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Biodiversity conservation and livelihoods in human-dominated landscapes: Forest commons in South Asia

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ABSTRACT

Strict protected areas are a critical component in global biodiversity conservation, but the future of biodiversity conservation may well depend upon the ability to experiment successfully with a range of institutional forms, including those that permit human use. Here, we focus on forest commons in human-dominated landscapes and their role in biodiversity conservation at the same time as they provide livelihood benefits to users. Using a dataset of 59 forest commons located in Bhutan, India, and Nepal, we estimated tree species richness from plot vegetation data collected in each forest, and drew on interview data to calculate a livelihoods index indicating the overall contribution of each forest to villager livelihoods for firewood, fodder, and timber. We found that tree species richness and livelihoods were positively and significantly correlated (rho = .41, $p < 0.001$, $N = 59$). This relationship held regardless of forest type or country, though significance varied somewhat across these two factors. Further, both benefits were similarly associated with several drivers of social-ecological change (e.g., occupational diversity of forest users, total number of users, and forest size), suggesting identification of potential synergies and complexes of causal mechanisms for future attention. Our analysis shows that forest commons in South Asia, explicitly managed to provide livelihoods for local populations, also provide biodiversity benefits. More broadly, our findings suggest that although strict protected areas are effective tools for biodiversity conservation, a singular focus on them risks ignoring other resource governance approaches that can fruitfully complement existing conservation regimes.

1. Introduction

Despite numerous innovations in conservation design over the past two decades, the protected area model remains the chief strategy for biodiversity conservation worldwide. The PA model constitutes a distinct form of resource governance, designed to promote conservation through territorialized restrictions on human use and access. About 12% of the world's terrestrial extent is currently within a protected area (Chape et al., 2005). However, substantial increases in the existing global extent of protected areas seem unlikely, particularly for stricter categories (IUCN categories I–III), due in part to a vocal reaction against them in many parts of the world. This reaction is particularly visible in arguments around displacement and conservation refugees (Schmidt-Soltau and Brockington, 2007). Nevertheless, a large proportion of the world's species – marine and terrestrial – remain outside strict protected areas (Karieva, 2006; Rodrigues et al., 2004; UNEP-WCMC, 2007). Protecting large numbers of additional species and ecosystems requires that conservationists consider other types of biodiversity protection regimes more seriously than has been the case till now.

Many conservationists view strict protected areas as the only assured means of preserving the last remnants of the natural landscape from human encroachment and human-induced deforestation (Joppa et al., 2008), but strict protected areas have also generated social costs that have been borne disproportionately by the rural poor in developing countries (Adams and Hutton, 2007; West et al., 2006). Although strict protected areas are and will likely remain a critical component in global biodiversity conservation, a large body of research also suggests the importance of alternative governance regimes in curbing deforestation and maintaining sustainable use patterns for extended periods (Bray et al., 2003; Nepstad et al., 2006). Indeed, the future of biodiversity conservation may well depend upon the ability to experiment successfully with a range of institutional forms, including those that permit human use.

Conservation policies frequently overlook the contribution of alternate resource governance regimes towards biodiversity conservation, particularly institutional arrangements that permit human use. Although an increasing number of conservation projects

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have incorporated limited multiple-use zones into larger project designs, these are utilized almost exclusively for their potential to deflect human pressure from areas with higher conservation priority. On the other hand, a growing literature has sought to draw attention to the importance and challenges of biodiversity conservation in human-dominated, mixed-use landscapes (Chazdon et al., 2009; Harvey et al., 2008; Perfecto and Vandermeer, 2008). Recent scholarship has affirmed the interrelatedness of ecological processes at the landscape level, calling attention to the quality of the broader landscape matrix in which protected areas are embedded (Andersen and Jenkins, 2006; DeFries et al., 2005; Hansen and DeFries, 2007; Schelhas and Greenberg, 1996). But, limited empirical bases for manipulating social-ecological dynamics within human-dominated landscapes, as well as an absence of coherent policy frameworks for the incorporation of such dynamics into broader conservation projects (Gardner et al., 2009), has meant that conservation programs and policies have rarely deployed institutional arrangements for multiple-use areas explicitly for their contributions to biodiversity conservation. At the same time, existing work on the subject has rarely examined empirical evidence from multiple locations comparatively to identify how biodiversity-related outcomes under specific resource governance regimes relate to other outcomes such as livelihoods, and the factors that simultaneously affect both.

