Impacts of Climate Change on Natural Ecosystems in the Andes

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- **INCA - International Network on Climate Change**
- **UNDERSTANDING ADAPTATION AND MITIGATION STRATEGIES OF ANDEAN PEOPLE**

Sponsored by DAAD

Introduction to Global Change
Indicators for Climate Change in the Andes
Phenology
Adaptation
Effects on the ecosystem
Effects on Species
Protected Areas
GLORIA Example for Monitoring

Results of a workshop on vulnerability of the ecosystems
(2010, Policy of the Bolivian Government)

Todo cambia, todo cambia…

but, processes more accelerated and out of "normal" range

- Temperatures rose above variability of the last decades; it is not just a variability of a multiannual cycle

- Reduction, deglaciation and loss of glaciers, collapsing of glacier lakes

Signs of Global Change

Global warming: last 3 decades 0,6 °C, by 2100 6°C ?
Increasing ocean level

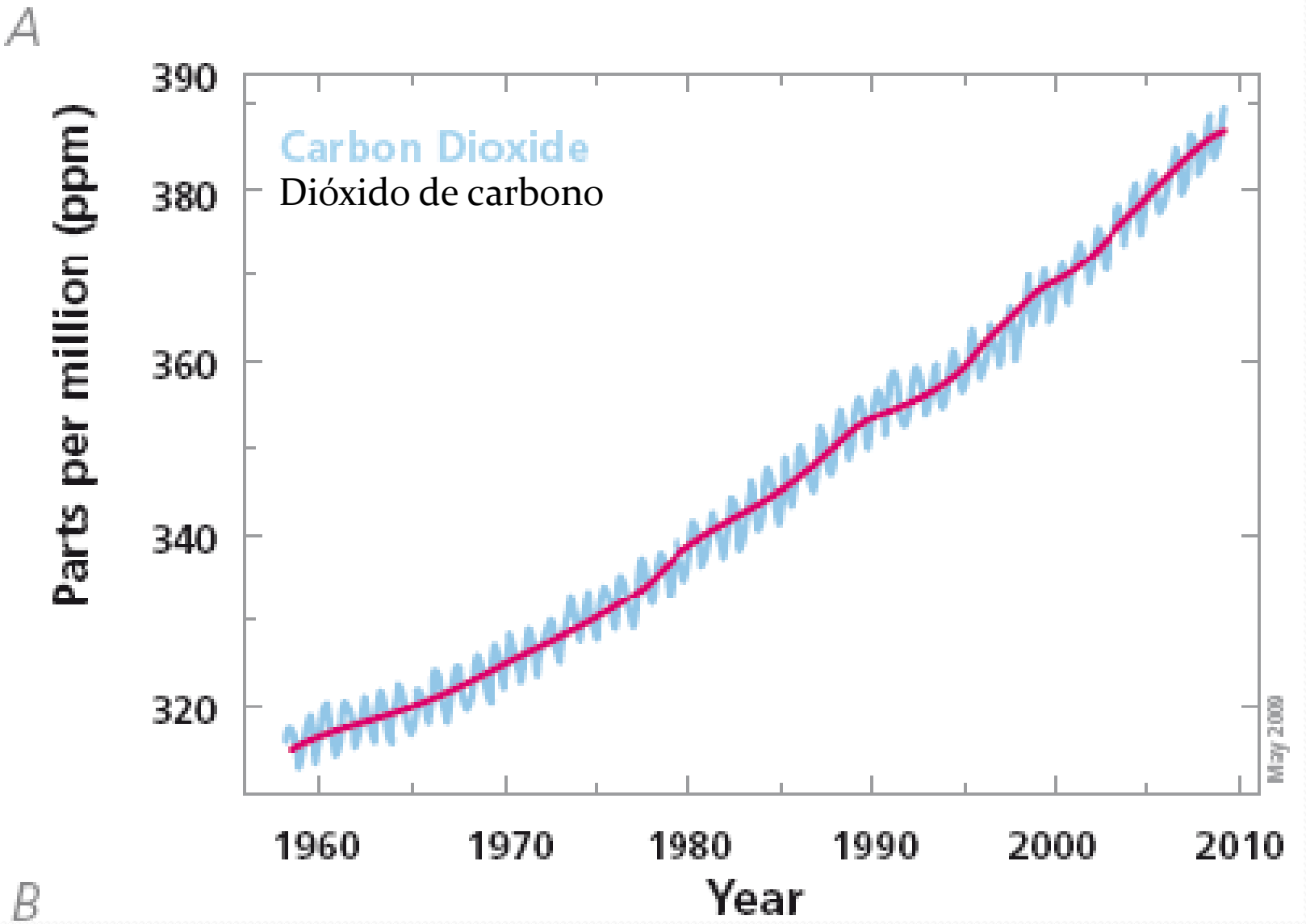
Alteration of precipitacions:
Some regions getting more humid, others drier

Extreme Events:
Hurricanes, droughts, inundations

People and Natural Ecosystems in the Andes

- Strong relation of humans to ecosystems
- Grazing: 90% of the cattle on natural pastures
- Supply of wood for construction and fuel nearly totally from natural vegetation

