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Habitat Relationships of Asian Elephants in Shifting-Cultivation Landscapes of Meghalaya, Northeast India

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Introduction

In Asia and India, Asian elephants (*Elaphas maximus*) attain their highest densities and numbers in Meghalaya (Santiapillai & Jackson 1990), particularly in Garo Hills, of northeast India. Little quantitative work has been done on elephant-habitat relationships in this region where the species' distribution is known to be highly fragmented (Santiapillai & Jackson 1990; Choudhury 1999; Choudhury & Menon 2006).

If elephants and their habitat are to be conserved, particularly in Garo Hills, and elephant-human conflicts reduced, the initial steps are to understand their spatial and temporal distributions, determine habitat conditions associated with elephant densities, identify key population stressors, and suggest conditions conducive to elephant population persistence.

Much of the native forest cover used by elephants in Garo Hills has been greatly altered over recent decades, largely through accelerated short-cycle *jhum* activity (local form of slash-and-burn shifting cultivation; Kumar *et al*. 2008). Such intensive land use has been previously implicated in the decline of elephant populations of the region (Marcot *et al*. 2002).

In this paper, we further analyze landscape-scale habitats of elephants in Garo Hills and determine population trends throughout Meghalaya based on state-conducted censuses.

Study area

The state of Meghalaya consists of the three hill regions, east to west, of Jaintia, Khasi, and Garo Hills. The regions constitute steeply inclined and eroded topography with local valleys, and are each inhabited by peoples of varying origin and cultures. From such geography, the elephant population of Meghalaya is essentially isolated from other populations in south Asia (Santiapillai & Jackson 1990).

Garo Hills consists of East, West, and South Garo Hills Districts, collectively 8167 km^2 of western Meghalaya (Fig. 1). About 7% of Garo Hills consists of 4 protected areas and 15 reserved forests, and about 93% is under non-government ownership by native Garo tribe people. The Garos use the forest for jhum, in which forest vegetation is cut and burned on site, and the site is cultivated for crops (Momin 1984; Momin 1995).

The study area contains several large townships, including the large urban city of Tura. Imagery taken by IRS (Indian Remote Sensing) satellite was interpreted for mapping of 11 vegetation and land cover types in Garo Hills (Kumar *et al*. 2000, 2002).

Vegetation and land characteristics of Garo Hills are heavily influenced by jhum activities (Kumar *et al*. 2008), which have greatly increased in recent decades with increases in human population, resulting in severely fragmenting previously intact forest tracts (Lele *et al*. 2008). Other resource-use activities in Garo Hills,

