

REASSESSING THE CAUSES OF DECLINE OF *POLYLEPIS*, A TROPICAL SUBALPINE FOREST

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Key words: Accessibility, Andes, Bolivia, deforestation, fragmentation, mining, Montane forest, road-building.

INTRODUCTION

A growing body of research has documented declines in tropical montane forests worldwide (González-Espinosa *et al.* 1991, Henderson *et al.* 1991, Young 1994, FAO 1997). The disruption or destruction of any habitat contributes to local and global species loss, and this threat is especially grave in tropical montane areas, where endemic or restricted-range species comprise a particularly high proportion of the local biota (Henderson *et al.* 1991, Peterson *et al.* 1993, Young 1994). In an already fragmented landscape, the removal of a few key habitat patches can substantially impact the viability of associated metapopulations (Bancroft *et al.* 1995, Moilanen *et al.* 1998, Hanski 1999). Thus, in zones of high endemism and habitat fragmentation, small-scale habitat loss may easily cause global loss of biodiversity, and deforestation in these areas deserves particular attention. Remaining highland forest patches also play a key role in ecosystem functions, such as capture of rainwater and stabilization of soil.

Here, we document a very high deforestation rate in *Polylepis* forest, a subalpine ecosystem found in fragments well above the present-day closed timberline throughout South America's Andes mountain range. *Polylepis* forest was once the natural vegetation cover for large areas of the Andes (Kessler 2002), but has been reduced by human activity to 1–3% of its potential area on the eastern Andean slopes of Peru and Bolivia (Fjeldså & Kessler 1996). In our study area in the La Paz department of Bolivia, less than one third of the *Polylepis* area documented in a 1991–93 series of surveys remained in 2003. While the La Paz department patches may not be representative of all Andean highland areas, this rate of habitat loss may be expected to have severe effects on biodiversity, and

prompts a reassessment of the probable causes of the decline of this ecosystem.

Previous studies argued that *Polylepis* forests were threatened mainly in the long term, because burning and overgrazing of the surrounding grassland prevents regeneration of young trees (Fjeldså & Kessler 1996, Fjeldså 2002a). In addition to this long-term degradation, we contend that many fragments are more immediately threatened by cutting, as the expansion of roads and industrial development projects, such as mines and hydroelectric power stations, brings an influx of new people to areas previously less accessible and less populated. Our survey therefore reiterates the critical conservation status of *Polylepis* forest and its associated flora and fauna on the eastern slope of the Andes.

STUDY AREA AND METHODS

We returned in 2003 to the *Polylepis* sites described by Fjeldså and Kessler (1996) in the Cordillera Real and surrounding areas, covering all sites in three sectors in the northeastern Bolivian Andes (Fig. 1). These sectors were defined in order to group areas with similar environmental conditions that are inhabited by one or two *Polylepis* species. At each *Polylepis* site we evaluated the current state of the fragment and took photographs, which we then sent to Michael Kessler for confirmation of location and an evaluation of the change in condition for each site. Therefore to facilitate confirmation and accurate size measurements, we include only those sites visited by Michael Kessler or Jon Fjeldså personally.

RESULTS

About 87% of the total previously described extent of *Polylepis*, especially in eastern Cordillera Real valleys, has been eliminated in the last 12 years (Table

