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The population and distribution of orangutans (*Pongo pygmaeus pygmaeus*) in and around the Danau Sentarum Wildlife Reserve, West Kalimantan, Indonesia

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Abstract

We report estimates of orangutan distribution and population size in and around the Danau Sentarum Wildlife Reserve (DSWR) in West Kalimantan, Indonesia, one of the few areas in Borneo that may still support a large population. We generated estimates in line with each of three proposed definitions for the reserve — its current boundaries, a moderate extension, and a greater extension. Estimates were based on current nest survey methods, adjusted for habitat type variability. Measures of habitat type coverage derived from a GIS developed for the DSWR region. Our estimates support impressions that the current DSWR harbors few orangutans (±200) but the greater extension supports a substantially larger population (>2000). Findings are discussed with respect to distribution (habitat preference), behavior in the DSWR area (migration, local stresses, human tolerance), and habitat protection plans. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Orangutans; Borneo; Orangutan distribution; Population estimation; Protection plans

1. Introduction

The IUCN classifies orangutans (*Pongo pygmaeus*) as vulnerable, i.e. at high risk of extinction in the medium future. Reasons for this classification are steep declines in population caused by habitat loss and exploitation, and the likelihood that steep declines will continue (Baillie and Groombridge, 1996). The global orangutan population is divided between geographically isolated subpopulations, on Borneo and Sumatra, of no more than 16,000 and 12,500, respectively (Rijksen and Meijaard, 1999). The Bornean population, while larger, may be the more vulnerable of the two. It is fragmented into 61 forest sectors, few of which are securely protected, and Bornean habitat commonly supports orangutans at only 50–66% of the densities supported by Sumatran habitat (Rijksen and Meijaard, 1999; Schaik et al., 1995b; Soemarna et al., 1995). Government plans have allocated vast tracts of Bornean rainforest to agricultural and commercial use. The most notorious of these, which aimed to convert a million hectares of good orangutan habitat to agriculture (Presidential Decree RI/82-26, 1995), is estimated to have displaced several thousand orangutans (Rijksen and Meijaard, 1999). Borneo also lost up to 33% of its orangutan population in 1997–1998 because of the droughts and fires that plagued the island (Rijksen and Meijaard, 1999).

As recently as 1995, however, almost no detailed information was available on Bornean orangutan distribution to guide habitat protection proposals (Rijksen et al., 1995; Soemarna et al., 1995). We therefore surveyed orangutans in and around the Danau Sentarum Wildlife Reserve (DSWR) in the Kapuas Lakes region of West Kalimantan (W. Indonesian Borneo), an area that could support a substantial population (Sugardjito and Schaik, 1992; Meijaard et al., 1996).

The Kapuas Lakes region consists of a core of seasonal lakes and freshwater swamps, surrounded by peat swamp forest and hills. The area is flooded annually by the upper Kapuas River. It is attractive to orangutans because of its peat swamp forest, lowland alluvial forest,

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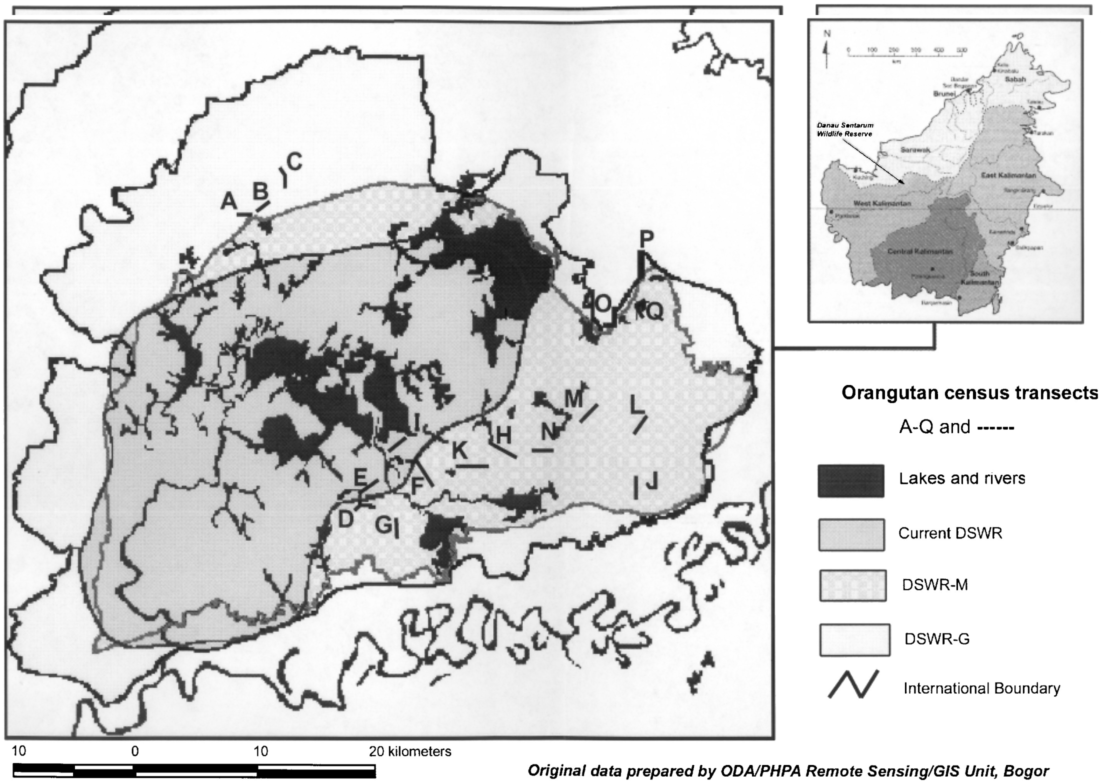

