Oryx Vol **34** No 4 October 2000

Bird and mammal conservation in Gaoligongshan Region and Jingdong County, Yunnan, China: patterns of species richness and nature reserves

Daoying Lan and Robin Dunbar

Abstract Elevational and latitudinal patterns of species richness for birds and mammals were compared with human population density in relation to nature reserve designation in two areas of Yunnan Province, China. Results suggest that species richness is not the same for the two areas. In Gaoligongshan Region, species richness is inversely correlated with elevation and altitude, while reserve designation is positively correlated with elevation and latitude. In Jingdong County, reserve designations are positively correlated with elevation, but species richness shows no clear trends. In general, the present situation is strongly influenced by human activities. It appears that reserve designation is mismatched with species richness in Gaoligongshan Region, while there is a better fit between the two in Jingdong County. In both areas, however, it appeared that reserves were located primarily in order to reduce conflict with humans rather than to maximize conservation of biodiversity, probably because humans were responsible for forest—especially primary forest—destruction and degradation in the low-lying areas.

Keywords Biodiversity, birds, China, human density, mammals, nature reserves, species richness, Yunnan Province.

Introduction

Conservation of biological diversity has become an issue of great debate, and a topic of concern worldwide. In particular, the conservation of biodiversity in tropical forests has aroused much concern, making such areas the 'hot spots' within a hot topic (McNeely, 1990). Situated in south-west China, Yunnan Province constitutes one such hot spot. The area is one of the most biologically diverse in China (Zhang & Lin, 1985), and arguably the world (Wang & Wang, 1990). Within Yunnan, Gaoligongshan Region and Jingdong County are the most outstanding in terms of biodiversity, and have been the subject of great concern by conservation biologists.

In response to the increased need to conserve biodiversity, China has rapidly expanded its system of nature reserves since the 1980s (Li & Zhao, 1989). In Gaoligongshan Region, three reserves have been established (one at the national level and two at the provincial level), encompassing *c.* 13.5 per cent of the total land area (27,981 sq km). In Jingdong County, two reserves have been established (one at the national level and one at the provincial level), encompassing *c.* 7.8 per cent of the total land area (4465.85 sq km). Designation of all these nature reserves was carried out in the early 1980s (No. 5 Forest Resources Survey Team of Yunnan Province, 1983; Forestry Planning and Surveying Institute of Yunnan Province, 1989).

The management of these reserves has been problematic; this issue is treated in more depth by other publications (see, for example, Ma *et al.*, 1994, 1995, 1997; Lan *et al.*, 1995 [Gaoligongshan]; Wuliangshan Mountain Reserve Management Bureau, 1994; Lan, 1995a,b [Jingdong County, Mt. Wuliangshan and Mt. Ailaoshan]). In this paper, we address a different concern: how well do current reserve boundaries correspond with the requirements of biodiversity conservation? More specifically, we examine how reserve areas correspond with documented species richness for birds and mammals. We selected Gaoligongshan Region and Jingdong County as case studies not only because they are important in terms of Yunnan's wildlife conservation, but also because the data available for these areas are more complete.

Study areas

Gaoligongshan Region

The region referred to as Gaoligongshan here includes all lands west of the Salween (Nujiang) River in

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Revised manuscript accepted for publication 5 June 2000

https://doi.org/10.1046/j.1365-3008.2000.00131.x Published online by Cambridge University Press

Yunnan. The entire region is situated at the southern edge of the eastern Himalayas, the westernmost region of Yunnan Province, and in the western part of the Trans-Himalayan Mountains. The geographic coordinates for this region are *c.* 23°50′–28°30′N, 97°31′–99°05′E (Fig. 1).

In accordance with its complex topography and extreme elevational gradients (210–5128 m), the bioclimatic conditions of Gaoligongshan Region are wide ranging, from the cold Tibetan Plateau in the north to tropical rain forest in the south. The region forms a link between very different biotic realms, with species of both the Oriental and Palaearctic communities being represented. There are also many endemic and rare species (Wu *et al.*, 1979; Zhang, 1979; Zheng *et al.*, 1981).

Three nature reserves established to protect these varied natural resources are, from north to south:

i) Nujiang (provincial level) Nature Reserve, established in 1986, principally to protect temperate and cold forest ecosystems and associated rare species such as the takin *Budorcas taxicolor*, pileated langur *Trachypithecus pileatus* and Sclater's monal *Lophophorus sclateri*. This reserve is divided into two sections of 2376 sq km (northern section) and 415 sq km (southern section), respectively, totalling 2791 sq km. For the northern section, only the part to the west of the Salween River (1767 sq km) is included in the present analysis.

ii) Gaoligongshan (national level) Nature Reserve (1240 sq km) was established in 1983, mainly to protect subtropical forest ecosystems and rare species such as the hoolock gibbon *Hylobates hoolock*, red panda *Ailurus fulgens* and Temminck's tragopan *Tragopan temminckii*.

iii) Tongbiguan (provincial level) Nature Reserve, established in 1986, primarily to protect tropical forest ecosystems and species such as binturong *Arcticis binturong*, gaur *Bos gaurus* and peacock pheasant *Polyplectron bicalcaratum*. This reserve is made up of three sections of 260, 23 and 71 sq km, respectively (total 354 sq km). The location of these protected areas is shown in Fig. 1.

