Report

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Ethnobotanical Skills and Clearance of Tropical Rain Forest for Agriculture: A Case Study in the Lowlands of Bolivia

Indigenous peoples are often considered potential allies in the conservation of biological diversity. Here we assess whether ethnobotanical skills of indigenous people contribute to a reduction in the clearance of tropical rain forest. We measured ethnobotanical skills of male household heads and area of rain forest cleared for agriculture among 128 households of Tsimane', a native Amazonian group in Bolivia. We used multivariate regressions to estimate the relation between ethnobotanical skills and area of rain forest cleared while controlling for schooling, health status, number of plots cleared, adults in household, and village of residency. We found that when the ethnobotanical skills of the male household head were doubled, the amount of tropical rain forest cleared per household was reduced by 25%. The association was stronger when the area of old-growth forest cleared was used as the dependent variable than when the area cleared from fallow forest was used as the dependent variable. People who use the forest for subsistence might place a higher value on standing forest than people who do not use it, and thus they may be more reluctant to cut down the forest.

INTRODUCTION

The conservation of biological diversity outside of protected areas presents many challenges because nonprotected areas include many different types of land users with different objectives. For each type of land use, the conservation of biological diversity can be more successful by finding allies. Studies suggest that biological and cultural diversity correlates across many sites (1, 2) and that indigenous peoples are potential allies in the conservation of biological diversity (3, 4). However, there is little research on the mechanisms through which indigenous cultures might help preserve local biological diversity.

In this article, we study the relation between indigenous ethnobotanical skills and the clearance of tropical rain forest for subsistence agriculture in order to assess how ethnobotanical skills might relate to conservation. We focus on the clearance of fallow and old-growth tropical rain forests because they supply many ecological services, both locally and globally, including conservation of biological diversity and carbon sequestration (5–7). Although we recognize that there are many actors that contribute to tropical deforestation (8–13), we study indigenous people because the share of deforestation caused by indigenous peoples could grow as these populations become more integrated into the market economy (14) or grow in numbers (15). We study land cleared for agriculture, although we do acknowledge that lands owned by indigenous peoples face many external pressures (e.g., encroachment) that might influence total deforestation in indigenous lands (16). Last, we focus on ethnobotanical skills, or the ability to put ethnobotanical knowledge into practice because many qualitative studies have suggested that indigenous knowledge contributes to the management of natural resources (17).

MATERIALS AND METHODS

We conducted research among Tsimane', a native Amazonian society in the province of Beni, Bolivia. Research lasted from May 2003 until November 2004. We interviewed 128 households in 13 villages along the Maniqui River. The villages were selected to capture a range of variation in geographic distances to market towns.

The Tsimane' and their Land

The Tsimane' territory spreads from the foothills of the Andes to the northeast, reaching the edges of the Moxos savanna (14°35′–15°30′S, 66°23′–67°10′W). Some Tsimane' inhabit areas of tropical rain forest at the foothills of the Andes, about 500 m above sea level. In those forests, top canopy species are deciduous. Other Tsimane' villages are settled in moist forest in the savanna region at 150–250 m above sea level. This forest is similar to Amazonian wet forest, but it is less diverse and lacks some of the typical species such as rubber or Brazil nut. Part of the Tsimane' habitat is made up of savanna. The floristic composition of the savannas changes with relief and flooding. In the plains, the main vegetative formations are flooded forest, with relatively low tree diversity (18).

The Tsimane' avoided contact with outsiders until the late nineteenth century, but by the early twentieth century they had started to work for cattle ranchers and loggers (19). Encroachment in the Tsimane' territory was moderate until the 1950s, but it increased during the 1970s when the Bolivian government encouraged migration from the highlands to the lowlands. During the 1990s, the Bolivian government granted the Tsimane' legal title to the land they had traditionally occupied. Communal titling has not been enough to stop encroachment; loggers, cattle ranchers, and farmers currently compete with the Tsimane' for the land of the Tsimane'.

Rights of usufruct and ownership to forest lands are also changing as land becomes scarce due to population growth and encroachment from outsiders. Until recently, any Tsimane' from any village could settle in any other Tsimane' village, clear forest for their own production, and do so without consulting other villagers. In the past decade, villages close to market towns have started to organize themselves to establish boundaries for their villages and fields. Tsimane' have begun to fence fallow plots to exclude others from using the plots.

