalyptus is confined to Australia, and oaks are Holarctic.

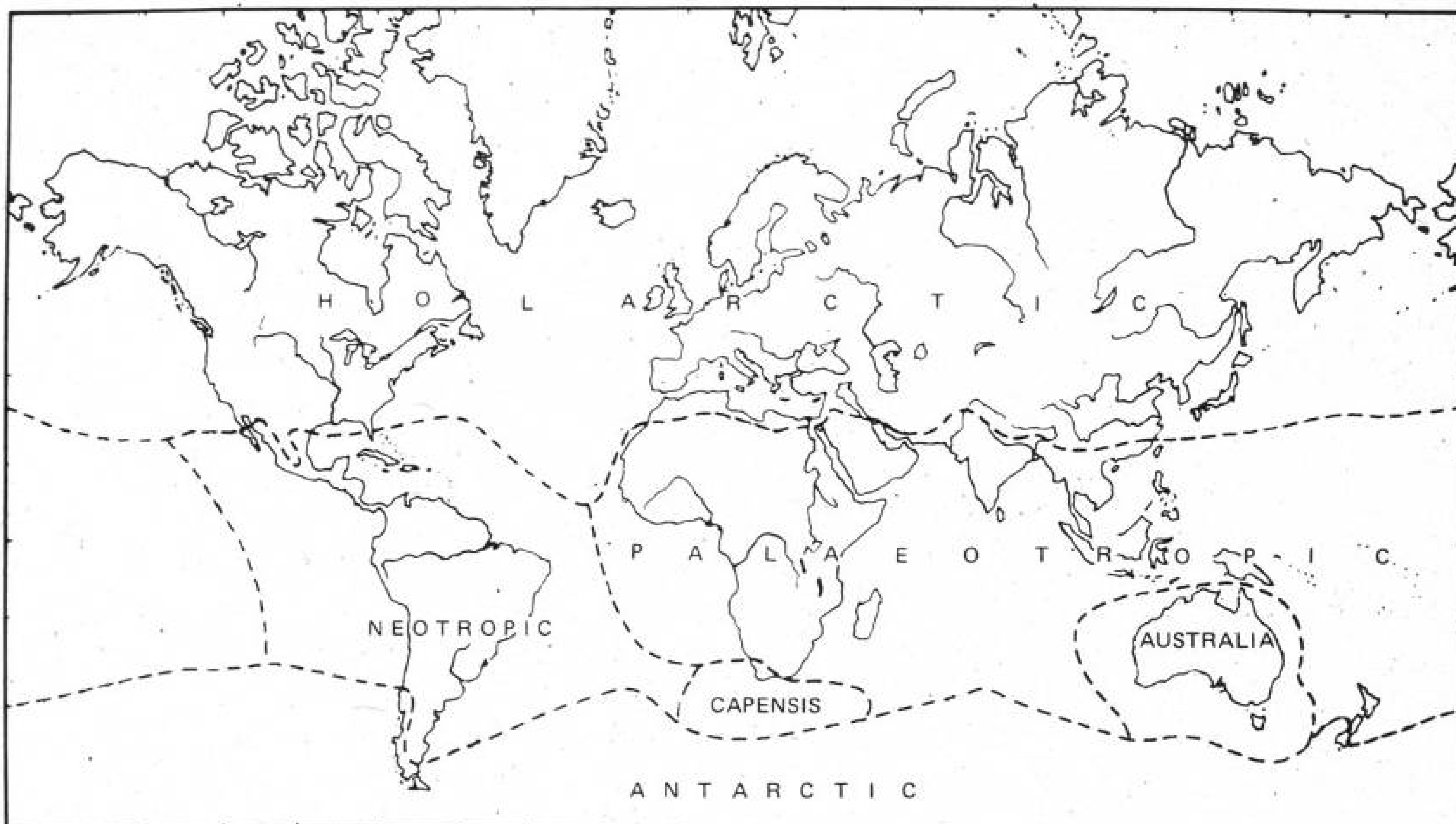
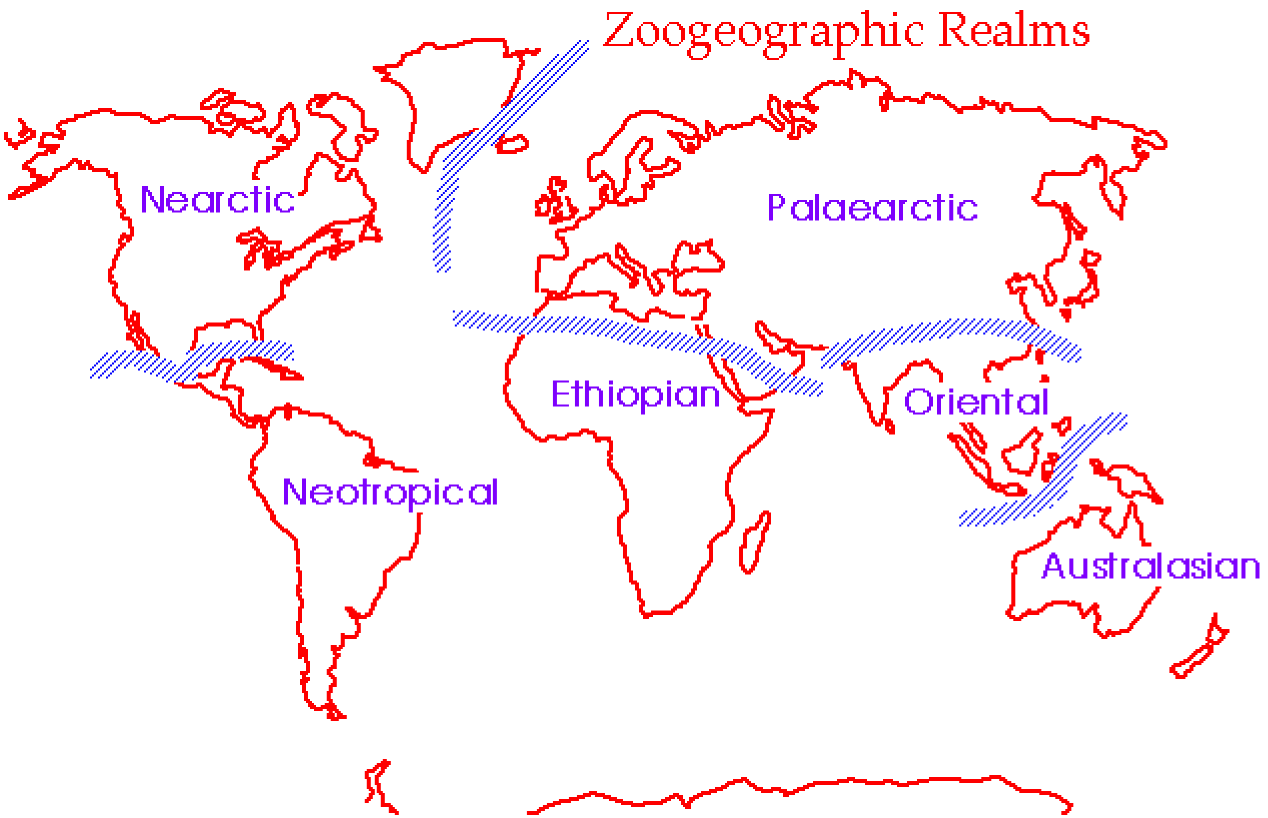


Fig. 2. The floristic realms of the Earth (Diels and Good, modified, from Walter/Straka 1970). In New Zealand and Tasmania antarctic, as well as palaeotropic and australian elements occur.

The animal classification is a little different



Of course, biogeographers can and do argue about all these lines too.

Walther's Biome Scheme: Adaptation

This classification ignores species composition. It focuses on the ecological similarities produced by adaptive convergences in similar environments

