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Mushrooms and Cash Crops Can Coexist in Mountain Livelihoods: Wild Mushrooms as Economic and Recreational Resources in the Greater Mekong

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Cash crop cultivation and harvesting of non-timber forest products (NTFPs) are both important parts of rural livelihood portfolios worldwide. In mountainous areas of the Greater Mekong Subregion, government programs, scholars, and private-sector interests have promoted both as strategies for rural economic development. NTFPs are also often championed as an incentive for rural communities to protect forests. However, little is known about how cash crops and NTFPs interact in the daily lives and economic decisions of rural people in this region, or how they may differentially encourage forest conservation practices and values. With a focus on mushrooms as an NTFP and maca, rubber, and tea as cash crops, we conducted household surveys and key informant interviews in 2 prefectures of Yunnan, China, and 1 province in northern Thailand. Based on the results of this research, we make 4 key arguments. First, although cash crops are generally perceived to diminish the importance of NTFPs such as mushrooms in rural livelihoods, the potential also exists for complementarity between these 2 livelihood strategies. Second, while some species of wild edible mushroom incentivize forest conservation, others may incentivize practices that have a negative impact on forest ecosystems. Third, even in households where NTFPs make little or no contribution to livelihoods, people are likely to value forests for supporting, regulating, and cultural ecosystem services. Fourth, even households that rely primarily on cash crops may value NTFP collection as a leisure activity. The latter phenomenon is previously unreported in NTFP research, and we suggest that it also reflects a blind spot in ecosystem services research. Mushrooms and cash crops can coexist in mountain livelihoods; wild mushrooms are both economic and recreational resources in the Greater Mekong.

Keywords: *Non-timber forest products; cash crops; Greater Mekong Subregion; southwest China; northern Thailand; natural resources; land use; wild mushrooms; ecosystem services.*

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Introduction

Non-timber forest products (NTFPs) play an important role in livelihood strategies in the mountainous communities of the Greater Mekong Subregion. As such, many scholars have proposed exploitation of NTFPs, and mushrooms in particular, as a way to make forest conservation economically sustainable for local communities (Kusters and Belcher 2004; Yang et al 2008; He et al 2009; see also Neumann and Hirsch 2000; cf Belcher and Schreckenberg 2007). Studies of land-use change in the lowlands of this region and elsewhere in the world, however, suggest that the introduction of cash crops and the accompanying increase in rural incomes tend to undermine local interest in NTFPs (Neumann and Hirsch 2000; Senaratne et al 2003; Gopalakrishnan et al 2005; Fu et al 2009) and thereby reduce incentives to conserve forest biodiversity and ecosystem services. This suggests that the ongoing introduction and expansion of cash crops in the Greater Mekong could have a significant detrimental impact on the region's ecosystems, and therefore on the sustainability of livelihoods and development in this mountainous region.

In this study, we used household surveys and key informant interviews to investigate the role of wild edible mushrooms in the livelihoods of people from 3 areas in

the Greater Mekong: Diqing, in northern Yunnan, China; Xishuangbanna, in southern Yunnan; and Chiang Mai, in northern Thailand. In Diqing, mushroom harvesting is a significant part of rural livelihood strategies, but the cultivation of maca (*Lepidium meyenii*, an edible root crop) is for the first time offering rural households the opportunity to cultivate cash crops. Because of the very recent arrival of cash crops, Diqing provides an excellent case study of the immediate impact of cash crops on mushroom harvesting, and therefore it was the major focus of this study. In Xishuangbanna, rubber cultivation has dominated the landscape for several decades. In Chiang Mai, there is a long history of cultivating *miang* tea and a more recent history of numerous other cash crops, including coffee.

With a focus on edible mushrooms, this study addressed the following questions:

1. Are new and expanding cash crops usurping NTFPs in the livelihood strategies of mountain people in the Greater Mekong Subregion?
2. For rural households that continue to harvest mushrooms, do mushrooms incentivize forest conservation?
3. When NTFPs play a diminished role as livelihood sources, do forests continue to be valued for other ecosystem services?

In addressing these questions, we challenge common assumptions about rural peoples' valuations of forest ecosystems in this region, and we discuss the implications of our findings for the role of NTFPs and cash crops in ecologically and economically sustainable mountain development.

NTFPs and cash crops

NTFPs are often proposed as "win–win" solutions for environmental conservation and sustainable economic development in forest-dependent communities. Because they are often sourced from natural forests, the potential income generated from such products is seen as providing long-term financial incentives for forest conservation, which may counteract interest in the short-term benefits of destructive extractive activities such as commercial logging and mining (Delang 2006). The widespread promotion of NTFPs in the last decades of the 20th century has since been scrutinized, with case studies demonstrating that NTFP commodification does not automatically promote sustainable and equitable development in forest-dependent communities (Belcher and Schreckenberg 2007; le Polain de Waroux and Lambin 2013).

Wild harvestable mushrooms are important income-generating and subsistence resources for many communities, both throughout the Greater Mekong Subregion (Mortimer et al 2012) and worldwide (Boa 2004; Garibay-Orijel et al 2009). Although many NTFPs offer financial incentives for forest conservation, this may be particularly true for ectomycorrhizal fungi, which rely on particular ecological assemblages and symbiotic relationships with certain plant species in order to grow and flourish. In addition, despite concern from some scientists and government officials, overharvesting may not be a major conservation issue for ectomycorrhizal fungi species (Pilz and Molina 2002; Robinson et al 2013). Instead, disturbances such as logging, displacement of soil or leaf litter, and trampling of underground mycelia are more likely to reduce fruiting body numbers than harvesting pressure alone (Egli et al 2006; Luoma et al 2006; Egli 2011). Moreover, due to their relative resilience against overharvesting, time-tested widespread (local to global) appeal, and inability to be cultivated, wild fungi in our study area may overcome many of the barriers to commercialization of NTFPs identified by Belcher and Schreckenberg (2007)—including niche or fad-driven demand, issues of intellectual property rights, and product research and development costs. However, the availability of wild mushrooms remains unpredictable across both space and time (Pilz and Molina 2002), and the market for them is subject to fluctuations, making them a somewhat risky livelihood strategy.