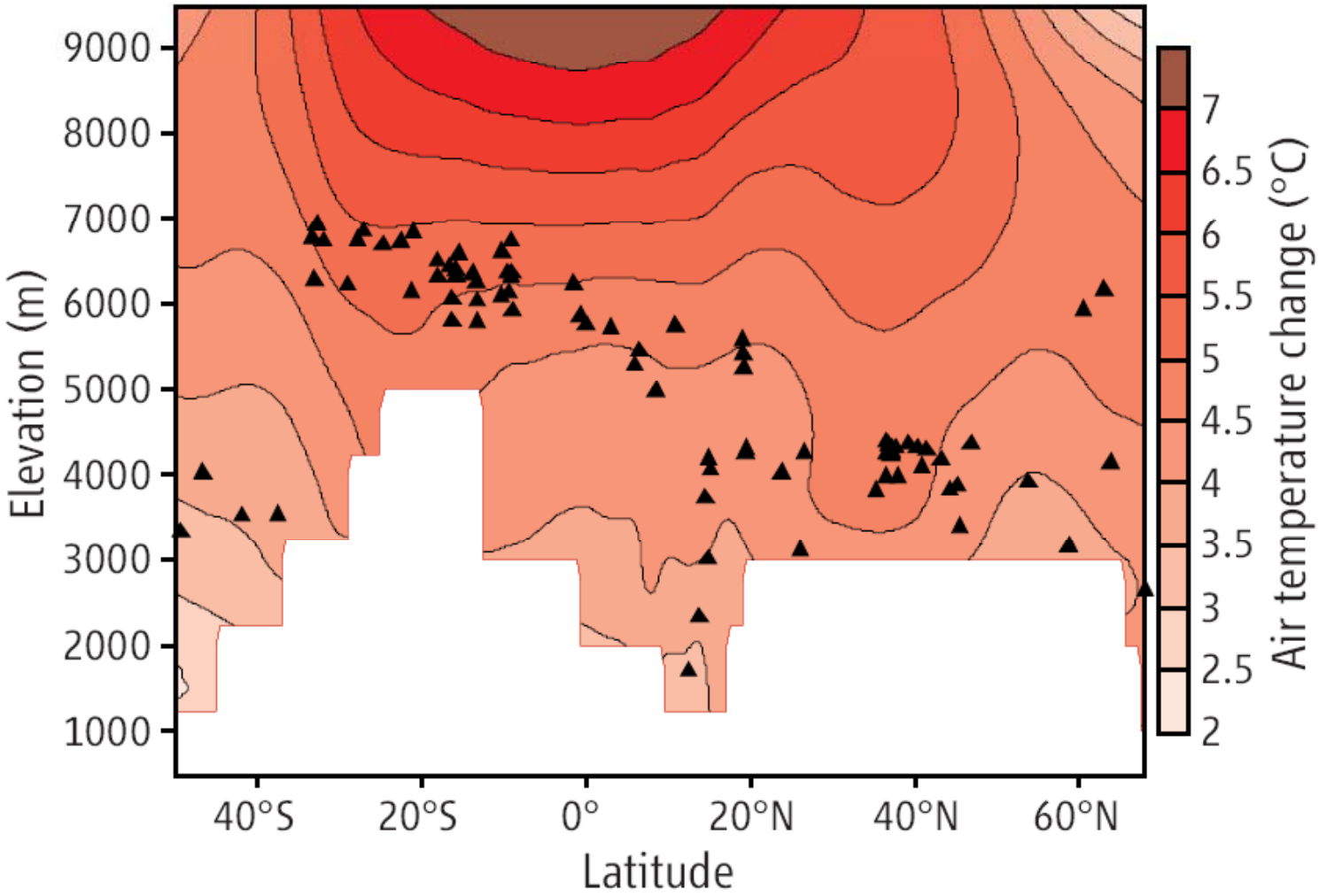
CO_2



Fuente: Richardsen et al. 2009

Global Warming in the American Cordillera

(projected Ø temp. 1999–2099)



Fuente: Bradley et al. 2006

Cordillera Real, cerca La Paz

Chacaltaya (5300 m)

años 70

el parche superior del Glaciar 2005

el parche superior del Glaciar 2009

Phenology staggering!

- Describes the timing of transitions between stages of organisms' life cycles, can be directly affected by climate (physiological constraints)
- Physiological mechanism – Closing mechanism of *Gentianella* (temperature and pressure change, (Claus 1926, He 2006) : pollination of *Nototriche*
- Frequency of animal pollinated and dispersed species (90%) : *Clusia*

Pollination of High Andean Puna plants

Nototriche obcuneata

Gentianella sp.

Impacts on Ecosystems

- Total precipitations – Change of vegetation type
- Increasing seasonality in the south of Andes
- Warming will shift the orographic cloud banks (ceja de monte)
- Elevation profiles will change

