

“Orobiomes” Mountain Biomes

Lecture 14

“Orbiomes” in relation to sea level biomes. Very roughly, the sea level biomes become mountain biomes at higher elevation towards the equator. This equivalence is rough because even if mean temperatures in the mountains are similar to a sea level biome further poleward, the seasonal variation in temperature is dependent upon latitude. Sometimes sea level species enter the mountain biomes but often species turnover is high and the resemblance is more structural. Mountains have complex effects on rainfall too. Mountains are generally rainier (snowier) than surrounding lowlands and often cast a distinct “rain shadow.” As the prevailing winds are forced upward by the mountain, the air cools and dumps its moisture, often maximally at elevations around 2,000 m (~6,000ft). As the wind drops on the other side of the mountain it heats by compression and is much drier than it was at equivalent elevations on the windward side.

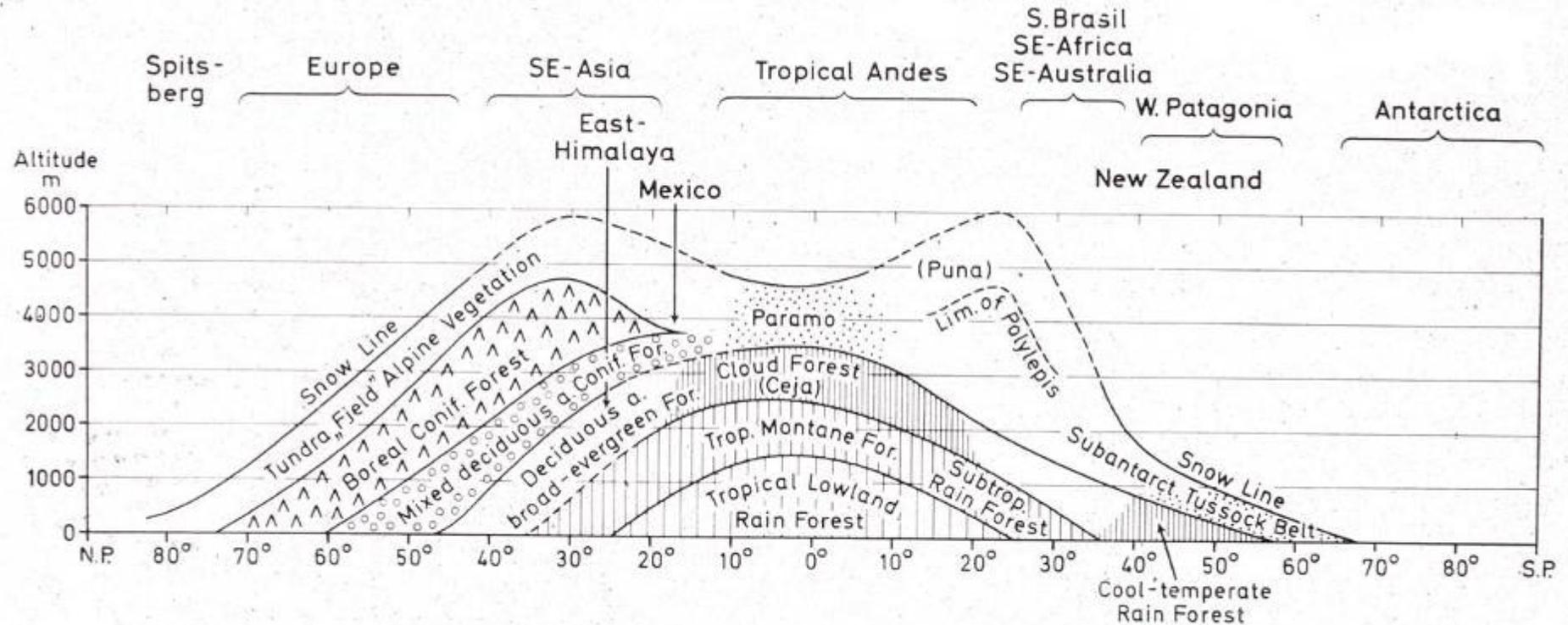
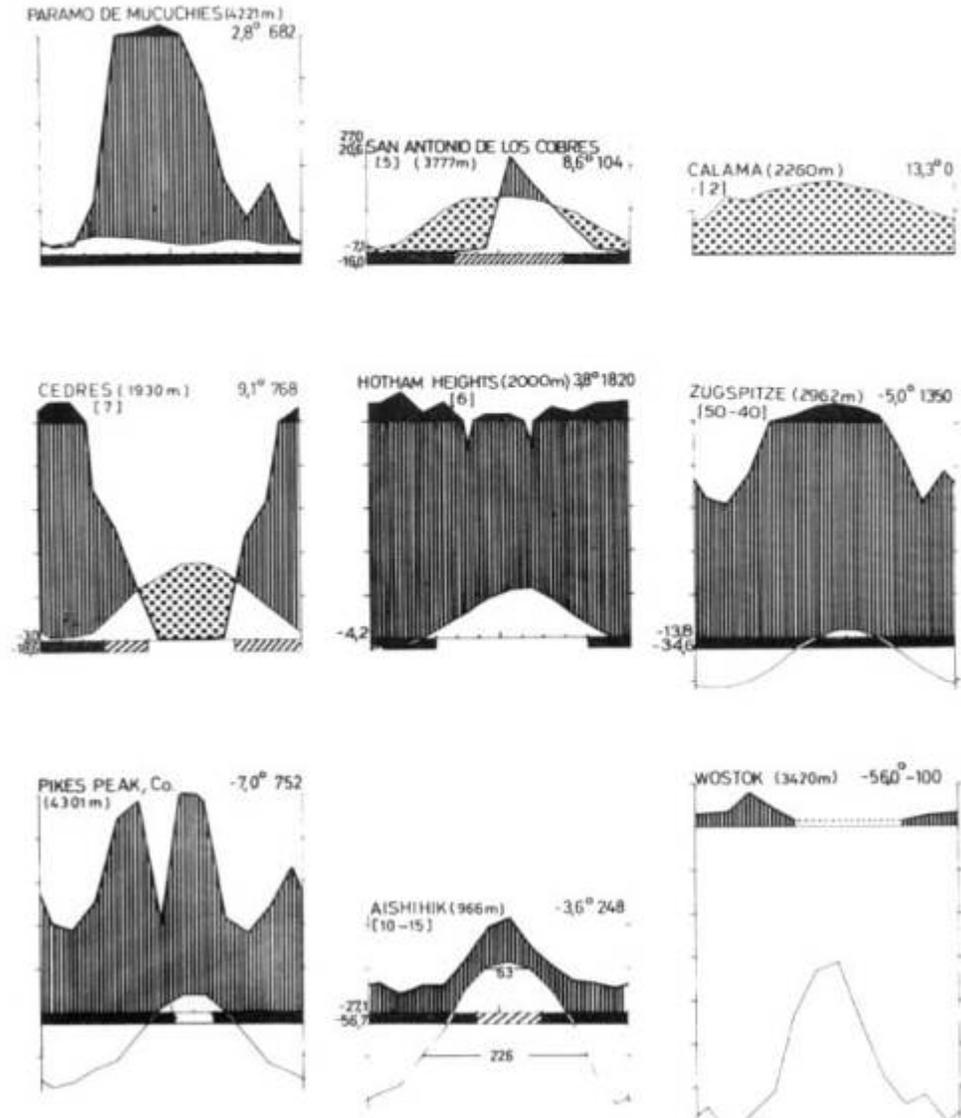