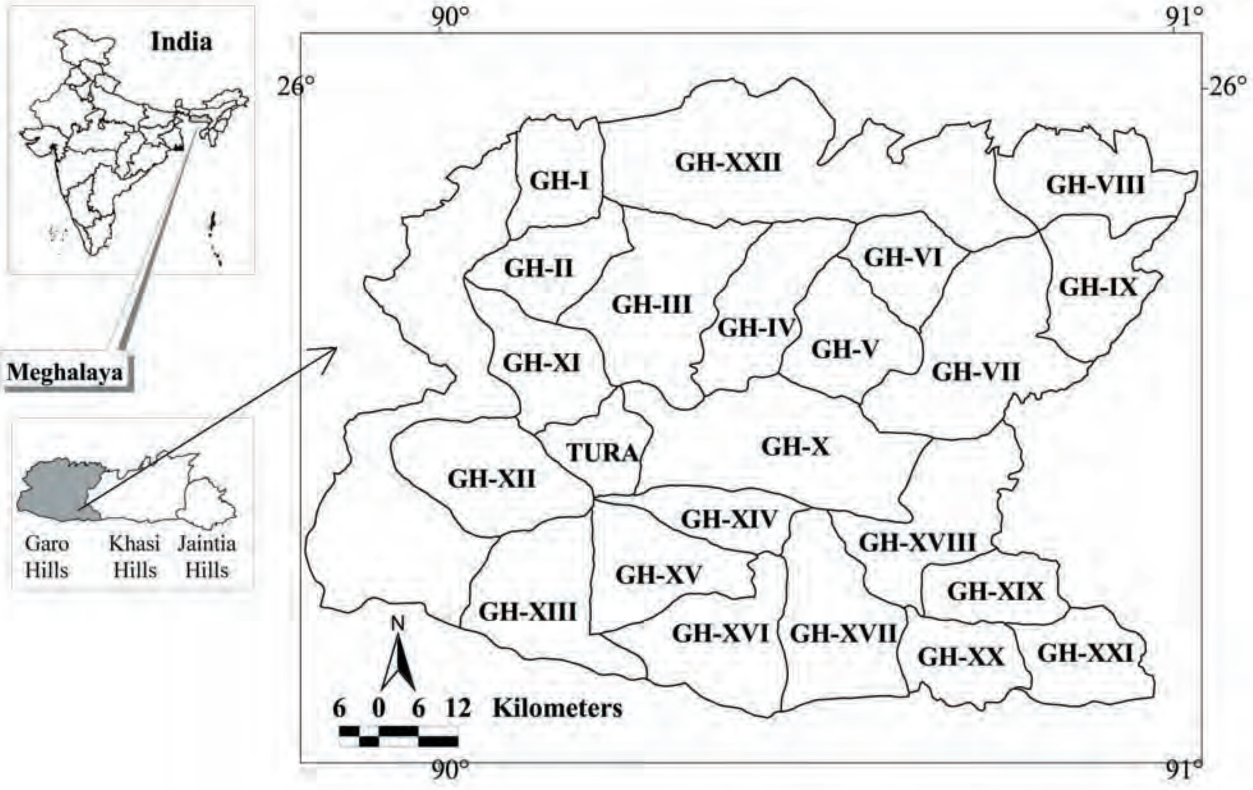

Figure 1. Elephant census zones in Garo Hills (GH). Source of census zones: Marak (1998).

which adversely affect old native forests of the region and their biodiversity, are mining (coal and limestone), excessive collection of timber and non-timber forest products, and hunting of animals (for meat, skin etc.). Contributing to increases in these activities, Meghalaya State Forest Department began ecodevelopment activities in 1985 around Balpakram National Park and Nokrek National Park, covering 101 and 33 villages, respectively (Kumar *et al*. 2000). Concern has arisen for the future of biodiversity in general, and elephant populations specifically, from the host of anthropogenic activities and stressors in the region.

Methods

We correlated elephant numbers, derived from state-conducted census counts, with topographic and vegetation or land-cover attributes (please contact corresponding author for details) of 22 elephant census zones in Garo Hills (Fig. 1). The unnumbered census zone on the west margin (Fig. 1) was not included in the analysis because of the lack of elephant census data. We calculated areas of census zones in Garo Hills by digitizing the map of census zone boundaries from Marak (1998) in GIS. We calculated vegetation and landscape variables by using ArcInfo GIS and the Bio_CAP landscape analysis program (IIRS 1999). Because the elephant census zones varied in size, we converted all area-based variables to percentage of each census zone to avoid area effects and to better compare the relative contribution of each habitat variable on elephant density. We also evaluated trends of elephant census results summarized state-wide and also among the three hill regions of Garo Hills, Khasi Hills, and Jaintia Hills, where such elephant census data were available, to better understand the broader context of Garo Hills.

Elephant variables

Elephant census data on individual census zones were reported from 1993 (Office of Divisional Forest Office, East and West Garo Hills Wildlife Division, Tura, Meghalaya), 1997-98 (hereafter, referred to as 1998; Marak, 1998), and 2002 (S. Kumar 2002). An additional summary of a census conducted in 2008 provided data only by hill regions and state-wide for Meghalaya (Anonymous 2010).

The census zone boundaries were the same for all years, although the specific zones surveyed or excluded during any given census slightly changed. Elephant numbers were reported for up to 22 census zones in Garo Hills, 12 census zones in Khasi Hills, and 4 census zones in Jaintia Hills (Table 1). However, for reasons unreported, the 1993 census did not include Garo Hills elephant census zone GH-XXII (Fig. 1), nor did it include the Khasi and Jaintia Hills. The 1998 and 2002 censuses included all three hill regions although one Jaintia Hills census zone (J-IV) was not included in the 1998 census. We presumed that the composite 2008 census figures included all 38 census zones in all 3 hill regions. Some of our analyses pertained only to South Garo Hills (census zones GH-X and GH-XIV through GH-XXI) because that portion of the Garo Hills region has been the focus on special wildlife research and biodiversity conservation measures (Kumar *et al*. 2002).

