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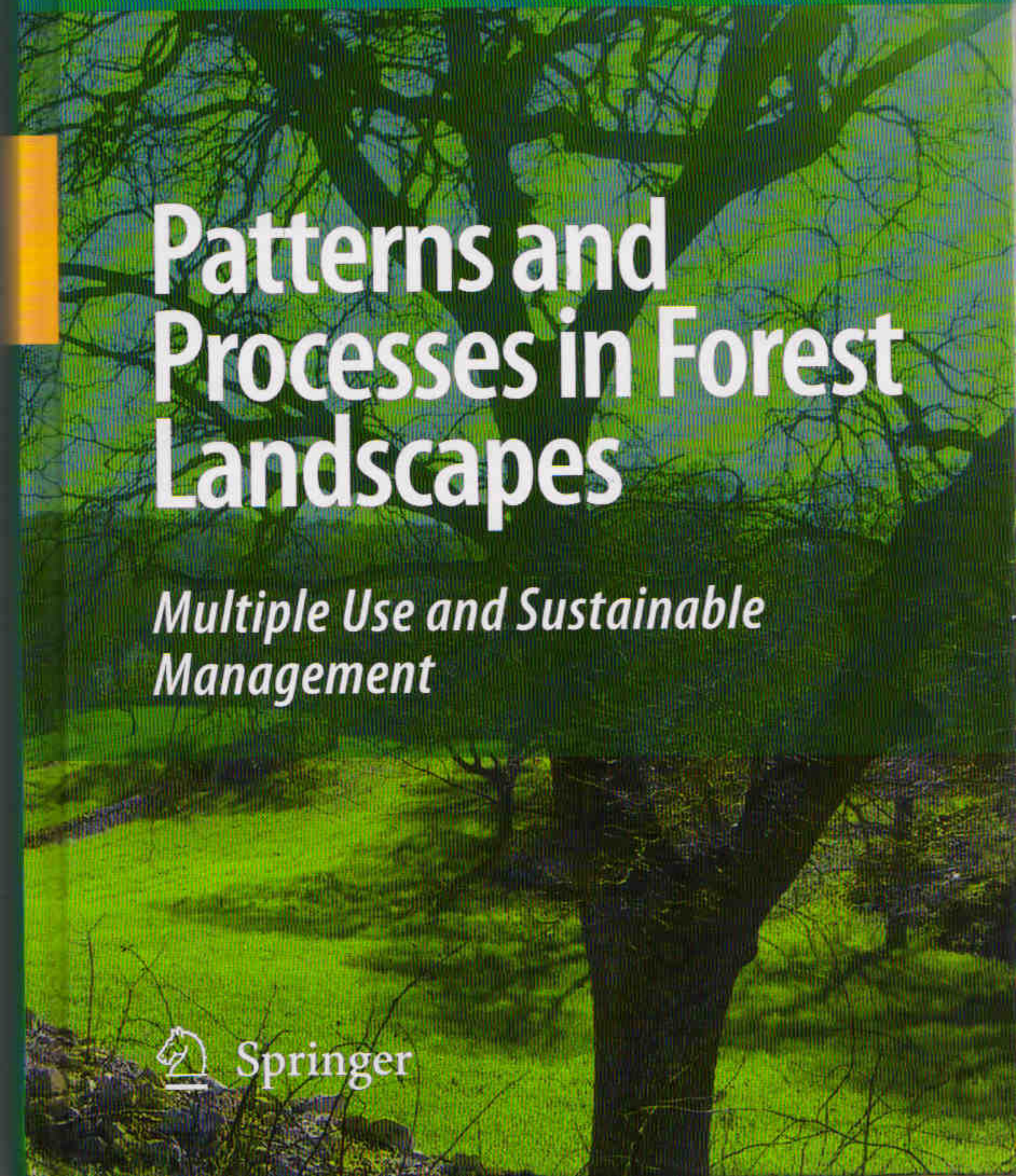

Patterns and Processes in Forest Landscapes

Multiple Use and Sustainable Management

Springer

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Chapter 8

Spatial Patterns and Ecology of Shifting Forest Landscapes in Garo Hills, India*

Ashish Kumar, Bruce G. Marcot and P.S. Roy

Abstract In many parts of the world, increasing rates of shifting cultivation – also called slash-and-burn cultivation, swidden, and (in India) *jhum* – has compromised native forest biodiversity. We explore this relationship with a case study from North East India where much of the remaining, intact, old tropical forest is found in the few protected areas and reserved forests (collectively PAs) of the region, and where *jhum* has largely permeated much of the rest of the landscape. Our analysis and mapping of land use and cover types, levels of forest fragmentation, and occurrence of *jhum* lands suggests that: buffer zones around PAs could contain additional, intact forest; incursion into PAs can reduce their effective interior core forest area; and forest wildlife habitat, particularly for Asian elephant, can be delineated among PAs in corridors consisting of low-fragmented, native forest cover. As human population density and concomitant anthropogenic stressors increase, however, more severe effects of increased rates of *jhum* on forest biodiversity will be felt. Offsetting such effects will entail not just redirecting *jhum* activities but also addressing the full cultural, social, economic, and even religious context in which shifting cultivation is pursued. Solutions must consider effects on nutrition, health, education, economic trade, and traditional lifestyles.