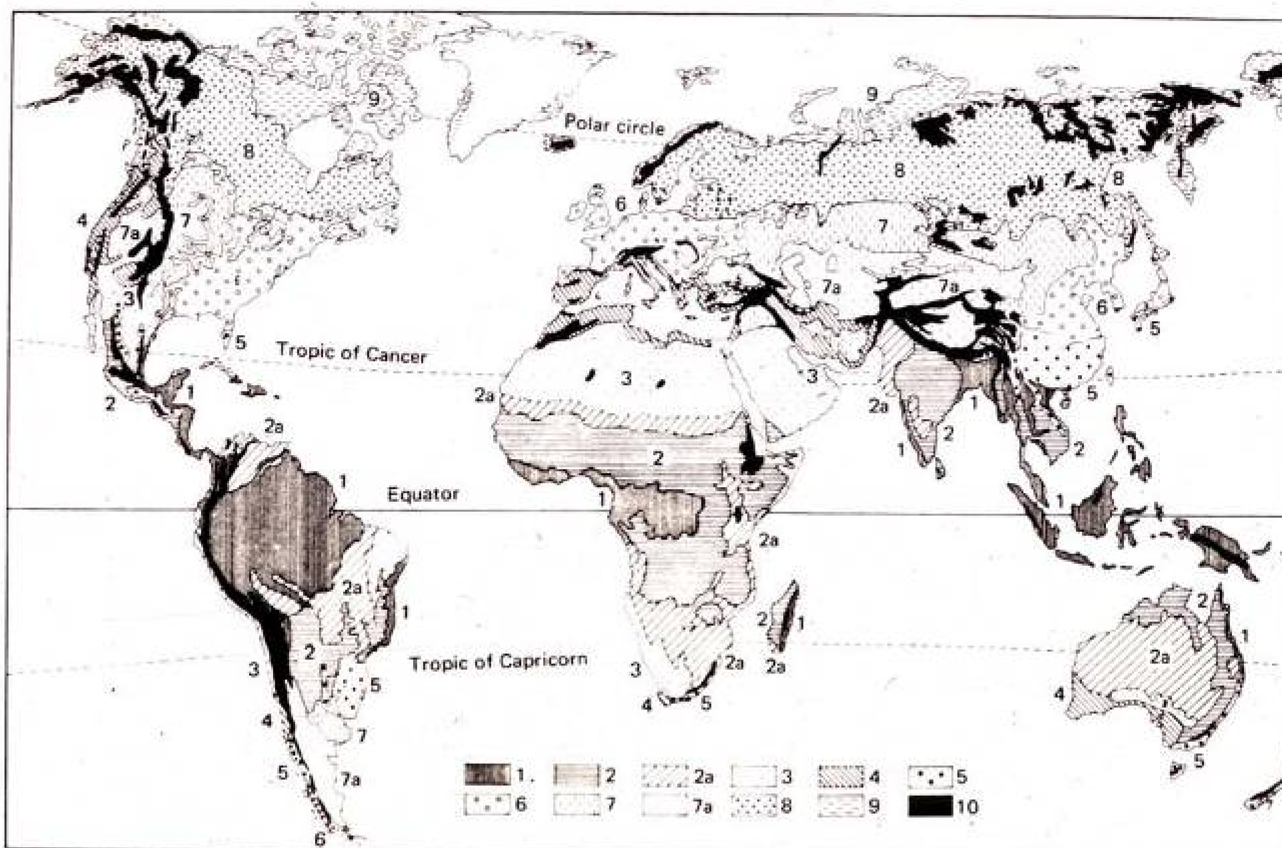


Fig. 13. Vegetational zones (much simplified, without edaphically or anthropogenically influenced vegetational regions). I. Tropical and subtropical zones: 1 Evergreen, rainforests of the lowlands and mountain-sides (cloud forests), 2 semi-evergreen and deciduous forests, 2 a dry woodlands, natural savannas or grassland, 3 hot semi-deserts and deserts, polewards up to latitude of 35° (see also 7 a). II. Temperate and Arctic zones: 4 Sclerophyllous woodlands with winter rain, 5 moist warm temperature woodlands, 6 deciduous (nemoral) forests, 7 steppes of the temperate zone, 7 a semi-deserts and deserts with cold winters, 8 boreal coniferous zone, 9 tundra, 10 mountains.

Walter's "Climographs"

A neat pictoral representation of seasonal patterns temperature and rainfall

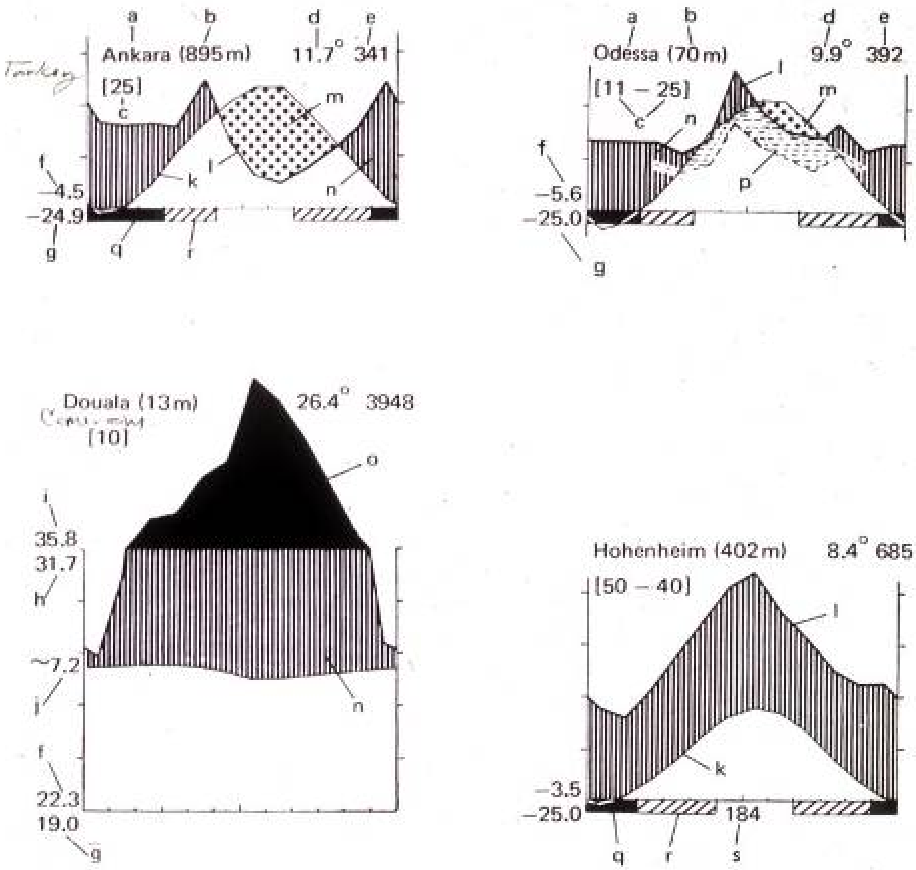


Fig. 7. Key to the climatic diagrams. Abscissa: Months (N. Hemisphere January—December, S. Hemisphere Juli—June); Ordinate: one division = 10° C or 20 mm rain. a = station, b = height above sealevel, c = duration of observations in years (of two figures the first indicatea temperature, the second precipitation), d = mean annual temperature in ° C, e = mean annual precipitation in mm, f = mean daily minimum of the coldest month, g = lowest temperature recorded, h = mean daily maximum of the warmest month, i = highest temperature recorded, j = mean daily temperature variations, k = curve of mean monthly temperature, l = curve of mean monthly precipitation, m = relative period of drought (dotted), n = relative humid season (vertical shading), o = mean monthly rain > 100 mm (black scale reduced to 1/10), p = reduced supplementary precipitation curve (10° C = 30 mm) and above it (dashes) dry period, q = months with mean daily minimum below 0° C (black) = cold season, r = months with absolute minimum below 0° C (diagonal shading) = late or early frosts occur, s = mean duration of frost-free period in days. Some values are mising, where no data are available for the stations concerned (h—j are only given for diurnal types of climate).

Don't worry overmuch about the details. The important parts are the temperature and rainfall lines, and whether they indicate any drought months. Note that the scales for rainfall and temperature are adjusted to roughly show when rainfall is likely to be insufficient to support full plant production. The bars at the bottom indicating freezing and frosty weather are also important.

Walter's "Homoclimates"