FIG. 50. Schematic vegetation profile of the world from the Arctic to the Antarctic, showing asymmetrical altitudinal belts in the humid regions (after C. Troll).

Fig. 13. Examples from mountain stations in the various orobiomes: OB I, Páramos de Mucuchies in Venezuela; OB II, Antonio de Los Cobres in the Peruvian puna, OB III, Calama in the North Chilean desert puna; OB IV, Cedres in Lebanon; OB V, Hotham Heights in the Snowy Mountains of Australia; OB VI, Zugspitze in the northern Alps; OB VII, Pikes Peak in the Rocky Mountains above the Great Plains of North America; OB VIII, Aishihik in southern Alaska; OB IX, Wostok on the ice cap of the Antarctic.

Climographs for the mountain
relatives of the various sea level
biomes



Tropical Orobiomes. On tall mountains in the tropics one can go from tropical forest on the windward side to permanent ice on the peaks above ~5,500 m to desert on the lee side of the mountain. Two examples shown below together with a generalized structural diagram of how the vegetation changes. Note in figure 15 below that temperature drops about 6 C for each 1,000 m of elevation. Why?

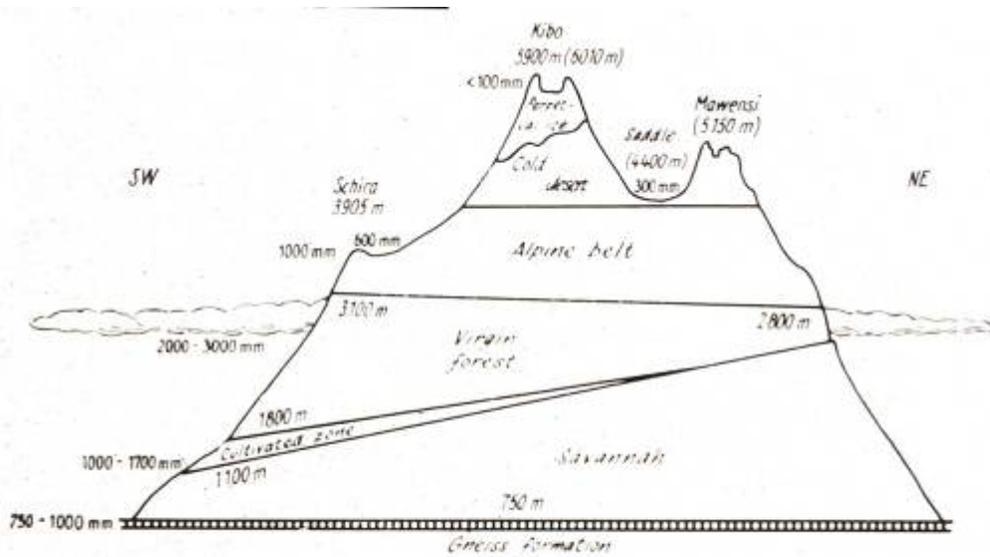


Fig. 112. Schematic vegetation profile through Kilimanjaro with information on the approximate annual precipitation (in mm) at different altitudes.

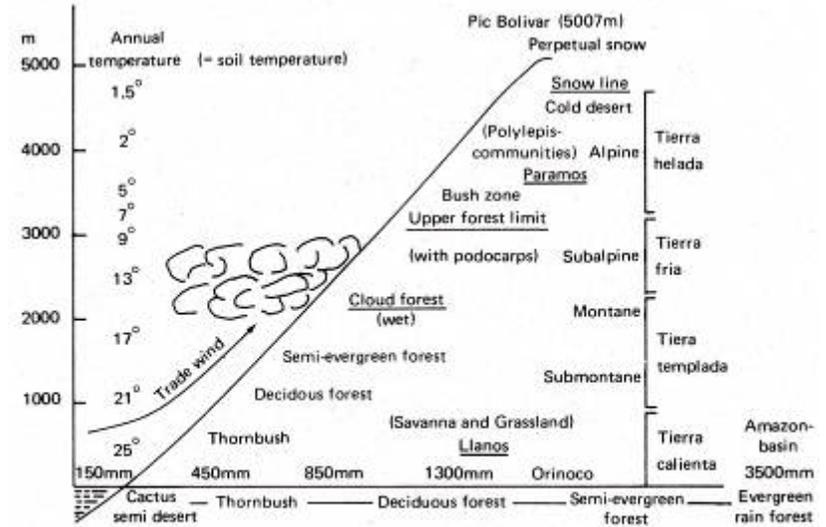
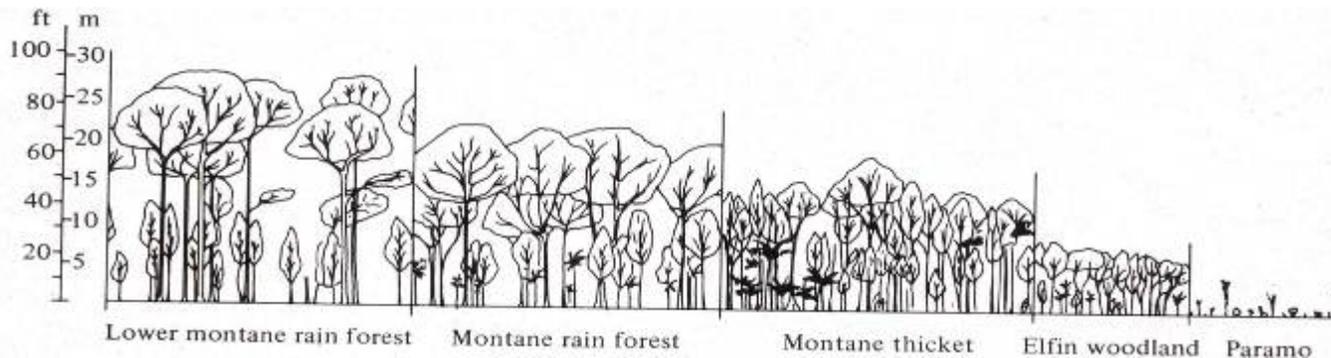


Fig. 15. Schematic representation of vegetational zones in Venezuela, from north to south, with annual temperatures in °C (left).



