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The conservation status of the restricted-range lowland birds of Buru, Indonesia

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Summary

The island of Buru in Maluku province, Indonesia was visited in November and December 1989. Using a point count method, we assessed the conservation status of the island's restricted-range lowland birds by examining their abundance and habitat associations. Thirteen of Buru's 19 lowland restricted-range species were recorded during the fieldwork. Of these we assign nine (White-eyed Imperial Pigeon *Ducula perspicillata*, Moluccan Red Lory *Eos bornea*, Buru Racquet-tail *Prioniturus mada*, Black-tipped Monarch *Monarcha loricatus*, White-naped Monarch *Monarcha pileatus*, Dark-grey Flycatcher *Myiagra galeata*, Flame-breasted Flowerpecker *Dicaeum erythrothorax*, Buru Yellow White-eye *Zosterops buruensis* and Black-faced Friarbird *Philemon moluccensis*) to IUCN's Safe/Low risk category of threat, on the basis of their large populations, widespread occurrence on Buru and association with non-pristine habitats. We recommend that the remaining six of the recorded species remain Data-deficient but some of these (e.g. Blue-fronted Lorikeet *Charmosyna toxopei* and Buru Cuckoo-shrike *Coracina fortis*) may be Vulnerable. While data on the birds which we did not record are obviously needed, we suggest that the amount of forest remaining, the abundance of many species and their tolerance of selectively logged forests bodes well for the immediate future of the bulk of Buru's lowland avifauna.

Introduction

The island of Buru in Maluku province, Indonesia lies within the biogeographical region of Wallacea. Buru is one of Wallacea's 11 "Endemic Bird Areas" and has 29 "Restricted-range" species (Stattersfield *et al.* in press) of which ten are endemic (White and Bruce 1986). The island has received very little recent attention from ornithologists and remains Maluku's least known Endemic Bird Area. A chronology of ornithological exploration on Buru is given in Jepson (1993) and, since the 1920s, the island has been visited briefly only by Smiet in 1980 who identified protected areas for UNDP/FAO (Smiet 1980, 1985). Our 1989 Buru expedition was therefore the only avifaunal survey of recent time. Anecdotal notes on the birds that we recorded have already been published in the form of an annotated checklist (Jepson 1993). In this paper we present baseline population estimates for Buru's restricted-range birds, examine their habitat association, and use this information to assign each species to one of IUCN's categories of threat.

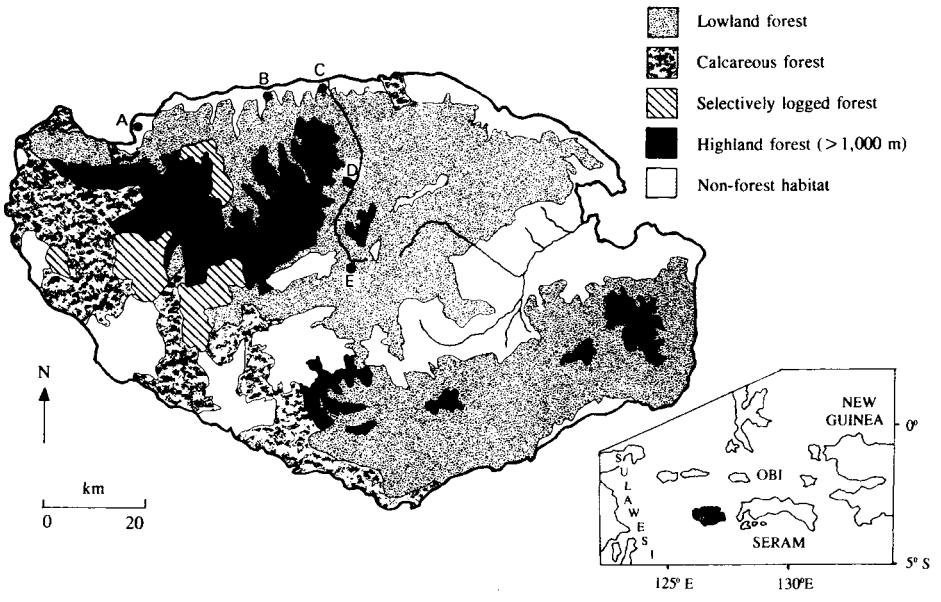

Figure 1. Map of Buru showing location of study sites (A–E) and coverage of broad habitat types. A, Bara; B, Balbalu; C, Wanibe; D, Wanibe; E, Lake Rana.

Buru and its birds

Buru is 140 km long and has a total land area of around 8,000 km^2. Much of the island away from the coast is rugged and mountainous with the highest peak (2,692 m) in the north-west (see Figure 1). Most of Buru has an ever-wet climate supporting evergreen forests dominated by Dipterocarpaceae (e.g. *Shorea*), although the north-east of the island holds some seasonal forest (Collins *et al.* 1991). Primary forest and slash-and-burn regimes predominate inland, with grassland, agriculture and plantation in the more accessible coastal areas. Much of Buru's remaining primary forest has been, or is due for, selective logging (Jones and Banjaransari 1990). At present, Buru has no gazetted protected areas although two have been proposed (Smiet 1980).

Table 1 lists Buru's restricted-range lowland birds that were the subject of this study. The ten restricted-range species which are only found in submontane and montane habitats are omitted but three "highland" species which we recorded on several occasions are included.

Methods

Areas/habitats surveyed

Field data were collected between 8 November and 18 December 1989. Bird surveys were conducted at five sites, all in the north and centre of the island (Figure 1 and Table 2). Birds were censused at 176 census stations from sea level to 880 m. Repeat counts were carried out at 55 of these stations. There were 39

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Table 1. Restricted-range birds occurring in the lowlands of Buru (following Stattersfield *et al.*, in press)

Species	Status	
	Species	Subspecies
Rufous-necked Sparrowhawk *Accipiter erythrauchen*	EM	EBS
Moluccan Scrubfowl *Megapodius wallacei*	EM?[a]	
Elegant Imperial-pigeon *Ducula concinna*		
White-eyed Imperial-pigeon *Ducula perspicillata*	EM	
Long-tailed Mountain Pigeon *Gymnophaps mada*[b]	EM	EB
Blue-fronted Lorikeet *Charmosyna toxopei*	EB	
Moluccan Red Lory *Eos bornea*	EM	EB
Buru Racquet-tail *Prioniturus mada*	EB	
Lesser Masked Owl *Tyto sororcula*		EB
Moluccan Hawk-owl *Ninox squamipila*		EB
Pale Cicadabird *Coracina ceramensis*	EM	EBS
Buru Cuckoo-shrike *Coracina fortis*	EB	
Cinnamon-chested Flycatcher *Ficedula buruensis*[b]	EM	EB
Black-tipped Monarch *Monarcha loricatus*	EB	
White-naped Monarch *Monarcha pileatus*		EB
Dark-grey Flycatcher *Myiagra galeata*	EM	EB
Tawny-backed Fantail *Rhipidura superflua*[b]	EB	
Drab Whistler *Pachycephala griseonata*	EM	EB
Flame-breasted Flowerpecker *Dicaeum erythrothorax*	EM	EB
Buru Yellow White-eye *Zosterops buruensis*	EB	
Black-faced Friarbird *Philemon moluccensis*		EB
Black-eared Oriole *Oriolus buruensis*		EB

Sequence and taxonomy follow Andrew (1992). EB, endemic to Buru; EM, endemic to Maluku Province; EBS, endemic to Buru and near-by Seram.