Cash crops offer the promise of steady incomes for rural households. Appropriately integrated into agroecological systems, cash crops can be ecologically sustainable and contribute to diverse household portfolios—sometimes alongside NTFPs (Dove 1993; Xu 2007). Cash crops can, however, also generate new forms of ecological and economic vulnerability. A well-documented example of this in the Greater Mekong Subregion is the rapid expansion of rubber in lowland Xishuangbanna (Xu 2006; Yi et al 2014; Zhang et al 2014). The high economic returns promised by rubber have led farmers to replace diverse forests with monoculture plantations. This has not only caused severe ecological degradation, but it has also left farmers vulnerable to fluctuations in global markets. In this respect, any assessment of the potential impacts of cash crops on mountain livelihoods will require an understanding of the ways in which cash crops relate to the broader social and ecological systems of which they are a part.

Methods

Research sites

We surveyed communities engaged in both wild mushroom collection and cash crop cultivation at 3 sites: Shangrila County, Diqing Prefecture, northern Yunnan; Mengla County, Xishuangbanna Prefecture, southern Yunnan; and Mae Taeng District, Chiang Mai Province, northern Thailand (Figure 1). At each of these study sites, we selected villages neighboring areas where existing

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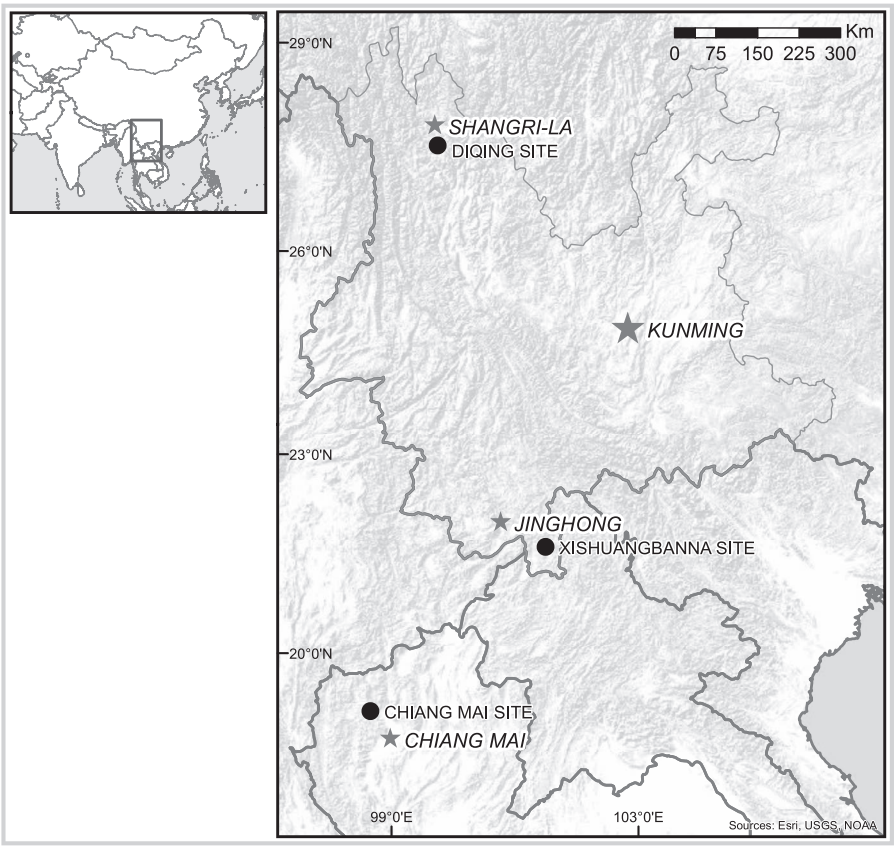
FIGURE 1 Location of the research sites. (Map by Madeline Brown)



biophysical macrofungi surveys have been carried out as part of a collaborative project involving the World Agroforestry Centre, Mae Fah Luang University, and Kunming Institute of Botany. Data from these studies allowed us to be confident that there were abundant wild edible mushrooms in the forests surrounding these communities. At each of our sites, the local government groups 5–10 natural villages (*zirancun* in Chinese and *ban* in Thai) together into a single administrative village (*xingzhengcun* in Chinese and *muban* in Thai). The real names and global positioning system (GPS) coordinates of the study villages are excluded to ensure the anonymity of survey participants.

Diqing Tibetan Autonomous Prefecture in northwest Yunnan has a monsoon-influenced humid continental climate. Tibetans make up the largest ethnic group, but other ethnic groups, including Lisu, Han Chinese, Naxi, and Yi, also inhabit the area. Diqing lies in the Mountains of Southwest China Biodiversity Hotspot (Critical Ecosystem Partnership Fund 2002). Agricultural enterprises have recently introduced the large-scale cultivation of maca, but no research has yet been published on this development. Highly valuable matsutake mushrooms (*Tricholoma matsutake*) have been harvested here since the mid-1980s (He 2010). The impacts of wild mushroom harvesting, and of matsutake in particular, on local economic development in Diqing are well documented (Arora 2008; Yang et al 2008). Much prior research on wild fungi collection in this region has focused on harvesting (and overharvesting) practices and other resource management concerns (Yeh 2000; Amend et al 2010). The present study, however, assessed the role of wild mushroom harvesting as one of several local livelihood strategies, in particular, the ways in which it may compete with or be complemented by the cultivation of recently introduced cash crops.

Our Diqing study site is at 3250 m elevation. It lies around 40 km from Shangrila City. Inhabitants are almost exclusively Tibetan. We refer to the 3 natural villages surveyed at this site as Village A, Village B, and Village C.