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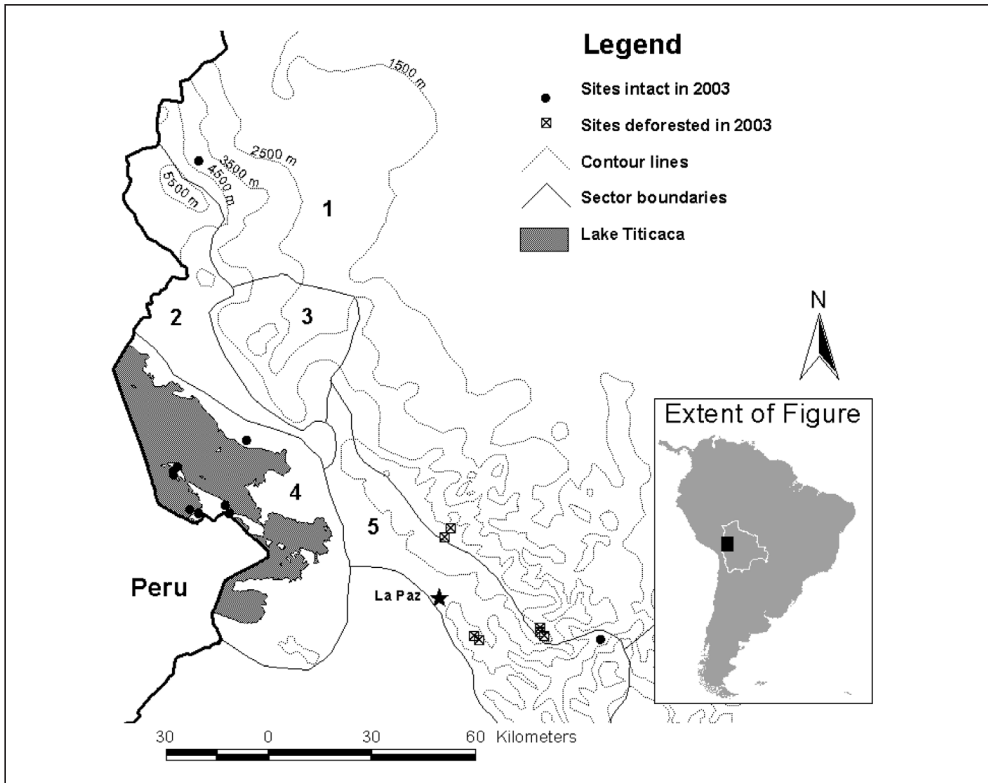


FIG. 1. Location of Fjeldså and Kessler (1996) documented *Polylepis* sites in the northeastern Bolivian Andes that were resurveyed in 2003. No sites were found in which *Polylepis* area was partially reduced; X boxes indicate sites that were completely eliminated between 1991 and 2003.

1). Sector 1, which includes the eastern slope of the Andes from the Rio La Paz to the Peruvian border, has lost about 97% of its recorded *Polylepis* area (5 of 6 sites). Similarly, in Sector 5, which includes the western side of the Cordillera Real and Cordillera Tres Cruces to the south, at least 75% of the recorded *Polylepis* has since disappeared (2 of 3 sites). In contrast, none of the eight *Polylepis* sites in the Lake Titicaca basin (sector 4) have been destroyed.

DISCUSSION

The findings of this study reinforce the need for immediate conservation action to preserve *Polylepis* forests in the Andes of Bolivia. In addition to previously documented forms of disturbance (i.e., cutting back, overgrazing, and partial burning), it is evident from the disappearance of numerous sites in 12

years that entire *Polylepis* fragments are being clear-cut. Thus the rate of disappearance and degradation is much greater than previously believed.

While the total extent of remaining *Polylepis* in the La Paz department is not known, our observations suggest that the deforestation we document accounts for a substantial share of what existed in the early 1990s. In collaboration with a group of Bolivian researchers, we mapped *Polylepis* stands in several valleys in the La Paz department, amounting to approximately 25% of Sectors 1 and 5. We liberally estimate the total existing area of *Polylepis* in this subregion to be 520 ha. The 205 ha of documented loss since 1991–93, all of which was also in this smaller subregion of the Cordillera Real, is therefore about 40% of the amount of forest still standing in the area. Thus, if current deforestation rates continue, *Polylepis*

could be effectively extirpated from this section of the cordillera within less than three decades.

The *Polylepis* fragments surveyed by Fjelds  and Kessler were near roads, which probably increased the likelihood of deforestation. For this reason, the extreme deforestation rate we observe is unlikely to be representative of the rate for all *Polylepis* in the Cordillera Real. However, about 85% of the new *Polylepis* area we encountered was within 2 km of existing roads, making almost all of the region's remaining forests vulnerable, even without additional road building.

While we believe that short-term *Polylepis* deforestation is a problem in other areas, the magnitude of loss may be particularly high in the La Paz department for two reasons. First, the department contains a relatively low proportion of land ecologically suitable for *Polylepis* forest, and most of this original forest cover had been eliminated prior to Fjelds  and Kessler's surveys. Second, road building and mining projects may be more active in this region surrounding Bolivia's largest urban area. Nonetheless, even a deforestation rate less extreme than the 87% we observed here would be a considerable threat to the larger *Polylepis* forests of other regions.