8.1 Introduction

The history of land use and agriculture in the forest landscapes of the greater Indian subcontinent and south Asia is strikingly diverse. Over the centuries, multiple overlapping cultures have occupied and tilled the forests of sal (*Shorea robusta*), teak (*Tectona grandis*), and hundreds of other evergreen, semi-evergreen, and deciduous tree species. In North East India, the dense tropical forests of the Himalayan hill

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regions and the vast river plains of the Brahmaputra and Ganges in the areas of Bengal, Assam, and adjacent regions were originally viewed as major obstacles to the expansion of rice paddies and other agricultural cultivation. Over time, the land was tamed and soil seen as having immense fertility. Today, however, it is human population density and its toll on soils and native forests of the region that have become an impediment to prosperity (Ludden 1999). Increasing rates of shifting cultivation have led to increased fragmentation of intact, native forests, and the implications of such changes in forest landscape patterns on native biota, particularly Asian elephants (*Elephas maximus*).

The hill country of this region has always had distinctive, indigenous tribal farming societies dating back at least six millennia. These societies have had complex relations with the lowland agrarians and with the 19th century British settlers. Today, the sustainability of these societies and their forest resources are facing the greatest challenges as markets for forest products and other natural resources are being more fully opened to pressures and demands of the outside world.

8.1.1 The Role of Shifting Cultivation in Cultural and Landscape Ecology

Jhum – also known elsewhere as shifting cultivation, swidden, and other terms – is a primitive but sometimes complicated form of forest agriculture practiced mostly in tropical countries world-wide, for example in Honduras (House 1997), Indonesia (Sunderlin 1997), Brazil (Metzger 2002), and Mexico (Pulido and Caballero 2006) as well as India (Momin 1995; Sachchidananda 1989). Under low human population density, fallow periods can extent to 20–30 years or more and much of the forest landscape can escape the slash and burn cycle in any given year, and thus there is minor influence on overall forest biodiversity and soil productivity. But high human density in many tropical areas of the world, including North East India, has caused fallow periods to drop to just a few years and large portions of forest landscapes to be converted, resulting in major losses of old, native forest cover, soil fertility, biodiversity, and crop health (e.g., Raman 2001).

From 1980 to 1990, > 6% of worldwide tropical forests and 10% of Asian tropical forests were converted to shifting cultivation (WRI 1996). As per the 1979 report of the North Eastern Council, in the Indian state of Meghalaya a total of 4116 km^2 was placed under *jhumming*, of which 760 km^{2}was used at one point of time every year by 68000 *jhummias*, i.e., families involved in *jhumming* (DSWC 1995).

Such forest perturbations in western Meghalaya included the Garo Hills, which are one of the richest botanical regions of India (Awasthi 1999). The Garo Hills represent the remnant of an ancient plateau of the pre-Cambrian peninsular shield (Momin 1984) and are prominently inhabited by the native Garo tribes. The major stressor to native forest biodiversity in the Garo Hills is the increasing rate of anthropogenic conversion of mature and primary forests to *jhum* land. Apart from *jhum*, other major land uses are the habitation and practice of permanent agriculture in valley plains.

8.1.2 Shifting Cultivation in Garo Hills, Meghalaya

Our study focused on the South Garo Hills district, which includes much community *jhum* land as well as several protected areas, notably Balpakram National Park and the adjoining Nokrek Biosphere Reserve and National Park (Fig. 8.1). Our study area (hereafter, also "landscape") represents the western-most hill ranges of Meghalaya state in North East India. The landscape contains four protected areas (PAs) and four reserved forests (RFs) (Fig. 8.1) which collectively comprise 15% of the area and which offer excellent prospects of conserving native forest and the associated biodiversity of the region. The PAs include Balpakram National Park (BNP; 220 km^2), Nokrek National Park (NNP; 47.48 km^2), Siju Wildlife Sanctuary (SWS; 5.18 sq km^2), and Baghmara Pitcher Plant Sanctuary (BPPS; 2.7 ha). The four RFs are Baghamara Reserved Forest (BRF; 44.29 km^2), Rewak Reserved Forest (RRF; 6.48 km^2), Emangiri Reserved Forest (ERF; 8.29 km^2), and Angratoli Reserved Forest (ARF; 30.11 km^2). Like the PAs, these RFs have been considered by Kumar et al. (2002) as elements of a Protected Area Network (PAN) because forests in the RFs are not being actively harvested and are not occupied by native Garo communities. Little work has been done to evaluate the landscape, PAN, and plant and animal communities of the Garo Hills except for a few studies (Kumar and Rao 1985; Haridasan and Rao 1985; Khan et al. 1997; Sudhakar and Singh 1993; Kumar and Singh 1997; Roy and Tomar 2001; Talukdar 2004).