We focus in this article on forest commons and their role in the conservation of biodiversity at the same time as they satisfy other social objectives – in particular, provision of livelihood benefits to users. Forest commons are patches of forests embedded within heterogeneous landscapes, characterized by clear boundaries of the forest, and used in common by an identified group of users who possess enforceable property rights to benefits from the forest (Chhatre and Agrawal, 2008). Several countries in South Asia (most prominently India and Nepal), and others around the world, are implementing policies that support decentralized management of forests as commons (Agrawal and Chhatre, 2006; Nagendra and Gokhale, 2008). Although these policies often aim at regeneration of degraded forests rather than biodiversity conservation, we show in this article that such forests can play an important conservation role complementing that of protected areas. Utilizing forest commons as elements within broader conservation designs represents one of the most effective ways to augment terrestrial areas under conservation and enhance conservation outcomes, particularly in human-dominated landscapes.

Forest commons are important for the future of biodiversity conservation for at least three reasons. First, there is a limit to the expansion of restrictive conservation, and only a relatively small proportion of the global terrestrial surface will ever be protected through strict protected areas. For instance, current terrestrial coverage of protected areas in IUCN categories I–III is 4.3% (Chape et al., 2008). Further, in most developing countries, few significant patches of relatively untouched nature remain, and there is considerable political opposition to the constitution of new protected areas in regions with moderate population densities. Although they may not be designated as such, forest commons in many cases may function similarly to more permissive protected area categories (IUCN categories IV–VI), which currently cover 8.6% of global terrestrial extent (Chape et al., 2008). Second, well-managed forest commons can enhance the overall quality of the landscape matrix around stricter protected areas, and improve connectivity and ecological functions (Andersen and Jenkins, 2006). Lastly, climate change will likely alter global species distribution dramatically. As species range limits contract or shift (Parmesan and Yohe, 2003), existing protected areas may no longer protect desired biota. Hannah et al. (2002, 2007) argue that conservationists must plan explicitly for climate change by creating new protected areas in strategic locations and focusing on the broader landscape matrix. Given the political difficulties of creating additional strict protected areas, a network of well-managed forest commons may be a more tenable strategy to deal with the inherent uncertainty of future species distribution changes.

A conservation paradigm that focuses solely on maximum protection of limited area constrains itself to using only a subset of available conservation strategies. The biodiversity values of a given forest represent the outcome of the dynamic interplay of a number of biophysical, but also socio-economic and institutional contextual variables. Using a dataset of 59 forest commons located in Bhutan, India, and Nepal, we explore the relationships between several of these contextual variables and tree species richness on the one hand, and the same variables and livelihood contributions of these forests on the other. In exploring the relationships of the same set of variables to two forest outcomes – tree species richness and livelihood benefits – we seek to draw attention to the joint production of these two outcomes of interest, and attend to a more nuanced understanding of the complex dynamics of social-ecological systems that produce these two outcomes.

2. Data and methods

Diversity, livelihoods and other contextual data were collected at each site as part of the broader International Forestry Resources and Institutions (IFRI) research program (www.umich.edu/~ifri), operating in 12 countries since 1992. Data were collected with an interdisciplinary set of research instruments to measure related elements of socio-economic and livelihoods characteristics of forest users, patterns of forest use, forest vegetation structure, composition and species diversity, and forest governance arrangements. The IFRI program aims to better understand connections between social and ecological processes in diverse forested landscapes. The research instruments include plot-based forest vegetation sampling to measure aspects of forest condition, as well as semi-structured interviews and group discussions with members of communities, government institutions, and other related actors who rely on or are involved in forest management at the site in some capacity. Interviews cover a range of forest governance variables, but focus particularly on gaining an understanding of forest use rules and rule formation, monitoring and enforcement processes, forest product harvesting and use at household and user group levels, and information about how forest management is structured and implemented at local and higher levels. Data for this analysis were extracted from the full IFRI database of more than 350 forests across 12 countries. All cases with forest vegetation data for Bhutan ($N = 6$ forests), India ($N = 19$ forests), and Nepal ($N = 34$ forests) were selected for analysis, and comprised relatively similar riverine ($N = 7$), temperate deciduous ($N = 12$), temperate evergreen ($N = 9$), and tropical moist deciduous or semi-evergreen ($N = 31$) forest types (Negi, 1989). Most of the 59 forests in our sample (Fig. 1) were located in conservation landscapes, in that they were in close spatial proximity to some form of traditional protected area. Sixty-six percent of our sites were within 20 km of any category (IUCN category I–VI) protected area contained in the 2009 World Database on Protected Areas (IUCN and UNEP, 2009), while 44% were within 20 km of a strict protected area (IUCN category I–III). Additionally, nearly all of our sites were within 10 km of a reserved or protected forest, categories which are not included in the 2009 WDPA for any of the countries in our sample.

