Conservation and use of *Polylepis pepei* woodlands in the Apolobamba Mountains of Bolivia

by

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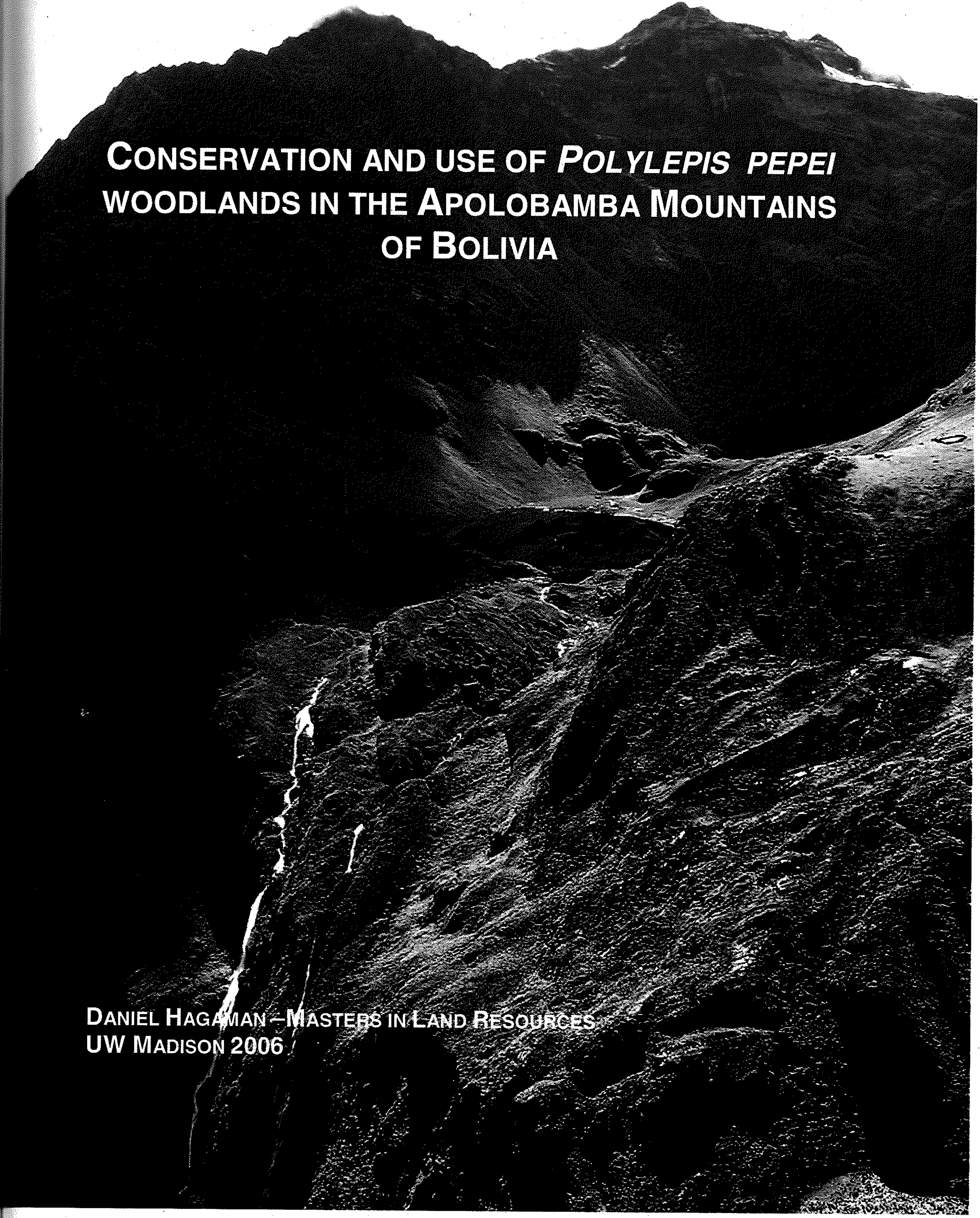

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ABSTRACT

This research examines the use and conservation of *Polylepis* sp., or *queñua*, forests within the Apolobamba Mountains of northwestern Bolivia. In a highland largely devoid of trees, these forests provide firewood and building materials for the local agro-pastoral communities of Puina and Keara centered on agriculture, mining, and animal husbandry. These woodlands also provide the critical 'ecosystem services' of watershed protection and habitat for endemic species of mammals and avifauna. My research addressed some questions pertinent to the conservation and management of these forests in the region. I sought to identify the location of these woodlands in the rugged Apolobamba Mountains, determine the degree of disturbance to these forests and identify some of the root causes of this disturbance. I also examined the perceived cultural and ecological relationships between local communities and *Polylepis* forests in the area to compare ecological 'realities' between what might be perceived and what is observable through the lens of ecological science. In this study, I located and surveyed eight forests in the valleys of Puina and Keara, examined the heterogenic patterns of disturbance (fuelwood cutting, fire and grazing) on these forests, and documented evidence of regeneration / degradation and practices of conservation unique to the area. Twenty-two semi-structured interviews in the communities of Pelechuco, Puina and Keara helped explore the intimate relationship the Quechua people have with their environment and the use of *Polylepis* woodlands. Are *Polylepis* forests regenerating themselves, or are the pressures from local communities degrading the quality of these forests to unsustainable populations? My results suggest a positive correlation between the degree of disturbance

and the proximity to community centers. The interviews conducted in this study imply that the Quechua and Aymara people of these valleys alter *Polylepis* forests in both negative and positive ways through their daily activities and livelihood choices that reflect an acute awareness of the changes they have on the Andes landscape. Finally and most importantly, this study exemplifies the need to work with local communities, to gain their trust, and not exclude them from the process of conservation. My study of *Polylepis* is designed to aid communities, development organizations, and park managers to arrive at sustainable approaches for forest management. The results of this study illustrate ways that communities and park service can manage *Polylepis* forests to optimize both ecological value and goods and services the forests provide.

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This cross-cultural research was inspired by the majestic Apolobamba mountains, the Quechua and Aymara people living in this sacred landscape, and their hospitality and willingness to share their homes and lives. This paper was also inspired by the dedication of many researchers including Jon Fjeldså and Michael Kessler, whose efforts pondering and documenting the mysteries of *Polylepis* forests throughout the Andes have sparked interest in the conservation in these unique species.

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INTRODUCTION

THE ANIMAL WORLD: QUECHUA ADAPTABILITY IN THE APOLOBAMBA MOUNTAINS

> The Andean world is an "animal world" (Kusch 1962). It is like ourselves; it needs to nourish itself and to rest. It is highly sensitive, changeable according to the circumstances, susceptible of becoming a prisoner of its own preferences, desires, appetites, passions, joys, sadnesses and angers, and, of course, of its sensuality. Like any other animal it is mysterious, unpredictable and even capricious. The Andean people who live in a world with such a temperament know what they are contending with and because of this they interact with it all with spontaneity and familiarity. The Andean people are at ease with the unexpected, the unstable and the contradictory, and face them without repugnance or apprehension. They are seen simply as things that sometimes happen in life, and so do not surprise or frighten anyone in our living world. And so the frost, the hail, the drought, the floods, the exaggerated abundance of insects or fungi "happen" in the Andes in close relations with the harmony of our world (Fernandez 1998: 129-130).

The mid-morning mist thickens in the valley below, a reminder of my close proximity to the headwaters of the Amazon River. The frosty sponge-like mosses crunch underfoot in this wetland bordering an elfin forest of twisted and gnarled shapes of *queñua* (*Polylepis pepei*) or *queñua sacha* (tree in Quechua). Their red tissue paper bark and bonsai-like appearance engenders respect and awe in this harsh environment. Even at 4000 meters in the virtually treeless *puna* and *páramo* on the eastern slopes of the Bolivian Andes, small isolated patches of forests exist, clinging to the steep valleys in the Apolobamba mountains. The *queñua* forests appear out of place, suspended in thin clouds, islands of biodiversity within a sea of grass and rock. Their tiny leaves harvest or "comb" humidity from the atmosphere, water droplets that eventually unite forming the turbid Puina River that cascades down to where it joins the Keara and Pelechuco Rivers.

It then rages onward to become the Tuichi, a formidable challenge for many historical adventurers and treasure hunters searching for gold, rubber and the 'lost' tribes of the Amazon. This tributary mellows when it reaches the navigable Beni and completes its journey to the mighty Amazon. This document is an attempt to understand the conservation of the *queñua* (*Polylepis* sp.) forests, the birthplace of a resource more precious than gold.... water.

The small community of Puina (Figure 1), nestled between the rising mountains, bustles with activity. Terraced potato fields and stone walls delineate the *canchas*, agricultural plots located within the housing complex of each individual family. The slightly darker patches of ground near the houses indicate newly planted fields. Llamas and alpacas graze across the expansive valley, climbing on an exposed northern face, nibbling on tufts of what appears to be bunchgrass (*Stipa ichu*), recently burned to stimulate regeneration and growth. A small mule train loaded with supplies snakes up the valley, headed for the community cooperative gold mine located three hours to the west in the *rinconada,* beneath the snowcapped 6000-meter Chaupi Orco or "middle peak". The *monte*, or montane forest lies three hours down the valley to the East, where small pastures and maize fields are nestled between the canopy of epiphytic forests astride the rocky crags.

The Quechua people of this Andean valley are resilient and proud, adapting to changing climatic and political circumstances with hundreds of years of collective knowledge and diversified strategies for the generation of household incomes. At first glace, the utilization of natural resources by local communities seems timeless, not so very different from scenes depicted in books about the sustainability of pre-Incan Andean agriculture. The "vertical archipelago" of the Andean valleys encouraged the construction of human engineered cobblestone roads and social networks to facilitate trade among the various communities (Murra 1983).

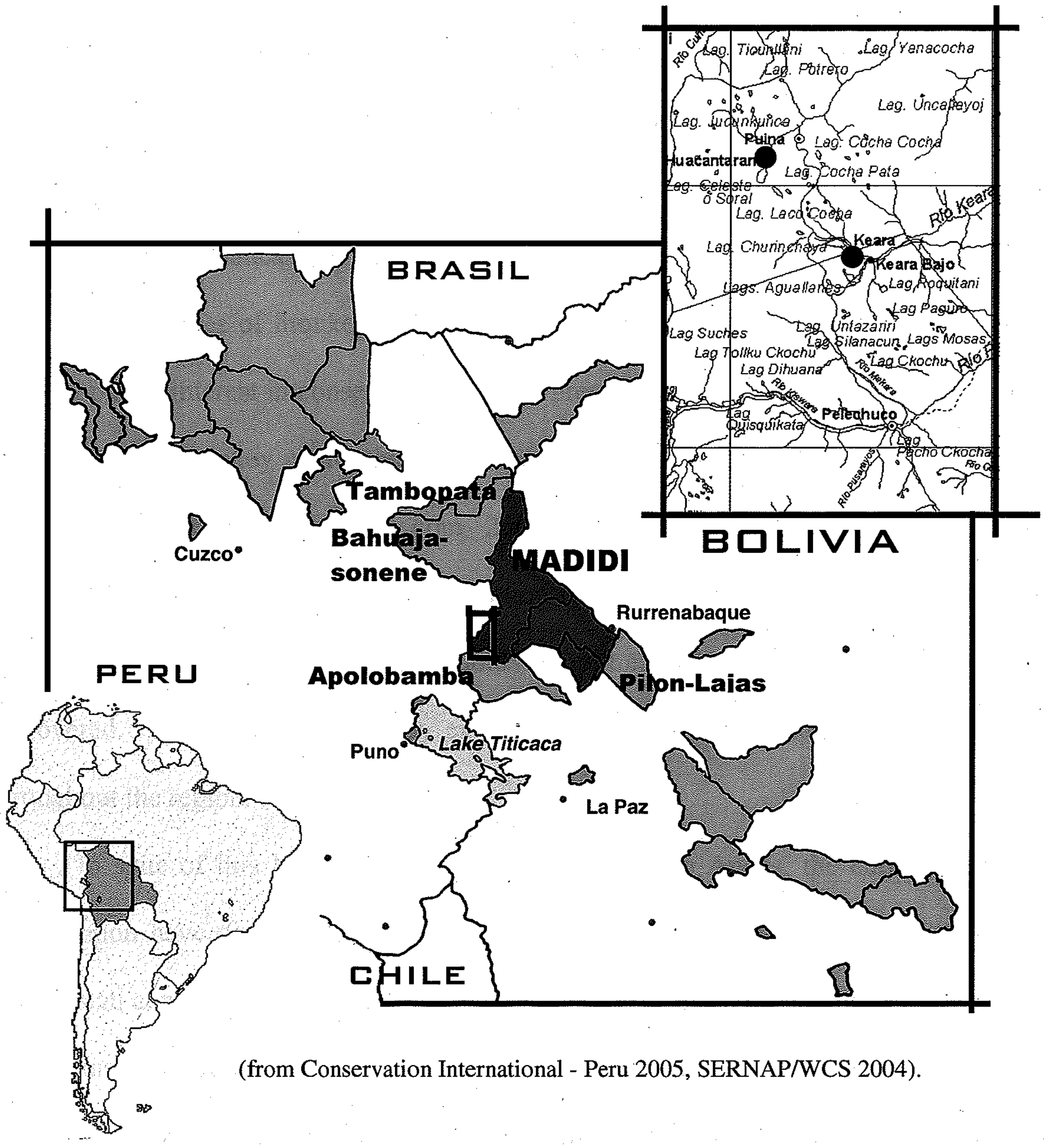
The existing agro-pastoral system in Puina, rooted firmly in ancient traditions, appears extremely dynamic. While *llameros* (llama ranchers) are justly concerned about the welfare of their alpacas and llamas, they are not oblivious to the impacts these animals have on the landscape. Nor are they blind to the many ways in which they as a community alter the Andean landscape, the pastures and the forests. Anyone intricately connected to the land cannot help but observe the smallest differences in the daily cycles and seasonal fluctuations. Accordingly, residents make changes in response to these perceived changes in their surrounding environments.

So in essence, local communities have managed and 'conserved' the Andean landscape since ancient times, preserving the fertility of the soil, the woodlands and also the productivity of the land and the bountiful harvest of potatoes (Schulte 1998). The contemporary term *conservation*, or 'with service', is nothing new to Andean peoples who have given their service to *pachamama* or 'mother earth' long before the existence of conservation biologists, park guards and national parks.

CONSERVATION IN THE ANDES

Considering the rapid growth of global conservation efforts and the relative political stability of the Andean countries has attracted both money and press in recent years. International conservation organizations, in partnership with local NGOs have staked out their territories and allocated resources for biodiversity conservation in even the most remote corners of the Andes. Conservation organizations, both local and international have benefited from this "conservation boom" (Zimmerer 2003 and 2000). Every park and protected area seems to be unique in some way or another, Madidí National Park in Bolivia is no exception to this recent interest in conservation. Madidi appears in the center of this mosaic of conservation activity; my study area is indicated by the box and is shown in detail below (Figure 1). Madidi represents one of the most biodiverse protected areas in the world; the reason being the wide range of altitudes and thus climates. The Park's altitudes range from 180-5,760m above sea level, meaning that mean annual temperatures can range from 26-12 degrees Celsius respectively, and annual rainfall can range from over 2,000 mm/yr to as little as 700 mm/yr respectively as well. Such habitats include: permanent snow, *puna*, cloud forests, dry tropical forests, tropical rainforests, savannahs, and grasslands (SERNAP/WCS 2002).

Figure 1: The Vilcabamba - Amboro Corridor of National Parks, Protected Areas, and Indigenous reserves in the central Andes of Bolivia and Peru.



(from Conservation International - Peru 2005, SERNAP/WCS 2004).

Conservation in the Andes, especially in Madidi has taken on renewed interest in both public and private support for such efforts. A National Geographic article in 2000 illustrated the potential for eco-tourism and adventure tourism as sustainable ways to promote and sustain the economic needs of the park as well as the people living within the park boundaries (Kemper 2000). The eco-lodge of Chalalán as well as the mountain lodges in Aguas Blancas and Lagunillas have increased awareness of these areas. In 2005 a new species of monkey discovered in Madidi by Wildlife Conservation Society sparked public interest in conservation and the preservation of biodiversity. The naming rights for the monkey were then auctioned off by charityfolks.com for a sum of $650,00.00 (goldenpalacemonkey.com 2005), a sum now retained by the fund, FUNDESNAP, to support future conservation efforts in the region (WCS 2005). It is quite clear that these remote areas hold many treasures of biodiversity yet to be discovered. The result being many extraordinary parks and protected areas scattered throughout the region.

In spite of this long tradition of *conserving* in the Andes, the current trends in conservation have diminished community involvement in this process. It appears that many small communities are more disconnected from the decision-making processes now administered in Bolivia by SERNAP (*SERvicio Nacional de Areas Protegidas*). The popular uprising sparked by the creation of the Carrasco National Park in Bolivia in 1991 exemplifies the need for a constructive dialogue between the 'landless' people *sin tierra* and SERNAP, before the decision to set land aside for protection. Local residents entered the park and threatened to "burn the forests if they were not allowed to continue using them" (Kessler 2003). *Polylepis* forests within the areas under national protection now fall in the hands of the national park system but the lack of resources to enforce "no-cutting" is both unrealistic and dangerous from the standpoint of gaining community support for new parks like Madidi.

Management of national parks using the top-down approach represents what some scholars refer to as the 'new imperialism' (Guha 1998, Chapin 2004). The outcry by human rights organizations for a more humanistic approach to conservation has reached the popular press. "Putting People Last: Big Conservation Groups Are Failing Even As they Succeed" (Dowie 2005), describes the plight of these struggling indigenous groups forced off their traditional lands in the name of 'conservation'. Naughton utilizes the "garden metaphor" to guide a discussion about the need to manage parks like Tambopata in Peru with both an ecological and social responsibility. Connecting these "gardens" to surrounding "ecosystems and human communities" becomes the job of the conservationist (Naughton-Treves 2002).

The difficult realities that conservation of parks 'with people' brings, forces conservationists to revaluate their methods and realize that a more multi-faceted interdisciplinary approach is necessary to understand the driving forces behind environmental change. Zimmerer and Young (1998) examine the inconsistency of environmental disturbances over space and time using the framework of 'political ecology', to incorporate social, political and geographical factors into scientific research. In fact, many conservationists are advocating for this socio-ecological integration in conservation that more holistically assesses local adaptations to change and social movements that affect conservation efforts (Preston 2003, Zimmerer and Bassett 2003, Gade 1999, Zimmerer and Young 1998, Fjeldså and Kessler 1996). Forsyth (1998) supports the development of these 'new ecologies' to further understand the underlying causes of environmental changes in the Andes.

Other research emphasizes the adaptations of local peoples to political, cultural and socioeconomic changes In many cases, external global markets have guided the development and exploitation of resources in remote mountain areas. Ben Orlove (1977) details the influence of global wool markets on local economies in the highlands of Southern Peru and Northern Bolivia. The current landscape reflects the historical use of land and market 'booms' creating hot spots for resource extraction or agro-pastoral production. Orlove (2002) provides vivid narratives of cultural resiliency and adaptation in the Lake Titicaca Basin; the community-based conservation of natural resources in relation to the management of *totora* reeds. These anthropologic perspectives provide a more humanistic approach to understanding conservation and also a much richer explanation for environmental change that does not overlook the cultural and historical influences that are so intricately a part of the people and the Andean landscape.

The socioeconomic and cultural context of *Polylepis* has advanced with more interdisciplinary studies using ethnobotanical and anthropological approaches to research. Tohan (2001) further examines the 'distribution, location, and conservation' of *Polylepis* forests in the Huascarán Biosphere Reserve in Peru using a 'political ecology' framework. His discussion highlights the multiple perspectives and interpretations of *Polylepis* forest change in Huascarán, and the importance of site-specific information for management of these woodlands. Capriles and Flores (2002) surveyed the historical and cultural use of *Polylepis* of Pre-Colombian cultures in the Andes. Hensen (2002,1991) and Lazcano and Espinoza (2002) examined the socioeconomic use of *Polylepis* as a fuelwood in Cochabamba, Bolivia. In Bolivia and elsewhere in the populated highlands of the Andes many *Polylepis* forests lie outside of park jurisdiction, in the "buffer zone" or "area of influence". Whether or not the forest grows in or outside the park is not important, bringing forward awareness to local communities about the ecosystem services these forests provide becomes the challenge. There must be a "sustainable compromise between use and conservation" (Purcell 2004). A state of equilibrium must be reached between the 'use' and 'management of resources like *Polylepis* forests.

My study of *Polylepis* in Madidi National Park benefits from the framework of political ecology. I focus my study on the local perceptions of environmental change in relation to *Polylepis* forests. Some of these perceived changes relate to changes in land tenure systems, the increased involvement of international conservation organizations, the alterations of modern power structures of governance, changes in economic livelihood and the increased importance of the global economy.

THE "*POLYLEPIS* PROBLEM."

It does seem strange that many of the early western explorers of the region around 1900 (Evans 1903, Fawcett 1911, Lummis 1893 and many others) there is not the slightest mention of *Polylepis* forests. I would think that a tree so bound to human survival and prosperity in the highland Andes, and integral to the lifestyles of the people was not 'important' enough to be mentioned in these travel logs and adventurous tales. These noble trees provided support for bridges fording raging rivers to transport these products to markets overseas and local and charcoal for the smelting of the precious ore desired by the masses thousands of kilometers away in Europe and the United States. Maybe these visitors weren't interested, or maybe they weren't keen enough to observe the obvious. With the blinders typical of earlier explorers, they only saw economic wealth in the form of gold, rubber and *quina*, not the rich of biodiversity (Silva et al. 2002).

The construction of knowledge about the environment of *Polylepis* woodlands has frequently been viewed from the perspective of the ecologist, biologist and/or land manager wishing to preserve biodiversity. Anthropogenic 'threats' to *Polylepis* forests documented by ecologists and biologists is the discourse with which I am most familiar. The principle threats outlined by Fjeldså and Kessler (1996) and Kessler (2002) include: (1) grazing and browsing; (2) the accompanying burning to stimulate grass regeneration for domestic animals-- fire is considered to be the most damaging agent in these forests in the Andes; and (3) fuelwood cutting, which has been the focus of many papers concerning the 'fuelwood crisis' (Eckhorn 1976). Fuelwood cutting has been shown to impact *Polylepis* forest regeneration, growth and survival in the Cochabamba province in Bolivia (Ibisch 2002).

The unique and somewhat mystical depiction of the *queñua* or *Polylepis* forests has prompted increased academic interest during the last twenty years. The names "forgotten" (Kessler 2003), "world's highest" (Purcell et al 2004), "vanishing" (Fjeldså 2002) and "islas en el cielo" (Arévalo 2003) or 'islands in the sky', have all been used to describe the remote nature of these forests. The "*Polylepis* problem" (Kessler 2002, Meihe & Meihe 1994) refers to the ongoing and seemingly unilateral discussion about the past distribution of *Polylepis* sp. throughout the Andes. Most academics who identify a "problem" tend to maintain that through conservation efforts we can solve this "problem". Much current research begins from the disturbance hypothesis proposed by Heinz Ellenberg in the 1950's that humans' influence on the natural environment has modified and decreased the normally widespread distribution of *Polylepis* forests throughout the Andes. This view challenged the conventional wisdom that natural environmental factors in an extreme environment determined where *Polylepis* forests are currently located and how they fared (see Kessler 2002 for a complete overview of the debate). Most researchers who adopt the disturbance hypothesis attribute the current reduction and isolation of *Polylepis* forests to three major anthropogenic factors, grazing, fire and fuel wood cutting (Fjeldså and Kessler 1996, Purcell 2004, Tarifa and Yensen 2001).

Conservation organizations working in the high Andes have also adopted this hypothesis as a basis for their conservation work (SERNAP/WCS 2002, CEMEX/CI 2005, CI 2000). According to potential distribution models developed by Fjeldså and

Kessler (1996) only an estimated 10% of the original *Polylepis* spp. forest cover is left in the Andes. Evidence of current surveys shows the complete elimination of seven out of seventeen *Polylepis* forest patches originally surveyed by Kessler and Fjeldså in the 1980s (Purcell et al. 2004). The "critical" status of *Polylepis* forests has also prompted development of more regional and global conservation strategies utilizing GIS tools and broad landscape approaches to conservation. According to WCS (2005) in Bolivia, the landscape conservation approach is used "to attain the goal of conserving biodiversity within the region". Conservation International (2005) has promoted park unification through the Vilcabamba-Amboro conservation corridor comprising several national parks and protected areas linked with buffer zones that flank the Andes mountains of Bolivia and Peru (Figure 1). Although these broad landscape approaches to conservation have been widely touted by conservation organizations and funding sources alike, a growing number of questions examine the lack of efficacy of such approaches relating to socio-economic issues and the power structures of conservation. Community resentment of conservation is becoming more prevalent (Chapin 2004).

Almost ten years after the publication of Fjeldså and Kessler's "guide" for management of *Polylepis* woodlands in the Central Andes of Peru and Bolivia, the practical and financial limitations of facilitating a widespread recovery of these forests is evident (Ibish, 2002; Purcell et al. 2004; Kessler 2003). It seems the complexity of conserving these forests is not so much an ecological question, but a socio-economic question. Until these questions are resolved, the conservation outlook for *Polylepis* seems quite dismal, if not a lost cause. Reforestation programs described by Ibish (2002) in Cochabamba, Bolivia seem to have failed even after a 10-year introductory period, a result of institutional failures and a lack of community interest.

Other researchers even question the common interpretation by conservationists that all forests are degrading. The forest transition thesis presented by Rudel (2002) states that the regeneration of some forests might in fact be a result of rural-urban migrations and the decrease in pressures of fuelwood extraction. There is also evidence to support increased growth of *Polylepis* forests in certain areas. In a photographic study by Byers (1999), some *Polylepis* forest patches in the Huascarán Biosphere Reserve remained stable and appear to have increased since the 1930's. This suggests that some pressures restricting the regeneration of *Polylepis* patches has been removed in recent years, allowing the expansion of these forest patches. This view supporting current forest resiliency to environmental disturbance is also supported by findings presented by Tohan (2001) working with the Mountain Institute in Huascaran National Park in Peru. Is it possible that humans are actively managing and facilitating the regeneration of these forests in certain areas? Are they destroyers or protectors of these forests? Are communities actively promoting the growth of these forests or has this been a result of other socio-cultural-economic changes in the area.

The importance of *Polylepis* for local communities must not be underestimated. *Polylepis* is resilient and has the ability to grow at high altitudes. Communities rely on it for windbreaks, the leaf litter provides green manure for their intensively farmed house gardens, and the roots stabilize terraces and protect soil from wind and water erosion. It also provides protection for humans and domestic animals against the high altitude solar radiation. Most importantly, these community-managed forests provide fuelwood for cooking and take pressures off the 'naturally' occurring forests further up the valleys. In many communities, the only remaining *Polylepis* forests are located in the most densely populated villages (Purcell 2004). These forests might therefore be attributed to the "stewardship" of local communities, which promoted the expansion of "forest islands" or trees brought from other locations (Fairhead and Leach 1996).

The literature on *Polylepis* conservation spans several academic disciplines, so I will attempt to provide a brief overview of these contributions as a useful context for my particular research. Next, I provide a general overview of the study area, the Bolivian national park service, and the local environment. My contribution will examine local perceptions of impacts from resource extraction and use pertaining to the Andean landscape, forests, fuel wood and other natural resources. These viewpoints will then be compared to conclusions from existing studies and my own observations in the communities of Puina and Keara.

Faunal Studies

Ornithological studies provide a powerful tool for conservation biologists wanting to protect *Polylepis* forests. Studies focused on avian specialists of *Polylepis* forests and regional endemism in avifauna are specific focal points for conservation programs. Species like *Anairetes alpinus* and *Cinclodes aricomae* are extremely rare in Bolivia, less than 100 individuals are known to exist (Isabel Gómez 2004). The presence of other species specializing in *Polylepis* forests includes the species *Oreomanes fraseri* and *Leptasthenura yanacensis* (Herzog et al. 2004, Fjeldså and Kessler 1996, Purcell 2004). These surveys identify hot spots of endemism centered on avifaunal diversity, and can help attract necessary funding to support large-scale conservation projects (CEMEX/CI 2005). The presence of these species, or absence thereof, becomes an indicator determining the overall health of a particular forest patch or region. The gap in information from Madidi National Park has provided incentives for more research in the area (Hennessey and Gómez 2003). Current research in Madidi includes mapping distribution patterns of *A. alpinus* and *C. aracomae*, and working with local communities to conserve these forest habitats (Gómez 2004).

Botanical studies of *Polylepis* and related vegetation

Research on the genus *Polylepis* as a whole is modest. From the foundational works by Simpson (1979) and Kessler (1995), the distribution of the approximately 20 species of *Polylepis* is generally known, although due to the size and the remote nature of these forests, the documentation is incomplete. Revisions of the taxonomic classifications of *Polylepis* in Bolivia (Navarro 2005) will continue as more literature is published on the genus. Studies focusing on the plant community composition (Fernandez et al 2001) and denrochronology (Roig et al 2001) allow for more detailed understanding of the genus *Polylepis* and the ecological niche of individual species within the environment. From this pioneering research, it appears that *Polylepis* forests are centers of high endemism in the highland valleys of the Andes and the human presence in these areas has influenced the types of vegetation present at this time.

Climate change related to *Polylepis* forests

Understanding climate change is fundamental to understanding the root causes of current *Polylepis* distribution and regeneration in the Andes. Climate change is the central argument of the anthropogenic disturbance theories (Heinzberg 1958, and Fjeldså and Kessler 1996). These historical changes in climate have altered the composition of plant communities and forests for thousands of years (Chepstow-Lusty 2002 and 2000, Gade 1999). Evidence of receding glaciers in historical photography by Byers (1999) in Huascaran provides a visual clue to the general warming trends because they actually document the shrinking snowfields of the Andes. Data recorded from historical climate records and glacial cores (Barry 2000, Francou 2000) provide even more evidence that a warming trend is occurring throughout the Andes. Although this might benefit Andean agriculture due to an upward shift in the zone of frequent frosts (Barry 2000), it is inconclusive how this might affect the 20 species of *Polylepis* that inhabit many diverse ecological zones (Kessler 2002). According to some dendrocronological studies conducted by Roig (2001), this daily fluctuation of temperatures, the freezing and thawing of trees may determine the growth of rings. In conclusion, and aside from all anthropogenic disturbances, this warming trend appears to encourage *Polylepis* forest regeneration.