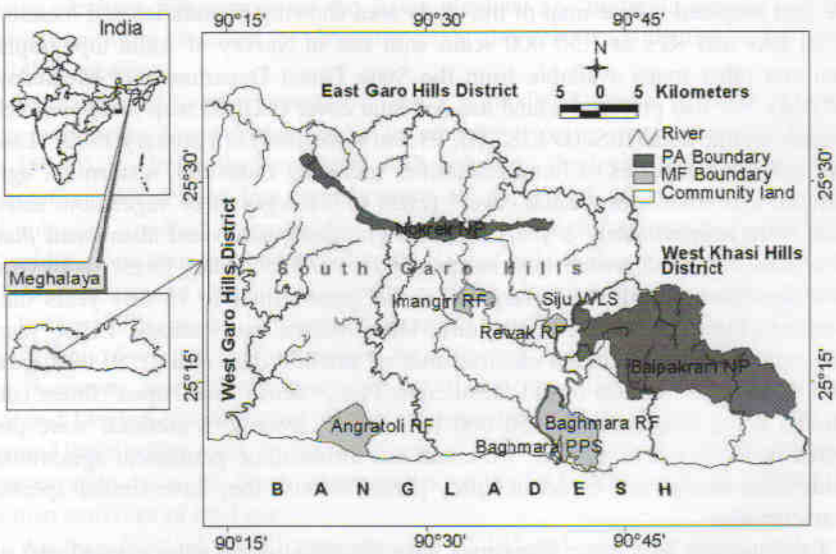

Fig. 8.1 Study area of South Garo Hills and geographical location within India and Meghalaya PA = Protected Areas, NP = National Park, WLS = Wildlife Sanctuary, MF = Managed Forests, RF = Reserved Forests and PPS = Pitcher Plant Sanctuary

In general, human activities can influence patterns and processes of forests in diverse ways. In many parts of the world, for want of food and shelter, agrarian societies have impinged upon the distribution and amount of native forests across landscapes. In this chapter, we address a particular kind of rural agricultural activity – shifting ("slash and burn") cultivation or *jhum* – and its influence on conservation of native forest biodiversity at the landscape scale, using our research in India as a case study. We offer some guidelines for conservation or restoration of native forest biodiversity. Most North East Indian forests are under tremendous pressure of exploitation from unplanned traditional forestry practices, especially the widespread use of *jhum*. *Jhum* entails native people clearing and burning the old forest growth over a piece of land to get fertile land for raising agricultural crops. A given plot of land is used for crops typically for only one or two years, and then it is left fallow for several years before being cleared and used again. In this paper we explore the effects of *jhum* on forest diversity and conditions in Garo Hills as a case study. We generalize results as lessons to learn for other tropical forests of the world undergoing accelerated shifting cultivation with associated loss of old, native forests and their attendant biodiversity. Our present study examines the spatial patterns and processes of the *jhum*-influenced landscape to identify and prioritise the wildlife habitat areas for conserving native biodiversity.

8.2 Methods

We first prepared a base map of the study area showing boundaries and locations of all PAs and RFs at 1:50 000 scale with use of Survey of India topographic data and other maps available from the State Forest Department of Meghalaya (SFDM). We also prepared a land use and land cover (LULC) map using remotely sensed satellite data (IRS-1D LISS III, 23.5 m resolution) of February 1999. "Land use" reflects categories of human activities including industrial, residential, agricultural, and other uses. "Land cover" refers to 9 categories of vegetation: active *jhum* (0 to approximately 3 years old) and grassland; scrub and abandoned *jhum* (3–6 years old) on degraded sites; bamboo brakes and secondary forest (6–10 years old); deciduous forest; semi-evergreen forest (approximately 15–30+ years old); evergreen forest; permanent agriculture; water bodies; and shadows. LULC mapping was done using guided classification of satellite data at a 1: 50 000 scale, with additional attributes of old-forest cover (viz., "dense" and "open" forest conditions) being mapped at 1: 250 000 (FSI 2001). Details of methods were presented in Kumar et al. (2000). We could not differentiate permanent agricultural fields from sandy river banks in valley plains because they have similar spectral characteristics.