Andean Forests of Bolivia

Potential natural Vegetation

Green: Evergreen montane Yungas forest

Green-Blue: Seasonal montane Tucuman-Bolivian forest

Yellow: Dry forest

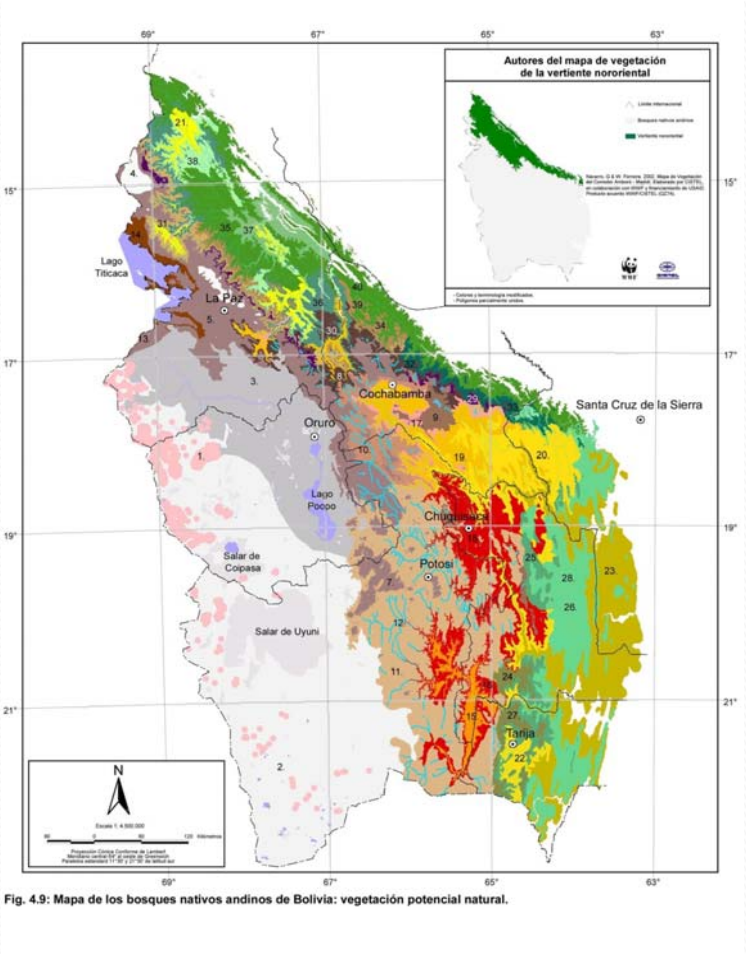


Fig. 4.9: Mapa de los bosques nativos andinos de Bolivia: vegetación potencial natural.

Most endangered ecosystems: Wetlands

Focal point for services

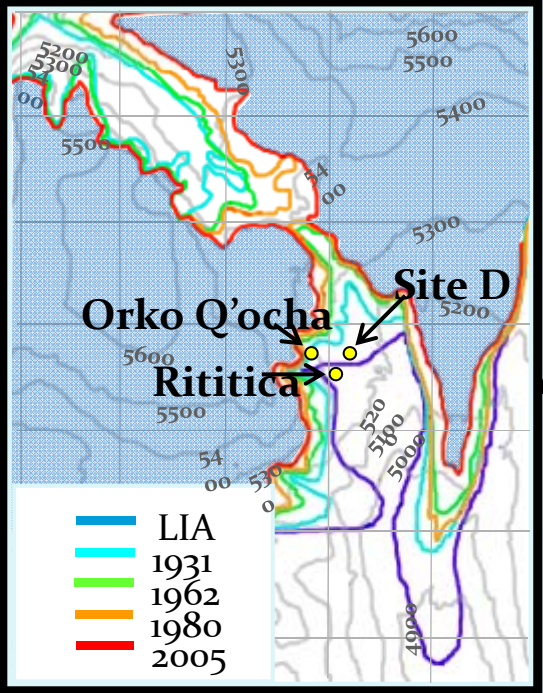
- Water regulation, can ‘replace’ melting glaciers
- Concentrated high biodiversity and endemism
- Massive carbon storage
- Centers of productive activities
- Centers of culture and dwellings

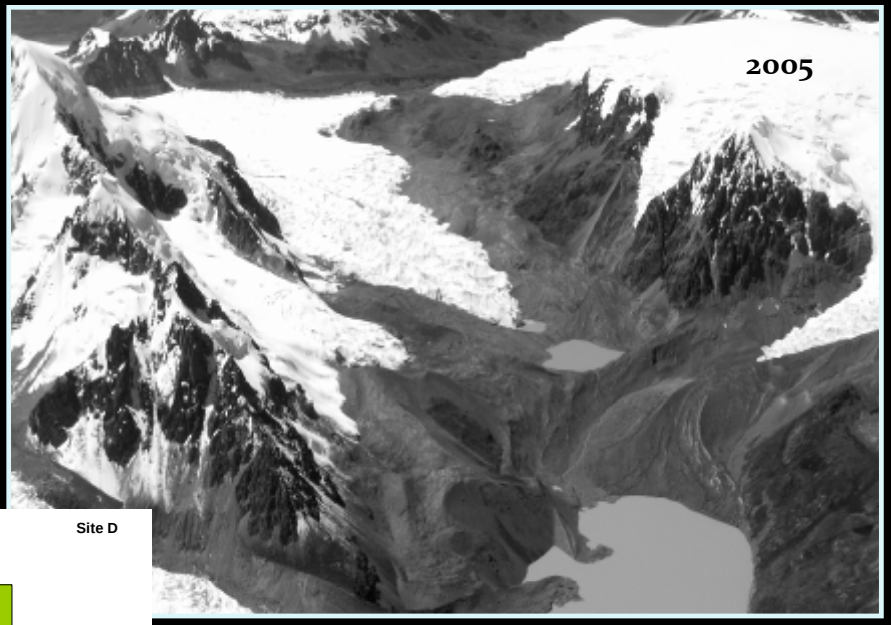
Impact on Species

- Alteration of the timing of interaction (temporal mismatch)-no example known!!
- Shifts of geographic range (spatial mismatch) – perhaps Malaria vectors near Lake Titicaca (3850m)
- Changes in phenotypes or abundance of acting species (strong biotic interactions, herbivory, missing large vertebrates affect regeneration of trees…complex…non mono specific composition of forests
- Missing or changed habitat: 10-20% of 216 reptiles of Bolivia lost till 2080 (Embert, not publ.)

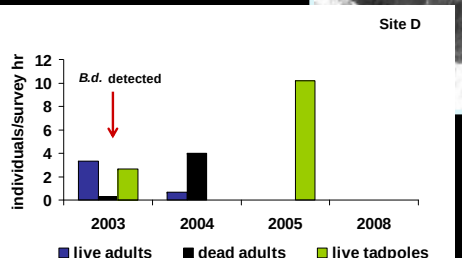
Accelerated deglaciation

Cordillera Vilcanota, Perú
Glacial isochrones since Little Ice Age retreat (~1850)





Invasion of chytridiomycosis (fungi)
disease into *Telmatobius* (frog) populations has
decimated s
2007).