For each elephant census zone and each hill region, we summarized results from the census periods 1993 (Garo Hills only), 1998, and 2002 as total number of elephants of all sex and age classes from both direct and indirect sightings, and also as elephant crude density. We calculated crude

Table 1. Results of Asian elephant censuses conducted in Garo Hills (1993 and 1998) and in Khasi Hills and Jaintia Hills (1998). N = number of elephants, CD = crude density.

Zone	Census zone name	Area	1993		1998		2002	
		[km^2]	N	CD	N	CD	N	CD
Garo Hills District								
GH-I	Dibru Hills – Chibinang	188.2	27	0.143	15	0.080	93	0.494
GH-II	Rongchugre – Ringre-Kalsingre	210.0	61	0.290	35	0.167	73	0.348
GH-III	Chasing – Dananggre – Manggakgre	441.5	22	0.050	46	0.104	20	0.045
GH-IV	Romgre – Rongsep – Marakgre	294.1	34	0.116	47	0.160	0	0.000
GH-V	Asil – Sokadam – Songsak	258.0	31	0.120	43	0.167	29	0.112
GH-VI	Dagal – Chimimit – Cheran	181.5	50	0.275	55	0.303	13	0.072
GH-VII	Dambu – Koknal – Baringgre	517.2	57	0.110	59	0.114	20	0.039
GH-VIII	Dhima – Kharkutta – Rajasimla – Ildek	299.0	36	0.120	37	0.124	37	0.124
GH-IX	Norangga – Gabilbila – Agrapathal	258.7	4	0.015	29	0.112	12	0.046
GH-X	Nokrek – Samanda – Rongrenggiri	574.8	211	0.367	65	0.113	29	0.050
GH-XI	Ranggira – Sadolpara – Sasatgre	238.6	48	0.201	26	0.109	57	0.239
GH-XII	Damalgre – Nengsangre – Rongmagre	332.4	35	0.105	34	0.102	0	0.000
GH-XIII	Kherapara – Medagre – Thalampara	341.2	3	0.009	74	0.217	44	0.129
GH-XIV	Dana Adugre – Mansaggre – Rongmagre	168.0	93	0.554	61	0.363	18	0.107
GH-XV	Rongmagre – Dareng – Kakija – Warimagre	276.7	37	0.134	11	0.040	26	0.094
GH-XVI	Mibonpara – Ruga – Angratoli	333.4	138	0.414	10	0.030	24	0.072
GH-XVII	Rongdong – Tholegre – Rewak-jadigittim	364.6	141	0.387	78	0.214	160	0.439
GH-XVIII	Rekmangre – Emangre – Chengbagre	357.5	102	0.285	84	0.235	163	0.456
GH-XIX	Siju – Rongchuagal – Rongcheng – Balpakram	182.3	240	1.317	116	0.636	95	0.521
GH-XX	Baghmara – Halwa – Dambuk – Balpakram	193.4	248	1.282	156	0.807	107	0.553
GH-XXI	Mahadeo – Chimitap - Balpakram	214.3	223	1.041	216	1.008	84	0.392
GH-XXII	Banjengdoba – Rongsai	551.2	n/a	n/a	9	0.016	89	0.149
Khasi Hills District								
K-I	Jirang – Pathar – Khmah	702	n/a	n/a	61	0.087	54	0.077
K-II	Rambrai	233	n/a	n/a	6	0.026	6	0.026
K-III	Kyndongnai-Nonglang	105	n/a	n/a	0	0.000	0	0.000
K-IV	Umatang-Amjong	230	n/a	n/a	14	0.061	26	0.113
K-V	Lamalong-Sunidan	164	n/a	n/a	8	0.049	19	0.116
K-VI	Mawlasnai – Tyrso	141	n/a	n/a	12	0.085	0	0.000
K-VII	Suanggiri – Songssak (Shallang)	248	n/a	n/a	79	0.319	76	0.306
K-VIII	Rongshi – Rongkai (Rongdim)	325	n/a	n/a	58	0.178	99	0.305
K-IX	Nongmein – Umdhkar (Maweit)	186	n/a	n/a	69	0.371	54	0.290
K-X	Umbytit – Sooling (Shikoitweikut)	246	n/a	n/a	99	0.402	145	0.589
K-XI	Nongmalang – Mawpat	197	n/a	n/a	37	0.188	54	0.274
K-XII	Nongmaharu – Kynshi (Nongkulang)	138	n/a	n/a	68	0.493	101	0.732
Jaintia Hills District								
J-I	Narpuh block I -Lakadong Forest Areas	290	n/a	n/a	14	0.048	15	0.052
J-II	Narpuh block II and it's adjoining areas	365	n/a	n/a	0	0.000	5	0.014
J-III	Saipung R.F. and adjoining areas	200	n/a	n/a	9	0.045	6	0.030
J-IV	Saitsama-Namdong Forest Areas	95	n/a	n/a	n/a	n/a	15	0.158