The biome hypothesis predicts similar ecosystems in places with homoclimates

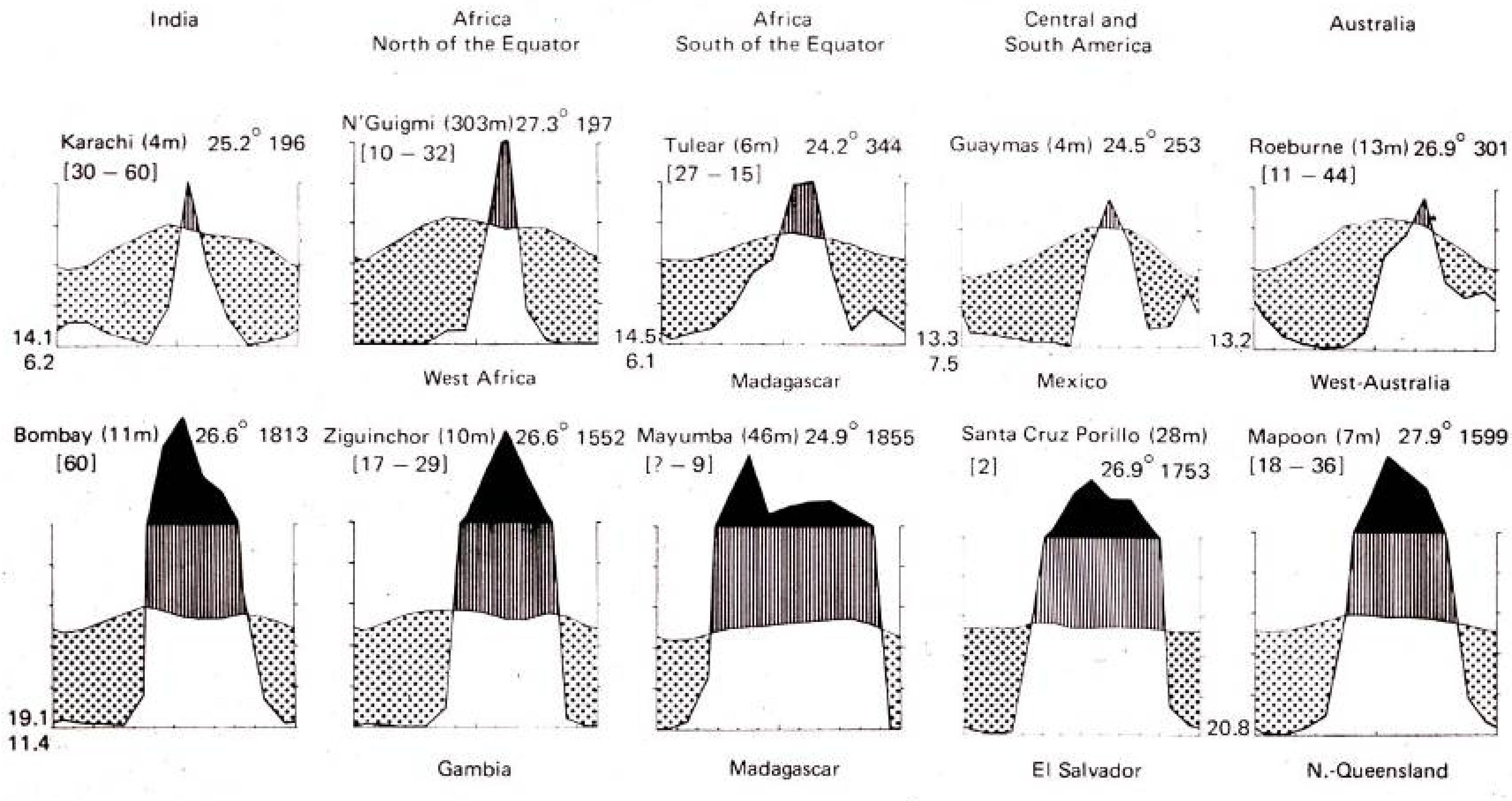
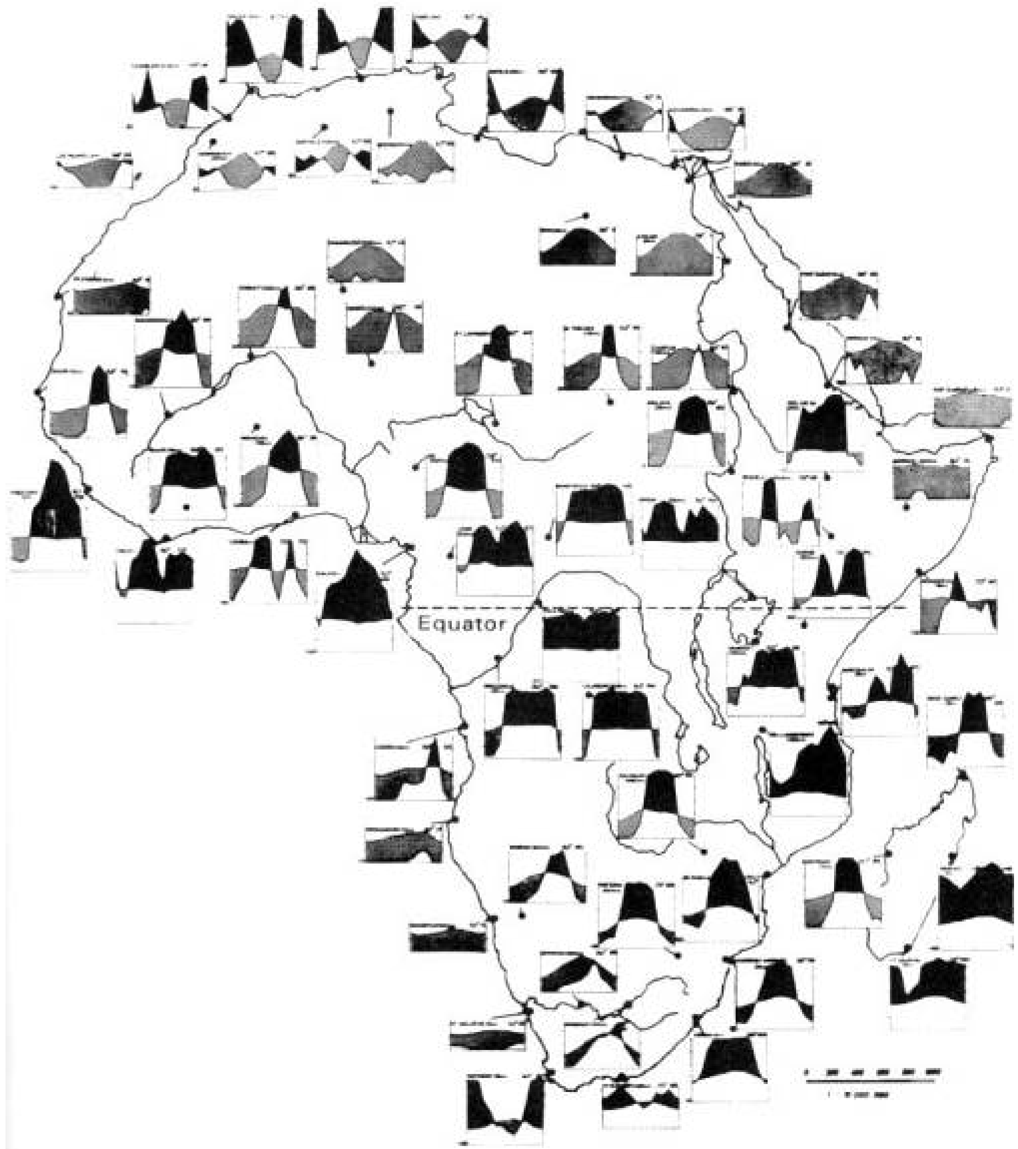
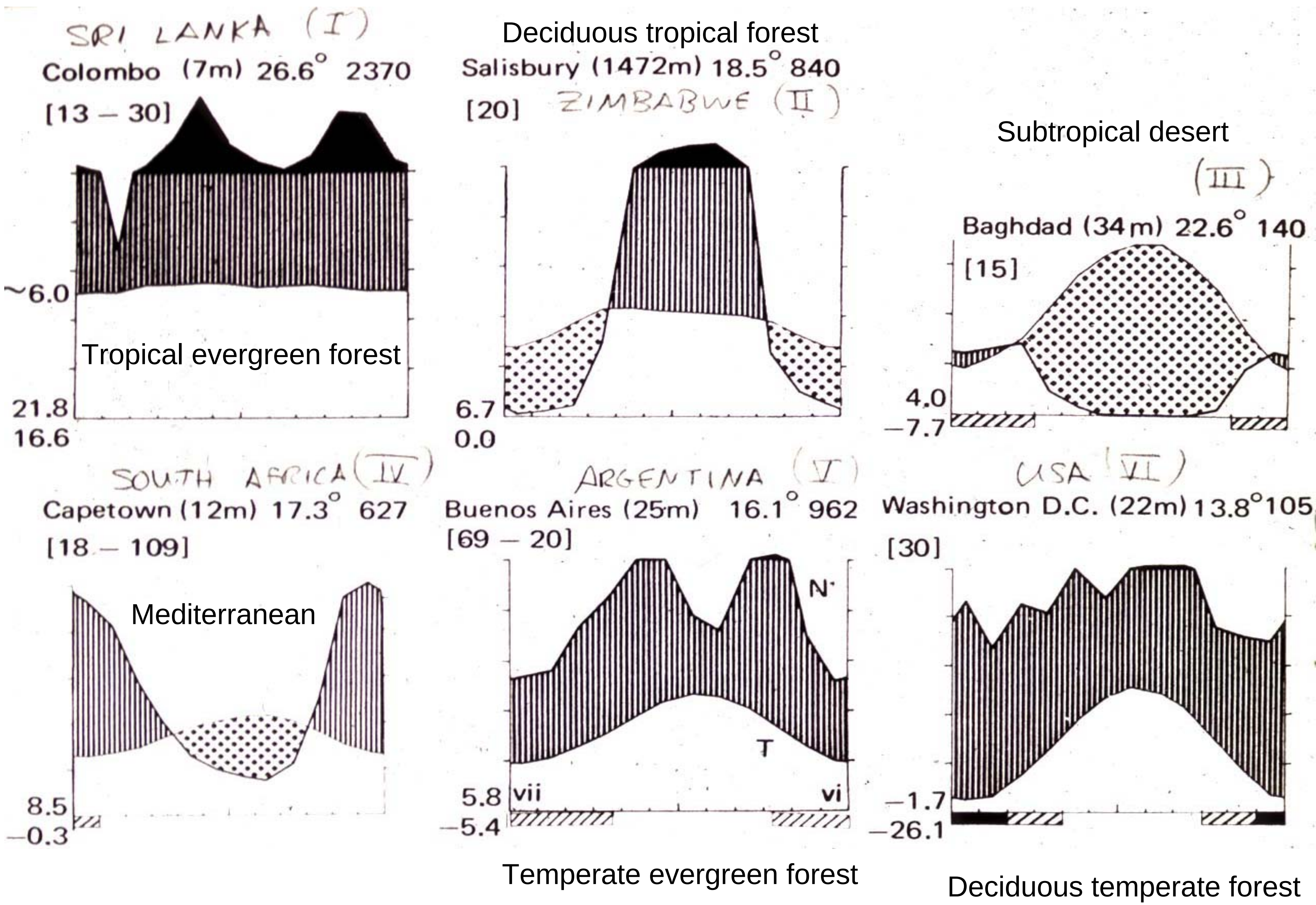


Fig. 9. Homoclimes, on other continents, of the Indian stations Karachi and Bombay.