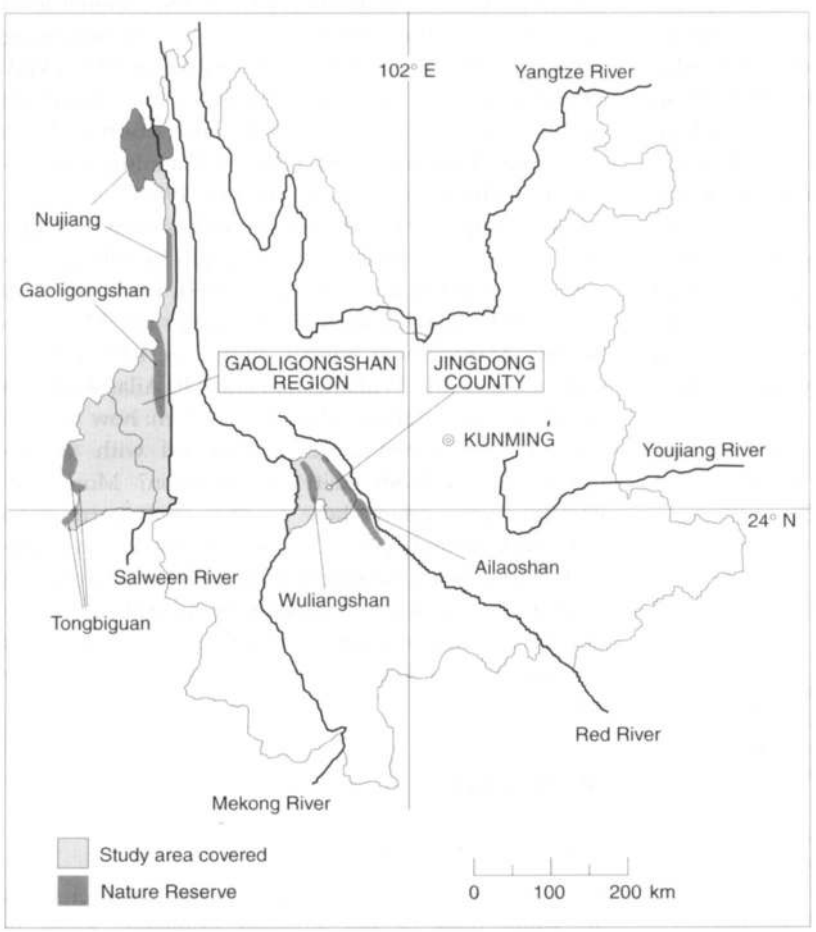

Fig. 1 Map of Yunnan Province, China. Gaoligongshan Region (west) and Jingdong County (central) are indicated by shading.

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Jingdong County

Jingdong County is located to the east of the Mekong (Lancangjiang) River in central Yunnan. The entire region is situated at the southern edge of the eastern Himalayas, in the south-central region of Yunnan. The geographic coordinates for this region are *c.* 23°57′–24°50′N, 100°24′–101°15′E (Fig. 1).

Jingdong County also has a complex topography, extreme elevational gradients (795–3372 m) and contrasting climatic conditions (temperate to tropical). Below 1300 m altitude, the land has generally been cultivated for agriculture, with only a few areas of dry and hot riverbed savanna vegetation remaining. Between 1300 and 1800 m, the vegetation is generally pine forest (*Pinus kesiya* var. *langbianensis*); in some valleys, deteriorated leaf forest remains following considerable human disturbance. From 1800 to 2400 m, the forest is mostly monsoon broadleaf forest, although some parts have been converted into pine forest by human activity. Mid-montane humid evergreen broadleaf forest dominates from 2400 to 3000 m. Above 3000 m, only shrub and herb vegetation are found. Jingdong County also forms a link between two different biotic realms (Oriental and Palaearctic). There are many endemic and rare species (Liu *et al.*, 1994; Peng, 1997).