We used tree species richness as a proxy indicator for overall forest biodiversity. We estimated tree species richness from plot-based vegetation data collected in each of the 59 forest commons in the study. All stems at least 10 cm DBH within 10 m radius circular plots distributed randomly throughout each forest were mea-

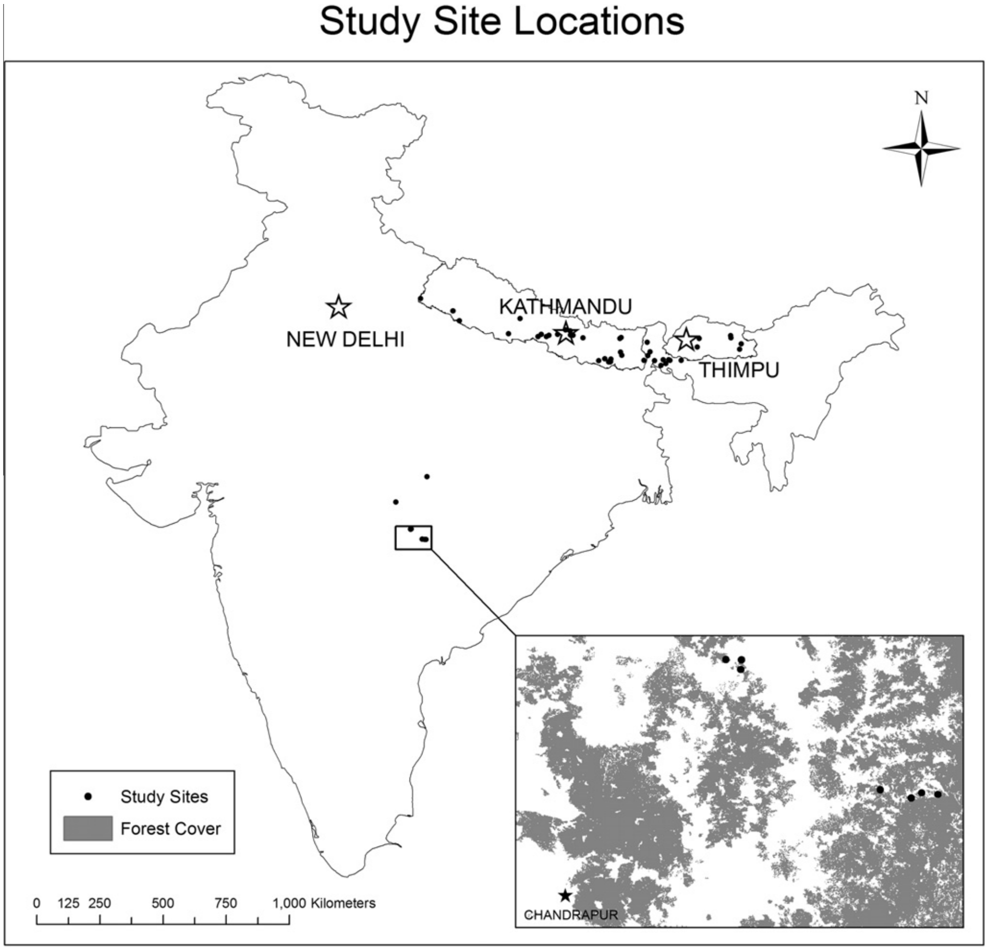

Fig. 1. Map of study site locations in India, Nepal and Bhutan.

sured and identified to species. The number of plots measured in each forest was generally thirty, while up to 69 plots were measured in some of the larger and more heterogeneous forests to ensure adequate sampling, as determined by species accumulation curves. Forests in the study ranged from 55 to 10,123 ha in area, with a median size of 260 ha (Fig. 2).

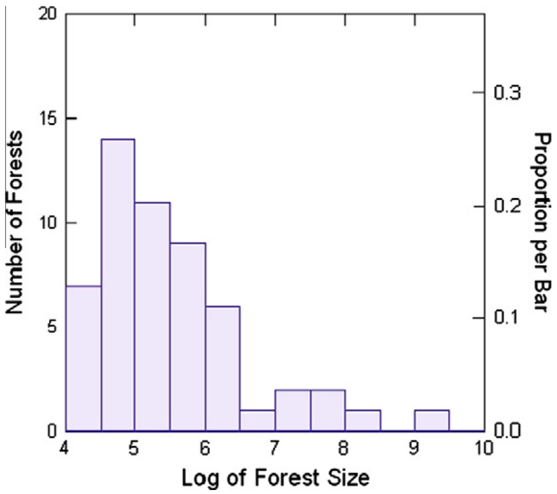

Fig. 2. Size distribution of the forest commons study sites.

