



Tropical Alpine Ecosystems - Distribution

Most extensive in South America

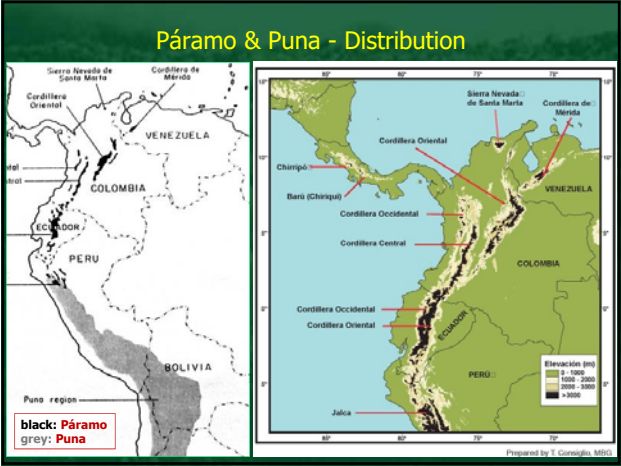
UPPER LIMIT (substrate)

- permanent frost or snow (*nival zone*)
- solid rock or scree
- topography (top of mountain)



LOWER LIMIT (treeline)

- temperature:
 - Carbon Balance Hypothesis
 - UV-B
 - Patchy resources
- human impacts



Páramo vs. Puna



Páramo in Northern Andes

- 11° N – 8° S latitude
- aseasonal (equatorial) climate
- wetter
- grasses, shrubs, cushion plants

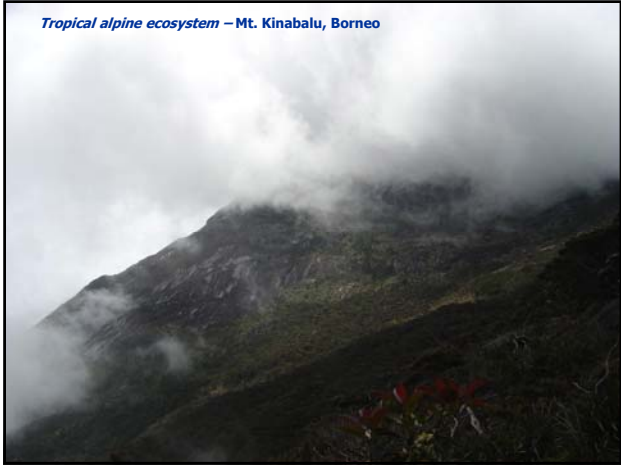
Puna in Southern Andes

- 8° S – 27° S latitude
- seasonal climate
- drier
- grass-dominated

Warm Nazca current brings wet air: **Páramo**

Cold Humboldt current brings dry air: **Puna**





Abiotic Conditions

"Summer every day, winter every night"

- Low mean temperatures
- Daily freeze-thaw cycle
- Dry
 - ▼ rainfall (esp. in puna)
 - ▲ evaporation
- Rapid insolation changes
- High winds
- Low O₂ & CO₂
- High UV-radiation
- Soil rocky, dry (esp. Puna)
- Solifluction



Super Páramo / Upper Páramo
aka "Cushion Paramo"
(~4000-5000m)



Middle Páramo / True Páramo
aka "Bunchgrass Paramo"
(~3500-4000m)



Sub Páramo / Lower Páramo
aka "Shrub Paramo"
(~3000-3500m)



Most lower paramo in the Andes have been converted to agriculture

Shrub dominated alpine scrub on Mt. Kilimanjaro

Plant Adaptations TO FREEZING TEMPS...

Insulation

- pubescence
- marcescence
- nyctinasty

Protection of Buds

- cushion, rosette, & bunchgrass forms
- sunken buds
- acaulescence
- "antifreeze" mucus



Valeriana sp.

Espeletia sp.

Plant Adaptations TO DROUGHT...

Sclerophylly

Succulence

Pubescence

Poikilohydry

High Root : Shoot ratio

C4 / CAM

- Grasses (C4)
- Puya
- Cacti



Chiquiragua sp.