Xishuangbanna in southern Yunnan has a monsoon tropical climate at lower elevations and a subtropical climate at higher elevations. The Dai (Tai Lue) are the largest ethnic group, followed by Han Chinese, Hani (Akha), and a number of smaller ethnic groups. Xishuangbanna lies in the Indo-Burma Biodiversity Hotspot (Critical Ecosystem Partnership Fund 2011). Efforts by the Chinese state to promote rubber cultivation in recent decades have led to well-documented deforestation, with rubber now accounting for at least 22% of land use in Xishuangbanna (Zomer et al 2014). Extensive research on rubber cultivation and forest

biodiversity conservation in Xishuangbanna has investigated the social and ecological unsustainability of rubber cultivation (which is primarily monoculture), climate change, forest resource use, and potential payment for ecosystem services (Xu 2006; Li et al 2007; Hu et al 2008; Sturgeon 2013; Yi et al 2014; Zomer et al 2014; Mertens et al 2015). There is some research on NTFP harvesting in Xishuangbanna (Xu et al 2004; Xu 2007; Fu et al 2009; Ghorbani et al 2011), but no research has been published on wild mushroom harvesting in this area.

Our Xishuangbanna study site is at 700 m elevation. It lies around 15 km from Mengla County Town. Inhabitants are almost exclusively Hani. We refer to the 3 natural villages surveyed at this site as Village D, Village E, and Village F.

Chiang Mai Province in northern Thailand has a monsoon tropical climate. The largest ethnic group is the Northern Thai (Mueang), but, like our other sites, this is an ethnically diverse area; other ethnic groups living here include the Akha, Lisu, Karen, and Shan. *Miang* tea has been grown in the province for many centuries, along with a number of other cash crops, including coffee and various fruits. The new crops are often promoted by the Royal Project, a nongovernmental organization founded by the Thai king. Both new and old crops are often grown in biologically diverse agroforestry systems (Thomas et al 2002; Withrow-Robinson and Hibbs 2005; Toedpraipanawan et al 2013). Local harvesters of *hed thob* mushrooms (*Astraeus hygrometricus*) are said to burn forests in order to increase mushroom yields. One mycological study has investigated the impact of these practices on fungal diversity (Sysouphanthong et al 2010). No social science research has been published on mushroom harvesting in Chiang Mai.

Our Chiang Mai study site is at 900 m elevation. It lies around 30 km from Mae Taeng District Town. Inhabitants are predominantly Northern Thai, but there are also significant Lisu and Karen communities, along with a small number of Shan residents.

Survey instruments

Data were collected through a household survey and key informant interviews. Pilot studies to test survey instruments were conducted in Diqing in December 2014 and Xishuangbanna in May 2015. A further survey, carried out in Chiang Mai in February 2015, was originally intended to serve as a third pilot study, but budget constraints required us to drop Thailand from the main survey. In the absence of more comprehensive survey data for Chiang Mai, we include the results of the February 2015 study in this paper. Though the Chiang Mai data set is relatively small, we believe that the lack of social science research on mushrooms in Thailand and the resonances between our preliminary findings in Chiang Mai and our findings in Yunnan justify their publication alongside the larger Diqing and Xishuangbanna data sets.

Our survey incorporated 3 instruments. First, an open-ended interview with a senior official at each site's administrative village focused on potential variation between natural villages within the administrative village in terms of ethnicity, mushroom harvesting, cash crop cultivation, and livelihoods more broadly. Second, we conducted a structured key informant interview with the head of each natural village. This interview contained 54 questions covering themes such as land tenure, local governmental and social institutions, the local economy, mushroom harvesting, and local cash crop cultivation. Finally, we conducted individual household interviews involving 77 questions that covered diverse themes including household demographics, forest resources and management, mushroom harvesting and marketing, cash crop harvesting and marketing, and household economic and livelihood strategies. The structured key informant interviews and household questionnaires included a combination of open-ended and closed-ended questions.

Surveys in Diqing and Xishuangbanna were conducted within a single administrative village, with 3 natural villages selected at each site. During the interviews with administrative village officials, we identified variations between natural villages; we then selected natural villages to capture this diversity. In Diqing, Village A was selected based on its reputation for having especially abundant mushroom resources; Village B was selected because households there were cultivating maca for a different maca company and under a different contractual arrangement than Village A; and Village C was selected because it was the only natural village within the administrative village where no companies had yet contracted farmers to cultivate maca. In Xishuangbanna, a key informant interview suggested relative homogeneity across all natural villages, so 3 villages were selected at random.

In each natural village, we attempted to carry out a key informant interview with the leader of the village. Due to potential respondent refusal or absence, we were only able to complete 2 key informant interviews in Diqing (in Villages A and B) and 1 in Xishuangbanna (in Village E). Within each natural village, we surveyed a random sample of 20 households, giving us 60 household surveys each in Diqing and Xishuangbanna.

In Chiang Mai, our site spanned 2 administrative villages. We carried out 4 key informant interviews with natural village leaders or their deputies, including leaders from each of the 3 dominant ethnic groups at the survey site—Lisu, Karen, and Northern Thai. We then randomly selected 4 Northern Thai, 3 Lisu, 3 Karen households, and 1 Shan household to respond to our household survey. An additional Northern Thai respondent was selected to respond to the survey based on a key informant interview that highlighted a member of this household as one of the more active local mushroom harvesters. This made a total of 12 household surveys.

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Data analysis

Responses to open-ended survey questions, such as those relating to conservation attitudes, were either directly analyzed or coded and standardized into analytic categories. Each of these categorizations is described in the relevant part of the results section.

For the purposes of some statistical analyses, we categorized households according to whether they reported either cash crops or mushrooms as a significant income source. We considered an income source to be significant if the survey respondent listed it in his/her household's top 3 income sources. In some instances, we further categorized those households with significant mushroom incomes according to whether they specialized in a single species of mushroom such as matsutake. We categorized households as matsutake specialists if the respondent listed mushrooms among his/her household's top 3 sources of income and listed matsutake among their top 3 most collected mushroom species.