Tsimane' farming is extensive and mostly oriented to meeting subsistence requirements. Tsimane' practice slash-and-burn agriculture and cultivate rice, maize, manioc, and plantains (20). After one or two cultivation cycles, people abandon their plots and clear more old-growth or fallow forest to establish new plots. Tsimane' over ~15 years of age have their own plots. Typically, the male household head clears the plot, but

Table 1. Regression results of hectares of tropical rain forest cleared versus adult ethnobotanical skills (n = 128).

	a	*b*	*c*	*d*
Explanatory variable	**Total hectares cleared**	**Hectares cleared (log)**	**Hectares old-growth forest cleared**	**Hectares fallow forest cleared**
Male household head ethnobotanical skills (log)	−0.59**	−0.25*	−1.17***	−0.05
Male household head ethnobotanical knowledge (log)	0.19	0.002	−1.14	0.81
No. plots cleared/household	0.43***	0.28**	0.57**	0.32*
No. adults in household	−0.20*	−0.09*	−0.019	−0.12
Male household head school grade	0.004	0.02	−0.03	−0.01
School grade of father of male household head	0.03	0.01	0.03	−0.001
Physical stature of male household head (cm)	−0.02	−0.01	−0.07*	0.01
R^2	0.25	0.25	0.11	0.06

Notes: Regression results include 12 village dummy variables and a constant (not shown). Columns *a* and *b* use ordinary least squares regressions with robust standard error and clustering by village. Columns *c* and *d* use lowered-censored Tobit regressions. *, **, and *** are significant at the 10%, 5%, and 1% level.

thereafter plots belong to the person who sows the plot. The owner of the plot makes decisions on what is to be planted on the plot. Every year, during July-August, Tsimane' draw on their knowledge of soil types, topography, and weather to decide where and how much forest to clear. Accuracy in timing matters—if left too late, brambles and brush will get too wet to burn well and leave too much debris when Tsimane' burn their fields (typically in August-September). In previous research (20), we found that a growing share of Tsimane' clear forest to plant cash crops, mostly rice, and that the amount of rice sown for cash bears a positive relation with deforestation.

Dependent Variable: Forest Clearance

To estimate the area of rain forest cleared, we asked all household heads to report the area of all plots they had cleared during the last farming cycle and the type of forest cleared (i.e., old growth, fallow). Our previous research has already demonstrated that self-reported estimates closely match measurements of the area cleared (21). We aggregated the measures to the household level to obtain the total area deforested by the household and then divided the total area cleared by the number of adults in the house to obtain an estimate of area cleared per adult.

Explanatory Variable: Ethnobotanical Skills

We used the ethnobotanical skills of the male household head because male household heads are responsible for choosing and clearing the plot for farming. We focused on practical ethnobotanical skills because the ability to make objects from plants implies not only knowledge of plant uses, but also knowledge of the ecology of the plant and of the techniques needed to use the plant. To proxy ethnobotanical skills, we measured the self-reported ability to make objects from wild and semidomesticated plants. First, we asked a subsample of participants (n = 50) to list plant-made objects. From that list, we randomly selected 18 objects from 15 different plant species. We then asked all adults in the sampled households whether they had ever made the items on their own. We weighted scores to reflect the fact that only a few people reported knowing how to make difficult objects. The score for an object was inversely proportional to the number of participants who reported knowing how to make the object.

Control Variables

Control variables include: *i)* a standard measurement of the theoretical dimension of ethnobotanical knowledge measured as the agreement among informants on a test on uses of wild plants (22); *ii)* individual and parental schooling, as proxy measures of integration to the market; *iii)* physical stature, as a proxy for income, health, and labor productivity (23); *iv)* number of plots cleared by the household; *v)* number of adults in household; and *vi)* 12 dummy variables for the 13 villages in the sample (n = 13 − 1 = 12).

RESULTS

On average, every Tsimane' household cleared 1.50 plots/y (standard deviation [sd] = 0.77; min = 0; max = 4), where the 1.50 plots covered a total area of 0.88 hectares (ha). Of these plots, 0.53 ha were in fallow forest (sd = 0.56) and 0.35 ha were in old-growth forest (sd = 0.52). The scores of ethnobotanical skills ranged from 0 to 9.58, with a mean of 4.62 (sd = 2.02).