Paramo Plants – Life Forms

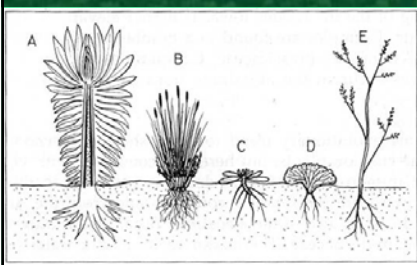
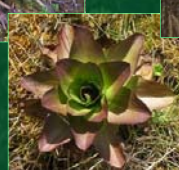


Figure 3. The five most important life forms of the afroalpine belt. A. giant rosette plant, B. tussock grass, C. acaulescent rosette plant, D. cushion plant, E. sclerophyllous shrub (modified from Hedberg, 1964a).

Plant Growth Forms THE ROSETTE PLANT



Rosette plants (from left to right): *Puya*, *Valeriana*, *Espeletia*, and *Hypochoeris*



Páramo Plants

Characteristic Giant Rosette Plants
a case of convergent evolution



Puya (Bromeliaceae) Ecuador

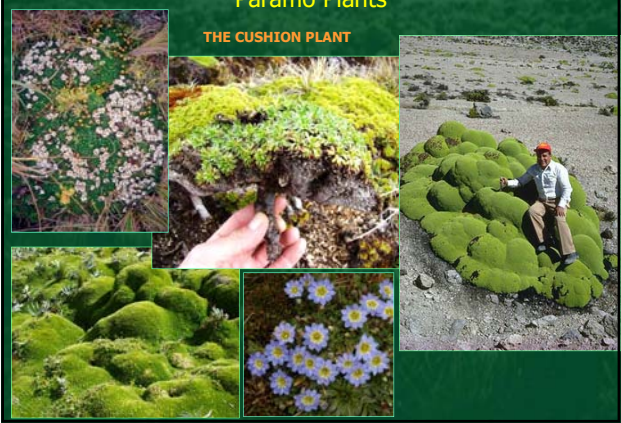
Espeletia (Asteraceae) Ecuador

Lobelia (Lobeliaceae) Uganda

Senecio (Asteraceae) Mt. Kilimanjaro

Páramo Plants

THE CUSHION PLANT



Páramo Plants

THE BUNCH GRASSES

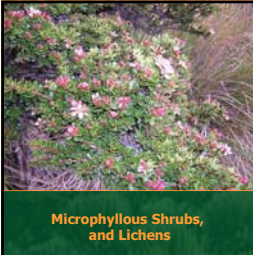


Cortaderia sp.

Stipa ichu

Páramo Plants

Microphyllous Shrubs, and Lichens



Sclerophyllous Shrubs



Polylepis Woodlands

"The highest trees in the world"



Family Rosaceae

Family Asteraceae

The "Composites"

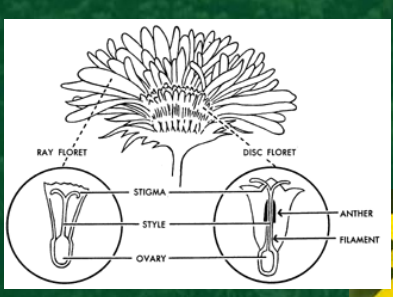
daisies, dandelions, chrysanthemums, lettuce, thistles, artichokes, etc...



- largest plant family: ~25,000 spp.
- herbs, shrubs, trees, vines
- alternate or opposite leaves
- flowers in heads – "composite"

Family Asteraceae

The Composite Flower



- "Heads" with ray and/or disc flowers
- Fruit = one-seeded achene, occ. with tuft of hairs (e.g., dandelion)
- Ornamentals, food, medicinals, insecticides, weeds



Family Poaceae

grasses, bamboo, sugar cane, corn, wheat, rye, etc...

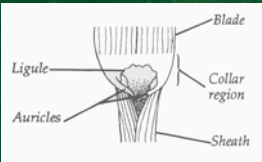
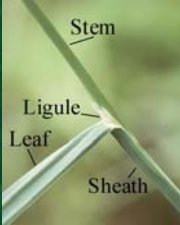


- herbs, often dense tufts
- stems round, internodes hollow
- leaves alternate, linear
- leaves sheath stem at base, with **ligule**
- flowers very reduced
- fruit a grain

Cortaderia sp.