My Contribution

My research attempts to expand on the literature concerning conservation of *Polylepis* forests in the Bolivian Andes. This is not an especially large literature, but it is growing, mostly focused on the ecology of *Polylepis* forests and the associated biodiversity contained therein. The first conference on *Polylepis* in 2000 explored the diversity of findings from different geographical areas on the various species of *Polylepis* (see Herzog 2000, *Ecología en Bolivia* 2001 for abstracts and papers). The second conference on *Polylepis* research will be held in Cuzco, Peru in May 2006, to advance research on the subject. I have chosen to focus my study on one very specific geographic area, and try to understand the local/indigenous perspective from surrounding access and use of products from these *Polylepis* forests. I appreciate that any effort by an outsider to document and interpret the diverse perspectives of indigenous communities is subject to various interpretations and misinterpretations, but this does not dismiss the value or importance of obtaining multiple perspectives on the ambiguous term of 'conservation'. Other questions need to be asked include: What is being conserved, and why? Who does this conservation benefit? Can *Polylepis* forests be managed 'sustainably"? Who will manage these forests? Maybe a better question is to find out who is managing these forests, if at all?

These questions have been answered in part by Kessler, Fjeldså and many others in relationship to specific patches of *Polylepis* forests. Because of the uniqueness of each individual species and also the variation of social and environmental pressures affecting these forests patches, it seems that a universal plan for *Polylepis* management would be ineffective. Each region, and maybe even individual communities will have to develop a different solution to the *Polylepis* 'problem'. I do not wish to misinterpret the extent and root causes of environmental degradation that are only perceived by outsiders, including conservationists. Assumptions about environmental deterioration may result in unpopular and socially exclusive policies that disadvantage communities living in these areas. Brower and Dennis (1998) and Preston (2003, 1998) criticize these assumptions that overgrazing is the root cause of these problems in Nepal and Tarija, Bolivia. According to Sundberg (2003) management organizations "have the power to construct truths about human-land relationships" that frame the conceptualization of environmental degradation at the local level. In relation to *Polylepis* forests, the framework of political ecology supports a site-specific approach to understanding the intricacies of local subsistence and use patterns within a specific geographic area (Zimmerer and Young 1998, Tohan 1999).

In this case study I hope to give a voice to the people of Puina and Keara in the Apolobamba mountains. Their knowledge and insight about the landscape, forest and pasture resources might facilitate the conservation dialogue between communities and institutions working in the area. This study also provides some new data on the forest resources of several *Polylepis* forests, including forest locations and patterns of disturbance and regeneration on the border of Peru and Bolivia. Forest surveys of eight *P. pepei* forests provide ecological data on the potential for regeneration of these unique forests. In this study, the perceived threats to *Polylepis* forests are examined in some detail: the potential impacts of firewood collection, grazing, and fire have directed many of my research questions and interviews with community members of Puina and Keara.

METHODS

TIME FRAME

I conducted my fieldwork on two separate trips to Bolivia and Peru; the first from July-August of 2003 and the second from July to December 2004. The first exploratory trip, from June 2003 – July 2003 involved making contacts and designing the research project. The second trip from July 2004 - December 2004 involved mapping the location of *Polylepis* forests, conducting semi-structured interviews with community members, participant observations, completing a structural analysis of the eight forests. Most ecological and social data were gathered during the 2004 season on two 30-day field trips to the communities of Pelechuco, Puina and Keara. Informal interviews were also conducted with conservation organizations, governmental institutions, national park authorities and individuals within the Bolivian cities of La Paz, Cochabamba, and Santa Cruz, as well as Lima and Huaraz in Peru.

STUDY AREAS

All field research was conducted in Bolivia, near the border of Peru in the Madidi and Apolobamba Protected Areas (NIMNA- National Integrated Management Natural Area). I worked with the isolated communities of Pelechuco, Puina and Keara in the municipal government of Franz Tamayo, Province of La Paz. The National Protected areas of Madidi and Apolobamba (see Figure 1) border Peru and are managed by SERNAP (*Servicio Nacional de Areas Protegidas*). Although the administrative office for Madidi is in the tropical town of Rurrenabaque, the nearest Apolobamba park stations are located in Pelechuco and other communities outside of my study area.

Working in this remote region requires a certain level of comfort for dealing with the unexpected. Residents and travelers alike must alter plans and quickly adapt to meteorological events such as heavy rains, extreme solar exposure and freezing temperatures that create discomforts and some minor transportation delays. Private transportation rarely passes along this once highly traveled passage from the *altiplano* to the tropics. Bus transportation arrives twice weekly to the town of Pelechuco, a rough sixteen hour drive from the capital of La Paz. Small four-wheel drive vehicles able to run the gauntlet of snow, ice and mud on the pass at *Paso Sanchez* are the only vehicles able to traverse the newly excavated road from Pelechuco to Keara. Horses, mules and llamas are the preferred vehicles for transporting cargo, surely a much safer and more reliable mount than the rusty and temperamental Land-Rover.

Pelechuco became the staging area for my field trips; this was where we rented mules and llamas to transport equipment and food to the more remote communities of Puina and Keara. Coordination with local guides and the Apolobamba Guide Association (*Associación de Guías y Arrieros de Apolobamba*) allowed us to traverse the remote and rugged Apolobamba Mountains with relative ease.

Climate

The close proximity of Pelechuco to the study areas in Puina and Keara give a good approximation of the climatic conditions of the *Polylepis* forests in the region. The elevational difference between Pelechuco (3600m) and the communities of Puina and Keara, around 3800 meters may account for slightly higher temperatures and precipitation in Pelechuco, conditions influenced by the humid Yungas of La Paz (Lorini 1997). According to the management plan for the Ulla Ulla Protected Area, Pelechuco receives an average of 1052mm of annual precipitation and has an average temperature of 13.8°C. Monthly precipitation levels exceed 50mm for the months of September to March (wet season). June and July are the driest months, with between 50-100 days of frosts concentrated in these months. More important than the difference in seasonal fluctuation in temperature is the daily fluctuation of 12-15 °C (SERNAP/WCS 2004).

People and Madidi

Created officially on September 21, 1995 Madidí National Park is located between the Franz Tamayo and Iturralde Provinces of Bolivia, 300 km north of La Paz. It covers an area of 18,957 sq km (1,271,500 has). Peru borders the park to the west with the Andes Mountains to the East. Madidí is part of a larger Bolivian wilderness area that also includes the Apolobamba Natural Area of Integrated Management and the Pilón Lajas Biosphere Reserve. The approximate number of people living within Madidi is 3,500 (Table 1).

Table 1: Demographic distribution of population in Madidi

Region	Towns and settlements	Number of families	Estimated population
Highland areas	Mojos, **Puina**, **Queara**	180	900
Interandean valleys	25 communities including Santa Cruz de Valle Ameno y el Peru	370	2000
Lowland areas	San Jose de Uchupiamonas and settlements on the Heath river	120	600
Total		670	3,500

(from SERNAP/WCS 2004)

Keara and Puina are some of the larger towns within the Madidi protected area and together with Mojos have an estimated number of 180 families or 900 individuals. According to the same source, the town of Puina currently has 115 adults, 47 adolescents, and 82 children (adapted from WCS 2004, data collected from SERNAP 2002). Other researchers estimate the populations of Puina and Keara to be 55 and 50 families respectively, with Pelechuco totaling 130 families (Schulte and Magne 1997).

In Apolobamba, the observations from community members give us an idea about how communities have adapted to these changes in weather patterns and socioeconomic activities, most notably, the slow and deliberate migration upward of both the communities of Keara and Puina. The "ancient towns", complete with a colonial church, bell tower, main plaza and houses bordering the plaza have been abandoned for the most part, where only a few families remain in these lower communities. In the case of Puina, the village of Puina*pampa* lies an hour walk from the current plaza that centers on the soccer field. The 2 evangelical churches (*Santidad* and *Aventista*) border the field as well as houses and the *CEDE communal* or local governance building. The school and 2-3 stores now provide basic supplies (rice, sugar, salt, *fideo* (pasta), candles, soap, drink mixes, and *charque* (dried meat), etc.) Similarly, Keara has moved all the important social and communal activities up the valley from Keara "Antigua" where the old hacienda of Carlos Franck lies in ruins in the main plaza. Other remnants of past domination and control exist further up the valley in the current town center where the remains of a covered corral and stable for sheep, horses and cattle provides ample evidence of the importance of these animals in the local economy in the past.

P. pepei Forest Locations

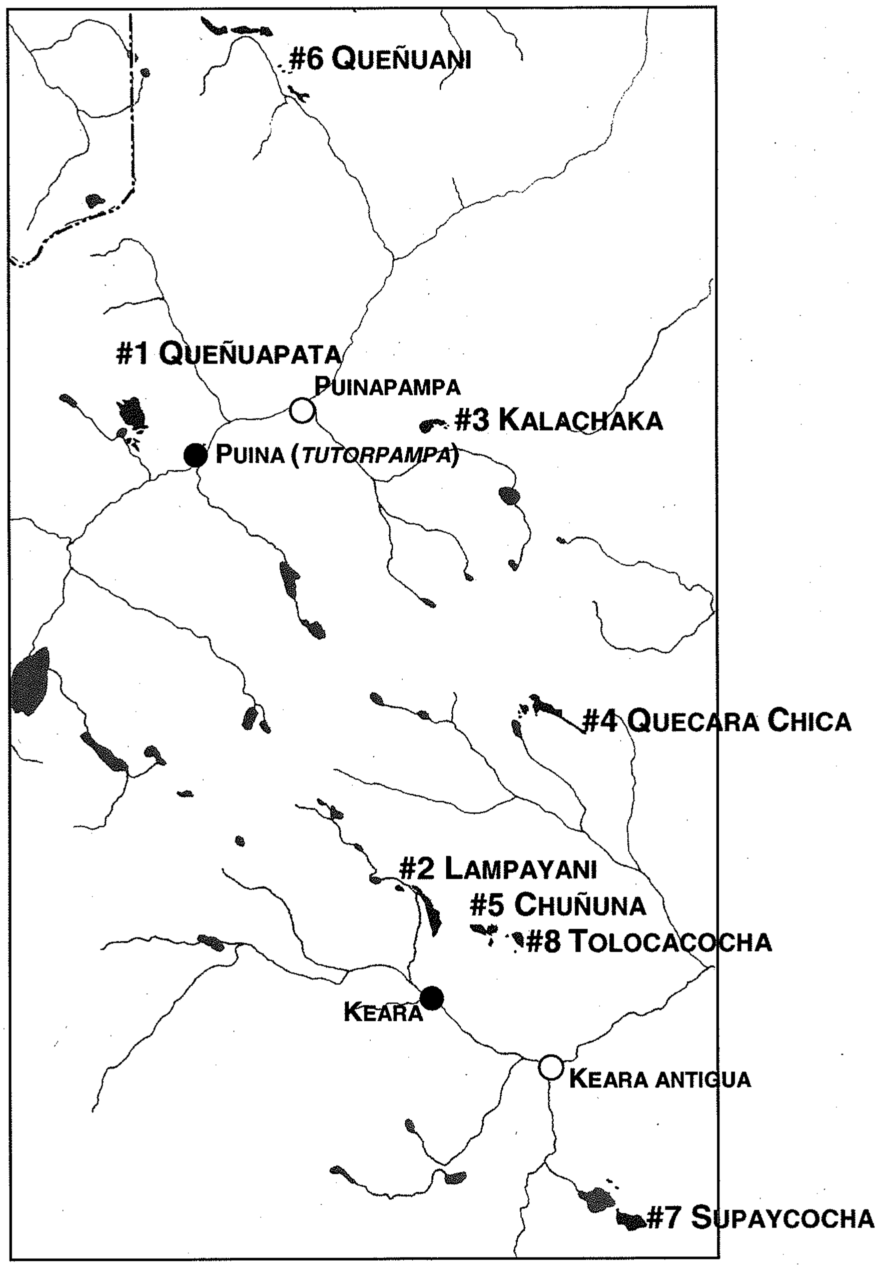
The location of *Polylepis* forests within the landscape together with some of their attributes such as elevation, size, within the larger forest (Table 2 and Figure 2) are important for understanding the community use and management of these forests. Note the border of Peru in the upper left corner for reference. In some cases the 'user-group' includes members from both Puina and Keara (Table 2 and Figure 3). The distance between forests and community 'user-groups' is significant. Note the closer proximity of forests to the community center of Keara, facilitating the collection of fuelwood.

Table 2: Forest area, patch number and geographic information for the *Polylepis pepei* forests included in this study.

#	Forest Name	Community / user group	Area (Ha)	# patches	Elevational range	Average elevation
1	Queñuapata	Puina	16.4	6	4111-4500	4305
2	Lampayani	Keara - Puina	10.0	2	4062-4261	4161
3	Kalachaka	Puina	4.8	3	4184-4276	4229
4	Quecara Chica	Keara - Puina	10.8	5	4171-4366	4269
5	Chuñuna	Keara	4.8	3	4045-4300	4172
6	Queñuani	Puina	11.5	7	4003-4304	4153
7	Supaycocha	Keara	9.4	4	4017-4333	4175
8	Tolocacocha	Keara	3.4	3	4018-4260	4139

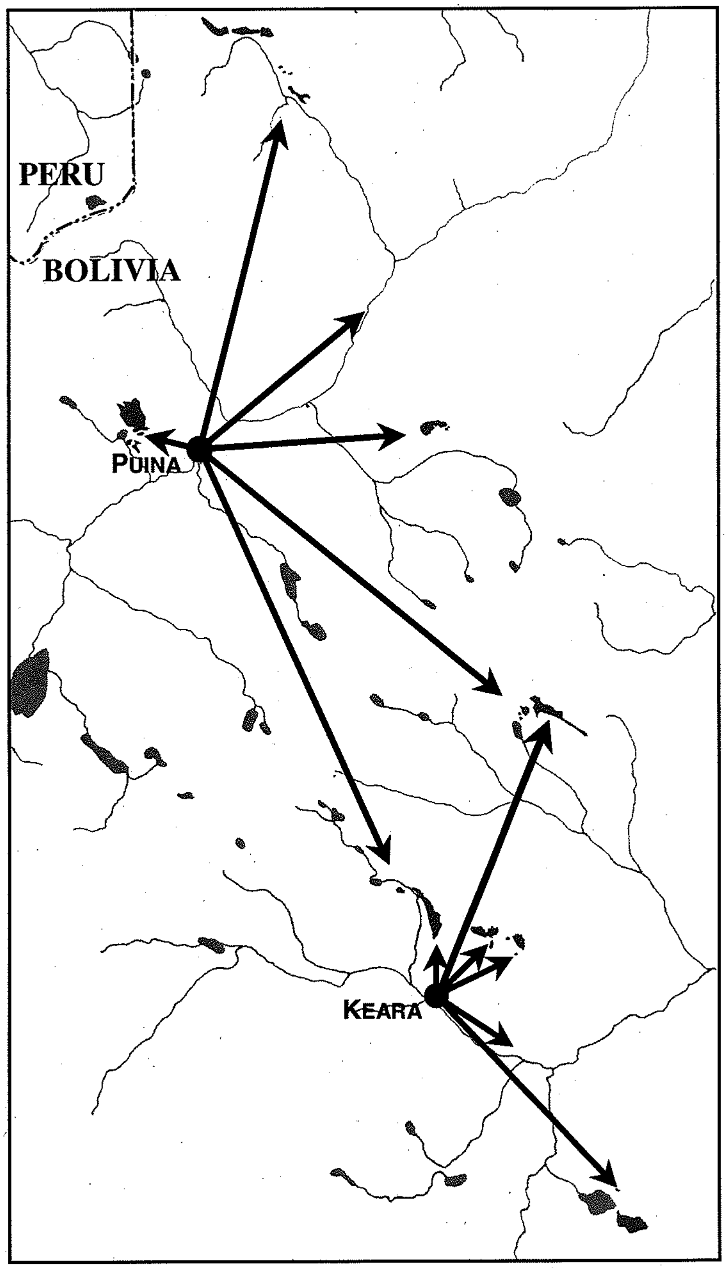
(Latitude / Longitude coordinates in Appendix E)

Figure 2: Location and names of the eight forests of *P. pepei* surveyed in the valleys of Puina and Keara.



(Adapted from topographic map with scale 1:100 000, Pelechuco, IGM 1997)

Figure 3: User groups of *P. pepei* and other forest locations.



(Adapted from topographic map with scale 1:100 000, Pelechuco, IGM 1997)

STUDY QUESTIONS

My specific research objectives grew out of the need to provide information to communities, NGOs, researchers and management institutions working on *Polylepis* woodlands. The questions themselves reflect a need for both a qualitative and quantitative approach.

1) Where are *Polylepis* forests distributed throughout the valleys of Puina and Keara in the Apolobamba mountains of Bolivia?
2) What kinds of disturbances are evident in these *Polylepis* forests, and which forests are most damaged? Least damaged? Are there patterns of disturbance related to human activities and settlements or geographic locations?
3) What are the perceived cultural and ecological relationships between local communities and the natural environment, specifically *Polylepis* forests? Have these relationships changed over time?

FOREST IDENTIFICATION AND MAPPING

To determine the distribution pattern of *Polylepis* spp. forests in the valleys of Puina and Keara in the Apolobamba mountains, several field trips were conducted. Considering the difficulty of identifying *Polylepis* forests from aerial photos and satellite images, fieldwork was essential in locating and identifying *Polylepis* forest patches. Patches are small (sometimes less than one hectare) and therefore difficult to recognize on images. Although some of these patches are visible in aerial photos of 1; 60,000 most of them are not. The rugged terrain and the southern aspect of these forests create shadows in existing photos that make positive identification of these patches difficult, and in some cases, impossible.

Informal and exploratory interviews with community members in the towns of Pelechuco, Puina and Keara allowed us to direct our attention to certain forests of particular interest. In many cases, local guides were contracted to guide us to the forest. We then mapped the forests by walking the perimeter of forest patches and marking GPS coordinates (Appendix E). Geographic coordinates combined with topographic maps, aerial photography, and LANDSAT satellite imagery provides a fairly accurate representation of the spatial distribution of these forests in the Cordillera Apolobamba. General information for each forest was also gathered: elevation range, slope, aspect, area, distance to nearest community, difficulty of trail, location to other anthropogenic and natural features (watercourses, trails, communities, houses, etc) (see Appendix C and D). Extensive photos were taken of the forest patch to aid in mapping those areas difficult to access and to document those distinct features located in the patch (Appendix A). This information was then compiled into a general mapping program, Google-Earth Plus.

ECOLOGICAL

Forest Stand Analysis

Along with the general spatial characteristics mentioned earlier, I conducted a forest structure analysis, which assessed the type and amount of vegetation within the *Polylepis* forest patches. To accomplish this analysis, two randomly chosen plots of 100

m^2 were sampled in each of the eight forests. Given the nature of these forests, certain areas inaccessible by foot were avoided and not included in the sampling.

The $100m^2$ circular plots were then divided into four quadrants (NE, SE, SW, and NW). General cover estimates (vegetation types, woody plants, rocks and bare soil), damage indicators (number of 'cow pies', cut stumps, anthropogenic features), and a general description were completed for each quadrant. More detailed measurements were made of woody plants, including average diameter at breast height (DBH) of all trees (defined as stems >2.5in DBH), number of seedlings / saplings (stems <2.5in DBH), and the percentage of canopy cover of each species (Appendix F).

Using these baseline ecological data, further calculations were made after the initial site visit. Basal area and relative dominance of various tree species were then estimated from the gathered data. I then used these data to describe the general characteristics or a particular plot and to estimate the overall health of the forest, as well as the apparent impacts of local pressures on patch regeneration (see Appendix I).

Disturbance index

To measure the damage associated with various disturbance factors, I developed a simple 'disturbance index' that assigns a value from 0-3 for each of the three factors of fire, grazing, and fuelwood cutting;

0 = no disturbance
1 = slight disturbance
2 = moderate disturbance
3 = severe disturbance

This creates a scale ranging from zero (no disturbance) to 9 (severe disturbance) associated with all three factors, grazing, fire and fuelwood collection. It should be noted that the 'index' is an estimate of the disturbance within that particular 100 m^2 plot; sampling of two patches in each forest was an attempt to estimate the damage over the entire forest.

Grazing and browsing damage was determined by estimating numerous factors including: roughness of terrain and presence or absence of boulders that might trip thwart grazing; the presence or absence of cattle, llama or other animal scat; game or livestock trails and transportation routes; evidence of bud browsing and heavily pruned re-growth; height of seedlings and shape of saplings.

Cutting damage was determined by examining the following: the location of transportation routes; counting the number of cut stumps; the location of fuel wood preparation areas; and the presence or absence of fuel wood drying and storage piles.

Fire damage was determined by looking for evidence of recent or past burns on the stem, leaves, bark of *Polylepis,* as well as evidence of burning of grass or other flora in the forest. Confirmation of recent burns by our local guides and community members and other clues allow estimates of the frequency and extent of recent fires and changes of vegetation due to fire (high percentage of grass).

These scores were then summed to establish a total 'disturbance index' for each individual 100m^2 plot. This damage index provided a method for comparing the differences between plots and forests in relation to distance to communities, aspect, and forest health data collected for the forest stand analysis (DGH size, regeneration of seedlings, canopy cover, etc.).

CULTURAL AND SOCIAL ASSESSMENT OF *POLYLEPIS*

Informal and semi-structured interviews, participatory mapping, and participant observations were all used to examine the social and economic importance of *Polylepis* forests to individuals in the communities of Puina and Keara. The methods sought to elicit individual perceptions of environmental and social changes in the region, specifically regarding individual and family use of *Polylepis* forests in the community and how they might differ between individuals (farmer, rancher, shop owner, housewife, hunter and national park service employees) and between communities (Keara vs. Puina). This type of cross-referencing allowed me to see similarities between the ecological 'realities' and social perceptions of *Polylepis* woodland conservation in the area.

To guide me in this qualitative research, I utilized the texts by Bruce Berg (2001) and Jennifer Mason (1996) as well as other participatory techniques employed in rural areas in Latin America (Tillmann and Salas 1994).

Workshops and Participatory Mapping

Community workshops with residents of Puina (September 12 and November 2, 2004) and Keara (September 23, 2004), provided invaluable information on the forest locations and community perceptions of conservation and management of these areas. Workshops were completed with the older students (ages 12-17) of Puina and Keara from and also with a larger gathering of adults in the community of Puina. These workshops sought to gather information on the location, health and perceived changes in forest ecosystems as well as explain to community members the purpose of our visit and develop a working relationship with them. Participants mapped out areas important to community growth and development and identified ecosystem changes (both productive and destructive). Participants were also asked to map historical changes within the community related to agriculture, forests and grazing lands. They worked in small groups and then shared this information with the rest of the community. These workshops were also invaluable tools to understand localized names for places, plants and animals present in the surrounding forests, especially avifauna.

Semi-structured interviews

Interviews were taped on a hand-held magnetic tape recorder using 45-minute tapes; all interviewees responded in Spanish. A typical interview was 30 minutes long and was conducted informally, sometimes in small groups of people or as a family where mother, father and children were present. The dates of interviews span from September 10th to November 10th, 2004 with two separate trips to the field site, each trip being four weeks long. The tapes were then transcribed, recording the interview questions and answers. For those parts of conversations that were incoherent or repetitive, the conversation was briefly noted as not audible or repetitive and then omitted from the transcription. Twenty-three interviews were conducted in three different communities: sixteen members from Puina, five from Keara and two from Pelechuco participated. All interviewees were between the ages of nineteen and sixty-five. With the exception of one young miner from Peru and a man from Puina, all interviewees had at least one child, with the maximum being seven. Only two Quechua women were interviewed who spoke limited Spanish, both from the community of Puina. Although under represented in this study, women accompanied their husbands and sometimes provided their own answers to the interview questions. In over half of the interviews with men, the interviewee consulted with his wife in Quechua before answering some of the questions in Spanish. The language and social customs of the area would have make it uncomfortable and inappropriate for me to interview a single or married woman in their home without prior consultation with the entire family.

When conducting the interviews, I encouraged individuals to openly share their experiences and knowledge (see Appendix B1 for English and B2 for Spanish). In many cases the interview evolved and changed according to the interests of the individual or individuals present in the room. Participants for the interviews were selected because of their availability at the time of the interviews. Although many of the men of Puina and Keara work in the mine and were not readily available to interview, there were a few days many of them came back. I then consolidated the transcription of the interviews and indexed them according to their subject matter. Community perceptions of *Polylepis* forests, their conservation and regeneration guide this research. Many of the interview questions asked specifically about the qualities and characteristics of *Polylepis* trees and how they might be utilized and consumed, how they reproduce and where they might grow.

The following general categories were used:

***Polylepis* trees**
Fuel wood and other fuels
Forest history and location
Community and family history
Mining
National protected area
Land tenure
Climate change
Medicinal plants
Animals (domesticated and wild)
Agriculture

When analyzing the interviews, I looked for patterns of consistency and opposition within each of the categories and between the two communities of Puina and Keara. I also sought to compare my own interpretations with the answers provided by these interviews. Responses to the interviews varied from individual to individual, depending on their experiences and knowledge on the subject. Answers specific to *Polylepis* forests were gathered in all interviews and provided a solid foundation from which I could make inferences into the conservation of these forests in the region.

RESULTS: ECOLOGICAL 'REALITIES' OF *POLYLEPIS* FORESTS

DISTRIBUTION OF *POLYLEPIS* SPECIES

Following are the physical characteristics, habitat preferences and uses of all three *Polylepis* species mentioned by community members in Puina and Keara: *Polylepis racemosa, Polylepis pepei* and *Polylepis sericea* (Figure 4). For more information on the morphological traits and distribution of these species, they are described by Simpson (1986, 1979) and Fjeldså and Kessler (1996).

Polylepis racemosa (in figure 4a), also considered a 'domesticated' *queñua*, is found around stone fences and fields close to houses in Puina and Keara. *P. racemosa* is said to originate in Pelechuco and then transported and transplanted in Puina and Keara as seedlings or cuttings. The elevation of *P. racemosa* ranges from 3500 – 4200 in these valleys, which coincides with the community centers. The branches, or *ch'umi,* provide fuel for cooking and fodder for animals close to the principal residence.

Polylepis pepei (in figure 4b), called *queñua,* is found in small forest patches on steep southern facing slopes in the valleys of Puina and Keara. Elevational range is from 4000 - 4500 meters. This species is harvested for fuelwood, construction, and tools. The smaller darker leaves, lighter colored and better quality wood (for burning), flaky red bark distinguish it from the closely related *Polylepis sericea.* It also grows high up in the ravines and valleys in and among boulder slopes and talus fields.

Polylepis sericea (in figure 4c), also called *Lampaya*, is the "other" variety of wild *queñua*, found in mixed forests at the *ceja de monte* or beginning of the *yungas* forest. It is quite "rare" and only found sporadically at elevations around 3500 meters. *P.*

sericea is used for fuelwood on occasion but it is said to stay wet because of thicker bark. It grows faster and taller than *P. pepei* and the leaves are larger, with white or silver, "hoja plateada" and rose-colored wood.

Figure 4: Three species of *Polylepis* in the valleys of Pelechuco, Puina and Keara. a) *P. racemosa*; b) *P. pepei*; c) *P. sericea*:

Aspect of *Polylepis pepei* Forests

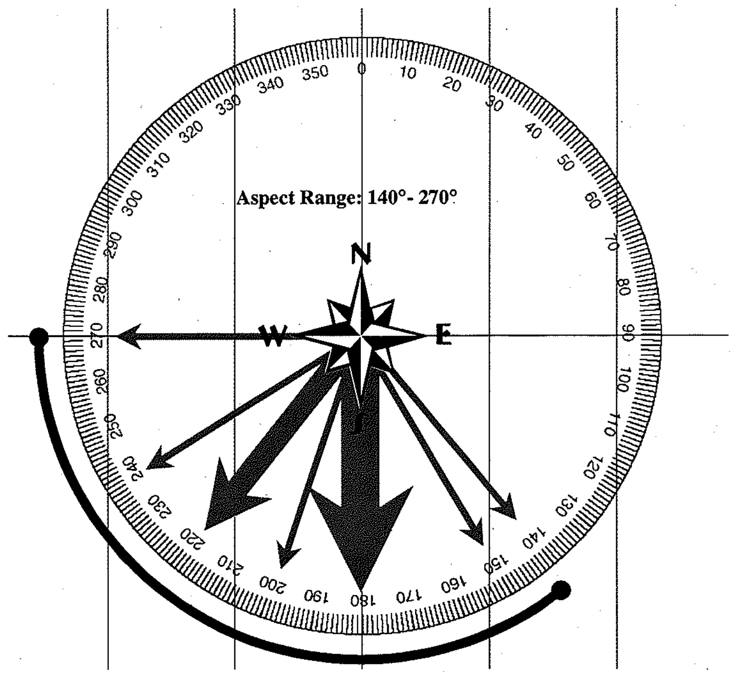
Polylepis pepei forests in the region typically occur on southwest facing slopes (Figures 5a and 5b) that provide cooler, more humid environments. The morning sun typically arrives late, after 10am, blocked by the vertical mass of rock and earth surrounding the forests. Of the sixteen forest plots examined in this study, eight faced due south (180 degrees). The aspects of all forest plots ranged from 140 to 270 degrees.

Kessler (2002, 1995) and Hensen (1993) document this characteristic in other species of *Polylepis* in Cochabamba and Peru. This preference might also indicate sensitivity to high solar radiation, restricting the regeneration of these forests on the northern slopes (Kessler 2002). North facing slopes are also likely to be hotter and (especially) drier in certain seasons; restricting regeneration, survival and growth of seedlings and saplings. Studies of *Polylepis tarapacana* on the dry, western Andes suggest the opposite. They prefer northern facing slopes (Jordan 1983), indicating that temperature rather than moisture might be the limiting environmental factor restricting further expansion of the species (Kessler 2002).