density as total number of elephants divided by area of each census zone. We calculated percent change in total elephant census numbers (or in elephant crude density, which yielded the same percent change values) in each census zone for various combinations of time periods in which the censuses were based on the same census zones and hill regions. Using analysis of variance, we also tested if elephant numbers and densities differed among the three hill districts and over time for each hill district and census zone for which comparable data were available. We also tested for correlation of elephant numbers and densities with census zone area to determine if any habitat associations may have been artifacts simply caused by census area.

Habitat variables

Our analysis of elephant-habitat relationships focused on the Garo Hills where habitat and land cover data, as of 2000, were available by elephant census zone. We used 40 independent variables representing various habitat attributes including 4 topographic variables, 9 direct anthropogenic variables, and 27 vegetation and landscape variables (Porwal *et al*. 2000; Kumar *et al*. 2000). Topographic variables included total area and 3 levels of terrain complexity of each elephant census zone. Direct anthropogenic variables included length and density of roads, 5 levels of road buffers, and number and density of villages of each census zone. Vegetation variables included percent cover in each census zone by 11 vegetation and land cover categories of forest, agriculture, grassland, and water. Landscape variables included 3 levels each of vegetation patchiness, porosity, interspersion, fragmentation, and disturbance, and proportion of each census zone in protected areas. We summarized each dependent (elephant) and independent (habitat) variable statistically.

Statistical analyses

We then determined the degree to which variation in the elephant variables can be explained by variation in the habitat variables by developing correlation and linear regression models with the statistical software SYSTAT 12 (SYSTAT 2007). The topographic, vegetation and land cover data were available only from the year 2000, so we could not analyze how temporal changes in these habitat variables might account for changes in elephant density between the elephant census periods. We determined the degree of simple correlation and the form of the relations between the elephant variables and the retained habitat variables. This analysis identified simple relations of elephant density with individual habitat parameters and potentially critical values of those parameters. Next, with linear regression, we determined the combinations of habitat variables that best account for variation in the elephant variables, that is, the set of habitat conditions that might most influence elephant density.

Elephant numbers reported from the state censuses included both direct and indirect sightings. Field methods used to estimate these numbers were not made clear in the elephant census reports. There is no way to analyze or judge potential errors in observation, errors of estimation in elephant numbers, or bias in numbers arising from differential detectability of elephants by cover condition or by age and sex classes.

Results

Elephants

For Meghalaya as a whole, numbers of elephants were reported to total 1,868 in 2002 and 1,811 in 2008 among all 21 census zones, and to total 1,840 in 1998 and 1,853 in 2002 excluding census zone J-IV (not censused in 1998). Crude density in Meghalaya remained nearly consistent throughout the state at approximately 0.15 elephants/km^2 (Table 2). Crude density in the three hill districts varied from 0.027 elephants/km^2 in Jaintia Hills in 1998 and 2008, to 0.296 elephants/km^2 in Garo Hills in 1993.

Elephant numbers and crude densities varied across census periods, showing a consistent decline only in Garo Hills from 1993 to 2002 (excluding census zone GH-XXII, which was not censused in 1993), but a rebound from 2002 to 2008 when GH-XXII was included (Table

Table 2. Overall elephant numbers (N) and crude densities (CD) by hill district and Meghalaya*.