Seimon et al., 2007

Adaptacion

Altitudinal and latitudinal range shift

- Restricted range size species problematic!
- Seasonal interandean dry forest breeding birds depend on precipitation and insect biomass
- Migrant bird species – little known (Herzog 2011)
- Pollination by Hummingbirds, dispersal of *Piper* seeds by bats - altitudinal advantages

Aguirre et al. 2011

Pollination – Dispersal

Range shift

Humming birds

Cantua buxifolia - No seeds

Bats dispersal

Cecropia

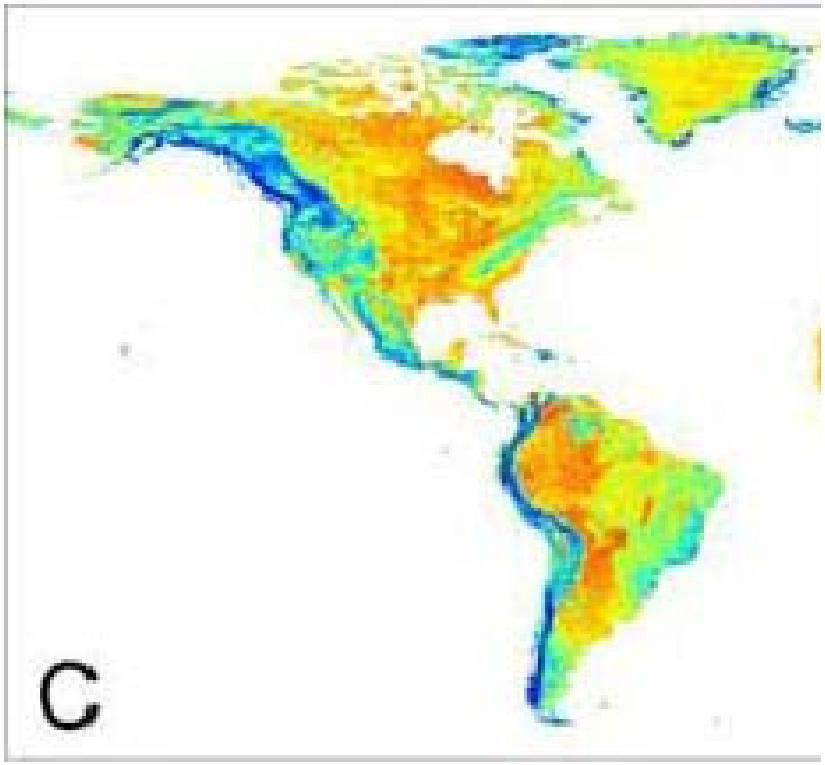
Deciduous or non deciduous

***Juglans boliviana* (nogal)**

***Swietenia macrophylla* (mara)**

Mountains as refuges

"mountainous biomes require the slowest velocities to keep pace with climate change" and hence residence time for protected areas is maximized (Loarie et al., 2009)