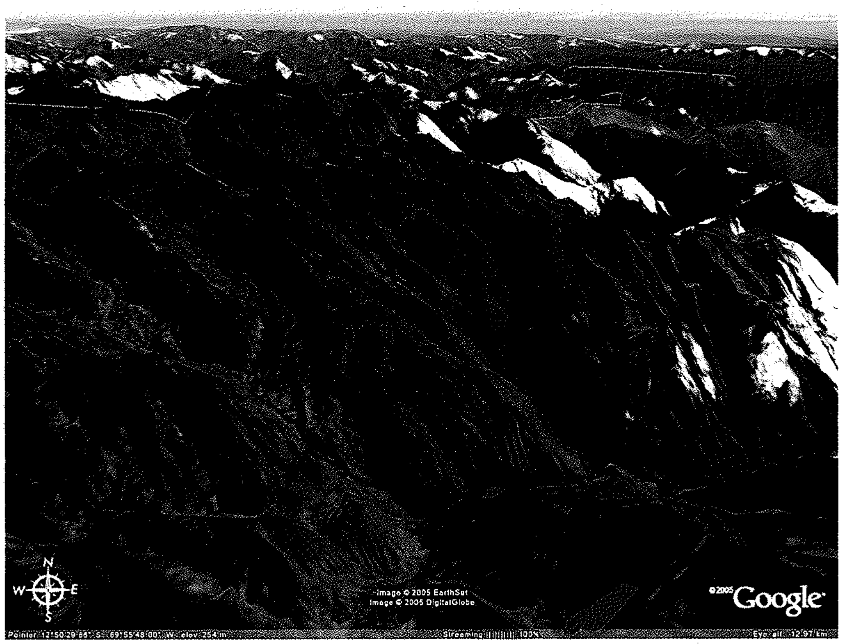
Figure 5: *Polylepis pepei* aspect in Apolobamba.

(a) Southern exposure between 140 and 270 degrees with the majority of the forest plots with aspect of 180 or due south. A smaller concentration is at 220 degrees. The view (b) shows the southern face of the forests, all visible looking from due south.

a)



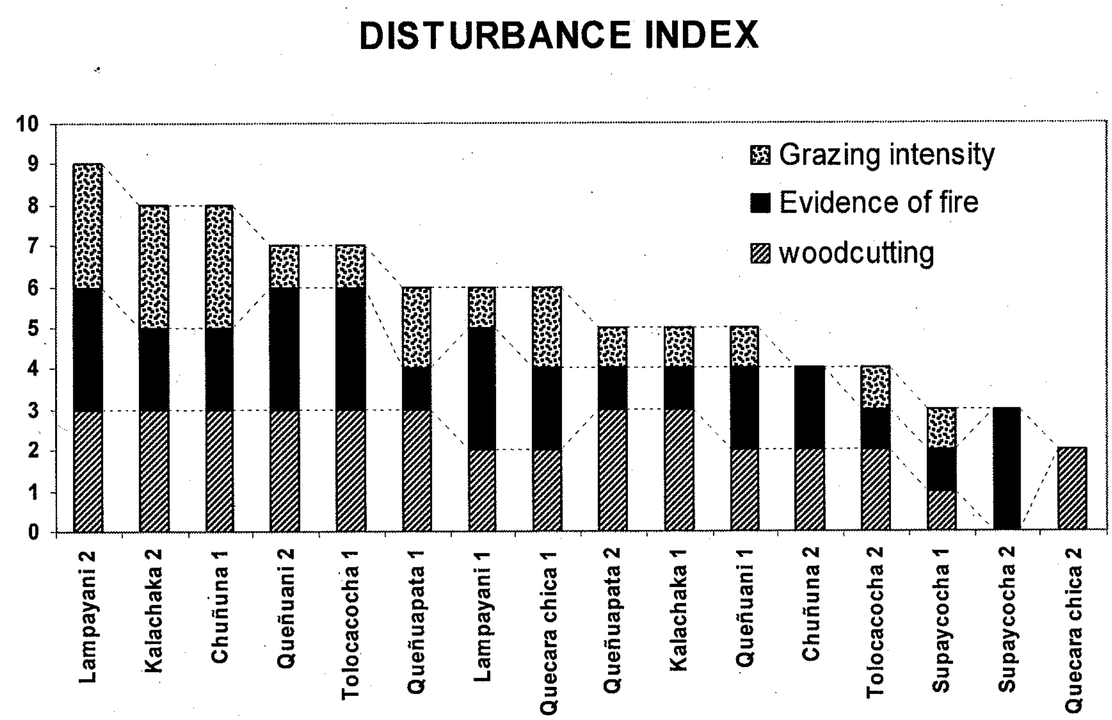
b)



DISTURBANCE OF *POLYLEPIS PEPEI* FORESTS

It is understandable that differences exist regarding the interpretations of disturbance to *Polylepis* forests as viewed by the biologist/ecologist as compared to the Quechua farmer. Farmers, ranchers, storeowners, authorities, and landowners will all have their own personal views as to what constitutes their 'reality' and what constitutes 'damage' or disturbance. To establish a standard for disturbance, I developed a disturbance index (Figure 6) that compares the damage observed between individual plots among the eight forests examined in this study. This index indicates considerable variation of disturbance due to fuelwood cutting, grazing and fire.

Figure 6: Observed grazing, fire and cutting disturbances for each plot



The index is a qualitative 'rating' of observable disturbances based on personal observations and some quantitative measurements in the case of cutting and grazing (Table 3). The index provides a basis for understanding why some forests may experience more or less damage from one or more agents. Some forest plots exhibit significant disturbance from all three agents (e.g. Lampayani 2). Lampayani forest also happens to be the forest nearest the community of Keara and within a 15 minute walk of some residences. Other forests exhibit strong disturbance by only one agent, as in the case of woodcutting in Quecara Chica 2 and fire in Supaycocha 2. These forests also happen to be forests further from the community centers of Puina and Keara. Disturbance by only one agent is atypical, while most forest plots are affected by a combination of all three agents (Table 3).

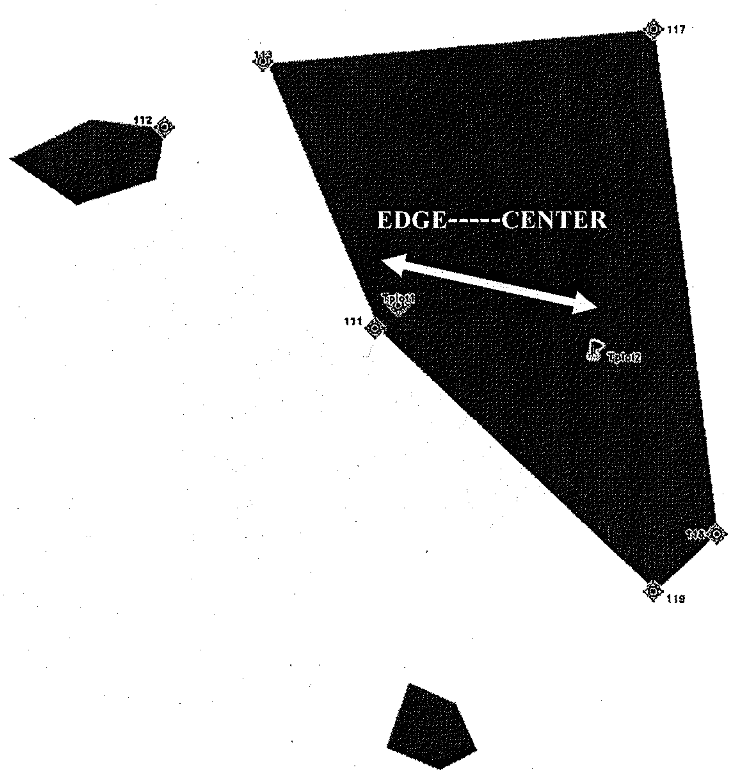
A combination of quantitative and qualitative indicators was used to establish the disturbance index for each type of disturbance (cutting, grazing, fire). Quantitative indicators include the numbers of cut stems, the proportion of stumps to stems, and coppicing (seedlings and saplings <6cm), number of cow pies. Qualitative indicators were also taken into consideration when determining the levels of disturbance on a particular plot (Table 3).

Table 3: Qualitative and quantitative measurements of disturbance within plots.

	CUTTING												GRAZING								FIRE					
Forest plot	woodcutting	Total # cut stumps	Ratio of stumps to stems	≥20 *Polylepis pepei* seedlings	≥ 60% of stems ≤ 6 cm DGH	Recent cutting activity	Old cutting activity	human / animal trails present	Absence of large boulders	Absence of dead stands	< 20 degree slope	Located at edge of forest	Grazing intensity	Total # cow pies	Browsing damage present	< 20 *Polylepis pepei* seedlings	human / animal trails present	Absence of large boulders	< 20 degree slope	Located at edge of forest	Evidence of fire	Recently burned vegetation	*Gynoxis* sp. NOT present	Absence of large boulders	Absence of dead stands	Located at edge of forest
Queñuapata 1	3	17	0.33	X	X		X	X	X	X	X		2	4	X		X	X	X		1		X	X	X	
Queñuapata 2	3	37	0.55	X	X		X		X	X			1	3	X			X			1		X	X	X	
Lampayani 1	2	10	0.83			X		X		X	X		1	0	X	X	X		X		3				X	
Lampayani 2	3	6	0.46			X	X	X	X	X	X		3	5	X	X	X	X	X		3	X	X	X	X	
Kalachaka 1	3	10	0.45	X	X	X		X		X		X	1	0	X		X			X	1		X		X	X
Kalachaka 2	3	24	0.39	X	X				X	X		X	3	9	X			X		X	2		X	X	X	X
Quecara chica 1	2	12	0.43		X	X		X	X	X	X		2	5	X	X	X	X	X		2	X		X	X	
Quecara chica 2	2	13	0.46							X		X	0	0		X				X	0				X	X
Chuñuna 1	3	7	0.70			X	X	X	X	X	X		3	26	X	X	X	X	X		2			X	X	
Chuñuna 2	2	3	0.20	X	X		X			X	X		0	0					X		2		X		X	
Queñuani 1	2	7	0.10	X	X		X			X	X		1	0	X				X		2	X			X	
Queñuani 2	3	66	2.00	X				X	X	X	X	X	1	0	X		X	X	X	X	3	X		X	X	X
Supaycocha 1	1	4	0.20	X	X		X			X	X	X	1	0					X	X	1				X	X
Supaycocha 2	0	0	0.00	X	X		X				X	X	0	0					X	X	3	X				X
Tolocacocha 1	3	24	1.85			X		X		X		X	1	0		X	X			X	3	X			X	X
Tolocacocha 2	2	13	0.52	X									1	0							1					

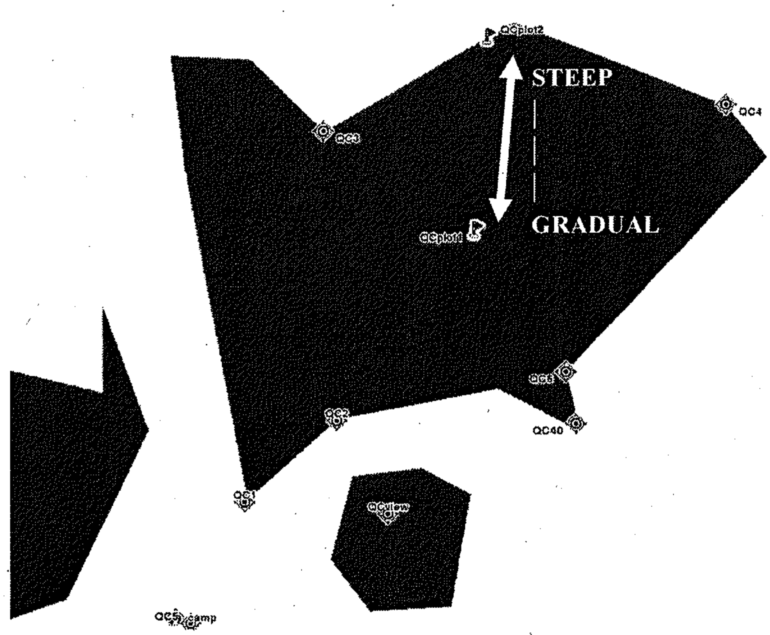
The location of the plot within the forest patch seems to be a significant factor when considering potential disturbances within a forest, as plots near the edge of a forest patch will exhibit a higher damage index than forest deep within the patch. This obvious conclusion is demonstrated by the differences expressed in the 'disturbance index' of the forest of Tolocacocha; the center plot has a disturbance ranking of four while the edge plot has a disturbance of seven (Figure 7).

Figure 7: Map of the forest of Tolocacocha showing the variation of disturbance between the forest edge and the forest center.



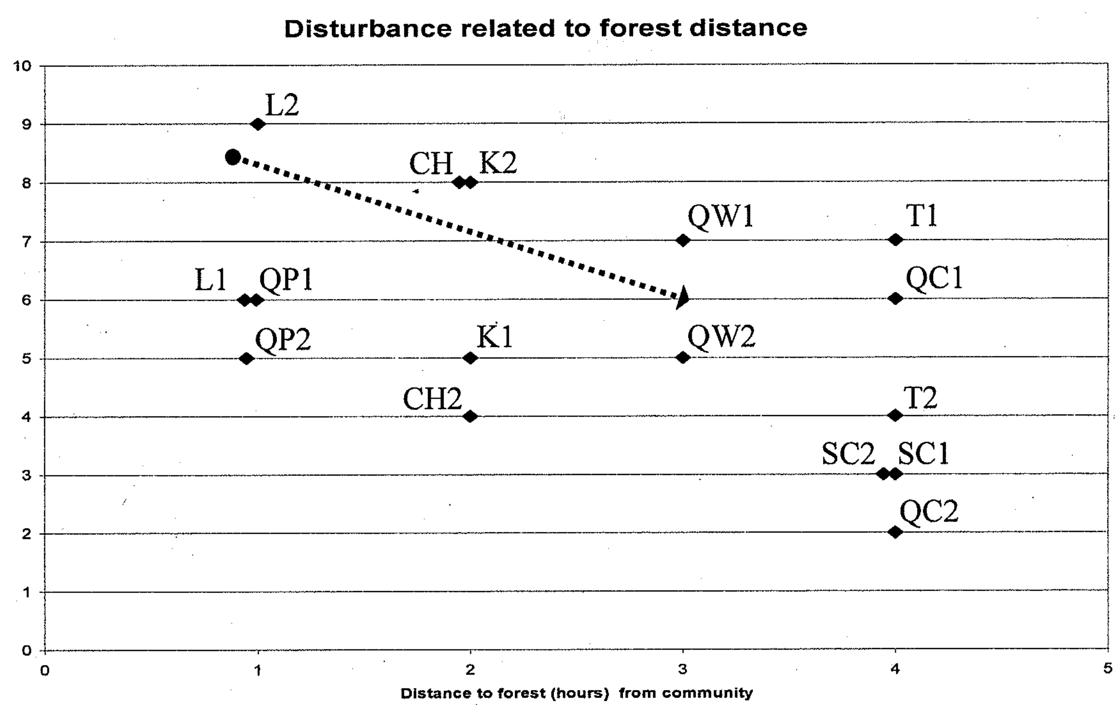
Areas difficult to access with steep slopes also protect forest patches from potential disturbances. A comparison between slopes in the forest of Quecara Chica provides some evidence to support this claim (Figure 8). Plot 1 (QCplot1), with a gradual slope of 10 degrees is more disturbed than plot 2 (QCplot2) with a slope of 27 degrees located near a vertical cliff with difficult access. The difference between the two plots (six and two respectively) suggest that access and slope might also affect the level of disturbance related to the factors of fire, grazing and cutting.

Figure 8: Map of Quecara Chica forest indicating the variation of disturbance related to access and slope of the terrain (steep-gradual).



In addition to the heterogeneity of disturbance within each forest patch, forests close to communities appear to exhibit more pronounced patterns of disturbance. For example Lampayani, a half-hour walk from the center of Keara and located on a major route between the communities of Puina and Keara, has a high disturbance index (6 and 9) for both plots (Figure 6). This pattern also holds true for the relatively close forests of (L), Chuñuna (CH) and Kalachaka (K). Forests far from community centers show fewer disturbances; this is especially noticeable in Supaycocha (SC) and Quecara Chica (QC)(see Figure 9). Figures 10-12 examine distance related to the disturbance type.

Figure 9: The relationship between forest disturbance and distance to community.



Grazing and browsing disturbance

Grazing disturbance especially shows a positive correlation to proximity to community centers (Figure 10). Forests close to communities tend to have high grazing damage, a finding consistent with Fjeldså and Kessler (1996) who concluded that grazing combined with fire is the major factor limiting *Polylepis* regeneration in the highland Andes. The forests at Lampayani, Chuñuna and Kalachaca are all within two hours walk of either Puina or Keara, and are also located in valleys that are easily accessible to grazing along wide grassy approaches. The wide Lampayani valley is ideal for grazing and the proximity of the forest to both these communities appears to permits more intensive use by both user groups. In Puina and Keara, most pastures within close proximity to community centers operate as common property, and on any given day numerous flocks of llamas or alpacas will frequent a valley, exploiting common pool resources such as *Polylepis* forests.

On the other hand, the forest of Supaycocha, four hours walk from the community of Keara on a little traveled route to the *Yana Orqo*, or "Black Mountain", mine shows relatively little damage. The distance from Keara and the difficulty in transporting wood from this forest apparently has deterred extensive wood collection and grazing in the plots, although past cutting and burning is evident (Table 3, Figure 9). A similar pattern exists for Quecara Chica, a forest less visited probably because it is not located within close proximity to a village or on a major trade/transportation route.

Queñuapata in Puina is somewhat of an anomaly and deserves further exploration because the 'disturbance index' score does not seem to accurately represent the observed high levels of disturbance. The forest appears stunted, in part due to heavy browsing and burning. Cattle were seen browsing on *P. pepei* branches while their hooves kicked up loose ash, the result of a recent burn. *Polylepis* trees rarely reached a height above 3 meters, an average well below most other forests (see Appendix I for averages). Although the forest appeared to be the most disturbed of all the forests upon surveying the forest in it's entirety, it was also the largest of all the forests with an approximate size of 16 hectares (see Table 2 for forest size). This could be explained by the location of the plots within the center of the patch with somewhat high slopes (15 and 30 degrees) that might in turn receive fewer disturbances than a plot along the edge of the forest.

Areas where grazing pressures are severe might also be reflected in the diameter distributions (DGH) of stems and seedlings in each of the forest patches. One could argue that if grazing damage were extreme in a particular plot, the smaller seedlings and saplings would most likely suffer a loss, which would then be under represented when looking at the diameter distributions of each plot. Some forest plots (Lampayani 2 and Chuñuna 1) within Keara exhibit this pattern of DGH distribution (Figure 14). At first glance, the diameter distributions seem much more random, varying between plots and between forest patches. It also appears that some plots are more affected than others, creating a heterogeneic patchwork of disturbance within the forest patch. Three of the forest patches have poor regeneration with < 10 seedlings per plot. It is obvious that the feeble growth of seedlings would eventually lead to the decimation of the forest. Without seedling regeneration, the forest is unhealthy and unsustainable.

Cutting disturbance

Fuel wood cutting disturbance is high in many of the forests, apparently higher in relation to community proximity (see Figure 11). In some plots woodpiles, recently cut trees, or a significant amount of wood chips, indicated fuelwood staging areas and the presence of human actors on the environment. All fuelwood cutting is done manually with machetes; the evidence on stumps is clearly marked. Cutting disturbance also seems to be more severe near major trails and trade routes. Certain families tend to prefer to cut in certain forests because of proximity to their own 'inherited' pastures. Larger trees are preferred, making woodcutting a more economical activity may also led to exploitation of all forests. Of the plots studied in the more distant forests of Tolocacocha, Supaycocha and Quecarqa Chica, only one plot located on the edge of Tolocacocha exhibited high cutting damage (Figure 11).

Given that community members prefer to cut larger trees for fuelwood, the presence of numerous larger trees in a forest might indicates less fuelwood cutting damage. If the forest is healthy and regenerating, a significant number of seedlings should also be present within the plot. If cutting is high, the larger trees would logically would be missing because of their preferred use as fuelwood.

In the forest plots close to Puina (Queñuapata and Kalachaka) the lack of larger diameter trees indicates higher fuelwood disturbance on these forests (Figure 13). Diameters over 10 cm are significantly under represented in Puina forests, the exception being Queñuani. Also, the rates of regeneration appear high in all plots, as represented by the presence of >20 seedlings in all plots. The high proportion of seedlings and saplings less than 6 cm suggests that both plots have a high regeneration rate, possibly from intentional coppicing and fuelwood collection.

The two plots in the forest of Quecara Chica exhibit moderate amounts of disturbance due to cutting (Figure 9), but exhibit little evidence of other disturbances. Both forest plots (Figure 14) exhibit more or less the same amount of seedling regeneration (10 and 11) and both contain modest numbers of trees > 10 cm DGH. These plots could possibly represent a 'normal' diameter distribution from a forest without any anthropogenic disturbances.

The forest of Queñuani (Figure 13e, 13f) also deserves some further explanation due to the observable differences in disturbance indices between the two plots. Fuelwood cutting damage within the two plots demonstrate stark differences in total number of cut stumps and also the number of cut stumps to trees. Both plots have very high stem counts, sixty- nine for Queñuani 1 and thirty-three for Queñuani 2. The low stump to stem ratio of Queñuani 1 (.10) compared to Queñuani (2.0) suggests that very little cutting has occurred in the first site, although old burning and cutting scars are evidence of past disturbances. High stem counts are most likely a response to past damages that have since decreased in intensity. This pulse of growth is notable in the histograms of both the plots, indicating a surge of regrowth that may have happened over 10 years ago.

Burning disturbance

Burning the grasslands is common practice and does not seem to positively correlate with proximity to community centers (Figure 12). The evidence of burns is found in grasslands and forests alike, leaving scars on rocks and trunks. Recent burns within the last few years are easily discernable with the presence of burned grasses and scorched bark on *Polylepis* and *Gynoxys* stems. Older burns are difficult to calculate in age and extent. In some forests, old burns were evident on large trunks up to 2-3 meters tall. Fire scars on the trunk sometimes create many growth irregularities evident when viewing the cross section of a stem. Almost all forests exhibited some form of fire disturbance, whether older or newer. Only the wetter, larger or denser forest patches like Tolocacocha and Supaycocha exhibited little or no burning evidence on the trunks of trees. The location of the plot within the forest has much to do about the presence of burns; edge plots being more susceptible to burns than center plots. The rough ground and boulders also seem to protect the trees from frequent burns. Burning (*el chaqueo*) is usually done at the onset of the dry season to promote the new growth of bunchgrass (*Stipa ichu*). Winter solstice in the summer hemisphere occurs on June 24th, the day of San Juan, or the "burning of grasslands" around the forests.

The effects of burning on the regeneration and diameter distribution sizes of stems within the plot seem less evident than either cutting or grazing. Assuming that large trees will be more resistant to burns than seedlings, a plot with frequent burns would have a disproportionate amount of large diameter stems. The elimination of small diameter stems and seedlings by the fire would create a diameter distribution similar to that of high grazing. It is still unclear how fire might affect seedling regeneration after fire disturbances.

Figure 10: Grazing disturbance related to forest distance

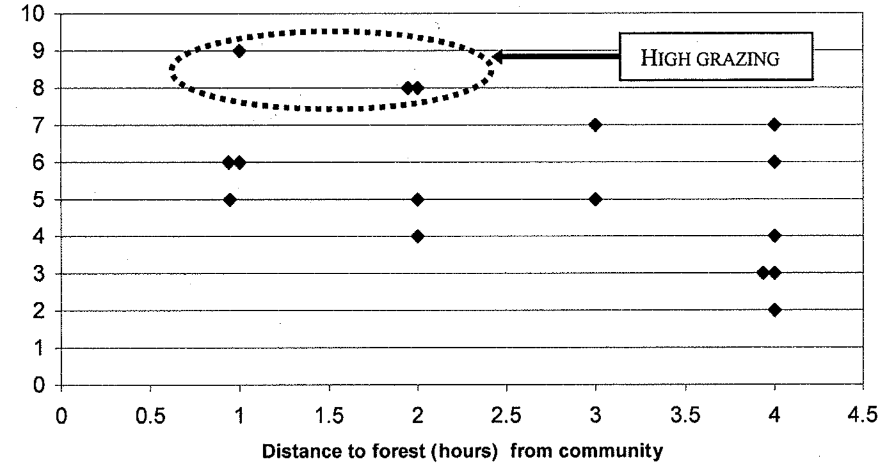


Figure11: Cutting disturbance related to forest distance

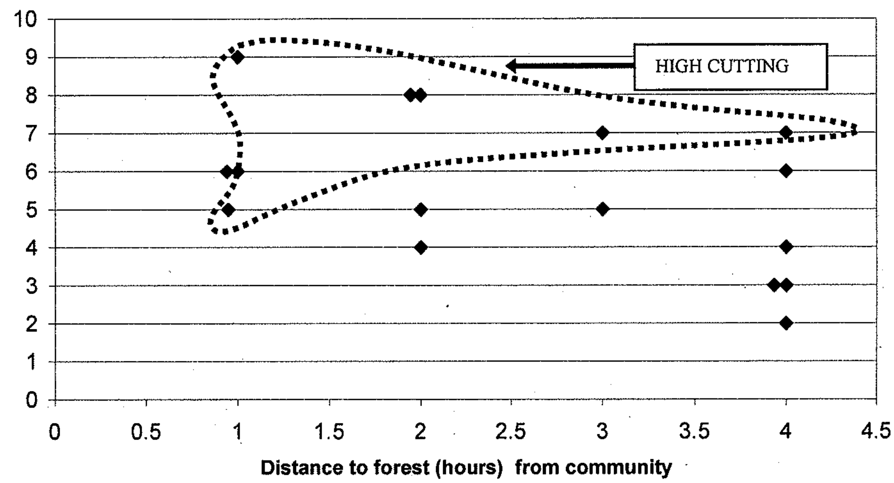
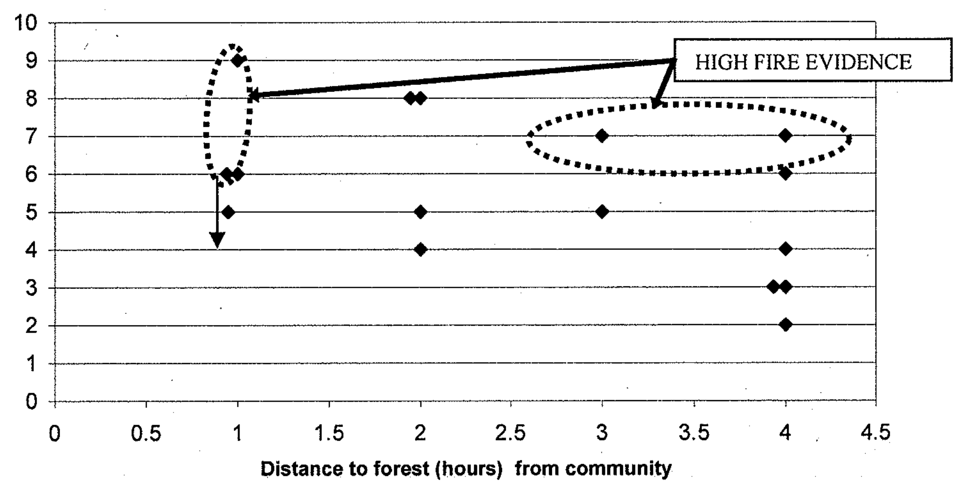


Figure 12: Fire disturbance related to forest distance



DIAMETER OF *POLYLEPIS / GYNOXYS* FORESTS

A comparison of diameters of stems and seedling regeneration (both *Polylepis* and *Gynoxys* species) allows us to make further conclusions about the health of these forest plots and the frequency of grazing, cutting and fire disturbances affecting these plots in both communities of Puina and Keara (refer to Figures13, 14 and 15).

Figure 13: DGH / Seedlings of Puina forest plots, a) and b)Queñuapata; c) and d) Kalachaka; e) and f) Queñuani.

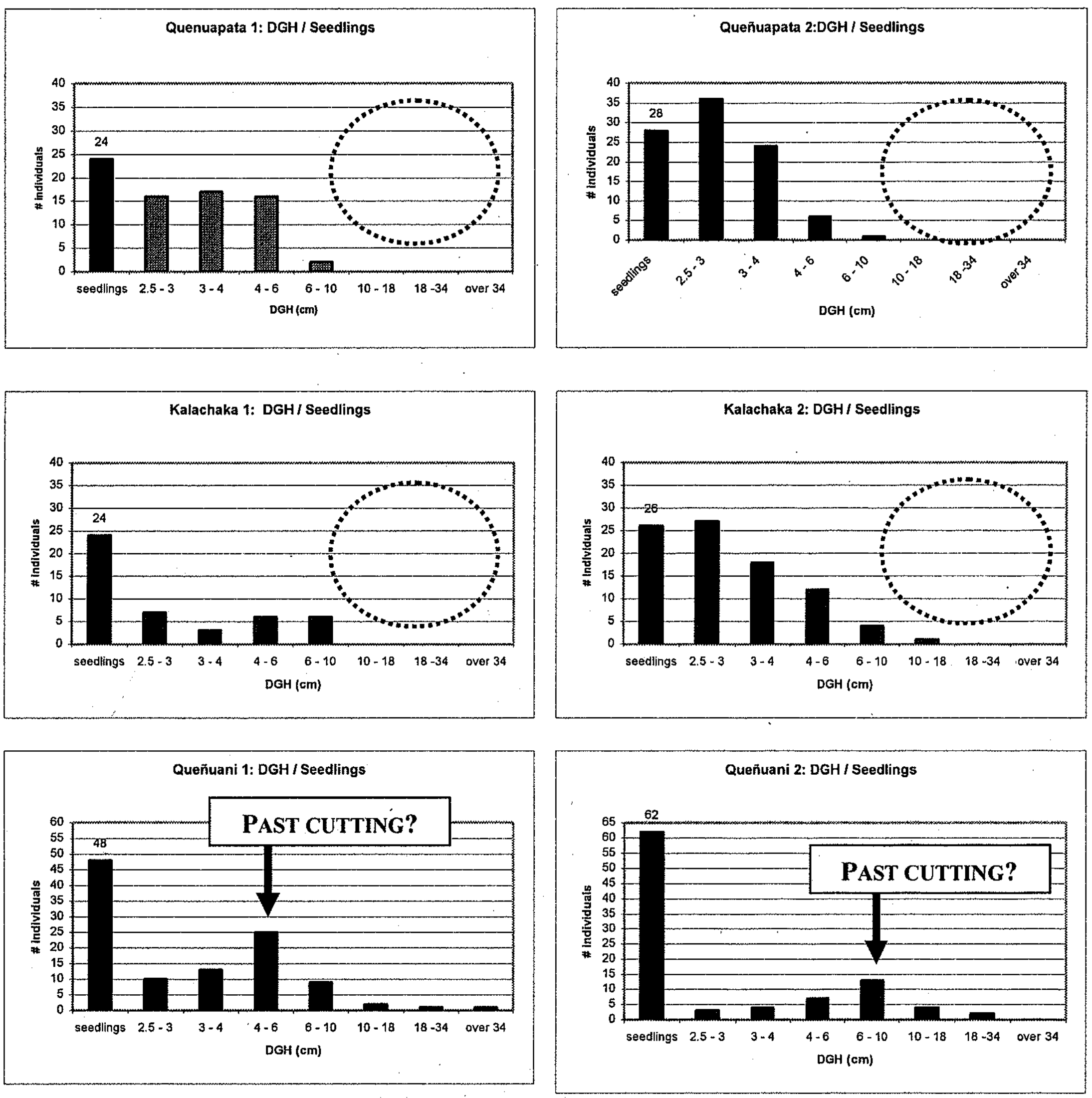


Figure 14: DGH / Seedlings of Keara forest plots; a) and b) Lampayani; c) and d) Chuñuna; e) and f) Tolocacocha; g) and h) Supaycocha.