In this county, two nature reserves have been established to protect biodiversity. They are, from west to east:

i) Wuliangshan (provincial level) Nature Reserve (234 sq km), established in 1986, primarily to protect temperate and cold forest ecosystems and associated rare species such as the black gibbon *Hylobates concolor* and Phayre's langur *Trachypithecus phayrei*.

ii) Ailaoshan (national level) Nature Reserve, established in 1986, principally to protect the subtropical forest ecosystem and rare species such as the black gibbon, Phayre's langur, red panda and Temminck's tragopan *Tragopan temminckii*. Part of the Ailaoshan Nature Reserve lies outside Jingdong County in the counties of Zhengyuan, Xinping, Shuangbai and Chuxiong. The total area for this nature reserve is 504 sq km. Only the part within Jingdong County (116 sq km) has been included in the analysis in this paper. The area of the two reserves combined (350 sq km) represents 7.85 per cent of Jingdong County.

Methods

Estimates of total land area, human population density and area currently provided Nature Reserve status, stratified by elevational bands (at intervals of 500-m altitude) were calculated. For Gaoligongshan Region, we also stratified the land by latitudinal bands (roughly 1°). Our general approach followed Hunter & Yonzon (1993).

In each case, the figure for human population is that which pertained at the time the nature reserve was designated, rather than the current population size because our concern is with the factors that influenced the decisions of the planners when they established the reserves. The data are for 1978 and 1984 for Gaoligongshan Region and Jingdong County, respectively. Based on interviews with local officials and villagers, we found that the distributions of villages and the human population altered little prior to the early 1980s. Although significant changes occurred thereafter, these changes were limited to increases in the size of the population, not to the establishment of new villages. Furthermore, most of the population increase over the last two decades has been confined to the major low altitude urban centres.

Data on mammals and birds were based on the specimens in the collections of the Kunming Institute of Zoology up to 1994. Those specimens were collected mainly during surveys prior to the 1980s, and reflect the original fauna when the nature reserves were designated (e.g. Bird Group of Kunming Institute of Zoology, 1980, for birds). One of the surveys used was carried out between 1992 and 1994, but the results mainly clarified the original distribution of those species among the elevational bands, rather than yielding many new species. Although we have not listed the species involved (the combined examples contain about 300 bird species and 90 mammal species), full species lists can be obtained from the corresponding author.

Gaoligongshan Region

Total land area was calculated by adding up the area of each of the 13 counties within the region (Yunnan Mapping Bureau, 1982). We defined Gaoligongshan Region as only those areas west of the Salween River. However, because some counties are located on both sides of the Salween River, we first determined the proportion of each county on each side of the river (digitized from county topographic maps and calculated using AUTOCAD 11.0), and included the western section only in the calculations. Total human population was assumed to be uniform within each county.

To estimate the proportion of area within each latitudinal and elevational band, we first overlaid each county topographic map with an acetate grid, and counted the number of grid intersections within each band. The total area within each band was then computed by multiplying the published county total by the proportion of total intersections falling within each band. Nature reserve boundaries (Forestry Planning

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and Surveying Institute of Yunnan Province, 1989) were then plotted onto the county topographic maps, and all steps described above were repeated for areas within the plotted boundaries.

Departing somewhat from the procedures of Hunter & Yonzon (1993), human population density was estimated by tallying the total number of towns on county topographic maps falling within each elevational and latitudinal band ($n = 1620$). The 13 county seats (mean population = 9600) were assumed to equal five towns each for the purposes of this estimation. The population within each band was then calculated by multiplying the published county total by the proportional distribution of towns.

Total species richness of all avian and mammalian species was calculated (including, within Mammalia, the orders Artiodactyla, Carnivora and Primates) (Ma *et al.*, 1994). We examined locational records for 2523 mammal specimens (totalling 178 species through 1994) and 3130 bird specimens (totalling 487 species through 1993). Each species was classified as belonging to one or more latitudinal and elevational bands using the minimum and maximum recorded latitude and elevation of all specimens.

Jingdong County

Similar methods were applied to Jingdong County. However, because data about vegetation types and climatic zones are clearly defined for the county, we divided the land surface into five elevational strata, in accordance with the vegetation types and climatic zones.

Once again, we counted the altitudinal distribution of total land and nature reserve land by overlaying acetate grids on 1 : 50,000 maps of Jingdong County. We checked the altitude of each intersection of the grid (1×1 sq km for nature reserve, with 3×3 sq km for the total land area). In addition, we counted the number of intersections within each altitudinal stratum. The area within each stratum was then computed by multiplying the total area of the county by the proportion of intersections landing within each stratum.

On the map of Jingdong, a total of 341 points was checked for the nature reserves and 603 points for the total county. The actual area above 3000 m, calculated from the 1 : 50,000 map, was about 11 sq km. We determined the human density by adding up the human population figures according to the altitude of each administrative village centre (Committee of Annals Compiling of Jingdong County, 1994). The population data for each village are based on a survey conducted in 1984 (Forestry Zonation Office of Jingdong County, 1986).