Climographs allow you pick out homoclimates at a glance

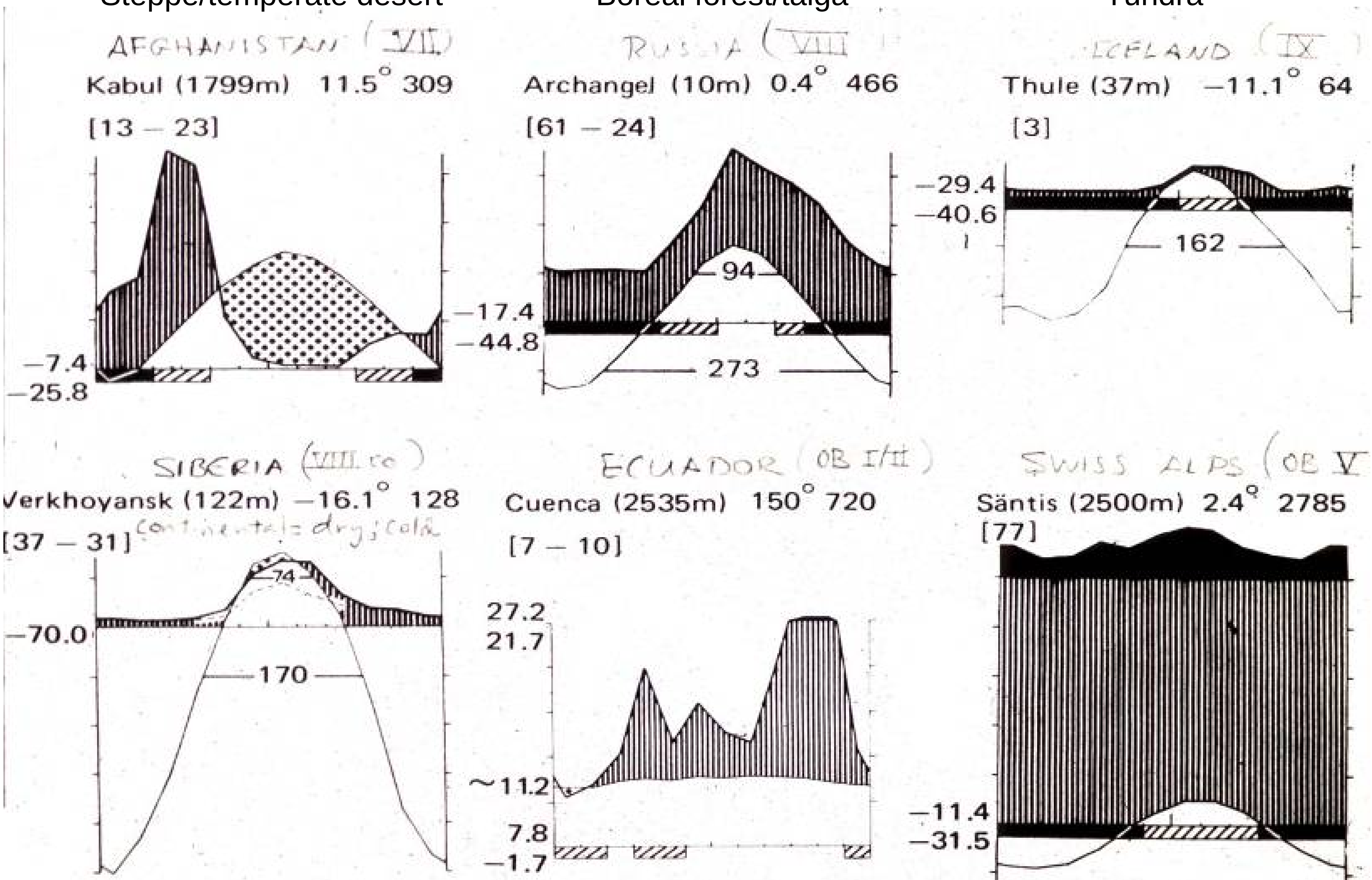


Climates of the major biomes I



Climates of the major biomes II + some "orobiomes" and another outlier

Steppe/temperate desert | Boreal forest/taiga | Tundra



Very cold, dry boreal forest

Fairly high tropical mountain

Fairly high tropical mountain

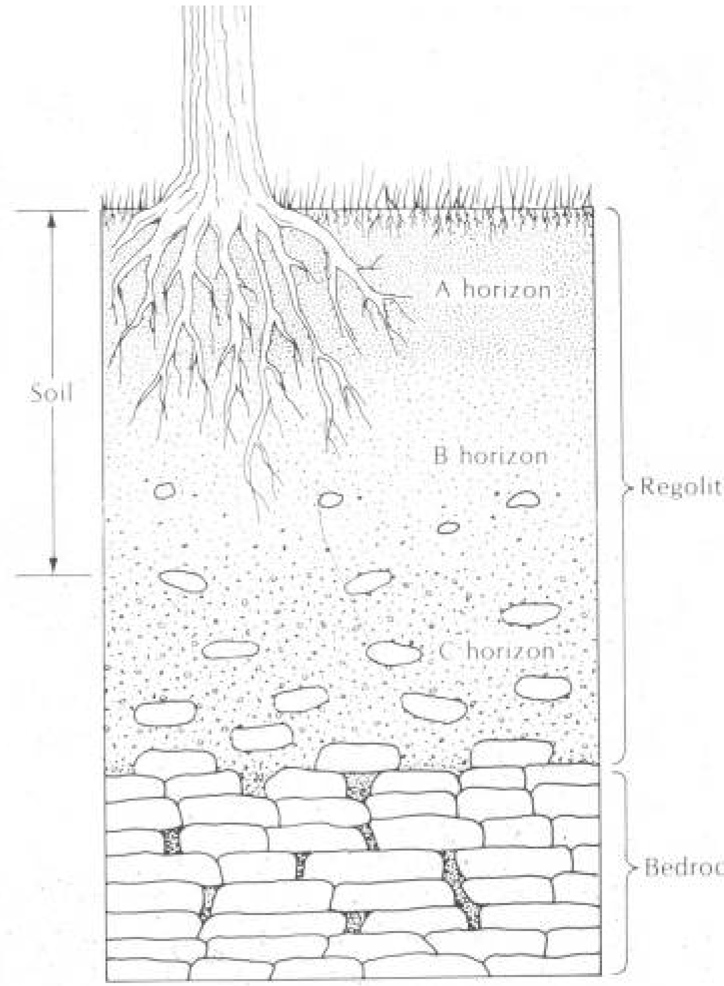
Soils

- Soils are the second most important influence on vegetation after climate
- They are also an intermediary between climate and vegetation
- Soils develop on land surfaces over time as a complex function of
  - “Parent material” the rock or other raw material (geology)
  - Temperature and rainfall
    - Chemical aging processes fast under hot wet conditions
    - Chemical aging processes are slow under cold or dry conditions
  - Organisms
    - Surface plants and animals deposit organic matter
    - Soil animals, fungi, and microorganisms very important soil “workers”, for example earthworms structure soil
    - People are also potent soil builders and destroyers

Soil “horizons”