Fig. 1. . DSWR area protection boundaries and nest-count survey transect sites.

and primary freshwater swamp forest. This habitat offers high yields of soft-pulp fruit, orangutans' dietary mainstay (Schaik et al., 1995b). Other types of habitat offer less than half the carrying capacity (Sugardjito and Schaik, 1992; Payne and Andau, 1994; Schaik et al., 1995b). The core lakes area was gazetted as the 80,000 ha DSWR in 1982 to protect the area's wetland habitat. DSWR was declared a Ramsar site in 1994, a wetland of international importance (Jeanes, 1996). Since then, two proposals have been made to extend the reserve (Fig. 1). A moderate extension (DSWR-M) would append about 50,000 ha of the hill areas to the south-east plus the immediate catchment of peat swamp and low hills (Giesen et al., 1994). A greater extension (DSWR-G) would append an additional 60,000 ha to cover much of the unprotected swamp forest beyond the reserve (Jeanes, 1996).

Initial surveys indicated very few orangutans in the DSWR region by the mid 1980s, probably because of human disturbance (Giesen, 1987). The human population within DSWR-G comprises about 6900 permanent inhabitants, and about 9000 in the dry season, who reside in 47 permanent and 10 seasonal villages (Aglionby, 1995). Most are Melayu, who mostly fish the lakes, but some are Iban Dayak, who hunt and practice slash-and-burn agriculture. Commercial logging in the 1970s and 1980s seriously degraded the swamp forest just beyond DSWR and much of that forest is designated Production Forest (Ministry of Forestry, National Forest Inventory, 1993: see Giesen, 1987; Meijaard et al., 1996). Both agriculture and logging degrade areas of prime orangutan habitat (Sugardjito and Schaik, 1992; Payne and Andau, 1994). Giesen (1987) concluded that any orangutans remaining around DSWR ranged more or less permanently on relatively undisturbed high ground beyond the reserve's boundary. Recent surveys based on reports of incidental sightings reaffirm low orangutan presence within DSWR but higher presence in the extensive swamp forests adjacent to DSWR to the north, west, and east (Erman, unpub.; Meijaard et al., 1996). These recent surveys provide only qualitative estimates of orangutan presence. We therefore undertook to estimate the region's orangutan population quantitatively, based on a systematic survey of orangutan nests.

2. Methods

2.1. Estimating orangutan distribution

Surveying orangutan nests is the established method for estimating orangutan distribution (e.g., Schaik et al., 1995b; Blouch, 1997; Page et al., 1997). The number of nests identified along line transects allows estimating nest density per km^2, d_{nest}, using the equation

$$d_{\text{nest}} = N/(L \times 2w) \quad (1)$$

where N is the total nest count, L is the total length of the transects surveyed (km), and w estimates the width of the strip, on either side of the transect, within which nests are sighted reliably (km). Adjusting d_{nest} for three nest-related parameters gives an estimate of orangutan density, d, using the equation

$$d = d_{nest}/(p \times r \times t) \tag{2}$$

where p estimates the proportion of nest-builders in the population (some individuals do not build nests, like infants), r estimates the daily rate at which nest-builders build nests (normally one night nest plus, sometimes, one day nest), and t estimates the rate of nest decay (the number of days nests remain visible).