Land use and land cover categories were identified using unsupervised and supervised classification techniques. The unsupervised classification consisted of a remote sensing image with 50 distinct spectral classes, which more or less represented the natural features of the landscape. This image was taken to the field and verified on 80 ground control points. Half of the ground control points easily identifiable on the image were used as training areas to perform the supervised classification, while the remainder of the points was used to evaluate the classification accuracy of the land use and land cover categories. The training areas provided a numerical description of the spatial attributes of each class and the basis for merging similar spectral classes into the more meaningful and identifiable land use and land cover classes.

We then computed selected patch indices from the LULC map in a geographic information system (GIS). We computed and mapped various indices of forest landscape pattern for each LULC category, and mapped forest patch core areas at two distances of 250 m and 500 m from the forest patch edge, by using Bio_CAP, a GIS-based programme developed by the Indian Institute of Remote Sensing, Dehradun. The landscape pattern indices included average, minimum, and maximum map polygon (patch) area; and indices of terrain complexity (topographic relief variation), patchiness, porosity, interspersion, fragmentation, polygon (patch) edge length, and disturbance (see Kumar et al. 2002; Marcot et al. 2002 for definitions and details of analyses). These indices mainly represented the degree to which forest and non-forest patches were intermixed. Core area calculations were based on 250 m and 500 m distances because these distances were suggested by a general review of the literature on "depth of edge" influences and boundary effects within protected areas (Kumar et al. 2002).

We next overlaid the map of forest fragmentation index results with the base map of boundaries, and delineated areas of low levels of fragmentation that span adjacent PAs and RFs as potential wildlife forest-habitat corridors, particularly for Asian elephant. We considered the Asian elephant an "umbrella species" so that habitat corridors identified for elephants might also benefit a wide diversity of other wildlife species.

We calculated forest fragmentation as the normalized number of forest and non-forest polygons found within a 6.25 ha area (in a roving map window of 250 m $\times$ 250 m); the lower the number of such polygons, the lower the degree of fragmentation. We defined low fragmentation as $\leq$ 30% of the normalized number of polygons, medium fragmentation as $\leq$ 80%, and high fragmentation as >80%. Corridors were thus mapped as polygons (1) that linked adjacent or nearest PA and RF boundaries, and (2) that consistently contained low fragmentation index values.

In Garo Hills, most villagers tend to restrict their movements inside forests up to two km and five km from forest edges, for collecting non-timber forest products and for *jhumming*, respectively. Hence we calculated forest area within buffers of two km and five km extending out beyond the boundaries of the PAs and RFs, and we termed these buffer areas "zones of influence" (ZIs). ZIs represent areas of potential conservation value for biotic communities of the PAN that could be affected by human activities of land use.

We then overlaid the ZI map onto the LULC and core area maps, and used Chi-square analysis to determine significant differences of forest cover and core areas among ZIs, the PAs and RFs, the wildlife habitat corridors, and other ZIs within community lands. We also used secondary information on elephant census records of SFDM for the years 1993 and 1998 and spatial information of Garo Hills (Talukdar 2004) to analyze elephant habitat relationship at the landscape level. We also used information on *jhum* families and other socio-cultural and economic factors to help suggest conservation strategies for biodiversity, productivity and sustainability of the ecosystem.

8.3 Results

8.3.1 Mapping Land Use and Land Cover

Results of the LULC analysis included mapping of the following forest and cover classes: tropical moist evergreen forest (TMEF), tropical semi-evergreen forest (TSEF), tropical moist deciduous forest (TMDF), bamboo growth & young secondary forests up to six years old, shola type forests along with associated grasslands at Balpakram Plateau, habitation and abandoned *jhum*, agriculture and sand, shifting cultivation and grasslands and water bodies, especially rivers (Fig. 8.2). Six of these nine land cover classes including various land uses and forest type were grouped into two broad categories, i.e., (i) land uses, including land area under habitation, permanent agriculture and *jhumming*; and (ii) old forest growth including TMEF, TSEF, and TMDF. The classification accuracy for these two broad categories combined was 100% and 83% when assessed for each land cover class separately.

