# 13. BRUIJN"S BRUSH-TURKEY *Aepypodius bruijnI*: FIELD DISCOVERY, MONITORING AND CONSERVATION OF AN ENIGMA

**Iwein Mauro**
**P.O. Box 289, 98401 Sorong, Indonesia,**
**e-mail: iweinmauro@gmail.com**

## Abstract

The endemic brush-turkey of Waigeo Island in eastern Indonesia, *Aepypodius bruijnii*, managed to remain entirely unknown in the living world during the more than 120 years that elapsed in between its formal description from trade skins in 1880 and its field discovery by the speaker in May 2002. Since then, Bruijn's Brush-turkey has been shown to nest only on the island's previously ornithologically unexplored highest summits, along an ecological gradient above 620 m elevation, where a structurally distinctive, wind-sheared and possibly locally edaphically controlled, stunted cloud-forest grows on infertile substrates. This breeding habitat comprises just 60 $km^2$ or 1.9 % of the island's area and is contained within six locations *sensu* IUCN (2001), three of which are now confirmed to support breeding populations. The species' global population has been estimated at 349 mound-owning males or 977 mature individuals, with 98 % of the population restricted to just three locations in the eastern part of the island (Mauro 2004; 2006). Threats that impinge on the species are discussed, and it is concluded that its current precautionary treatment as Vulnerable warrants upgrading to Endangered in accordance with the revised IUCN Red List categories and criteria. Habitat destruction as a consequence of wild fires and a recent logging epidemic had previously been identified as the major factor threatening this unique brush-turkey's long-term survival (Mauro 2004; 2006). In addition, the species' second and third largest breeding populations could now rapidly come under extreme pressure if proposed mineral extraction projects in Waigeo's northern ultramafic belt materialize.

## Introduction

Bruijn's Brush-turkey *Aepypodius bruijnii*, (Figure 1) is endemic to the Indonesian island of Waigeo (0°12'S; 130°45'E), situated just below the Equator, at the northern end of the Raja Ampat or 'Four Kings' archipelago off New Guinea's northwestern tip. With a total area surface of *c.* 3,100 $km^2$ Waigeo is the largest island in the group, which is further made up of the main islands of Misol, Salawati, and Batanta, plus a myriad of more than 600 satellites scattered around these, altogether comprising over 40,000 $km^2$ of land and sea. Waigeo reaches a highest point at 970 m a.s.l. on the summit of Mt. Sau Lal, but the island's most notable topographic features are probably the cone of Mt. Nok or Buffelhorn, standing *c.* 880 m a.s.l., and the stunningly beautiful fjord-like Mayalibit Bay, surrounded by precipitous limestone karst country, dividing Waigeo in roughly two equal halves. Access to the island is still only through a 60 km long boat journey across the Dampier Strait from the gateway town of Sorong on the westernmost tip of the Bird's Head Peninsula.

Bruijn's Brush-turkey became known from 23 historical trade specimens that reached European museum cabinets between 1880 and 1904, through the services of the immortal Dutch merchant of Ternate, Anton August Bruijn, a dealer in almost every product that the Moluccas and Bird's Head region had to offer, including natural history specimens (Oustalet 1880; Jones *et al.* 1995; Voisin *et al.* 2000; Dekker 2000; Moeliker *et al.* 2003). Some of these specimens are actually lovely mounts (Voisin *et al.* 2000), testimony to the great skills of the native field collectors and preparators

**Figure 1.** Bruijn's Brush-turkey. Photo Iwein Mauro.

that Bruijn was employing, and many were labelled 'Waigeo'. But subsequent authors (Rothschild *et al.* 1932; Peters 1934) queried whether this island was really the species' homeland. And this doubt appeared justified considering that 15 ornithological expeditions between 1793–1937 failed to record the species on Waigeo (Rothschild *et al.* 1932; Rand & Gilliard 1967; Frith & Beehler 1998), and Bruijn, after all, was notorious for his inexact labeling practices (De Schauensee 1940). A classic example is the duck *Anas waigiuensis*, which was originally described as a monotypic genus, *Salvadorina*, from a specimen supplied by Bruijn that allegedly originated from Waigeo and hence it's scientific binomial. But Salvadori's Teal has not subsequently been relocated on the island, and although Waigeo does not give up its secrets easily, most probably does not occur there.

However, Bruijn's Brush-turkey was rediscovered on Waigeo in 1938 when Jusup Kakiaij, a native Misolese field collector first trained during the Denison-Crockett Expedition to New Guinea, collected a female specimen from Jeimon in the Siam R. valley on the east side of Mayalibit Bay, at the behest of the Academy of Natural Sciences, Philadelphia (De Schauensee 1940). Another six expeditions between 1948 and 2000 failed to record the species in the wild, despite prevailing confidence that Bruijn's Brush-turkey still existed on the island (see *e.g.* Jones *et al.* 1995; Dekker *et al.* 2000; BirdLife International 2000). Then, in February 2001, local hunters presented the head and gnawed bones of a female they had hunted and consumed to a local contact person working for the operation 'Waigeo Expeditions', which ran under the auspices of Natuurmuseum Rotterdam (Heij & Post 2001). However, subsequent searches at the location where the bird had been hunted, yielded no success, and again Bruijn's Brush-turkey could not be located in the wild.