Area included	1993 N	1993 CD	1998 N	1998 CD	2002 E	2002 CD	2008 E	2008 CD
Garo Hills (excluding GH-XXII)	1841	0.296	1297	0.208	1104	0.177	n/a	n/a
Garo Hills (including GH-XXII)	n/a	n/a	1306	0.191	1193	0.145	1285	0.156
Khasi Hills	n/a	n/a	511	0.175	634	0.217	500	0.172
Jantia Hills	n/a	n/a	23	0.027	41	0.043	26	0.027
All Meghalaya (excluding J-IV)	n/a	n/a	1840	0.153	1853	0.154	n/a	n/a
All Meghalaya (including J-IV)	n/a	n/a	n/a	n/a	1868	0.154	1811	0.150

*n/a = not applicable, not reported

2). In Garo Hills, 1841, 1297, and 1104 total elephants were reported in the 1993, 1998, and 2002 censuses, respectively. This represented a statistically significant decrease from 1993 to 2002 of 40% when excluding census zone GH-XXII, but only a 2% decrease between 1998 and 2008 when including GH-XXII. Census zone GH-XXII occurs in the north edge of Garo Hills along the Brahmaputra River Valley, contains a moderate cover of native forests, and links to 7 other census zones. Nine elephants were reported from this census zone in 1998 and 89 elephants in 2002, suggesting that this census zone may serve at least as an intermittent travel lane.

Population trends of elephants throughout Meghalaya as a whole were slightly positive over 1998-2002 but dipped thereafter to 2008. Trends were consistently in decline, however, for Garo Hills and especially the South Garo Hills district, over all time periods for which comparable census area results were available. Whether such negative trends in Garo Hills was due to variation or unevenness in census methods, movement of elephants to other census zones, or actual loss of elephants through mortality is unknown, although ancillary data on negative trends in forest conditions may shed some light (discussed below).

Among individual census zones throughout the three hill regions, numbers ranged from 0 elephants in several zones, to 248 elephants in zone GH-XX in 1993; and crude density ranged up to 1.317 elephants/km^2 in zone GH-XIX in 1993 (Table 1). Overall crude densities particularly in Garo Hills (Table 2) were far higher than the crude density of elephants reported by Chowdhury *et al*. (1997) in nearby North Bengal, viz., 0.09 elephants/km^2 (reported by the authors as 10.7 km^2/elephant).

The southeast portion of South Garo Hills consistently had the highest numbers and greatest crude densities of elephants among all census periods (Table 1). These 3 census zones encompass three major protected areas of the region – Balpakram National Park, Siju Wildlife Sanctuary, and Baghmara Reserved Forest - which have some of the least fragmented native forest cover and lowest major road densities in Garo Hills (Fig. 2). Other individual census zones with high crude densities included zones K-XII and K-X of Khasi Hills. Overall, elephant numbers and densities seemed to shift among census zones and hill regions over the various census periods, suggesting either differences in census intensity and methods, or a real redistribution of elephants.

Census zones varied in area from 95 to 574 km^2 (Table 1) but there was no statistically significant difference in census zone area among the 3 hill regions, nor a significant correlation between census zone area and elephant numbers in any of the census periods, nor was percent change in elephant numbers significantly correlated with census zone area. Thus, number and density of elephants per census zone in Garo Hills likely varied due to factors other than area, although random variation in census outcomes from chance redistributions of elephants during the census periods cannot be ruled out.

Habitat description of Garo Hills

The highest level of terrain complexity (variability in topographic relief) occurs in the southeast,