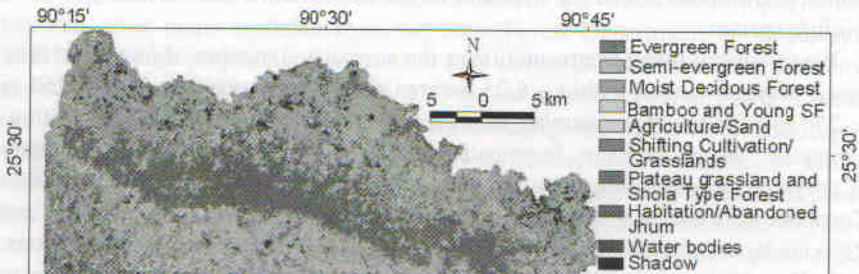

Fig. 8.2 Land use and land cover map of the study area

8.3.2 Landscape Patterns of Forest and Jhum Patches

The Garo Hills area, totaling 2459 km^2, was 75% forested (Table 8.1). The single largest forest patch occupied nearly 5% of the entire landscape area and was represented by old forest growth, specifically, the TSEF. *Jhum* patches covered only 4% of the landscape area, but were well dispersed. In general, forest patches averaged more than five times as large as *jhum* patches with three times the average patch edge length (Table 8.2). As the larger, native forest patches have become carved into smaller patches of *jhum* fields, the densities of individual patches and patch edges have increased (Table 8.2).

One-third of all native Garo families inhabiting the landscape were engaged in *jhumming* (DSWC 1995) over 47 km^2 of the total landscape area per year (Table 8.3). The land consumption per family for *jhumming* varied across the landscape from 0.28 ha for Rongra Community Development Block to 0.80 ha for Chokpot Community Development Block.

Table 8.1 Patterns of the Garo Hills study area, forests and core areas

Component	Number of patches	Area (km^2)
Garo Hills	227 977	2459
Forest	8 921	1844
Core areas >250 m from edge	2 236	561
Core areas >500 m from edge	644	291

Table 8.2 Patterns of all, forest, and *jhum* patches in Garo Hills, Meghalaya

Component	Patch size (km^2), mean ± 1SD	Patch edge length (km), mean ± 1SD	Patch density (n/ km^2)	Patch edge density (km/km^2)
All patches	0.10 ± 1.23	3 ± 18	10	28
Forest patches	0.17 ± 1.86	4 ± 27	6	24
Jhum patches	0.03 ± 0.04	1.3 ± 1.3	37	49

Table 8.3 Families engaged in shifting cultivation (*jhumming*) in selected locations within Garo Hills, Meghalaya

Community Development Block	Total no. of *Jhumia* families	*Jhum* area (mean ha/family)	Total area under *Jhumming* (km^2)	Total Households
Chokpot	2991	0.80	24	5519
Baghmara	763	0.70	5	6175
Rongra	989	0.28	3	2698
Samanda	1960	0.75	15	5782
Total	6703	0.70	47	20174

Source: Directorate of Soil and Water Conservation, Meghalaya (1995)

8.3.3 Forest Cover and Core Areas

The forest types TMEF, TSEF and TMDF together constituted 68% of the landscape area. TMEF represented old primary forest growth and occupied about 14% of the landscape area. TSEF occurred mostly as a buffer to TMEF and occupied 26% of the landscape area. TMDF usually occurred along fringes of human settlements or habitations and other land use subjected to frequent anthropogenic disturbances, and occupied 29% of the landscape area.

The core area analysis revealed that the total area within PAs and RFs >250 m from the edge was nearly twice the total area >500 m from the edge, with nearly 3.5 times as many patches (Table 8.1). This means that greater depths of incursion into PAs and RFs, such as from *jhum* or human habitation, may leave lesser total areas and smaller patch sizes undisturbed. This could have ecological ramifications for protecting plants and animals that require or select for undisturbed forest interior conditions.

8.3.4 Forest Fragmentation and Wildlife Forest Corridors

Most of the existing old forest area, occurring in TMEF, was intact or subjected to very low levels of fragmentation or anthropogenic disturbance. Only 1% of the landscape was under high levels of forest fragmentation, and 21% of the landscape was under medium levels of forest fragmentation (Fig. 8.3).