## The field discovery of Bruijn's Brush-turkey

In 1985 J. M. Diamond had pointed out that it remained unknown whether any ornithological collectors had reached Waigeo's summits (Diamond 1985). Moreover, the idea first introduced by Dekker & Argeloo (1993), that Bruijn's Brush-turkey, by analogy with the Wattled Brush-turkey of continental New Guinea and Misol, presumably inhabits the mountains proper, became the dominant view by the turn of the century (see *e.g.* Jones *et al.* 1995; Dekker *et al.* 2000; BirdLife International 2000). Nevertheless, the long-awaited decisive assault on the island's peaks did not occur during three

consecutive 'Waigeo Expeditions' in 1999, 2000 and 2001, devoted primarily to rediscovering Bruijn's Brush-turkey (Heij & Post 2001).

So when I visited Waigeo in the spring of 2002 with the strong desire to observe this most enigmatic of all New Guinea bird species, I embraced these insights and headed for the summit of Mt. Nok, Waigeo's best known mountain. In so doing, I located an active incubation mound that I instantly recognized as pertaining to *Aepypodius*, just one hour after reaching cloud-forest at 715 m elevation on the mountain's eastern spine on 14 May 2002. I monitored this mound from a well-concealed hide for a total of 91 hours spread over 13 consecutive mornings from 15 to 27 May between first light and noon (Mauro 2002; 2004; 2005). This produced five excellent sightings of the mound-tending male down to point-blank range. On one occasion the male was watched during more than 20 minutes, digging a test hole in the centre of the flattened top of the mound. Another five sightings, all of solitary birds scurrying away, were made in forests in the vicinity. Novel insights into the species' broad habitat requirements and conservation needs (Mauro 2002; Anonymous 2002ab) served as the basis for follow-up field work at the request of the WPA/BirdLife/SSC Megapode Specialist Group in October–December 2002 and again in May–June 2003, bringing to light the existence of a viable population of the species (Mauro 2003; Dekker 2003). I eventually published the first comprehensive descriptions of the species' bare parts, which until my work remained essentially unknown (Mauro 2004; 2005). I described the species' appearance, vocalizations and behaviour in the field, and further unveiled various aspects of its life history and social organization, corroborating and adding considerable detail to previous assumptions founded on its generic affinities. In the first place, I confirmed that Bruijn's Brush-turkey indeed is a mound-builder, and provided the first descriptions of its mounds at different stages of development (Mauro 2004; 2005). I also provided evidence for a male resource-defense polygyny and polyandry mating system, which, uniquely among the megapodes is rooted within the closely allied New Guinean and Australian brush-turkey genera *Aepypodius* and *Alectura* (henceforth collectively referred to as the brush-turkeys).

In retrospect, the overall neglect of the island's summits, which can now be identified as the major flaw in the hunt for Bruijn's Brush-turkey, was probably due to a combination of three factors. First, and foremost perhaps, the possibility that the island could harbour strictly montane bird populations may have been deemed unrealistic in view of its modest topography not exceeding 1,000 m in elevation and effectively lacking significantly large areas above the 900 m contour where montane conditions normally set in on New Guinea (Paijmans 1976). What is more, the sole locality-specific historical specimen of Bruijn's Brush-turkey, definitely collected below 640 m elevation from Jeimon in the Siam R. valley in 1938 (De Schauensee 1940), gave rise to the common misconception, most recently perpetuated by Moeliker (2002abc), that the species is rare but widely distributed across Waigeo. Second, virtually all historical collecting and modern reconnaissance took place in coastal, rugged limestone karst country where higher elevations are very difficult to reach (*cf.* Dekker & McGowan 1995). On the other hand, the only ornithologist having searched the more accessible ultramafics, G. Stein, rather discouragingly tagged this zone 'a generally strikingly animal-poor region' (Rothschild *et al.* 1932). Third, Waigeo's interior remained preponderantly uncharted until long after World War II, and its crucial montane sites were not appreciated until the recent advent of high-resolution digital elevation models.

Finally, transfer of local knowledge often proves crucial in tracking-down little-known species. However, in the instance of Bruijn's Brush-turkey, I found that information conveyed by local respondents rested almost entirely on tribal oral lore and narration, an increasingly fragmented, decaying 'collective memory' so to speak, which albeit riveting by no means is necessarily true and accurate, and which in the overall absence of counterevidence from the field, unfortunately, was all too credulously embraced in the past. That the species appears to be known and goes by its own local name in certain villages, as various sources reported (Diamond 1986; Dekker & Argeloo 1993; Post 2001), cannot be considered proof that it occurs, not even incidentally, in the wider vicinity as suggested in the Megapode Action Plans (Dekker & McGowan 1995; Dekker *et al.* 2000). The fact that none of the respondents recognized the species as a mound-builder in the first place, quite understandably rather perceiving it as an ordinary fowl, to me suggests that the inhabitants of Waigeo perhaps always have possessed merely casual knowledge of the species and never entered its secluded breeding habitat. In any case, the method of extensive village interviewing in order to gather presence/absence data recommended in the last Megapode Action Plan (Dekker *et al.* 2000), especially as executed by the 'Waigeo Expeditions' without earnest ground-truthing, proved

immensely ineffective and to generate merely secondary, ambiguous information, prone to considerable misinterpretation.

## Monitoring

It is the males that site, construct, tend and own the incubation mounds in the brush-turkeys, and adult male territoriality is assumed to centre on the mound. In addition, vocal advertisement is restricted entirely to the mating season and may primarily be associated with sexual display on or in the immediate vicinity of the mound (Jones *et al.* 1995; Sinclair 2002; I.M. unpublished data). The number of reproductively mature males capable of permanently defending a mound is the single most relevant population unit to conservation assessment in a male resource-defending promiscuous megapode given that exactly these males secure virtually all copulations, and monopolize the chance of successful progeny (Jones 1990ab).