We handled three problems associated with estimating parameters as follows.

1. Validated estimates for the proportion of nest-builders, p, and rate of nest- building, r, exist for only a few Sumatran populations because they require long-term, direct study of resident orangutans (Rijksen, 1978; Schaik et al., 1995b). Values are unlikely to vary substantially between populations (Schaik et al., 1995b) so we used the published estimates for the DSWR region.
2. Estimates of nest decay rate, t, and effective strip width, w, probably vary substantially with local conditions (Schaik et al., 1995b) so we generated estimates for the DSWR region from data collected during the nest survey. Nest decay rate, t, can be estimated from a sample of short-term changes in decay state when nest decay is modeled as a Markov process with one absorbing state (Kemeny et al., 1956). Markov estimates of t have been validated on known populations in Sumatra (Schaik and Azwar, 1991; Schaik et al., 1995b). Strip width, w, can be estimated from the perpendicular distances of nests from survey transects via a Fourier series approximation (Burnham et al., 1980; Brockelman and Ali, 1987).
3. Population estimates are commonly direct extrapolations from orangutan densities in small sample areas of a few km^2 to expanses of thousands of km^2. These are undoubtedly inaccurate because orangutan densities vary widely with habitat type. Schaik et al. (1995b), for instance, found orangutan density estimates in Sumatra to vary from $6.9/km^2$ in fresh water and peat swamp to $0.4/km^2$ in montane areas. We adjusted our estimates for two facets of habitat type known to affect orangutan distribution, vegetation type and disturbance/degradation level (e.g. Sugardjito and Schaik, 1992; Rijksen et al., 1995; Schaik et al., 1995b; Meijaard, 1997).

We assessed vegetation and disturbance/degradation from field observations during the survey. We recorded vegetation features at each location surveyed then classified them into four types that group Giesen's (1987) vegetation classes according to their capacity to support orangutans: swamp/peat forest (tall swamp, tall swamp with some peat, stunted swamp, stunted swamp/riparian, dwarf swamp), lowland hill forest (lowland hill, heath), farmland/clearing/secondary forest (same); unusable (regeneration after fire, recently burnt, settlement, water). We also recorded all habitat disturbances observed at each location surveyed, primarily logging and local farming, then coded an overall disturbance level for that location (low, medium, high) based on the degree of damage observed. We validated coding for both variables against a 1990 Landsat Land Cover Map of the Kapuas Lakes region. Coverage of each habitat type within each of the three proposed protected areas derived from a Geographic Information System (GIS) developed for the Kapuas Lakes region (Dennis, 1997). This is one of the few areas in Borneo for which GIS is available.

2.2. Sampling

We surveyed nests along line transects in the three proposed protected areas — DSWR, DSWR-M, and DSWR-G. This was the first orangutan survey in the region so we sampled seven areas where residents reported recent orangutan presence (Meijaard et al., 1996). For each area, we sampled ±3 km of transect (per Schaik and Azwar, 1991). Transect length increases within-transect habitat variability (Schaik et al., 1995b) and the time involved in traveling to transect sites in the lakes region limited the distance that we could survey daily. Samples took the form of three 1 km or two 1.5 km transects.

Within DSWR we sampled three areas: (1) Hutan Nung, a protected forest located southwest of the Melayu town of Sekulat (transects D, E, G), (2) northwest of Bukit Pegah, one of DSWR's few hills (transect F), and (3) a logged forest northeast of the Melayu town of Leboyan (transect I). In the DSWR-M extension, we sampled an additional three areas, (4) Pegah (transect K) and (5) Piat/Menyukung (transects H, J, L–N), two hill regions in the southeast, and (6) lowlands near the Dayak town of Meliau (transects O–Q). In the DSWR-G extension, we sampled one additional area, (7) lowlands in the largest block of the extension, to the north of DSWR (transects A–C).

2.3. Data collection

A team comprised of Russon, Erman, local guides, and nature conservation staff surveyed nests along these transects from 20 January to 1 March 1996. The lakes were rising and close to full and trees were fruiting in some locations. The team re-surveyed 15% of the transects after 37 days to sample short-term changes in nest decay state, the basis for estimating nest decay rate. It was not possible to re-survey more extensively because several team members fell ill.