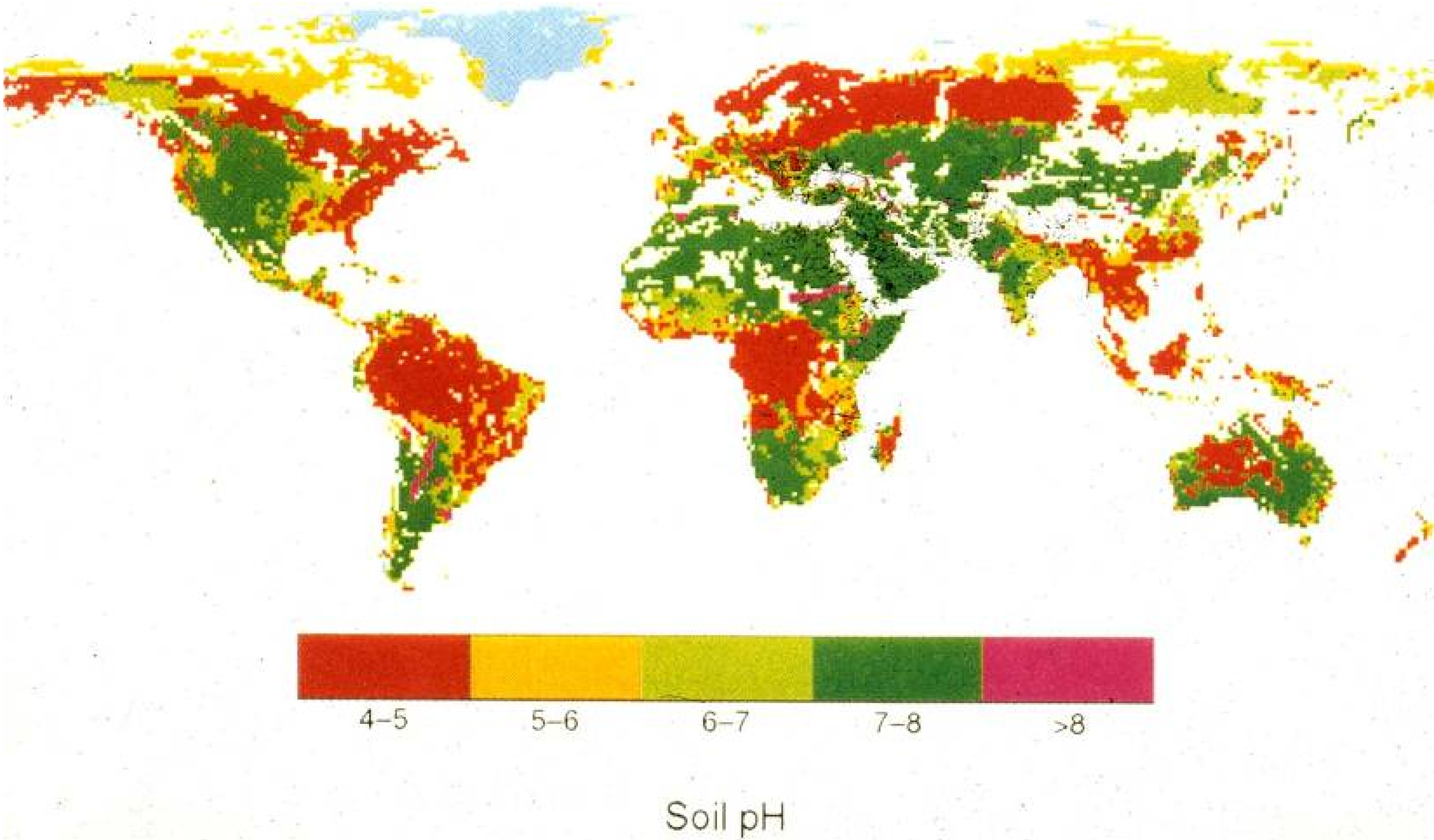
from unmodified “parent material” at the bottom to the heavily modified A horizon at the top

In this “spodsol” soil clays have been carried out of the A horizon, leaving a bleached, acidic sandy layer. This is typical of soils that develop under cool moist conditions.



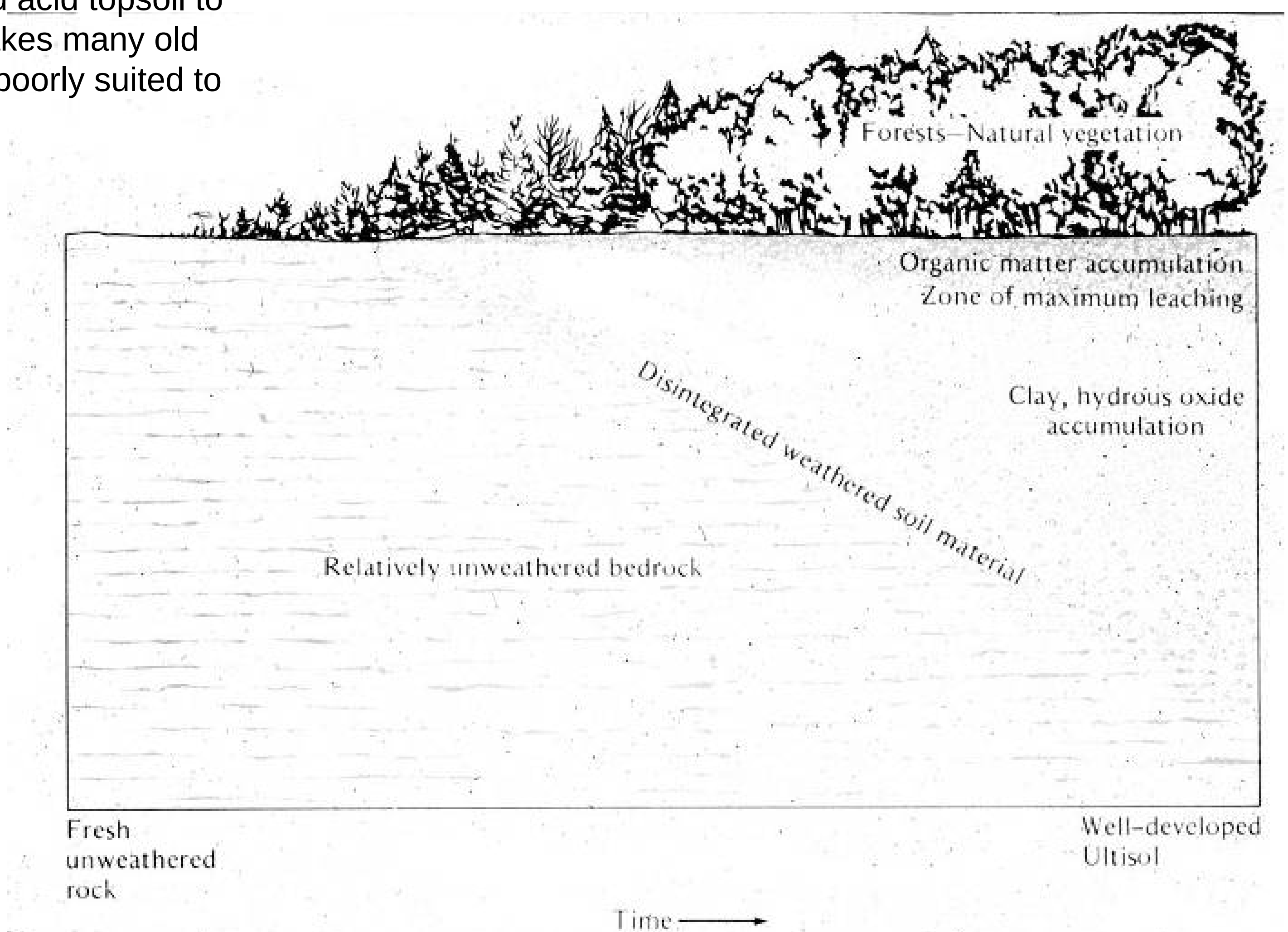
The influence of geology comes in at the bottom

Humid climates generally produce acid soils as basic minerals are leached away over time



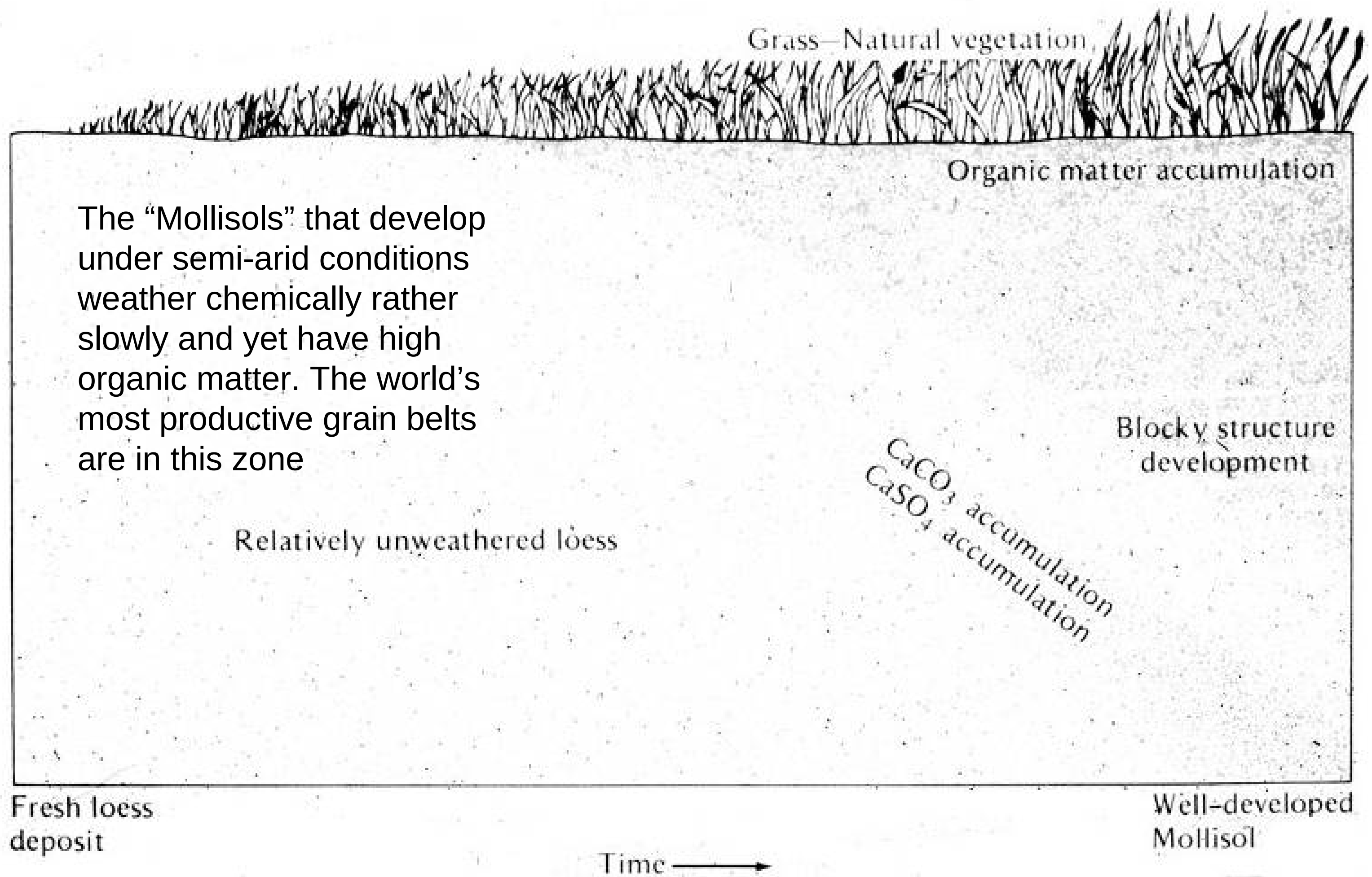
Soil evolution under a humid temperate climate

