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Recovery within a population of the Critically Endangered citron-crested cockatoo *Cacatua sulphurea citrinocristata* in Indonesia after 10 years of international trade control

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Abstract Moratoria on international trade are frequently used to protect threatened species but few studies have examined their effectiveness in allowing populations to recover. We present population data collected before and after a moratorium on trade in the citron-crested cockatoo *Cacatua sulphurea citrinocristata*, a distinctive subspecies of the yellow-crested cockatoo endemic to Sumba, Indonesia. Before legal trade ceased in 1993 numbers of cockatoos leaving Sumba averaged *c*. 1,600 per year, and the 1992 population, estimated at 3,200, surely could not sustain such a level of trade. We surveyed cockatoos in four forest patches on Sumba in 1992, and then surveyed these same forest patches 10 years later, using the same field methods. Forest cover within the four patches was similar between years. We recorded a statistically significant increase in overall cockatoo density, from *c*. 2 birds per km^2 in 1992 to >4 per km^2 in 2002. Group sizes were also larger in 2002 than in 1992. Densities at two forest sites had increased considerably, at another the population was stable, but at one small forest patch a small population in 1992 had probably decreased. While the population has made a modest recovery, densities remain low compared to cockatoo populations elsewhere. Illegal trade is known to persist and its volume should be monitored closely.

Keywords *Cacatua sulphurea citrinocristata*, CITES, cockatoo, Indonesia, parrot, population density, Sumba, trade ban.

Introduction

Since 1975 CITES has regulated international trade in animals, plants and their parts through a system of quotas and certification pertaining to import and export of specimens. Currently, nearly 500 species of vertebrates are included on CITES Appendix 1 (under which international trade is almost always banned) and almost 2,500 on Appendix 2 (under which trade levels are controlled). Many species are also protected through legislation within range states themselves and within the main importing countries (e.g. US Wild Bird Conservation Act 1992). CITES trade control and this bundle of supporting legislation may often result in reductions in trade volume and better trade monitoring (Ginsberg, 2002), but many problems with CITES and other wildlife trade legislation have been identified (Wells & Brazdo, 1991; Li *et al*., 2000). Trexler (1990) found no measurable evidence that CITES had benefited any species at all. A review commissioned by the Convention's parties was only a little more optimistic with the status of two, from 12 selected species, having appeared to have improved as a result of CITES listing (Martin, 2000).

The yellow-crested cockatoo *Cacatua sulphurea* has suffered catastrophic declines across its range in the Lesser Sundas and Sulawesi, Indonesia, and is categorized as Critically Endangered on the IUCN Red List (IUCN, 2004). Although habitat loss has undoubtedly played a part in its decline (BirdLife International, 2004), attention focused on extremely heavy trade during the 1970s and 1980s as the main cause of the decline (PHPA/LIPI/BirdLife International-IP, 1998; BirdLife International, 2004). In consequence a zero quota for export of all subspecies of the yellow-crested cockatoo has been imposed since 1994, following a primary recommendation in the 1992 report of the CITES Animal Committee (see Table 1 for a history of trade and control measures implemented since 1980). In 2004 the yellow-crested cockatoo was placed on CITES Appendix 1.

We present pre- and post-moratorium abundance estimates for the citron-crested cockatoo *Cacatua sulphurea citrinocristata*, a distinctive subspecies endemic to the island of Sumba. We surveyed cockatoos in four forest patches in 1992, just before the zero quota was imposed, and again in the same forest patches in 2002. The same

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Table 1 Chronology of trade in *Cacatua sulphurea* and legislation implemented to control it.