Waigeo receives an annual rainfall of 1,500–2,000 mm (van Royen 1960), most of which falls in a distinctive wet season from December through to May (local information). Elsewhere in seasonally humid environments the onset of breeding for mound-building megapodes has been found to be defined by local precipitation regimes (Jones *et al.* 1995). Incubation evidently was in progress on Mt Nok in mid-May 2002 following normal rainfall in the year 2001 and the first quarter of 2002. More recently, I witnessed territorial display on Mt. Danai in early April 2007, further corroborating that the species' habitual breeding season unfolds in the March-May second half of the normal wet season on the island (Mauro 2002; 2004; 2005; 2006; Papua Expeditions 2007). Severe ENSO-induced drought conditions, however, afflicted the entire Raja Ampat region during the follow-up field work, and reproductive and vocal activity in the Bruijn's Brush-turkey was not forthcoming. Hence I relied exclusively on qualitative mapping of its mounds to assess population status.

Assisted by a variable team of local hunters, I searched for incubation mounds during *c.* 4,500 person-hour, initially within every altitudinal belt, later on mainly confined to the species' increasingly tested and confirmed altitudinal breeding distribution (Mauro 2004; 2005; 2006). I spot-mapped each mound using GPS and barometric altimeter, and assigned it to one of four distinctive phases through which the mounds of this species normally pass: Construction phase, Active phase, Collapsed phase and Spread-out phase. By repeating this procedure over disjunct survey periods, I obtained static snapshots that provide insight into spatio-temporal distribution and utilization of incubation sites.

In retrospect, such laborious qualitative 'limited resource' mapping would anyhow have been desirable since: (1) both the population of Bruijn's Brush-turkey and the extent of its breeding habitat on Mt. Sau Lal are comparatively small and manageable with a group of motivated searchers; (2) for reasons that we were unable to quantify within the given time-frame, the spatial distribution of incubation mounds was truncated in many seemingly suitable environments, indicating that highly specialized ecological and behavioural requirements determine selection of incubation sites; and (3) we now know that the species has very timid territorial vocalizations, consisting of *Gallus*-like wing-flapping as in the Wattled Brush-turkey, followed by a short nasal hiss (I.M. unpublished data). Such vocalizations are unlikely to be audible beyond 75 m in dense cloud-forest, while average Nearest Neighbour distance between concurrently tended mounds on Mt. Sau Lal was slightly more than 200 m (Mauro 2004, 2006).

The lowest altitude at which I recorded a mound of Bruijn's Brush-turkey was 620 m. Adopting this as an altitudinal cut-off, I delineated in a study area for Mts. Nok and Sau Lal the external boundary of breeding habitat realistically suitable to the species through exclusion of geomorphologically unsuited terrain. I then applied Minimum Spanning Tree, Nearest Neighbour and Delaunay/Dirichlet (Voronoy Polygon) Tesselation connection schemes (Rosenberg 2001) to describe and analyse spatio-temporal distribution of incubation sites within the Mt. Sau Lal SA in GIS. Finally, I used the unedited NGA-NASA SRTM-3 three arc-second resolution digital elevation model to assess distribution and extent of land above 620 m elevation on Waigeo, and estimate the species' breeding range and global population (Mauro 2004; 2006).

## Conservation

I found incubation sites of Bruijn's Brush-turkey only on Mts. Nok, Sau Lal and Danai along an ecological gradient above 620 m elevation, where a structurally distinctive, wind-sheared and possibly

locally edaphically controlled, stunted cloud-forest grows on infertile substrates (Mauro 2004; 2006; Papua Expeditions 2007). Compression of the altitudinal vegetation belts on low and exposed mountains as on Waigeo, the so-called 'Massenerhebung' effect, has long been documented for many Wallacean and Northern Melanesian islands (Mayr & Diamond 2001). Conversely, it remains possible that a shortage of one or more macronutrients (except Mg), very high soil Mg/Ca quotients or high soil Ni concentrations contribute to the dwarfed nature of forests growing on ultramafic outcrops like Mts. Nok and Sau Lal (Proctor 2003). In any case, these stands of cloud-forest on the island are sufficiently large to have biological meaning, and there is prospect for substantial future taxonomic discovery in the Waigeo cloud-forest zone. In addition to Bruijn's Brush-turkey I found the owlet-nightjar *Aegotheles wallacii*, the scrubwren *Sericornis beccarii*, and the honeyeaters *Meliphaga orientalis facialis* and *Myzomela [nigrita] steini* to be normally confined to the cloud-forest on the island (Mauro 2004; Papua Expeditions 2007). The exact taxonomic affinities of the novel populations of the owlet-nightjar and scrubwren, recorded for the first time on the island during my work, are under systematic investigation currently, whereas the morphologically highly distinctive *steini*-subspecies of the Black Myzomela certainly qualifies as an endemic allospecies (I.M. unpublished data). The restriction to cloud-forest of bird taxa distinct at the species and allospecies level, and the complete dissimilarity between the mix of montane bird populations on Waigeo and Batanta (Mauro 2004), are testimony that potential even minor ecological gradients can exercise to isolate taxa and sustain speciation across Pleistocene land-bridge islands.

Within its specialized breeding habitat I observed a density of 4 and 8 mound-territories/km$^2$ respectively for the small relict Mt. Nok and the sizeable Mt. Sau Lal (Mauro 2004; 2006). While little comparable published information exists on population densities in megapodes derived from qualitative mapping of incubation mounds, Bruijn's Brush-turkey appears to rank as a low-density species. In comparison, Australian Brush-turkey in the wild occurs at densities up to 22.2 mound-territories/km$^2$ (Marchant & Higgins 1993), an order of magnitude 2.4–5.5 times greater. Importantly, more than 20 years after the last fire event on Mt. Sau Lal, the species' population density in areas of post-fire succession there was still 4.5 times lower than in adjacent primary tracts (Mauro 2004; 2006).

