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Forum Essay

The context and potential sustainability of traditional terrestrial periodic *tambu* areas: insights from Manus Island, Papua New Guinea

Nathan Whitmore[A,E], *John Lamaris*[A], *Wallace Takendu*[A], *Daniel Charles*[A,B], *Terence Chuwek*[C], *Brian Mohe*[D], *Lucas Kanau*[D] *and Stanley Pe-eu*[D]

[A]Wildlife Conservation Society Papua New Guinea, PO Box 277, Goroka, Eastern Highlands Province, Papua New Guinea.
[B]Tipu-u Clan, Sohoniliu, Manus Province, Papua New Guinea.
[C]Welei Clan, Lehewa, Manus Province, Papua New Guinea.
[D]Lahok Clan, Tulu 2, Manus Province, Papua New Guinea.
[E]Corresponding author. Email: nwhitmore@wcs.org

Abstract. Within the Pacific over the last two decades there has been greater recognition of the pre-existing tools within indigenous communities for natural resource management. Periodic *tambu* (Tok Pisin: a prohibition) is an indigenous resource management tool often used across Papua New Guinea. On Manus Island terrestrial periodic *tambu* areas are characterised by a cycle of resource closure followed by instantaneous harvest. We examine the differing application of periodic *tambu* areas by three different clans who are using the technique to restock areas with the Admiralty cuscus (Phalangeridae: *Spilocuscus kraemeri*), an arboreal possum-like marsupial. We examined the plausibility of cuscus population recovery over differing closure periods at three different harvest rates using a composite female-only population projection matrix approach based on the vital rates of closely related phalangerid surrogates. The resultant trajectories suggest that commonly used closure durations may allow recovery at low to medium harvest rates (10–30%) but not at high harvest rates (50%). From this we infer that periodic *tambu* areas may be a sustainable strategy for customary resource use of Admiralty cuscus at low to medium harvest rates. We found periodic *tambu* management on Manus Island to be culturally dynamic with clans differing with respect to their purpose, adherence to tradition, and hybridisation with modern land governance practices. Given the past difficulties of imposing exogenous conservation systems in Papua New Guinea, we advocate greater exploration of the merits of endogenous systems such as periodic *tambu* areas.

Additional keywords: harvest, matrix, Melanesia, population, taboo, traditional management.

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Introduction

Protected areas are a western paradigm of conservation built on the concept of wilderness, a landscape unfettered by, and not occupied by, humans (Brockington *et al.* 2010; Dowie 2011). In Papua New Guinea (PNG) many communities maintain a subsistence lifestyle in which much of their protein and other requirements are derived directly from the species inhabiting the forest (Mack and West 2005). Virtually all the land, much of it forested (~280 000 km^2: Laurance *et al.* 2012) remains under customary ownership (potentially as high as 97%: Cooter 1991). Despite this, PNG has 14 720 km^2 of formally registered terrestrial protected areas (Independent State of Papua New Guinea 2014).

Shearman *et al.* (2008) suggested that in PNG neither the formal protected area system nor local efforts to combine conservation and resource-based development have safeguarded forest resources. Many of these protected areas were set up as Integrated Conservation and Development Projects (ICDPs) with dual objectives of delivering development to communities and protecting biodiversity. The only protected areas and regionally managed biodiversity ICDP projects that have been critiqued in detail have been the Lak area of New Ireland (Ellis 1997), Crater Mountain Wildlife Management Area (West 2006; West and Kale 2015), and a marine conservation initiative in the Milne Bay area (Dowie 2011; Balboa 2014). While the approaches of these projects differed they all shared one common characteristic: a difficulty in coupling the culture of a large-scale conservation project with that of local resource-dependent communities.

It could be argued that alternative models of use limitation that operate at smaller scales and/or do not permanently curtail resource use may be a better fit for PNG and other countries in