For each orangutan nest located, we recorded nest location (distance along and off the transect), nest features (age, height, size, position in tree), and habitat features (vegetation type, disturbance level). Data other than distance along transect reflect observer judgment; we accepted judgment data only with consensus of two or more experienced observers. Nest age was classified in four stages: A (new — green leaves abundant), B (recent — older leaves still attached, nest still firm and solid), C (old — almost no leaves, holes appearing in nest), D (very old — a few twigs and branches remain, original nest shape no longer evident) (Schaik et al., 1995b). We also recorded the type and degree of any habitat disturbances observed along each transect.

3. Results

3.1. Orangutan distribution patterns

Within DSWR, we found few orangutan nests (Table 1). We found very few nests in Hutan Nung, the protected forest. We surveyed only the forest periphery, however, because the center is difficult to access, and the periphery was badly degraded by commercial logging. The center is less disturbed so it might yield different results. We found no nests on or near the hill, Pegah. The hill area may be important to orangutans nonetheless, because it provides a corridor linking the protected forest with the southeastern hills (Giesen and Deschamps, 1993). We found moderate numbers of nests in the degraded (logged) forest near Leboyan, perhaps because this forest is connected to relatively undisturbed hills to the southeast of DSWR. Orangutans may survive by ranging between this logged forest and the hills.

In the moderate extension, DSWR-M, we found moderate to high numbers of nests (Table 1) even though the areas we sampled were designated Production Forest. Transects up hills (J, L) and along the foot of a highly disturbed hill (O) tended to reveal fewer nests than transects in adjacent lowlands (H, K, M, N, Q). Nest counts from transects P and Q, near the Iban Dayak town of Meliau, beg explanation. Transect P passed through farming areas and a corridor of forest that ran between fruit gardens. We found 40 nests through this corridor although it was narrow, under 100 m long, and the only forest along transect P. Transect Q, the shoreline of a lake, generated a relatively high number of nests even though only one side of Q was

Table 1
DSWR area transects and nest survey data

Transect locations	Transect data				
	Label	Nest count	Length (km)[a]	Habitat types[b]	Habitat disturbance level
DSWR					
Hutan Nung	D	1	0.50	Tall swamp forest with peat	High
	E	2	1.00	Tall swamp forest, some with peat	High
	G	0	1.00	Tall swamp forest, some with peat; cleared/farmed	High
Pegah	F	0	0.75	Tall swamp forest, some with peat	High
Leboyan	I	32	1.50	Stunted swamp forest/riparian	Mid
DSWR-M					
Pegah	K	25	1.00	Stunted and tall swamp forests	Mid
Menyukung/Piat	H	7	1.50	Tall swamp forest	Mid
	J	18	1.00	Lowland hill forest	Mid
	L	6	1.00	Lowland hill fores	Mid
	M	31	1.00	Tall swamp forest	Mid
Meliau	N	25	1.00	Tall swamp forest with peat	Mid
	O	10	1.00	Stunted swamp forest	High
	P	46	1.00	Cleared/farmed	High
	Q	19	> 1.00	Stunted swamp forest/riparian	Mid
DSWR-G					
Radai/Tangit	A[c]	41, 57	1.00	Tall swamp forest	Low
	B[c]	26, 41	1.00	Tall swamp forest	Low
	C[c]	20, 25	1.00	Tall swamp forest	Low

[a] Transect < 1 km (occurred when time constraints precluded completing 1 km).
[b] Predominant Land Cover Classes along each transect, from Landsat Land Cover Map (1990) plus current observation. Classification is based on Giesen (1987).
[c] Transect was resurveyed to sample short-term changes in nest decay; the second value is the nest count at re-survey.

forested and that forest represented poor orangutan habitat (stunted inundated forest, repeatedly burned) (Giesen, 1995). There are plausible explanations for both unexpected results. The nests found along P and Q were commonly near fruit trees, which suggests a characteristic orangutan pattern of traveling to food trees and nesting nearby (Sugardjito, 1986). Both P and Q sampled an area just west of a large expanse of tall swamp forest so orangutans traveling to feed in this area could have been transients or overflow from that swamp forest. The swamp forest is unprotected Production Forest that lies just beyond the eastern DSWR-M boundary.

Transects in the greater extension, DSWR-G, generated our highest nest counts per km (Table 1). These transects passed mostly through prime orangutan habitat, tall swamp forest with some peat near waterways. They tapped the edge of a large contiguous expanse of swamp forest that extends to the north and west of DSWR, up to the hills to the northeast and northwest and almost to the Sarawak border to the north. Numerous reports of orangutans from this forest and the forest's relatively low levels of disturbance suggest that orangutan densities may be similar across much of it. This swamp forest is contiguous with the swamp forest to the east of DSWR-M. It is currently unprotected Production Forest or Non-Forest.