The Andes of Peru and Ecuador are a good example of a tropical orobiome system. Traveling southwest, one starts in the evergreen or deciduous tropical forest, moves through a succession of vegetation types before descending into the coastal fog desert along the Pacific. The moist and dry Puna communities are roughly equivalent to steppe and steppe desert. Human occupation is concentrated in these zones due to favorable soils and reasonable rainfall during the growing season. People also follow the oasis rivers down into the western deserts.

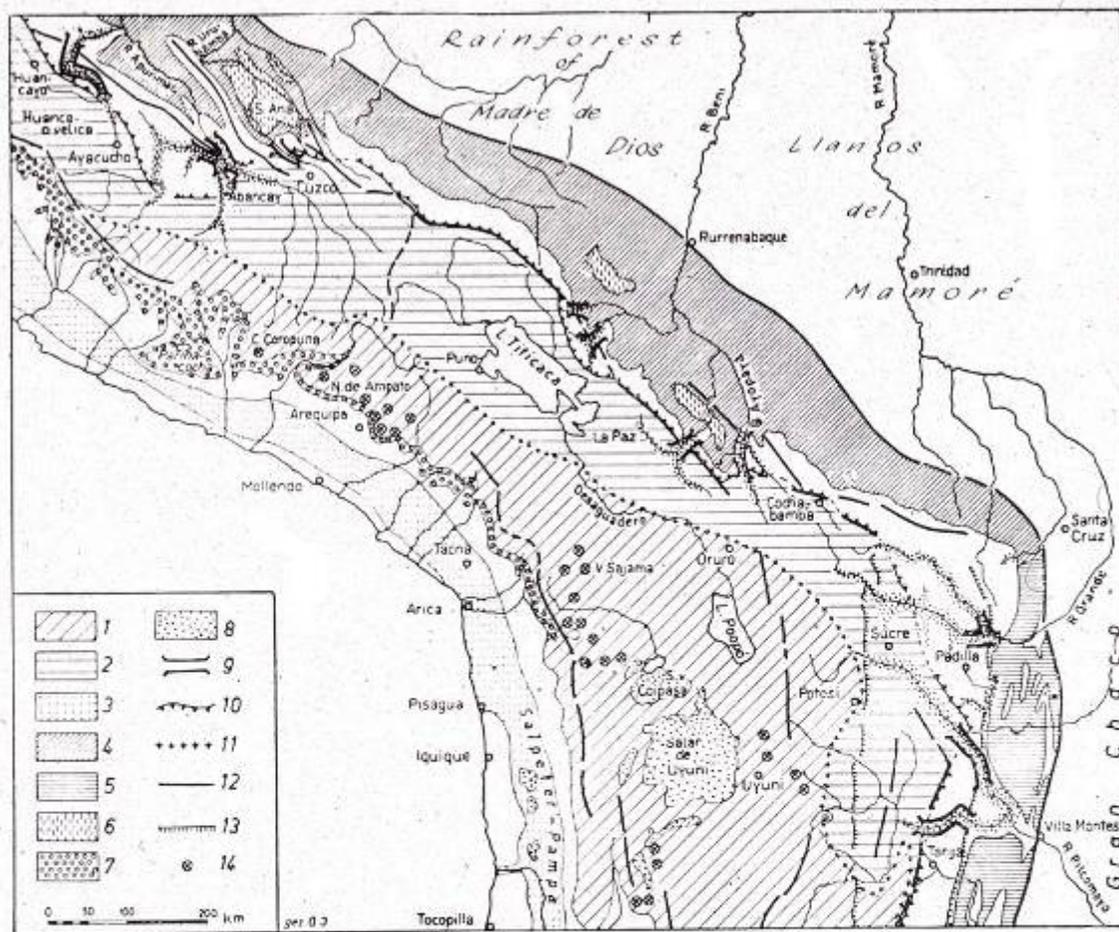
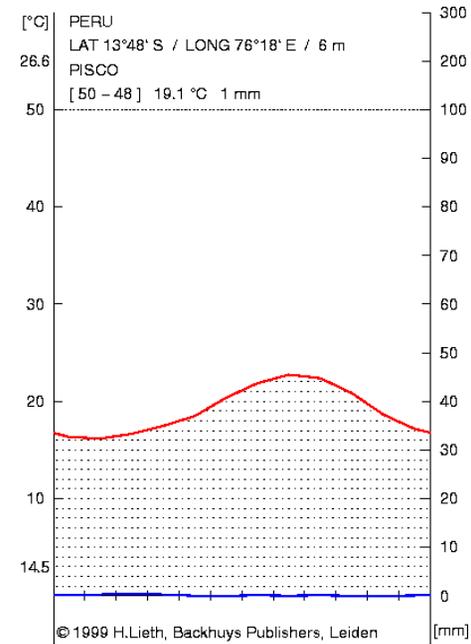