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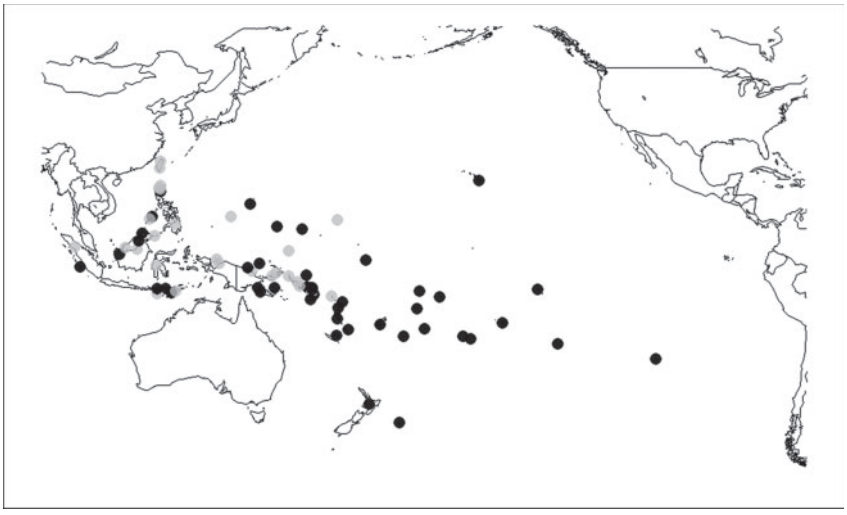

Fig. 1. Distribution of resource taboos in Austronesian cultures based on historic records (presented with permission from Pulotu database of Pacific religions (https://pulotu.shh.mpg.de/): Watts *et al.* 2015). Key: black dots = resource taboo present, grey dots = true absence.

Melanesia. Such models include the use of size or bag limits, controls on hunting equipment and techniques, seasonal closures, land-use mosaics (e.g. hunting blocks and reserve areas), payment for ecosystem services (e.g. Reducing Emissions from Deforestation and forest Degradation (REDD+)), and certification programs (adhering to a series of rules aimed at achieving sustainability). While these methods may be more conducive to local needs in that the use of resources is controlled rather than prohibited (and in the case of certification and REDD+ programs, financially compensated) they do not avoid the issue that the system is still likely to be imposed on the community rather than originating from it.

Traditional natural resource management

Over the last two decades there has been a growing recognition of traditional knowledge and practices relating to natural resource management used by indigenous communities in the western Pacific (e.g. Kitson and Moller 2008; Sinclair *et al.* 2010; Cohen *et al.* 2013). Perhaps most prominently, New Zealand Māori concepts of *rahui* (temporary closure), *tapu* (spiritual prohibition), *taiāpure* (customary fisheries), and *mātaitai* (exclusive customary fishing areas) have been enshrined in New Zealand national legislation, i.e. *Resource Management Act 1991*, and *Fisheries Act 1996* (e.g. Mise 2006; Kallqvist 2009).

In PNG there is a similarly culturally rooted concept of *tambu* (Tok Pisin: a prohibition) which is used broadly to represent periodic closure as well as customary, social and spiritual prohibitions. On occasion, a community or landowner will place a *tambu* on a resource to prohibit resource extraction. Such periodic resource taboos were historically widespread amongst the Austronesian cultures of the Pacific (Watts *et al.* 2015) (Fig. 1). In many places these practices remain active and are increasingly being investigated as a basis for sustainable resource management, especially with regard to fisheries (e.g. Cohen *et al.* 2013; Jupiter *et al.* 2014).

In PNG genealogical relationships are paramount and land rights are determined by culturally specific systems of patrilineal or matrilineal descent (Chand and Yala 2009). Land rights are vigorously protected and constantly challenged. Tribal warfare resulting from land disputes is not uncommon in the highlands of the mainland (Mathew 1996). On Manus Island, a heavily forested 1900-km^2 island to the north of the Papua New Guinean mainland (Fig. 2), it is usual that only small parcels of land remain undisputed (typically 5–30 ha). Consequently, it is these that become designated as periodic *tambu* areas typically to assist in restocking a resource or to fulfil a specific future cultural obligation.

The Admiralty cuscus

As there are few large animals in PNG forests a disproportionate share of the indigenous diet comes from a limited number of relatively small wild game (Mack and West 2005; Cuthbert 2010). Consequently, the comparatively large-bodied (typically 2–7 kg) spotted cuscuses (Phalangeridae: *Spilocuscus*), a genus of nocturnal generalist frugivore–folivore marsupials endemic to the tropical Australo-Papuan region (Helgen and Flannery 2004), are often sought after by hunters. Scientific knowledge, however, regarding the biology, life history, and ecology of the spotted cuscuses is scant (Tyndale-Biscoe 2005).