[a] Also known from a single and apparently dubious record from Misool Island, Irian Jaya (Collar *et al.* 1994).

[b] Listed as highland species by Stattersfield *et al.* (in press).

Table 2. Locations and habitat descriptions for census stations

Site name	Map reference	Altitude (m)	Number of stations		
			P/S	LG	NF
Wafawel	3°14′15″S 126°37′26″E	400–770	47 (75)	0	5 (8)
Lake Rana	3°23′06″S 126°34′51″E	700–800	15	0	0
Wanibe	3°04′03″S 126°36′03″E	0–100	9 (18)	38	8 (16)
Balbalu	3°04′49″S 126°32′37″E	110–620	0	42	0
Bara	3°10′41″S 126°13′54″E	0–150	0	12 (19)	0

Under Number of stations, the values in parentheses are the total number of counts, i.e. the number of stations plus repeats of stations. P/S, primary/secondary forest; LG, selectively logged forests; NF, non-forest habitats.

stations in primary forest (nine were repeated), 32 were in secondary forest (28 repeated), 50 in 2 to 5 year old logged forest (7 repeated) and 42 (no repeats) in 12-year-old logged forest. A further 13 stations were classified as non-forest vegetation. Of these, 11 (all repeated) were in coastal vegetation (including agriculture) and two were in grassland (neither repeated). For the calculation of bird population densities and encounter rates, stations were categorized into

three groups; primary/secondary forests, logged forests, and non-forest vegetation.

The investigation of bird/habitat associations

The methods used to census birds and the habitat recording methods were the same as those used in Jones *et al.* (1995). At each census station, vegetation cover at different strata, tree architecture, gradient, altitude and tree girths and heights were recorded. A woody biomass index and tree density were calculated from these data as in Jones *et al.* (1995). As previously described data on tree architectures are important in elucidating the recent history of forest disturbance at census plots (Torquebiau 1986; Jones *et al.* 1995, Marsden 1995). Trees which have their first major branch above halfway to their crown tend to be associated with primary forest while trees branching below halfway to their crown are characteristic of areas where there has been recent timber extraction, or a treefall. Areas which are regenerating after timber extraction or a treefall are characterized by trees which either branch above halfway but which have scars from dropped branches, or have vertically growing branches.

An objective indication of the broad habitat associations of individual species was gained by examining the differences in measured habitat between the census stations at which a bird species was recorded and those at which it was not. There are many ways of doing this (e.g. Fielding 1993) and for this study two methods were used: first, altitudinal ranges of birds were investigated and second, all the habitat parameters were considered together using discriminant function analysis (DFA). Table 4 (see later) includes the units of measurement or estimation and the means and standard deviations of each of the 15 habitat variables entered in DFA. All variables which were recorded as proportions or percentages were normalized by arcsine transformation.

DFA was carried out using the DISCRIMINANT package of SPSS. Only species which were recorded at three or more census stations were included in the analysis. Positive stations were those at which a particular species was recorded within 100 m of the plot's central point. If a station was sampled more than once then the presence of a bird on either/all visits made it positive. Prior probabilities of group membership (positive or negative) were set at 0.5 for each species.

The calculation of bird population estimates

Birds were censused using a point count distance sampling technique known as the variable circular plot method or VCPM (Reynolds *et al.* 1980, Buckland *et al.* 1993). The field methods were the same as those used in Jones *et al.* (1995). As on Sumba, stations were set out at 250 m intervals along transects and every other station was positioned 50 m to the side of the transect route. Bird census was carried out between 06h30 and 11h00 and only in the absence of rain, mist, low cloud or strong wind. Two experienced recorders censused all birds for 10 minutes at each station.

Population density estimates (individuals per square kilometre) and encounter rates (number of individuals per station) were calculated from the VCPM data using the DISTANCE software (Laake *et al.* 1994). Encounters with flying birds

at census stations were included in the analysis for all species apart from parrots. In this group, such a large proportion of birds recorded are in flight that including aerial birds causes serious overestimation of density (Marsden 1995). For contacts where birds (all species) were heard only, the mean group size of contacts (with that species) where birds were seen was substituted for the missing group size values. The assumption here is that the mean group size of observed birds was similar to that of aural contacts. This assumption may be violated to a degree but the problem may only be slight since most visual contacts were with birds which were located by their calls first anyway (and just happened to be close enough to allow observation).

For all species, between 10% and 20% of the most distant bird records were truncated using the RTRUNCATE option in DISTANCE (Laake *et al.* 1994). The actual percentage which were truncated differed between species and in each case the value which minimized the Akaike Information Criterion (for a particular model) was chosen. The Akaike Information Criterion (AIC) is a measure of how well the observed detection curve fits a proposed model. Data were entered in a grouped format (DISTANCE=INTERVAL) but, as with the data truncation, the interval measures used differed between species. Groups were entered as clusters (OBJECT=CLUSTER) for all species. All detection function models and adjustments were considered and the model with the lowest AIC selected (PICK=AIC). Standard errors of density estimates were calculated using the BOOTSTRAP command.

To calculate precise density estimates using DISTANCE, over 100 bird records are needed to model a species's detection function accurately (Buckland *et al.* 1993). Such sample sizes are usually not achievable during short surveys such as on Buru, so various strategies were used to maximize the precision of estimation following the recommendations of Marsden (1995). They were as follows.

For the commonly recorded species, bird records from each habitat were entered into DISTANCE separately (i.e. habitat and species-specific detection functions were modelled). For other species which were less frequently recorded, data from both forest habitats were combined to produce a species-specific but not habitat-specific detection function. In these cases, records from each habitat were treated as subsets of all records, and separate density estimates calculated for each habitat based on the pooled detection function. This has the advantage that sample size is maximized and yet separate density estimates are produced for the two habitats. It is of course not as satisfactory as calculating habitat-specific detection functions, although patterns of detectability of the same species in different types of forest may not differ greatly (Marsden 1995).

For species which were recorded on even fewer occasions, two or more species were combined to create a "detection function template" (Marsden 1995). For example, records of the two *Monarcha* species and Dark-grey Flycatcher *Myiagra galeata* were combined to create a "monarch detection function" and this was used to calculate a density estimate for each species. Similarly, records of Tawny-backed Fantail *Rhipidura superflua* were combined with those of the similar and often-recorded Northern Fantail *R. rufiventris* (not a restricted-range species) to model the detection function and therefore calculate the density of the former. The same was also done for Drab Whistler *Pachycephala griseonata* (combined with the congeneric Golden Whistler *P. pectoralis*). In the above cases,

the regime is probably satisfactory since the pairs/triplets of species are similar in habits and habitat but most importantly in the detectability of their vocalizations. It may not work well at all with other species groups and we did not attempt to derive density estimates for the two *Coracina* species because they were different in character from each other and from any other species on Buru.