FIG. 109. Distribution of the Puna in the Central Andes around Lake Titicaca (after Troll, 1959).

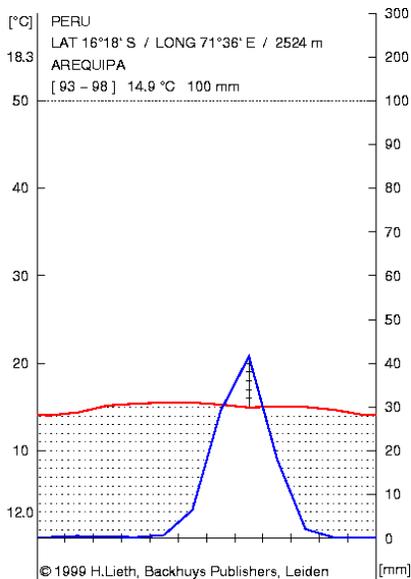
1. Zone of the dry and salt Puna; 2. Zone of the moist Puna; 3. Desert plains (pampas) of Atacama; 4. Evergreen and high-forests (Montana) of the east Andian slopes; 5. Summergreen, changing upwards into evergreen, tropical/subtropical transition forests (Tucumano-Bolivian forest); 6. Savannah islands in the Montana (Medio Yungas); 7. Mesophytic shrub belt on the west slopes of the Puna-Andes; 8. Hot-dry valleys of the east Andian slopes (Low-Valles); 9. Channels of the valleys which cut through at their lowest points (wind 'gates' permitting passage of counterbalancing easterly winds); 10. Main climatic boundary of the Andes (western border of the ascending rains and fogs that spread from the continuously humid vegetation located to the east); 11. Eastern boundary of the *Lepidophyllum* heath vegetation; 12. Important mountain ranges and eastern foot hills of the Andes; 13. Downward slope of the Puna block in Southeast Bolivia; 14. Tall cylindrical mountains.

Climates across the Andean transect vary dramatically over rather short distances. Note the low seasonality of temperature everywhere and the low maximum temperatures in the Moist Puna. The Dry Puna is colder as well as drier (no climographs available).

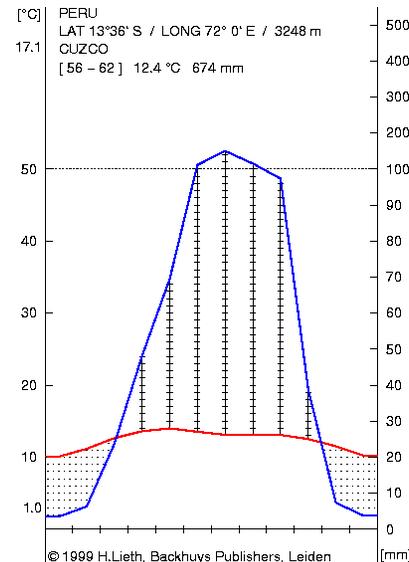
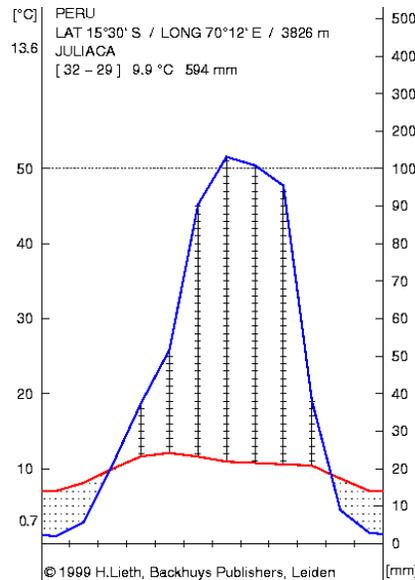
Coastal Fog Desert