T-tests, pairwise comparisons with Holm adjustments, and chi-squared tests were used to test the statistical significance of observed trends. R statistical computing software was used to conduct statistical analysis and to produce figures. A map of the research sites was produced using ArcMap 10.3.1 (Figure 1).

Results

Cash crops and mushrooms: an overview

Maca was first introduced to the Diqing site in 2013. In Villages A and B in Diqing, all or almost all households surveyed had adopted maca cultivation—90% in Village A, and 100% in Village B. Maca is a significant source of income for the overwhelming majority of households—90% in Village A and 95% in Village B. Average land area cultivated was also similar in both villages—5530 m^2 (Standard Deviation [SD] = 4280 m^2) per household in Village A and 6330 m^2 (SD = 1390 m^2) per household in Village B. Maca was first introduced to Villages A and B in 2013. Both communities were approached by maca companies via local government and signed contracts to cultivate the crop. Though the terms of these contracts are different in the 2 villages, in both cases the maca companies cultivate seedlings in polytunnels and provide the seedlings to the contracted farmers.

In Village C, no maca company had offered contracts to local farmers. Fifty percent of households surveyed had attempted to cultivate maca on their own, but this cultivation was not on a large scale, with an average of only 2130 m^2 (SD = 2280 m^2) per household cultivated by these households. Only 25% of respondents in Village C reported maca as a significant income source; 30% told us that they had considered cultivating maca on a commercial scale but could not do so because no maca companies were available to invest in their farms.

Mushrooms were collected by a large majority of households in the 3 Diqing villages (100% in Village A, 85% in Village B, and 100% in Village C) and were a significant income source for the majority of households (100% in Village A, 60% in Village B, and 85% in Village C). The most valuable mushroom harvested in these villages was matsutake, which can fetch US$ 1.50–76.00 per kg.

At the Xishuangbanna site, rubber was first introduced around 30 years ago. All households surveyed at this site cultivated rubber, and all household survey respondents reported rubber as a significant income source. The average area of a household's rubber plantation was 15,680 m^2 (SD = 8460 m^2) for Village D, 23,570 m^2 (SD = 9240 m^2) for Village E, and 17,930 m^2 (SD = 10,050 m^2) for Village F. A minority of households in each village (15% in Village D, 20% in Village E, and 35% in Village F) spent time harvesting mushrooms. Only a small minority reported mushrooms or any other wild NTFP as a significant income source (10% in Village D, none in Village E, and 15% in Village F). The most valuable mushroom harvested in these villages has the common name *da hong jun* or "big red mushroom" (*Russula* sp.), which fetches prices ranging from US$ 3.80–18.30 per kg. Since these 3 villages had very similar mushroom and cash crop portfolios, we treated them as a single population for the remainder of our analysis.

At the Chiang Mai site, *miang* tea has been cultivated as a cash crop for several centuries, with more recent cash crop introductions including coffee (30–40 years ago), rubber (8 years ago), and eggplant (2 years ago). Ninety-two percent of households either cultivated cash crops or were employed on cash crop plantations. Seventy-five percent of households reported cash crops as a significant income source. While no households reported mushrooms as a significant income source, 83% of the families surveyed did harvest them. In Chiang Mai, mushrooms are harvested not only in natural forests but also in *miang* tea plantations. The most valuable mushroom harvested in Chiang Mai is *hed thob*, for which harvesters receive US$ 42.50–70.90 per kg. Since our household survey sample was extremely small, it is worth noting that this picture of livelihoods dominated by cash crops with minimal NTFP incomes tallies with both our small household survey and our key informant interviews with 4 local leaders.

Are poorer families more mushroom dependent?

Households were grouped into 3 livelihood categories: those who did not harvest any mushrooms commercially, harvesters who reported matsutake as a significant source of income, and harvesters who reported significant income from mushroom species other than matsutake. Both the mean and median incomes were highest in matsutake-harvesting households, while the mean income was lowest for households harvesting mushrooms other

TABLE 1 Household income (US$) compared to mushroom-harvesting practice.

	Mean income[a)]	SE mean	Standard deviation	Median income
Harvest matsutake ($n = 32$)	7079	791	4480	5775
Harvest other mushrooms ($n = 39$)	4762	527	3294	3850
Don't harvest mushrooms ($n = 48$)	6089	955	6615	3850

[a)] RMB were converted to US$ using the US Internal Revenue Service's 2015 average annual conversion rate of US$ 1 = RM 6.489 (IRS 2016).

than matsutake (see Table 1; Figure 2). The nonharvesting household category was the most skewed of the groups, with several outlier incomes significantly higher than the rest. We carried out statistical comparison between the incomes of these different household categories both by site and across sites. *T*-tests revealed no statistically significant trends ($p > 0.05$) across the mean incomes of households with different mushroom-harvesting profiles.

Two nonharvesting households reported incomes of US$ 30,800, over 5 times the average income of nonharvesting households and 33% more than the next highest reported income; they were also the only households to report rental income as 1 of their top 3 incomes. When we removed these 2 households from the nonharvesting category, a pairwise comparison with a Holm *p*-value adjustment of pooled standard deviations showed higher incomes among matsutake mushroom harvesters than among nonharvesting households ($p = 0.053$). A further pairwise comparison with a Holm *p*-value adjustment between the pooled standard deviations of matsutake harvesters and harvesters of other kinds of mushrooms indicated higher incomes among matsutake harvesters ($p = 0.050$) than among harvesters of other mushroom species.

Impact of maca on mushroom harvesting in Diqing

We asked respondents, "Has the time your household spends harvesting mushrooms changed since the introduction of maca?" and "Can you please describe this change?" We excluded respondents who did not report maca as a significant income source, as this suggested that maca would have had only a small impact on their household labor allocation, and we only included respondents who had harvested mushrooms prior to beginning maca cultivation. This gave us a sample size of 39.