The rarity of Bruijn's Brush-turkey has been linked to potential competitive exclusion by the only other species of megapode on Waigeo, the Dusky Megapode *Megapodius freycinet* (Dekker & Argeloo 1993; BirdLife International 2001; *cf.* Ripley 1960), considered a more recent arrival on the island. However, Dusky Megapode was found to occur chiefly in flat alluvial lowland forests along the broader river valleys between sea level and *c.* 100 m a.s.l., and occurs only patchily up to 285 m a.s.l., where extensive expanses of flat or only slightly undulating terrain are available. Hence the two species of megapode on the island breed in complete vertical parapatry, separated by an altitudinal gap exceeding 300 m, set against a maximum elevation of 970 m a.s.l. available for the island. Moreover, these mutually exclusive breeding ranges are mirrored by a comparable occupancy pattern of Dusky Megapode on neighbouring Batanta (I.M. unpublished data), where *Aepypodius* is absent till further notice (but see below). All this suggests that the brush-turkey's isolated montane breeding distribution may be better explained in terms of the unique evolutionary adaptation to upland forests of the genus *Aepypodius*. Recent molecular work brought to light that Dusky Megapode may be paraphyletic, *M. f. quoyii* and nominate *freycinet* each clustering with other species rather than as sisters in a ND2 mitochondrial gene tree (Birks & Edwards 2002). Such a relatively steep phylogenetic gap within Dusky Megapode suggests that *Megapodius* also has an ancient history on Waigeo and that the disjunct breeding zones both species maintain are a result of a long-term and stable evolutionary *status quo*.

Bruijn's Brush-turkey presently is confirmed to breed at only three locations *sensu* IUCN (2001), and the known population totals 54 mound-owning males (Mauro 2004; 2006; I.M. unpublished data). The species' global population is estimated at 349 mound-owning males or 977 mature individuals, primarily confined to 60 km$^2$ of inferred cloud-forest breeding habitat spread over six locations, with 94 % of breeding habitat and 98 % of the world population contained within three locations east of Mayalibit Bay (Mauro 2004; 2006). These figures pinpoint Bruijn's Brush-turkey among Indonesia's most restricted-range and rarer bird species (Stattersfield *et al.* 1998; BirdLife International 2000; 2001). Mt. Danai alone is believed to contain 60 % of breeding habitat and 65 % of the world population of Bruijn's Brush-turkey, and the paramount importance of this mountain for the species' long-term survival cannot be overstated. The only location in Waigeo's western sector to conceivably harbour a tiny population is restricted and isolated to such an extent that until a population is proven

extant there indeed, I recommended querying the species' occurrence west of Mayalibit Bay (Mauro 2004; 2006).

Lowland occurrences of the Bruijn's Brush-turkey remain poorly understood. Six traceable positions of lowland records were on average only 6 km distant from the nearest known or inferred breeding habitat and lie east of Mayalibit Bay, and all refer to female type individuals (Mauro 2004; 2006). Some cases demonstrably coincided with prolonged periods of drought. Indeed, adult mound-tending males were found to endure extreme drought conditions on territory, whereas female type individuals appeared to have completely vacated optimum cloud-forest habitat. However, the species ranks as technically undetectable when dispersed in small numbers across vast lowlands hence the possibility looms that such apparent altitudinal shifting of female type individuals extends far beyond the casual disturbance-response and obscures juvenile dispersal and/or genetically strategic interchange of adults between isolated breeding habitats. As a matter of reasonable precaution, any *in situ* conservation initiative for the species should therefore soundly consider this potential temporal dependency upon lowlands of at least a subset of the population. Nonetheless, I recommended that these lowland occurrences be treated as cases of vagrancy with regard to applying criterion B of the IUCN Red List criteria (IUCN 2001).

While we now know more about Bruijn's Brush-turkey than ever before, the threats that impinge on the species too have never been greater. Waigeo consists predominantly of limestone and ultramafics, infertile substrates that are known to delay recovery of vegetation following environmental perturbation (overview in Proctor 2003). I identified habitat destruction as a result of wild fires as the most serious threatening process for Bruijn's Brush-turkey. Four traceable fire paths from the past 25 years averaged nearly 65 $km^2$, together affecting *c.* 260 $km^2$ or 8.4 % of the island's area (Mauro 2004; 2006). These known fire events acted over disproportionately large surfaces when compared to the size of individual locations of the species. Fires are directly responsible for severe internal degradation and partial obliteration of 18 % of cloud-forest on Mt. Sau Lal plus a presently unquantifiable yet significant portion of the Mnier Hills, and probably irretrievably degraded hundreds of $km^2$ of low-lying forested areas, including corridors between locations. The impact of fire must also be assessed against the backdrop that the predominant scrub vegetation over ultramafic outcrops on Waigeo, long interpreted as an edaphic climax, now is considered to represent an early stage in a successional sequence induced by fire (Takeuchi 2003; see also Proctor 2003). Finally, three out of four wild fires occurred during the El Niño-induced drought event of 1982–83, but interviews indicated that most fires on the island are started deliberately, and the use of fire certainly increased significantly in the wake of logging operations.

In the accessible lowlands of Waigeo, forest was being lost at an extremely alarming pace due to illegal logging from 1999 to 2005. About 14 % of the West Waigeo Nature Reserve was already affected in 2000 (Anonymous 2000), and while commercial timber extraction was halted in mid-2005 following a large-scale crack-down operation throughout Indonesian Papua, evidence is mounting that most of the accessible tracts within the reserve have been severely degraded by the usual interplay of logging, road building, and the widespread subsequent use of fire as a cover up. While timber extraction likely will only affect low-lying areas in the short term, the preservation of lowland forest corridors linking breeding habitats of Bruijn's Brush-turkey is imperative in view of a potential temporal dependency upon lowlands of at least a subset of the population.