Pre-1980s	After a long history of heavy trade, *C. sulphurea* becomes expensive in mid 1970s (Inskipp *et al*., 1988).
1981	*C. sulphurea* added to CITES Appendix 2.
1981–1992	Heavy trade continues with 96,785 *C. sulphurea* exported from Indonesia in this period (WCMC, unpub. data collated from CITES Annual Reports).
1984–1991	15–31% of the capture quota set for the species as a whole were issued for capture of the Sumba subspecies (PHPA/LIPI/Birdlife International-IP, 1998).
1989	Net reported imports of *C. sulphurea* to CITES countries peaks at >12,000. Numbers of *C. s citrinocristata* leaving Sumba estimated at 1,350–3,000 (Marsden, 1995).
1991–1992	CITES-reported exports of *C. s citrinocristata* averaged 1,600 per year (WCMC, unpub. data collated from CITES Annual Reports).
1992	Population of *C. s citrinocristata* on Sumba estimated at *c*. 3,200 (Jones *et al*., 1995).
1992	*C. sulphurea* is subject of a Significant Trade Review on behalf of the CITES Animals Committee. CITES Management Authority of Indonesia institutes a temporary moratorium on exports.
1992–93	Local decrees banning trapping and transport of cockatoos issued by Regent of West Sumba (Decree no. 147, 1992) and Regent of East Sumba (Decree no. 21, 1993).
1994	Indonesia imposes a zero export quota for *C. sulphurea* that stood until 2004.
1997	*C. sulphurea* protected within Indonesia by Forestry Ministerial Decrees No. 350/Kpts-II/1997 and No. 522/Kpts-II/1997.
2002	Abundance of *C. s citrinocristata* reassessed in key forest patches on Sumba (this study).
2004	*C. sulphurea* placed on CITES Appendix 1.

point count distance sampling method was used in both surveys, and the 2002 team was given precise details of the study sites and, in some cases, walked the same transects as in 1992. We test for a statistical difference in the overall population density across years, and discuss local abundance changes in relation to the regulatory regime and other conservation efforts in place since 1992.

Study sites

Sumba (Fig. 1) is located in the Lesser Sundas within the Indonesian province of Nusa Tenggara Timur. The island has a seasonal and relatively dry climate and, although some of the island may never have been forested, there has undoubtedly been severe loss of forest in recent times (Jones *et al*., 1995). Closed-canopy forest now covers *c*. 10% of the island, mainly as discrete blocks surrounded by anthropogenic grasslands (Jepson *et al*., 1996).

We conducted surveys in 2002 at four of the six forest sites previously surveyed by Jones *et al*. (1995) in 1992. The sites were chosen because they were located within a newly designated national park or in areas recommended by Jepson *et al*. (1996) for strict nature reserve protection. Manupeu forest in central west Sumba (6,200 ha) is one of the last lowland forest fragments on Sumba. The study area (200–450 m altitude) is an area dominated by semi-deciduous monsoon vine forest. Langgaliru forest (405–620 m) in central east Sumba (15,300 ha) is contiguous with Manupeu and together they comprise the newly gazetted Manupeu-Tanadaru National Park. Poronumbu (2,500 ha) is also a semi-deciduous monsoon forest situated along a ridge (550–800 m) in the north-east of the island. This small forest block is more heavily disturbed than the other sites. Luku Melolo Protection Forest (7,750 ha), is an isolated forest block situated in east Sumba (200–600 m). It consists of a river valley with evergreen forest along the Luku Melolo River and is surrounded by steep limestone escarpments supporting semi-deciduous monsoon forest.

Methods

Sumba and its cockatoos

Cockatoos were abundant on Sumba in the 19th century (Hartert, 1896) and as recently as the 1970s were blamed by local people for damage to maize crops (Kendall, 1979). A serious decline on Sumba and throughout the species' range was observed in the 1970s and 1980s and this triggered a sequence of control (Table 1). Most important was the decision in the early 1990s not to place *C. sulphurea* on CITES Appendix 1, but to control its trade levels through a catch quota system. In reality, quotas have been set at zero in every year from 1994 to 2004, when the species was added to CITES Appendix 1. During the period 1993–2002 Indonesia has reported the export of only 712 wild-caught birds although import records from other CITES countries recorded 1,646 (Fig. 2). These figures, while reflecting clearly the sub-optimal performance of the zero quota regime, no doubt represent a substantial reduction in international trade since 1992.

The above trade control measures have worked in parallel with forest protection initiatives on Sumba and these are important for the cockatoo, which is associated with lowland primary forest in valley bottoms (Jones *et al*., 1995) and nests in extremely large trees of just a few species (Marsden & Jones, 1997). A Forest Conservation Strategy for the island has involved land use planning, reafforestation, and control of livestock grazing and fire, as well as environmental education.