Two-thirds of mushroom-harvesting households who had begun cultivating maca experienced a change in the time spent collecting mushrooms. Of these, some respondents described a division of household labor between maca cultivation and mushroom harvesting; some stated either that individuals worked harder or that they divided the day between maca cultivation and mushroom harvesting (eg working in the fields in the

FIGURE 2 Incomes in households with different mushroom-harvesting strategies.

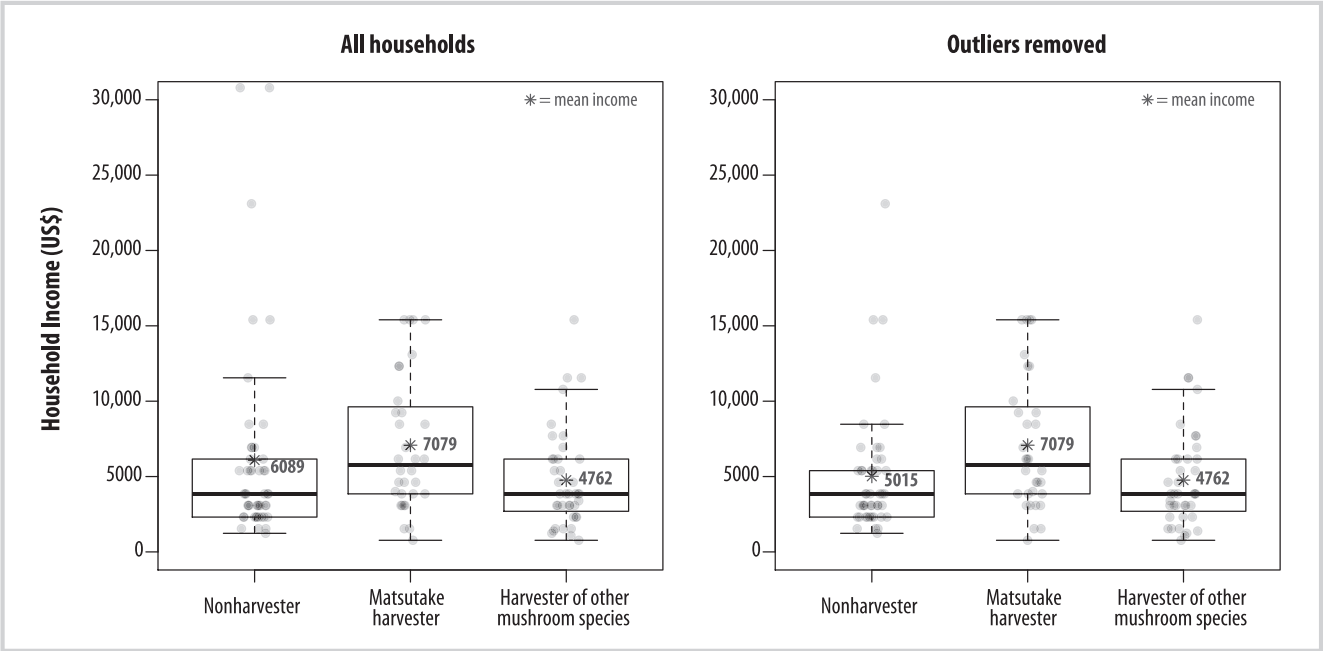

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TABLE 2 Impact of maca cultivation on mushroom harvesting in Diqing.

Reported impact	Number of responses
Divide household labor between cash crop and mushrooms	3 (7.7%)
Busier than before/work overtime	7 (17.9%)
Spend less time collecting mushrooms	16 (41.0%)
No longer collect mushrooms	0
No change	13 (33.3%)

morning and harvesting mushrooms in the afternoon); some said that they spent less time harvesting mushrooms or only harvested mushrooms when the maca labor was completed (Table 2).

Mushrooms as an incentive for conservation

In Village A in Diqing, a key informant suggested that in addition to government regulations restricting timber harvesting, there had been local efforts to limit livestock grazing in forests because of the detrimental impact of grazing on matsutake yields. Of those surveyed in Village A, only 30% of households reported grazing livestock in the forest—despite high cattle ownership, with all but 1 household in Village A owning at least 1 head of cattle. Though restrictions on grazing were not mentioned specifically in Village B, which also had a high proportion of matsutake harvesters, grazing livestock in the forests was similarly rare, practiced by only 15% of households. In Village C, where most households harvested mushrooms other than matsutake, livestock grazing in forests was more prevalent. Grazing practices, livestock ownership, and matsutake specialization across the 3 villages are summarized in Table 3.

Our survey asked mushroom harvesters in Chiang Mai ($n = 10$), "What techniques do people use to maximize mushroom yields?" In Chiang Mai, fire is known to be used by mushroom harvesters as a technique for enhancing yields of *hed thob* mushrooms, and we therefore prompted fire as a possible response. Though all respondents said that they themselves would never start a forest fire, 50% of harvesters told us that fire had a positive impact on *hed thob* yields and said that if they saw a forest fire, they would visit the site to collect mushrooms. Only 1 respondent reported fire as having a negative impact on mushroom yields. The burning of forests to promote mushroom yields was not reported at any of the other study sites.

Valuation of supporting, regulating, and providing cultural ecosystem services

Our survey asked the open-ended question, "Apart from resources that you can harvest from the forests, are there any other reasons that the forests are valuable to you or why you would want to protect them?" Those who simply answered "yes" to this question were asked to elaborate on their reasons. We categorized answers into 5 response types:

1. Respondents who unambiguously stated that the wild harvestable resources forests provide are the only reason to value or protect them;
2. Respondents who answered "yes" but, when elaborating on their answer, mentioned only provisioning ecosystem services (such as the supply of mushrooms, timber, or firewood), implying that they might view provisioning services as the only reason for protecting or valuing forests;
3. Respondents who answered "yes" but then offered only a vague explanation (for example, "yes, there are other benefits to protecting forests" or "yes, it is good for us to protect forests");
4. Respondents who answered "yes" and offered reasons that mentioned supporting, regulating, and/or providing cultural ecosystem services (such as water, climate, the ecosystem or environment, pollution, aesthetics, ancestral/cultural heritage, and generalized ideas of reliance on the forest/mountains), the strongest sign of valuing forests for reasons other than harvestable resources;
5. Respondents who said that they did not know the answer to this question.