Species richness of avian and mammalian species (including, within Mammalia, the orders Artiodactyla, Carnivora and Primates) is based on Wang *et al.* (1994) and Yang *et al.* (1994). A total of 101 mammal species and 296 avian species were classified into different elevational strata. Both Wang *et al.* (1994) and Yang *et al.* (1994) provide detailed tables that classify the distribution of each species in different habitats at different altitudes and include good descriptions about the distribution. We also used numbers of protected mammal and bird species from the same sources for analysis.

Standard correlation and linear regression analyses were run to deduce trends. Proportions were normalized using arc-sine transformation, and significance was taken as $P < 0.05$, unless otherwise specified.

Results

Gaoligongshan Region

Total area, population and the extent of the area protected by reserves are shown in Table 1. Table 2 illustrates area and species richness by elevational bands, and Table 3 presents a comparison of area protected and human population density analysed by latitude.

Patterns in species richness

For mammal species, 36 and 71 per cent of all recorded species were found in the 0–500 and 2000–3000 m strata, respectively. For birds, 68 per cent of all recorded species occurred below 2500 m and 59 per cent occurred within the narrow 1000–1500 m stratum.

Fifty-four avian (11.1 per cent) and 63 mammalian species (35.4 per cent) were recorded in the lowest elevational band (210–500 m) despite the fact that it accounts for less than 0.3 per cent of the region's total area. Species richness in the highest elevations appeared to be much lower, but may have been underestimated if proportionately fewer specimens were collected in these inaccessible areas.

Patterns of species richness by latitudinal strata were less clear (in part because data were unavailable for the 26–27° strata, conditions for sampling in this region being so difficult that few surveys had been conducted). It appeared that bird species richness decreased with latitude, although mammals showed a less clear pattern.

Both elevational and latitudinal patterns suggested a similar underlying dynamic, particularly for birds: species richness tended to be higher in tropical and sub-tropical areas, and lower in the simpler forest types at higher elevations (which, in Gaoligongshan Region, were themselves correlated with higher latitudes). We

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Table 1 Total area, population and extent of protected area (nature reserves) within the 13 counties of Gaoligongshan Region, western Yunnan (*source*: Yunnan Mapping Bureau, 1982; Forestry Planning and Surveying Institute of Yunnan Province, 1989)

County	Total area (sq km)	Area west of Salween River (sq km) (per cent)	Total population of the county (*× 1000*)	Human density for the county (per sq km)	Area west of Salween River covered by nature reserve (sq km)	Proportion of total area west of Salween River covered by nature reserve (per cent)
Luxi	2987	2987 (10.7)	224	75	0	0
Ruili	917	917 (3.3)	62	68	71	7.7
Wanding	103	103 (0.4)	7	68	0	0
Longchuan	1931	1931 (6.9)	112	58	23	1.2
Lianghe	1159	1159 (4.1)	112	97	0	0
Yingjiang	4429	4429 (15.8)	175	40	260	5.9
Tengchong	5845	5845 (20.9)	450	77	424	7.3
Longling	2884	2884 (10.3)	210	73	0	0
Baoshan	5011	1072 (3.8)	643	128	387	36.1
Lushui	2343	1465 (5.2)	88	38	429	29.3
Bijiang	1597	719 (2.6)	45	28	415*	57.7
Fugong	1802	1136 (4.1)	41	38	0	0
Gongshan	4506	3334 (11.9)	26	6	1767	53
Total	35,514	27,981 (*100*)	2195	*63*	*3776*	13.5

* This area corresponds to the southern section of the Nujiang Nature Reserve and differs from the figure of 1378 sq km cited by Forestry Planning and Surveying Institute of Yunnan Province (1989). The figure of 1378 sq km constitutes 86 per cent of the county and we consider this figure to be an overestimate. For this reason, we base our estimate on the written description in this source that the nature reserve in Bijiang County includes all land above 2500 m on the eastern slope of Mt. Gaoligongshan.

did not sample other taxa, but Hunter & Yonzon (1993) suggested that, at least in Nepal, which is topographically similar, amphibians, reptiles and fish show similar trends.

Reserve location

How well did existing reserves, stratified by elevation and latitude, correspond with the patterns of species richness? Contrary to the ideal strategy—from the perspective of biodiversity conservation—the proportion of total land in reserves showed a negative, rather than positive, correlation with species richness (Fig. 2). For example, stratified by elevation, the proportion of land in reserves was negatively correlated with total mammalian richness ($r = -0.685$, $P = 0.029$), avian richness ($r = -0.973$, $P < 0.0001$), as well as number of carnivore ($r = -0.759$, $P = 0.019$) and primate ($r = -0.843$, $P < 0.0001$) species, although the correlation with the

Table 2 Total area, area under nature reserve designation, species richness and human population density in Gaoligongshan Region, stratified by elevational band

Elevation (× 100 m)	Total area (sq km)	Reserve area (sq km)	Bird species number in the whole area	Mammal species in the whole area	Human density (per sq km)
2.1–5	73	24	54	63	55
5–10	3316	106	245	94	104
10–15	5987	140	289	100	72
15–20	7734	201	235	104	89
20–25	5369	582	194	112	24
25–30	2223	988	95	111	0
30–35	1733	901	51	95	0
35–40	1279	678	1	49	0
40–45	204	117	0	31	0
>45	63	39	0	16	0
Total (average)	27,981	3776	487	178	(58)

For details of calculation, see text.