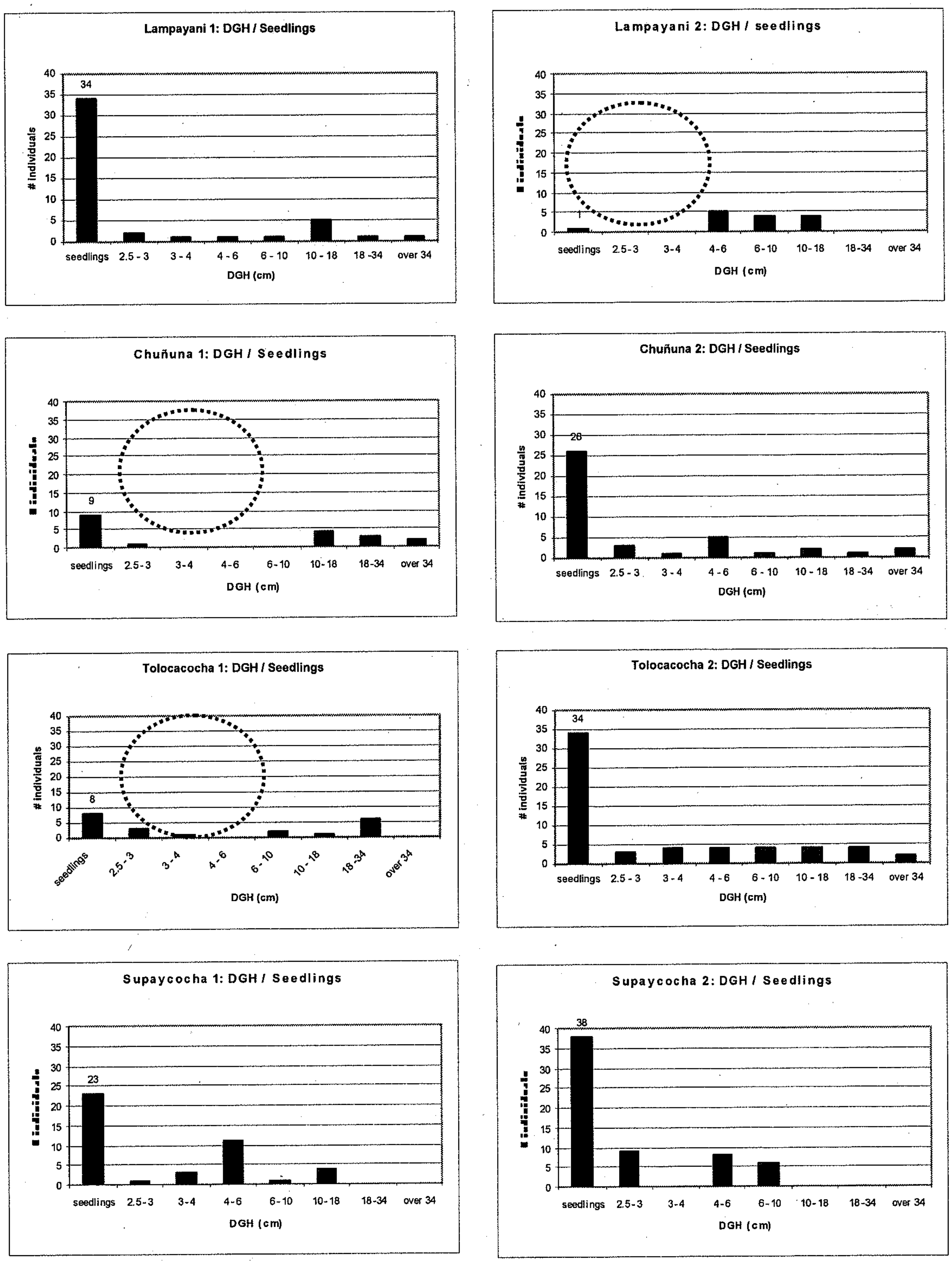
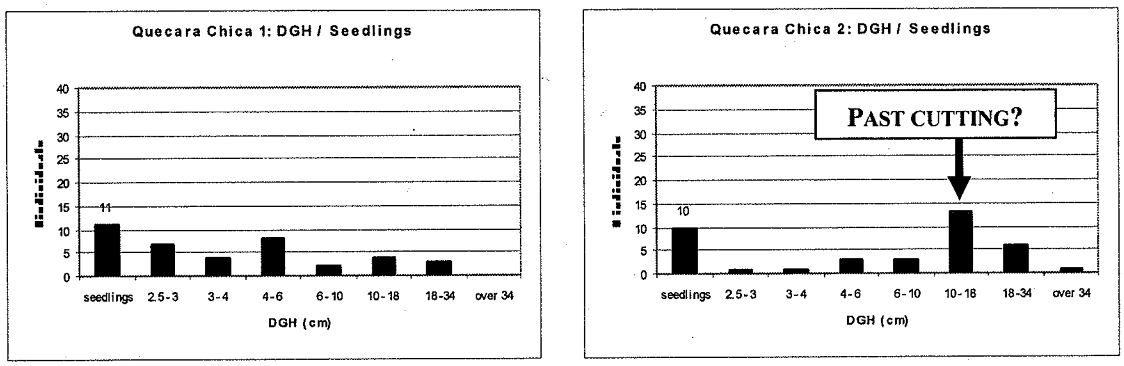


Figure 15: a) and b) DGH / Seedlings of Quecara Chica forest plots located between Puina and Keara.



The gaps in diameter classes might in fact represent events of high disturbances, like a fire or clearcutting a particular patch of forest. These gaps are noted with dotted circles on the diameter distributions for each forest patch. Conclusions made from these data indicate that the observable differences in disturbance between forest patches and plots are not easily explained by a few factors. Disturbance is a site-specific, the result of many geographic and anthropogenic variations on the landscape.

RESULTS: SOCIAL PERCEPTIONS OF ECOLOGICAL 'REALITIES'

Environmental processes must be seen as real, but that all knowledge about environment is constructed (Forsyth 1998, 112).

POLYLEPIS FORESTS IN APOLOBAMBA

Wild vs. 'domesticated' *Polylepis*

Interviews in the three communities of Puina, Keara, and Pelechuco identified at least three different species of *Polylepis* in the area, each with distinct characteristics and habitats (note that an additional "variety" was mentioned in Pelechuco but not investigated). Interviewees described the geographic locations and distribution of these species in the landscape, as well as the morphological 'characteristics' of these species. Subsequently these areas were visited and documented using GPS coordinates to 'ground-truth' the locations of these patches.

Over half of the interviewees mentioned the *queñua domesticado* or 'domesticated' species, *Polylepis racemosa,* together with its origin in Pelechuco. This species, found in both the communities of Puina and Keara, is also present in the communities of Aguas Blancas and Makara and planted along bordering fields overlooking the Pelechuco valley. According to Purcell (2004), this *P. racemosa* forest in Pelechuco is over 200 hectares. Eleven community members of Puina and Keara stated they have personally transplanted *P. racemosa* trees from Pelechuco and placed them as borders around their terraces and *canchas*. When asked about the larger, and obviously older trees, interviewees stated their parents or grandparents brought them years ago from Pelechuco.

The *silvestre* or 'wild' species of *Polylepis* include *queñua* (*P. pepei*) *and lampaya* (*P. sericea*). These two 'wild' species have been shown to be closely related genetically, "... the dwarfish *P. pepei* is the high-altitude offspring from *P. sericea*" that exhibits higher tolerances for cold (Fjeldså and Kessler 1996). *P. sericea*, although rare in Bolivia, is the most widely distributed species of *Polylepis* throughout the Andes (Simpson 1978, Kessler 1996) and has been documented as occurring by Fjeldså and Kessler (1996) in the valley of Pelechuco river.

Conversations with community members of Puina and Keara led me to investigate this 'rare' species that community members said, "there is hardly any (*casi no hay*)", or "there are only a few trees, no more (*quedan algunos arboles no mas*)". The rarity of this tree is attributed to past cutting but also to the invasion of other trees "from below" that "don't let it grow (*que no dejan crecer*)". With our guide Alejandro Noa, authority or *mallku* of Puina, we found *P. sericea* in Puinapampa located around 3300 meters elevation in mixed montane forests about 1.5 hour walk from Puina. This species was also mentioned in interviews in Keara but not investigated and sampled.

Other forests in the valleys of Pelechuco, Puina, Keara are also important sources of wood resources and fuel. In addition to the eight forests surveyed in this study, fifteen other forests were mentioned in one or more interview. I mention these other forests only to note the total area of forest cover is not limited to these eight forests. The total forest area in these valleys may in fact be much larger than what I have recorded. It also should be noted that communities are not limited to these *Polylepis* forests for fuelwood sources. The other forests include the montane forests at Quecara Grande (P,K), Narajani (P), Puinapampa (P), and Queñuapampa (K). Other high elevation *P. pepei* forests (not studied here) include Chillcani (P), Amallani (P), Chuluwayu (P), Sillu sillu (K), Pasto Grande (K), Huaskaychuro (P), Turukunka (P), and Portrero (P). Several forests located within community centers also occur in the region, including Makara (on the road to Pelechuco), Pelechuco and Aguas Blancas. The Chilcani and Amayani forests of Puina are said to be some of the most pristine and least damaged forests in the area covering more area than any of the other researched forests in this study.

P. pepei reproduction and growth

Are the perceived 'ecological threats' to *Polylepis pepei* woodlands shared by people living in the communities of Puina and Keara? Are their observations consistent with the 'disturbance index' or are there notable differences? How do community members interpret disturbance and damage in these forests? What are the causes of disturbance and is there a pattern to the distribution? What spatial relationship does it have with communities and other geographic and demographic features? How might perceptions of disturbance relate to perceptions of 'health' and do these correspond with my own observations of forest health?

Community members of Puina and Keara are keen observers, describing *Polylepis* species and their biological characteristics with accuracy. Questions about growth rates, size and reproduction of three species of *Polylepis*, were included in the interviews, with most responses directed at *P. Pepei*. These responses provided valuable information with which to compare field measurements to determine the level of understanding of individuals concerning the forests.

When asked about the variability of tree size between forests, interviewees attributed this difference to both environmental and anthropogenic factors. Environmental factors included the cold and drought, which were believed to contribute to the reduction of tree size in Queñuapata, the forest nearest the community of Puina. The responses relating to *P. pepei* maximum tree height ranged from 3-10 meters, depending on the forest in question. Forests closer to communities (e.g. Lampayani and Queñuapata) were said to have smaller trees because "*nos hemos acabado*" (we finished them off), indicating the limiting factor in these forests being fuelwood cutting. Forests further from communities (e.g. Quecara Chica and *Queñua*ni) are said to be larger in both area and tree size. These observations by community members are congruent with field data. Some individual trees may in fact reach the height of 10 meters in the forests of Quecara Chica, Chuñuna and Lampayani.

The age of *Polylepis* seems somewhat misunderstood by community members. To gather information about the potential growth of *Polylepis pepei*, I asked a very straightforward question. I held out my hands, making a circle with my thumbs and index fingers (estimated at 13 cm) and asked how old was a *Polylepis* tree of this size? The answer was not as consistent as I thought, and many of the interviewees said at first they did not know. The answers provided ranged from 4 years to over 20, with the average being around 10. A typical 13 cm tree is estimated by counting growth rings to be over 40 years old, a significant difference to the 'perceived' age of the tree. Therefore, individuals believe *Polylepis* trees grow faster than they actually do, underestimating the time needed for forest regeneration and recovery.

Regeneration of *P. pepei* is thought to be primarily by vegetative sprouting although a few interviewees mentioned that seeds bring forth new plants in that same forest as well. Some community members recount times in which they have tried to transplant *P. pepei* in their houses and it "just dries up", they say it "needs the cold" to survive. My own observations confirm that all trees planted around houses and fields are *P. racemosa; P. pepei* is never seen in villages.

Fuelwood, charcoal and the demands of the *concha*

One potentially important human activity affecting the regeneration of *Polylepis* forests is fuelwood harvesting. Wood fuel is essential for cooking on the *concha* (the traditional ceramic and clay wood burning stove). Fuelwood resources are scarce at elevations above 4,000 meters, as is the case in the Andean highland valleys. *Polylepis* species supply much of this needed fuel wood in the Puina and Keara valleys. Fuelwood harvesting in Puina and Keara occurs following periods of sunny weather that 'dry out' the forests, typically in June and July (see Table 4). Due to the difficulty in accessing forests in the wet summer season (October to April), this task becomes an important household activity for several weeks during the dry months. Once the wood has been cut, it is stacked and dried on site to reduce the water content and facilitate transport via llamas, mules and horses. A horse or mule can carry up to two *quintales* (or 200 lbs) of wood or about 100 kilograms per trip.

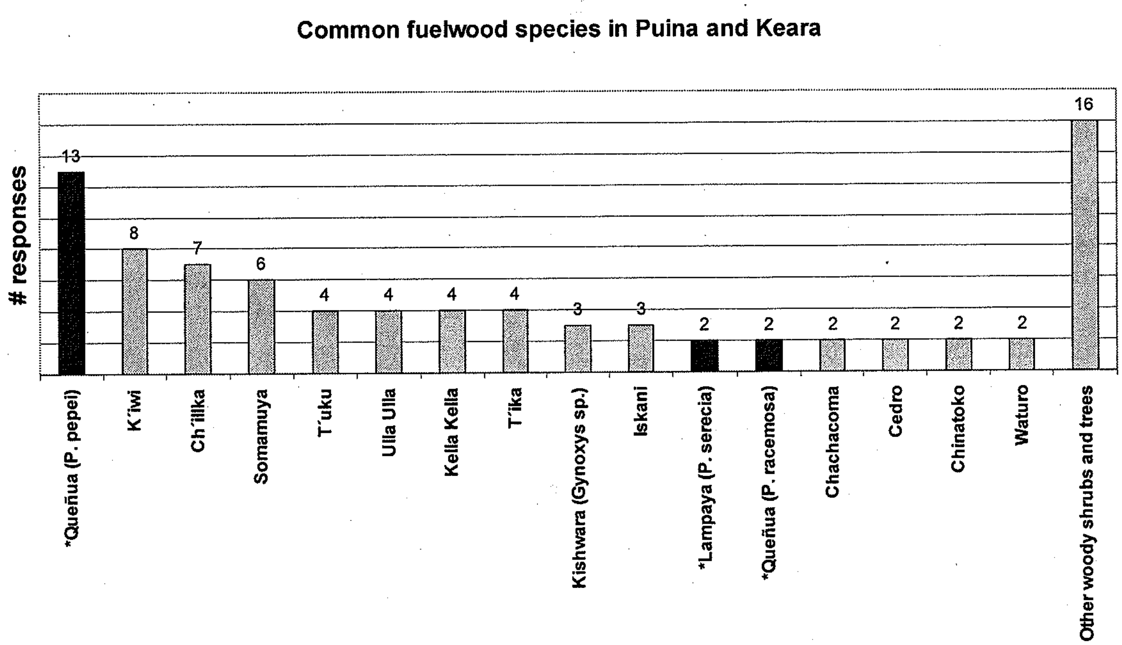
When asked about the most recently visited forest, most participants mentioned the forest nearest their residence. Some families living in the highest part of the valleys without forest resources must dedicate more time to the collection of fuelwood. They might travel longer distances for fuel wood, in many cases three hours to a full day to reach forests in a different valley. Fuel wood harvesting is often combined with shepherding livestock and bringing salt and vaccines to cattle left in remote valleys with better pasture.

Thirty-two species of woody plants are used for fuel in the communities of Puina and Keara (Figure 16). Sixteen of twenty-two interviewees mentioned their fuelwood collection practices and preferences. These species of trees and shrubs exhibit a wide range of habitats. *Ch'umi* is generally considered a woody shrub but the term may refer to any small diameter plant. *Ch'ata* are cuttings, primarily of *Polylepis racemosa* from trees bordering fields near the family's principle residence. One resident in Keara says he rarely (once a year) goes to collect large amounts of firewood because he cuts and collects the *ch'ata* from the thirty or so *P. racemosa* trees bordering his house and adjacent fields. This seems to provide his wife and him adequate fuel for cooking in the wet summer months.

Fuelwood species and preferences

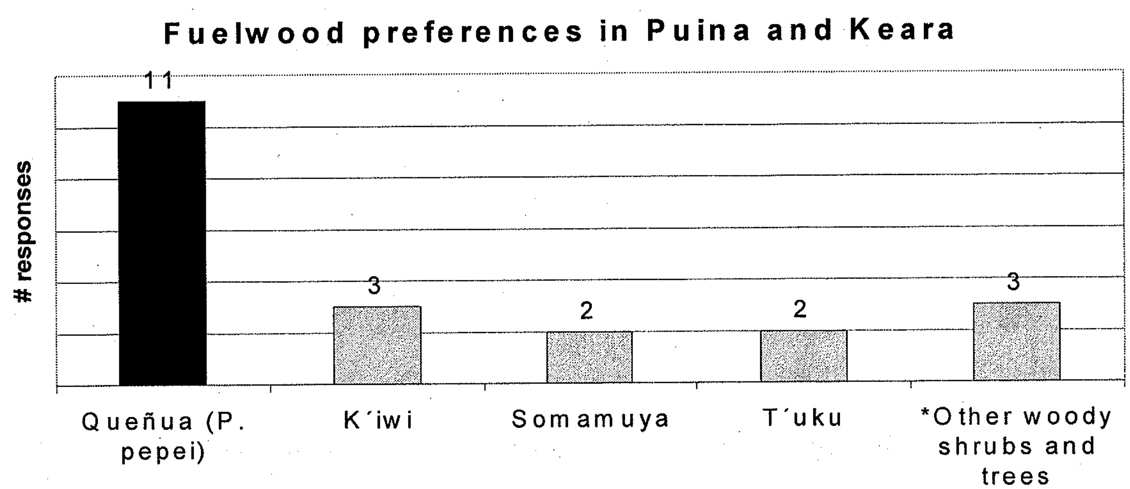
The most important wood fuel source was queñua (*P. pepei*), preferred by eleven of sixteen interviewees from Puina and Keara (Figure 17). K´iwi, Somamuya, T´uku and Kella Kella were other superior woods mentioned in the category of preferred fuel. This preference was pronounced with respect to elevation; families living at lower elevations of the communities preferred species other than *queñua* like the K'iwi that is said to "burn wet" because of the oils contained in the wood. Those families that preferred *Polylepis* fuelwood live at higher elevations where fuelwood is scarcer. A family living at 4200 meters will prefer *Polylepis* wood because the access to K'iwi or Somamuya is more labor intensive and difficult; collecting these lower elevation trees would be an inefficient use of time. All other species are present below 3500 meters while queñua ranges from 4000 and 4500meters. On the other hand a family living at 3600 meters would prefer to collect the other variety of trees in the *monte*.

Figure 16: Woody plant species used for fuel in Puina and Keara



*Other spellings and common names for *queñua* (all *Polylepis* spp.) include: queñuar, quinuar, kehuiña, kiwiña, keñua, qunoa, lampaya (Gade 1999, Fjeldså and Kessler 1996).

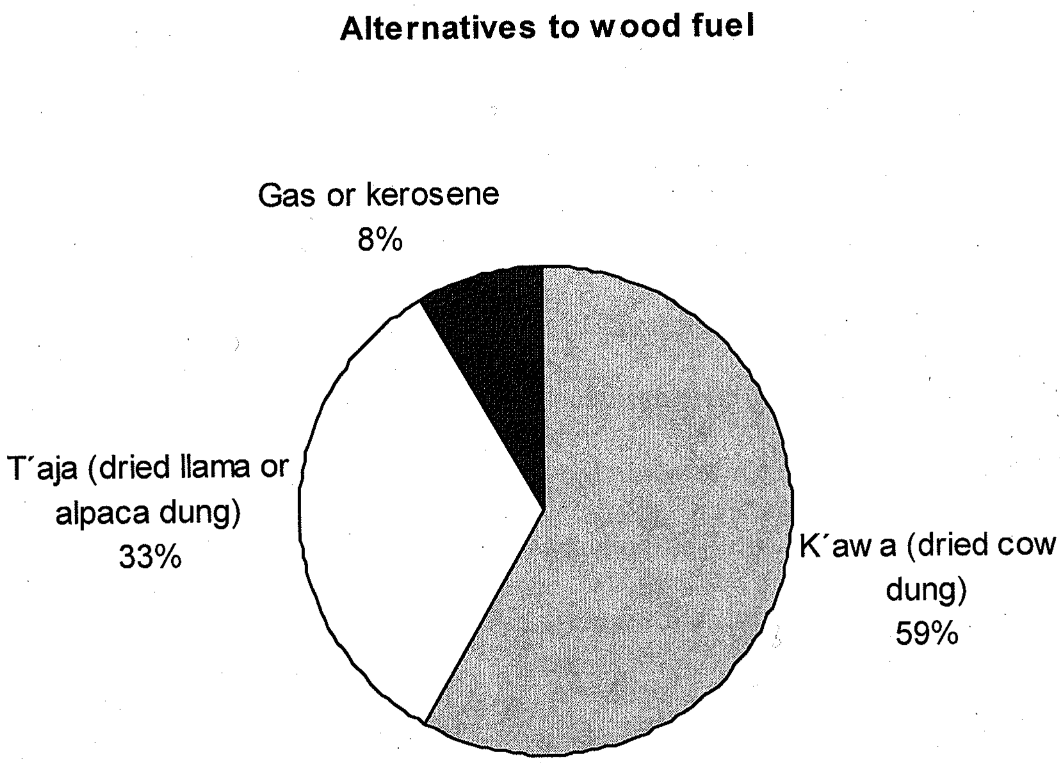
Figure 17: The preference for *queñua* fuel wood among families in Puina and Keara.



Alternative fuels

While wood is the most common cooking fuel, other fuels are used for cooking including animal scat, grasses, roots, shrubs, gas and kerosene. In the community of Puina, most interviewees use 50% fuelwood and 50% alternatives (*t'aja* or *k'awa*) for cooking. In Keara, fuelwood use increases to 70%-80%. The differences between the communities seem to reflect the availability of wood within that valley and the proximity of the forests (in the community of Keara). Gas and kerosene are used primarily in the mines where other fuel resources are scarce, absent and difficult to transport. These fossil fuel sources represent 8% of the alternative fuel consumption in the area (see Figure 18). Kerosene and gas, although used in the mines is also expensive and difficult to transport in large quantities for every day cooking. Therefore, *t'aja* and *k'awa* provide a significant percentage of fuel for use within the households. *K'awa* is preferred because of it's ability to burn cleaner when dried, not smoking as much as *t'aja*. Burning *t'aja* and *k'awa* is also said to cause respiratory problems over long periods of use. It is not only cheap, but also easier to dry, collect, transport and store than other fuels.

Figure 18: Alternative fuels to woody plants in the communities of Puina and Keara.



Polylepis use other than firewood

Individuals have many uses for *Polylepis* trees other than firewood including handles for tools, beams and rafters used in construction. In the past, trunks were used for the construction of bridges because the wood is strong and does not rot. *Kerus*, or wooden cups used in Incan times to drink ceremonial *chichi* (corn beer) are known to be made of *queñua* wood (Capriles and Flores 2002). The twisted and gnarled branches are cut for use in traditional dances like the Machu Tusuj (*auqui auqui* or *khopo khopo*) in the Apolobamba communities of Curva and Charazani, The crooked staff, a symbolic phallus, makes a parody of the Spanish conquistadores (Oblitas Poblete 1978). The iterant healers and herbalists from the region, known as *Kallawayas,* use the *queñua* or kkewiña tree for many herbal remedies, including an infusion of the bark to alleviate coughs. Ashes derived from the branches are used for chronic diarrhea and other cures and superstitions (Oblitas Poblete 1992). Although a rich pharmacopoeia of medicinal uses of *Polylepis* still remains today less than 50 kilometers to the south in the valleys of Charazani and Curva, no medicinal uses for the tree were mentioned in my interviews. Their response was somewhat curious, *hemos perdido este conocimiento*, or "we have lost this knowledge". (see Appendix A for photos of *Polylepis*)

THE PART-TIME FARMER: AGRICULTURE IN PUINA AND KEARA

> ***One must relish the taste of the rains, listen to the corn growing, observe the colour of the winds – feeling oneself at all times accompanied by our deceased ancestors. The nurturing of the chacra is the heart of Andean culture which, if not the only activity carried out by the peasants, is the one around which all aspects of life revolve*** **(Valladolid Rivera 1992:51)**

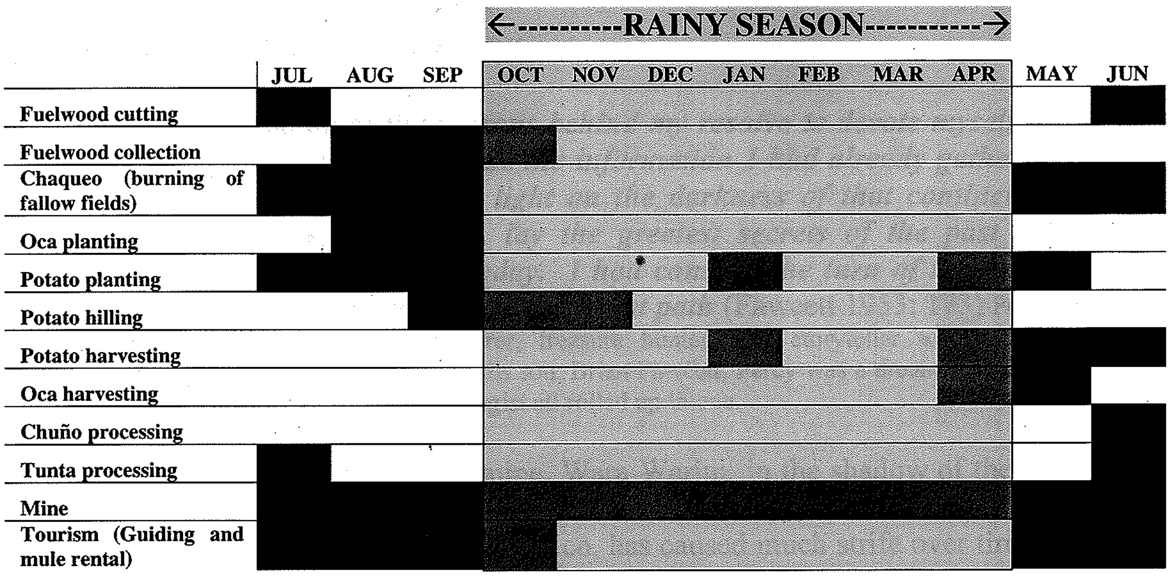
The general assumption that all members of communities in this region are full-time agriculturists is not accurate and misrepresents the heterogeneity of the source of cash flow into the community. Quechua people in the valleys of Puina and Keara employ multiple strategies for the generation of household income. Agriculture is the most notable use of land in the region but this does not generate much cash flow because of the isolation, lack of local markets and the high costs of transporting products to markets. Therefore, to increase cash flow many households seasonally migrate to other areas of the country for work. Some work in La Paz, others in Santa Cruz and still others in Puno and Juliaca in Peru. The lowlands of both Peru and Bolivia also provide labor opportunities in the coca and coffee industries (Collins 1989, Zimmerer 1993, Painter 1995). Many people of Puina and Keara stated that they not only participated in seasonal off-farm work but they had worked for up to a few years in a city, or joined the military, ultimately returning to Puina to work on the farm.

The permeable border between Peru and Bolivia allows the flow of labor and commerce, trade and *truque*, the bartering of products. As a result, many family and cultural ties exist between the communities on either side of the border. The closest markets in the region include the Peruvian border market in Chejepampa, north of Ulla Ulla and Patamanta in the south in the community of Moroqarqa (Schulte and Maqne

1997, Schulte 1999). Other local markets include Huankasaya on Saturdays and several small stores in Pelechuco. In Puina, commerce continues across the border into Peru in the communities of Saqui and Sina both of which are much closer than the larger markets of La Paz or Juliaca. Whether or not agricultural products are sold at markets or are grown for internal household consumption, a large percentage of time is spent on agricultural activities. Climatic and seasonal restrictions on farming tend to dictate the time and duration of other off-farm income generation.

I created an agricultural/activity calendar for the area to examine when farm and other work is conducted throughout the year (Table 4). Many agricultural activities appear to peak at the beginning and end of the rainy season, with periods of limited activity occurring during the middle of the rainy season. Fuelwood harvesting occurs during a limited period during the dry season, while burning of fallows extends over a longer period of the dry season. Only mining, commerce, and limited tourism activities can be considered 12-month activities. Important to this study are the times of collection of firewood and the time of *chaqueo*, or burning of fields to improve pastures, an activity that begins at the onset of the dry season when grasses have dried out. As noted in the calendar, much of the agricultural work is concentrated in the dry season, which leaves less time for other activities of wood collection, mining and tourism.

Table 4: Agricultural and work calendar



The practices of crop rotation and field rotation used by people in the region are believed to promote the fertility and production of certain crops. Crop rotation in the communities of Puina and Keara follow a traditional planting cycle; the first year potatos, second year *oca*, followed by an eight-year fallow cycle. Sometimes *aba* is planted in the third year. Barley (*Cebada*), *papalisa*, peas (*arbejas*) also are planted intermixed with potatoes and but they are not staple crops. Animal manure, mainly from llamas and alpacas, is said to enrich the soil more than other fertilizers (Puina interviewee).

