



# The relative effectiveness of protected areas, a logging ban, and sacred areas for old-growth forest protection in southwest China



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## ABSTRACT

Forests are critically important for life on earth, prompting a variety of efforts to protect them. Protected areas and logging regulations are the most commonly used forest conservation strategies, but local traditions and religious beliefs can also protect natural resources by limiting exploitative use. We compared the effectiveness of protected areas, a logging ban, and sacred areas to protect forests from logging in Northwest Yunnan, China, a global biodiversity hotspot. We combined Mahalanobis matching and panel regression techniques to measure effectiveness of these three protection strategies paying special attention to old growth forest communities. We found that protected areas had no impact on total forest cover, but effectively conserved old-growth forests relative to non-protected areas. The implementation of the logging ban resulted in positive forest conservation outcomes over most of the landscape. The exception was that logging in old-growth forests inside sacred areas accelerated following the implementation of the logging ban, suggesting that local institutions may have been weakened by official policies. Our research finds little evidence that overlapping conservation policies decrease deforestation and suggests that the implementation of official policies may displace local forms of protection. Our results further highlight that relying on total forest cover as a single indicator of conservation outcomes can lead to misleading conclusions about the impacts of forest protection strategies.

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## 1. Introduction

Forests provide indispensable ecosystem services, including carbon sequestration, climate regulation and recreation, and are essential for biodiversity conservation (Kinzig et al., 2011). Their importance has prompted a wide range of efforts to protect them, including protected areas, logging regulations, and payments for ecosystem services (PES) programs (Brandt et al., 2012; Morell, 2008; Nepstad et al., 2011). The implementation of protected areas, where logging is legally restricted, is a common governmental policy tool worldwide (Bertzky et al., 2012). While 12.7% of the terrestrial earth is now protected, protection efforts have had mixed effects, especially in countries with weak governance or rampant growth in population and consumption (Ewers and Rodrigues, 2008; Knorn et al., 2012; Liu et al., 2001). Other government-sponsored forest protection measures include

prohibitions on logging, including full or partial bans on timber harvesting (Margono et al., 2012; Sarker et al., 2011). However, conflicts with local people or lax enforcement can limit the effectiveness of logging bans (Brandon and Wells, 1992; Ferraro et al., 2011).

Community-level institutions can be effective alternatives to governmental forest protection efforts (Bray et al., 2003; Nagendra et al., 2008). In particular, many traditional cultures respect “sacred areas” where logging is prohibited for religious reasons (Allendorf et al., 2014; Bhagwat and Rutte, 2006; Verschuren et al., 2010). Sacred areas act as *de facto* protected areas in traditional landscapes, are often effective at protecting forests, and are resilient to social change (Brandt et al., 2013; Dudley et al., 2009). However, there are examples of recent degradation of sacred areas, as cultural change, globalization, and national policies alter local forms of land management (Ostrom, 1990; Rutte, 2011).

To identify effective conservation solutions, it is crucial to (a) rigorously assess the impacts of alternative forms of protection and (b) examine if there are interactions among them. These issues

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gain special relevance in the context of the Northwest (NW) Yunnan Province, China. NW Yunnan is both a biodiversity hotspot (Myers et al., 2000) and a UNESCO world heritage site. NW Yunnan's natural forests, the most diverse temperate forests in the world (Morell, 2008), were decimated by government logging companies from the 1950s through the 1980s. Since 1990, multiple forest protection strategies, including protected areas, a logging ban, and community-managed sacred areas, have been concomitantly in effect.

Our goal was to compare the effectiveness of these different protection strategies to conserve old-growth forest cover. We created a spatial dataset of protection strategies by delineating boundaries of protected areas, logging ban areas, and Tibetan sacred areas. We quantified forest cover types (old-growth forest and pine forests) and changes among them based on Landsat satellite images over two decades: 1990–1999 and 1999–2009. Simply comparing changes in forest cover over different tenure systems and over time is not sufficient to assess the relative effectiveness of different protection strategies, because the areas under the different protection strategies are in almost all cases inherently different in other aspects as well (Andam et al., 2008; Joppa and Pfaff, 2010, 2009). For example, in our setting, sacred areas have higher levels of old growth forests, and are at higher elevations and have steeper slopes than protected areas or logging ban areas. Given these differences in initial conditions, they experience different demands for forest resources.