Table 3 Total area west of the Salween River, total area under nature reserve designation, and proportion of total area protected, by latitudinal bands, Gaoligongshan Region, western Yunnan

Latitude band	Total area (sq km)	Protected area (sq km)	Proportion protected (per cent)	Human density (per sq km)
23°51′–25°00′	13,992	378	3	72
25°00′–26°10′	7805	1215	16	67
26°10′–27°00′	1577	415	26	27
27°00′–28°23′	4607	1767	38	10
Total (average)	27,981	3776	13	(58)

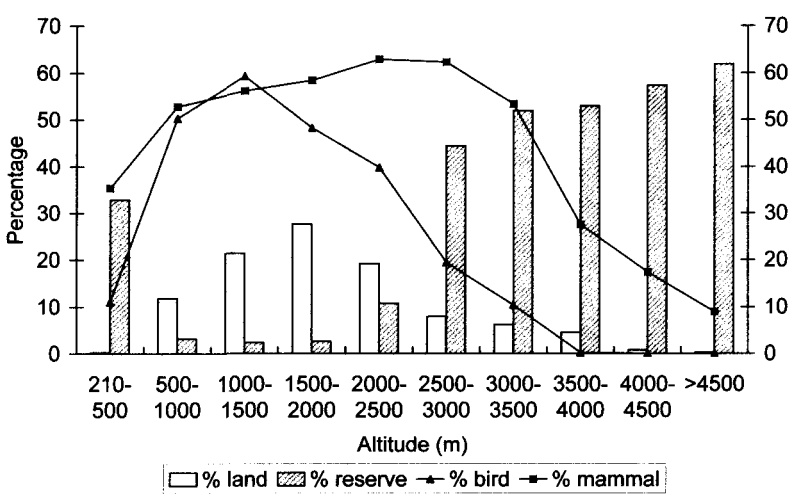

Fig. 2 Proportion of total land, land under reserve designation and species richness in elevational bands for Gaoligongshan Region.

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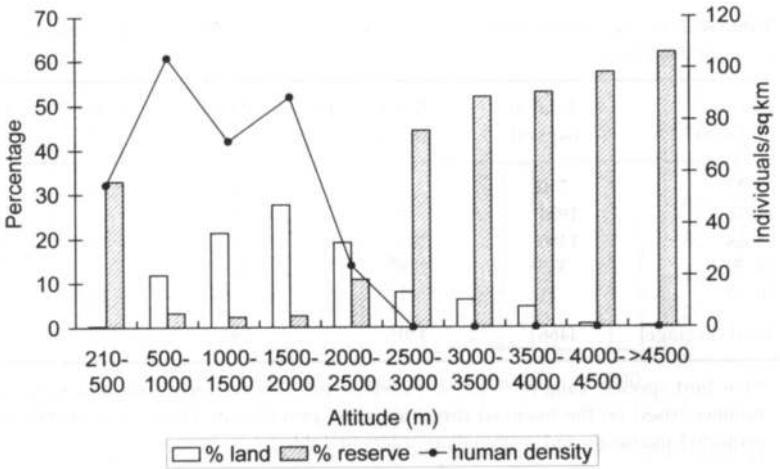

Fig. 3 Human population density and proportion of total land under reserve designation in elevational bands for Gaoligongshan Region.

number of artiodactyl species was not significant ($r = -0.451$, $P = 0.342$). In short, areas with highest species richness had the least nominally protected land, and vice versa.

What, then, motivated the location of reserves, if not consideration of vertebrate richness? It appears that reserves were established where human density was lowest, i.e. where conflicts with established uses would be minimal. Stratified by elevation, the proportion of land in reserves was negatively correlated ($r = -0.873$, $P = 0.001$) with human population density (Fig. 3). The relatively high proportion (32 per cent) of protected land in the lowest elevational stratum could be misleading because such low elevations are rare in Gaoligongshan Region: the total area in this stratum is only 73 sq km, with 24 sq km (33 per cent) covered by nature reserves.

The negative relationship between protection in nature reserves and existing human settlement was seen even more clearly when stratified by latitude ($r = -0.9$, $P = 0.037$). A linear regression of the proportion of protected land on human density suggested that, at least in Gaoligongshan Region, nature reserves have not been (and perhaps cannot be) established where human density exceeds 96/sq km (Fig. 4). Only in regions with a density less than 47/sq km did reserve area exceed a quarter of the total land area.