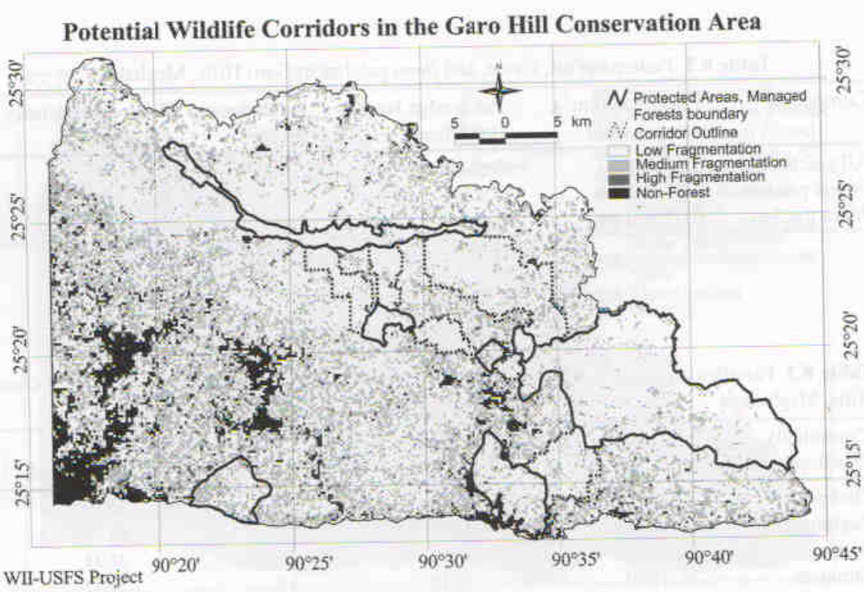

Fig. 8.3 Forest fragmentation within the study area. Dotted lines denote potential wildlife habitat corridors

We mapped seven potential wildlife forest corridors which totalled 14,340 patches of all cover types including forest and non-forest (Fig. 8.3). The corridors consisted mostly of native forests with low levels of fragmentation. The total corridor area included 6944 forest patches of TMEF, TSEF and TMDF and constituted 92% of the total corridor area.

8.3.5 Zones of Influence

The 2-km ZIs had low proportions of agricultural, *jhum* and scrubland areas, suggesting a low degree of stress from human use and occupation. The 2-km ZIs of BNP, SWS, and RRF overlapped (with a total non-overlapping area of 135 km^2). Therefore, we calculated a combined ZI for these areas.

The 5-km ZIs had much overlap among the zones around BNP, NNP, SWS, BRF, RRF and ERF. The total area under the 5-km ZIs was seven times greater than that under the 2-km ZIs, although the proportion of forest and non-forest was the same, i.e., almost 80% under forest growth (TMEF, TSEF, TMDF). The overall land uses in this ZI comprised about 13% of land area of 5 km ZI.

8.3.6 Comparison of Landscape Segments

Our findings revealed that larger and more intact (less fragmented) patches of native forest occur within the PAs and RFs, the wildlife habitat corridors, and the ZIs buffering the PAs and RFs, as compared with the rest of the community forest landscape of Garo Hills (Fig. 8.4). More specifically, the area of the three main forest

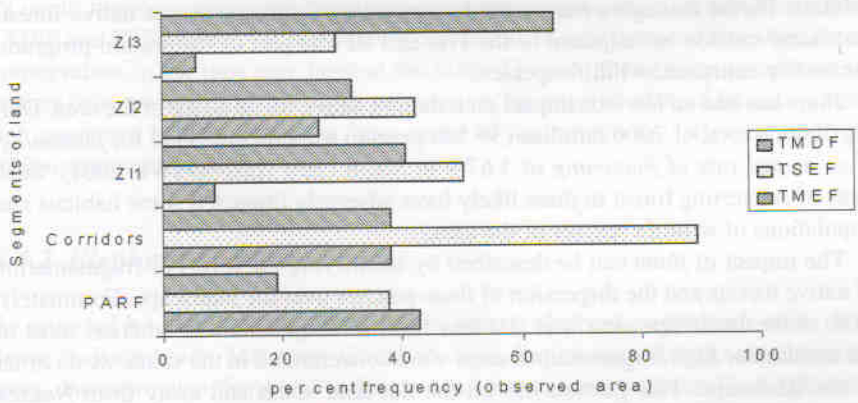

Fig. 8.4 Observed per cent area of forest types among landscape segments
TMEF = Tropical Moist Evergreen Forests, TSEF = Tropical Semi-evergreen Forests; and TMDF = Tropical Moist Deciduous Forests. ZI1 = zone of influence out to 2 km from boundaries of protected areas and reserved forests; ZI2 = out to 5 km; ZI3 = land area beyond 5 km

types (TMEF, TSEF, TMDF) differed significantly among PAs and RFs combined, wildlife habitat corridors, 2-km and 5-km ZIs, and all land area outside the 5-km ZI (likelihood Chi square ratio = 411.472, df = 8, $P < 0.001$).

8.4 Discussion

8.4.1 Landscape Patterns and Trends in Garo Hills

Our analysis suggests that, although most of the land area in Garo Hills is forested, residential and agricultural use by the Garo community is widely dispersed throughout the area. Also, most of the area around human settlements is extensively used for *jhumming* until the recent past. Past *jhumming* has left degraded scrub areas concentrated around villages or settlements. Most arable land is being used either for settled permanent agriculture or *jhumming*, and other forest resource uses such as firewood gathering (Bhatt and Sachan 2004) are also having a toll on native forests of the region.