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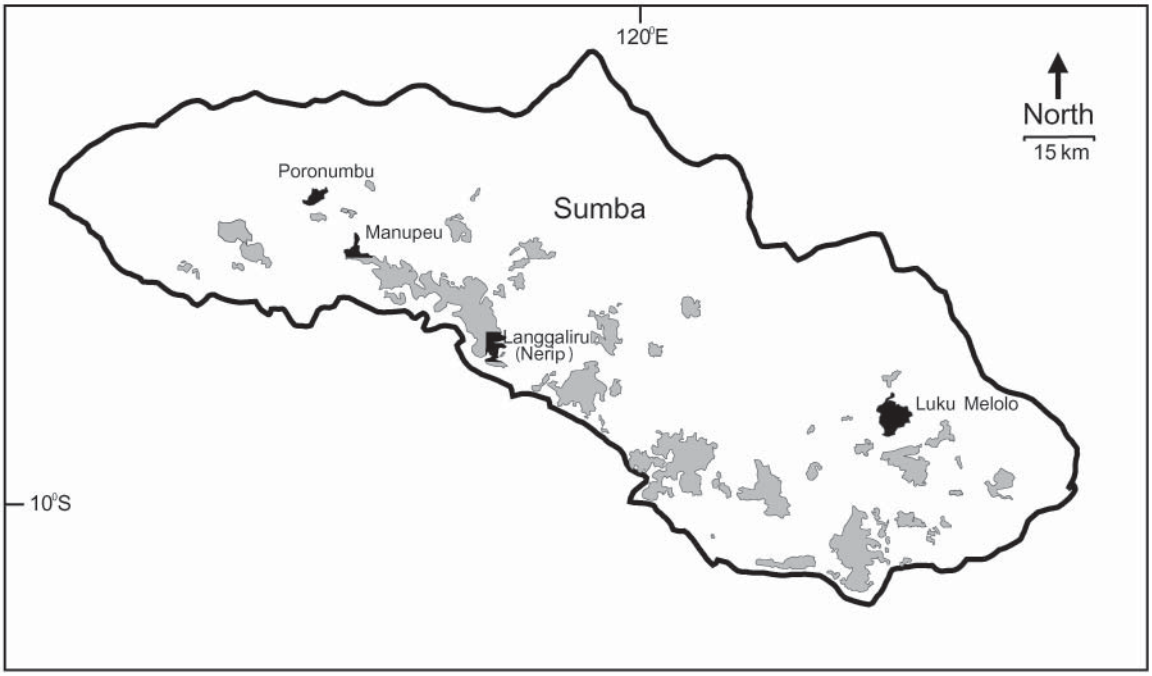

Fig. 1 Map of Sumba showing the four study sites (in black) and main areas of remaining forest (in grey).

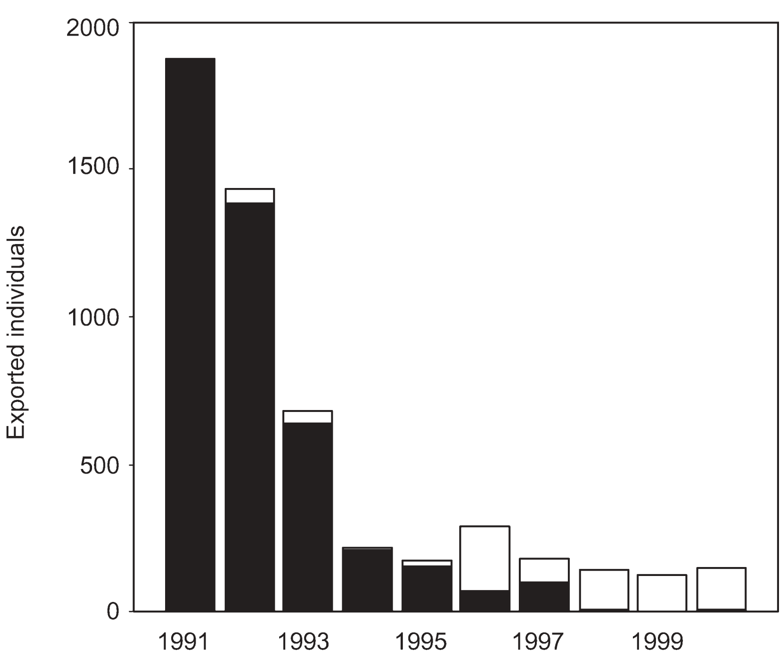

Fig. 2 CITES-reported exports of *C. s. citrinocristata* from Indonesia during 1991–2000. Black portions of bars indicate wild-caught birds and white portions represent birds apparently captive-bred within Indonesia.

The Manupeu-Tanadaru and Laiwangi-Wanggameti National Parks (1,350 km^2) were designated by Ministerial Decree No. 576/Kpts-II/1998.