Jingdong County

Total area, population, the extent of the area protected by reserves and species richness by elevational bands are presented in Table 4 for Jingdong, and the proportion of each category in each elevational zone is shown in Table 5.

Patterns in species richness

Ninety-two per cent of all recorded mammal species inhabited the 1800–2400 m stratum; 50 per cent of recorded bird species appeared in the 2400–3000 m stratum. Eighty-two avian species (27.7 per cent) and 58 mammalian species (57.4 per cent) were recorded in the lowest elevational band (800–1300 m), despite the fact that this band accounted for less than 15.9 per cent of the region's total area. Species richness in the highest elevations appeared to be similar to the proportion of land surface area.

For both birds and mammals, the elevational pattern suggested a similar underlying pattern: species richness tended to be higher in the mid to high altitudinal zones, and lower in the areas of highest human density (the 1300–1800 m stratum). Considering the overall trends, these results differ from those for the topographically similar Gaoligongshan Region and Nepal, where species richness tends to be higher in tropical or hot low-altitudinal zones (Hunter & Yonzon, 1993).

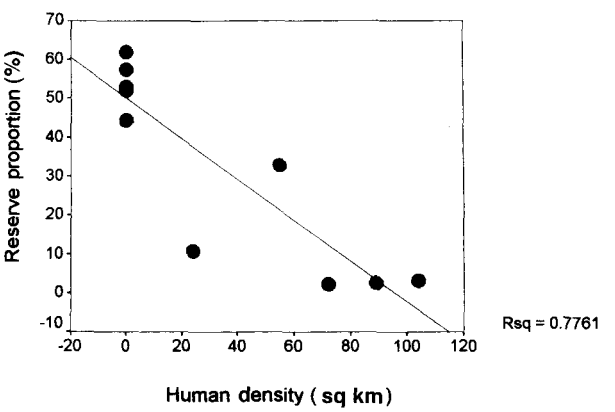

Fig. 4 Linear regression of reserve area on human density in Gaoligongshan Region.

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Table 4 Total area, area under nature reserve designation, species richness, and human population density in Jingdong County, stratified by elevational band

Elevation (× 100 m)	Total area (sq km)	Reserve area (sq km)	Bird species* in the whole area	Mammal species* in the whole area	Human density (per sq km)
8–13	710	0	82	58	158
13–18	1924	2	98	43	72
18–24	1486	109	145	93	51
24–30	335	228	148	72	1.6
30–34	11	11	32	19	0
Total (average)	4466	350	296	101	(73)

* For bird species, Yang *et al.* (1994) provided the data for each band based on the habitats; for mammals, we calculated the species number based on the mammal distribution list provided by Wang *et al.* (1994). Similar methods were used in the calculation of the protected mammals and mammalian orders in Table 5.

Table 5 Human population, protected species numbers and species of three mammal orders in Jingdong County, stratified by elevational band

Elevation (× 100 m)	Total population	Number of protected bird species*	Number of protected mammal species*	Primates	Carnivores	Artiodactyla
8–13	112,180	11	8	3	19	1
13–18	138,528	7	3	7	8	2
18–24	75,786	19	22	7	22	7
24–30	536	11	23	6	21	7
30–34	0	1	6	0	7	3
Total	327,030	30	25	7	25	7

* Protected by law in China (source: Wang *et al.*, 1994; Yang *et al.*, 1994).
Note: The total corresponds to the number of species in the whole region; it is not the sum of each elevational band because the same species can occur at several elevational bands.

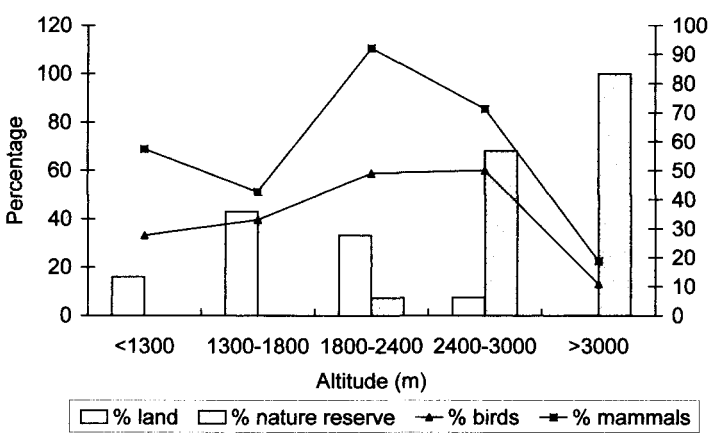

Fig. 5 Proportion of total land, land under reserve designation and species richness in elevational bands for Jingdong County.