Results suggest a negative association between ethnobotanical skills and the total area of forest cleared by the household for agriculture (coefficient = –0.59, p = 0.04) (Table 1, column a). To facilitate the interpretation of the coefficient, we transformed the dependent variable into natural logarithms (column b). We found that doubling the stock of ethnobotanical skills was associated with a 25% reduction in the amount of tropical rain forest cleared. Theoretical ethnobotanical knowledge bore no significant relation with forest clearance.

We tested whether the association was stronger for the clearance of old-growth or fallow forests. Seventy-seven households reported not having cleared any old-growth forest, and 26 households reported not having cleared any fallow forest. Results suggest that there is a negative and statistically significant association between ethnobotanical skills of the male household head and the area of old-growth forest cleared by the household (coefficient = –1.17, p = 0.01) (Table 1, column c). When using area of fallow forest as the dependent variable, the magnitude of the association and level of statistical significance decreased (coefficient = –0.05, p = 0.82) (Table 1, column d).

We tested the robustness of our finding in three ways (not shown). First, we ran the same models using the total area cleared per household as the dependent variable (rather than the area cleared per adult). Second, we assessed whether the ethnobotanical skills of other members of the household (e.g., female head of household, average of all adults) bore an association with the clearance of rain forest. Neither case resulted in a statistically significant association between ethnobotanical skills and forest clearance.

Last, we examined the impact of cash cropping. As noted, some Tsimane' are moving from a subsistence to a cash economy, mostly by planting the cash crop rice. An alternative explanation to our findings would be that Tsimane' use their ethnobotanical skills to maximize the income from the sale of rice rather than to make an efficient use of the land. To test this alternative hypothesis, we ran the regression model in Table 1, column a, and included a variable to control for the total amount of rice sold by the household at the end of the season. We found that the ethnobotanical skills of the male household

head were associated with less clearance of forest for agriculture (coefficient = −0.73, p = 0.04) even after controlling for the amount of rice sold by the household.

DISCUSSION

Our results suggest that the ethnobotanical skills (but not ethnobotanical knowledge) of the male head of household are associated with lower clearance of tropical rain forest for subsistence agriculture. The association was stronger when using the area of old-growth forest as a dependent variable than when using the area of fallow forest or the total area cleared per adult as a dependent variable.

Why might ethnobotanical skills bear a negative relation with the clearance of tropical rain forest? A possible explanation has to do with the value attached to the forest by indigenous people who depend on the forest for subsistence. Research suggests that forest products provide nutrition, medicines, construction materials, and forage to indigenous people who live the forest (24). Research also suggests that the forest may provide additional sources of income (24, 25). Therefore, it is possible that people who use the forest more might place a higher value on the standing forest and thus be more reluctant to cut it down than people who use the forest less.

Why might only the skills of the male household head be associated with less forest clearance? Ethnobotanical skills might be related to a more efficient use of labor and capital inputs. As noted, Tsimane' male heads of households are in charge of clearing the forest, independent of who owns or sows the plot. Male household heads with greater ethnobotanical skills might be better at selecting soils or forest types suitable for farming, might have a greater likelihood of correctly choosing the best timing for different chores, and might be more likely to take precautionary steps (e.g., scatter plots) to reduce losses from potential unexpected events (e.g., diseases of crops). Thus, the ethnobotanical skills of the person in charge of clearing the land would reduce the demand for farmland by improving its efficient use. The association between ethnobotanical skills and less clearance of forest persists even after controlling for the amount of rice sold by the household, which suggests that Tsimane' do not use their ethnobotanical skills to maximize the income from the sale of cash crop but to increase land productivity.

Previous research has documented the antiquity and ubiquity of indigenous wisdom and the many benefits it confers to people in small-scale societies (26–28). Researchers have also lamented the lost of indigenous knowledge because it represents the irreversible lost of humanity's heritage and diversity (29, 30). Here we estimate some of the benefits that indigenous wisdom might confer to the rest of the world beyond the person, village, or ethnic group holding the knowledge. Our results suggest that ethnobotanical skills might produce benefits by lessening the clearance of tropical rain forest, especially old-growth forest. The finding supports arguments about the importance of preserving and strengthening indigenous knowledge and skills.

These findings, however, apply only to the clearance of rain forest for agriculture, and primarily to old-growth forest. Indigenous peoples face many external pressures that might increase total deforestation in indigenous lands. In addition to the preservation and strengthening of indigenous knowledge and skills, indigenous groups and their local institutions should be strengthened to better cope with external drivers of deforestation.

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