Field rotation is another way to minimize agricultural crop loss and increase soil fertility. These fields in Puina and Keara are planted in solidarity with other members of that community. Rotations are based on available space and family need within the community. The community of Puina completes the field rotation every ten years while Keara completes a cycle every seven years, which might indicate the lack of available land suitable for planting in the community of Keara.

EL MINERO: "ESTAN LOCO PARA ORO"

> ***These were some of the reasons behind my resolve to devote myself to exploration in future, and use the information I had already gathered in an attempt to cast some light on the darkness of that continent's history. There, I believed, lay the greatest secrets of the past yet preserved in our world of today. I had come to the turn of the road; and for better or worse I chose the forest path*** (Fawcett 1953: 173) Percy Fawcett was a British Adventurer, treasure hunter, and storyteller who visited Pelechuco in 1911. According to his son, Brian Fawcett, Percy was a dreamer, mystic, explorer, archaeologist and ethnologist all rolled up in one.

The Puina cooperative gold mine, Wara Warini, in the shadow of the 5000 meter mountains Chaupi Orco and Palomani Chico, has caused much strife over time, and there remains a sense of conflict in the communities even today. The day after I arrived in Puina, the village began taking measures to reclaim the mine in their valley from the 'owner', a man named Carlos Sambran who lives in Pelechuco. About eight years ago, Sr. Sambran opened the mine and staked a claim to it. Those that wanted to work in the mine paid a fee to become shareholders of the mine's production. From what I gather, it's not a particularly lucrative proposition but many villagers see no other opportunity to earn a wage in the area. The new Puina cooperative mine replaced the Sambran mine; which promises to more equally distribute the wealth produced from the mine among community members who are able to make the initial payment of $US 200 dollars. In October 2004, community members traveled to La Paz to purchase a compressor for use within the mine. Over a two or three week time period, the community transported the compressor by hand over the roadless terrain from the end of the road to Keara to the mine in the valley of Puina.

Mining has taken its toll on *Polylepis* forests in the area. Members of Puina recount the times of their parents and grandparents and remember the *carbon* or charcoal sales to Peruvian mines just across the international border in the towns of Saqui and Sina in the areas near where the mines are located. The charcoal was primarily used for the smelting of gold at the mine. The proximity of the forests in Puina and Keara along well established trade routes to Peru provided easy-to-access timber and fuel wood resources needed in the mines. Interviewees said that their ancestors "finished off the large trees", and this was mentioned as an important cause of deforestation. Peruvian and Bolivian mines and processing facilities in the urban centers of Juliaca and Puno required charcoal for the smelting of gold ore and for cooking. Individuals commented on the profitability of the charcoal trade for their parents and grandparents in the virtually "treeless" *altiplano.* Many kilns are said to exist within some *Polylepis* forest patches; the structure found in Quecara Chica could possibly have been a kiln used many years ago.

LLAMEROS: ANIMAL HUSBANDRY IN APOLOBAMBA

The presence or absence and numbers of animals, especially ruminants, is important when interpreting the disturbance of *Polylepis* forests in the area. The intimate relationship between people and animals, both wild (*silvestre*) and domestic, plays an important role in the local economies of small communities like Puina and Keara. Domesticated animals are in essence, money and security while wild animals threaten to take that security away through predation and crop damage. The systems of management of the herds and the promotion of grasses appear elastic and adaptable to environmental conditions and seasonal variability. Interview questions sought to explore the perceptions local people have about animals and the perceived changes wrought by these animals over time.

One llama and cattle owner in Puina mentioned that herds of llamas will “acabar” or finish off the *queñua* trees Queñuapata. He also noted that the cattle *no come* or "don’t eat" the *queñua* trees. During a visit to that same forest a few days later we saw cattle browsing on the *queñua* branches high up on the rocky edges of the forest patch (see photos in Appendix A). Not once was a llama observed to be within forest patches; on the other hand cattle and sheep were seen in forests. These discrepancies between my own observations and the responses to interview questions warrant some attention. Are community members inattentive to the damage done by cattle browsing or does this response reflect some desire to downplay the damage done by cattle?

Fourteen interviews mentioned the increase in animal husbandry in recent years, attributed by some to be the result of increased cash flow brought about by mining and commerce. The increased income generation resulting from mining stimulated some local households' capacity to purchase animals, thereby providing a more secure and useful storage for surplus cash (Table 5). Sales of animals take place informally between family relations and in the local markets of Pelechuco, Huankasaya, Ulla Ulla or in the Peruvian towns of Saqui or Juliaca.

Domesticated animals provide transportation (horses, mules and donkeys), food (alpacas, llamas, pigs, cattle, sheep, chicken, guinea pigs), clothing and cash (alpaca, llama, sheep wool and hides), companionship and protection (dogs), and labor (oxen).

Other animals owned by people in these valleys include the *waluko* (alpaca/llama mix), highly prized pack llamas with three toes on their hind feet, pigs, chickens and guinea pigs. Prices are more variable for cattle, mules, horses and donkeys depending on size, temperament and age of the animal for sale. Llamas, alpacas and sheep prices do not vary much from the local market price.

Table 5: Prices paid for domestic animals in October 2004 in the area of Puina and Keara

Domesticated animal	Price (Bolivianos)	Price (US dollars=8.2 Bs)
Alpaca	250 Bs	$30.00
Llama	350 Bs	$43.00
Cattle	800-1200 Bs	$98.00-$146.00
Sheep	50-70 Bs	$6.00-$9.00
Donkey, horse, mule	250-1500 Bs	$30.00-$183.00

The interviews indicate significant fluctuations in market prices for sheep and alpacas/llamas that are reflected in the community preferences for cattle, llamas and alpacas in Puina and Keara. According to interviews, sheep (and sheep wool) have decreased significantly in market price in the last 20-30 years. A large animal now selling for 70 Bs would have been worth 110-120 Bolivians in the past. Alpacas and llamas have increased in price, especially for the sale of wool/hides that sell for 12 Bs/lb. The relatively stable and high purchase price for cattle has only increased the importance of this animal in recent years. Although the community's ability to purchase cattle has increased with the increased cash flow from the mine, the cost of these animals is high and risky if the animal is lost over a cliff or preyed upon by mountain lions.

Eleven interviews noted an increase in alpacas and llamas and a decrease in sheep in recent years. Horses and to a greater extent, llamas, are primarily used as pack animals, as are mules and donkeys but the latter are less common in these valleys. Cattle seems to have been maintained by those individuals with access to land, although they are sometimes, but not always, moved seasonally in accordance with the production of suitable forage. In the cold/dry season (May-October) cattle are brought up to the *bofetales* where grasses are green and they are closer to houses and the community centers of Puina and Keara. Cattle are left alone in the *rincon* of glacial carved valleys where pasture is green year-round and sometimes only visited once every month. In the summer rainy season (September-April) the cattle are brought down to lower altitudes where they give birth and allow pastures to recover in the highland valleys. One wealthy cattle owner, who also has many alpacas and llamas also has cattle in the valley of Quecara Grande, noted that he spent a few weeks in October to assist in the successful birth of one of the cows. At birthing time in September-November, owners will visit more often, providing protection against predators like condor *(Vultur gryphus)*, puma *(Puma concolor)* and zorro (*Pseudalopex culpaeus)*. In lower valleys like Quecara Grande, the *jucumari (Tremarctos ornatus)* is also considered a threat to domesticated animals (see Table 6).

Table 6: Animals *silvestres* (wild) considered a threat to livelihood

Common name	Other names (E=English, S=Spanish Q=Quechua, A=Aymara)	Scientific Name	Comments
Zorro,	Andean fox, atoj (Q)	*Pseudalopex culpaeus*	Predation on sheep and young llamas and alpacas
condor	Andean condor, mallku (A)	*Vultur gryphus*	Predation on cattle, sheep, llamas, alpacas
puma	Mountain lion, puma	*Puma concolor*	Predation on mules and horses but also cattle, alpacas and llamas
Jucumari	Andean Bear, Spectacled Bear	*Tremarctos ornatus*	Primarily cattle predation but also horse and mule
Taruka	White tailed deer, Venado macho	*Odocoileus virginianus*	Crop predation but generally looked upon as a source of
	Andean deer	*Hippocamelus antisensis*	food

(from 2004 interviews and Tarifa et al. 2001)

LAND TENURE

Community Forests and Pastures

One of the interview questions posed to members of the communities involved the "ownership" of the forests. Who manages the *Polylepis* forests and the precious grasslands adjacent to these forests? The response across the board was, *nadie es dueño de los bosques,* or "no one owns the forests" (Interview with community member of Puina).

Following the land reform laws established in 1953, haciendas dissolved into community owned and managed lands. With few exceptions, most of the haciendas in the area were located on the eastern slopes of the Andes, in the high valleys (Schulte 1999). The historic division of Madidi into eras or boom cycles is briefly outlined in Table 7 and provides further context for the importance of natural resources and land use in the area. In the case of communities in the Apolobamba Mountains, the formation of local syndicates of *campesinos* began to organize and eventually replace the colonial structures established by the Spanish (Silva et al 2004). By 1965 this transformation was in essence complete although some evidence of the hacienda system lingers even today and continues to create some conflicts over land ownership in the region (Schulte 1999).

Table 7: The historic division of PNANMI-Madidi.

Historical period	**Approximate dates**
Pre-Hispanic period	?-1536
Colonial period	1536-1824
Beginning of the Republic and *quina* boom	1825-1880
Rubber boom	1880-1917
Hacienda period	1917-1964
Hide and skin, *quina* and *coca*	1964-1985
Timber boom and colonization	1985-2001

(from Silva SERNAP/ WCS 2004)

According to Michael Schulte (1999) the Western concept of private property does not apply in this region. In essence, property in the region is established only through working the land. Considering this idea of property as a function of work, land that is worked can be 'owned', while the un-worked land cannot be owned. Agriculture and grazing then are considered ways to establish ownership of the land; the more labor available for farming and the more animals grazing on the land allow households to work or lay claim to more land.

Apparently, family name and origin are important, indicating which families have certain 'rights' to pastures and agricultural plots and sometimes conflicts arise about ‘original’ families, those that originated in Puina and Keara. Testimony of family origin is used to validate claims to grazing lands and agricultural plots by the next generation. There seems to be an undocumented 'user permission' that certain families have on certain territories. These rights are passed on from father to son and cannot be taken away as long as that portion of land is still being used. Once the land is abandoned, the community has the right to redistribute the land according to necessity. Families in need of land for grazing or planting may request to use certain pastures. The locally appointed authorities will then approve or decline the petition. The same user rights apply to the rotational plantings of potato and *oca* on communal fields every year. It seems that if you do not use your 'inheritance' and 'right' to the land, it can be redistributed to others in the community who might request it.

One such 'owner' of an ex-hacienda has 200 + head of llamas and alpacas on an idyllic bridge of pasture between the Puina and Keara Rivers. His inherited land even appears on the topographic maps from the IGM (Instituto Geographica Militar 1997) and historic maps of the region drawn by explorers. He came back to Puina after his parents died to 'reclaim' his property so that he would not lose it. He and his son constructed a half-kilometer wall of stones on the border of his 'property'. The purpose of the wall was two-fold: (1) to contain his own flocks of *machos*, male llamas that he states "like to look for those llama girls" on the other side of the valley; and (2) to protect 'his' grassland from other people's animals.

Although the communities of Keara and Puina have many family ties between them, the boundaries between the communities are drawn at the *apacheta*, or mountain pass. These devisions are well known and generally respected by both communities, members from one community do not casually graze their animals on the other communities pasture. Influences of the old hacienda system still seem to play an important role in the way communities manage these properties and how individuals interact within certain families. There is still respect for the limits of the hacienda, as long as it is still being used, but the importance of these land holdings seems to be a bitter source of resentment for some individuals without sufficient access to grazing lands. Although many travelers pass through the land, it appears that any extended stay in the valley would be unwelcome. Some forests are used for different purposes or at different times of the year, depending on other duties and travels related to household livelihoods. If a farmer is checking on his cattle he left to graze the lower and more productive pastures of Quecara Chico, he is most likely to combine his work and bring back the firewood he might have split a few months earlier. It seems that from interviews that certain forests are preferred over others. This might depend on where a family has access to grazing land, their relationship with ex-hacienda owners, their own ability to transport fuelwood (horses, mules, llamas or by foot).

Since agricultural land and pastures are both considered 'worked' land, where do forests fall? They cannot be considered worked in the same way as pastures and fields so they fall into the category of common pool resources, accessible to all members of the community. On the other hand, the forests are isolated within pastures that are 'worked' by individuals and their animals. Those families with grazing rights near that forest are more likely to collect fuelwood in those forests also, providing an opportunity to check up on the animals and complete two household duties at the same time. Similar to the territorial nature of grazing, the act of burning the grasslands of another person without their permission would constitute an infraction on the culturally accepted norm. It would be equally unacceptable to kill a neighbor's animal that wanders away. This may be why adults avoided the questions regarding burning of the grasslands; most interviewees attributed the burning to children "that don't listen" or "they're young", and possibly a little rambunctious.

From H*acienda* to National Park

"Conservar el patrimonio natural y cultural del Bolivia, es una tarea que nos compromete y responsabiliza a todos por igual."
FUNDESNAP mission statement

[To conserve the natural and cultural patrimony of Bolivia is a challenge that we all should undertake as our personable responsibility.]

The establishment of national parks and protected areas represents a growing importance placed on biodiversity and conservation, although the establishment is not without serious conflicts of interest. Many of these conflicts originate from misinterpretations, but some are deeply rooted in the loss of power to control community-based resources. Conflicts associated with land use and control of timber resource extraction has played out recently in Madidi (La Razon 2005). If we take a look at the the changes in management of the landscape in the communities of Puina and Keara, we see that individuals respond to the challenge of conservation with mixed responses. This above quote by FUNDESNAP, a foundation established to financially support the system of national parks in Bolivia, describes this universal stewardship goal, that 'all of us' are responsible for conservation.

Interviews with community members were mixed with respect to the park; some expounding on the benefits of becoming a part of Madidi, while others sharply criticized the inactivity of the park in recent years. Since the establishment of the park in 1995, it is unclear from the interviews that any official visits to the community of Puina have been made, and no interview mentioned the current park authorities or park staff or park guards. Recently, due to a newly established road, SERNAP directors have visited the community of Keara. They also conducted a workshop in Pelechuco the day we arrived in November 2004.

The presence of the park has not created a lasting impression on the community. Those individuals, tourists and biologists who dedicated weeks and months in the area are remembered over all. In many interviews, the names of park personnel and park guards were unknown. Representatives of NGOs, tourism agencies and governmental institutions were misinterpreted as "park guards" or personnel.

Confusion continues regarding the boundaries of the park. The border between two the protected areas of Apolobamba and Madidi passes right through the community lands of Keara. Some members of Keara preferred to be part of Madidi because of the benefits associated with the park (tourism), in contrast to the disadvantages associated with Apolobamba. Apolobamba park stations were generally well known. Recent training workshops taught by COBIMI have provided institutional support for tourism in the region and the Association of Guides and *Arrieros* of Apolobamba. The neighboring Peruvian park stations were mentioned in two interviews, possibly a reference to Bahuaja – Sonene park just over the border in Saqui where they tourists are said to watch vicuña. The most common wildlife cited in interviews was birds, most likely a result of my work with birds in the area.

The interviews explored the concept of "conservation" and the "purpose" of the National Park as well as identifying park guards and personnel. Some resentment is evident regarding the creation of Madidi; comments like "they (SERNAP park guards) should come more often" or "they don't do anything " (*no hacen nada*) or they "just watch, nothing else" suggest that national park personnel are looked upon as authorities that are not doing their job. In many cases, community members feel that they should directly benefit in some way from the park service; it is looked upon as a source of money and projects to develop the community. One interviewee from Puina said he wanted Madidi to build an office in Puina "to attract tourists" and to "provide a radio for communication". In conclusion, the park service is misunderstood in the communities of Puina and Keara for lack of contact with park service personnel and a reasonable misconception about the goals of biodiversity conservation.

DISCUSSION

This brief snapshot of *Polylepis* forest conservation and use within the landscape of the Apolobamba Mountains shares many common themes with *Polylepis* conservation in other corners of the Andes. In this discussion, I hope to provide a more detailed interpretation of *Polylepis* conservation in the Andes as well as more specific insights from Madidi National Park. I will bring together both qualitative and quantitative data gathered from interview results and the ecological analysis of individual forests. First, I want to summarize some of the dominant themes present in the interviews and ecological surveys. Second, I will examine the social and environmental pressures presented in this research that contribute to *Polylepis* degradation and also to the recovery of these woodlands. I will then offer some site-specific suggestions for management of these resources in Madidi and Apolobamba. In conclusion, I offer recommendations for future research methods and study in *Polylepis* forests to improve our knowledge forward from both a botanical and socio-environmental standpoint.

ADAPTATION AND CHANGE

Adaptability could be the single most important recurring theme present in the interviews from Puina and Keara. The people, plants and animals must adapt to the changing and unpredictable environment in which they live. *Polylepis* trees are well adapted to their harsh environment, as are the people who use them. *Queñua* are able to coppice when cut for firewood, and appear to accommodate the pressures of grazing, fire, and cutting when the frequency of these disturbances is low. They have persisted through times of widespread cutting and exploitation for charcoal use. *P. pepei* seems to have followed a parallel history with the Quechua people in this landscape, as both are victims and survivors of the incredible array of adversities thrown at them.

Human adaptability in view of changes in climatic conditions is another important theme. Climate change has appeared to alter certain livelihood choices for families in these communities. First, and most importantly, some climate changes appear to benefit local agriculture, a benefit also discussed by Barry (2000). The apparent elevational rise in frost lines now allows families to plant new crops in their *canchones*; including lettuce, chard, and carrots. In the fields, barley grows at higher altitudes now and apple trees cover some of the riversides in the lower valleys, below the Puina and Keara. Potatoes are now harvested one month earlier than before and the wild plants are 'coming up the valley', indicating a vertical spread of vegetation up the valleys due to an apparent warming trend.

The communities of Puina and Keara are adapting to these ongoing climatic changes in their management of grazing lands adjacent to *Polylepis* forests. Similar observations by Orlove (1977) in the altiplano region of southern Peru and Preston (2003 and 1998) in Tarija, discuss the practice of seasonal movement of cattle to improve pasture quality. What is seen in the valleys of Pelechuco, Puina and Keara is consistent with the way other communities adapt to changing environmental conditions. Seasonal movement of cattle is a necessary activity for protecting the vegetation according to Preston (1998), and the movement of cattle to lower elevations at the onset of the rains to permit pasture growth is a practice that in turn promotes conservation of the grasslands and forests alike. Preston challenges the orthodox view that farmers and ranchers in small communities manage their resources in unsustainable ways. His criticism of the 'urban based' orthodoxies seems at odds with what is generally perceived by conservation biologists and ecologists as destructive overgrazing practices of *campesino* communities in the Andes. The persistence of *Polylepis* forest patches in the area suggests resilience in spite of the environmental and social changes that have occurred on the landscape.

Cultural changes and *Polylepis* forests

The cultural 'loss' of certain traditions also immerged as a common theme guiding the interviews. Community members attributed this alteration in the social and cultural fabric to two major changes in both the communities of Puina and Keara; mining and religion. Although mining has played an important role in the livelihoods of local residents since the colonial and hacienda periods, the recent formation of the Puina cooperative mine established in 2004 further alters the social fabric of the community and how they relate to *Polylepis* forests in the area. Some community members blame the mines for this disruption of traditional livelihoods, for taking men away from their families and community. Others praise the mine as the salvation of the community, the only way to earn a living in this remote area. Although the social pressure to participate in mining activities is great, not all men choose to participate. The importance of the mine is also reinforced by the movement of the town to closer proximity to the mine. Decisions about the mine now dominate the community discussions, creating contention and jealousy as well as undermining the autonomous power of local authorities. Community work days traditional fiestas, once a forum for hashing out disagreements and creating community solidarity have been virtually eliminated from local life as a result of the mine. The mine provides fewer opportunities to gather, to talk and to share.... this is what is lost as the malevolent *fiebre de oro*, 'gold fever', takes control.

Many researchers have documented the effects of labor shortages and the effects on local economies in the highlands of Bolivia and Peru (Zimmerer and Young 1998, Collins 1979, Orlove 1995). The seasonal and permanent migration requires that men and women participate in economic activities further from the principle residence, the less time they have for the daily agricultural chores. Activities might include mining, tending the cattle (which may be grazing more than a day's walk from the residence) and other urban off-farm labor or transporting tourists may require them to travel days and even weeks at a time.

The lack of time to complete the necessary agricultural tasks has resulted in increased dependence on external markets. Mining seems to have altered the traditional base of agro-pastoral livelihoods and local markets and introduced a more consumptive orientation into a global cash economy. Maize fields planted on the lower mountain slopes are now more distant, overgrown, and in many cases totally abandoned. Crop damage from wild animals makes maize farming in the mid-valleys nearby impossible and few residents consider the effort worth the while. Families now buy stables like rice and pasta that are easily transportable and storable for indefinite periods of time. Although this 'buys into' the capitalistic system, it allows families to accommodate the lack of manual labor and the increased movement of individuals.

Although mining activities allow households to diversify their income generation, the increased importance of the mine might be detrimental to certain *Polylepis* forests in the area. Since men are busy working in the mine, and women are burdened with additional household and field chores, less time is available to collect fuelwood. Mining creates a labor shortage for other activities associated with farming that must be compensated for in other ways. Those persons not participating in mining activities, principally women and children, then take up these additional chores needed to maintain the farm. The daily activities include herding animals, planting and harvesting crops and gathering firewood. These changes might result in the overcutting and overuse of forests within close proximity to community centers. Traditionally men harvest large diameter fuelwood with axes and machetes. If women and children are now responsible for fuelwood harvesting, an increase in small diameter fuelwood harvesting might result. In turn, this might restrict the regeneration of the forests close to community centers. On the other hand, this same scenario might benefit the regeneration of forests further from community centers, a result of the abandonment of traditional and more difficult to access collection sites.

The benefits of llamas over sheep

Why do the communities of Puina and Keara prefer to reintroduce the llama and alpaca? The reintroduction of the Andean *camelids* is at first confusing and inconsistent with what has been written about changes in animal husbandry in the Andes. Investigations in Cochabamba and Cusco where sheep and goats have been preferred by community members (Fjeldså and Kessler 1996, Ibish 2002, Hensen 1994) indicate a preference for these animals instead of the more traditional *camelids*.

Conversations with community members suggest that the change in domesticated animals is deliberate, with some people pointing to factors that affect the productivity of their crops and economic livelihoods. First and foremost is the increased sale of alpaca and llama wool at the local Bolivian/Peruvian markets at Huancasaya and Chejepampa, where it sells between 10-12 Bs per lb. Also, *tajia,* alpaca /llama scat, is said to provide a better fertilizer than either manure from cattle or sheep. Cattle provide *K'awa*, which is flipped over and dried, collected and then burned as an alternative fuel for cooking. Its utility then is best used for fuel, not fertilizer. Cattle dung is also said to harden the soil, unlike the properties of alpaca or llama scat.

Llamas and alpacas involve less work for the farmer; they are more independent and require less care. They also are said to be 'smarter' and 'need less care' in comparison to sheep. This need for more independent animals may in fact be a result of labor shortages and out-migration of young men and women and other members of the extended family. Unlike sheep, full-grown alpacas and llamas can more easily defend themselves against the threat of foxes and possibly a puma, the major predators in the area. Although the young and newly born are easy prey for these predators, a fully-grown animal has a better chance of survival. Llamas and alpacas are sometimes left alone for days at a time without any problems. Sheep on the other hand must be herded daily, for they tend to overgraze certain patches, and are no match for a hungry predator.

Overgrazing was noted as a problem by about a third of the interviewees, as was grazing in areas off limits to domesticated animals. Stone walls protect the precious potatoes and *oca* from predation from domesticated animals. Without these walls in areas of high livestock traffic, the animals tend to destroy a crop in no time at all. Over half of the interviewees mentioned the switch to alpacas and llamas as a result of needing to protect these crops in the *canchones*. Sheep tend to enter more readily into these walled fields while alpacas and llamas refrain from entering these fields. Mules and cattle were mentioned as high grazers, needing up to four times as much grass as llamas and alpacas. This past overgrazing by sheep, mules and cattle is said to have caused sickness and death to many of the sheep. Alpacas and llamas are believed to be better able to eat the "drier" grasses and survive.

The renewed interest in llamas and alpacas in Apolobamba may in turn be a blessing for *Polylepis* forests for reasons other than conservation. This could be a result of many factors, including the resurgence of Andean pride and a manifestation of their cultural heritage. Increased influence of conservation organizations, the strengthening of indigenous organizations and the improvement of training and educational programs provided by the national park system also could play a role in the reintroduction of the llama. This trend may result from many years of indirect educational reform in the region, placing value on traditional animals and the development of accessible markets in both Bolivia and Peru for wool and meat. Perhaps this change is rooted in the keen observations of local people, who noted the ability of llamas to adapt to environmental conditions and then made household livelihood changes accordingly. However, the line between 'traditional' and 'exotic' has been significantly blurred in some cases where community members identified cattle and sheep as *conocidos* or ‘known’ animals, and llamas and alpacas as 'not traditional'.

Valley Shape

The various shapes of the valleys of Puina and Keara also seems to have a significant importance concerning the livelihood choice of local people living in that valley and the anthropogenic disturbances present in *Polylepis* forests. If we compare the two valleys considered in this study, Puina has more gradual slopes and a much wider U-shaped valley, while Keara’s valley is much more abrupt and V- shaped. Although this comparison seems very simplistic, it becomes important when considering the disturbances upon *Polylepis* forests. The importance of grazing in the communities cannot be denied and is somewhat limited by the pasture resources of the community. The difference in pastureland availability between the two communities of Puina and Keara may also cause more disturbances due to browsing in the community of Keara. Puina has plenty of pasture, ideal for large herds of llamas and alpacas with wide-open areas populated by cushion plants and tough bunchgrass. Keara on the other hand is located further down the valley and is more hemmed in by the mountains, without wide open areas for grazing and pasture. Many of the gradual slopes, ideal for grazing, are in or near the *Polylepis* forest patches. The proximity of these forest patches to community centers promotes repeated and daily grazing disturbances in and around these forests. In many cases, these forests are located on transportation routes to other valleys. In more vertical valleys, animals graze within close proximity of the forests, allowing animals to browse the seedlings and saplings and reducing regeneration of these areas near trails and highly traveled areas.

'Wild' vs. 'domesticated'

Another theme explores the dualism of the natural world; plants like the *queñua* tree as well as animals fall into one of two categories, domestic or wild. The former embodies a sense of control, while the later a sense of being unpredictable, untamable and even dangerous. Many of the interview questions explored the personal feelings towards these elements in nature. The 'domesticated' *queñua*, *Polylepis racemosa* is a perfect example of this dichotomy. It suggests that humans may have played a much more significant role in the spread of *P. racemosa* within larger urban centers. It comes only from the civilized world of Pelechuco; people are able to manipulate it or control it, to take it elsewhere and reproduce it, encourage it so that it might prosper and provide fuelwood for the family. The domesticated llama or mule is under people's control, useful and productive, and an Andean sign of wealth.

The 'wild' variety of *queñua*, *Polylepis pepei*, cannot be easily transplanted, reproduced or otherwise tamed (although one interviewee said, "it should be"). It is not planted in garden plots near houses, and only exists in the remote corners of distant valleys. The 'wild' cat or *jucumari* (Andean bear) prey on these innocent and precious domesticates and damage the overall wealth accumulated by the concentration of cattle. A 'domesticated' llama or cow is free to browse the forests of 'wild' *queñua*, but the 'domesticated' *queñua* is protected from this damage with rock walls and the owner's watchful eye.

Who is responsible for the management of the 'wild' animals and the 'wild' plants? From interviews with community members, it appears that the responsibility for the wild animals that are 'unpredictable' and 'uncontrollable' falls in the hands of the National Park. Park guards are looked upon as guardians and protectors of the 'wild' or gardeners of the 'garden' of biodiversity. As Naughton (2002) states, "these multiple gardeners value different kinds of wildlife". For the llama or alpaca farmer in Puina, the foxes, bears and puma are only a hindrance to the growth of the farmers herd, killing many of the young animals. When asked about the purpose of Madidi, interviewees commented about the park mission to 'controlar', 'protect' and 'guard' the wild animals within the park boundaries. No mention was made of the 'domesticated' varieties. They mentioned only the protection of animals like the vicuña, Andean bear, *viscachas*, *taruka*, and the many birds including the Andean Goose or *huallata*.

REGENERATION OF *POLYLEPIS* FORESTS?

The real concern for conservationists and local communities alike comes down to the practical issue of "management" of these forests. Considering that determining the natural distribution of *Polylepis* has proven quite enigmatic in light of the long history of anthropogenic disturbances on these forests, one question remains for land managers in the area: Are the threats to the *Polylepis pepei* forests within sustainable limits in the area of Puina and Keara? The answer to this question is still quite illusive in respect to the results I have presented in this paper. The individual changes that have taken place in the area can lead us to certain conclusions that depend on the community, each individual forest, and the location within that forest.

The following conditions favor the growth of *Polylepis* in the region: human population is not increasing; the communities are bringing back the traditional animals of llama and alpaca, especially in Puina; the bridges that once crossed the Puina and Keara rivers have fallen into disrepair and these valleys are now isolated and accessible only in the dry season when the rivers are low; out-migration to urban centers has increased as well as the off-farm work; terraced croplands are not maintained and fallow fields resprout with tussock grass and return to their wild state. Nature appears to have taken back some of the areas once damaged in the past. It is important to note the numbers of forests in the area that I did not survey as well as those that are 'known' to exist. Chilcani and Amayani forests of Puina are said to be some of the most pristine and least damaged forests in the area.

Changing circumstances also threaten *Polylepis* growth in the area: tourism and mining activities have increased and provided sources of cash that can in turn be used to buy more animals; other environmental damage from these industries might even further erosion and contamination problems along rivers and trails; grazing is not controlled and animals can graze where they want; human settlements are more concentrated in community centers; burning the grassland continues and encroaches on *Polylepis* forests; community education and reforestation programs are non-existent.