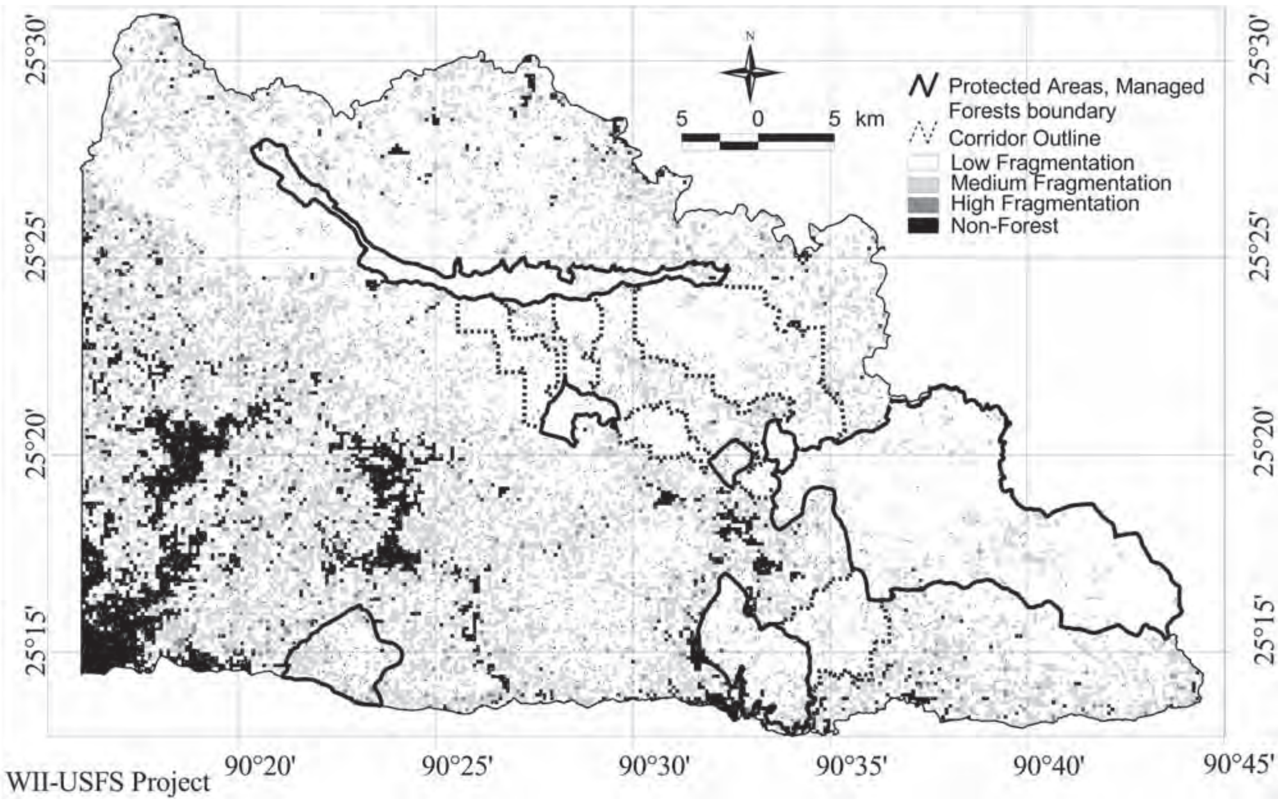

Figure 2. Fragmentation levels of native evergreen, semievergreen, and deciduous forest, locations of existing protected areas (national parks, reserved forests, and wildlife sanctuaries), and recommended elephant habitat corridors. (Source: Marcot *et al.* 2002).

central, and northeast portions of Garo Hills, and the lowest in the southwest and western portion.

Some 1909 villages and 467 km of roads are mapped within 21 census zones of Garo Hills (data not available for census zone GH-XXII). Among census zones, village density ranged from 0.10 (north-central Garo Hills) to 0.69 (northeast Garo Hills) and averaged 0.31 village/km^2. Road density ranged from 0 (south-central Garo Hills) to 0.15 (northwest Garo Hills) and averaged 0.07 km/km^2. Road length, road density, and road buffer areas were highly correlated with each other, but were largely uncorrelated with number of villages and village density.

Number of villages did not correlate significantly with any other independent variable including topography and vegetation cover variables. However, village density was negatively correlated with moderate topographic complexity and positively with low topographic complexity. This suggests that villages often are in areas of low relief, such as along the inland valleys, although other factors (such as traditional use, soils, etc.) also determine the density and location of villages.

Areas of recent and abandoned jhum occurred both within and well away from individual census zones having higher village density, as there was no correlation between jhum density and village numbers or density. This is likely because at least some impermanent settlements migrate to different locations after abandoning jhum sites.

Native forest covers 52% of Garo Hills and includes tropical evergreen forest, semievergreen forest, moist mixed deciduous forest, and some sal/teak forest, although there are also extensive plantations of sal forest particularly in the northern portion. Non-forest and non-native forest together cover 48% of Garo Hills. Most of Garo Hills consists of semievergreen forest and abandoned jhum (43% and 33% of total Garo Hills area, respectively; Fig. 3). The greatest density of native forest cover in Garo Hills occurs in the southeast portion, and the greatest density of jhum, agriculture, and disturbed cover occurs in the western portion.