To calculate total population estimates, individual species density estimates were multiplied by the total area of habitat available to that species. As was done for islands in North Maluku (Lambert 1993), areas of broad habitat types on Buru were calculated by digitization of the land-use map produced by the Regional Physical Planning Programme for Transmigration (RePPProT). The RePPProT land use map itself was based on aerial photographs and Landsat imagery collected during the period 1976–78. Thus the areas of each habitat will have changed by an unknown amount in the 12 years or more between mapping and our bird survey.

The amount of habitat available to birds depended on their broad habitat and altitudinal associations, and whether or not we were able to calculate density estimates in specific habitats (e.g. logged forest and non-forested areas). Thus, in some cases, the total population of a lowland species was calculated simply as its density in lowland forest multiplied by the total area of lowland forest. As such, the total population estimates are seen as very rough indications of the likely magnitude of the population on Buru. More specifically they are used to allocate species to a relevant category of threat (Mace and Stuart 1994).

Results

A total of 12 lowland restricted-range species were recorded at census stations in primary and secondary forests. Three highland restricted-range species (Long-tailed Mountain Pigeon *Gymnophaps mada*, Tawny-backed Fantail and Cinnamon-chested Flycatcher *Ficedula buruensis*) were also recorded at stations in this category. Nine lowland restricted-range species were recorded at stations in the logged forest category (along with Long-tailed Mountain Pigeon), and seven lowland and one highland species (Tawny-backed Fantail) in the non-forest category.

Altitudinal ranges

Table 3 shows measures of the altitudinal range of each restricted-range bird and of the three habitat types surveyed. It is important to note that while both forest categories were surveyed very close to sea level, the mean altitude of logged forests was more than 300 m lower than that for primary/secondary forests. The highest points reached in the latter category were 350 m higher than those in logged forest. While these differences may reflect actual land use on Buru quite well, they also have important implications when densities and habitat associations of birds in the two habitats are interpreted. Some of these implications are discussed in the species account section.

Five species were recorded at altitudes of 50 m or less and seven at, or below 100 m a.s.l. Three were recorded within 100 m of the highest point of our survey and six more than 700 m a.s.l. It is difficult to define the true altitudinal range of

Table 3. Altitudinal ranges of habitat and bird species at census stations on Buru

	n	Mean alt.	SD	Max.	Min.	Rge
Habitat categories						
All habitats	176	326	235	880	5	875
Primary/secondary	71	541	217	880	10	870
Logged forests	92	201	118	530	20	510
Non-forest	13	195	240	510	5	505
Bird species						
White-eyed Imperial Pigeon *Ducula perspicillata*	87	324	237	810	5	805
Long-tailed Mountain Pigeon *Gymnophaps mada*	4	633	162	790	460	330
Moluccan Red Lory *Eos bornea*	21	251	210	750	50	700
Buru Racquet-tail *Prioniturus mada*	19	313	207	620	55	565
Pale Cicadabird *Coracina ceramensis*	2	345	–	590	100	490
Buru Cuckoo-shrike *Coracina fortis*	3	473	67	530	400	130
Black-tipped Monarch *Monarcha loricatus*	15	247	212	590	15	575
White-naped Monarch *Monarcha pileatus*	3	647	90	750	590	160
Dark-grey Flycatcher *Myiagra galeata*	7	430	180	620	80	540
Tawny-backed Fantail *Rhipidura superflua*	3	510	17	530	500	30
Drab Whistler *Pachycephala griseonata*	5	649	112	770	515	255
Flame-breasted Flowerpecker *Dicaeum erythrothorax*	57	278	185	630	20	610
Buru Yellow White-eye *Zosterops buruensis*	8	543	63	630	440	190
Black-faced Friarbird *Philemon moluccensis*	100	299	215	810	5	805

All altitude measures are in metres a.s.l. *n* = number of census stations at which that bird or habitat was recorded, mean and SD are the mean and standard deviation of altitudes of the positive stations (those at which the species or habitat was recorded). Max. and Min. are the maximum and minimum altitudes of positive stations and Rge = Max. minus Min. (= range).

many species as they were rarely recorded but we can confirm that several had extensive ranges. These include White-eyed Imperial Pigeon *Ducula perspicillata* and Black-faced Friarbird *Philemon moluccensis* (both 5–810 m), Moluccan Red Lory *Eos bornea* (50–750 m) and Flame-breasted Flowerpecker *Dicaeum erythrothorax* (20–630 m). One species (Buru Yellow White-eye *Zosterops buruensis*) was recorded several times but only within a narrow range (190 m in total). The range of this species may however extend to higher altitudes not covered by our survey.

Habitat associations

Discriminant function analysis of bird/habitat associations was performed for 13 of Buru's birds and produced significant discrimination in nine of these species. Summary results of the analyses are shown in Table 4 and these are used to build the habitat profiles shown in Table 5. The four species for which habitat

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Table 4. Summary results of the discriminant function analysis (DFA)

Variable and units	Bird species												
	D.p	*G.m*	*E.b*	*P.m*	*C.f*	*M.l*	*M.p*	*M.g*	*R.s*	*P.g*	*D.e*	*Z.b*	*P.m*
Altitude (m a.s.l.)	+0.01	+0.55	+0.19	−0.09	−0.32	−0.39	+0.48	+0.18	+0.46	+0.35	−0.52	+0.58	−0.40
Gradient (%)	−0.22	−0.08	−0.61	+0.22	−0.17	−0.19	−0.14	−0.03	−0.06	+0.21	+0.21	+0.29	+0.35
Canopy cover (%)	+0.13	+0.17	+0.35	+0.70	0.00	−0.49	+0.09	+0.28	+0.02	+0.10	+0.13	+0.31	+0.18
Mid-level cover (%)	+0.20	+0.33	+0.30	+0.15	+0.28	+0.19	+0.22	+0.20	−0.02	−0.02	−0.19	+0.20	+0.11
Low-level cover (%)	+0.49	−0.16	−0.01	+0.11	+0.27	+0.15	−0.36	−0.20	−0.46	−0.17	+0.14	−0.04	+0.32
Ground cover (%)	+0.01	−0.29	−0.07	−0.24	+0.46	+0.16	+0.18	−0.42	0.00	−0.13	+0.12	+0.05	−0.06
Tree heights (m)	+0.03	−0.07	−0.09	+0.28	−0.33	−0.43	−0.34	−0.47	−0.14	+0.19	−0.39	−0.27	+0.08
Tree girths (m)	−0.15	+0.27	+0.13	+0.12	−0.04	−0.36	−0.11	+0.36	+0.01	+0.43	−0.18	−0.17	−0.06
Largest girth (m)	+0.17	+0.15	+0.11	+0.25	−0.02	−0.22	+0.07	+0.35	−0.04	+0.18	−0.16	+0.02	+0.02
Tree density (trees hect^{-1})	−0.17	+0.08	+0.23	−0.11	+0.08	−0.24	+0.01	+0.09	−0.14	+0.73	−0.21	−0.12	−0.40
Biomass index (m^3/M^{-2})	−0.23	+0.10	+0.14	−0.10	+0.08	−0.27	−0.10	+0.07	−0.05	+0.83	−0.17	−0.09	−0.40
No. trees above (no.)	+0.62	+0.38	−0.01	+0.54	−0.24	+0.04	0.00	−0.23	−0.21	−0.02	−0.34	−0.11	+0.42
No. trees below (no.)	+0.03	−0.13	+0.25	+0.02	+0.08	−0.05	+0.26	+0.40	+0.25	+0.02	+0.43	+0.18	−0.18
No. regenerating (no.)	0.00	−0.10	+0.25	+0.05	+0.26	−0.16	+0.18	−0.23	−0.16	−0.13	−0.22	−0.18	+0.25
No. dead trees (no.)	+0.30	−0.09	+0.06	+0.02	+0.14	+0.01	+0.06	−0.10	−0.09	−0.11	+0.16	−0.12	+0.30