Polylepis forests in the area seem to have varied degrees of disturbance related to distance to community centers. The forests of Queñuani and Quecara Chica, once closer to the community centers, seem to be in a stage of recovery from past disturbances while the forests (Lampayani and Queñuani), now closer to current populations, are significantly more affected by anthropogenic activities. The following Table 8 explains some of the changes happening in the landscape and direct and indirect influences this may have in relation to *Polylepis* sp. forests in the area of Puina and Keara.

Table 8: Community changes contributing to *Polylepis* forest regeneration/ degradation in Puina and Keara
(↑ = increasing; ↔ = static; ↓ = decreasing).

CHANGES	PERCEIVED BENEFITS	PERCEIVED THREATS
Animal Husbandry		
↑ **llamas / alpacas**	less damaging than sheep dung used as alternative fuel can graze tough grass fertilizer for fields	may reach critical carrying capacity
↔ **cattle**	seasonal damage only dung used as alternative fuel	high capacity grazers hooves damage substrate
↓ **sheep / mules**	reduced trampling damage	hooves damage substrate
Income generation		
↑ **tourism**	conservation awareness	more foot traffic and need for pack animals more cash flow to buy cattle / llamas cash creates more community inequity
↑ **mining**	income	contamination of water supply cash creates more community inequity loss of autonomous power structure more cash flow to buy cattle / llamas
↑ **road transportation (Keara)**	accessibility to gas	more vehicular traffic
↓ **highland / tropics trade**	limited forest access	
↑ **off-farm income**	income less pressure on local resources	increased use of forests close to communities loss of cultural traditions
Population demographics		
↑ **population concentration**	less damage to remote forests	increased damage to proximal forests
↑ **low population growth**	less demand for fuelwood	
↑ **urban migration**	less connection with land	less available labor for farming
Land tenure / management practices		
↔ **fire management**		threatens forest expansion and seedling establishment
↔ **inherited land tenure system**	limited use of certain forests	more intensive use of 'community' forests
↑ **National Parks**	conservation awareness funding opportunities NGO interest	loss of autonomous power structure
↑ **transplantation of *P. racemosa***	provides needed fuelwood without forest depletion	

MANAGEMENT SUGGESTIONS AND RESEARCH POSSIBILITIES FOR *POLYLEPIS*

> *A simple ban on its use would either be met with disdain or, if enforced, would result in the emigration of people from their ancestral lands. The only practical way forward is an integrated approach that recognizes the needs of local communities". They accomplish these goals through different projects: reintroduction of conchas or traditional clay stoves. Conversion of old building to greenhouses, agroforestry, and revegetation of both native and introduced tree species* (ECOAN 2005).

Projects like ECOAN in Cusco, Peru are a promising future for development and conservation within *Polylepis* woodlands in the area of Peru. This type of community-based research combined with education and development could be broadly applied to areas throughout the Andes. This program ECOAN (Asociacion Ecosistemas Andinos) was founded in 2000 and works currently in Cordielleras Vilcanota, Vilcabamba, and Apurimac near the city of Cusco, Peru. They claim to have "achieved increased awareness and stewardship" in the communities in which they work. "Agreements with local people lie at the heart of ECOAN's philosophy" (ECOAN 2005). The project ECOAN has utilized some creative ways to promote conservation of *Polylepis* forests in three primary areas in Peru. These methods target the use of resources by providing firewood for communities in hopes that this will reduce pressure on the forests so they have a chance to recover (Aucca 2005).

My study could be looked at as the initiation of a "long introductory period" (Purcell 2004:461) needed for conservation of *Polylepis* in the communities of Puina and Keara. The challenge for the communities, park managers and organizations working in the area will be to work together to create community-based, long-term and sustainable solutions for the use of *Polylepis* forests. At this time, these communities are relatively remote and pressures on the *Polylepis* forests have not grown far beyond the regeneration of some of these patches. This means the careful nurturing of a constructive dialogue between these actors to promote conservation and satisfy the needs of all parties involved in the process. Many researchers (Fjeldså and Kessler 1996, Ibish 2002, Purcell 2004) have suggested the need to work directly with communities to understand their resource use and livelihood needs. These authors adamantly state the need for community members to benefit directly from conservation, whether it is with increased tourism, or financial and institutional support. Many respondents mentioned the (potential) benefits of tourism. Some mentioned workshops in Pelechuco or trekking and climbing agencies in La Paz. Eleven interviewees recounted the trips taken with tourists, including climbers, biologists, film crews, trekkers and geographers. Tourism has been touted as a source of potential but unrealized income generation for the towns of Puina and Keara.

Opportunities for future research on *Polylepis* forests abound, especially in conjunction with local communities in remote corners of the wrinkled Andean landscape. These opportunities not only offer a different perspective from the dominant urban-based orthodoxy, but also develop an interactive relationship with communities and a mutual learning environment. Promoting reforestation projects would take the pressures of fuelwood collection off existing forests. In Apolobamba, *community members are already transplanting Polylepis racemosa*. A reforestation project could reinforce some existing conservation practices like these and expand the project if the project appears to be successful. *Polylepis* reforestation is outlined in detail by Fjeldså and Kessler (1996) and (ECOAN 2005) as well as more species-specific studies about the regeneration;

Polylepis australis (Renison et al 2002, Enrico et al 2004) and *Polylepis tarapacana* (Kleier and Lambrinos 2005).

Communities could be involved in the scientific studies of *Polylepis* forests on community lands. The knowledge retained by communities about *Polylepis* forests has rarely been tapped by conservationists and might lead to more sound and reasonable management plans for the area. Improving the level of documenting the disturbance level and health of forests could improve the accuracy of ecological fieldwork on *Polylepis* forests. Disturbances could be evaluated by community members as well as researchers, involving community members perceptions of the damage might lead to some interesting findings about how this particular species of *Polylepis pepei* reacts to certain anthropogenic disturbances.

Conducting experiments to recreate the original composition of *Polylepis* forests would help to understanding the role of anthropogenic changes on the current distribution, growth potential and sustainable cutting yields of these forests. Enclosures within forest patches could be built and enforced by local communities to restrict access by grazing animals and allow the effects of grazing to be studied in more detail. These types of studies might help gain a better understanding of the natural parameters and limitations of *Polylepis* forests. Considering the ecological knowledge about *Polylepis pepei* forests is quite limiting, more work needs to be done comparing and contrasting this species with others and looking at the variation of the species in light of disturbances and ecological parameters.

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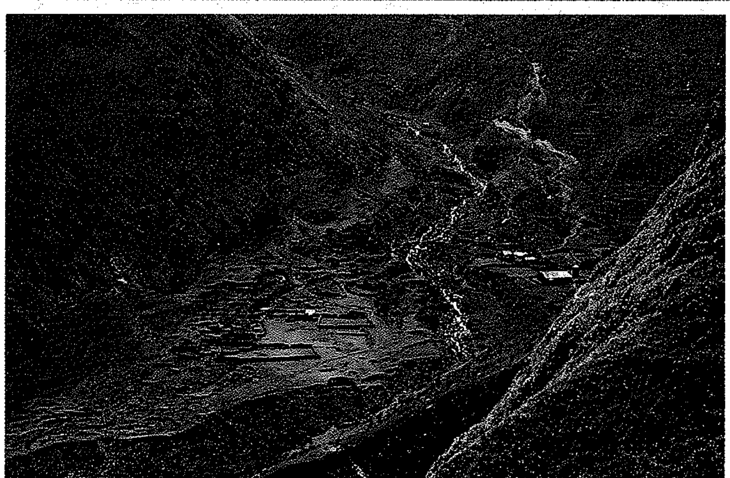
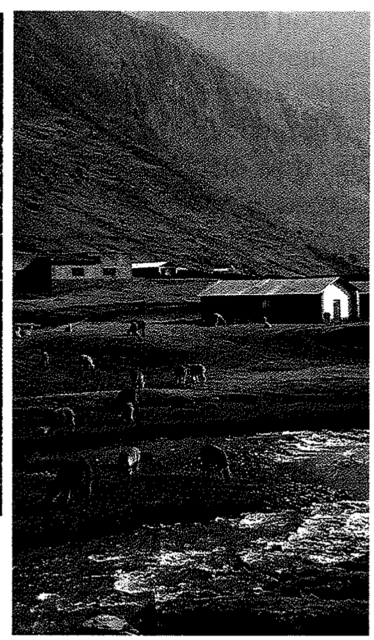
APPENDICES

APPENDIX A: A PHOTOGRAPHIC JOURNEY

Puina valley

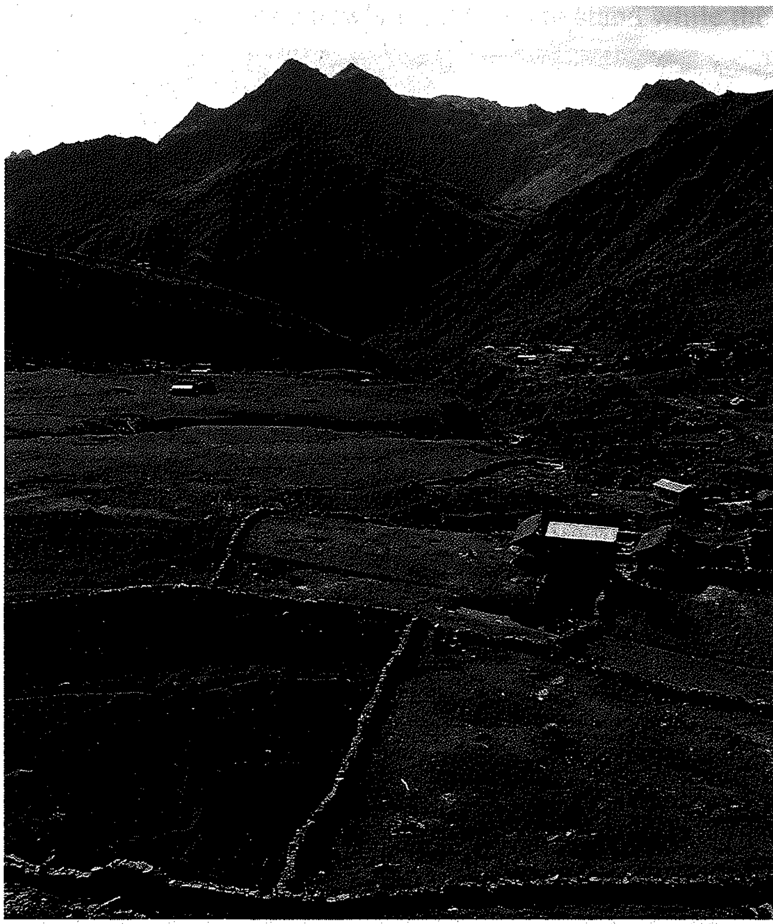
(Below and lower right) is the town of Puina'*pampa*', also called *Tuturpampa* (the large plain, *pampa*, of the *tutur* or teacher) the school is the red roofed building on the left of the soccer *cancha*. A herd of llamas and alpacas is passing through the field at the time of the photo. This town, at 3,800 meters is now the 'center' of the community with two churches, three stores and a CEDE or community meeting hall.

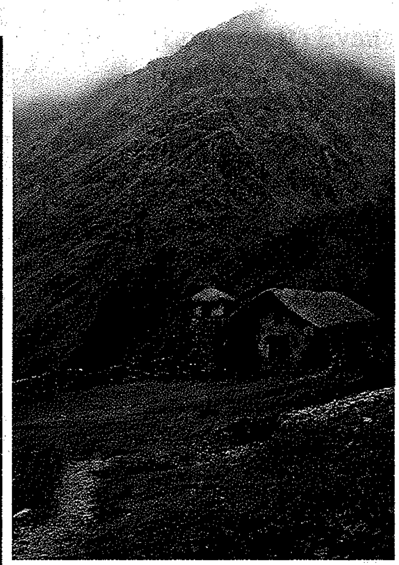




(above)The old town of Puina lies an hour walk down the valley of the Puina River, at the juncture of the waters from Supaycocha. The land is more abrupt, where the shrubs and trees of the *monte* dominate landcover. You can see the old Catholic church in the center of town.

Keara valley



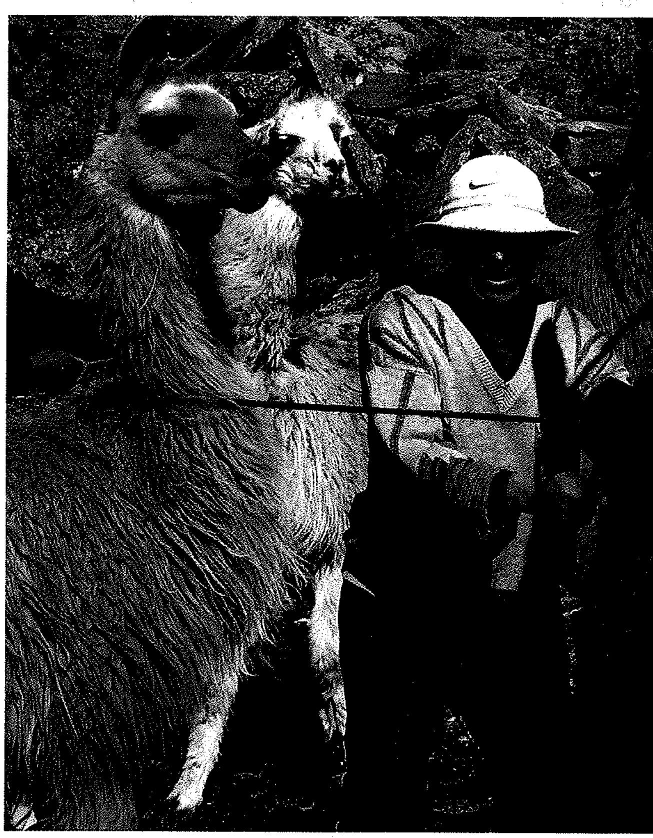


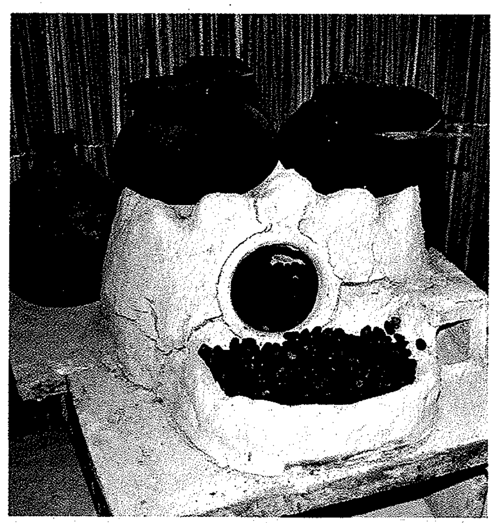
The landscape at 'new' Keara (left) is very different, more abrupt and broken without large plains. The valley is narrow and the vegetation begins in the (old) town of Keara (above) an hour walk from the current center of the town. Above is the Catholic church in Puina complete with bell and bell tower, unused and abandoned. In the (lower left) is a view of Keara antigua from the new center of Keara. Note the apparently burned upper treeline of monte vegetation on the upper portion of the photo.

Llamas and alpacas

(Below) Limber aids a newly born llama to stand while the mother watches on.

(Lower left) Evan rounds up the llamas for the trek to Puina. Their dung is valuable as a fertilizer for the canchones, rock walled fields located within close proximity to houses and also collected as as source of fuel. The traditional concha or ceramic and clay stove is shown (below) fueled with llama dung.





***Polylepis* use**

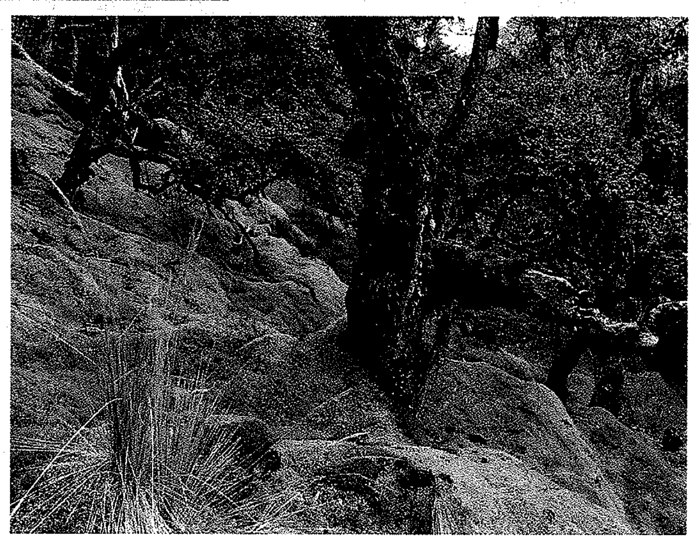
Puina and Keara is primarily for construction (top) and fuelwood (upper right and lower right) but also used in the for props in dances (lower left) in this image of the *aukie aukie* dance from the region of Charazani (taken from Oblitas Poblete 1992).

***Polylepis* conservation**

On the right is the forest of *Queñua*pata, the largest of forests surveyed in the valleys of Puina and Keara. Although trees here are stunted, rarely exceeding two meters, the forest has high seedling regeneration rates.

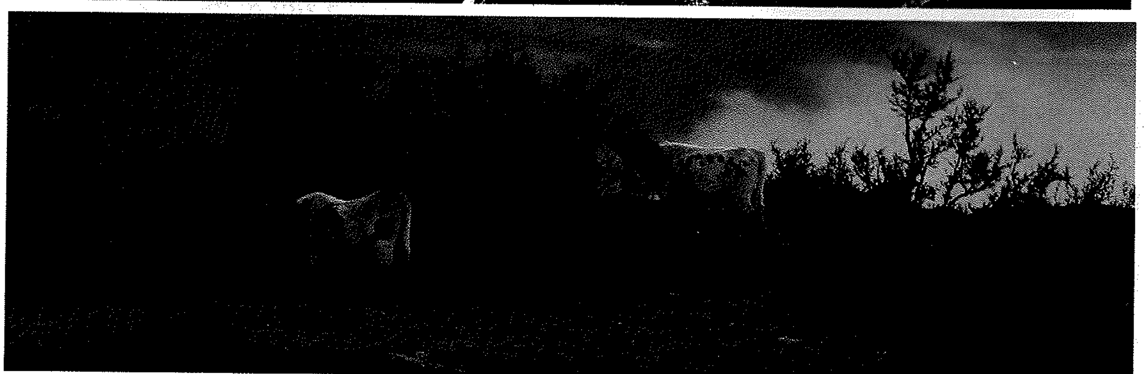
On the left is a stone walled field near a residence in Puina, The 'domesticated' *queñua* trees, *P. racemosa* border the field, supporting the wall that in turn protects the tree from excessive browsing from llamas and alpacas corralled in nearby fields.

On the right is a splendid example of a *Polylepis pepei* forest in *Queñua*ni. Parts of this patch appeared untouched from the pressures of human damage of fire, grazing and cutting. Notice the moist moss mat covering the large boulders and talus slope and the stem to tree ratio in this area being close to 1:1.

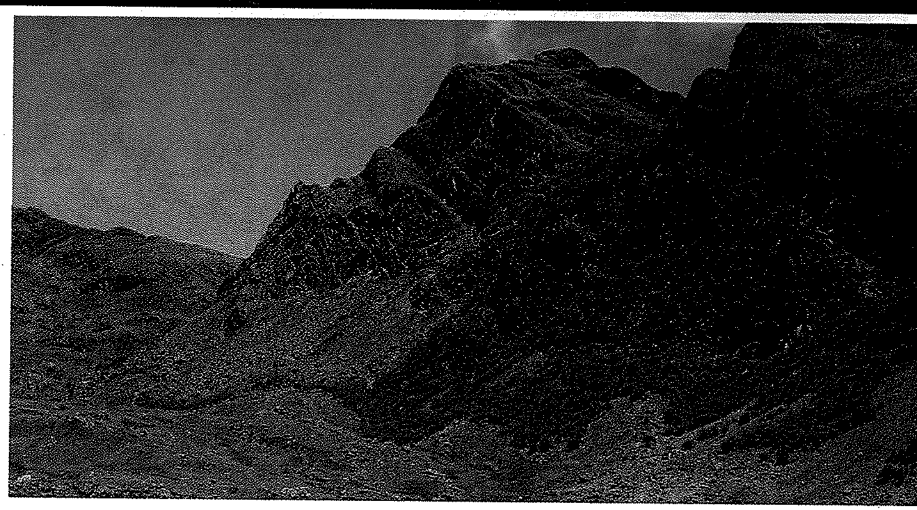


Damage to *P. pepei*

Below, in the forest of *Queñua*pata is visual evidence of all three of the anthropogenic factors of grazing, fire and cutting.



(Above) cattle are seen browsing on *P. pepei* in *Queñua*pata. On the left the restriction of *P. pepei* forests to scree and boulder slopes.

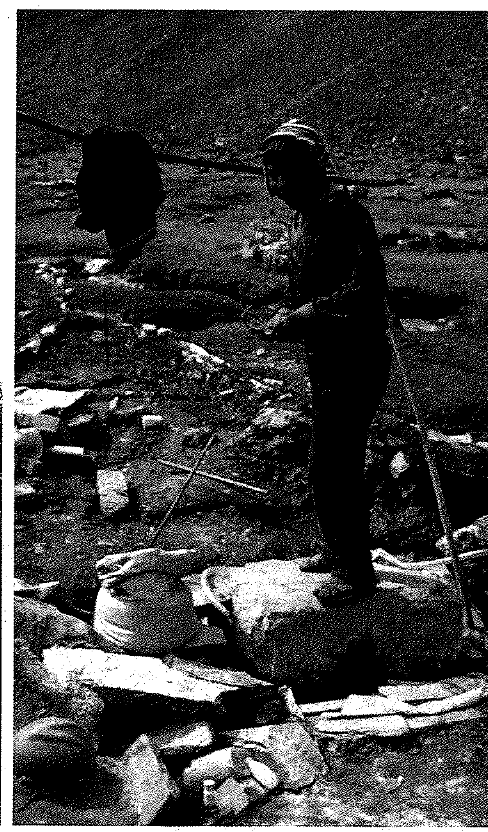


Markets and history

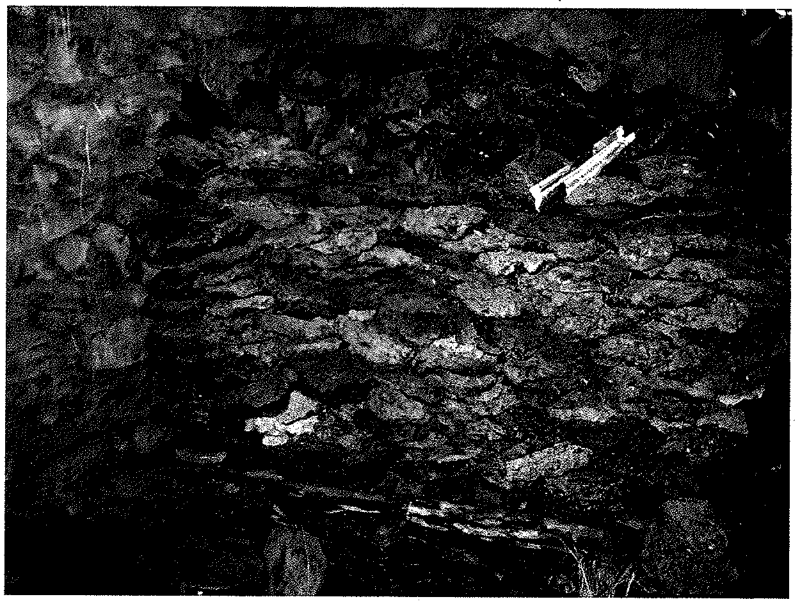
(Below) is the weekly Peruvian / Bolivian market of Huancasaya, crossing the Suchez River. According to Orlove (1977) and Schulte (1999) much of the llama wool and hides are bartered and traded for export to processing houses in Peru.

On the (bottom right) a miner from Pelechuco is using mercury to separate the gold from the ore he is crushing under the heavy rock. Water is diverted from the river in long canals to aid in this process.

On the (right) is *P. pepei* tree over 7 meters tall from the forest of Chuñuna near the community of Keara with a diameter close to 45 cm. These large diameter trees were made into charcoal and exported to Peruvian mines.



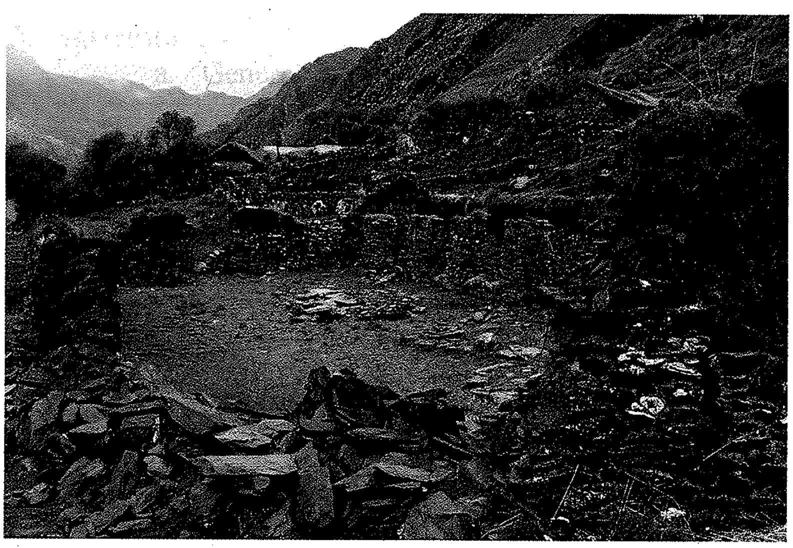
Introduced fauna

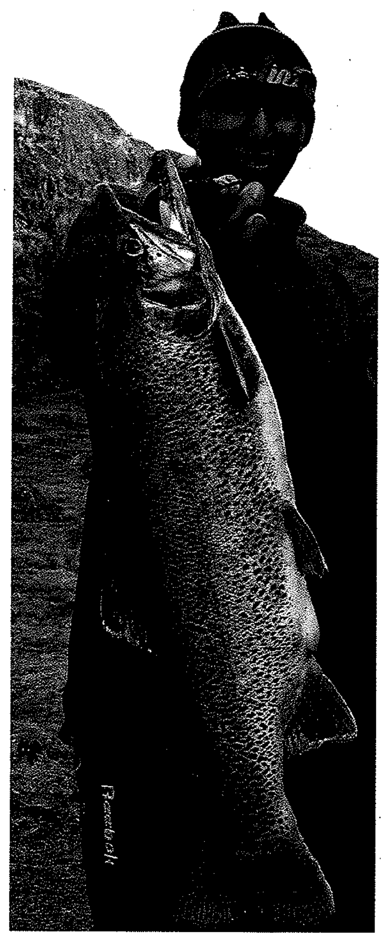


On the (left) *k'awa,* or flipped and dried cow dung is used as an alternative fuel for cooking. Collection of k'awa is done in the dry season by whole families and then transported to households when dry.

On the (far right), Limber hold a rainbow trout, introduced into the highland lakes that dot the landscape at 4500 meters.

(Below) is the corral for sheep and cattle built by hacienda owner Carlos Franke around the 1920s in the town of Keara.





APPENDIX B1: ENGLISH INTERVIEW QUESTIONS

Interview questions about the use and conservation of *Polylepis* spp. forests in the Cordillera Apolobamba

1. **General Questions, Family History and Environmental Changes**
    a) Family History
        i) When was the community founded? What was the landscape like then?
        ii) How many children do you have? Where are they now? What do they do?
        iii) Why do they not live here? Explain?
        iv) How did your parents, grandparents or others use the forest? Did they manage/extract/interact with the forest in a different way that is not practiced today in the community or by individuals?
        v) Did they teach you anything important about the forest?
        vi) Do you have more animals than your parents did? Your grandparents?
        vii) Do you have more land than your parents did? Your grandparents?
    b) Area History and forest Changes
        i) Is there more, less or the same amount of forest than before?
        ii) Are there any new forests?
        iii) Are there forests that have disappeared?
        iv) When did the change take place?
        v) Are there any historical fires?
    c) Ecosystem changes
        i) Do you think the fertility of the land is increasing, decreasing or staying the same?
        ii) Vegetation changes
        iii) Soil changes (drying up, fertility, etc.)
        iv) Climate changes (more or less rain, temperature, etc.)
        v) Are there more or less domesticated animals? What animals?
        vi) Are there more or less wild animals?
2. **Agriculture**
    a. General Info
        i. Where are the majority of fields? Names?
        ii. What crops are grown in _____________ village?
            1. Percentage of each crop?
            2. Rotation of fields? Fallow?
            3. When is each crop planted?
        iii. Where do you get / buy seeds?
        iv. Any use of pesticides/ herbicides/fungicides? Fertilizers? Do they work?
    b. Changes in yield and product
        i. Have certain fields had more success in recent years? Why do you think they have had more success?

   ii. Have certain fields dried up or are not productive? Why do you think they have been less productive?
   iii. Have the crop yield increased, decreased, or stayed the same (for each crop)?
   iv. Has there been any change in the quality, fertility of seeds?
   v. What crops have had more success in recent years? What can this be attributed to?

3. **Vision of the forest, Cultural Perspective**
   a. Spiritual View of the forest
      i. Describe different forests in the area?
      ii. When you enter one of these forests, what do you feel?
      iii. What good is the forest? Who does it serve?
      iv. May vary depending on kids, women, men
   b. Stories about the forest (Queñua forests).
      i. Stories about the forests? Or the animals that live in the forest?
      ii. Any stories about fires?
      iii. Does the forest change at all? Why is the forest constantly changing? What might be wrong/happening with the forest?
      iv. How many years has the forest existed?
      v. How old is the oldest tree in the forest?
      vi. At what age can the trees reproduce? How do they reproduce?
4. Use of *Polylepis* and other forests
   a. Firewood needs (Individual, family, community needs)
      i. How often do you collect firewood for your family? How much firewood is collected (in mule loads or kilograms)? Do you use mules?
      ii. How much firewood do you use per day? Week? Month? Year?
      iii. Do firewood needs vary throughout the year?
      iv. What wood is preferred?
      v. Where is this wood collected? Names of places? How far away is this forest, place (km)?
      vi. How much time does it take to collect the wood? Who collects it?
      vii. Is your family ever short of firewood? Why? What do you do?
      viii. What other fuels do you use in the house (gas, kerosene, cow or llama dung)? What percentage? Are these fuels used at specific times of year or for cooking or heating certain things?
      ix. How much does gas cost? Is it even available?
   b. Fire Regime (Range management)
      i. When are fires usually started? Type of fire(grass, forest, etc.)? Who starts the fires? Why? Where? Location?
      ii. When was the last fire you can remember? Type of fire(grass, forest, etc.)? Location? Who?
      iii. When was the largest fire you can remember? Type of fire(grass, forest, etc.)? Location? Who?

   iv. Can you tell how long ago an area has been burned? How?
   v. Does burning the area change the soil? Fertility? Something else?

c. Grazing patterns
   i. What domesticated animals do you own? How many? Where do they graze? When do they graze there? What do they eat?
   ii. Are domesticated animals restricted to certain areas? Why?
   iii. Are the animals healthy? Are they worse or better off than ten years ago?

d. Other uses for the forest
   i. Are any of the trees in the forest useful as medicine? As tools? For another reason?
   ii. What about herbs that are located in the forests, are they collected?
   iii. Is the Queñua used medicinally?
   iv. What are some other uses for the Queñua tree? Leaves, bark, roots, stem?