The potential for nickel extraction is an old curse resting on Waigeo's mineral-rich northern ultramafic belt, and very recently loomed up again (Hermanto 2007). During the course of 2005 and 2006, the government of Raja Ampat regency has granted concession rights for nickel exploration in 11 contiguous blocks covering *c.* 900 $km^2$ of land over ultramafic rocks, or 29 % of Waigeo's area. Included are the entire Mnier–Werar Hills and sizeable parts of the Mount Sau Lal–Waimila ridge system, respectively harbouring the world's second and third largest populations of Bruijn's Brush-turkey. Concessionaires have started to move ground during the course of 2006, and earlier this year the Raja Ampat government has approved actual exploitation in three blocks. Fortunately, this decision was promptly overruled at provincial level on account of these operations being in conflict with the protected area network on Waigeo. However, a reduction in size of the strict nature reserves on the island in order to accommodate mining has long been hanging and it appears that the government of Raja Ampat is now actively pursuing this option. It is feared that the materialization of these mineral extraction projects potentially could signify the total obliteration of breeding habitat of Bruijn's Brush-turkey within the ultramafic belt, and entail a reduction in the species' global population

by as much as 34 % in the short- to medium-term future. Clearly, the development of the novel Raja Ampat regency, with Waisai on Waigeo's south coast as its capital, impels very attentive monitoring.

My work suggests that human predation, contrary to previous speculations (*e.g.* Dekker & McGowan 1995; Moeliker 2002ab), currently is a negligible threat to the population, and that introduced mammalian predators may be a more serious cause for concern. I listed the prehistorically introduced Wild Boar *Sus scrofa* as a potential nest predator of the Bruijn's Brush-turkey (Mauro 2004), and recently found mound raiding by boars to be at least locally rampant on Mt. Danai in April and June 2007 (Mauro *et al.*, *in prep.*). Runaway dogs are also a problem locally in Waigeo's forests, and potentially imply a hazard to Bruijn's Brush-turkey considering its behavioural reluctance to flush (Mauro 2002; 2004; 2005; 2006). In addition, my work suggests that natural predation by the native monitor lizard *Varanus indicus kalabeck*, which unexpectedly manages to exist near permanent water sources up to at least 840 m elevation locally in the mountains of Waigeo (I.M. unpublished data), may pose a contributory threat, especially where subpopulations already are dwindling and territories occur at low densities such as on Mt. Nok.

I formally proposed that Bruijn's Brush-turkey, currently treated as Vulnerable (BirdLife International 2001), be upgraded to Endangered based on criteria EN B1+2ab(ii,iii,v) (IUCN 2001; Mauro 2004; 2006). The species is almost certainly confined to an area of 1,734 $km^2$ in the eastern half of Waigeo and Extent of Occurrence as delineated by Minimum Convex Polygon (MCP) comprising all locations there amounts to 751 $km^2$ [<5,000 $km^2$; criterion B1]. The species' Area of Occupancy (AOO) now stands at 24 $km^2$ and even if all locations within its Extent of Occurrence eventually should prove to be fully saturated at the IUCN 4 $km^2$-gridcell reference scale, still could not exceed 192 $km^2$ [<500 $km^2$; criterion B2]. Viable populations that are safe from genetic stochasticity exist at only three locations [<5 locations; qualifier a]. Fires severely degraded and partially obliterated 18 % of cloud-forest on Mt. Sau Lal plus a significant portion of the Mnier Hills, and quite possibly irretrievably degraded hundreds of $km^2$ of low-lying forested areas including corridors between disjunct breeding zones [qualifier b(ii,iii)]. A continuing decline in number of mature individuals is inferred from the species' observed constrained population density in post-fire successional regrowth on Mt. Sau Lal [qualifier b(v)] (Mauro 2004; 2006).

## Where from here?

I make the following recommendations:

[1] Urgently invest in preferably immediately effective cash-generating for-profit project interventions in order to alleviate increasing claims to deleterious resource-extraction.

Following endorsement of law No. 21/2001 on special autonomy for Indonesian Papua, customary land rights over forested land — previously considered state land — increasingly are being reinstated throughout the territory. While this, theoretically, tips the balance of power towards the communities, and while traditional societies may appear more receptive to long-term conservation goals than governments without adequate budget, I would at this point in time very cautiously say that it remains to be seen whether the conservation outlook for Bruijn's Brush-turkey can really be enhanced under this scenario.

Traditional societies on Waigeo are rapidly being overtaken by the 21$^{st}$ century. Adherence to customary law, ownership and tenure of land, reefs and natural resources slackens as integration into the market-oriented cash economy accelerates rapidly. Growing cash-dependency combined with dramatically increased prices of basic commodities and services deeply impact the islanders' livelihood. Hence to ease the financial burden, there are enormous incentives from the communities' perspective to sell off natural resources on customary-owned ancestral land. Internal conflicts emerge because young generations increasingly reject the limitations on resource exploitation imposed by customary so-called *Sasi* regimes that essentially evolved to ensure long-term sustainability through moderation and temporary abstinence. Waigeo's population is also structurally diverse (Masinambouw 1983; Silzer & Clouse 1991), further complicating the issue of customary land and resource ownership because original inhabitants, ancient migrants, and indeed any community inhabiting a given sector for a prolonged period of time, all readily claim access rights beyond subsistence use (Donnelly *et al.* 2003; I.M. unpublished data). Finally, another important element is