Correlation coefficients of individual habitat variables with the discriminant function for each species. Positive correlation coefficients indicate that high values of the variable are associated with species presence. *D.p*, *Ducula perspicillata*; *G.m*, *Gymnophaps mada*; *E.b*, *Eos bornea*; *P.m*, *Prioniturus mada*; *C.f*, *Coracina fortis*; *M.l*, *Monarcha loricatus*; *M.p*, *Monarcha pileatus*; *M.g*, *Myiagra galeata*; *R.s*, *Rhipidura superflua*; *P.g*, *Pachycephala griseonata*; *D.e*, *Diaeum erythrothorax*; *Z.b*, *Zosterops buruensis*; *P.m*, *Philemon moluccensis*.

associations could not be identified were the little recorded Buru Cuckoo-shrike *Coracina fortis* and Tawny-backed Fantail (both had just three positive stations), Buru Racquet-tail *Prioniturus mada* (19 positives) and Flame-breasted Flowerpecker (57 positives). The lack of discrimination in these species may be due to a wide habitat preference (in Flame-breasted Flowerpecker), the sporadic nature of the few records we did have (in the little-recorded species), or because we did not record those features of habitat most important to the species.

Of the nine successful analyses, tree size parameters were "key variables" in eight species. Vegetation cover parameters featured in seven species, and tree architectures and altitude in six species each. Of course not all species responded to habitat parameters in the same way. Five species were associated with small or short trees and/or low biomass, while three were associated with large or tall trees and/or high woody biomass. Likewise, of the six species for which certain tree architectures were important, three were associated with primary forest trees and three with non-primary forest trees.

While the habitat associations of each species must be looked at individually (see species account section), the habitat profiles of some species were broadly

Table 5. "Habitat profiles" for Buru's restricted-range birds derived from the results of DFA. Also shown is whether DFA produced significant discrimination (χ^2 and P), the number of census stations at which the species was recorded (n^+) and the percentage of stations reclassified correctly by DFA (%)

Species and summary statistics	Key variables	Habitat profile
White-eyed Imperial Pigeon *Ducula perspicillata* $\chi^2 = 22.8$, $df = 6$, $P < 0.001$, $n^+ = 87$, % = 63.4	Primary forest trees Dense low-level cover Many dead trees Low biomass Gentle slopes	Recently disturbed forests (especially after extraction of big trees). No altitudinal preference
Long-tailed Mountain Pigeon *Gymnophaps mada* $\chi^2 = 21.4$, $df = 7$, $P = 0.02$, $n^+ = 4$, % = 88.6	Higher altitudes Primary forest trees Dense mid-level cover Sparse ground cover Large-girthed trees	Closed canopy primary forest at high altitudes
Moluccan Red Lory *Eos bornea* $\chi^2 = 24.2$, $df = 6$, $P < 0.001$, $n^+ = 21$, % = 72.2	Steep slopes Sparse canopy cover Sparse mid-level cover Few trees branching below Few regenerating trees	Recently disturbed open canopied forests on steep slopes. No strong altitudinal preference
Buru Racquet-tail *Prioniturus mada* $\chi^2 = 7.5$, $df = 5$, $P = 0.15$, $n^+ = 19$, % = 65.8	Dense canopy cover Primary forest trees Tall trees Some very large grees Sparse ground cover	Possibly closed-canopy primary forest with some very large trees
Buru Cuckoo-shrike *Coracina fortis* $\chi^2 = 10.9$, $df = 7$, $P = 0.17$, $n^+ = 3$, % = 86.4	Sparse ground cover Tall trees Higher altitudes Sparse mid-level cover Sparse low-level cover	Possibly higher-altitude primary forest with an open understorey
Black-tipped Monarch *Monarcha loricatus* $\chi^2 = 11.6$, $df = 6$, $P = 0.03$, $n^+ = 15$, % = 67.9	Sparse canopy cover Few tall trees Lower altitudes Small-girthed trees Low biomass	Open canopied lowland woodland with few big trees
White-naped Monarch *Monarcha pileatus* $\chi^2 = 22.9$, $df = 8$, $P = 0.004$, $n^+ = 3$, % = 91.3	Higher altitudes Sparse low-level cover Few tall trees Secondary forest trees Dense mid-level cover	High-altitude secondary forests (and preferring old secondary forests?)
Dark-grey Flycatcher *Myiagra galeata* $\chi^2 = 17.0$, $df = 6$, $P = 0.009$, $n^+ = 7$, % = 82.1	Few tall trees Sparse ground cover Secondary forest trees Large-girthed trees Dense canopy cover	Secondary forest with a fairly full canopy. Prefers short but stout trees. No strong altitudinal association
Tawny-backed Fantail *Rhipidura superflua* $\chi^2 = 8.6$, $df = 6$, $P = 0.19$, $n^+ = 3$, % = 78.8	Dense low-level cover Higher altitudes Secondary forest trees Few primary forest trees Few tall trees	High-altitude secondary forest (and young secondary forest with dense low-level cover preferred)