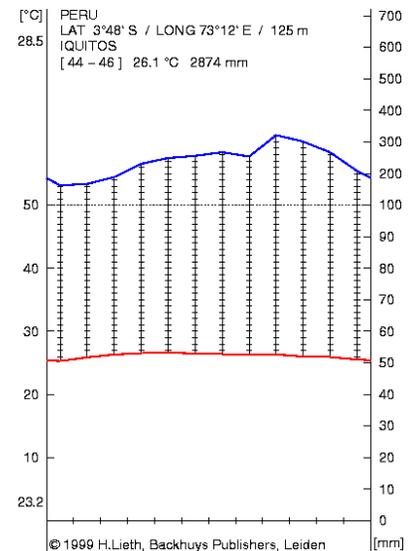
Relatively Moist Desert



Moist Puna



Evergreen Forest



Lower Montane Forest. Looks little different than lowland forest, but species turnover is considerable. 1,000 m.



Mid-Montane Forest. Trees are low enough here that tree ferns can compete. 1,500-2,000 m



The east slope of the Andes at about 2,000 M, ~6,500 feet, has a lovely moist temperate climate. In Peru, this is called La Ceja de la Selva, the eyebrow of the jungle. Even though it is very steep, people make a living here in fair numbers. Machu Picchu (“Lost City of the Incas”) Peru





The Ceja de la Selva temperate mid-elevation humid climate is as close to “grow anything” as climates get. This is the climate where the best coffee grows (Coffee Tree lower left). It is also the climate where Coca (for cocaine, not chocolate) is grown. Coca shrubs at left. But temperate plants do well too. Garden below has Day Lilies and hybrid Lupines from the temperate zone. You can grow strawberries and bananas in the same plot. Plants that require dormancy are hard to grow here because there is no cold season to induce dormancy.



Sandia Valley, east of Lake Titicaca. This area has a road connection to the populous Puna zones just to the west. Tropical crops are grown here for the highland market. Notice the intricate terracing. The scattered white spots are the metal roofs of farm families' houses. Notice the cloud hanging just above the farms.



Cloud Forest. Because the temperature changes little throughout the year and humidity is generally high, the bottom of the cloud deck stays at about the same elevation all the time. This creates a cool misty climate that produces dwarf forests. Because the relative humidity is always near 100%, plants can transpire little and hence are nutrient limited. Agriculture is impossible and this zone is little used by humans. ~2,500 – 3,500 m.





Above the Cloud Forest, the sun comes out again and various shrubby communities dominate. In moister equatorial sites a strange vegetation dominated by woolly plants exists called "Paramo." The photo on the left is from Mt. Elgon, Africa, but very similar looking communities with convergent woolly adaptations also occur in the Andes (lower left, northern Ecuador).

Alpine scrub east of La Paz, Bolivia



Mt. Chimborazo, Ecuador. Here we cross the high passes into the interior of the Andes. Passes are often above 4,000 m and the mountain peaks with glaciers are above 6,000 m. Note the arid Dry Puna here. The native camelids, Alpacas and Llamas, are grazed in the Dry Puna.





Dry Puna/Moist Puna ecotone. Grazed more intensively. Stone-walled fields in the background are sometimes planted with bitter potatoes, but this is the absolute limit of cultivation. ~ 4,000 m. Near Lake Titicaca, Peru.

Dry Puna, elevation ~ 4,500 m. Dominated by large spiny bunchgrasses (Ichu) and cushion plants. Much bare ground. Compares roughly to Temperate Desert. Llamas and Alpacas are pastured here at low density. Also near Lake Titicaca, Peru



The soils of the Moist Puna are reminiscent of the mollisols of the Steppe. Here humus rich soil about 1.5 m thick has developed over the parent material. The dense sward of bunchgrasses generates the organic matter that builds this soil. Just above the limits of cultivation, this community shows little obvious sign of human activity. Except that it is a road cut!



The Moist Puna bears comparison with the Steppe. Rainfall is sufficient for many crops, and the countryside is densely populated. Rather steep slopes are cultivated as level land is at a premium. Both of these pictures from Ecuador south of Quito



The Moist Puna is a landscape transformed by human activity. Farming started here perhaps 8,000 years ago. Scraps of relict *Polylepis* woodland suggest that low forest communities were once more important. Today people grow *Eucalyptus* and various pines for wood.





Village in the Spanish Style near Cuzco, Peru. Notice the terraced hillside opposite and the level irrigated fields on this side of the river. Extensive irrigation was employed here in pre-incan times.

Inca period tombs in the vicinity of Lake Titicaca. The Inca Empire was a late phenomenon. But for a long time sophisticated chiefdoms and city-states dominated the Puna.