We calculated the Chao1 richness estimator for each forest (stems ⩾ 10 cm dbh) using the EstimateS software program (Colwell, 2005), and standardized the results to the mean. For each forest, we ran 200 randomized runs on the plot abundance data, summarized by species, to generate 95% confidence intervals around the mean of Chao1. Chao1 is a non-parametric estimator of species richness that draws on abundance-based species data, and is considered relatively robust to potential under-sampling and differences in sample size (Chao et al., 2005), as was the case for our data. We generated a livelihoods index, indicating the overall contribution of each forest to villager livelihoods. The livelihoods index was based on the factor score for each forest extracted from a confirmatory factor analysis of the proportions of three sources of livelihoods benefits which accounted for the bulk of benefits provided to local users of the forest commons in our sample, according to our interviews. We constructed the index in order to incorporate the information on each of these major benefits in our analysis, yet reduce the dimensionality of the data. The three benefits were: (i) firewood, (ii) fodder, and (iii) timber for domestic use. The proportion of household needs met within a village for each of these forest products was obtained through group discussions with a majority of village residents. The factor analysis was weighted by the number of cases, i.e., villages, for each of the three countries – Bhutan ($N = 6$), India ($N = 19$), and Nepal ($N = 34$). All three constituent variables load on a single factor (LR test: independent vs. saturated: $\text{chi}^2(3) = 49.45$; prob > $\text{chi}^2 = 0.0000$, all factor loadings >80%).

We used the Cronbach's alpha (Cronbach, 1951) to test the reliability and internal consistency of the livelihoods index (average inter-item covariance: 21.86; scale reliability coefficient: 0.7677;

a coefficient greater than 0.7 is considered adequate (Nunnelly, 1978)). Cronbach's alpha is an index of reliability associated with the variation accounted for by the true score of the "underlying construct", that is, the hypothetical variable that is being measured (Hatcher, 1994). The coefficient ranges in value from 0 to 1, and a higher value indicates greater reliability of the generated scale.

We also used the Kaiser–Meyer–Olkin measure of sampling adequacy, which compares the magnitudes of the observed correlation coefficients of variables to the magnitudes of the partial correlation coefficients, to test whether a factor analysis of the three variables in our livelihoods index was warranted. This test also suggests that our livelihoods index is a robust measure of the aggregate contributions to livelihoods for firewood, fodder, and timber (KMO = 0.6865, value greater than 0.5 is considered adequate (Kaiser, 1970; Dziuban and Shirkey, 1974)).

3. Results

Multivariate analysis of variance suggests that there is no significant difference in tree species richness and the livelihoods index across the four forest types (Wilk's lambda = 0.88, $F_{(6,\ 108)} = 1.18$, prob. > $F = 0.32$, $N = 59$; Lawley–Hotelling trace = 0.11, $F_{(6,\ 110)} = 1.16$, prob. > $F = 0.33$, $N = 59$). In our sample, tree species richness and livelihoods index are correlated positively and significantly (rho = .41, $p < 0.001$, $N = 59$; Fig. 3). Across forest types, the correlation was strongest for tropical moist deciduous or semi-evergreen forest (rho = .38, $p = 0.04$, $N = 31$), moderate for riverine (rho = .66, $p = 0.10$, $N = 7$) and temperate evergreen forest (rho = .53, $p = 0.14$, $N = 9$), and weakly positive for temperate deciduous (rho = .11, $p = 0.73$, $N = 12$). If stratified by country, only the Nepal forests show significant correlation between tree species richness and livelihoods index (rho = .45, $p = 0.008$, $N = 34$), though all in-country correlations are positive.

Relationships between the standardized tree species richness and livelihoods index and several biophysical, socio-economic, and institutional contextual factors were explored with spearman's rank correlations. Variable descriptions are provided in Table 1. Correlation coefficients were Bonferroni-adjusted to account for multiple comparisons. Table 2 presents the results. For the most part, the direction of association between tree species richness and livelihoods index on the one hand, and a suite of biophysical, socio-economic, and institutional variables was the same (Table 2, Fig. 4). Variables across these categories had statistically significant positive relationships with both species richness and livelihoods index: size of forest, population density, diversity of benefits, and years of human settlement (Table 3). No biophysical variables were significantly negatively associated with both species richness and livelihoods, or only with livelihoods irrespective of the direction of correlation.

4. Discussion

Recent attention to coupled human and natural systems has led in particular to a greater focus on the interactions and multi-scalar relationships between social and ecological outcomes (Chazdon et al., 2009; DeFries et al., 2007). In this context, it is particularly important to understand the nature of variations in institutional and socio-ecological outcomes and their drivers. But despite conceptual recognition and emphasis on the coupled nature of social and ecological outcomes, scholarship on conservation in human-dominated landscapes has tended to concentrate on alternative mechanisms for promoting livelihoods vs. biological diversity. Indeed, many scholars (and practitioners) of conservation view improvements in conservation outcomes as being feasible only through deflection of consumption pressures from areas of high conservation priority (McShane and Wells, 2004). On the other hand, social-scientific scholarship on community-based natural resource management has often attended to the institutional dynamics of livelihoods and sustainable use arrangements, but seldom analyzed institutional variation and its impacts in the context of livelihood and biological diversity outcomes simultaneously.