The close association between the construction of new roads and the total elimination of local *Polylepis* stands provides a valuable insight into the threats facing this ecosystem. As new areas are opened to exploitation, many people from other regions are drawn in, increasing demand for firewood and upsetting any informal community-based forest management traditions that may have existed. *Polylepis* is highly valued by Andean peoples as firewood or charcoal, for its high burning temperature and long burning time, and because over much of its range it is the only available woody plant (Fjelds  & Kessler 1996, Lazcano & Espinoza 2001). Therefore, while many commu-

nities actively manage *Polylepis* forests to provide a long-term fuelwood supply (Fjelds  2002a), it is unsurprising that people with short-term interests in a high, remote place would exploit these resources unsustainably.

This is not to say that long-standing local residents do not cause degradation of *Polylepis* forests. We have also located a significant number of previously undocumented *Polylepis* stands in more remote valleys, all of which have been affected in some way by human activity. Many sites have been severely cut back, burned, or are heavily grazed by livestock, even those in seemingly isolated mountainous areas. Therefore, while complete forest loss may be limited to heavily populated or road-accessible areas, all of the *Polylepis* that we have located is being threatened one way or another by human activity. It seems that road building, mining, and other resource development cause deforestation at a truly astonishing rate in these Andean valleys, while local communities exploit forests perhaps unsustainably, but without causing their immediate destruction. Therefore, while the reported rate of habitat loss should not be applied to all *Polylepis* forest fragments, every site that we found is being threatened at some level.

In some areas, exemplified by the Lake Titicaca area *Polylepis* fragments in sector 4, sites have remained relatively static in size and quality as a result of active human stewardship and use. At first glance, this seems to be a very promising conservation approach, with forests protected as windblocks or woodlots supplying timber and fuel to local communities. However, the natural avifauna of these areas tends to be out-competed by human-adapted birds (Fjelds  & Kessler 1996; pers. observ.). So even if small forest fragments are conserved in some regions, the conservation status of the specialist fauna is not necessarily

TABLE 1. Number and approximate area of *Polylepis* sites in 3 sectors surveyed during 1991–93, and number and area of these sites remaining in 2002–2003. The total number of sites and area (ha) are given for each sector and for the total of all sectors surveyed in 2002–2003. Figure 1 shows sector boundaries.

	Number of sites 1991–93	Number of sites 2003	Percent change	Area 1991–93 (ha)	Area 2003 (ha)	Percent change
Sector 1	6	1	–83%	209	7	–97%
Sector 4	8	8	0%	22	22	0%
Sector 5	3	1	–67%	4	1	–75%
Total	17	10	–41%	235	30	–87%

improved, although a few trees in villages can play an important role in decreasing subsistence pressure on other stands.

Conservation Implications. Because of the fragmented nature of *Polylepis* forests and the economic circumstances of rural Andean people, effective protection will require community-based reforestation and conservation initiatives as well as the creation of small private reserves. Researchers (Fjelds  & Kessler 1996, Fjelds  2002a, Hensen 2002, Ibisch 2002) have drawn up proposals for integrated conservation of *Polylepis* and economic development of associated rural communities, including factors such as environmental education, substitution of alternative fuels for firewood, reintroduction of high-yielding agroforestry techniques, use of native rather than introduced species in reforestation projects and, most importantly, change in the current land use patterns of overgrazing and burning. These programs are necessary to combat the gradual degradation that we have observed of nearly all *Polylepis* of the eastern Andes, but do not address the problem of rapid clear-cutting provoked by new roads and mines.

In addition to the above mentioned sustainable development strategies, Fjelds  (2002b) describes several key areas for the conservation of *Polylepis*-adapted birds, one of which is located within our study area. To avoid extinction of many endemic birds, conservation efforts in these areas must combine sustainable development initiatives with improved protection of the remaining more remote and biologically intact *Polylepis* stands, possibly through small-scale private reserves. We wish to emphasize that potential future construction of roads, mines, and other resource-extraction infrastructure should be a key factor in the selection of forest fragments for a protected areas network, in *Polylepis* and in other montane ecosystems worldwide (e.g., Sargent *et al.* 1985, Young 1994, Kaimowitz & Angelsen 1998). In *Polylepis* as in other forest ecosystems, these developments and the associated population influx have often led to rapid and total habitat loss.

ACKNOWLEDGMENTS

We thank S.K. Herzog for thoughts on this study, I. Gomez, M. Molina, J. Martinez, M. Ocampo, and K. Naoki for collaborating with us in locating new *Polylepis* sites, and N. Jonz n, J. Fjelds , and M. Kessler for comments on the manuscript. Research was supported by a US State Department Fulbright grant to J. Purcell.

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Accepted 24 July 2004