Today, big and medium sized cities are built in the Moist Puna zone. Here, La Paz, Bolivia. Many provincial Peruvian towns are in this zone, as is Quito, the capitol of Ecuador.



Andean farmers domesticated a number of important crop plants. Potatoes (right) are today a globally important crop, but others are still grown in the Andes. Quinoa, left below, is sold here in natural food stores. Tarwi, a domesticated Lupine, needs leaching to remove a toxic alkaloid. Uca, below right, is a domesticated Oxalis (sourgrass) with a starchy tuber.



In Peru, Bolivia, and Ecuador, vibrant Indigenous cultures survive. Some tens of millions of people speak Quechua or Aymara as their first language. Perhaps you know Andean music. Here a mountain pilgrimage in Peru.



High altitude environments require considerable human adaptation. Some of this is phenotypic and some of it is genetic. Andean people are short and broad, with a low surface to volume ratio to conserve heat. They have comparatively large chests and high blood hemoglobin concentration.

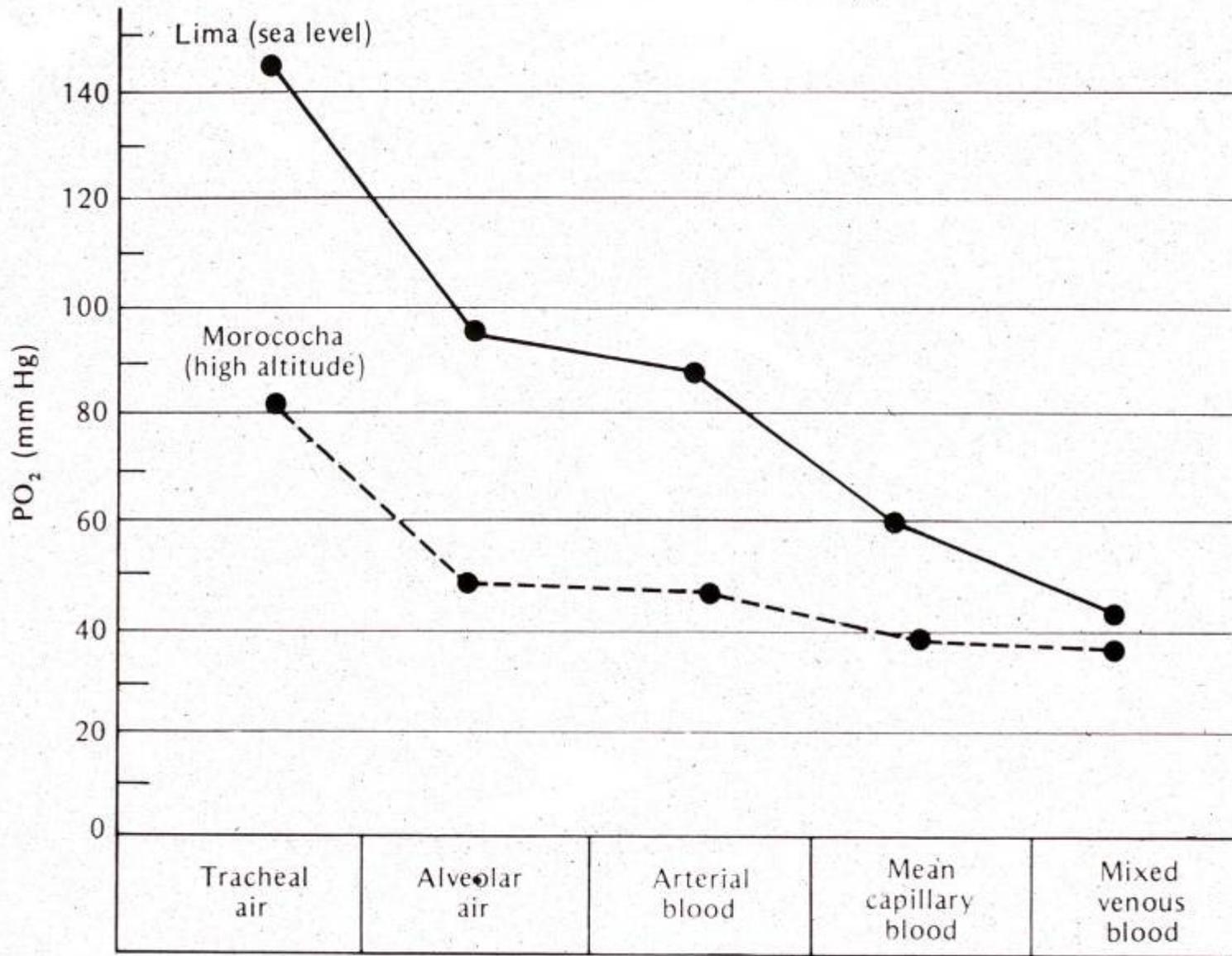


Figure 6.6

Mean Oxygen Pressure Gradients from Tracheal Air to Mixed Venous Blood Values are derived from a sample of sixteen healthy adult subjects, eight of whom reside at sea level and eight at an altitude of 4,540 meters.