We disaggregated results by whether or not households reported mushrooms or any other wild NTFP as a significant source of income, and by site (Table 4).

TABLE 3 Livestock grazing and matsutake harvesting in Diqing.

Responses	Village A ($n = 20$)	Village B ($n = 20$)	Village C ($n = 20$)
Efforts made to limit livestock grazing in forest?	Yes	No	No
Households grazing livestock in forests	30%	15%	50%
Households owning cattle or goats	95%	100%	100%
Mean number of livestock per household	10.9	4.6	21.5
Households specializing in matsutake	70%	40%	25%

TABLE 4 Valuations of forest ecosystem services.

Value forest for ecosystem services other than provisioning?	Mushroom income		Location		
	High ($n = 54$)	Low or none ($n = 66$)	Diqing ($n = 60$)	Xishuangbanna ($n = 60$)	Chiang Mai[a] ($n = 12$)
1. No, forest is only valuable for harvestable resources	13.0%	3.0%	13.3%	1.7%	0%
2. Yes, but mentioned only harvestable resources	18.5%	4.5%	18.3%	3.3%	16.7%
3. Yes, but offered only vague reasons	20.4%	34.8%	18.3%	38.3%	33.3%
4. Yes, and mentioned specific supporting, regulating, and/or providing cultural ecosystem services	44.4%	56.1%	48.3%	53.3%	33.3%
5. Do not know	3.7%	1.5%	1.7%	3.3%	16.7%

[a] Because of differences in sampling, data from Chiang Mai are not included in data disaggregated by mushroom income.

In order to carry out chi-squared tests, we grouped categories 1 and 2 together as valuing forests exclusively for provisioning ecosystem services. This composite category was compared to those who viewed supporting and regulating ecosystem services as providing a reason to value forests (Table 5). This chi-square test showed a statistically significant trend ($p = 0.0023$), with households with significant mushroom incomes more likely to value forests exclusively for their provisioning services. By contrast, households who did not have significant income from mushrooms were more likely to appreciate forests for supporting, regulating, and/or providing ecosystem services in addition to their provisioning services.

Because survey respondents with mushroom income were primarily from the Diqing site, and most survey respondents with no mushroom income were from the Xishuangbanna site, we did a second chi-square test to assess site as a variable (see Table 5). This test also showed a statistically significant result ($p = 0.0038$). Our data set was not large enough to allow site-disaggregated chi-square tests assessing goodness of fit between significant or nonsignificant mushroom income and forest conservation values. (For Diqing, we had only 9 responses from households with nonsignificant mushroom income, and for Xishuangbanna, we had only 2 responses from households with significant mushroom income.) As such, we cannot be sure the statistically significant trend observed was not due to other site-specific differences.

Mushroom harvesting as recreation

Several Chiang Mai survey respondents mentioned that mushroom harvesting is an enjoyable activity. Indeed, a respondent who did not herself collect mushrooms told us, "I would love to go [mushroom harvesting]. It looks fun and I would also get some mushrooms, but I have a problem with my knees [so I cannot go]." Similarly, during preliminary surveys in Xishuangbanna, several respondents told us that collecting mushrooms was "good fun" (*hao wan*). This led us to include the question "Do you enjoy collecting mushrooms?" in our final survey instrument. Respondents who enjoyed harvesting mushrooms outnumbered those who did not regardless of whether their households had significant mushroom income (Figure 3).

Discussion

Cash crops do not necessarily eclipse NTFPs

Differences in income between mushroom-harvesting and non-mushroom-harvesting households we surveyed do not support the broadly observed trend reported in the NTFP literature that NTFPs are collected primarily by lower-income households. Indeed, though a larger survey size might be needed to show a statistically significant trend, our findings suggest that households who harvest matsutake tend to have a higher income than rural households in the same province who collect no mushrooms. This may suggest that matsutake has unique

TABLE 5 Valuations of forest ecosystem services, chi-squared tests.

Ecosystem services valued	Mushroom income[a]		Location[b]	
	High ($n = 41$)	Low or none ($n = 42$)	Diqing ($n = 48$)	Xishuangbanna ($n = 36$)
Provisioning only (items 1 and 2 from Table 4)	41%	12%	40%	11%
Supporting, regulating, and/or providing cultural services (item 4 from Table 4)	59%	88%	60%	89%

[a] Pearson's chi-squared test, $p = 0.0023$; Yate's correction for continuity, $p = 0.0051$.
[b] Pearson's chi-squared test, $p = 0.0038$; Yate's correction for continuity, $p = 0.0081$.

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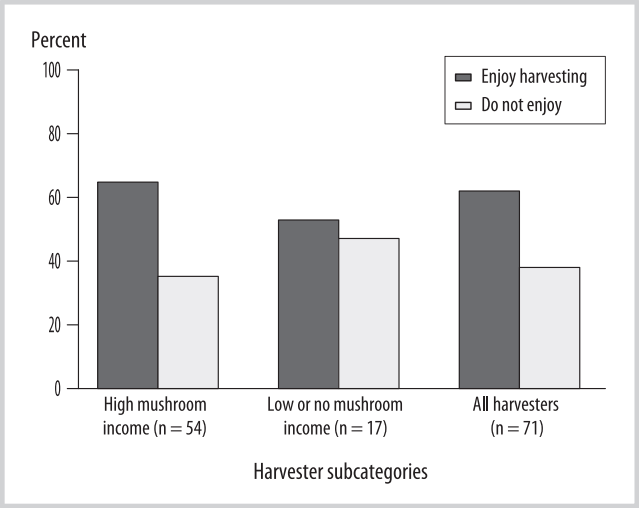
FIGURE 3 Enjoyment of mushroom harvesting.



characteristics that make it an exception to the ordinary rule. One such characteristic might be its high value; it fetches prices as high as US$ 76 per kg.