the fact that the private sector as a whole essentially took over the central role of governments in providing basic services, and because the communities often are not principally opposed to resource extraction in itself but merely expect to reciprocally benefit from it, convincing them not to enter into novel, or terminate existing, unsustainable resource exploitation might prove exceedingly difficult, even if they do understand the long-term deleterious impact of such practices. To seriously rival destructive resource use, any conservation project intervention therefore likely will require immediately effective cash-generating alternatives, enabling the communities to earn sufficient hard cash in order to obtain, at the very least, those basic goods and services that cannot be fulfilled from their subsistence way of living. However, the development expectations of local communities are already known to extend beyond merely acquiring basic goods and services, and it can also be expected that companies responding by evincing greater corporate responsibility through more equitable profit-sharing with compliant communities, due to the remunerative nature of unsustainable exploitation, will prove unchallengeable. Let the 'battle for the hearts and minds' of traditional societies living inside biodiversity hotspots begin!

[2] Through an elaborative process of participatory mapping and consultation with local communities, secure a consensus protected area east of Mayalibit Bay containing at least the *c.* 750 $km^2$ convex hull that incorporates and interconnects all known and inferred breeding zones through overall well-forested corridors covering the species' complete altitudinal range.

The whole of the world population of Bruijn's Brush-turkey is believed to occur east of Mayalibit Bay and this has far-stretching implications for conservation planning and prioritization on Waigeo. Based on the principle of representation, both in terms of species diversity as habitats, the region east of Mayalibit Bay must now immediately be upgraded as the key area for terrestrial conservation on Waigeo and project intervention *a priori* should serve that sector. The East Waigeo Nature Reserve covers 1,195 $km^2$ or 69 % of the island's eastern half (Ministry of Forestry Decree 251/Kpts-II/1996 d.d. 25 November 1996; Donnelly *et al*. 2003) and, quite fortunately, largely includes the *c.* 750 $km^2$ convex hull delineating the species' Extent of Occurrence. While no significant management on the terrain has been forthcoming since its establishment in 1996, the reserve at least has clearly shown its value in legally halting proposed mining operations contravening with its boundaries while already approved by customary landowners. I am therefore highly convinced that the 'consensus' protected area should be within the legal framework of the national conservation network. But in order to secure a viable lowland forest corridor between Mt. Sau Lal and Mt. Danai, a concerted effort must somehow be made to include into the reserve the Siam and Lapon R. valleys, presently classified as production forest. However, local communities and customary landowners were not consulted at the time when the reserve was created in 1996, and reopening the discussion now, under the present circumstances, has the potential to trigger a complete rejection of the reserve.

[3] Declare the species' core locations as strictly no hunting areas and restrict access for scientific monitoring only.

This measure should not pose any foreseeable problems to local communities since these highest ridges remain entirely unexploited, if ever visited by man even. A complete hunting ban on wild boar is probably highly unrealistic and even undesirable in view of locally rampant nest predation (see above).

[4] Set up an island-wide awareness campaign to prevent future wild fires, the majority of which occur because of either imprudence or deliberate action of man.

[5] Restrict 'parforce' pig-hunting and snaring to designated sectors near habitation and subsistence areas.

[6] Conduct additional field work in order to ground-truth current population estimates for Mt. Danai and the Mnier–Werar Hills complex, and the remaining unsurveyed ridges and peaks identified by Mauro (2004; 2006).

Mt. Danai is believed to contain in excess of 60 % of inferred breeding habitat and 65 % of the estimated global population of Bruijn's Brush-turkey. While I recently ascertained the presence of the species on Mt. Danai in itself, ground-truthing is urgently required to confirm these figures. All the more, given that the long-term survival of populations on Mt. Sau Lal and in the Mnier-Werar Hills,

could now rapidly come under extreme pressure through the development of proposed mineral extraction projects (see above).

[7] Establish beyond reasonable doubt whether the species is indeed absent from Batanta.

There is a contemporary report of a 'large brush-turkey' of undetermined generic identity, yet speculated to involve Bruijn's Brush-turkey, from 700 m elevation on Mt. Batanta in the centre of the eponymous island (Diamond 1986). Yet two lines of albeit circumstantial evidence suggest occurrence of the species there is not particularly likely. Firstly, an ornithological expedition in 1964 collected 11 field days within cloud-forest in the summit area of this mountain without encountering the species (Greenway 1966). Second, my work showed that the mix of strictly montane bird populations persisting on Waigeo and Batanta respectively is totally dissimilar. However, if Bruijn's Brush-turkey, after all, would be proven extant on the latter island, Mt. Batanta, supporting 47 $km^2$ of optimum breeding habitat above the 620 m contour, in effect could support the species' most viable subpopulation. Negative evidence is hard to prove but a meticulous search of Mt. Batanta is clearly warranted in view of the species' sheer elusiveness.

[8] Investigate the impact of especially alien mammalian predators on Waigeo.

[9] Study nesting site philopatry and the extent of gene flow across locations, preferably using a non-invasive molecular technique.

[10] Study the impact of ENSO-induced drought events on the species' reproductive success.

The impact of ENSO-induced drought events on the breeding activity of mound-building megapodes has not been studied. However, Bruijn's Brush-turkey may be a particularly vulnerable species in this respect because drought has the capacity to directly reset the reproductive cycle to the following year's nesting period when coinciding with the species' habitual breeding season in a seasonally wet environment like Waigeo, and my work already provided circumstantial evidence for this (I.M. unpublished data). Moreover, because of their comparatively lower critical mass of near-exclusive organic composition *Aepypodius* mounds decompose and cool much faster when drought conditions start impinging upon the microbial activity that generates heat; Sinclair (2001) showed that they are less stable homeotherms.