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Table 5. *cont.*

Species and summary statistics	Key variables	Habitat profile
Drab Whistler *Pachycephala griseonata* $\chi^2 = 67.1$, $df = 9$, $PP < 0.001$, $n^+ = 5$, % = 97.8	High biomass High tree density Large-girthed trees Higher altitudes Steep slopes	Strong preferrence for high-altitude "big tree" (high-biomass) forests. These may be primary or old secondary forests
Flame-breasted Flowerpecker *Dicaeum erythrothorax* $\chi^2 = 12.1$, $df = 8$, $P = 0.15$, $n^+ = 57$, % = 62.0	Lower altitudes Secondary forest trees Few tall trees Few primary forest trees Few regenerating trees	Young secondary forest at low altitudes
Buru Yellow White-eye *Zosterops buruensis* $\chi^2 = 20.4$, $df = 8$, $P = 0.009$, $n^+ = 8$, % = 79.4	Higher altitudes Dense canopy cover Steep slopes Few tall trees Dense mid-level cover	Higher-altitude closed canopy forest
Black-faced Friarbird *Philemon moluccensis* $\chi^2 = 17.1$, $df = 8$, $P = 0.04$, $n^+ = 100$, % = 61.9	Primary forest trees Low tree density Low biomass Lower altitude Steep slopes	Widespread but may prefer open areas with some old trees remaining. Low altitudes preferred as may be valleys

similar to each other: three species (Long-tailed Mountain Pigeon, Drab Whistler and Buru Yellow White-eye) had associations with primary forests, two species (Flame-breasted Flowerpecker and Moluccan Red Lory) with recently disturbed forests, two (White-naped Monarch *Monarcha pileatus* and Dark-grey Flycatcher) with older secondary forests, and two (Black-tipped Monarch *Monarcha loricatus* and Black-faced Friarbird) with more heavily disturbed forests.

Bird densities and encounter rates

Estimation of population density was possible for ten species in primary/secondary forests, for eight in logged forests, a further two in forest as a whole, and for only two in the non-forest category (Table 6). Standard errors of density estimates ranged from 11% to 85% of the estimate but in only seven of 22 estimates produced were standard errors less than 25% of the estimate itself. This means that the figures should be interpreted cautiously. Nevertheless, we are confident that birds such as White-eyed Imperial Pigeon, Moluccan Red Lory, Buru Racquet-tail, Black-tipped Monarch, Flame-breasted Flowerpecker and Black-faced Friarbird occurred at high population densities in the areas visited. In fact a total of nine species had estimated population densities in excess of 100 birds per km^2 in at least one of the forest categories. Density estimates were notably high in logged forests for White-eyed Imperial pigeon (125±17 per km^2), the endemic Buru Racquet-tail (166±82 per km^2) and Flame-breasted Flowerpecker (641±154 per km^2). The above species, along with Moluccan Red Lory and Black-faced Friarbird were almost certainly commoner in logged forests than in primary/secondary forests. White-eyed Imperial Pigeon and Black-faced

Table 6. Density estimates and encounter rates for Buru's restricted-range lowland birds

Species	Primary/secondary		Combined		Logged		Non-forest	
	DE	ER	DE	ER	dE	ER	DE	ER
White-eyed Imperial Pigeon[a]	38.3 ± 7.5 (60)	0.56 ± 0.08			125 ± 17.4 (114)	1.15 ± 0.11	88.4 ± 31.8 (10)	0.42 ± 0.14
Long-tailed Mountain Pigeon[c]	7.15 ± 4.96 (5)	0.05 ± 0.03						
Moluccan Red Lory[b]	44.2 ± 23.4 (7)	0.07 ± 0.02			141 ± 42.4 (26)	0.26 ± 0.03		
Buru Racquet-tail[b]	55.8 ± 32.1 (7)	0.06 ± 0.03			166 ± 81.9 (18)	0.18 ± 0.06		
Pale Cicadabird	(2)	0.01 ± 0.01			(4)	0.03 ± 0.01		
Buru Cuckoo-shrike	(3)	0.02 ± 0.01			(1)	0.01 ± 0.01	(1)	0.04 ± 0.04
Black-tipped Monarch[d]	213 ± 112 (6)	0.06 ± 0.02			163 ± 83.1 (7)	0.07 ± 0.03	(3)	0.04 ± 0.06
White-naped Monarch[d]	133 ± 94.6 (3)	0.03 ± 0.02						
Dark-grey Flycatcher[d]	160 ± 101 (5)	0.05 ± 0.02			46.5 ± 33.7 (2)	0.02 ± 0.01		
Tawny-backed Fantail[a]			15.2 ± 10.6 (2)	0.01 ± 0.01			(1)	0.12 ± 0.09
Drab Whistler[f]			48.9 ± 26.4 (5)	0.02 ± 0.01				
Flame-breasted Flowerpecker[a]	171 ± 43.4 (20)	0.2 ± 0.05			641 ± 154 (53)	0.54 ± 0.07	(4)	0.17 ± 0.01
Buru Yellow White-eye[b]	240 ± 141 (8)	0.07 ± 0.03			52.3 ± 44.5 (1)	0.01 ± 0.01	(2)	0.08 ± 0.05
Black-faced Friarbird[a]	109 ± 22.4 (73)	0.68 ± 0.01			316 ± 37.4 (128)	1.29 ± 0.01	159 ± 40.1 (18)	0.75 ± 0.19

DE, density estimate (individuals per km^2); ER, encounter rate (mean number of birds recorded per census station). Estimates include ±1 standard error. The numbers in parentheses are the sample size for that habitat category (number of encounters not actual birds).

[a] Separate "detection function" calculated for each habitat.

[b] Single detection function calculated (habitats combined) but separate density estimates calculated for each habitat "subset".

[c] Records of *G. mada* combined with those of *D. perspicillata* to produce a single "pigeon" detection function.

[d] The two *Monarcha* species combined with *Myiagra galeata* to produce detection function for "Monarchs", then density estimates calculated for each habitat (i.e. pooled species detection function).

[e] Records of the commonly recorded *R. rufiventris* used to model *Rhipidura* detection function (habitats combined).

[f] As [c] but using the commonly recorded *P. pectoralis* to model detection of *P. griseonata*.

Friarbird had density estimates in the non-forest category which were comparable with those in the forest categories, while a further five species were recorded at least once at non-forest stations.

Other species (and these were often small passerines) had density estimates greater than 100 birds per km^2 but we are not so confident about their abundance simply because we recorded them at relatively few stations. As was found on Sumba (Jones *et al.* 1995), the encounter rate of a species did not necessarily relate to its density estimate. For example, White-eyed Imperial Pigeon was recorded at three times as many primary/secondary forest stations as Flame-breasted Flowerpecker and yet the easily detectable pigeon had a density estimate four-times lower than the diminutive flowerpecker.

Only two species (Long-tailed Mountain Pigeon and Tawny-backed Fantail) had low density estimates. Both of these are higher-altitude species and it is almost certain that our survey underestimated their density for two reasons. First, our density figures relate mostly to lowland forests where the highland species are largely absent. Second, the highest points we surveyed may still have been at the periphery of the species' altitudinal range where local density may be lower than at higher elevations.