3.2. Orangutan density and population estimates

Table 2 shows the parameter values we used to estimate orangutan densities, where strip width (w) and nest decay rate (t) values reflect local conditions. Table 3 shows critical calculation details for t. Table 4 shows the orangutan density estimates generated by these values, for each of five habitat types.

Using these values, we estimated the orangutan population for each proposed protected area from these density estimates (Table 5). Total population estimates are DSWR- 206, DSWR-M- 1024, DSWR-G- 2741.

4. Discussion

This nest survey generated two main findings. First, a population of over 2000 orangutans survives in the Kapuas Lakes region. This confirms that the region supports an important orangutan population, one that may represent as much as 15–20% of the remaining Bornean population. Second, most of this population ranges in unprotected areas beyond DSWR, especially within DSWR-G. These findings concur with Giesen's (1987) impression, that the eastern hills beyond DSWR but within DSWR-M and DSWR-G are important to the area's orangutans, and with Meijaard et al.'s (1996) qualitative estimate, that the highest orangutan densities are in swamp forests beyond DSWR-M but within DSWR-G. Our findings are also consistent with previous findings that the richest habitats for orangutans are good quality swamp/peat forest and lowland alluvial forest (e.g. Schaik and Azwar, 1991; Payne and Andau, 1994; Meijaard, 1997). They support almost twice the orangutan densities of other habitats, like

Table 2
Nest-related parameters used in orangutan density estimates

Parameter	Value	Comments
N Number of nests	264	Total nest count, minus nests from atypical transects (P, Q) and three outliers (> 50 m from transect)
L Length of transects surveyed	15.75 km	Measured distance
w Effective strip width	0.01597 km	Survey-based Fourier series estimate
p Proportion of nest-builders	0.9	Published estimate (Schaik et al., 1995b)
r Daily nest-building rate	1.6–1.7	Published estimates (Rijksen, 1978; Schaik et al., 1995b), $r=1.6$ for areas with potentially higher representation of adult males like upland/hill sites
t Nest decay rate	145 days	Survey-based Markov model estimate

Table 3
Estimating nest decay rate: changes in decay state from survey to re-survey

	Frequency of state changes					No. of steps in each state				
Survey	Re-survey					Re-survey				
	A	B	C	D	Gone	A	B	C	D	Gone
A	0	4	3	0	0	1.0	0.713	1.672	1.713	5.098
B	0	12	24	3	3	0	1.25	1.425	1.573	4.248
C	0	0	12	9	3	0	0	2.0	1.9	3.9
D	0	0	0	9	6	0	0	0	2.5	2.5

Table 4
Orangutan density estimates by habitat type

Habitat: type (disturbance level)	Density estimate per km^2	No. of nests per transect km	Comments
Swamp/peat forest (low)	4.09	24.86	
Swamp/peat forest (medium)	3.29	23.33	
Swamp/peat forest (high)	0.43	3.06	
Lowland hill forest	1.8	7.00	Assumes higher adult male representation ($r = 1.6$)
Farmland/secondary forest	1.28	17.45	50% of estimate for comparable undisturbed habitat (Sugardjito and Schaik, 1992); using survey estimate for all swamp/peat forest (2.56/km^2)

Table 5
Orangutan population estimates for each proposed reserve

Habitat type	DSWR[a]			DSWR-M[a]				DSWR-G[a]			
	Total area (km^2)	% of total area	Total population	Added area (km^2)	% of total area	Added population	Total population	Added area (km^2)	% of total area	Added population	Total population
Swamp/peat forest	420	52	180[c]	218	44	660[d]	841	502	82	1652[b]	2493
Lowland hill forest	1	0.1	2	69	14	124	126	2	0.3	3	129
Farmland/ secondary forest	18	2	24	28	5	35	59	48	8	61	120
Unusable	368	45	0	187	37	0	0	63	10	0	0
Totals	807		206	501		819	1025	615		1717	2741

[a] Area sizes are from Giesen et al. (1994) and Jeanes (1996).
[b] Density estimate for moderately disturbed swamp/peat forest (3.29/km^2). This area was represented by three transects (A, B, C) yielding exceptionally high density estimates, so we used a more conservative estimate for the whole area.
[c] Density estimate for highly disturbed swamp/peat forest (0.43/km^2).
[d] Density estimate for swamp/peat forest within DSWR-M (based on transects H, K, M, N, O, representing low to moderate disturbance, 3.03/km^2).

adjacent uplands. Orangutans found in poor habitat may migrate between habitat types according to food availability (Leighton and Leighton, 1983; Boekhorst et al., 1990).