The leached acid topsoil to the right makes many old forest soils poorly suited to agriculture



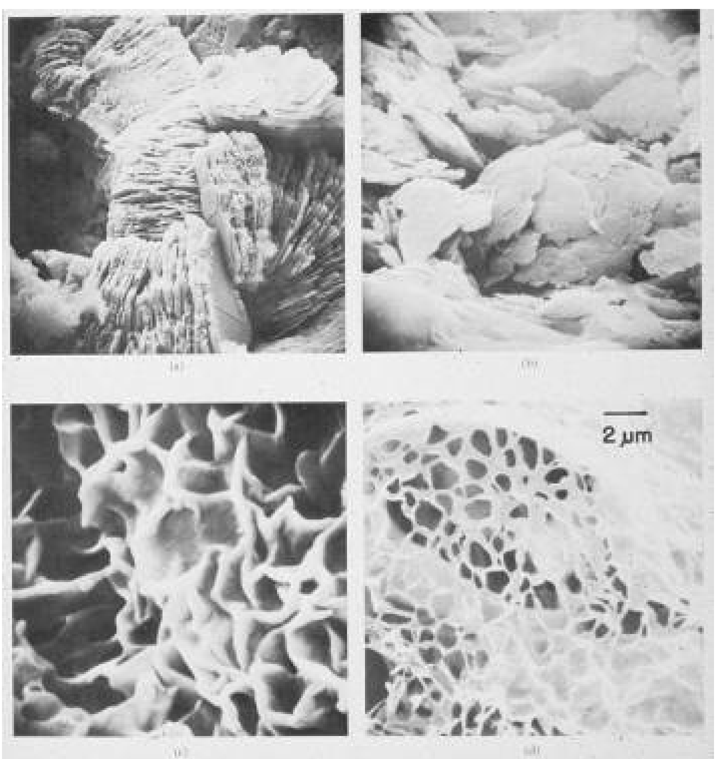
Soil evolution in semi-arid Steppe Biome

The “Mollisols” that develop under semi-arid conditions weather chemically rather slowly and yet have high organic matter. The world’s most productive grain belts are in this zone



Clay: Key component of soils

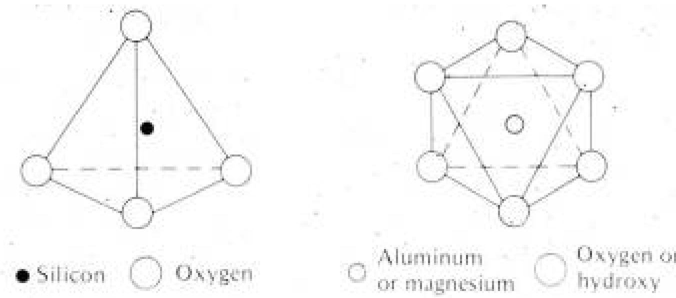
- Clays are the fine particles of soils
- Most are platy aluminosilicate minerals
  - Have huge surface area per unit weight
  - Have negatively charged surfaces that attract positively charged plant nutrients like ammonia, potassium, and calcium; hyper-important for soil fertility
  - Are sticky and help bind soil particles together

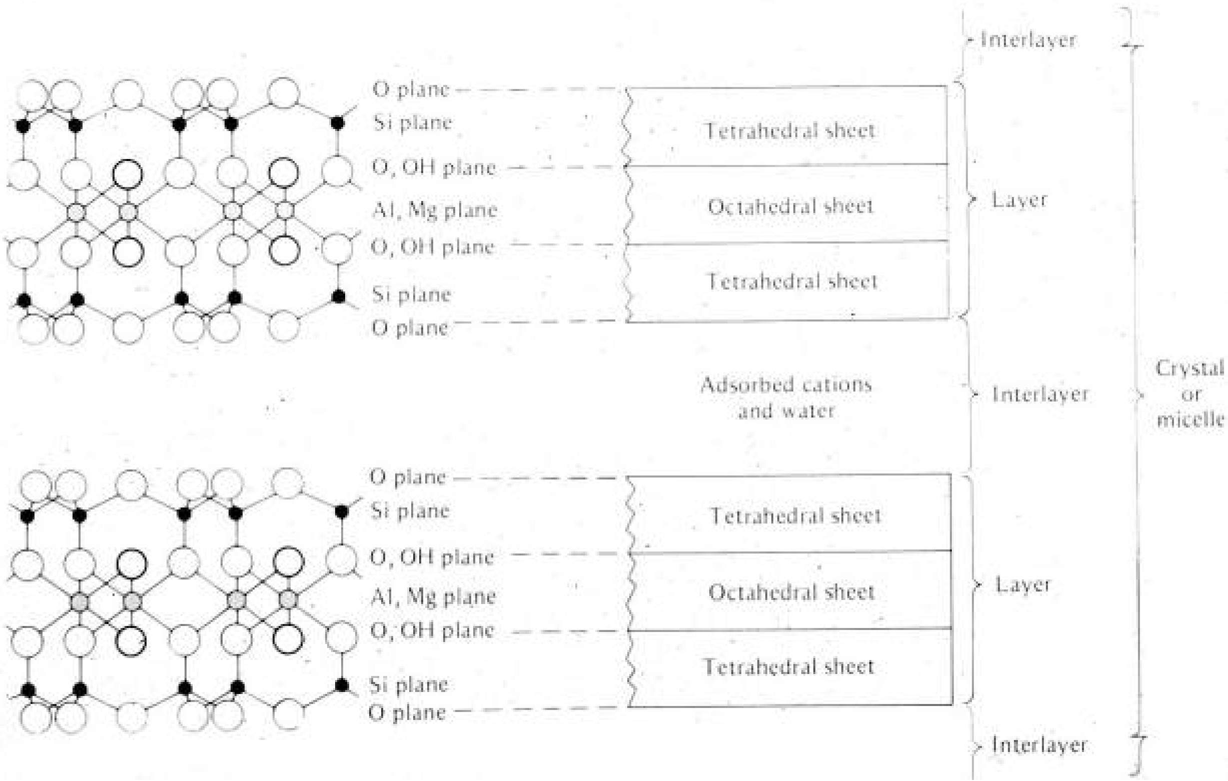


The clay content of soils is easy to observe by getting your hands dirty. Sandy (“light”) soils cannot be rolled into a sticky ball when wet. Pure clay (“heavy”) soils are completely plastic like modeling clay. Dream loams are just the right combination of clay, humus, and coarser particles. They have a texture that suggests something good to eat like heavy German bread.

Clay plates built from sheets silicon and aluminum oxides, plus embedded "impurities"