Lower mean patch size and smaller edge length of patches with intense human use, as compared to those of forest cover patches, suggested that forest cover is being fragmented by human use. This is also suggested by patches with intense human use having a higher patch density and edge density as compared to those of forest cover patches.

However, the landscape still holds larger tracts of old forest cover. Several large forest patches in the PAs and in BRF and ARF are the best examples, as these forest patches provide promising habitat for hoolock gibbons (*Bunopithecus hoolock*), which have gradually disappeared during the past two decades and have become locally extinct from these areas mainly due to increasing human disturbances in their habitats. Forest managers may consider protecting large patches of native forests that occur outside but adjacent to the PAs and RFs as part of restoration programs for locally extirpated wildlife species.

Jhum has had an obvious impact on reducing native forest cover of the area. During 2000, a total of 7900 families (39 500 people) used 68 km^2 land for *jhumming*, at an annual rate of *jhumming* of 3.67% in South Garo Hills (DSWC 2001). Such rates of converting forest to *jhum* likely have adversely impacted some habitats and populations of wildlife species of the area.

The impact of *jhum* can be described by identifying the levels of fragmentation of native forests and the dispersion of *jhum* patches over the landscape. Fortunately, 71% of the landscape area was at a low level of fragmentation, whereas most of the medium or high fragmentation areas were concentrated in the south-west corner of the landscape. This portion lies on the flat land south and away from Nokrek Ridge and far from Balpakram National Park. Nokrek and Balpakram are important protected areas of the region, and both seem have mostly retained extensive cover of native old forests.

Unfortunately, such intact forest cover in *Garo* Hills is suffering an increased rate of fragmentation from *jhum* and other human use. The seven wildlife habitat corridors we identified encompass three corridors identified previously by Williams and Johnsingh (1996). We observed that ARF is the most isolated of all PAs and RFs in the landscape, and has lacked forest connectivity with any other such elements, although evidence suggests that it was historically connected with ERF by a corridor of old native forest cover. This historic corridor once facilitated movement of elephants across NNP in the north and the plains of Bangladesh in the south. Such migratory routes could be restored with timely management interventions.

It is unclear the degree to which the existing PAs, which constitute over 15% of the landscape, will conserve the rich biodiversity of these old forests. Our finding of higher mean forest patch size and lower mean forest patch density within the PAs as compared with outside the PAs reflects the lower degree of forest fragmentation within PAs as compared to RFs and community land, and we speculate that fragmentation might sacrifice some biodiversity elements. However, most forest cover (60% of landscape) is found in community land. However, in a companion analysis, Kumar (2005) reported that most community forests had high tree species diversity, but some tree species were found only with, or at least more dominant within, the PAs.

Our findings included that the 2-km ZIs had lower proportions of TMEF forest and with negligible area under various land use activities, whereas the 5-km ZIs contained a higher proportion of forest and a moderate proportion of land use activities. The community forest land area beyond the 5-km ZIs contained the lowest proportion of TMEF but most of TMDF and the highest proportion of residential and agricultural (settled or *jhumming*) areas. The area of TMDF represented more or less open or disturbed forest growth.

Thus, efforts to conserve wildlife habitat and tropical evergreen forest in the 2-km ZI could focus on preservation and perhaps enlargement of PA boundaries or designation of intact forests as parts of corridors. Forest conservation in the 5-km ZI could focus on additional protection measures because most of this ZI contains TMEF and TSEF native forest with only low levels of land use activities. And forest conservation in the land area beyond the 5-km ZI could focus more on restoration (rather than preservation) activities, which may be coupled with additional protection measures to help protect at least some of the remaining, larger forest tracts within community land.

8.4.2 Elephant Habitat

As reported by Marcot et al. (2002 and in press), elephant populations were most dense in Balpakram, Mahadeo, Chimitab, Siju, Baghmara, Nokrek and Samanda areas, but were also dispersed in lower densities in other parts of Garo Hills, for example, Dambu, Dagal, Kherapara, Adugre, Ranggira and other areas (Marak 1998). Therefore, examining the requirements of such a widely distributed species as elephant within the South Garo Hills study area should also entail understanding its distribution and habitat associations in a broader geographic context (Fig. 8.5). For example, using spatial information from Talukdar (2004), Marcot et al. (2002 and

Fig. 8.5 Elephant census zones in the Garo Hills (GH), western Meghalaya. As used by Marcot et al. (2002 and in press), the All Garo Hills area included all labeled census zones, and the South Garo Hills area included zones marked with an asterisk (*). Map source: Marak (1998), as digitized by us into ArcInfo GIS

in press) analysed elephant-habitat relationships across all of Garo Hills, by using elephant censuses from 1993 and 1998. They presented a statistical model suggesting the following critical values of specific habitat variables significantly correlating with elephant density. Across the entire Garo Hills, elephant densities were reported to be greater in landscapes with:

- < 30% current and abandoned *jhum* (current *jhum* < 5%, abandoned *jhum* < 25%).
- < 20% in high forest patchiness (caused by *jhum*).
- Village density <about 0.4 villages/km^2.
- Annual *jhum* rates < 2% of the land *jhummed*/year.
- Evergreen, semi-evergreen, and mixed moist deciduous forest cover is > 40%.