In order to control for underlying differences among different protection strategies, we used a 2-step modeling procedure. First, we used matching statistics to create datasets consisting of observations in each protection category that had similar observable characteristics at the beginning of our study period (1990) (Caliendo and Kopeinig, 2008). However, matching only provides bias-free estimates when all factors that influence both protection strategy designation and deforestation are included as controls, an assumption which cannot be tested. Thus, we next also applied

panel regression techniques to account for unobserved heterogeneity and identify the impacts of the different protection strategies across forest types. We asked three specific questions:

1. Did protected areas protect all forest types equally?
2. Did the region-wide logging ban effectively reduce logging compared to other protection strategies?
3. Did sacred areas continue to protect old-growth forests, even as new policies restricted logging in the surrounding landscape?

## 2. Methods

### 2.1. Study area

Our study area (20,036 km<sup>2</sup>) was the Diqing Tibetan Autonomous Prefecture in the Hengduan Mountains in Northwest Yunnan Province, bordering Tibet and Sichuan Province (Fig. 1). Northwest Yunnan is a biodiversity hotspot (Myers et al., 2000) with elevations ranging from 1500 to 6000 m above sea level, creating a high diversity of ecological niches in a relatively small area. Northwest Yunnan is also a UNESCO world heritage site, with great cultural diversity and at least 15 different ethnic minority groups in the region. Northwest Yunnan is still relatively undeveloped compared to other parts of China, but is experiencing rapid change. Since the 1970s, NW Yunnan has undergone major changes due to national policies aimed at fostering both economic development and environmental protection. These policies stimulated rapid infrastructure development, immigration of culturally-dominant Han Chinese, tourism, new protected areas, and changes in land use. Local peoples continue to practice subsistence-based agriculture and pastoralism, but livelihood strategies and traditional land use practices are evolving rapidly with increasing climate change and economic development.

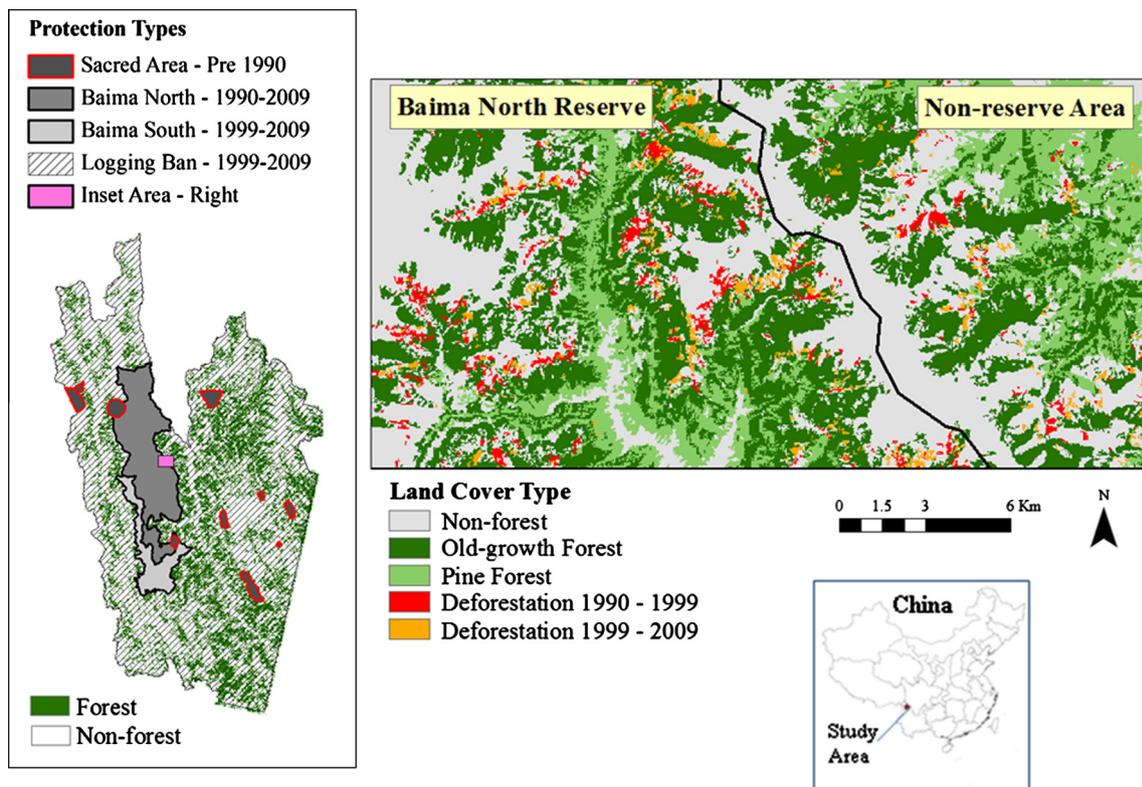


Fig. 1. Land cover and protection types in the study area in Northwest Yunnan Province of southwest China.

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