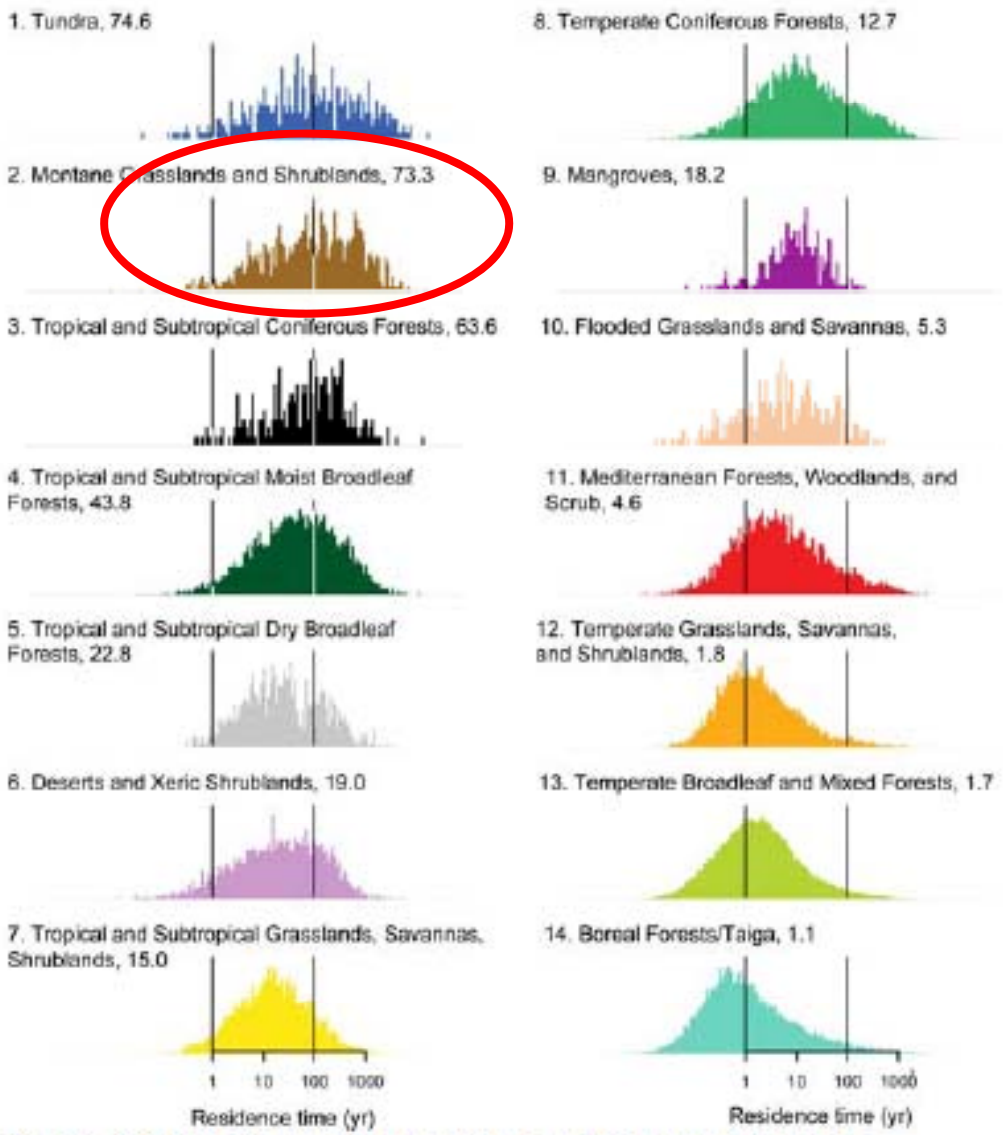


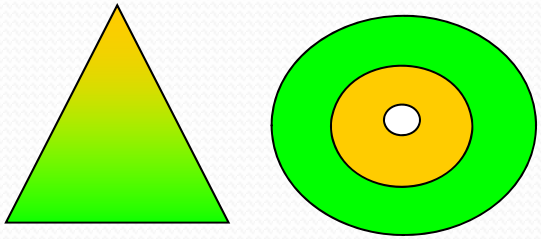
Figure 4| Climate residence time (yr) in protected areas.

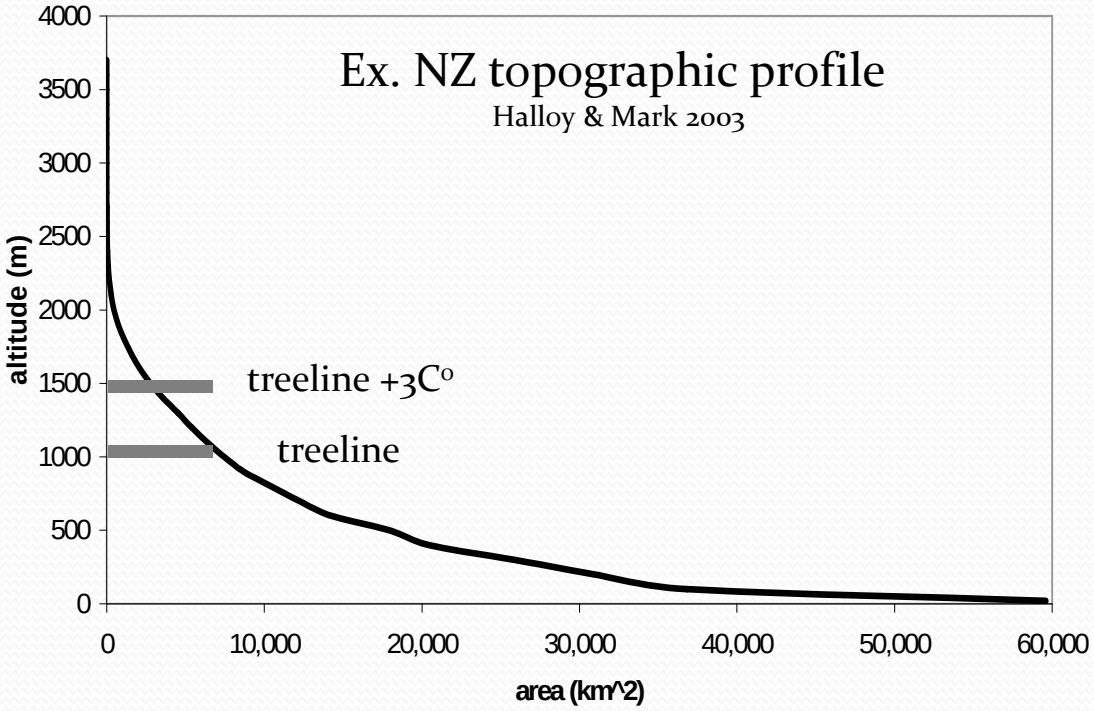
Mountains as Refuges?

Typical conical mountains reduce in area with altitude. A rise of ~500 m may reduce available area in the order of 30-60%