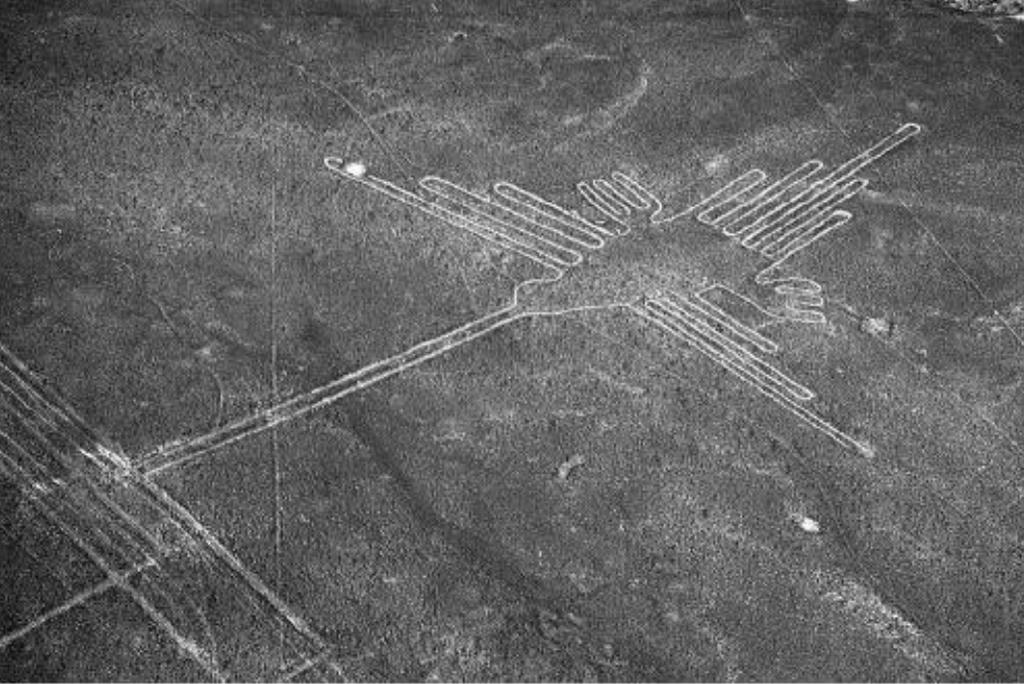


Moving south-west from the vicinity of Lake Titicaca toward the Pacific one crosses high passes in Dry Puna. At left, Vicuña, the delicate little wild camel of the high Andes. Once hunted to near extinction for its very fine wool, Peruvian conservationists have done an excellent job of bringing the numbers of this species up. Below, the arid high plains (Altiplano) around Lake Titicaca, and stretching far to the south, have many saline lakes. Flamingos feed on the algae and invertebrates that thrive in these fishless systems.



Dropping down to about 2,500 m on the west slope of the Andes near Arequipa, the dominant community is a cactus and shrub desert typical of the Subtropical Desert Biome.





The hyperarid Fog Desert of the Peruvian Pacific Coast. These images are of the “Nazca Lines,” images and abstract designs created by carefully removing the surface rocks darkened by desert varnish to reveal the lighter parent rocks and sand beneath. These constructions are on the scale of hundreds of meters. People in the Southern California deserts made similar things, but on a much smaller scale. Why did they go to so much trouble for something that could best be appreciated in aerial view? Everyone has their pet theory. Mine is that this was homework for surveying students.

If you take one of the Sierra field trips, you will get to observe the California Mediterranean Orbiome close up. Here is a basic diagram of its zonation. The Sierras cast a strong rain shadow. The east slope is drier at any given elevation than the west, causing the tendency of similar communities to grow at higher elevation on the eastern slope. They also fence off the moderating effect of the Pacific from the Great Basin to the East of the Sierra Crest. Reno is colder in the winter, hotter in the summer, and drier all year round compared to the same elevation on the west slope.