## Acknowledgments

The Australian National Malleefowl Recovery Team provided me with the opportunity to speak at the 'National Malleefowl Forum and First Western Australian Megapode Symposium' held Katanning, September 7–11, 2007, and S. Davies kindly raised adequate travel funds. R. W. R. J. Dekker, in his capacity of chairman of the WPA/BirdLife/SSC Megapode Specialist Group (MSG), has been a constant source of advice, logistical support and encouragement. Field work was funded through two small grants of the Van Tienhoven Foundation for International Nature Protection and a donation received from Project Bird Watch/Indonesian Parrot Project. To all these people and institutions I am greatly indebted and extend my sincerest thanks. Above all, I am grateful to the people of Waigeo, the village authorities and landowners who granted permission to trespass traditionally owned land, and especially the more than 20 field assistants who contributed immensely to the results presented here, and made this project both a successful and enjoyable one.

## References

Anonymous (2000). *Perubahan status sebagian kawasan hutan Cagar Alam Waigeo Barat [Status change of a part of the forest area West Waigeo Nature Reserve.].* Technical Paper, BKSDA Sorong.

Anonymous, (2001). Long-lost bird raises its head. *Science* **291**:2309.

Anonymous, (2002a). Bruijn's Brush-turkey seen. *World Birdwatch* **24**:5.

Anonymous, (2002b). Observations of Bruijn's Brush-turkey *Aepypodius bruijnii* on Waigeo, Papua. *OBC Bulletin* **36**:40–41, 49.

BirdLife International, (2000). *Threatened birds of the world.* Lynx Edicions and BirdLife International, Barcelona and Cambridge.

BirdLife International, (2001). *Threatened Birds of Asia: The BirdLife International Red Data Book.* BirdLife International. Cambridge.

Birks, S. M. & Edwards, S. V. (2002). A phylogeny of the megapodes (Aves: Megapodiidae) based on nuclear and mitochondrial DNA sequences. *Molecular Phylogenetics and Evolution* **23**:408–421.

Dekker, R. W. R. J. (2000). News about Bruijn's Brush-turkey and Waigeo. *Megapode Newsletter* **14**:7–8.

Dekker, R. W. R. J. (2002). *Boshoen.* NRC Handelsblad 6 juli 2002.

Dekker, R. W. R. J. (2003). *Megapode Specialist Group: Mounds "all over the place". In: The World Pheasant Association Review 2002/3. A report on the activities of the World Pheasant Association.* WPA, Fordingsbridge.

Dekker, R. W. R. J. & Argeloo, M. (1993). Bruijn's Brush-turkey *Aepypodius bruijnii* remains a mystery. *Megapode Newsletter* **7**:15–17.

Dekker, R. W. R. J. & McGowan, J. K. (1995). *Megapodes: An action plan for their conservation 1995–1999.* WPA/BirdLife/SSC Megapode Specialist Group. Gland, Switzerland, Cambridge and Reading, U.K.: IUCN and World Pheasant Association.

Dekker, R. W. R. J., Fuller, R. A. & Baker, G. C., Eds. (2000). *Megapodes: Status survey and conservation action plan 2000–2004.* WPA/BirdLife/SSC Megapode Specialist Group. Gland, Switzerland, Cambridge and Reading, U.K.: IUCN and World Pheasant Association.

De Schauensee, R. M. (1940). Rediscovery of the megapode, *Aepypodius bruynii. Auk* **57**:83–84.

Diamond, J. M. (1985). New Distributional records and taxa from the outlying mountain ranges of New Guinea. *Emu* **85**:65–91.

Diamond, J. (1986). *Proposed studies of conservation problems on the western Papuan islands (Raja Ampat Islands), Irian Jaya.* World Wide Fund for Nature Indonesia. Unpublished Report.

Donnelly, R., Neville, D. & Mous, P. J. (Eds.) (2003). *Report on a rapid ecological assessment of the Raja Ampat Islands, Papua, Eastern Indonesia, held October 30 – November 22, 2002. Final Draft November 2003.* The Nature Conservancy - Southeast Asia Center for Marine Protected Areas, Bali.

Frith, C. B. & Beehler, B. M. (1998). *The Birds of Paradise Paradisaeidae.* Oxford Univesity Press. Oxford.

Greenway, J. C. Jr. (1966). Birds Collected on Batanta, off Western New Guinea, by E. Thomas Gilliard in 1964. *Amer. Mus. Novit*. **2258**:1–27.

Heij, C. J. & Post, J. N. J. (2001). Bruijn's Brush-turkey *Aepypodius bruijnii* rediscovered on Waigeo. *Megapode Newsletter* **15**:2–5.

Hermanto, (2007). Bruijn's Brush-turkey *Aepypodius bruijnii*:
uplist to Endangered? BirdLife International Globally Threatened Bird
Forums, accessible from
http://www.birdlifeforums.org/WebX?50@164.PEEeaSIadBO.0@.2cba57d4

IUCN, (2001). *IUCN Red List Categories and Criteria: Version 3.1.* IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.

Jones, D. N. (1990a). Male mating tactics in a promiscuous megapode: patterns of incubation mound ownership*. Behav. Ecol*. **1**:107–115.

Jones, D. N. (1990b). Social organisation and sexual interactions in Australian brush-turkeys (*Alectura lathami*): implications of promiscuity in a mound-building megapode*. Ethology* **84**:89–104.

Jones, D. N., Dekker, R. W. R. J. & Roselaar, C. S. (1995). *The Megapodes Megapodiidae.* Oxford University Press. Oxford.