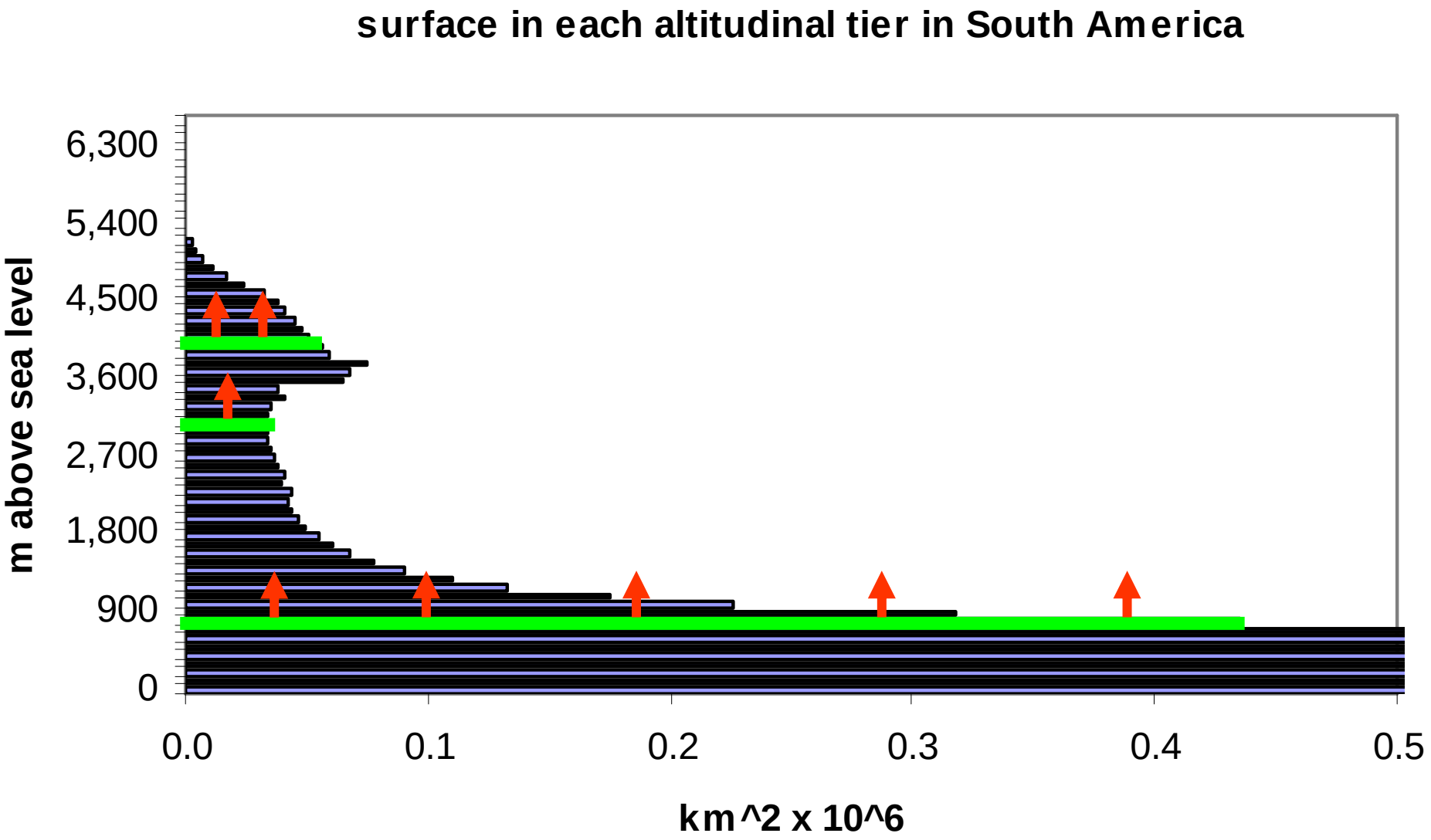
Species-area relation predicts massive loss of species

30-60% less surface



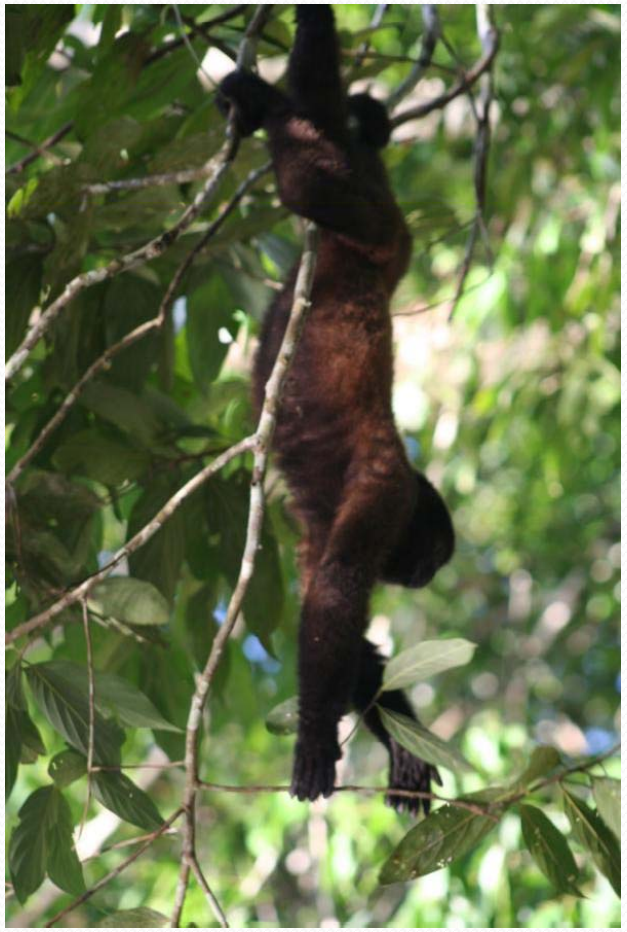


Andean profile above 900 m



Protected Areas for Conservation of Biodiversity

- The Protected Areas are one of the most important instruments for conservaction of biodiversity in the internacional, regional and nacional context.
- The Convention on Biological Diversity (CBD) promote programs concerning Protected Areas.
- All signed parties of the CBD as Bolivia and Peru agreed to establish national nets of Protected Areas.



Requirements to maintain biodiversity threatened by climate change in Protected Areas

- Provide sufficient buffer to prevent erosion of biodiversity
- Facilitate the migration of species in altitudinal and latitudinal ranges
- Provide sufficient conexion between the different natural ecosystems and by corredor
- Avoid or reduce human activities in PA as roads (high ways), deforestation, agriculture, lifestock

Marcgraviácea, hemi epifito en los bosques montanos

GLORIA
- Global Research Initiative in Alpine Environments

GLORIA is one of the few research projects which integrates climate change and biodiversity at a regional and global scale.