Also in contrast to the expectation that newly introduced cash crops might outcompete NTFPs, we found that despite very high levels of uptake for maca cultivation, no household in Diqing has ceased collecting mushrooms since the new cash crop's arrival in 2013. This may reflect specific characteristics of the mushrooms harvested in Diqing, such as the high value, especially of matsutake. It may also be that the abundance of mushroom traders in Diqing makes harvesting an attractive livelihood strategy, with harvesters able to indirectly access national and international markets for a broad range of mushrooms (He 2010; Tsing 2015).

In contrast to Diqing, livelihoods in Xishuangbanna are overwhelmingly dominated by rubber cultivation; this perhaps mirrors the trend noted elsewhere for relatively wealthy cash-crop farmers to abandon NTFPs. The difference between our 2 sites may reflect the relatively low value of mushrooms, as well as the lack of mushroom marketing opportunities in Xishuangbanna as compared to Diqing. The case of Xishuangbanna notwithstanding, results from Diqing suggest that lucrative new cash crops do not necessarily eclipse NTFPs in local livelihoods.

Potential for diverse cash crop–mushroom livelihood portfolios

In areas where high-value NTFPs dominate livelihood strategies, there is perhaps potential for cash crops to play a complementary role in diversifying incomes. Matsutake, for example, is subject to extreme price fluctuations, and so the addition of a cash crop like maca, the large-scale introduction of which has been promoted by the Chinese government, might be viewed as a positive risk-buffering development. Maca is, however, more labor-intensive than staple crops such as barley, which were cultivated prior to the introduction of maca. Much of this additional labor—including transplanting of seedlings, weeding, and harvesting—must be done during the mushroom-harvesting season, which can run from June through November. Our finding that a small number of households are splitting household labor between work in the maca fields and harvesting mushrooms suggests that communities may already be in the process of adopting strategies for integrating cash crops and mushrooms into diverse livelihoods. This local adaptation notwithstanding, the state-sponsored promotion of a labor-intensive crop with peak labor requirements during the mushroom season suggests that little consideration was given to how maca might fit alongside existing livelihood strategies. In this respect, we argue that agricultural land-use planning should be carried out in a manner that takes into account not only existing agricultural practices but also existing forestry practices.

Such consideration might extend not only to the choice of crops to promote, but also to the cropping systems in which they are embedded. In the case of maca, research in South America suggests that best practice is to cultivate it once every 5–10 years, leaving the land to fallow or using it as pasture in between. Among the benefits of such systems are increased yields and decreased weed problems (Quirós and Cárdenas 1997; Altieri 1999). A rotation system between livestock pasture and maca could be viable in Diqing, where 98% of the households we surveyed raised either goats or cattle. Moreover, such a system would reduce the labor input required for maca and thereby mitigate its impact on mushroom harvesting. In Diqing, however, maca is cultivated annually with no fallow or rotation. No research has been published on the efficacy or sustainability of maca cropping systems in China, with Chinese research instead focusing on the nutritional or medicinal benefits of the crop (eg Yu and Jin 2004; Feng et al 2009; Gan et al 2010). Given the rapid and large-scale introduction of the crop, we argue that research on maca crop systems in China is desperately needed and should be carried out in a way that is sensitive to the socioeconomic issues raised in this paper.

In the case of agroforestry cash crops, there may be further potential for promoting complementarity with NTFPs. Even though the seasonality of labor demands may often mean that farmers cannot spend much time in the forests during the mushroom season, our survey results from Chiang Mai show that mushrooms are also often harvested in *miang* tea agroforestry plantations. Research in Chiang Mai has shown more diverse and abundant fungi populations can be expected in sustainable tea plantations, which are in turn characterized by greater tree cover and tree species diversity (Sysouphanthong et al 2010). The potential for mushroom harvesting may therefore provide additional financial and recreational incentives for farmers to adopt diverse agroforestry systems. Researchers and development practitioners

might therefore include the potential for hosting wild mushrooms as a consideration in the design of agroforestry systems. Initiatives to promote wild NTFPs in agroforestry systems might be of particular value to Xishuangbanna, where the monocropping of rubber has not only resulted in huge biodiversity loss, but has also created livelihoods that are heavily dependent on a single crop and therefore extremely vulnerable to market volatility (Hammond et al 2015).

Mushrooms as an incentive for forest conservation

Our survey findings in Diqing suggest that as well as disapproving of illegal or legally restricted activities like harvesting timber or starting forest fires, matsutake harvesters may also support restrictions on forest livestock grazing as a means to minimize damage to matsutake mycelium (cf Tsing 2015). Though the lower levels of forest livestock grazing we observed in matsutake-specializing villages may be due to harvesters proactively limiting grazing, it is also possible that causation is the other way around: Forests used more intensively for livestock grazing do not produce high volumes of matsutake. We therefore propose 2 future directions of research: first, more in-depth investigation of matsutake harvesters' attitudes toward forest grazing specifically, as well as enquiry into the efficacy of community efforts to restrict it, and second, biophysical studies investigating the impact of forest grazing on matsutake yields.

From the narrow point of view of matsutake yields, the objection to livestock grazing is that as cattle move through the forest, they likely trample underground mycelium and damage any emergent fruiting bodies. Though, as we have already argued, there is a need for further research into the impact of livestock grazing, this indigenous understanding of matsutake is already supported by existing experiments showing the negative impact of disturbance such as human traffic on matsutake (Egli et al 2006; Luoma et al 2006; Egli 2011). In relation to forest conservation, moreover, research elsewhere has shown that livestock grazing can retard forest recovery and contribute to forest degradation (Aide et al 1996; Stern et al 2002). As such, local mushroom management practices might not only protect mushroom yields, but they may also contribute to forest ecosystem health more broadly. In this respect, an important forest protection strategy in Diqing is linked exclusively to the harvesting of a wild NTFP. This suggests that wild NTFPs can indeed play an important role in incentivizing forest conservation, even when official legal regulation is absent.