Our analysis shows that forest commons in South Asia, explicitly managed to provide livelihoods for local populations, in fact also provide biodiversity benefits. More importantly, the analysis shows that these benefits covary in similar directions. That is, forest commons that provide higher levels of livelihoods benefits also have higher levels of tree species richness. This pattern holds within each forest type represented in the study. Finally, we find that these twin benefits are often similarly associated with known drivers of social-ecological change. The fact that all significant pairs of associations between tree species richness and livelihoods index on the one hand and features of the social-ecological system on the other are in the same direction suggests that these relationships may allow synergistic enhancement of livelihoods and diversity related objectives of forest commons management.

It is worth noting that greater diversity of livelihood benefits derived from the forest – i.e., beyond firewood, fodder, and timber for subsistence use – is associated positively with species richness and the livelihoods index. On the face of it, this result may appear unremarkable. But it assumes significance in combination with associations among other variables. The occupational diversity of users with respect to the forest (number of user groups) is positively associated with species richness but not with the livelihoods index. On the other hand, the size of the forest has positive relationships, and the total number of users has negative relationships,

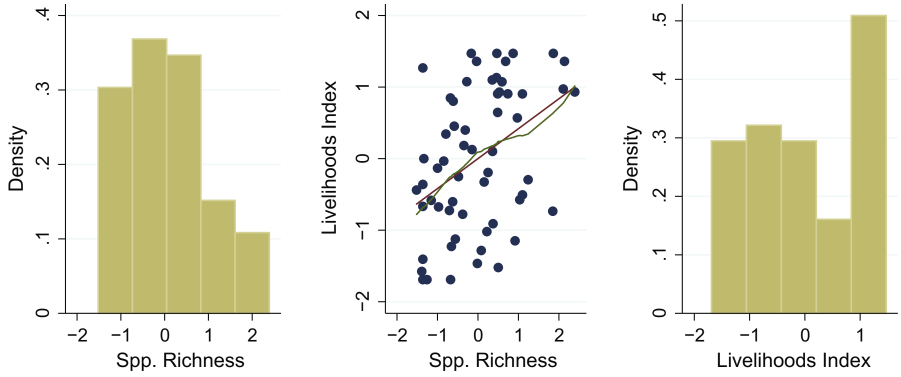

Fig. 3. Tree species richness and livelihood benefits in forest commons.

Table 1
Variable definitions and descriptive statistics.

Variable	Definition	*N*	Mean	Std. dev.	Min.	Max.
Species richness	Chao1 estimator of tree species richness	59	30.29	19.3	1	76.5
Livelihoods index	Index of firewood, fodder, and timber	59	0.151	1.00	−1.55	1.63
Woody biomass	Basal area of all trees DBH > 10 cm in >30 plots	59	17.02	12.3	0.408	47.7
Size of forest	Size in hectares	54	621.2	1497.03	55	10,123
Number of users	Number of adult local individuals using the forest	59	1792.2	2110.2	26	9663
Population density	Number of adult local individuals using the forest per hectare	54	1.06	2.47	0.01	14.73
Number of user groups	Number of different occupational groups using the forest	59	1.2	0.68	1	5
Diversity of benefits	Number of different forest products derived from the forest	59	5	2.02	0	9
Livestock grazing intensity	Proportion of forest plots reporting grazing activity	59	0.43	0.37	0	1
Steepness of topography	Average slope of the forest, calculated from forest plots	57	16.57	14.83	0	50.23
Tree plantation activity	Whether plantation activity was carried out in the forest in the last decade; yes = 1, no = 0	59	0.288	0.456	0	1
Forest improvement activities	Whether users carried out other forest improvement activities in the forest; yes = 1, no = 0	52	0.5	0.504	0	1
Frequency of collective action	1 = No collective action for other forest improvement activities, 2 = rare but present, 3 = once every few years, and 4 = every year	57	2.63	1.2	1	4
Distance of users to forest	1 = <5 km, 2 = 5–10 km, 3 = >10 km	53	1.67	0.54	1	3
Years of human settlement	Number of years of continuous human settlement	51	104.2	102.1	17	458
Commercial value of forest	1 = Substantially below normal for the forests of the region, 2 = below normal, 3 = normal, 4 = above normal, 5 = substantially above normal	55	2.96	1.01	1	5
Distance to nearest market	In kilometers	59	4.81	6.26	0	28
Distance to nearest administrative center	In kilometers	59	10.1	15.7	0	80

Table 2
Spearman's correlation.