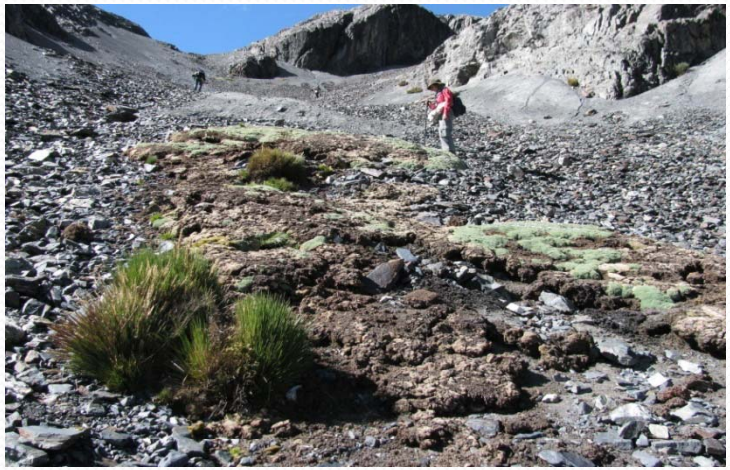
Cerro Saltuni, establecer cuadrantes en 5350 m

- GLORIA helps to install and to maintain a world network of observation of biodiversity to a long period in alpine environments.
- About 25 sites are installed from Chile to Venezuela in the Andes.
- In Bolivia are GLORIA sites in Protected Areas of Sajama, Apolobamba, Tuni-Condori andTunari .

5000 m: Por donde vayan las plantitas endémicas ?

Anthochloa lepidula

Deyeuxia spicigera



Cojines de *Werneria humilis* con *Deyeuxia*

Human context

Rising temperatures, coupled with socio-economic drivers, have pushed potato cultivation to higher altitudes, some 300 m, in the last 50 years in the Vilcanota. Traditional cultivation and genetic conservation **by local communities have resulted in the development of several hundreds of varieties of potatoes thereby contributing to risk management in the face of climate variability (Halloy et al. 2005a; 2005b)**

Combined ecological and social pressures further push camelid production into higher altitudinal tiers. Vegetation cover decreases and rates of erosion increase with overgrazing pressures and rising snowfall line.

Camelid and other herbivore migrations act as vectors transporting propagules to higher altitudes and accelerating the rise of plant distribution limits

Working with communities on adaptation

- Sajama and Apolobamba workshops with indigenous people (Ulloa and Yager 2007)
- developing awareness and understanding of local knowledge and local perceptions of change
- reaching a common understanding of multiple interdependent driving forces of change and what can be done about them (adaptation)

Some conclusions

- vascular plant species richness is strongly locally determined through geology, grazing, rainfall and other landscape heterogeneity, creating much richer and complex patterns than in temperate mountains. Trends related to climate change will consequently be more complex.
- there are clear indications of upward mobility in plants, vertebrates, cultivation and livestock (Seimon et al. 2007)
- disease organisms are advancing as well, sometimes negating advances in range expansion (amphibians followed by chytrids)
- declining water availability has dried lakes and wetlands (Andean peat bogs) in some areas, with significant changes in species composition and livestock carrying capacity

Bolivian State policy according to diagnose of vulnerability of ecosystems, July 2010

- Priority: food security
- Areas connected in Protected Areas
- Studies should be implied in ecotones
- P.A. Apolobamba and Madidi, areas of priority, being representative for a multitude of ecosystems
- Scenario of climatic change and its effect on P.A. set up by FAN
- RUMBOL prepares a map of dynamic and change of land use

Proyecciones futuras de cambio climático

(Robert Müller)

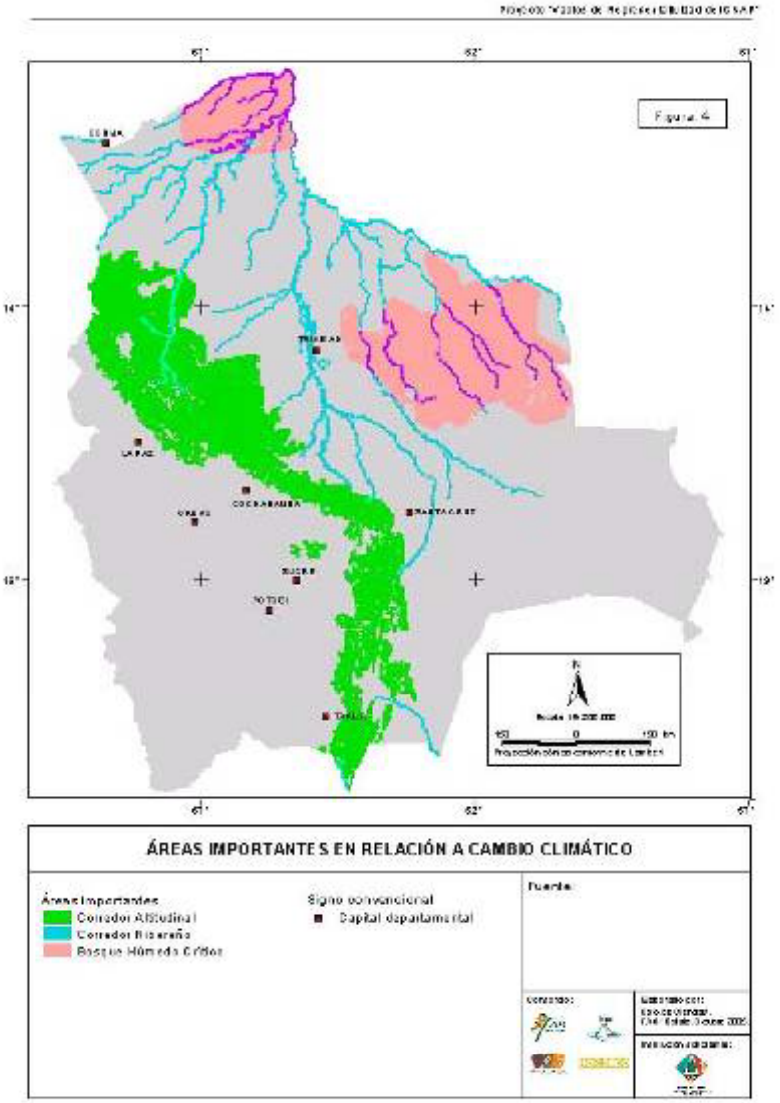
- El objetivo del análisis es la identificación cualitativa de ecosistemas cuya existencia en el futuro probablemente esté en peligro a causa de cambios climáticos, así como también la identificación de áreas que representan posibles “caminos de escape”.