Our Chiang Mai site, by contrast, provided an example of wild mushrooms incentivizing activities that have a potentially negative impact on forests. Although none of our respondents said that anyone in their households started fires, the burning of forests by mushroom harvesters in Chiang Mai is widely reported (eg Yongcharoenchai 2015), and our survey suggests that many harvesters are aware of the positive impact fire may have upon *hed thob* yields. Here, *hed thob* harvesting incentivizes the setting of potentially destructive forest fires.

The contrasting examples of matsutake and *hed thob* point to the dangers of generalizing about NTFPs or wild mushrooms as inherently incentivizing positive forest management practices; particular species create incentives for particular management strategies, which may or may not be broadly beneficial to ecosystem health. These contrasting case studies also point to the limits of existing research on the impact of fire on mushroom diversity in Chiang Mai. Sysouphanthong et al (2010) found that mushroom diversity was much lower in forests that had been burned by mushroom harvesters. From the point of view of mushroom harvesters, however, species diversity may be the wrong thing to investigate: A more important factor is the volume of specific valuable species. Rather than focus on species diversity, mycologists hoping to demonstrate to mushroom harvesters the advantages of not burning forests might instead productively combine biophysical macrofungi studies with research into the palatability and market value of the edible mushrooms they find in undisturbed forests. Researchers should of course also be open to the possibility that burning forests is an economically rational choice for harvesters in Chiang Mai Province who are concerned exclusively with increasing income from wild mushrooms.

Valuation of supporting, regulating, and providing cultural ecosystem services

The high number of respondents across harvesting and nonharvesting households who valued forests for nonprovisioning ecosystem services suggests that the widespread adoption of lucrative cash crops such as rubber is not necessarily accompanied by indifference to forests that no longer provide income or subsistence through wild NTFPs. Of course, conservation values may not necessarily equate to forest conservation. Indeed, in Xishuangbanna, the emergence of rubber—which was cultivated by all Xishuangbanna survey respondents—as a cash crop has had enormous negative impact on the prefecture's biodiverse forests. However, our survey results nevertheless suggest that it is not only urban Xishuangbanna residents who are concerned about reversing the negative impacts of rubber monocropping (Ahlheim et al 2015), but also rural rubber-cultivating households. In this respect, though promoting economic incentives through NTFP exploitation may have a role to play in reconciling local economic development with forest conservation, harnessing existing forest conservation values could be equally important in engaging local communities to promote ecological sustainability in cash crop-dominated areas such as Xishuangbanna.

Recreational mushroom harvesting

At our Chiang Mai study site, we observed something undocumented in NTFP research: the recreational or

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leisure value of mushroom harvesting. This phenomenon was further evinced by survey findings in Diqing and Xishuangbanna. Given the emergence of organizations offering recreational NTFP collection trips in developed nations, the fact that people can enjoy mushroom picking should not come as a surprise (see eg Wright 2007). The lack of attention to recreation as an ecosystem service for rural communities in developing nations is, however, one that should be rectified in both the NTFP and ecosystem services literatures. This absence perhaps also reflects overemphasis on quantitative methods capable of putting a monetary value on economic and subsistence income from NTFPs (Shackleton and Shackleton 2004; Mulenga et al 2011), as well as on the indirect benefits of ecosystem services (de Groot et al 2002; Fisher et al 2009; Yi et al 2014; cf Pei 1985; Xu et al 2005). One could of course attempt to quantify the subsistence and nutritional benefits of mushrooms collected recreationally, or even the economic value of a labor force that enjoys the positive health benefits associated with recreation, but this would miss the point of what makes mushroom picking pleasurable, and forests valuable, to many harvesters in China and Thailand. Further investigation of this phenomenon might be best served by participant observation of mushroom harvesting—a method well suited to investigating the broader meaning and significance of such activities beyond their utilitarian value (see eg Tsing 2015).

Conclusion

The introduction of cash crops into mountainous forest communities in Yunnan has had mixed effects on wild mushroom collection and forest resource use. In Xishuangbanna, our findings support the generally observed trend that in cash crop-rich communities, NTFPs tend to have a marginal role. In Diqing, by contrast, we found that cash crops have become a part of mixed foraging–agrarian livelihood portfolios. We argue that diverse livelihoods of this kind are economically and ecologically desirable, and that land-use policies and development initiatives should therefore attempt to foster them.

With respect to forest conservation attitudes, we discovered that in order to protect matsutake yields, mushroom harvesters are keen to prevent not only logging, but also livestock grazing in forests. In this way, matsutake mushrooms provide a financial incentive for valuable forest conservation measures. Such incentives may be especially important in Yunnan, because, although there are state-mandated logging bans in force, forest grazing does not appear to be subject to any government regulation. In Chiang Mai, by contrast, *hed thob* mushrooms, which flourish in burned forests, may incentivize ecologically damaging practices. The contrasting cases of matsutake and *hed thob* show that while NTFPs may often provide positive incentives, this is not always the case, and it is therefore important to appreciate the distinct characteristics of specific NTFPs. Harvestable resources such as mushrooms, however, provide just one of the reasons rural households value forest ecosystems. Indeed, we found that in households with both high and low income from wild mushroom harvesting, forests are valued for their supporting and regulating ecosystem services, as well as their cultural ecosystem services.

We argue that agricultural research for development programs must understand interactions between NTFPs and cash crops. Though our data are primarily from Yunnan, China, our preliminary findings from Thailand—where social science research on mushroom harvesting is almost entirely absent—suggest the pertinence of such integrative approaches to the mountains of the Greater Mekong Subregion more broadly. Where possible, initiatives should seek opportunities for complementarity between cash crops and NTFPs, and in so doing should simultaneously foster incentives for environmental conservation and diverse livelihood portfolios. Research on ecosystem services should, moreover, look beyond narrow utilitarian interests and appreciate the potential recreational value of ecosystems for rural communities.

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