Reserve location

How well did existing reserves in Jingdong County correspond with the patterns of species richness? Although the trends are not as clear as those for Gaoligongshan Region, the proportion of total land in reserves nevertheless showed negative, rather than positive, correlation with mammalian species richness (Fig. 5: $r = -0.200$, $P = 0.747$), although without statistical significance. Stratified by elevation, the proportion of land in reserves was negatively correlated with protected bird species numbers ($r = -0.359$, $P = 0.553$) (but not with bird species richness), as well as with numbers of primates ($r = -0.359$, $P = 0.553$) and carnivores ($r = -0.2$, $P = 0.747$). Positive correlations were found for artiodactyl species ($r = 0.667$, $P = 0.219$) and protected mammal species ($r = 0.2$, $P = 0.747$). In this

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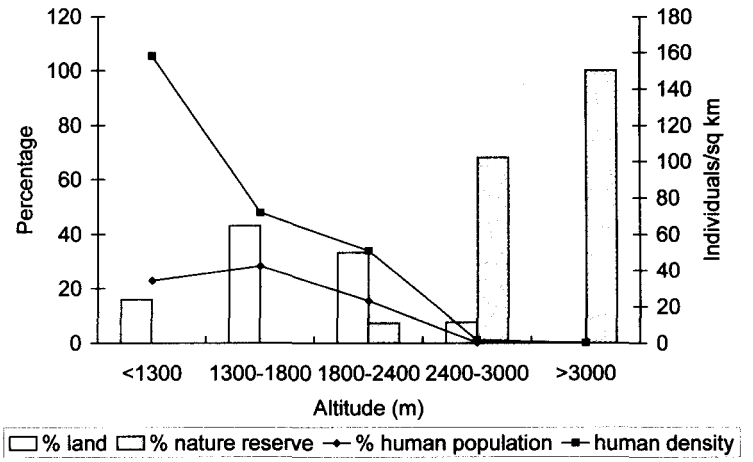

Fig. 6 Human population, human population density and proportion of total land under reserve designation in elevational bands for Jingdong County.

case, we cannot conclude that the areas with highest species richness (and numbers of protected species) correspond with the least nominally protected land.

As in the case of Gaoligongshan Region, we found that reserves were established where human population density was lowest. Stratified by elevation, the proportion of land in reserves was significantly negatively correlated with human population ($r = -0.9$, $P = 0.037$) and human population density ($r = -1.00$, $P < 0.0001$) (Fig. 6).

The linear regression equation suggests that the nature reserves have not been (and perhaps cannot be) established where human density exceeds 118/sq km (Fig. 7). Only in regions with a density less than 74/sq km and 30/sq km did the reserve area exceed a quarter or half, respectively, of the total land area. These areas are larger than those for Gaoligongshan Region.

Discussion

Nature reserve designation

This analysis of Gaoligongshan Region and Jingdong County makes clear one important point, which is self-evident upon reflection: nature reserves have been placed where conflicts with humans are lowest, while areas where human density is highest are avoided. For Gaoligongshan Region, the results also demonstrate that species diversity is generally highest in the lower elevation sections (where crop cultivation is most productive) and lowest in the highest elevation sections (where humans can subsist on livestock only, which necessarily has a low density because of low primary productivity). Because species richness responds to the same fundamental factors as human density, the inevitable result is that nature reserves are placed where, from a species richness perspective, they are needed least.

Recent surveys (for example, Ma *et al.*, 1994) have found that human disturbance is becoming more serious in those elevational bands with higher biodiversity (i.e. low-altitudinal bands). These activities include forest exploitation (commercial logging), cultivation by local shifting agriculture and cash-crop plantation (in some cases, valleys inside forest are exploited for their damp and shaded conditions). It should be noted here that the seemingly high level of protection afforded Gaoligongshan lands under 500-m elevation is misleading: although nominally under reserve protection, recent surveys (Ma *et al.*, 1994) have revealed a large influx of agriculturalists and frontier traders, and most original forest has now been replaced by cropland, highways and built-up areas, because it borders Myanmar and has a suitable climate for plantations. Moreover, a number of endangered bird and mammal species have disappeared from this area in the past 40 years or so (Ma *et al.*, 1994), including hornbills and

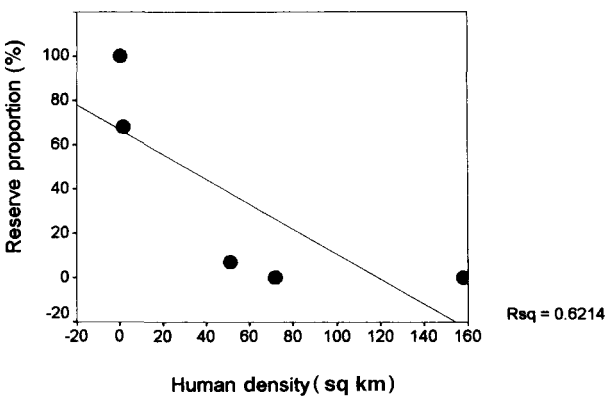

Fig. 7 Linear regression of reserve area on human density in Jingdong County.