Cockatoo surveys

Cockatoo surveys were conducted using a point count distance sampling method (Jones *et al*., 1995; Buckland *et al*., 2001) by AJC and JSW between February and May 2002. These sites were surveyed originally by a student team from Manchester Metropolitan University in August and September 1992 (Jones *et al*., 1995). Survey plots were located along transects and, wherever possible, we used the same trails used in 1992. Several of the guides and trail cutters employed in 1992 were again employed in 2002. Where the original trails had been

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abandoned or could not be relocated, new trails were cut in the vicinity (mainly at Manupeu and Poronumbo). Survey plots were 200 m apart along transects and each positioned 50 m from the trail on alternate sides.

Surveys were carried out by pairs of recorders between 06.00 and 10.30 and only in the absence of rain or strong wind. In both surveys a 2-minute settling down period was allowed before the 10 minute count period commenced. For each bird encounter we recorded group size, radial distance, type of contact (auditory or visual) and whether the birds were perched or flying. All records of birds in flight were omitted from the density calculations following Marsden (1999). In cases where group size was unknown, we used the mean group size for visual contacts as a surrogate.

Data Analysis

We calculated cockatoo encounter rates at each site and an overall encounter rate (sites combined) in each year. Encounter rates were expressed as the number of perched cockatoo groups recorded at any distance from the plot's central point per point count. We calculated group size parameters using data from visual contacts collected during both the point count survey, and at other times. We calculated mean group sizes for each year using these data but also used *Distance* (see below) to estimate group size and 95% confidence intervals.

Densities were calculated using *Distance 4.0* (Thomas *et al.*, 2003). We first assessed whether data from 1992 and 2002 could be combined by running detection functions for the two data sets separately and then comparing the two Akaike Information Criterion (AIC) values generated with that from a combined detection function. The AIC for the combined detection function was lower for the combined model than the sum of the individual AIC values and therefore we used a global detection function with post-stratification by year. Based on a low AIC value and a good fit determined by χ^2 tests, we chose the hazard-rate/cosine model, with data truncated to 156 m. Densities by site were produced by including the probability of detection (p) and SE of p, calculated from the global detection function, as a multiplier field, and re-running the analysis for each year using a uniform-cosine model with no adjustments.

A *z*-test was used to compare densities between years (Buckland *et al.*, 2001). While three variance components of the 1992 and 2002 density estimates are independent of each other (those associated with sampling effort, cluster size and encounter rate), one (estimate of g(0), the probability of bird detection at distance 0 m) is shared between the two density estimates because we combined data across years. A standard *z*-test gives a slightly conservative estimate of the test statistic in this case, yielding an increased likelihood of a Type 2 error (failing to find a real difference between the density estimates).

Population estimates were calculated for each site in 1992 and 2002 by multiplying the site density estimate by the area of forest. Forest cover data in 1992 were taken from Jones *et al*. (1994) who interpreted data from the 1976–78 Regional Physical Planning Programme for Transmigration mapping scheme. Data for 2002 were taken from 2000 Landsat imagery combined with the 1997 Peta Rupabumi (Government Topographical Survey). Habitat classification was carried out by Bapplan (the National Planning Agency) in collaboration with the EU-Forestry Inventory Management Project (EU-FIMP).

Results

Cockatoos were recorded at survey plots within all four sites in 1992 and from all sites except Luku Melolo in 2002 (Table 2). A total of 627 point counts yielded 108 records of perched cockatoos over the 2 years, with the overall encounter rate in 2002 being 56% higher than that in 1992. The highest encounter rates in both years were at Manupeu and the lowest were at Luku Melolo in both years. Group sizes differed between years (Table 3). There were significantly more birds in group sizes of two or more in 2002 compared with 1992 ($\chi^2 = 8.06$, df = 1, $P < 0.01$).

Overall cockatoo density was significantly higher in 2002 than in 1992 ($z = 55.8$, $P < 0.001$) (Table 4). The sites

Table 2 Number of groups encountered at any distance from the plot's central point (n), number of census plots (k), and encounter rates per survey point (n/k) at the four sites in 1992 and 2002.

	1992			2002		
	n	k	n/k	n	k	n/k
Manupeu	20	52	0.38	39	135	0.29
Poronumbu	3	42	0.071	20	100	0.20
Langgaliru	12	97	0.12	13	132	0.098
Luku Melolo	1	73	0.014	0	96	0
Sites combined	36	264	0.136	72	363	0.198

Table 3 Group sizes (with %) recorded in 1992 and 2002. Expected group size and 95% confidence intervals (CI) were estimated based on regression of log group size against log distance from the plot's central point.