These correlations, along with the wildlife habitat corridors, could also be used to help guide conservation or restoration of elephant forest habitat in Garo Hills. In addition, activities for maintaining or restoring overall forest biodiversity could also use our findings for conserving intact blocks of native forest, especially of TSEF, in the 2- and 5-km ZIs, and encouraging rates of *jhum* in the land areas beyond the 5-km ZIs to allow for some degree of forest regrowth and restoration.

The 2002 amendments in the Wildlife Protection Act (1972) of Government of India bestowed the State Governments and Forest Departments with a strong tool through designating some forests on private non-government lands (Garo community land in present study) as "Community Reserves," whereas government lands may be designated as "Conservation Reserves." The landscape under investigation during present study offers excellent prospects for declaring both community reserves and conservation reserves for the purpose of conserving or restoring elephant populations and overall forest biodiversity.

8.5 Conclusion

Results of our study support similar findings of adverse effects on native forest cover and diversity from intensive and accelerated shifting cultivation in India and elsewhere. For example, studies in the Chittagong Hills of Bangladesh, which borders the Garo Hills to the south, have shown that shifting cultivation had little affect on forests until it accelerated at the beginning of the colonial period (Thapa and Rasul 2006). Together with dam construction, expansion of permanent plot agriculture, commercial and clandestine logging, and population migration and increase, shifting cultivation in Chittagong Hills has caused loss of native forests and reduction in soil productivity (Gafur et al. 2003). Changing the course of this tide has been impeded there by policy problems in land rights and trade, and lack of infrastructures and support services (Thapa and Rasul 2006). Agroforestry – the mixing of semi-permanent crops with different harvest cycles and life forms on the same plot of land – has been suggested as an alternative to shifting cultivation in this area (Rasul and Thapa 2006), and indeed in many areas of the world such as in Amazonia (Mcgrath et al. 2000).

In other examples, studies by Lawrence (2004, 2005) of 10–200 years of shifting cultivation in rainforests of Borneo suggested that, over many cultivation cycles, tree diversity and regeneration has shifted from seed-banking species to resprouting species, and that the overall carbon sequestration capacity of the secondary forests may become compromised. In Peru, Naughton-Treves et al. (2003) reported that hunting had an additional impact on persistence of mammals in shifting cultivation forest landscapes. In Arunachal Pradesh, India, Arunachalam and Arunachalam (2002) found that degraded soil of *jhum* fallows, particularly soil microbial carbon, nitrogen, and phosphorous, could be rehabilitated by planting of *Bambusa nutans* bamboo. Tawnenga et al. (1996) suggested that second-year cropping and use of fertilizers could maintain yields in *jhum* fields in Mizoram, North East India, and those shorter cycles (6 yrs vs. 20 yrs) of traditional *jhum* methods result in declines in primary productivity and economic yield of rice crops. However, as our case study also revealed, *jhum* cannot be singled out as the villain, nor easily altered or replaced wholesale with other less-extensive forms of agriculture and land use, without considering the tapestry of fuller cultural traditions, society norms, and even religious beliefs in which old forms of forest agriculture have arisen. Moreover, it is not *jhum* per se that is the concern, but rather the unimpeded expansion of human populations into forest landscapes with fragile or erodable tropical and subtropical soils. Strategies for changing such long-standing traditions as well as ameliorating adverse effects of human density and occupation of forest landscapes must integrate consideration for nutrition, health, education, access to economic trade, and effects on traditional lifestyles.

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Patterns and Processes in Forest Landscapes

Multiple Use and Sustainable Management

Increasing evidence suggests that the composition and spatial configuration – the pattern – of forest landscapes affect many ecological processes, including the movement and persistence of particular species, the susceptibility and spread of disturbances such as fires or pest outbreaks, and the redistribution of matter and nutrients. Understanding these issues is key to the successful management of complex, multifunctional forest landscapes, and landscape ecology, based on a foundation of island bio-geography and meta-population dynamic theories, provides the rationale to deal with this pattern-to-process interaction at different spatial and temporal scales.

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