Gynerium sp.
"caña brava"

Family Poaceae - the ligule





Importance of Páramo & Puna

ECOLOGICAL IMPORTANCE

- Hydrological control
 - high water-holding capacity
 - soil water = 2X dry weight
 - natural vegetation = 12X of pasture
 - low to no run-off
 - sustained, constant streamflow
 - major water source:
 - Quito: **85%** from Cayambe-Coca and Antisana reserves!
 - Bogotá: **95%** from páramos
- Carbon storage (soil, peat)
- Biodiversity
 - high endemism



Tropical Alpine Fauna

SOUTH AMERICA'S CAMELIDS



Llama



Alpaca



Guanaco



Vicuña



- browsers / grazers in Puna
- very dense wool
- soft feet
- some domesticated



Guanaco (*Lama guanicoe*)

wild species in arid mountains; herds of females + 1 male



Vicuña (*Vicugna vicugna*)

smallest of the wild species: Peru, Bolivia, Chile, Argentina



Alpaca (*Vicugna pacos*)

bred (from vicuñas) for wool (*now only domestic)



Faunal Adaptation - Mammals & Birds

Temperature:

- large bodied - **Bergmann's Rule**
- small appendages - **Allen's Rule**
- endothermy
- diurnal activity
- burrows & protected nests
- live under shrubs, bunchgrasses



Elevation:

- higher RBC counts
- larger lung capacity
- larger wings
- egg shells thinner -- improve O₂ absorption
 - shell pores smaller -- reduce water loss
- torpor -- hummingbirds



Faunal Adaptation - Fish & Amphibians

Fish

- higher gill surface area
- require cold, flowing water

Amphibians

- large skin folds (*Telmatobius*)
- Peru: collected for "natural viagra" extinct in Ecuador - 1989
- ovovivipary
- lay eggs under rocks -- fish predation



Tropical Alpine Fauna
OTHER MAMMALS

Predators

- Puma
- Andean Fox (LC)



Herbivores

- Mountain Tapir (EN)
- Spectacled Bear (VU)
- White-tailed Deer
- Paramo Deer (Pudu)
- Vizcacha
- Rabbits
- Guinea pigs -- "cuy"





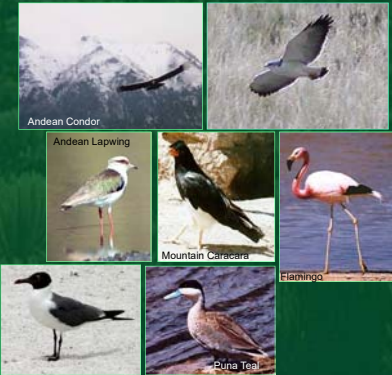
Páramo & Puna Fauna
BIRDS

Raptors & Scavengers

- Andean Condor
- Mountain Caracara
- Variable Hawk

Water Birds

- Andean Lapwing
- Andean Gull
- Puna Teal & other ducks
- Flamingo
- Black-faced Ibis



Human Impacts in the Páramo & Puna

Livestock Grazing:

- traditional vs. European livestock
- altered plant composition
- soil compaction
- loss of hydrological & carbon functions
Buytaert 2006 findings?
- water contamination



Human Impacts in the Páramo & Puna

Increased Fire Frequency & Scale:

- increase grasses
- improve pasture
- cushions, shrubs suffer
- water storage reduced
- biodiversity losses



Human Impacts in the Páramo & Puna

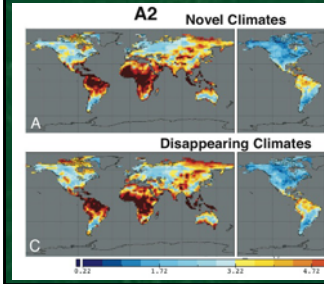
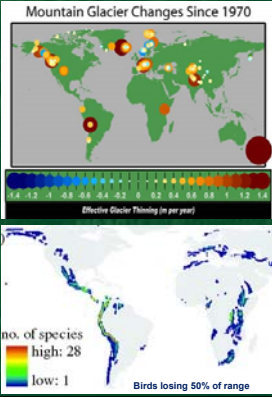
Sport Fishing:

- abundant lakes & mountain streams
- trout – introduced in 1950's
 - voracious predator
 - extirpated native fish & amphibians



Human Impacts -- Climate Change

- receding glaciers
- shifting vegetation zones
- altered bird ranges
- drier conditions -- ▲ CO₂ release



Conservation & Management

- Watershed Protection
- Tourism
- Fishing Clubs
- Native grazers
- Microlivestock