Group size	1992	2002
1	44 (88)	67 (66)
2	4 (8)	30 (30)
3	2 (4)	1 (1)
4	0	2 (2)
5	0	1 (1)
Mean group size	1.12	1.34
Expected group size (95% CI)	1.19 (1.03–1.39)	1.43 (1.27–1.61)

Table 4 Cockatoo density estimates, as individuals per km² (95% confidence interval), for 1992 and 2002.

	1992	2002
Manupeu	4.24 (2.28–7.88)	9.91 (5.33–18.4)
Poronumbu	0.87 (0.24–3.20)	6.98 (3.65–13.3)
Langgaliru	2.10 (0.88–5.04)	2.73 (1.38–5.40)
Luku Melolo	0.23 (0.02–2.15)	No birds recorded
Sites combined	1.98 (1.15–3.38)	4.26 (2.68–6.78)

contributing to most of this increase were Manupeu (2.3 times higher in 2002) and Poronumbu (8.0 times higher). Densities at Langgaliru were similar between years. Only Poronumbu had changed in rank order, having much higher densities than Langgaliru in 2002.

There is no evidence for a contraction of forest cover from the four sites as a whole, and forest cover at Manupeu was estimated to be more extensive in 2002 than in 1992 (Table 5). We are thus confident that the population density increases are a product of real increases in bird numbers rather than the same or lower population being squeezed into a smaller area of habitat. Our estimate of population size in 2002 was 1.9 times greater than that in 1992 (Table 5). Although Poronumbo had the greatest increase in population density, this is a small forest block and the rise did not contribute greatly to overall population growth. In contrast, the estimated increase in the population at Manupeu was nearly 400 individuals, suggesting this is now a more important site for the cockatoo than Langgaliru.

Discussion

Are we confident that the population has increased?

The survey in 2002 used the same methods, and we were able to obtain precise details of the study areas and, in some cases, the exact original transect routes. Survey effort and recorders were different, but we attempted to match the original survey as closely as possible. We resurveyed sites, originally surveyed between August and October 1992, between February and May 2002. This is not ideal, but we timed the surveys to coincide with the end of the breeding season, which differed between the 2 years, probably because of differences in rainfall patterns across years (Walker *et al.*, 2005) . It is also worth noting that the high numbers of cockatoos recorded in 2002 should not have resulted from a particularly productive breeding season, as recruitment was minimal during the 2002 breeding season, at least at Manupeu (Walker *et al.*, 2005). A greater proportion of cockatoos were detected close to the recorder in 2002 than in 1992. This may indicate a slight difference in search effort by the teams in the 2 years (with the former team tending to include more distant birds) but it could also, to a degree, reflect a change in behaviour of the cockatoos in response to reduced persecution. Either way, it is important to account for differences in detectability between surveys and this is a major advantage of using distance sampling.

With 50 cockatoo records from 1992, and 101 from 2002, we have enough bird contacts to produce reasonably precise density estimates (Buckland *et al.*, 2001). Combining records across surveys to produce a single detection function increased the sample size, making density estimates more stable, and resulting in both a precise and robust estimate for 2002, but also improved precision of the 1992 estimate. We suggest that this procedure, validated by checking visually for obvious differences in detection patterns, and formal testing using AIC values (Buckland *et al.*, 2001), will improve the power of data from repeat surveys.

While our large data set meant that we were able to identify a significant increase in cockatoo density across sites, the data set lacked the power necessary to confirm population changes between years at individual sites. This is a problem that will hamper attempts to monitor populations of rare and threatened species, in that relatively short field seasons and small numbers of bird detections will promote Type 2 errors: failing to find a significant population change when there really has been one (Forcada, 2000). There is a strong argument against formal hypothesis testing in population monitoring (Johnson, 1999), alternatives being Bayesian approaches, or interpretations based on decision theory or gut-feelings about the reliability of each data set.

Table 5 Areas of closed-canopy forest in 1992 and 2002, with corresponding cockatoo population estimates (95% confidence interval).