- Así se busca indicar áreas cuya conservación será importante para la mitigación de los efectos del cambio climático así como para recomendaciones acerca de actuales y potenciales áreas protegidas.

Análisis de Vacíos de Representatividad

Cont. Cambio Climático

- Priorización de corredores altitudinales y ribereños por su importancia para el mantenimiento de la conectividad entre ecosistemas y en diferentes gradientes – altitudinales y latitudinales – y que además actúan como corredores biológicos naturales, así como bosques tropicales húmedos donde el riesgo de sequía puede aumentar significativamente.



Levantamiento e evaluación del estado de amenaza de 152 especies

La publicación del Libro Rojo de Parientes Silvestres de Cultivos de Bolivia, es un documento que actualiza el conocimiento sobre el grado de amenaza de 152 especies de plantas emparentadas con cultivos de 12 géneros pertenecientes a 9 familias. Esta obra colegiada, en la que participaron 14 autores y coautores, 4 especialistas internacionales y 2 nacionales en calidad de revisores y más de 20 colaboradores, muestra la descripción de cada una de las especies, la distribución geográfica, los aspectos ecológicos, la situación actual, los principales factores que amenazan a cada una de las especies, su categoría de amenaza, las medidas y acciones de conservación propuestas, los usos e importancia y el material representativo existente en los Herbarios nacionales e internacionales. Utilizando la metodología para Listas Rojas de la UICN, los autores evaluaron/categorizaron 152 especies de parientes silvestres de cultivos, de los cuales 45 están amenazadas y 20 casi amenazadas:

- En Peligro Crítico (CR) - 7 especies
- En Peligro (EN) - 22 especies
- Vulnerable (VU) - 16 especies
- Casi Amenazada (NT) - 20 especies

La información de este libro debe ser utilizada no sólo como un punto de partida para planificar y realizar acciones de conservación in situ y ex situ específicas, sino también para promover el uso de los parientes silvestres de cultivos por la importancia que tienen para nuestro país y el mundo como recursos filogenéticos importantes para la alimentación de actuales y futuras generaciones.

INSTITUCIONES NACIONALES PARTICIPANTES EN EL PROCESO DE CATEGORIZACIÓN

"Bolivia, digna, soberana, productiva y democrática para vivir bien"

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Libro Rojo
de parientes silvestres de cultivos de Bolivia

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Estado Plurinacional de Bolivia

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Libro Rojo
de parientes silvestres de cultivos de Bolivia

Proyecto Global UNEP/GEF "Conservación in situ de parientes silvestres de cultivos a través del manejo de información y su aplicación en campo" – Componente Bolivia

En peligro: Recursos Genéticos de importancia global en Áreas Protegidas de Bolivia

Pariente de la Yuca, casava

YUQUILLA DEL MUTÚN

Manihot violacea
Pohl

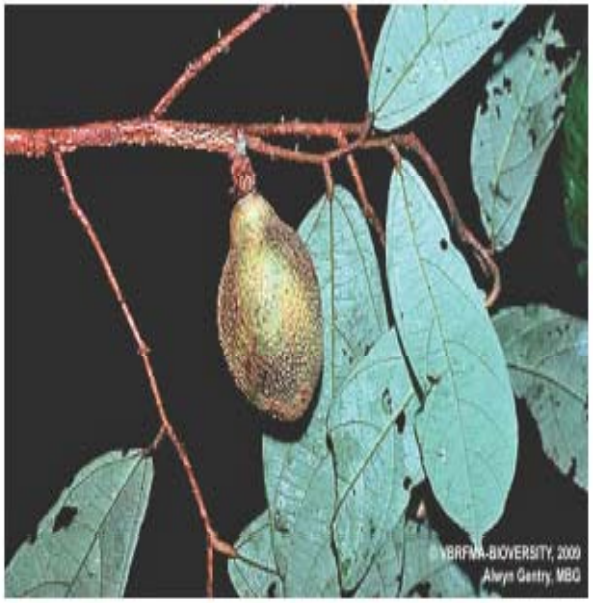
Familia
Euphorbiaceae

Categoría Nacional
En Peligro Crítico (CR), B1ab(i,ii,iv)

AP Otuquis – Complejo Siderúrgico Mutún (!) en el Pantanal

Pariente del Chocolate
(Otros parientes en TIPNIS)

CHOCOLATILLO MACHO



Theobroma obovatum
Klotzsch ex Bernoulli

Familia
Sterculiaceae

Categoría Nacional
En Peligro Crítico (CR), B2ab(i

AP Manuripi – Colonización, deforestación en la Amazonia

Biodiversidad – Seguridad alimenticia

Achacana (*Neowerdermannia vorwerkii)*

Maca (*Lepidium meyenii*)

- Con el progreso del cambio climático, recursos genéticos están ganando una nueva calidad ya que son vitales para la adaptación (plagas, sequia…)
- Especies alimenticias marginales tomaron un papel importante, crucial para hacer frente al clima cambiante.
- Las varias iniciativas internacionales de desarrollo son todavía poco concientes de la cercana relación entre el cambio climático y la seguridad alimentaria y el rol que la agro biodiversidad y las culturas tradicionales juegan ahora y en el futuro

Aspectos metodológicos

¿ Cómo medimos el impacto del cambio climático en la biodiversidad de las áreas protegidas?

- A mediano y largo plazo via el “monitoreo” (GLORIA)
- Estudios de percepción de los lugarenos
- Revisión de la literatura existente, documentos relevantes sobre APs, biodiversidad y clima
- Planes de manejo