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hoolock gibbons. Conflict of interest between local people, government and conservation staff occurs from time to time (Ma *et al.*, 1994). However, although we can expect many wildlife populations in low altitude habitats to have been extirpated due to these increasing conflicts with the growing human population, there are insufficient data from recent surveys to allow us to determine the exact number of local extinctions.

In the case of Jingdong County, the results do not confirm that the tropical areas are of greater biodiversity. However, this may be because the collection of specimens in low altitude areas is not as good as in the high areas (usually from 1800 to 2800 m a.s.l. where good forest remains). Most primary habitat in low elevations had been altered by human activities long before any surveys were conducted. The lower the elevation, the more disturbance there is from humans and the greater the amount of habitat that is destroyed. Another reason for the low species richness for land under 1300 m is that this zone represents a much smaller proportion of total land (16.9 per cent). If each county in Gaoligongshan Region was analysed in the same way as Jingdong County, the results might be similar. However, Gaoligongshan Region is not homogeneous, so the analysis would not be straightforward.

Biodiversity conservation in Yunnan: the present situation

The findings reported here should be seen not so much as a criticism of forestry or reserve officials, but as an acknowledgement of the pre-eminence in conservation activities of socio-economic over strictly biological considerations. Given the difficulties that existing reserves already face in protecting nature resources effectively (Ma *et al.*, 1994), we can only assume that attempts to establish reserves in more densely populated areas (albeit, areas that might have more species richness) would encounter even greater resistance.

Following the economic reforms of the late 1970s, the Chinese economy expanded greatly. Much attention in the West has focused on the rapid economic growth of Chinese cities and the south-eastern portions of China. However, the more remote, rural regions, like most of Yunnan, have not been immune to these pressures: if anything, pressures here are more intense due to the sense of having been 'left behind' by the more prosperous coastal regions. Unfortunately, the most immediate source of wealth in Yunnan is the rapid liquidation of existing natural resources, particularly forests, and this has inevitably increased the burden on biodiversity conservation.

In Yunnan, biodiversity in 90 per cent of the land area that lacks formal protected status is in a precarious state. There has been some progress in protecting forest habitats in some subregions. Some areas are being reforested or conserved for watershed protection and some relatively small patches of untouched forest remain beyond the protection of nature reserves in both national forests and collective forests. However, the general trend has been to simplify ecosystems, and to convert lowland forests to agriculture and upland forests to commercial production of wood. Conversions of formerly wild areas to commercial uses have been especially common in the lower elevation (< 1000 m) sections, as well as at mid-elevations (1000–2000 m). In contrast, creating new nature reserves is almost impossible, because the central and provincial governments are no longer prepared to support new reserves due to insufficient revenues and possibly sensitivity to criticism. In addition, recent government hydroelectric schemes, like those in Mekong Valley, may pose a further threat to low altitude habitats in Yunnan.

Two important points emerge: (1) conservationists who are dissatisfied with the current location or extent of China's nature reserve system, and who instead propose prioritizations based on species characteristics, must be prepared to describe how such biologically based designations can be realized, given that, thus far, designations have responded primarily to human realities; and (2) with or without formal reserve designation, a little conservation in currently unprotected areas, particularly in the lower elevations, is likely to go a long way. Absolute protection may not be realistic in these areas, but the moderation of habitat alteration and hunting practices can help stave off the elimination of many species.

Acknowledgements

This work was initiated at the suggestion of Dr William Bleisch when a conservation survey project was conducted in Gaoligongshan Region (1992–94) by the Kunming Institute of Zoology. The fieldwork for the survey in Gaoligongshan Region was supported by the MacArthur Foundation, and the main workers were Dr Shilai Ma, Dr Lianxian Han and Daoying Lan (DYL) and Dr Rich Harris (Wildlife Conservation Society). Many others also contributed to the survey. For the analysis of Jingdong County, data were collected by DYL during fieldwork on wild black gibbons [supported by the National Geographical Society (5845-97), the International Primatological Society and Primate Conservation, Inc.]. We sincerely thank Dr William Bleisch, Dr Harris, Dr Ma, Dr Han, DrWeizhi Ji and many others for their encouragement and support (including data, analysis and logistics) during DYL's stay in Yunnan. We would also like to thank WWF for providing DYL with a

https://doi.org/10.1046/j.1365-3008.2000.00131.x Published online by Cambridge University Press

Russell E. Train Education for Nature Program Fellowship, which supplied his tuition fee and living expenses while he was conducting fieldwork in 1998. The paper was prepared for publication while DYL was in receipt of a Developing Countries Training Fellowship from the Wenner-Gren Foundation for Anthropological Research. We are indebted to the anonymous referees for their kind help in improving the manuscript.

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https://doi.org/10.1046/j.1365-3008.2000.00131.x Published online by Cambridge University Press