Factors	Species richness (Chao1)			Livelihoods index		
	Rho	Prob.	*N*	Rho	Prob.	*N*
Woody biomass	0.32	0.012	59	0.13	0.34	59
Size of forest (ha)	0.43	0.001	54	0.43	0.001	54
Number of users	−0.3	0.019	59	−0.4	0.001	59
Population density (per ha)	0.52	0.000	54	0.53	0.000	54
Number of user groups	0.22	0.098	59	−0.05	0.68	59
Diversity of benefits	0.51	0.000	59	0.29	0.025	59
Livestock grazing intensity	0.12	0.35	59	0.2	0.13	59
Steepness of topography	0.24	0.078	57	0.05	0.67	57
Tree plantation activity	−0.24	0.068	59	0.07	0.57	59
Forest improvement activities	0.15	0.29	52	0.36	0.008	52
Frequency of collective action	0.15	0.27	57	0.23	0.082	57
Distance of users to forest	−0.29	0.035	53	−0.48	0.000	53
Years of human settlement	0.29	0.036	51	0.33	0.018	51
Commercial value of forest	0.27	0.046	55	0.16	0.25	55
Distance to nearest market	0.27	0.037	59	0.12	0.37	59
Distance to nearest administrative center	0.14	0.28	59	0.33	0.011	59

with species richness and livelihoods index. Taken together, these results suggest that the relationship between the diversity of benefits from a forest and its biodiversity and livelihood outcomes may be limited by the total number of users and the size of the forest.

Several variables have a statistically significant relationship with either tree species richness or livelihoods, but not both. Thus, tree species richness is lower for forests with plantation activities, but there is no association between such forests and their livelihood benefits. This finding reflects the strong focus of the region's forestry departments on monoculture plantations throughout much of the 1980s and 1990s. In contrast, where communities have undertaken forest improvement activities in addition to tree plantation and where the frequency of such collective action is high, forests show statistically significantly higher values of the livelihoods index. In other words, when communities undertake management activities, it is usually associated with higher livelihood benefits and, on average, there is no association with species richness of these forests.

We should emphasize that the complexity of the social-ecological relationships that comprise the forest commons and their outcomes are only partially described through a focus on bivariate correlations. It is important to keep in mind that the variables and their relationships are elements in complex social-ecological systems, and that the interactions between any two sets of variables are not constituted independently of other interactions. In this sense, the clusters of associations that we identify above point to potential synergies and complexes of causal mechanisms that need further attention in order to determine more clearly the direction of causation and key drivers of change. For instance, our analysis does not identify whether forests with inherently higher levels of tree species diversity enable greater livelihoods benefits, or whether higher levels of livelihoods dependence on forest resources might lead to increased tree species diversity in some forests.

The complexity of factors and processes operating in social-ecological systems likely also plays a role in why our country stratification found a significant correlation between livelihoods and tree

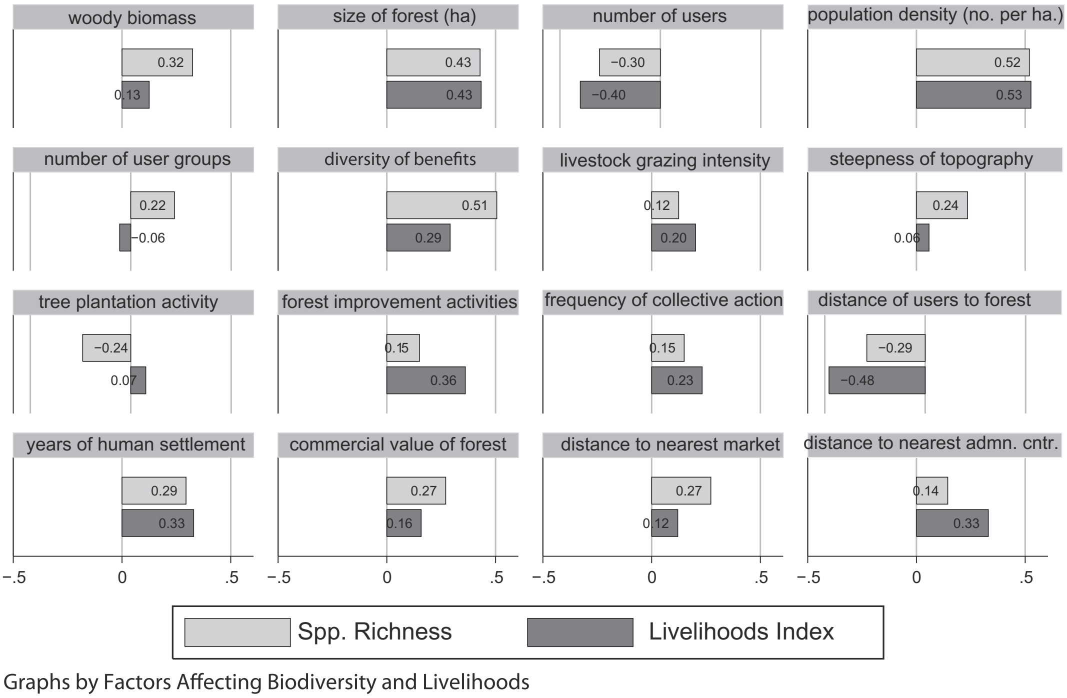

Fig. 4. Spearman's rank correlations of 16 contextual variables with species richness and livelihoods index.