Since 2010 the Wildlife Conservation Society (WCS) of Papua New Guinea has been undertaking research on the Admiralty cuscus (*Spilocuscus kraemeri*), the smallest of the spotted cuscuses (adult weight: 2–4.5 kg). The Admiralty cuscus is endemic to the Bismarck archipelago, with the only confirmed populations recorded from the Admiralty Islands (Helgen and Flannery 2004), of which Manus Island is the largest. Archaeological evidence from Manus Island shows that prehistoric hunting of the Admiralty cuscus occurred as early as 11 000 years ago (Williams 1999). Currently, the cuscus has been classified as Near Threatened on the IUCN Red List (Helgen *et al.* 2008) on the basis of overhunting and habitat degradation.

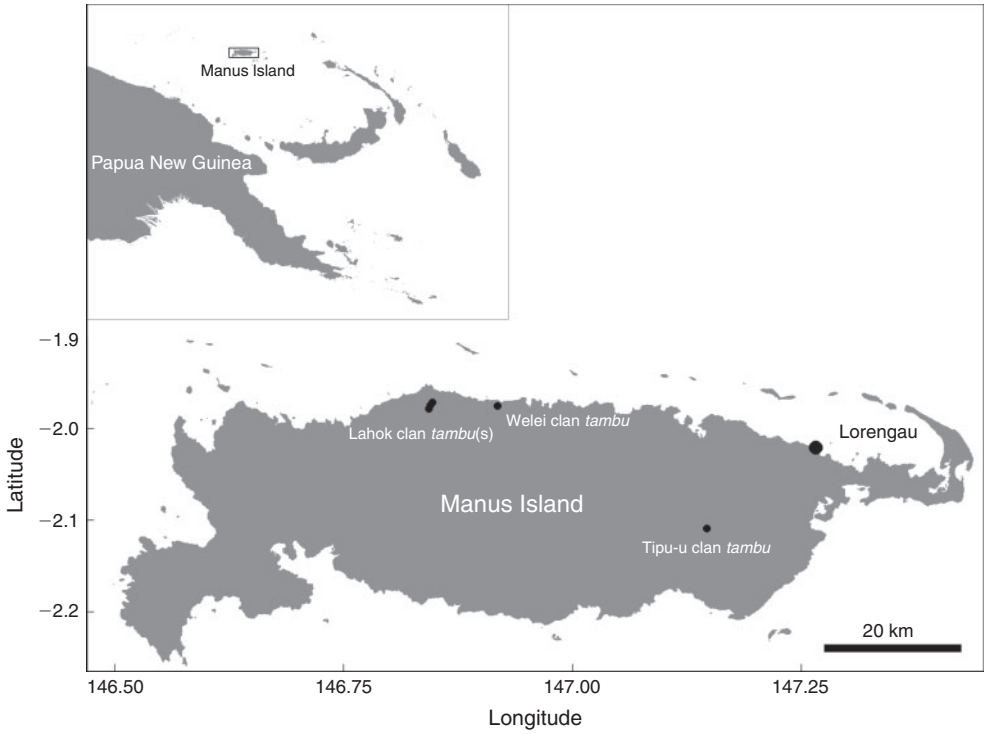

Fig. 2. Location of periodic *tambu* areas referenced on Manus Island, Papua New Guinea.

On Manus Island the cuscus is the largest game animal and is still considered a staple food source, but is also often expected to be presented at ceremonial occasions including payment of 'bride price', and at a mourning ceremony held 1000 days after a death. Traditionally, periodic *tambu* areas were commonly instigated in advance of such ceremonies in order to build up harvestable numbers of cuscus.

Here we examine the differing approaches clans take to the periodic *tambu* system for sustaining the Admiralty cuscus on Manus Island (as outlined by the resource owners themselves), the plausibility of the sustainability of the resource given reported harvesting frequencies and recovery intervals, as well as issues regarding the influence of external actors, ownership, risk, and the supernatural.

Three approaches to the periodic *tambu* system

The traditional approach: Welei clan

The Welei Clan of Lehewa village on the north coast of Manus Island have been operating a periodic *tambu* area according to traditional practices. Currently, they have a 26-ha forested periodic *tambu* area (Fig. 2). The periodic *tambu* area was most recently opened by the late Charles Chuwek on 31 May 2013 to commemorate a 1000-day mourning period. After 18 cuscus were collected on a single day from in and around the *tambu* area (13 within, 5 outside) it was closed again.