We were concerned that our estimates were upwardly biased. Our survey, like others, was biased to higher density areas because of the statistical and practical difficulties of studying a sparsely distributed species (Rijksen et al., 1995; Schaik et al., 1995a). We compensated for this bias by calculating estimates by habitat type, a major determinant of orangutan density, but travel difficulties also biased our sampling to areas near waterways, which support disproportionately high orangutan densities (Page et al., 1997; Payne and Andau, 1994; Schaik and Azwar, 1991). Upwardly-biased estimates are especially problematic because they fail to detect the critical pattern for orangutans, dangerously small populations (Schaik et al., 1995a). Accordingly, experts recommend correcting calculated estimates for systematic upward bias by a factor of 0.6 for Borneo and 0.75 for Sumatra (Rijksen et al., 1995; Schaik et al., 1995a). The 0.6 value incorporates an additional source of bias in Borneo, extrapolation based on outdated maps. These values are admittedly ad hoc (Rijksen, pers. comm.) but they derive from extensive studies of orangutan distribution and were accepted by the Orangutan Population and Viability Analysis Workshop (Tilson et al., 1993). Considering our second source of upward bias and our up-to-date map information, we suggest correcting calculated population estimates by 0.75. This gives DSWR — 155, DSWR-M — 768, DSWR-G — 2056. Corrected values may be interpreted as lower bound estimates (Rijksen et al., 1995).

Some of our transects yielded unexpectedly high nest counts (3/17 transects yielded more than 34 nests/km, 6/17 transects yielded more than 24 nests/km, only 6/17 transects produced fewer than 11 nests/km). A count from central Indonesian Borneo of 19 nests/km was described as “abundant” (Yanuar et al., 1996; Meijaard, 1997). In Sumatra, the highest values that have been recorded are 33.5, 24.4, and 12.2 nests per km (except Suaq Balimbing) (Sugardjito and Schaik, 1992; Schaik et al., 1995b). Our high counts are especially surprising because they represent areas that are unprotected, disturbed, and sometimes seriously degraded.

A plausible explanation for our moderately high nest densities in logged areas is post-disruption recovery. The onset of disturbing activities like logging tends to cause immediate declines in densities as orangutans escape (Rijksen, 1978; MacKinnon et al., 1996). Some recovery tends to occur a few years after disruption ceases, probably in step with habitat regeneration and cessation of disturbing activities (Marsh and Wilson, 1981; Leighton and Leighton, 1983). This fits the DSWR region; logging was intense in the 1970s and 1980s but then dwindled. The likely explanation for our exceptionally high nest densities in logged areas is that habitat disturbances elsewhere were displacing orangutans into these areas. Our highest nest counts were from locations in the proposed extensions just beyond the DSWR boundary. Orangutans could have been migrating into these extension areas from outer regions because of disturbances there (Meijaard et al., 1996) or from inside DSWR because of continuing disturbance due to increasing human pressure. Other areas of Borneo show similar patterns (Rijksen and Meijaard, 1999) so our high counts may reflect population stress.

Our findings show that both DSWR extensions would benefit orangutans but DSWR-G offers proportionally greater gains. We estimate that 69% of the regional orangutan population, over 2000 individuals, lives in this segment. Because of the distribution of habitat types, the 2.5-versus 1.5-fold increase in reserve size offered by DSWR-G versus DSWR-M could support a 7-versus 3-fold increase in orangutan numbers. The signs of population stress, however, indicate that protecting the area's orangutans requires extension beyond DSWR-G. GIS data show that DSWR-G stops short of unprotected swamp forests to the east, north, and west of DSWR. Orangutans ranging in the DSWR area likely depend on these swamp forests, perhaps migrating back and forth because of the area's pronounced seasonality. Further, forest fires in 1997 seriously affected peat swamp forests northeast of the reserve (Rijksen and Meijaard, 1999). These data bolster recent recommendations to extend the reserve to cover all surrounding orangutan habitat and to create a forest corridor linking the extended reserve with a nearby reserve, Lanjak Entimau/Bentuang-Karimun, which also supports an important orangutan population (Blouch, 1997; Rijksen and Meijaard, 1999).

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