Lowest vegetation patchiness, lowest vegetation porosity, lowest vegetation interspersion, least forest fragmentation, and lowest vegetation disturbance all occur in the areas of Nokrek National Park and Nokrek Ridge, Balpakram National Park, Angratoli Reserved Forest, and immediately adjacent areas of South Garo Hills (Fig. 3).

Habitat relations of elephants in Garo Hills

Crude densities of elephants in 1993, 1998, or 2002 census periods correlated significantly and positively with proportion of census zones in tropical evergreen forest, moist mixed deciduous forest, sal/teak forest, water, medium vegetation patchiness, intact vegetation porosity, and proportion of the census zone in protected areas; and negatively with village density, and with proportion of census zones in bamboo, degraded, current jhum, abandoned jhum, porous vegetation, and fragmented vegetation conditions. Of particular interest in southeast Garo Hills is census zone GH-XX which contains a high number of villages but they occur near isolated protected areas of high habitat quality - likely explaining why the area can have high forest patchiness yet high elephant density.

Elephant densities also were consistently positively correlated with high terrain complexity, low vegetation patchiness, low and intermediate levels of vegetation porosity, intact vegetation fragmentation conditions, and low and medium disturbance conditions; and consistently negatively correlated with road length and road buffer areas, village density, grassland, high vegetation interspersion, and high disturbance conditions.

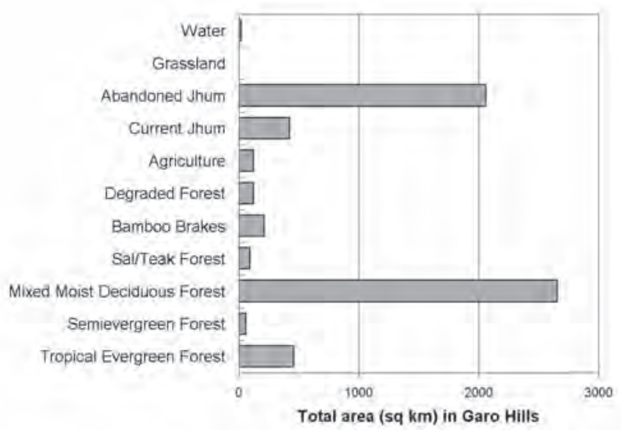

Figure 3. Coverage of vegetation and land cover types in Garo Hills.

Regression analysis yielded highly significant models relating crude density of elephants in 1993, 1998, and 2002 positively to percent cover in moist mixed deciduous forest and high terrain complexity; and negatively to medium terrain complexity, village density, and bamboo cover.

We also found no statistical difference among Garo, Khasi, and Jaintia Hills in elephant census numbers or crude density. These results suggested that elephants were not unevenly distributed among the three hill regions of Meghalaya, given variations among census zones, although the highest number of elephants and highest elephant density in individual census zones were in Garo Hills and the lowest were in Jaintia Hills. The tests also suggested that there was no significant area effect, that is, neither elephant numbers nor densities were strictly influenced by size of census zones. This means that results of the habitat correlations and regressions are not spuriously related to simple area effects.

Census zones GH-VII, XXII, and X may serve as central connectors for elephant travel and dispersal throughout this hill region or to the Khasi Hills to the east. Census zones GH-XIV, XIX, and XXI each have >70% native forest cover. Overall, 18 of the 21 census zones provide >40% native forest cover, and these include all but one (GH-VII) of the high-linkage zones. In general, the zones are well connected within Garo Hills and to Khasi Hills to the east, and still provide a mostly well-distributed pattern of native forest cover although that is least well represented in the northwest and northeast corners of the district.

Our previous analyses have also suggested some 7 habitat corridors may serve to connect protected areas throughout South Garo Hills (Fig. 3). This analysis was based on delineating shortest-route connections among protected areas that would contain least-fragmented native forest cover. Further details on this analysis and these results are available in Marcot *et al*. (2002) and Kumar *et al*. (2010).