Available habitat and total population estimates

Figure 1 shows the location, and Table 7 the area of broad habitat types on Buru according to RePPProT in 1978. The total area of forest on Buru was calculated to be 6,319 km^2 or 77.8% of the island's land area. We classify the great majority of this as lowland forest. RePPProT describe 1,082 km^2 of the lowland forest as being "calcareous forest" and most of this is in the west and south-west of the island. We did not visit this area of the island and in our analysis we treat this forest as "lowland forest" even though it may hold different species composition or bird densities. According to RePPProT, in 1978, only 3.8% of the island's land area was covered with forest which had been selectively logged. This is probably the land use on Buru which has increased in area most significantly since the 1970s, and indeed some of our study sites appear as unlogged forest in Figure 1 but had been logged by 1989. We combined RePPProt's submontane forest (845 km^2) with the small amount of montane forest (48 km^2) to form a category "highland forest" which covers 11% of Buru. Included in this highland forest category are all forests at altitudes greater than 1,000 m. We combined RePPProT's various non-forest categories (e.g. grassland, bush and agriculture) to form a non-forest category. A large proportion of this non-forested area is within the catchment of Buru's longest river (the Kajeli) which flows west from the east coast (see Figure 1).

Table 7 shows population estimates of birds in individual habitat types and total estimates for Buru as a whole. In general, total population estimates may be underestimated for several reasons. Firstly, several species (e.g. Black-tipped Monarch and Flame-breasted Flowerpecker) were recorded at stations in non-forest habitats but in insufficient numbers to calculate a density estimate (and hence their populations were greater than zero in that habitat). Secondly, when estimating the densities of the higher altitude species it was assumed that

Table 7. Bird population estimates in different habitats, and total island populations. Also shown are the total areas and percentages of habitat types used to calculate populations (tidal forest (107 km^2) and swamp forest (30 km^2) are excluded). "Minimum" population estimates represent our density estimate (Table 6) minus the standard error, multiplied by habitat coverage. >0 denotes habitats where a species was recorded but no density estimation was possible. Question marks denote habitats where a species was not recorded

	Habitat types				
	Lowland	Logged	Highland	Non-forest	Total
Habitat coverage					
Area (km^2)	5,119	306	894	1,670	7,989
Percentage	63.0	3.8	11.0	20.6	98.4
Population estimates					Total (minimum)
White-eyed Imperial Pigeon *Ducula perspicillata*	196,058 ±38,392	38,250 ±5,324	?	147,628 ±59,953	382,000 (278,000)
Long-tailed Mountain Pigeon *Gymnophaps mada*	36,601 ±25,390	>0	6,392 ±4,434	?	43,000 (13,000)
Moluccan Red Lory *Eos bornea*	226,260 ±119,784	43,146 ±12,974	>	>0	269,000 (137,000)
Buru Racquet-tail *Prioniturus mada*	285,640 ±164,320	50,796 ±25,061	?	>0	336,000 (147,000)
Black-tipped Monarch *Monarcha loricatus*	1,090,347 ±573,328	49,878 ±25,429	?	>0	1,140,000 541,000
White-naped Monarch *Monarcha pileatus*	680,827 ±484,257	?	118,902 ±84,572	>0	800,000 231,000
Tawny-backed Fantail *Rhipidura superflua*	77,809 ±54,261	?	13,589 ±9,476	>0	91,000 28,000
Dark-grey Flycatcher *Myiagra galeata*	819,040 ±517,019	14,229 ±10,312	?	>0	833,000 306,000
Drab Whistler *Pachycephala griseonata*	250,319 ±135,142	14,963 ±8,079	43,717 ±23,601	?	309,000 142,000
Flame-breasted Flowerpecker *Dicaeum erythrothorax*	875,349 ±222,165	196,146 ±47,124	>0	>0	1,071,000 269,000
Buru Yellow White-eye *Zosterops buruensis*	1,228,560 ±721,779	16,004 ±13,617	214,560 ±126,054	>0	1,459,000 598,000
Black-faced Friarbird *Philemon moluccensis*	557,971 ±14,666	96,696 ±11,444	>0	265,530 ±66,800	920,000 93,000

they occurred in the highland forest category at the same density as in lowland forest. This is clearly likely to be incorrect and will underestimate the densities of any species associated with forests at higher elevations than those we surveyed.

The main reason for producing total population estimates was to compare them with the figures which qualify species for the IUCN categories of threat other than Safe/Low risk. While the population estimates themselves are likely to be imprecise, they do show that for all the species considered, total

populations are likely to be far greater than the 10,000 "Vulnerable" mark of Mace and Stuart (1994). In fact all the lowland species had lower limit population estimates in excess of 100,000 individuals.

Species accounts and conservation status

Information from previous authors is collated with our information on abundance and habitats in order to categorize each species's conservation status according to Mace and Stuart (1994). All but six species are listed. These species, Rufous-necked Sparrowhawk *Accipiter erythrauchen*, Moluccan Scrubfowl *Megapodius wallacei*, Elegant Imperial Pigeon *Ducula concinna*, Lesser Masked Owl *Tyto sororcula*, Moluccan Hawk Owl *Ninox squamipila* and Black-eared Oriole *Oriolus bouroensis* were not definitely recorded by the expedition, nor can we add anything that is not provided in White and Bruce (1986), Jepson (1993) or Collar *et al.* (1994).

White-eyed Imperial Pigeon *Ducula perspicillata*

Found on Buru from sea level to 1,400 m (Stresemann 1914). On nearby Seram, it is common in lowland forest (Bowler and Taylor 1989) with similar population density (100–150 per km^2) in unlogged and selectively logged forests (S. Marsden *unpubl. data*). Not listed as threatened or near threatened in Collar *et al.* (1994).

This species was common in primary/secondary forests but much commoner in the logged forests visited. It does not seem to have a particular preference for lower altitudes and tolerates, and possibly thrives on, habitat alterations such as extraction of large trees. It was also common in heavily degraded habitats (our non-forest category) with a density estimate actually higher than in primary/secondary forest. Although absent from the completely deforested area around Namlea, we are confident that its total population on Buru is large.

Recommended Mace–Lande category: Safe/Low risk.

Long-tailed Mountain Pigeon *Gymnophaps mada*

Listed as near-threatened by Collar *et al.* (1994). White and Bruce (1986) describe it as a bird of hill and mountain forest; mainly at 1,000 m and over on Seram (the type locality on Buru is at 930 m). Also occasionally recorded at fruiting trees near the coast (Siebers 1930; Jepson 1993).

As with the other highland species, our density estimate probably does not reflect its true abundance within the bulk of its range. DFA confirms that this species is associated with primary forest at high altitude. Our population estimate of between 30,000 and 56,000 was the lowest for any of the birds for which we have data but almost certainly underestimates the highland component of the population. Although protected from wholesale habitat alteration by the inaccessibility of the highlands, more data are needed on its full altitudinal range, the densities at which it occurs, and its possible intolerance of habitat disturbance before its conservation status can be properly assessed.

Recommended Mace–Lande category: Data deficient (Safe/Low risk?)

Blue-fronted Lorikeet *Charmosyna toxopei*

The history of this endemic is described in Jepson (1993) and in Collar *et al.* (1994), who list it as Vulnerable.