Table 3
Significant correlations of contextual variables by win–win, lose–lose, and trade-off combinations of species richness and livelihoods outcomes. Direction of correlation is shown in parentheses.

Species richness and livelihoods	Species richness	Livelihoods
Size of forest (++)	Woody biomass (+)	Forest improvement activities (+)
Population density (++)	Number of user groups (+)	Frequency of collective action (+)
Diversity of benefits (++)	Steepness of topography (+)	Distance to nearest administrative center (+)
Years of human settlement (++)	Commercial value of forest (+)	
Number of users (−−)	Distance to market (+)	
Distance of users to forest (−−)	Tree plantation activity (−)	

species richness only in Nepal. Our sample size in Nepal was greater relative to India and Bhutan, but differences among the countries in terms of broader restrictions on human activities in forest commons may help to explain those results more than sample size disparities. For instance, although most of the Indian sites showed a positive correlation between livelihoods and tree species richness, four of the Indian sites had a trade-off relationship of high tree species richness and low livelihoods contribution that is associated with greater restrictions on forest use. Only one forest in Nepal exhibited this particular relationship, while none did in Bhutan. Nevertheless, our forest commons sample in each country included cases from across the range of decentralized forest management regimes present in each country. Greater variation in the relationship between livelihoods and species richness in the Indian cases could reflect greater variation in restrictions or regulations on the extent of livelihoods benefits forest users can gain from different forest commons under Indian forest policies.

We note that tree species richness is one of many possible indicators of overall forest biodiversity, and a more comprehensive assessment necessarily includes faunal diversity measured across a range of taxa, and herbaceous vegetation. In the absence of such data, tree species diversity serves as an adequate though imperfect proxy, as it is an essential component of overall forest conditions and a basic structuring characteristic which facilitates diversity across other taxa. Additionally, because forest flora and fauna are coupled through processes such as pollination and seed dispersal, severe faunal diversity loss should eventually be detected in tree diversity measures as well (Cordeiro and Howe, 2003; Terborgh et al., 2008).

Since biodiversity conservation captures additional elements beyond species richness, such as compositional aspects, endemism and differences in conservation value among species, we also examined the similarity in abundance-based tree species composition in our sites to better interpret our results. We calculated the Chao–Sorensen abundance-based similarity index to generate a measure of similarity between pairs of forests, in terms of tree species presence and abundance of individuals (Chao et al., 2005). We compared forests in our sample under traditionally stricter protected area categories (wildlife reserve and national park buffer zones) to forests under less restrictive management, and ran the analyses separately for each combination of forest type and country to ensure we were using the most appropriate comparison case available for each set of more and less restrictive category forest pairs. Mean similarity to a stricter protected area was 0.64 for riverine forests in Nepal (0.39–0.74 range; $N = 4$), 0.35 for temperate deciduous forests in Nepal (0.02–0.71 range; $N = 19$), 0.43 for tropical semi-evergreen or moist deciduous forest in India (0.00–0.80 range; $N = 12$), and 0.30 for tropical semi-evergreen or moist deciduous forest in Nepal (0.00–0.68 range; $N = 45$ due to comparisons with multiple forests under a more restrictive PA category). We were unable to identify an appropriate comparison case in our sample for temperate evergreen forests in Bhutan.

These index results suggest that in many cases, though not all, the forest commons in our sample contained high tree species richness but were also similar in tree species composition to forests under stricter protected status. We make the assumption that forest commons in our sample which are within stricter protected area categories such as national park buffer zones, are likely under such arrangements for a wider set of conservation values than tree species alone (such as tigers, for instance), and that tree species composition is a basic component of broader forest habitat quality required for other species of interest or conservation concern associated with that forest type. Since all of the forests in our sample are used by local communities to some extent, a more robust future comparison would be between the forest commons in our sample and undisturbed forest of the same forest type.

Lastly, we note that our cases occur as forest patches within landscape mosaics that consist of small and larger patches of forests embedded in typically agricultural matrices. The majority of the 59 forests in our study are less than 1000 ha in area (five of them range from 1000 to 4000 ha, and one exceeds 10,000 ha in area). We found that forest size was positively correlated with both sets of outcomes, but we also note that the location of the forest commons in relation to other high quality patches is also likely to be important for long-term viability. Most of our forest commons were located in relatively close proximity to larger protected areas, and therefore are likely to retain viability as repositories of biodiversity to some extent due to these spatial relationships, and also to augment conservation benefits within the broader landscape by providing additional suitable habitat.