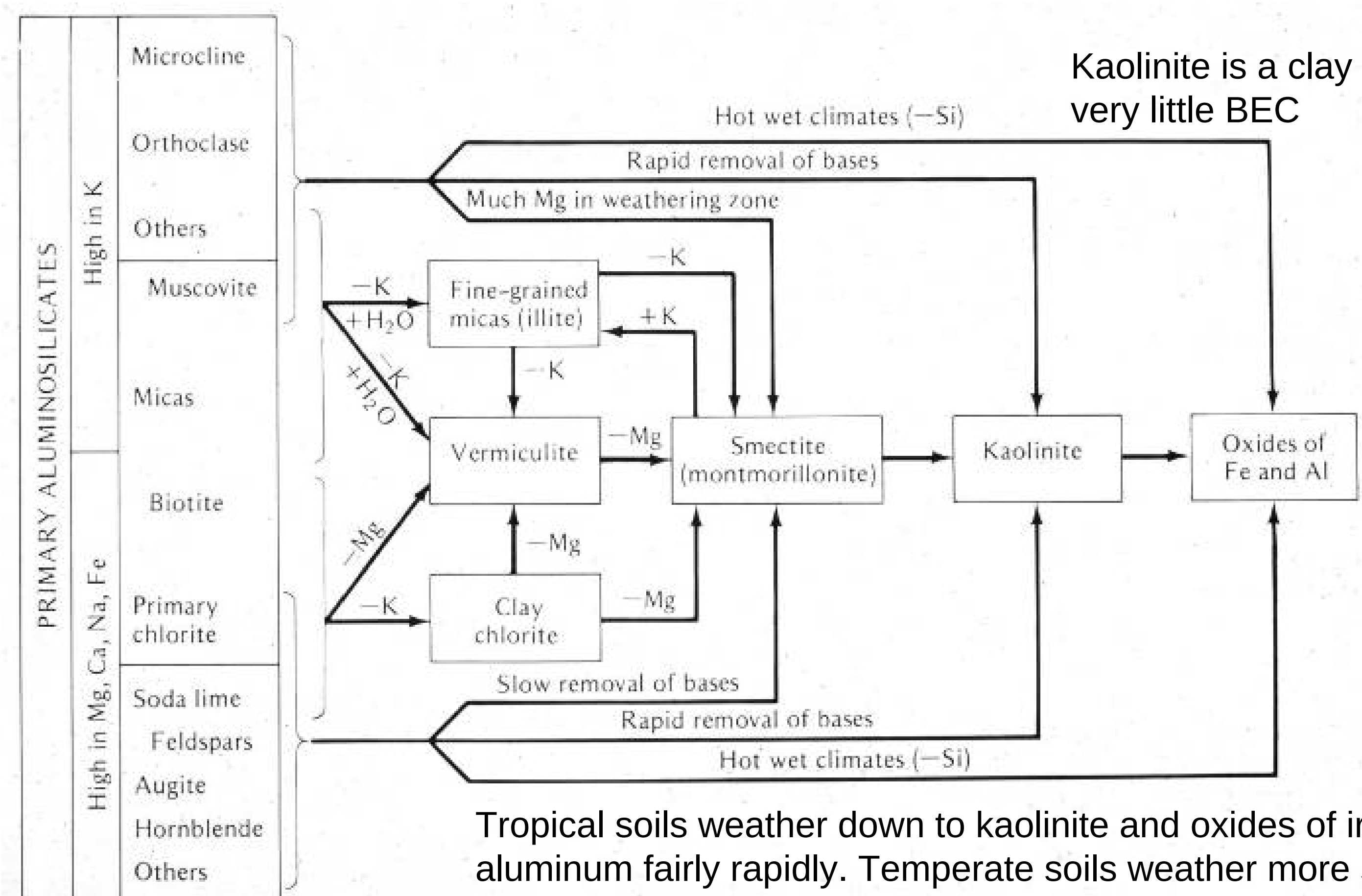
"Impurities" impart the negative charges make clays so important for plant nutrient retention





Clay evolution as a function of time

- Clays evolve over time by losses of minor constituents (magnesium, potassium, etc.) and other reorganizations
- As they weather, clays lose their nutrient holding capacity (“base exchange capacity” is the jargon)



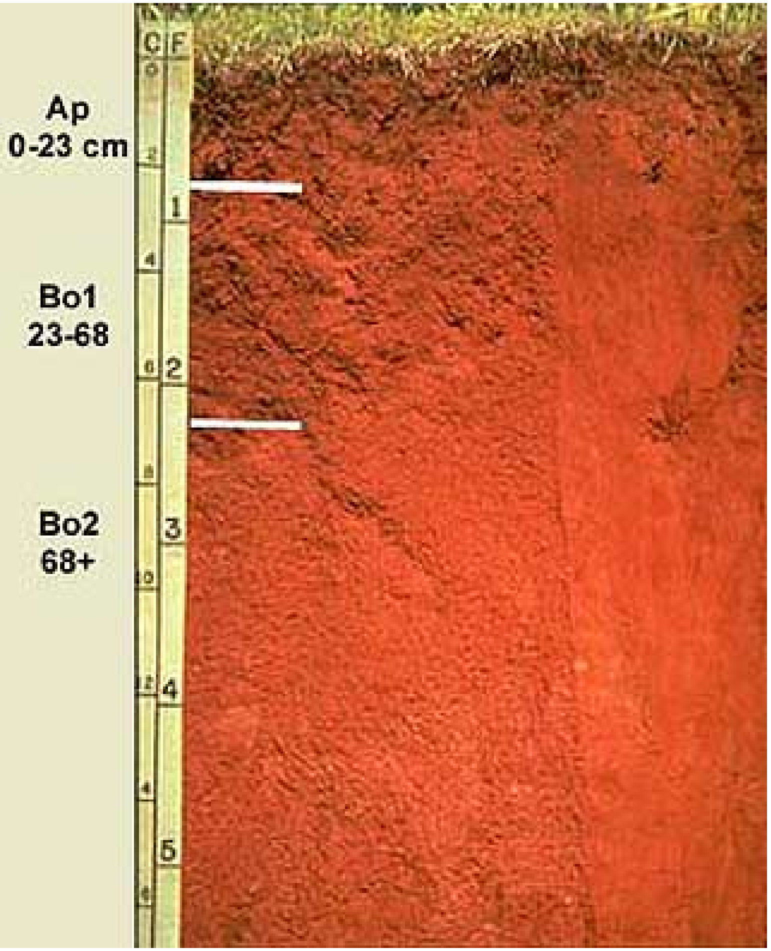
Kaolinite is a clay that has very little BEC

Tropical soils weather down to kaolinite and oxides of iron and aluminum fairly rapidly. Temperate soils weather more slowly and hence tend to be more productive.

Poor, heavily weathered soils

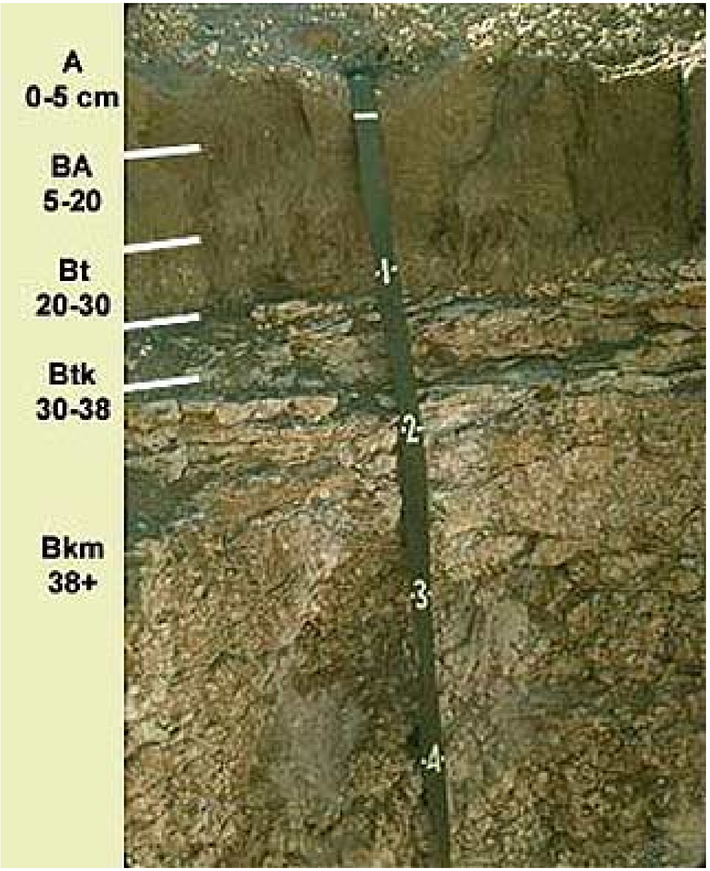
Under cold, wet conditions,
podsols or spodsols