Discussion and conclusion

This landscape analysis should be viewed as a broad, first step in identifying good and poor habitat for Asian elephants in Garo Hills, and for describing quantitative relations of elephant numbers and densities with habitat conditions. We did not study behavioural responses of elephants to habitat conditions, such as use of traditional travel lanes, redistribution of individual elephants among sites between the census periods and in response to human habitation, and selection for specific and alternative vegetation conditions. Our results are working hypotheses testable with more specific behavioural studies.

Elephants use vegetation and land cover categories in Garo Hills for a variety of needs. In North Bengal, northeast India, Chowdhury *et al*. (1997) found that elephants used dense mixed forest (47%), agriculture (25%), open mixed vegetation (15%), and grassland (10%), with other habitats (dense sal and plantation) rarely used. Elephants in Garo Hills follow somewhat similar patterns, particularly in use of dense, native evergreen, semievergreen, and deciduous forests. However, the type of agriculture most prevalent in Garo Hills – shifting cultivation – does not favour elephant use as much as permanent-plot agriculture does elsewhere, such as in North Bengal.

In northeast India, Sukumar (1989) reported that secondary jhum attracts some elephants that feed on grass and young trees, but that extensive jhum mostly has degraded elephant habitat, just as we found that too much jhum cover was negatively related to elephant number and density. Sukumar reported that extensive grassland area without effective tree cover is suboptimal elephant habitat. He also suggested that selective cutting of forests did not cause adverse habitat for elephants, but clearfelling did. In Garo Hills, there are essentially no forest harvest operations occurring in the (government-owned) reserved forests, although some illegal felling of trees has occurred there. This is a very real concern for protecting dense, native forest habitat.

Some elephant locations and densities in Garo Hills likely were related to their feeding, hiding, parturition, and travel between use areas (Williams & Johnsingh 1996; Silori & Mishra 1996). Our analysis could not separate habitat conditions selected by elephants for each of these kinds of use, and provides only a broad view of general landscape correlates.

We did not have maps or geographic data on the extent of large townships and urban areas. Especially those near to prime elephant habitats of Balpakram and Norkrek may have disproportionately greater impact on elephants than do jhum, villages, and rural roads, but this needs testing.

It is unclear, without further censuses and broader demographic studies on elephant vital rates, the extent to which the calculated decline of 40% in the elephant population of Garo Hills from 1993 to 2002 is real or an artefact of sampling or elephant movement. However, it seems apparent that some decline has occurred and is likely a result of increasing anthropogenic disturbance and jhum activity in the district. Further, Talukdar (unpub. data) has documented a decline in the percent of Garo Hills in intact forest condition, using remote sensing and the fragmentation indexing approach described above; in 1980, 54% of forest cover in Garo Hills was intact, declining to 26% in 1989, 25% in 1995, and 17% in 2000. Our current work suggests that such loss and fragmentation of forest cover is generally associated with lower elephant numbers and densities. A major decline in elephant numbers seems to have occurred in Garo Hills as a whole. In contrast, Chowdhury *et al*. (1997) reported that the elephant population in nearby West Bengal increased by 2.5% per year between 1987 and 1996. However, jhum is probably adversely affecting elephant habitat and resources in Garo Hills and is essentially absent in West Bengal.

Important for developing habitat management guidelines for conservation of elephant populations of the region may be our findings on negative associations with specific land cover and landscape attributes. Elephants of the region may be avoiding traditional travel routes when blocked by human habitations, road networks, mining, and industrial activities, even though they may move through clearings created by jhum (Choudhury 1999).

In particular, any conservation solution must consider the needs and traditions of the local people. For example, jhum activities are inextricably woven into the lives and livelihoods of the Garo culture, who has many religious rituals associated with various phases of the jhum cycle of clearing, burning, use of forest products, seeding, and harvesting (Thomas 1995). The answer lies not in dissuading jhum activity, but more in encouraging longer fallow periods between jhum cycles, disturbing less of the landscape per year, encouraging some degree of permanent-plot agriculture for individual family use, and apportioning the land to better emphasize some areas for habitat conservation and other areas for agriculture. Currently, social trends in Garo Hills include the younger generation showing low interest in agriculture and seeking alternative employment. Perhaps this provides an opportunity to encourage longer fallow periods in jhum cycles and to restore and conserve native forests in key locations including corridors and traditional elephant travel pathways.

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Musth male courting adult female (Corbett NP)
Photo by Christy Williams