5. Conservation and Management of Forests
   a. Community vs. Individual Conservation
      i. What does conservation mean to you? Who is responsible for "conservation"?
      ii. What community conservation practices exist? What do you do personally that might be considered beneficial to the forests. Examples?
      iii. Have there been any reforestation projects? Who participated? What species? Where were they planted? Are these lands private or public? Was it successful? Why was it successful, what was accomplished?
      iv. What "projects" have focused on conservation of the forests? Other conservation "projects"? Has the National Park Madidi implemented any "projects"? NGO's?
   b. Management of the forests
      i. Who should make important decisions concerning the existing public and community lands? What role does the Park Service have in the management of these forests? NGO's? What role does the community have? The individual?
      ii. Does the system of management of public lands work? How could it be changed?

APPENDIX B2: SPANISH INTERVIEW QUESTIONS

Cuestionario y entrevista sobre el uso y conservación de los bosques de *Polylepis* spp. dentro de la Cordillera Apolobamba

(bold indicates primary questions**)**

1. Preguntas Generales: Historia Familiar, Historia Comunal, y Cambios Ambientales
   a) Historia Familiar y de la comunidad
      i) Cuando fue fundada la comunidad de ________? Como era el paisaje en este tiempo?
      ii) Como han vivido sus antepasados?
      iii) Como ha cambiado su comunidad desde el tiempo de sus abuelos? Se ha mejorado? O es peor que antes?
   b) Visión hacia el futuro
      i) Ud. Cree que la vida de sus hijos será mejor o peor de la de Ud?
      ii) Que pasar'a con la comunidad dentro de 5 anos, 10 anos, 20 anos?
      iii) Que mas necesita la gente en la comunidad de ___________? Como se puede mejorar la vida de la gente aquí?
      iv) Que pasará con los bosques?
   c) De la familia
      i) Cuantos hijos tienes? Sus edades? Donde están viviendo? Que hacen ellos?
      ii) Como han usado la tierra antes? Sus padres o sus abuelos hacían cosas diferentes que ahora? Como fue su relación con el medioambiente? Los bosques?
      iii) Se han enseñado algo importante sobre los bosques o el medioambiente?
      iv) Como ha cambiado la posesión de la tierra desde esta tiempo?
      v) Ud. tiene mas o menos tierra de sus padres? Sus abuelos? Porque?
   d) Cambios ecológicos
      i) Había cambios en el clima? Mas o menos lluvia? Es mas o menos frió que antes?
      ii) Había cambios en la vegetación?
      iii) Ud. piensa que la fertilidad de la tierra ha cambiado? Aumento, disminuyo, o es igual?
      iv) Había cambios en la humedad de la tierra? Es mas seco? Mas húmedo?
      v) Hay mas o menos animales domésticos que hace 20 anos? Cual animales?
      vi) Hay mas o menos animales silvestres que hace 20 anos?
   e) Cambios en los bosques
      i) Hay mas, menos o igual área de bosques ahora que hace 40 anos? Y en estos bosques, hay mas, menos árboles que antes?
      ii) Hay bosques que recién han aparecidos?
      iii) Hay bosques que ha desaparecidos en este tiempo?
      iv) Cuando ha ocurrido este cambio en el bosque? Porque?
   f) De bosques de Queñua
      i) Cuantos anos puede existir un bosque? Un arbol?
      ii) Que edad tiene el árbol mas viejo en el bosque?

iii) Que edad tiene un arbol (de tamaño de mis manos)?
iv) Hasta que altura llega un arbol de queñua?
v) De que ano puede reproducir un árbol de queñua? Como se reproducen?
vi) Cuando mueren, que planta o árbol ocupa su lugar?

2) Agricultura
a) Información General
i) Donde están las chacras de la comunidad? Y los nombres de los lugares?
ii) Que siembran en la comunidad de _____________?
(1) Que porcentaje de cada sembradillo?
(2) Ud. Hace rotar las chacras? Hay rotación comunal? Se dejan descansar la tierra por un tiempo? Por cuanto tiempo?
(3) Cuando siembran (Papa, arbeja, haba, maíz, cebada, etc.)?
iii) Donde consigan/ compran la semilla? Son garantizados?
iv) Ud. Usa químicos / pesticidas? Fertilizantes? Funcionan?
b) Cambios en la cosecha y producto
i) Existen algunas chacras que siempre producen mas? Porque es así?
ii) Existen algunas chacras que siempre producen menos? Porque?
iii) La cosecha es mas, menos o igual que antes (Papa, arbeja, haba, maíz, cebada, etc.)?
iv) Había cambios en la fertilidad de las semillas? Lo consigues en el mismo lugar de antes?
v) *Que producto han tenido mas éxito en los últimos anos? Porque?*

3) ***Visión del Bosque y Perspectiva Cultural***
a) Cuentos y leyendas del bosque (bosque de Queñua).
i) Cuando entras al bosque, que sientes? Porque?
ii) Existen cuentos del bosque? Me puedas contar
iii) Existen cuentos de los animales que viven en los bosques?
iv) De gente que han vivido dentro del bosque hace muchos anos?
v) *Hay cuentos de encendeos?*

4) Uso de *Polylepis* y otros arboles
a) General de bosques
i) Cuantas veces al año vayas al bosque?
ii) Que haces en el bosque?
iii) Para que sirve el bosque? De quien pertenece?
iv) Cuales son los tipos de bosque que existen aquí?
v) Cual es la diferencia entre los arboles de queñua sembrados y natural?
vi) Como es la diferencia entre lampaya y queñua?
vii) Hay otros nombres que usan para la queñua?
b) Necesidades de leña (Individuo, familia, y la comunidad)
i) Cuando cortas leña para su familia? Como recolectas, con mula o solo? Cuantos kilos traes cada vez? Cuantas cargas en mula?
ii) Donde fue para su último viaje para recolectar leña?

iii) **Que puedas utilizar en vez de leña (gas, kerosén, bostas de vaca o llama)? Que porcentaje? Son utilizados para ciertas actividades o durante una temporada?**
iv) **Que porcentaje de leña contra bostas de vaca usas?**
v) Cuanta leña usas diaria? Semanal? Mensual? Anual?
vi) El uso de la leña varia? Se usa mas durante algunas temporadas?
vii) **Que leña es preferido? Hay alguna que quema mejor? Primero, segundo, tercero, otros? Porcentajes?**
viii) **Donde se recolecta la leña? Como se llaman los lugares? A cuantos kilómetros es el localidad (Km.)?**
ix) **Que tiempo necesitas para ir, colectar y regresar? Se puede combinar esta actividad con otros actividades? Quien haga la recolecta?**
x) Cuando falta leña, donde vas para recolecterla?
xi) Cuanto cuesta el gas? Esta disponible el gas? De quien compres el gas?

c) Manejo por encendeos (manejo del paisaje)
i) **Cuando hacen el chaqueo? Se utiliza el fuego? Que se quema? Quien? Porque? Donde? Locaciones?**
ii) Cuando fue la ultima incendio que se puede acordar? Que se quema? Quien? Porque? Donde? Locaciones?
iii) Cuando fue la mas grande incendio que se puede acordar? Que se quema? Quien? Porque? Donde? Locaciones?
iv) Se puede notar hace cuanto tiempo fue quemada un terreno? Como?
v) **El fuego puede cambiar de alguna manera el suelo? La fertilidad? Algo mas?**

d) El pastoreo
i) Que animales tienes? Cuantos? Donde pastorean? Cuando pastorean allí? Siempre quedan allí? Que comen?
ii) **Ud. tiene mas o menos animales domésticos que sus padres? Cuales animales? Sus abuelos?**
iii) Hay localidades donde no permitan que los animales domesticados entran? Donde? Porque no son permitidos?

e) Otros usos del bosque de queñua
i) **Cuales son los otros usos para la Queñua? Las hojas, la cáscara, el tronco, los raíces?**
ii) Hay otros árboles que son utilizados para la medicina? Y como herramientas? Por otras razones?
iii) Existan hierbas o plantas que se colecta en los bosques de Queñua? Para que se usan?
iv) Se utiliza la queñua como medicina?

5) Conservación y Manejo de los Bosques de Queñua
a) Conservación comunal y individual
i) **Que significa la conservación para Ud.? Quien es responsable para la conservación de los bosques?**

ii) Que hace la comunidad para conservar el bosque? Y que ha hecho Ud. Personalmente? Ejemplos?

iii) Había proyectos de reforestación? Quien ha implementado el proyecto? Quien ha participado? Que especias han utilizado? Donde lo han sembrado? Son tierras privadas o publicas? Fue exitoso? Porque? Que han hecho o no han hecho?

iv) Hay o había proyectos de "conservación" de los bosques? Había otros "proyectos"? Que "proyectos" ha hecho el Parque Nacional? ONG's? Que deberían hacer ellos?

v) Quien decide lo que pasa con las tierras comunales, individuales? Que papel tiene el Parque Nacional en el manejo de las tierras? Y los ONG's? Que papel tiene la comunidad? Y individuos?

vi) Esta funcionando el sistema de manejo de las tierras? Como tiene que cambiarlo para mejorar?

Appendix C: Forest Mapping

Forest Number:____________

Researcher:____________________ Date:____________________

Distribution and current forest stand structure of *Polylepis* spp. forest patches within the Apolobamba Mountains of West-Central Bolivia

Description of *Polylepis* spp. patch

Location: Bolivia; Department La Paz;

Provincia,________________________

____

Coordinates:__________________________Elevation

Range:______________

Aspect:________________________Percent

slope:________________________

Area:__________________________ Average elevation of

Polylepis:__________

Sketch of visible characteristics of *Polylepis* spp. forest patch

a) Presence of rocky zone ( ), bodies of water ( ), and open areas ( )
b) GPS coordinates
c) Vegetation characteristics
d) Location of roads, trails and other human influence
e) Observable damage to vegetation
    a) fire(f), grazing (g), cutting (c)
    b) none (0), low (1), medium (2), high (3)

Description of vegetation:

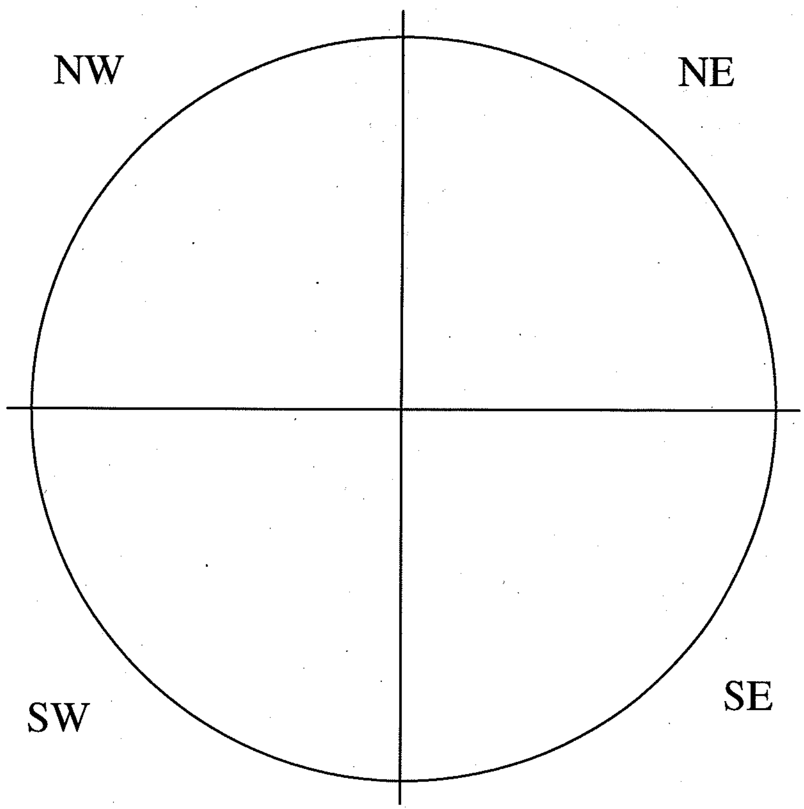
Species of *Polylepis*:______________________ % of *Polylepis* coverage:________
% overstory coverage:______________________% coverage of rocks:_______________
% coverage bare ground:_______% coverage of other woody vegetation:__________

APPENDIX D: INDIVIDUAL PLOT INFORMATION

Forest Number:_____________
Test Plot Number / Total test plots within forest:____________
Researcher:______________________________Date:_____________________

Polylepis spp. forest stand structure: Test Plot Information
All plots are 10m by 10m and subdivided into four quadrats(NE, SE, SW, NW)

1) Analysis of trees within the plot (common name, species, DBH, height)
2) Saplings and seedlings (species and number)
3) Density of canopy (%) and canopy coverage for each tree (m2)
4) Herbs (location, % coverage, grass vs. forbs)
5) Observable damage to vegetation
    a) fire(f), grazing (g), cutting (c)
    b) none (0), low (1), medium (2), high (3)
    c) number of dead stems



Observations:____
____

Appendix E: GPS coordinates

Forest	Waypoint	Latitude	Longitude	Elevation
Other waypoints	Pablo's house	14°41'22.81"S	69° 6'24.63"W	3950
	Paso Sanchez	14°44'58.76"S	69° 6'43.30"W	4808
	Keara Antigua	14°42'13.10"S	69° 5'16.10"W	3474
	Keara	14°41'38.80"S	69° 6'5.30"W	3830
	Puinapampa	14°36'18.11"S	69° 7'13.24"W	3697
	Puina	14°36'40.11"S	69° 8'13.39"W	3840
	Lampaya2	14°35'9.71"S	69° 6'32.26"W	3423
	Lampaya 1	14°34'56.75"S	69° 6'29.34"W	3482
	Monte	14°34'39.12"S	69° 6'2.27"W	3367
	Qwhouse	14°33'35.37"S	69° 7'25.99"W	4012
	PELECHUCOplaza	14°49'7.96"S	69° 4'15.30"W	3623
	Makara	14°47'0.10"S	69° 5'40.90"W	4080
	Evan's	14°37'35.00"S	69° 9'18.00"W	3968
#1 Queñuapata	QP1	14°36'44.97"S	69° 8'49.99"W	4114
	QP2	14°36'39.76"S	69° 8'55.74"W	4169
	QP3	14°36'39.04"S	69° 8'53.09"W	4217
	QP4	14°36'36.22"S	69° 8'54.47"W	4292
	QP5	14°36'31.41"S	69° 8'54.75"W	4256
	QP6	14°36'29.04"S	69° 8'54.16"W	4312
	QP7	14°36'28.73"S	69° 8'56.12"W	4333
	QP8	14°36'28.22"S	69° 8'58.03"W	4309
	QP9	14°36'27.35"S	69° 8'58.99"W	4284
	QP10	14°36'39.20"S	69° 8'56.07"W	4223
	QP11	14°36'38.05"S	69° 8'53.17"W	4239
	QP12	14°36'36.24"S	69° 8'54.05"W	4294
	QP13	14°36'30.02"S	69° 8'53.06"W	4301
	QP16	14°36'16.54"S	69° 8'55.94"W	4401
	QP17	14°36'15.12"S	69° 8'54.59"W	4440
	QP18	14°36'14.09"S	69° 8'52.14"W	4500
	QP19	14°36'16.62"S	69° 8'51.76"W	4512
	QP20	14°36'19.72"S	69° 8'50.31"W	4495
	QP21	14°36'24.81"S	69° 8'47.14"W	4461
	QP22	14°36'29.20"S	69° 8'47.99"W	4445
	QP23	14°36'30.91"S	69° 8'51.42"W	4338
	QP24	14°36'39.04"S	69° 8'51.34"W	4262
	QP25	14°36'38.44"S	69° 8'50.22"W	4267
	QP40	14°36'33.80"S	69° 8'52.90"W	4354
	QP41	14°36'34.20"S	69° 8'50.50"W	4392
	QP42	14°36'32.70"S	69° 8'50.70"W	4370
	QP43	14°36'35.40"S	69° 8'57.90"W	4324
	QP44	14°36'28.00"S	69° 9'2.80"W	4347
	QP45	14°36'25.40"S	69° 9'3.40"W	4378

	QP46	14°36'24.10"S	69° 9'0.90"W	4388
	QP47	14°36'22.00"S	69° 9'0.40"W	4379
	QP47a	14°36'22.00"S	69° 9'1.10"W	4397
	QP48	14°36'19.00"S	69° 9'1.90"W	4408
	QP49	14°36'16.10"S	69° 9'3.00"W	4401
	QP50	14°36'17.90"S	69° 9'0.70"W	4415
	QP51	14°36'22.10"S	69° 8'57.60"W	4430
	QP52	14°36'21.80"S	69° 8'56.80"W	4432
	QP53	14°36'15.90"S	69° 9'0.10"W	4434
	QP54	14°36'16.60"S	69° 8'56.80"W	4423
	QP55	14°36'15.00"S	69° 8'59.30"W	4433
	QP56	14°36'15.80"S	69° 8'56.00"W	4439
	QP57	14°36'19.00"S	69° 8'55.10"W	4437
	QPplot1	14°36'26.20"S	69° 8'54.40"W	4364
	QPplot2	14°36'25.30"S	69° 8'49.80"W	4382
#2 Lampayani	77	14°41'6.61"S	69° 6'5.90"W	4063
	78	14°41'0.84"S	69° 6'1.71"W	4107
	79	14°40'57.78"S	69° 6'1.36"W	4122
	103	14°40'41.52"S	69° 6'21.83"W	4191
	104	14°40'40.02"S	69° 6'26.72"W	4255
	L40	14°40'50.10"S	69° 6'10.00"W	4116
	L41	14°40'47.30"S	69° 6'10.20"W	4135
	L42	14°40'44.40"S	69° 6'12.10"W	4155
	L43	14°40'42.00"S	69° 6'13.70"W	4164
	L44	14°40'51.90"S	69° 6'9.20"W	4119
	L50	14°40'38.60"S	69° 6'16.80"W	4209
	Lplot1	14°40'51.47"S	69° 6'7.19"W	4126
	Lplot2	14°40'48.78"S	69° 6'8.93"W	4120
#3 Kalachaka	K1	14°36'34.61"S	69° 6'10.45"W	4184
	K2	14°36'34.04"S	69° 6'9.12"W	4190
	K3	14°36'33.37"S	69° 6'7.48"W	4194
	K4	14°36'32.12"S	69° 6'6.33"W	4204
	K5	14°36'31.03"S	69° 6'4.85"W	4234
	K6	14°36'29.41"S	69° 6'5.83"W	4267
	K7	14°36'28.12"S	69° 6'6.31"W	4280
	K8	14°36'27.57"S	69° 6'4.88"W	4295
	K9	14°36'27.46"S	69° 6'4.24"W	4305
	K10	14°36'27.04"S	69° 6'2.94"W	4328
	K11	14°36'27.01"S	69° 6'1.59"W	4276
	K12	14°36'28.48"S	69° 6'2.02"W	4251
	K13	14°36'29.20"S	69° 6'4.33"W	4252
	K14	14°36'30.32"S	69° 6'1.10"W	4227
	K15	14°36'29.54"S	69° 6'3.76"W	4220

	K16	14°36'30.72"S	69° 5'59.63"W	4229
	K17	14°36'31.96"S	69° 5'59.17"W	4258
	K18	14°36'30.61"S	69° 5'58.19"W	4238
	K19	14°36'30.71"S	69° 5'57.54"W	4235
	K20	14°36'31.49"S	69° 5'57.34"W	4222
	K21	14°36'32.30"S	69° 5'58.64"W	4227
	K22	14°36'28.94"S	69° 5'57.82"W	4243
	K25	14°36'33.51"S	69° 6'11.55"W	4210
	K26	14°36'33.19"S	69° 6'11.72"W	4210
	Kplot1	14°36'32.80"S	69° 6'8.10"W	4217
	Kplot2	14°36'28.70"S	69° 6'2.90"W	4256
#4 Quecara Chica	QC1	14°39'6.21"S	69° 5'14.75"W	4177
	QC2	14°39'5.58"S	69° 5'14.01"W	4171
	QC4	14°39'3.13"S	69° 5'10.90"W	4197
	QC3	14°39'3.33"S	69° 5'14.12"W	4186
	QC5	14°39'7.15"S	69° 5'15.18"W	4179
	QC6	14°39'5.20"S	69° 5'12.18"W	4187
	QC10	14°39'2.10"S	69° 5'9.13"W	4262
	QC11	14°39'0.48"S	69° 5'8.25"W	4241
	QC12	14°38'59.81"S	69° 5'7.07"W	4279
	QC13	14°38'58.79"S	69° 5'7.49"W	4299
	QC14	14°38'57.91"S	69° 5'9.51"W	4330
	QC15	14°38'57.14"S	69° 5'9.74"W	4339
	QC16	14°38'55.12"S	69° 5'10.70"W	4359
	QC17	14°38'55.19"S	69° 5'12.74"W	4366
	QC18	14°39'4.56"S	69° 5'3.80"W	4277
	QC40	14°39'5.60"S	69° 5'12.10"W	4254
	QC41	14°39'8.70"S	69° 5'7.70"W	4263
	QC42	14°39'3.20"S	69° 5'5.90"W	4313
	QC43	14°39'4.90"S	69° 5'4.00"W	4310
	QC44	14°39'4.70"S	69° 5'2.80"W	4314
	QC45	14°39'1.20"S	69° 5'1.10"W	4352
	QC46	14°39'6.90"S	69° 4'56.90"W	4287
	QC47	14°39'11.30"S	69° 4'47.30"W	4237
	QC48	14°39'17.70"S	69° 4'38.50"W	4147
	QCplot1	14°39'4.10"S	69° 5'12.90"W	4205
	QCplot2	14°39'2.60"S	69° 5'12.80"W	4218
	Qcview	14°39'6.30"S	69° 5'13.60"W	4251
#5 Chuñuna	68	14°41'6.82"S	69° 5'36.14"W	4107
	69	14°41'2.48"S	69° 5'44.15"W	4126
	70	14°41'0.95"S	69° 5'45.45"W	4280
	71	14°41'0.43"S	69° 5'44.65"W	4300
	72	14°41'0.08"S	69° 5'42.24"W	4285

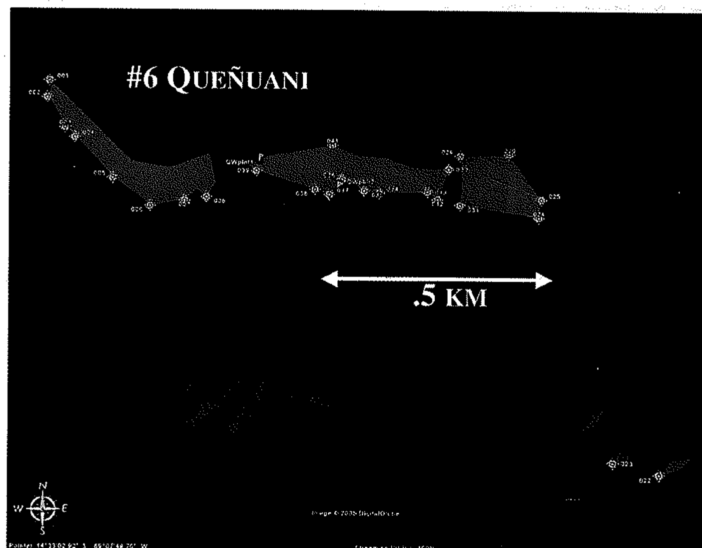
	73	14°41'0.32"S	69° 5'39.03"W	4263
	CH1	14°41'5.75"S	69° 5'34.89"W	4116
	CH2	14°41'5.66"S	69° 5'34.38"W	4105
	CH3	14°41'6.56"S	69° 5'33.00"W	4113
	CH4	14°41'4.73"S	69° 5'32.20"W	4096
	CH5	14°41'4.53"S	69° 5'30.83"W	4116
	CH6	14°41'2.59"S	69° 5'31.81"W	4088
	CH7	14°41'3.19"S	69° 5'34.73"W	4108
	CH40	14°41'12.70"S	69° 5'32.90"W	4069
	CH41	14°41'11.10"S	69° 5'34.90"W	4093
	CH42	14°41'8.40"S	69° 5'32.40"W	4077
	CHplot1	14°41'4.70"S	69° 5'33.80"W	4124
	CHplot2	14°41'3.30"S	69° 5'38.10"W	4177
#6 Queñuani	9	14°33'25.23"S	69° 7'26.16"W	4041
	10	14°33'24.46"S	69° 7'25.60"W	4044
	11	14°33'25.13"S	69° 7'25.10"W	4039
	12	14°33'26.79"S	69° 7'24.69"W	4016
	13	14°33'28.55"S	69° 7'23.07"W	4007
	14	14°33'28.90"S	69° 7'22.18"W	4003
	15	14°33'31.95"S	69° 7'19.34"W	3997
	16	14°33'33.30"S	69° 7'17.49"W	4004
	17	14°33'34.21"S	69° 7'15.11"W	4018
	18	14°33'33.45"S	69° 7'15.03"W	4024
	19	14°33'31.14"S	69° 7'14.36"W	4023
	20	14°33'32.82"S	69° 7'17.76"W	4006
	22	14°33'18.43"S	69° 7'25.77"W	4159
	23	14°33'17.56"S	69° 7'29.29"W	4108
	24	14°32'57.96"S	69° 7'35.22"W	4138
	25	14°32'56.57"S	69° 7'35.02"W	4140
	26	14°32'53.04"S	69° 7'37.59"W	4138
	29	14°32'53.19"S	69° 7'41.55"W	4200
	30	14°32'54.21"S	69° 7'42.48"W	4191
	31	14°32'57.02"S	69° 7'41.55"W	4121
	32	14°32'56.57"S	69° 7'43.36"W	4123
	33	14°32'55.99"S	69° 7'44.18"W	4153
	34	14°32'56.11"S	69° 7'48.06"W	4129
	35	14°32'55.91"S	69° 7'49.26"W	4140
	36	14°32'55.02"S	69° 7'51.01"W	4150
	37	14°32'56.21"S	69° 7'52.04"W	4179
	38	14°32'55.82"S	69° 7'53.19"W	4185
	39	14°32'54.37"S	69° 7'57.89"W	4187
	41	14°32'52.36"S	69° 7'51.82"W	4163
	QW1	14°32'47.42"S	69° 8'14.46"W	4304
	QW2	14°32'48.75"S	69° 8'14.63"W	4315

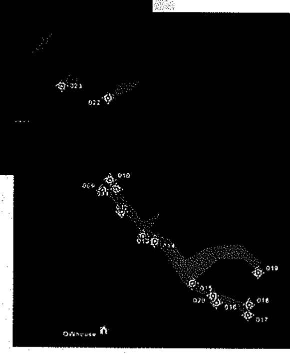
	QW3	14°32'51.05"S	69° 8'13.20"W	4298
	QW4	14°32'51.82"S	69° 8'12.41"W	4205
	QW5	14°32'54.97"S	69° 8'9.36"W	4251
	QW6	14°32'57.13"S	69° 8'6.37"W	4230
	QW7	14°32'56.71"S	69° 8'3.64"W	4162
	QW8	14°32'56.42"S	69° 8'1.89"W	4216
	QW9	14°32'54.37"S	69° 7'57.89"W	4018
	QWplot1	14°32'53.40"S	69° 7'57.58"W	4146
	QWplot2	14°32'55.55"S	69° 7'51.27"W	4159
#7 Tolocacocha	111	14°41'9.51"S	69° 5'19.68"W	4081
	112	14°41'6.48"S	69° 5'22.95"W	4227
	113	14°41'5.49"S	69° 5'21.42"W	4260
	116	14°41'9.72"S	69° 5'14.91"W	4079
	117	14°41'5.01"S	69° 5'15.38"W	4175
	118	14°41'12.60"S	69° 5'14.39"W	4022
	119	14°41'13.47"S	69° 5'15.38"W	4018
	Tplot1	14°41'9.16"S	69° 5'19.32"W	4076
	Tplot2	14°41'9.83"S	69° 5'16.29"W	4044
#8 Supay Cocha	88	14°43'44.25"S	69° 4'21.32"W	4036
	89	14°43'42.96"S	69° 4'17.98"W	4074
	90	14°43'45.99"S	69° 4'16.77"W	4091
	91	14°43'47.36"S	69° 4'13.68"W	4162
	92	14°43'44.97"S	69° 4'5.84"W	4330
	94	14°43'42.59"S	69° 4'22.46"W	4017
	95	14°43'40.49"S	69° 4'22.79"W	4005
	Scplot1	14°43'44.90"S	69° 4'21.20"W	4023
	SCplot2	14°43'38.19"S	69° 4'21.40"W	4017