Under hot wet conditions (Hawaii)
Oxisol, lateritic soil

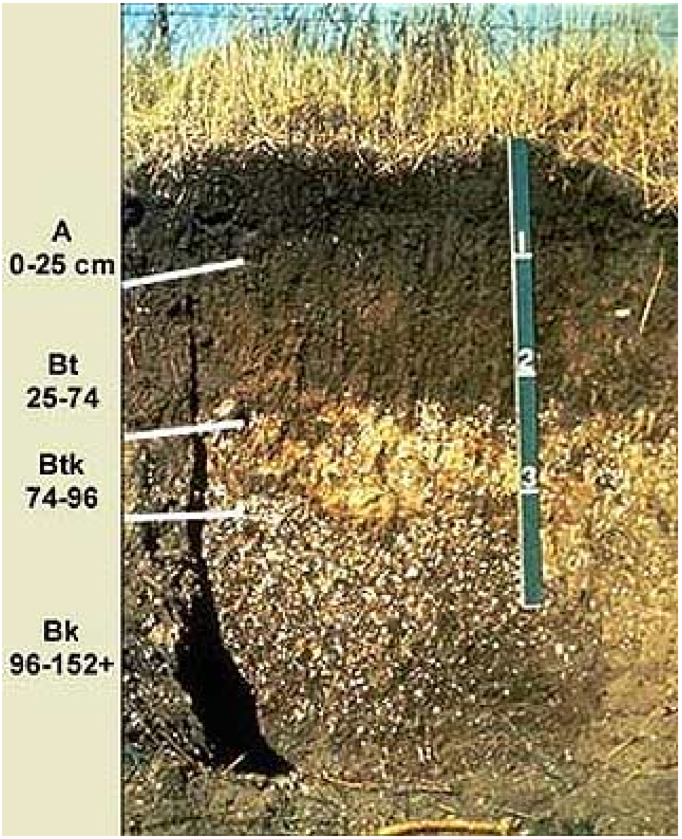


Good soils

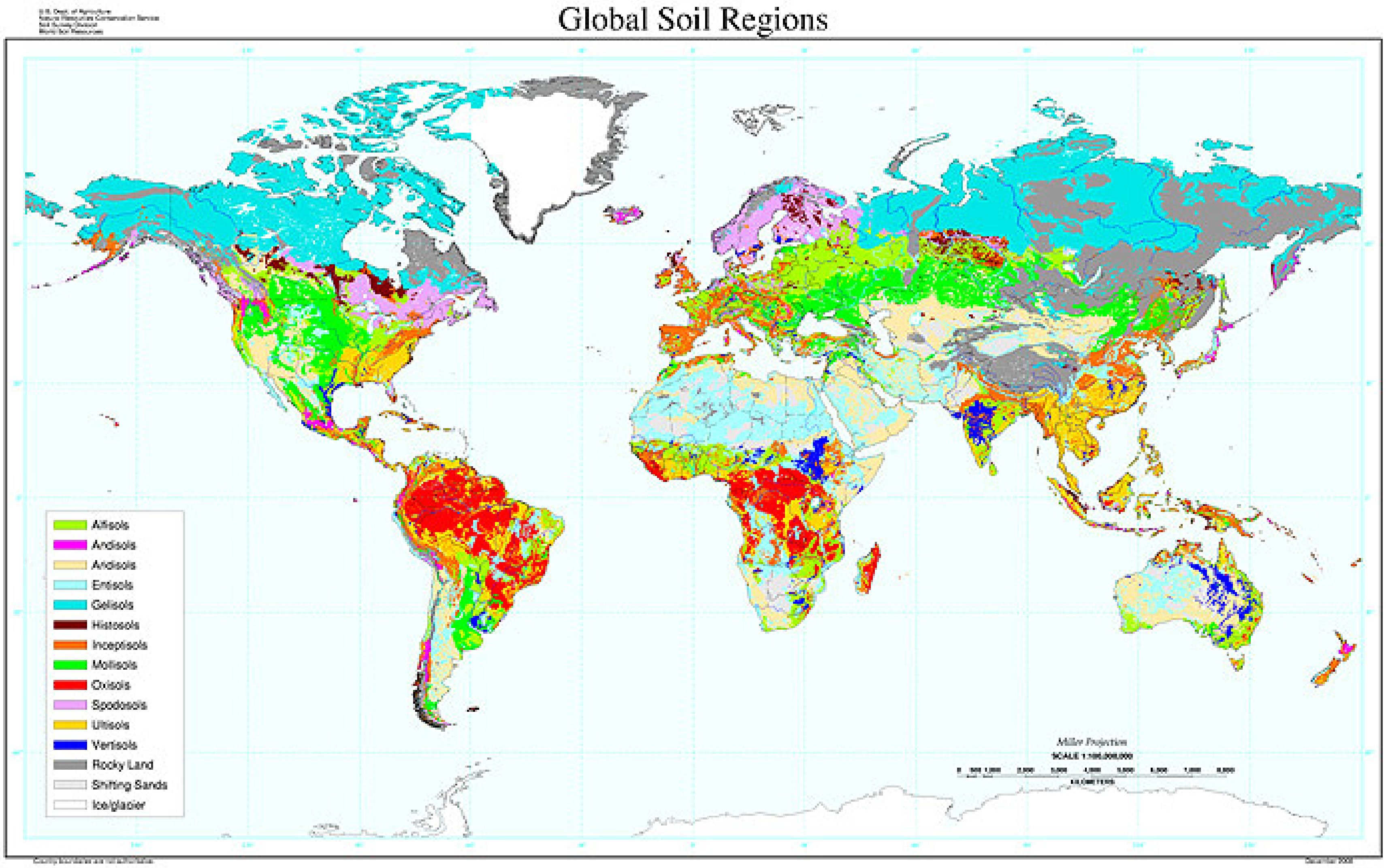
Alluvial soil (stream deposited) New Mexico



Mollisol (chernozem) South Dakota



A useful rule of thumb is that productive soils are brown. Poor soils typically have bleach surface layers or are rusty red. These latter conditions are the result long weathering or rapid weathering. Good soils often exist where either water or temperature are limiting for plant growth (and clay weathering). Good soils often exist where volcanic eruptions, floods, or earthquakes have kept soils young. Farmers are attracted to geological disaster areas! California is a good example. Lots of good soils, lots of earthquakes, floods, and deserts! Pick your poison.



Don’t worry about trying to figure out the classification system here. Just notice again how the gross patterns of soils, climates and biomes all have a family resemblance. If you want to learn the US soil classification system see http://soils.ag.uidaho.edu/soilorders/. Soil classification seems to be a complete confusion. Every country uses its own system. We amateurs cope as best we can.

10 Glacial margin (Antarctica)

8/9 Ecotone tundra taiga (Siberia?)

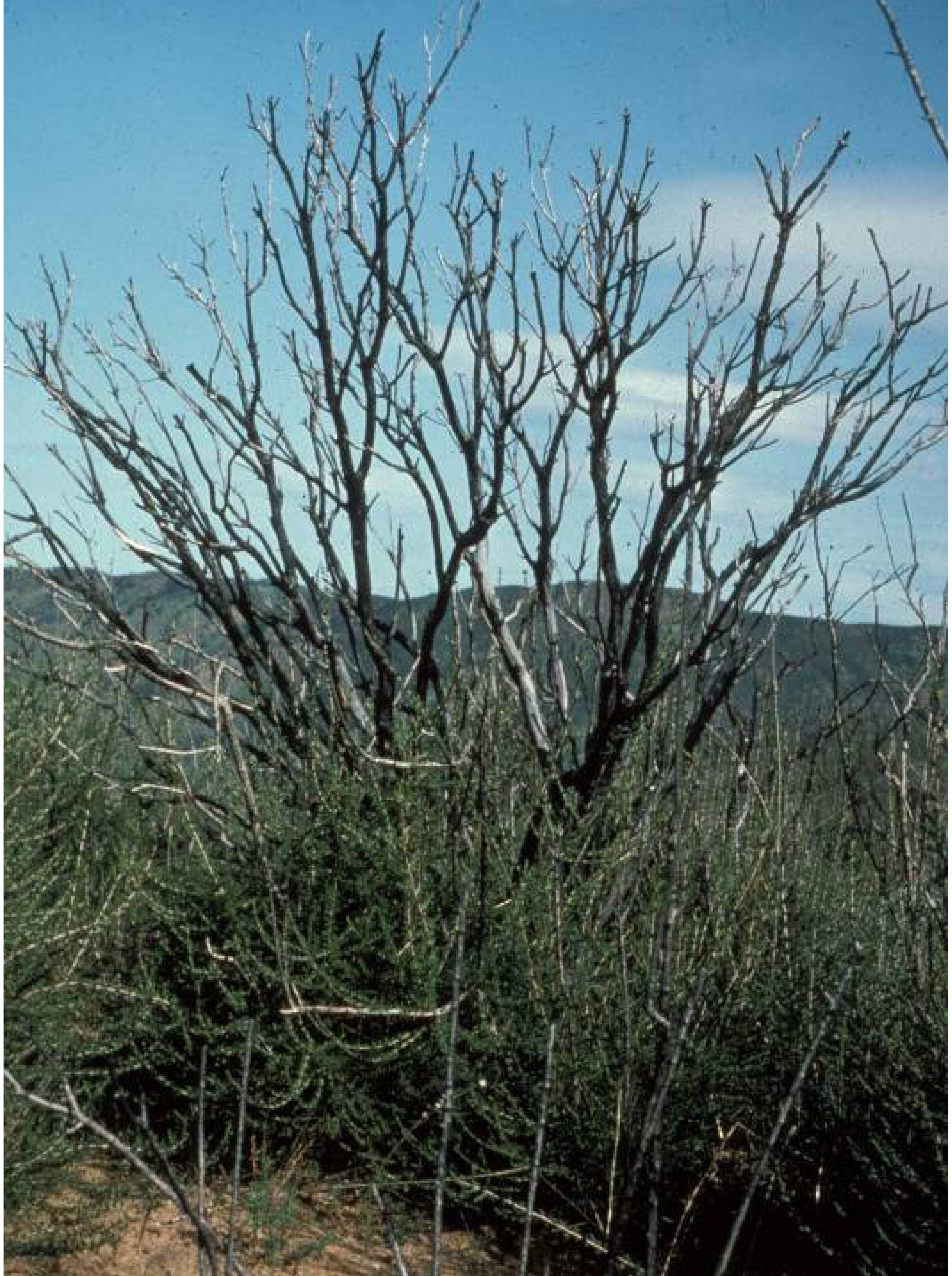
7a Temperate steppe/desert (Nevada)

6 Temperate deciduous forest (Wisconsin)

5 Temperate evergreen forest (New Zealand)

4

Mediterranean (California)



3 Subtropical desert (Peru)

2 Tropical deciduous forest (Mexico)

1 Tropical evergreen forest Ecuador