	1992		2002	
	Area (km²)	Population	Area (km²)	Population
Manupeu	50.9	216 (116–401)	62.0	614 (330–1140)
Poronumbu	9.1	8 (2–29)	6.6	36 (24–88)
Langgaliru	154	323 (135–775)	153	418 (211–826)
Luku Melolo	77.5	18 (1.5–167)	77.5	None observed
Sites combined	291	565 (255–1372)	299	1068 (565–2054)

The present and future for Sumba's cockatoos

The estimated 1992 island population of *c*. 3,200 could not have sustained heavy annual harvests (*c*. 50% of the 1992 population exported per annum, with presumably a much larger number actually caught). Thus, the original fieldwork on Sumba by Jones *et al*. (1995) was timely in alerting the authorities to the unsustainability of the harvest. Population density estimates were amongst the lowest recorded for any cockatoo species, and even 10 years later were still no higher than those of other threatened cockatoos in the region (*Cacatua alba* in North Maluku, Lambert, 1993; *C. moluccensis* on Seram, Kinnaird *et al*., 2003). They remain much lower than those of cockatoos that have been traded less heavily in proportion to the size of their wild population (*C. goffini* on Tanimbar, Jepson *et al*., 2001; *C. ophthalmica* on New Britain, Marsden *et al*., 2001).

Costs associated with a trade ban in *C. sulphurea* include principally the loss of revenue for local people and this must be considered, especially in one of the most economically deprived areas in Indonesia. At 1992 prices each cockatoo was worth *c*. USD 55 to the wholesalers who export birds from the island to Java (Marsden, 1995). If trade levels were sustained (probably unrealistic given the low population), the loss of income would amount to *c*. USD 90,000 per year in 1993. Additionally, we do not know whether the ban on trade in *C. sulphurea* has promoted heavier trapping in other species, shifted demand onto other cockatoo species elsewhere, or promoted other detrimental activities amongst ex-trappers. Although Sumba's cockatoo populations are not yet large, it is possible that individuals will again become pests of agricultural crops in some areas. If this does happen, then there will be conflict between local farmers and birds that would need to be mitigated.

Offset against these costs is the increase in cockatoo population size at least in parts of the island, and which, we suggest, is a direct result of the reduction in trapping pressure. While such a recovery in numbers of any threatened species should be welcomed, it is not clear how this increase in numbers necessarily translates to a reduction in extinction risk. It is certainly not clear for how much longer the population can increase as there is little suitable habitat, and more particularly, a paucity of good quality nest holes. We know that the recovery of the cockatoo on Sumba has been much slower than that of Philippine cockatoo *Cacatua haematuropygia* on Rasa island, where effective nest-guarding by local people has stopped human predation entirely (M. Boussekey, pers. comm.). There, a population of *c*. 20 birds increased four-fold between 1998 and 2003 (M. Boussekey, pers. comm.). Breeding success on Rasa is high (averaging 2.6 hatchlings per nest in 2002, for example), and availability of nest-sites may already be limiting further population growth. Breeding output in *C. sulphurea* is intrinsically lower, and breeding output has been extremely low in at least one recent season (Walker *et al*., in press). These factors, coupled with continued capture, may have hampered the recovery of cockatoos on Sumba.

Despite legislation there is evidence that trade continued, although not on the same scale as in the 1980s, at least until the placement of the species on CITES Appendix 1 in 2004. Signs of cockatoo trapping were seen in 1996 (Kinnaird, 1999) and shipments of cockatoos were confiscated on Sumba in 1998 and again in 2002 (when 32 were seized). In 2002 we recorded a low incidence of cockatoo trapping at Manupeu and Langgaliru, mainly in the form of snaring. However, many nests at Poronumbu had ladders attached to them for nest raiding and we suggest that trapping activity was still relatively high at this site. Despite this, Poronumbu is the site at which cockatoo densities increased most.

The CITES and Indonesian legislative measures seem to have had a positive effect on cockatoo numbers, but it is important to note that they have worked in parallel with habitat protection measures, and with education and law enforcement being promoted by conservation agencies and the Indonesian Government. The increases in cockatoo numbers at Manupeu along with the more modest increase at Langgaliru bode well as these areas are included in the newly gazetted Manupeu-Tanadaru National Park (280 km^2). This, along with Laiwangi-Wanggameti, are important protected areas ensuring safer habitat for cockatoos in the long-term. However, other forested areas of Sumba are small (there are only five patches >2,500 ha) and of 33 forest patches surveyed, cockatoos were recorded in only 17 (O'Brien *et al*., 1997). It is questionable whether cockatoos will persist in the long-term in these fragments and it is likely that effective protection against excessive trade coupled with management of the island's national parks and other large forests holds the key to the survival of Sumba's cockatoos.

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