Two flocks of six and five birds, thought to be this species were seen over selectively logged forest at about 600 m a.s.l. above Teluk Bara. The birds were not specifically identified at the time but subsequent experience of the Red-flanked Lorikeet *Charmosyna placentis* on Seram indicated that they were almost certainly Blue-fronted Lorikeets. The call of a *Charmosyna* lorikeet was also heard on one occasion in secondary forest at Wafawel. Probably more difficult to locate than the following species due to its small size, quieter high-pitched call and perhaps a different flight behaviour, this species may not be rare on Buru. Our records from logged forest suggest that it is not restricted to primary forests, although more work is needed to confirm its status.

Recommended Mace–Lande category: Data deficient

Moluccan Red Lory *Eos bornea*

Not listed by Collar *et al.* (1994) as either threatened or near threatened. Said to be "common in coastal lowlands and inland to 1,250 m, on Buru also, especially in mangroves" (White and Bruce 1986).

This species was common in primary/secondary forests but more abundant in the logged forests visited. Its preferred habitat would seem to be open-canopied forests and particularly those, such as logged forests, which have been disturbed recently. However, its strongest association was with forests on steeper slopes (presumably within river valleys), and as such it may have a patchy density distribution depending on topography. Within our survey range it did not show a strong altitudinal preference. It is a very common bird which may have benefitted from selective logging regimes in the lowlands but which does not tolerate near total deforestation (it was not recorded outside forest).

Recommended Mace–Lande category: Safe/Low risk

Buru Racquet-tail *Prioniturus mada*

Listed as near-threatened by Collar *et al.* (1994). Described as occurring in mountains over 1,000 m, and occasionally in the lowlands (White and Bruce 1986).

We recorded this endemic at all five study sites and in logged and unlogged forests between 55 m and 620 m a.s.l. This species had the largest mean group size (4.1) of the parrots studied by Marsden (1995) and was recorded in flocks of up to 55. Our density estimate was reasonably high in primary/secondary forests but three times higher in the logged forests surveyed. The total population estimate of 189,000–483,000 suggests that it may be one of the commonest Indonesian parrots. DFA was unable to pin down its habitat associations but it is certainly common and fairly widespread except in non-forested areas.

Recommended Mace-Lande category: Safe/Low risk.

Pale Cicadabird *Coracina ceramensis*

Listed as a bird of woods and forest from sea level to 1,500 m (White and Bruce 1986). On Seram, Bowler and Taylor (1989) found it to be fairly common in the

canopy of forest from sea level to the highlands. Recorded in logged forest on Obi (Linsley 1995).

Although observed in small numbers at most sites (Jepson 1993), it was only recorded at two census stations so density estimation and DFA were not possible. Although the encounter rate was low, this does not necessarily reflect a low population density. On Sumba, the Sumba Cicadabird *C. dohertyi* was associated with the higher levels of closed-canopy forest, where its inconspicuousness and soft call meant that it was only recorded at short distances from census points (Jones *et al.* 1995). On that island it had a surprisingly high density estimate and it is suggested that the situation may be similar on Buru. Although more data are needed, this species was not restricted to pristine forests and may be fairly common and widespread.

Recommended Mace–Lande category: Data deficient (Safe/Low risk?)

Buru Cuckoo-shrike *Coracina fortis*

Found from the coast to the mountains. Toxopeus (Siebers 1930) considered that it was not notably scarce, although White and Bruce (1986) suggest that the failure of others to collect it may mean that it is very locally distributed. Listed as Vulnerable by Collar *et al.* (1994) on account of a suspected small extent of occurrence, decline in habitat quality, and small and declining population.

We recorded this species on very few occasions but, by chance, it was present at three census stations. Nevertheless, its encounter rates were low suggesting either low population density or patchy distribution. We guess that it is associated with fairly pristine forests at higher altitudes. Overall it is unlikely to be common especially in more disturbed habitats.

Recommended Mace–Lande category: Data deficient (Vulnerable [Collar *et al.* 1994])

Black-tipped Monarch *Monarcha loricatus*

Listed as near-threatened by Collar *et al.* (1994), this endemic flycatcher has been described as occurring in cultivation or forest to 1,200 m (White and Bruce 1986).

Fairly common in both primary/secondary and logged forests, usually at lower altitudes although recorded up to 590 m. Not restricted to pristine habitats, on the contrary seems to prefer rather shrubby, low biomass and open-canopied areas including coastal agriculture. While our population estimate may be imprecise, its actual population presumably greatly exceeds 10,000 (below which a species may qualify for IUCN's Vulnerable status). Although habitats at lower altitudes are more under threat than those higher up, it seems to be tolerant of quite heavy forest disturbance.

Recommended Mace–Lande category: Safe/Low risk

White-naped Monarch *Monarcha pileatus*

This species, also known from Halmahera, Tanimbar and Tayandu (Kai islands), is not listed as threatened by Collar *et al.* (1994). Described by White and Bruce

(1986) as very little known; perhaps in hill forest on Buru, although also near the coast.

The endemic subspecies on Buru had a high density estimate in the areas visited and may be commoner in its preferred high-altitude range. It was not recorded below 590 m (the highest census station at which we recorded Black-tipped Monarch). DFA indicated that it prefers secondary forests and there is a hint that it was associated with less disturbed, or less recently disturbed habitats than its lowland congener. The species appears to be fairly common and may also be protected from wholesale destruction of its habitat by its altitudinal range.

Recommended Mace–Lande category: Safe/Low risk

Dark-grey Flycatcher *Myiagra galeata*

No information specific to Buru is given in White and Bruce (1986) but elsewhere the species occurs in coastal forests, sometimes to 800 m. On Seram, Bowler and Taylor (1989) found it to be fairly common in forest and non-forested areas in the lowlands. Not listed as threatened or near-threatened by Collar *et al.* (1994).

Described as uncommon but widespread by Jepson (1993), our density estimate was high in primary/secondary forests but lower in logged forests. As with Buru's other restricted-range flycatchers it was strongly associated with secondary forests and, in this case, perhaps more specifically with old, secondary forest. This association may account for its "scarcity" in our logged forest category which was composed mostly of forests which had been logged fairly recently. There was no strong association with particular altitudes but this may be partly due to the distribution of logged forests.

Recommended Mace–Lande category: Safe/Low risk

Tawny-backed Fantail *Rhipidura superflua*

Found in mountain forest at 700 m and above (White and Bruce 1986), this endemic is listed as near-threatened by Collar *et al.* (1994).

Our density estimate was relatively low but as with the other highland species, local densities within its proper altitudinal range may be considerably higher. DFA links it to higher altitude secondary forest, including newly abandoned slash-and-burn areas. The strongest association was with dense low-level cover and it is at this stratum that we most often observed it (Jepson 1993). Our population estimate (probably an underestimate) was large. Protected from wholesale forest destruction in the highlands, its distribution may be closely related to the patterns of forest disturbance caused by indigenous people.