Proximity to protected areas has been an important factor in several previous studies assessing conservation value and viability of remnant forest and agro-forestry patches in human-dominated landscapes. For instance, species richness of non-volant mammals (Bali et al., 2007) and birds (Anand et al., 2008) in shade coffee plantations was negatively correlated with distance to a nearby wildlife sanctuary or contiguous forest, respectively, in shade coffee plantation–reserved forest landscape mosaics in the Western Ghats, India. Abundances of priority species for conservation in forest fragments or agro-forests, such as restricted–range species or forest interior specialists, often have a particularly strong distance–dependent relationship to larger patches of high quality forest (Anand et al., 2008; Hawes et al., 2008). Our results here reinforce the policy implications of such findings, which draw attention to landscape-level processes, and highlight the important landscape-scale biodiversity conservation role that forest commons may also play, as higher-quality habitat islands in human-dominated landscapes, even as they also play an important livelihoods role for surrounding communities.

5. Conclusion

Conservation is in many ways a question of trade-offs, especially when the question focuses on enhancing conservation outcomes together with other outcomes in multiple biophysical and social dimensions. Thus, conserving all potentially desired species and their habitats while achieving improvements in human welfare, resource extraction levels, carbon sequestration, and commercial incomes may appear no more than a flight of fancy. Indeed, human and financial resources and political will to generate and maintain conservation territories are often limited. Given these limitations, the need for a balance between broader conservation objectives and more immediate human needs is highly desirable, and continues to be a subject of intense debate (DeFries et al., 2007). To surmise how this balance might best be achieved in human-dominated landscapes, it is imperative to develop a robust understanding of synergies between livelihoods and biodiversity conservation and the institutional arrangements or social conditions that facilitate potential synergies.

The findings of this paper suggest that although strict protected areas are effective tools for biodiversity conservation, a singular focus on them risks ignoring other resource governance approaches that can fruitfully complement existing conservation regimes. If the objective is to maximize conservation outcomes amidst real world limitations, management of forest commons through community forestry could play a prominent role in biodiversity conservation so as to improve conservation outcomes within existing realities. Where highly restrictive reserves are not feasible – for lack of financial resources, political resolve, or other reasons – community forests are a viable alternative, at least in terms of promoting some basic measures of biological diversity.

Forest commons, as an example of community-based natural resource management, have received substantial attention in the past two decades, both in scholarly literatures and in resource decentralization policies that call for greater participation of local communities (Agrawal and Chhatre, 2006). Indeed, community-based natural resource management is now widely recognized as capable of engendering sustainable resource management, given appropriate institutional design and enforcement (Chhatre and Agrawal, 2009; Dietz et al., 2003; Ostrom, 1990; Persha and Blomley, 2009). Many studies now show it can effectively retain or improve forest cover (Nagendra et al., 2008; Nepstad et al., 2006; Somanathan et al., 2009), endure sustainably for extended periods (Agrawal, 2005; Bray et al., 2003), and facilitate forest re-growth (Nagendra, 2007). Comparative studies have shown that a number of important ecological outcomes can be facilitated by different resource governance regimes. Nepstad et al. (2006) examined inhabited conservation areas (including indigenous lands, extractive reserves, and national forests) and uninhabited protected areas for fire and deforestation inhibition in the Brazilian Amazon. They find that deforestation and fire inhibition were similar for both uninhabited reserves and indigenous lands; in comparison, inhibition was much lower for extractive reserves. In northeastern Cambodia, Baird and Dearden (2003) examined the extractive sustainability of several resource management regimes with different ownership dimensions: common, private, and open access. They show that communal management worked well for certain resources, while private ownership worked well for others. In East Africa, Persha and Blomley (2009) found less illegal logging and better forest quality along several indictors in a communally-owned forest compared to neighboring co-managed and government forests. In a study of forest commons across Africa, Asia, and Latin America, Chhatre and Agrawal (2009) show that rule-making autonomy at local levels is associated with high biomass and high livelihood benefits, but forest ownership is characterized by a trade-off between biomass and livelihoods.

Our study joins this emerging and large body of evidence on the capacity of land tenure arrangements other than protected areas to deliver effective conservation outcomes. But in examining the association between specific drivers of both socio-economic and ecological outcomes (livelihoods and tree species richness), it goes a step beyond many existing studies. It examines the association between potential drivers of social and ecological outcomes, across both of these outcomes simultaneously. Our findings suggest that there may be some contexts and conditions under which given land use arrangements – forest commons – may be conducive to promoting both social and ecological measures, something of particular relevance to those interested in development as well as those interested in conservation.

More generally, our results suggest that the problem of effective conservation in the context of human livelihoods is importantly one of governance. Existing studies already indicate that there is no single preferred institutional arrangement for conservation

(Dietz et al., 2003; Ostrom and Nagendra, 2006). We can also say based on our findings that although strict protected areas will continue to be a necessary component of global biodiversity conservation strategies, future initiatives can also take advantage of a range of other institutional arrangements to complement traditional conservation regimes and extend conservation from the limited confines of the ‘pristine’ to broader human managed lands – by including forest commons.

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