Marchant, S. & Higgins, P. J. (Eds.) (1993). *Handbook of Australian, New Zealand & Antarctic Birds. Volume 2: Raptors to Lapwings.* Oxford University Press, Melbourne.

Masinambouw, E. K. M. (Ed.) (1983). *Halmahera dan Raja Ampat sebagai Kesatuan Majemuk [Halmahera and Raja Ampat as a Multiple-Unity].* LIPI-LEKNAS, Jakarta.

Mauro, I. (2002). Stop Press! 08/06/02 Bruijn's Brush-turkey *Aepypodius bruijnii* for the first time observed in the wild*. Megapode Newsletter* **16**:2–3.

Mauro, I. (2003). Viable population of Bruijn's Brush-turkey *Aepypodius bruijn*ii discovered*. Megapode Newsletter* **17**:1.

Mauro, I. (2004). *The field discovery, ecology, monitoring and conservation of an enigma: Bruijn's Brush-turkey Aepypodius bruijnii Oustalet 1880.* Final report to Van Tienhoven Foundation for International Nature Protection and WPA/BirdLife/SSC Megapode Specialist Group.

Mauro, I. (2005). Field discovery, mound characteristics, bare parts, vocalisations and behaviour of Bruijn's Brush-turkey, *Aepypodius bruijnii. Emu* **105**:273-281. doi: 10.1071/MU04052.

Mauro, I. (2006). Habitat, microdistribution and conservation status of the enigmatic Bruijn's Brush-turkey *Aepypodius bruijnii. Bird Conservation International* **16**:279-292. doi: 10.1017/S0959270906000372.

Mauro, I., Wonggor, Z., & Wijaya, L. (in prep.). *Nest predation by Wild Boar Sus scrofa in the Bruijn's Brush-turkey Aepypodius bruijnii.*

Mayr, E. & Diamond, J. M. (2001). *The Birds of Northern Melanesia. Speciation, ecology and biogeography.* Oxford University Press. New York.

Moeliker, C. W. (2002a). *Gered uit de kookpot.* NRC Handelsblad (Achterpagina) 9 September 2002.

Moeliker, C. W. (2002b). DB Actueel: Bruijn's Brush-turkey comes to life*. Dutch Birding* **24**:323–324.

Moeliker, C. W. (2002c). Bruijn's Boshoen komt tot leven*. Straatgras* **14**:26.

Moeliker, C. W., Heij, C. J., Post, J. N. J. & Kompanje, E. J. O. (2003). A new, a forgotten and a lost specimen of Bruijn's Brush-turkey *Aepypodius bruijnii. Megapode Newsletter* **17**:2–8.

Oustalet, E. (1880). *Monographie des oiseaux de la famille des Mégapodiidés.* Bibliothèque de l'Ecole des Hautes Etudes 22(5).

Paijmans, K. (Ed.) (1976). *New Guinea vegetation*. CSIRO and Australian National University Press, Canberra.

Peters, J. L. (1934). Check-list of birds of the world. Volume 2. Harvard University Press, Cambridge.

Post, J. N. J. (2001). De herontdekking van het Bruijn's Boshoen *(Aepypodius bruijnii). Straatgras* **13**:2–7.

Proctor, J. (2003). Vegetation and soil and plant chemistry on ultramafic rocks in the tropical Far East. 6: *Perspectives in Plant Ecology, Evolution and Systematics* **6**:105-124.

Rand, A. L. & Gilliard, E. T. (1967). *The handbook of the New Guinea birds.* Weidenfeld & Nicolson. London.

Ripley, S. D. (1960). Distribution and niche differentiation in species of megapodes in the Moluccas and Western Papuan area*. Acta XII Congressus Internationalis Ornithologici* **1**:631–640.

Rosenberg, M. S. (2001). PASSAGE. Pattern Analysis, Spatial Statistics, and Geographic Exegesis. Version 1.1.1.3. Department of Biology, Arizona State University, Tempe, AZ.

Rothschild, W., Stresemann, E. & Paludan, K. (1932). Ornithologische Ergebnisse der Expedition Stein 1931-1932*. Novit. Zool*. **28**:127–247.

Silzer, J. P. & Clouse, H. H. (1991). *Index of Irian Jaya Languages.* Uncen and SIL, Jayapura.

Sinclair, J. R. (2001). Temperature regulation in mounds of three sympatric species of megapode (Aves: Megapodiidae) in Papua New Guinea: testing the 'Seymour Model*. Australian Journal of Zoology* **49**:675–694.

Sinclair, J. R. (2002). Selection of incubation mound sites by three sympatric megapodes in Papua New Guinea*. The Condor* **104**:396–406.

Stattersfield, A. J., Crosby, M. J., Long, A. J. & Wege, D. C. (1998). *Endemic Bird Areas of the world: priorities for biodiversity conservation.* BirdLife International. Cambridge.

Takeuchi, W. (2003). *An Ecological Summary of the Raja Ampat Vegetation. In: Donnelly R., Neville, D. and Mous P. J. (Eds.). Report on a rapid ecological assessment of the Raja Ampat Islands, Papua, Eastern Indonesia, held October 30 – November 22, 2002. Final Draft November 2003.* The Nature Conservancy - Southeast Asia Center for Marine Protected Areas, Bali.

van Royen, P. (1960). Sertulum Papuanum 3. The vegetation of some parts of Waigeo Island*. Nova Guinea*, *New Series, Bot*. **10**:25–62.

Voisin, C., Voisin J-F., Somadikarta, S. & Dekker, R. W. R. J. (2000). Six overlooked specimens of Bruijn's Brush-turkey *Aepypodius bruijnii* (Oustalet, 1880)*. Bull. B.O.C.* **120**:146–148.