Recommended Mace–Lande category: Safe/Low risk

Drab Whistler *Pachycephala griseonata*

White and Bruce (1986) give no information on the abundance or habitat of this Moluccan endemic. On Seram it was found to be widespread but not common in the canopy of forest away from the coast and up to 1,100 m (Bowler and Taylor 1989). Not listed as threatened or near-threatened by Collar *et al.* (1994).

Our density estimate was 48.9±26.4 per km^2 in forests on Buru but its density at higher altitudes may be higher. DFA indicates that it is indeed a higher altitude species and that it is associated with high biomass forests. As such it may well be adversely affected by logging. Our population estimate is large but if logging concessions include large portions of mid-altitude forest, then this species may suffer.

Recommended Mace–Lande Category: Data deficient (Safe/Low risk?)

Flame-breasted Flowerpecker *Dicaeum erythrothorax*

Found on Buru to 800 m (White and Bruce 1986) but no habitat information. On nearby Obi, it is common (Linsley 1995).

This species had the highest density estimate of any of Buru's restricted-range birds. It was common in primary/secondary forests but superabundant in logged forests. Density estimates were of the same order of magnitude as those of the closely related Ashy Flowerpecker *Dicaeum vulneratum* on Seram (S. Marsden *unpubl. data*). Certainly associated with lowland areas, where it prefers recently disturbed habitats including non-forest areas. We are confident of its very large population in forests and it may also have considerable populations in heavily degraded habitats such as coastal agriculture.

Recommended Mace–Lande category: Safe/Low Risk

Buru Yellow White-eye *Zosterops buruensis*

Found to 1,500 m on Buru (White and Bruce 1986), this endemic is not listed as threatened or near-threatened by Collar *et al.* (1994).

Recorded in both forest categories and in non-forested habitat. Almost certainly very common in the primary/secondary forests visited but not so common in the logged forests and probably occurring at much lower density in non-forest areas. Strongly associated with the higher altitudes of our survey and within these areas with forests showing dense canopy and subcanopy vegetation. Whether this suggests that the species prefers more pristine forests than do other Wallacean white-eyes (Bowler and Taylor 1989, Jones *et al.* 1995) is not clear. Our population estimate is, however, large and it is difficult to imagine habitat destruction on Buru being so severe as to threaten this common bird.

Recommended Mace–Lande category: Safe/Low Risk

Black-faced Friarbird *Philemon moluccensis*

White and Bruce (1986) record nothing on the ecology of this species. The congeneric Seram Friarbird *Philemon subcorniculatus* on nearby Seram is very common and occurs in a wide range of habitats (Bowler and Taylor 1989).

Common in primary/secondary forest but superabundant in logged forests. This abundance is shared with Seram Friarbird on nearby Seram (S. Marsden *unpubl. data*) but on that island densities were similar in logged and unlogged forests. On Buru, it was recorded at more than half of the census stations surveyed, indicating that it has broad habitat needs. It was strongly associated with low altitude areas with scattered primary forest trees and may particularly

favour river valleys or gulleys. It has a large population in Buru's lowland forests and may also have a significant population in non-forested areas.

Recommended Mace–Lande category: Safe/Low Risk

Threats to Buru's birds and future work

We can confirm that nine of Buru's 19 lowland restricted-range birds are safe from extinction for many years. Some are undoubtedly very numerous and will presumably remain so unless Buru becomes largely deforested. We are less confident about the status of some other species (e.g. Drab Whistler) simply because we recorded them at census stations on few occasions. This does not necessarily imply that they are rarer than the more frequently observed birds, and some of these species are probably very common also.

Of the lowland species which we did not record, perhaps the Lesser Masked Owl *Tyto sororcula* is that for which data are most needed. This species is found only on Buru and Tanimabar and, while some Wallacean members of its genus are not restricted to primary forests (White and Bruce 1986), its ability to persist in habitats such as logged forest needs to be confirmed. In any case, its population is unlikely to be large. Possibly less worrying is the status of the Moluccan Hawk Owl *Ninox squamipila* which occurs in North Maluku, Tanimbar and Seram as well as Buru. As well as having a larger global range, this species is said to occur in thickets as well as forest (suggesting some tolerence of non-pristine habitats) and has a large altitudinal range (up to 1,750 m on Buru) (White and Bruce 1986). We recorded a "pair" of *Ninox sp.* in logged forest and these may well have been Moluccan Hawk Owls.

Of the main anthropogenic threats to Buru's birds, the alteration of forest is seen as being more significant than direct exploitation. Neither restricted-range parrot is traded on Buru in large numbers (relative to the likely magnitude of their populations). The effect of harvesting of the eggs of the Moluccan Scrubfowl is at present unknown and work on this aspect of megapode ecology is needed.

Although much of Buru's forest has been altered to some degree, either by indigenous or non-indigenous people, we were surprised by how much forest remained on Buru and other Moluccan islands compared with other parts of Indonesia such as the Sunda islands. This presumably bodes well for the future of Maluku's forest wildlife. At present, the most widespread and conspicuous forest alteration on Buru is the selective logging of the lowlands. The impact of logging on bird populations is likely to be complex and the data from Buru do not really tell us enough about birds' numerical response to logging. This is partly because the logged forests we surveyed were at lower altitudes than other forests so we can say little about the effects of logging *per se*. On nearby Seram, several species almost certainly declined after logging (S. Marsden *unpubl. data*) and, although restricted-range birds were no more affected than were widespread species, the scale of bird decline on that island was as significant as that suffered by species-rich avifaunas in Malaysia (Lambert 1992). It is encouraging that many birds on Buru and Seram have high population densities so a species could decline considerably after selective logging and still be fairly common.

Of greater significance to the conservation of Buru's birds is the total or near-total clearance of lowland forest. Within the area that we visited, total deforesta-

tion was restricted to the northern coastal strip and around the capital, Namlea. Some of these areas contained only dry grassland and were a complete contrast to the lush forests covering most of Buru. Bird species diversity was extremely poor in these areas. According to RePPProT, the largest "block" of deforested land on Buru is the catchment area of Buru's longest river, the Kajeli, where transmigration schemes have been set up. Many of the collectors last century procured birds in this valley (Jepson 1993) and a visit to assess the extent and importance of remaining forest in this region may be a priority.

While definitive data on some of Buru's restricted-range lowland birds are still lacking, the extent of forest remaining, the likely abundance of many bird species, their apparent tolerance of logged forests and the fact that few, if any, of the species are restricted to the coastal strip suggests a satisfactory immediate future for the bulk of Buru's important birds. Further surveys, both in the lowlands (e.g. in forests on calcareous substrates) and at higher altitudes (both in the mountainous north-west and in the "isolated" highlands of the south-east) should be welcomed. However, the ornithological rediscovery of much of Wallacea is nearly complete and attention must soon be directed towards specific research on the ecological factors influencing "problem" birds and their habitats.

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