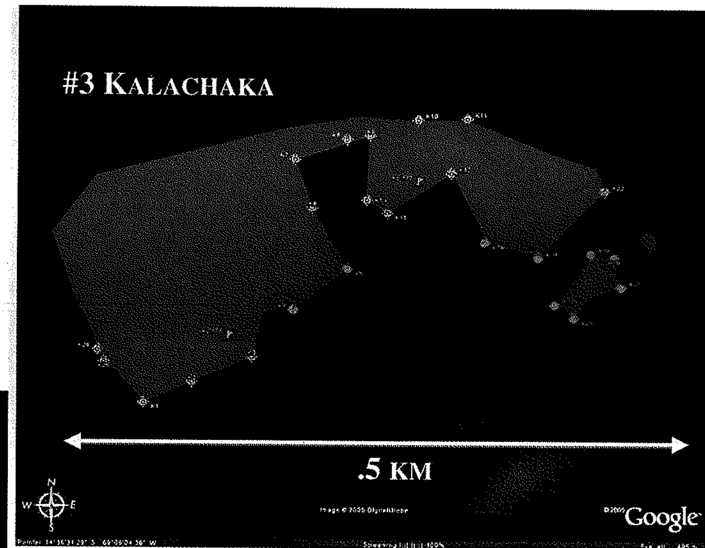
APPENDIX F: DGH DISTRIBUTION BY PLOT

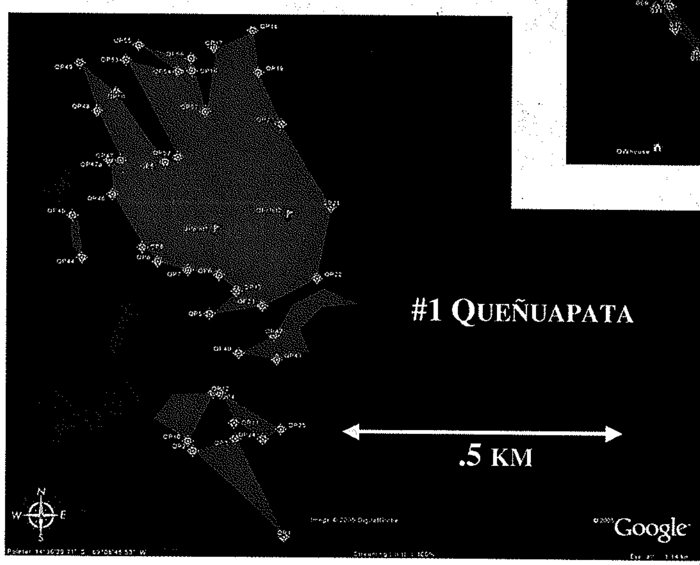
Quenuapata 1	Quenuapata 2	Lampayani 1	Lampayani 2	Kalachaka 1	Kalachaka 2	Quecara chica 1	Quecara chica 2	Chuñuna 1	Chuñuna 2	Queñuani 1	Queñuani 2	Supaycocha 1	Supaycocha 2	Tolocacocha 1	Tolocacocha 2
5	2.7	18	5.2	8.5	3	19	33	3	2.5	21	4.5	11	5.9	29.3	6.2
5.5	2.8	10	12	5.6	6.6	16	11	20	36	5	6.8	5.8	8.5	6.2	3.4
3.8	2.7	3	9.2	9.3	3	6	18	11	20	6.1	28	3.2	7.5	2.5	4
2.7	3.7	37	9.2	7.5	3	32	14	43	3.7	12	8.5	4.2	5.6	3	3.2
4.9	3.1	11	12	2.6	3.7	4.8	5.8	41	44	5	3.4	5	4.2	26.6	9.2
2.5	2.5	18	17	4.2	3.2	5.2	16	11	6.2	5.8	7	3.8	2.5	26.9	4.2
4	2.9	12	4.5	4.9	4.5	6.1	20	27	16	8.4	10	14	2.6	19.3	19.5
3.5	2.9	29	5.9	2.8	9.2	8	16	17	4.1	3	8.3	8.5	2.8	30	6.9
4.1	2.8	11	9.9	2.5	2.5	5.3	2.8	16	2.5	4.3	11	2.8	2.6	9	4.5
3.9	2.9	3.8	4.9	3.8	2.5	27	20	25	4.1	4.3	5.8	4.5	9.6	27	3
2.5	2.6	5.6	5.3	2.7	2.9	3.3	38		4.3	5.6	7.9	11	2.5	13.8	11.6
8.2	3.2	2.5	14	9.6	2.5	4.2	22		18	5.9	10	4.3	2.7	3.7	4.2
5.5	3.6		9.3	2.5	3.6	16	11		4.2	5.1	10	5.2	2.8	2.5	16.8
5.4	3.7			3.9	6.8	17	11		2.8	4.2	7.2	14	3		34.5
3	2.5			5.3	2.9	4.8	11		4.8	2.8	2.6	4.5	7.3		23.9
3.3	2.7			2.8	3.2	3	4.8			3.1	6.3	4.8	4.8		29
3.1	4.5			4.2	3.2	4	10			5.2	6.2	5.5	5.2		10.7
2.8	2.9			7.9	4	3.2	19			2.6	8.5	3.8	9.2		8.2
5.3	3			6.1	3.5	2.8	11			39	2.6	5.6	2.5		29.5
3.2	3			3	6	2.8	13			8	5.7	4.2	5		56.5
3.5	3.1			4.2	10	4.8	10			5.3	3.5		5.5		4.8
3.1	3.5			3.5	2.5	2.9	23			5.3	11		4.2		3.8
3.8	3.7				2.5	12	8.5			4.5	11		6.9		3
4.1	3.5				4.5	2.6	12			5	31				10.2
2.5	3.8				2.5	5.5	4.8			7.5	4.3				2.5
4	3				2.7	3	3.5			4.1	5.3				
4.9	2.6				5.2	3.6	12			3.5	5				
2.6	2.9				2.8	2.9	9			3.2	2.6				
2.8	3.2				5					7.8	8.3				
5.2	3.4				4.4					8.4	4.5				
3.6	6.4				4					5.5	3.8				
6	4				3.1					3	6.1				
3	4.7				3.4					2.5	3.6				
2.6	3.8				2.6					2.8					
2.6	5				2.5					3.8					
2.8	2.9				2.5					11					
3	3.1				2.6					5.3					
3.1	2.5				3.5					7.8					
3	2.5				3					7.8					
3.1	3.9				2.8					5.3					
3.5	4				3					6					
3.2	2.6				2.7					3					
4.2	2.6				3.2					3.5					
5.3	5.6				2.6					2.6					
2.8	4.1				3.9					4.1					
4.2	2.9				2.5					4.4					
4.9	2.6				2.8					4.3					
7.5	3.9				5.2					3.2					
4.8	2.5				4.4					3					
2.8	3.7				3					3.5					
3.5	3.6				2.6					4					
	3				4.1					3.8					
	4				3.1					3.4					
	2.5				2.8					3.5					
	3.7				4.1					7.2					
	2.6				5					3.2					
	4				3.5					3.4					
	2.5				7.4					5					
	2.9				3.1					4.7					
	2.8				4.5					3					
	2.9				3.4					4.8					
	4.9				3.2										
	2.5														
	2.6														
	2.6														
	4														

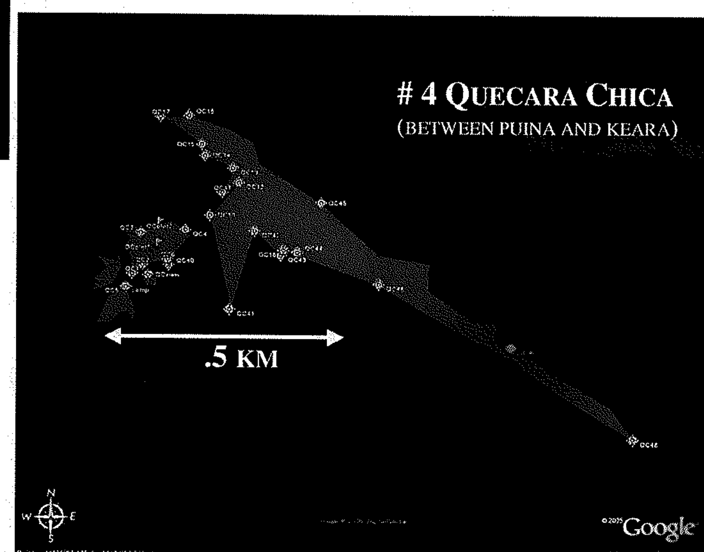
Appendix G1: Puina Forest Maps



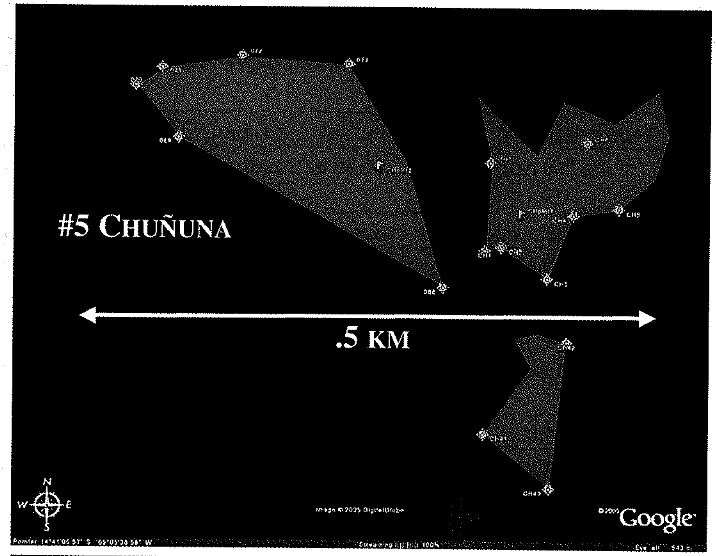


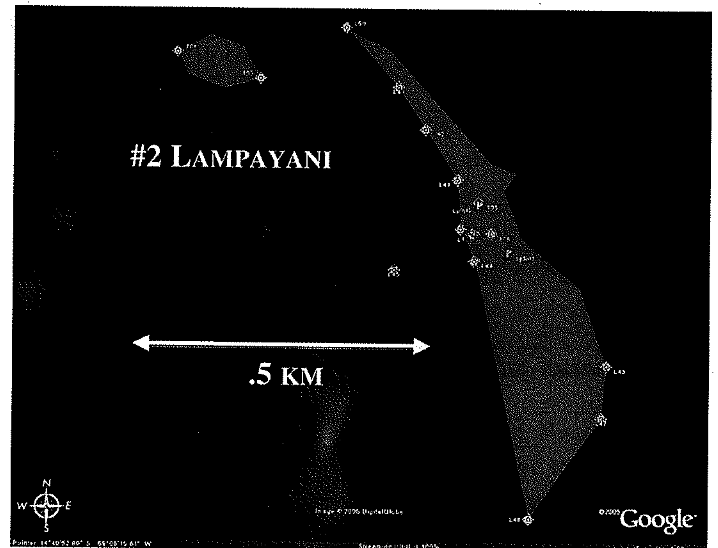


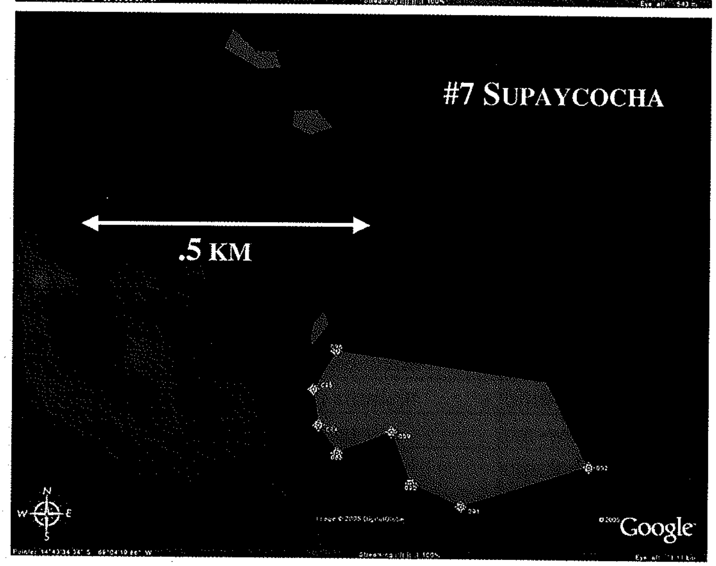


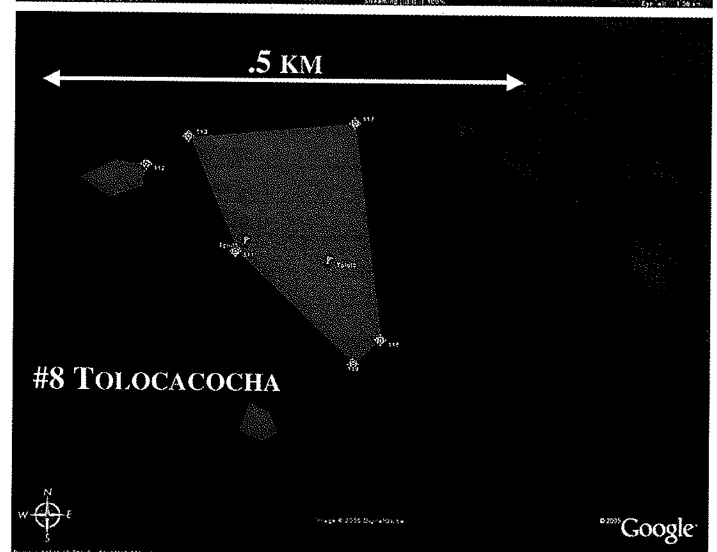


APPENDIX G2: KEARA FOREST MAPS









APPENDIX H: BIRDLIST

Birds: fieldtrip to Pelechuco, Puina and Keara: Sept. 5-Nov 14, 2004 (surveyed by Isabel Gómez **and Daniel Hagaman 2004)**

	FAMILY	***Scientific Name***	**English Name**	**Quechua/Spanish Name**	**Location**
1	Anatidae	*Chloephaga melanoptera*	Andean goose	**huallata**, wallata	rio en Puina, Keara
2	Anatidae	*Merganetta armata*	torrent duck	**chullumpi(e)**, chollompe, chullumpe	rio en Puina, Keara
3	Anatidae	*Lophonetta specularioides*	crested duck	**pato,** pato kancana	Kankani, Ulla Ulla
4	Anatidae	*Anas flavirostris*	speckled teal	kankana pato, pato	rio en Puina, Keara
5	Anatidae	*Oxyura jamaiciensis*	ruddy duck	pariwana puka, puka chullumpi, pato, kancana pato	Kankani
6	Threskiornithidae	*Plegadis ridgwayi*	puna ibis	**chawancara,** chawanquera, yana kake, ch´awanquira	rio en Puina, Keara
7	Threskiornithidae	*Theristicus melanopis*	black-faced ibis	**k´aque**, khaque, kake, q´aqe	rio en Puina, Keara
8	Cathartidae	*Coragyps atratus*	black vulture	chonquera, junin condor	**not seen on trip 2
9	Cathartidae	*Vultur gryphus*	Andean condor	**condor,** mallku	Queñuani, Supaycocha, camino Keara-Pelechuco-Puina
10	Accipitridae	*Buteo polyosoma*	red-backed hawk	**anka,** maman anka, jatun anka	camino a Queñuani
11	Falconidae	*Phalcoboenus megalopterus*	mountain kara kara	**halcamari,** maria, allkamare, alcamari	Keara, Puina, everywhere
12	Rallidae	*Fulica ardesiaca*	slate-colored coot	**ahuya,** ahueya, ayoya	Kankani, Ulla Ulla
13	Charadriidae	*Vanellus resplendens*	Andean lapwing	**leq´e leq´e,** leque leque	Ulla Ulla, Pelechuco
14	Laridae	*Larus serranus*	Andean gull	**kellua,** khellula, killua	Keara, Puina, Pelechuco
15	Apodidae	*Aeronautes andecolus*	Andean swift	**silu silu**	Keara, Puina, Pelechuco
16	Trochilidae	*Oreotrochilus estella*	Andean hillstar	**luli,** loli	Keara, Puina, Pelechuco
17	Trochilidae	*Pterophanes cyanopterus*	great sapphirewing	**luli,** loli	Keara, Puina, Pelechuco
18	Trochilidae	*Metallura aeneocauda*	scaled metaltail	**luli,** loli	Keara, Puina, Pelechuco
19	Trochilidae	*Chalcostigma stanleyi*	blue-mantled thornbill	**luli,** loli	Keara, Puina, Pelechuco
20	Furnariidae	*Cinclodes fuscus*	bar-winged cinclodes	**cach´ili,** kachili, kuach´eli	Keara, Puina, Pelechuco
21	Furnariidae	*Cinclodes aricomae*	cinclodes aricomae	quita cach´ili, puron cach´ili, kuach´eli	**not seen on trip 2
22	Furnariidae	*Leptasthenura yanacensis*	tawny-tit spinetail	chirequina, chirijaña	All forests (Queñuani, supaycocha, lampayani,

					tolocacocha, etc.)
23	Furnariidae	*Asthenes humilis*	streak-throated canastero	jeru chollo, ch´epta	Pelechuco, Keara
24	Formicariidae	*Grallaria andicola*	stripe-headed antpitta	poco poco, chirijeña, ichu pisq´o	Queñuani, camino Pelechuco-Puina
25	Rhinocryptidae	*Scytalopus magellanicus*	Andean tapaculo? Puno?		Keara
26	Tyrannidae	*Anairetes alpinus*	ash-breasted tit tyrant	choco choco, poco poco, chinchaya	all *Polylepis* forests except supaycocha and tolocacocha
27	Tyrannidae	*Ochthoeca fumicolor*	brown-backed chat-tyrant	ch´epta	*Polylepis* forests and mixed forests
28	Tyrannidae	*Ochthoeca oenanthoides*	D'Orbigny's chat-tyrant	ch´epta	
29	Tyrannidae	*Ochthoeca rufipectoralis*	rufous-breasted chat-tyrant	ch´epta	
30	Tyrannidae	*Muscisaxicola grisea*	Tacxanowski's ground tyrant	rete pesq´o, jatun silu silu, wuaycho	
31	Tyrannidae	*Muscisaxicola flavinucha*	ochre-naped ground-tyrant	paloma, wuaycho	
32	Hirundinidae	*Notiochelidon murina*	brown bellied swallow	silu silu, colondrina	
33	Troglodytidae	*Troglodytes aedon*	house wren	**chiriqueña,** chirihaña, cherekeña	Puina, Keara
34	Turdidae	*Turdus chiguanco*	chiguanco thrush	**chiwaco,** chiwanku	Valles Puina, Keara
35	Thraupidae	*Thraupis bonariensis*	blue and yellow tanager	hoch´e	**not seen on trip 2
36	Thraupidae	*Anisognathus igniventris*	scarlet-bellied mountain tanager	tonque rojo	Puinapampa y Keara antigua
37	Thraupidae	*Conirostrum ferrugineiventre*	white-browed conebill	asu pesq´o, pajero de palmeras	All *Polylepis* forests
38	Thraupidae	*Conirostrum cinereum*	cinereous conebill	pajero de palmeras, kia kia	All *Polylepis* forests
	Thraupidae	*Diglossa brunneiventris*	black-throated flowerpiercer		bosque Kearapampa
40	Emberizinae	*Zonotrichia capensis*	rufous-collared sparrow	**jeru ch´ullo,** herru chillu	Valles Puina, Keara
41	Emberizinae	*Phrygilus punensis*	Peruvian sierra finch	chiliquito, chirp´ista	Valles and bosques Puina, Keara
42	Emberizinae	*Phrygilus unicolor*	plumbeous sierra finch	azul chita, azul pes´qo, azul pisq´o	Valles and bosques Puina, Keara
43	Emberizinae	*Phrygilus plebejus*	ash-breasted sierra finch	chipta, ch´epta	
44	Emberizinae	*Diuca speculifera*	white-winged diuca finch	rit´i pesc´o	bosque de Queñuani
45	Emberizinae	*Sicalis uropygialis*	bright rumped yellow finch	chayña, jero ch´ollo, rit´i pesc´o	valle de puina
46	Emberizinae	*Catamenia inornata*	plain colored seed eater	ch´ipta	

47	Fringillidae	*Carduelis atrata*	black siskin	**chayña,** yana chayña, hitu pisq´o, tigre, tigrecillo, tigre pesq´o, estrongist	Pelechuco, Keara antigua, Puinapampa
New birds to second trip					
48	Rhinocryptidae	*Scytalopus simonsi*	puna tapaculo		Keara
49	Trochilidae	*Metallura phoebe*			bosque Chuñuna
50	Trochilidae	*Patagona gigas*	giant hummingbird	**luli,** loli	bosque Queñuani
51	Furnariidae	*Leptasthenura andicola*	Andean-tit spinetail		bosque Queñuani
52	Tyrannidae	*Ochthoeca leucophrys*	white-browed chat-tyrant		bosque Queñuani
53	Troglodytidae	*Troglodytes solstitialis*	mountain wren		camino bosque Queñuani
54	Thraupidae	*Diglossa carbonaria*	grey-bellied flowerpiercer		bosque Queñuapampa
55	Podicipedidae	*Podiceps occipitalis*	silvery grebe		bosque Supaycocha
56	Accipitridae	*Falco peregrinus*	peregrine falcon		camino Pelechuco-Ulla Ulla
57	Accipitridae	*Falco sparverius*	American kestrel		camino Pelechuco-Ulla Ulla
58	Columbidae	*Metriopelia melanoptera*	black-winged ground dove		Pelechuco
59	Rhinocryptidae	*Scytalopus parvirostris*	trilling tapaculo		Keara

APPENDIX I: PLOT DESCRIPTIONS AND MEASUREMENTS

Forest Name	Queñuapata 1	Queñuapata 2	Lampayani 1	Lampayani 2	Kalachaka 1	Kalachaka 2	Quecara chica 1	Quecara chica 2	Chuñuna 1	Chuñuna 2	Queñuani 1	Queñuani 2	Supaycocha 1	Supaycocha 2	Tolocacocha 1	Tolocacocha 2
DESCRIPTIVE INDICATORS																
Name of closest community (1=Puina, 2=Keara)	1	1	2	2	1	1	2	2	2	2	1	1	2	2	2	2
Distance to community (<1 hr, <2 hrs, <3 hours, >3 hours)	1	1	1	1	2	2	4	4	2	2	3	3	4	4	4	4
User group (1=Puina, 2=Keara)	1	1	2, 1	2, 1	1	1	1, 2	1, 2	2	2	1	1	2	2	2	2
Aspect in degrees	220	270	240	180	180	180	180	220	180	180	180	180	220	200	140	150
Slope in degrees	15	30	5	2	32	30	10	27	4	15	10	10	4	5	27	32
Average elevation in meters	4364	4382	4126	4120	4217	4256	4205	4218	4124	4177	4146	4159	4023	4017	4076	4044
Total # cut stumps	17	37	10	6	10	24	12	13	7	3	7	66	4	0	24	13
Total # cow pies	4	3	0	5	0	9	5	0	26	0	0	0	0	0	0	0
GROUND COVER																
Average % Grass	26%	3%	47%	72%	1%	24%	14%	12%	60%	26%	1%	1%	45%	45%	52%	32%
Average % Forbs	1%	4%	5%	3%	1%	4%	3%	5%	4%	1%	4%	1%	7%	2%	8%	8%
Average % Moss	49%	87%	48%	23%	98%	41%	83%	84%	26%	73%	95%	98%	45%	53%	40%	59%
Average % Bare soil	24%	6%	0%	2%	0%	31%	0%	0%	10%	0%	0%	0%	4%	0%	0%	0%
CANOPY COVER																
Average % *Polylepis*	26%	36%	39%	21%	29%	26%	29%	59%	53%	34%	59%	26%	18%	24%	43%	55%
Average % Gynoxys	0%	0%	3%	0%	0%	0%	15%	6%	30%	0%	13%	18%	6%	13%	15%	30%
Total canopy cover %	26%	36%	42%	21%	29%	26%	44%	65%	83%	34%	71%	44%	24%	37%	58%	85%

Forest Name	Queñuapata 1	Queñuapata 2	Lampayani 1	Lampayani 2	Kalachaka 1	Kalachaka 2	Quecara chica 1	Quecara chica 2	Chuñuna 1	Chuñuna 2	Queñuani 1	Queñuani 2	Supaycocha 1	Supaycocha 2	Tolocacocha 1	Tolocacocha 2
MEASUREMENT INDICATORS																
Average height of all trees (meters)	1.02	1.03	2.56	2.63	1.78	1.39	2.43	4.21	5.59	2.86	2.23	3.09	2.74	1.69	4.87	3.72
Average height *(P. pepei)*	1.02	1.03	2.41	2.63	1.78	1.39	2.02	3.84	6.18	2.95	2.20	3.15	3.19	1.36	5.57	4.90
Average height (Gynoxys)	0.00	0.00	3.79	0.00	0.00	0.00	3.36	7.70	4.42	2.13	2.85	2.90	2.14	2.89	3.65	2.99
***P. pepei* trees with DGH > 2.5cm**	28	34	8	6	14	29	9	19	4	8	17	12	4	11	7	8
***Gynoxys* trees with DGH > 2.5cm**	0	0	1	0	0	0	4	2	2	1	1	4	3	3	4	13
Total trees DGH > 2.5cm	28	34	9	6	14	29	13	21	6	9	18	16	7	14	11	21
***P. pepei* stems with DGH > 2.5cm**	51	67	11	13	22	62	22	25	6	14	67	28	17	13	7	8
***Gynoxys* stems with DGH > 2.5cm**	0	0	1	0	0	0	6	3	4	1	2	5	3	10	6	17
Total number of stems DGH > 2.5cm	51	67	12	13	22	62	28	28	10	15	69	33	20	23	13	25
***P. pepei* trees with DBH > 2.5cm**	0	0	3	5	0	0	1	16	4	4	2	8	1	3	6	7
***Gynoxys* trees with DBH > 2.5cm**	0	0	1	0	0	0	4	2	1	0	1	1	0	1	1	6
Total trees with DBH >2.5cm	0	0	4	5	0	0	5	18	5	4	3	9	1	4	7	13
***P. pepei* stems with DBH > 2.5cm**	0	0	4	8	0	0	1	27	5	12	4	16	1	0	9	10
***Gynoxys* stems with DBH > 2.5cm**	0	0	2	0	0	0	4	4	3	0	1	3	0	2	2	7
Total stems with DBH > 2.5cm	0	0	6	8	0	0	5	33	8	12	5	19	1	2	11	17
average size DGH for *P.pepei* (cm)	3.89	3.29	12.85	9.08	4.88	3.75	6.10	12.92	24.57	12.14	4.91	7.36	6.16	3.87	21.80	24.64
Average size DGH for *Gynoxys*	0.00	0.00	17.50	0.00	0.00	0.00	15.50	22.50	16.65	2.50	30.00	10.78	6.60	6.31	7.87	6.84
Average size DGH for all trees	3.89	3.29	13.24	9.08	4.88	3.75	8.12	13.95	21.40	11.50	5.74	7.88	6.23	4.93	15.37	12.53

Forest Name	Queñuapata 1	Queñuapata 2	Lampayani 1	Lampayani 2	Kalachaka 1	Kalachaka 2	Quecara chica 1	Quecara chica 2	Chuñuna 1	Chuñuna 2	Queñuani 1	Queñuani 2	Supaycocha 1	Supaycocha 2	Tolocacocha 1	Tolocacocha 2
Average size DBH for *P.pepei* (cm)	0.00	0.00	13.10	7.13	0.00	0.00	16.20	9.94	18.16	10.53	4.85	7.53	9.20	0.00	13.58	19.86
Average size DBH for *Gynoxys*	0.00	0.00	8.65	0.00	0.00	0.00	11.38	16.33	18.13	0.00	15.50	12.03	0.00	5.15	16.80	5.57
Average size DBH for all trees	0.00	0.00	11.62	7.13	0.00	0.00	12.34	10.82	18.15	10.53	6.98	8.24	9.20	5.15	14.16	13.98
Number of *P. pepei* seedlings	24	28	9	1	24	26	11	10	9	26	48	62	23	38	8	34
Number of *Gynoxys* seedlings	0	0	7	0	0	0	3	3	11	0	10	7	7	3	15	31
Total number of seedlings	24	28	16	1	24	26	14	13	20	26	58	69	30	41	23	65
Canopy cover *P. pepei*	45.29	44.18	99.33	51.07	46.47	42.24	49.87	190.89	80.88	92.33	87.62	67.20	43.66	19.19	262.92	142.77
Canopy cover *Gynoxys*	0.00	0.00	6.50	0.00	0.00	0.00	31.52	37.50	15.28	0.32	3.15	9.99	8.60	12.41	29.93	26.92
Total canopy cover (m2)	45.29	44.18	105.83	51.07	46.47	42.24	81.39	228.39	96.15	92.65	90.77	77.19	52.26	31.60	292.85	169.69
Total average canopy cover (m2)	1.62	1.30	11.76	8.51	3.32	1.46	2.15	10.88	16.03	10.29	5.04	4.82	7.47	2.26	26.62	8.08
Basal area *(P. pepei)*	0.0668	0.0604	0.2380	0.0982	0.0500	0.0801	0.1163	0.4334	0.3649	0.3410	0.1312	0.1807	0.0651	0.0199	0.2909	0.5395
Basal area *(Gynoxys)*	0.0000	0.0000	0.0241	0.0000	0.0000	0.0000	0.1552	0.1380	0.1108	0.0005	0.1541	0.0751	0.0126	0.0333	0.0732	0.0414
Total Basal area	0.0668	0.0604	0.2620	0.0982	0.0500	0.0801	0.2715	0.5714	0.4758	0.3415	0.2853	0.2558	0.0777	0.0532	0.3641	0.6341
Total BA/ha	6.6816	6.0360	26.2013	9.8171	4.9973	8.0128	27.1550	57.1388	47.5753	34.1461	28.5272	25.5752	7.7672	5.3189	36.4129	63.4095
Ratio stems to trees *(Polylepis)*	1.82	1.97	1.38	2.17	1.57	2.14	2.44	1.32	1.50	1.75	3.94	2.33	4.25	1.18	1.00	1.00
Ratio stems to trees *(Gynoxys)*	0.00	0.00	1.00	0.00	0.00	0.00	1.50	1.50	2.00	1.00	2.00	1.25	1.00	3.33	1.50	1.31
Ratio stems to trees (TOTAL)	1.82	1.97	1.33	2.17	1.57	2.14	2.15	1.33	1.67	1.67	3.83	2.06	2.86	1.64	1.18	1.19
Ratio seedlings to trees *(Polylepis)*	0.86	0.82	1.13	0.17	1.71	0.90	1.22	0.53	2.25	3.25	2.82	5.17	5.75	3.45	1.14	4.25
Ratio seedlings to trees *(Gynoxys)*	0.00	0.00	7.00	0.00	0.00	0.00	0.75	1.50	5.50	0.00	10.00	1.75	2.33	1.00	3.75	2.38
Ratio seedlings to trees (TOTAL)	0.86	0.82	1.78	0.17	1.71	0.90	1.08	0.62	3.33	2.89	3.22	4.31	4.29	2.93	2.09	3.10

APPROVED

Signature of Academic Advisor

Dr. Raymond Guries
Chairperson of Forest Ecology and Management
University of Wisconsin – Madison

10 January 2006

Date