Terence Chuwek is now the custodian of the Welei *tambu* following the death of Charles Chuwek (his father and village elder), from whom he learnt the necessary customs and rituals. The process of *tambu* establishment by the Welei clan follows the following protocol: an intention marker is placed on the provisional boundary, which carries the symbolic representation of the body of the cuscus and tools of cuscus hunting; the clan meets and discusses the purpose of the area; if there is consent, food is prepared, and the food is then shared with neighbours to proclaim the existence of the *tambu* area; clan members then perform a ritual to commune with their ancestors and invoke spiritual protection over the area; clan and family members walk the boundary and plant tanget (*Cordyline* spp.) as a demarcation marker, after which food is shared at the *hausboi* (a house dedicated to clan affairs); finally, sometime later a letter is distributed to other clans informing them of the area's status.

The penalties for breaking the *tambu* are illness and misfortune coming as a result of transgression against the supernatural. Indeed, Charles Chuwek recounted to WCS an instance in which a sick man from a neighbouring community confessed to poaching cuscus from the Welei *tambu* after he became fearful for his health. The man sought Chuwek's help in resolving the issue and sometime after the appropriate rituals were conducted the man recovered.

In 2012 Charles Chuwek invited WCS to study his clan's periodic *tambu* area. Chuwek's stated motivation was that he wanted the input of science to help ensure the sustainability of his clan's environment for the future. WCS were motivated to study the periodic *tambu* area because they believed it would allow the investigation of traditional management – a waning custom, and allow monitoring of an infrequently harvested cuscus population. At no point did WCS wish to influence the purpose of the Welei *tambu*. However, when the periodic *tambu* area was closed on 1 June 2013 by Charles Chuwek it was for an envisaged 5-year term with the specific purpose of providing WCS with a place to study cuscus. During a later 2015 visit by

WCS, when asked whether the family would open the *tambu* area for the 1000-day commemoration of Charles Chuwek's death, the answer was that no discussion of opening the *tambu* had taken place with him and consequently the elder's initial wishes stood with regard to the use of the area.

In the same 2015 visit WCS sought to establish a control site for the Welei *tambu* that was open to hunting so that a comparative assessment of Admiralty cuscus density between a managed and unmanaged area could be made. However, when the landowner of the comparative parcel of forest was approached, he decided, during the meeting, to turn the forest into an 18-ha *tambu* area, citing concerns over declining harvests. A provisional boundary for the new periodic *tambu* area was subsequently marked the next day.

A hybrid traditional-moratorium approach: Lahok clan

In 2014 the Lahok clan (along with other clans) of the Tulu 2 village entered into a conservation agreement with WCS, under which they would set in place a two-year commercial logging moratorium and a land-use plan on a 6589-ha parcel of forest (of which 567 ha belonged to Lahok) in return for predetermined community-wide benefits (i.e. a footbridge and water tanks). The conservation agreement was a good-faith, non-binding agreement. Three families within the Lahok clan then, without any engagement from WCS, extended the moratorium to include hunting of the cuscus for three adjacent blocks within the conservation agreement area and the forest area in between (to date only two blocks have been measured: 5 ha and 7 ha) for the duration of the conservation agreement (Fig. 2). The Lahok clan put the moratorium on hunting cuscus because the area also had historically been the prime hunting area before 1990, and they perceived the number of cuscus inhabiting the area to have declined substantially. The Lahok clan of Tulu 2 considered their use of a moratorium on hunting a revival of the traditional *tambu* practice, which began to fall into disuse around the 1950s, and was last active in 1994, when a block was closed for a three-year period to assist in a bride price payment. They, however, saw no need to invoke the traditional spiritual protection, believing that their blood ties to the land were sufficient to provide the necessary social deterrent.

A legally enshrined approach: Tipu-u clan

The Tipu-u clan's periodic *tambu* area (Fig. 2) was first established sometime around 2010. Daniel Charles is one of two clan heads who oversee the area of 13 ha. The impetus behind the establishment of the area came about over community concerns over dwindling forest resources, including both timber and animals. Like the Welei *tambu* the Tipu-u clan periodic *tambu* area boundary was delineated by markers denoting prohibitions against the hunting of cuscus, and has been bestowed with spiritual protection through traditional ceremony. The population of cuscus in the Tipu-u *tambu* was also being augmented by the occasional translocation of bought or captured cuscus into the area. The Tipu-u clan's *tambu* is perpetual with no termination date, but is opened on 31 December each year for one day of hunting to provide meat for a special New Year's meal (Daniel Charles recounted that 19 cuscus were caught over a period of three hours by 16 hunters in 2014 before the *tambu* was closed again). While this periodic *tambu* area is not opened to commemorate mourning periods two other *tambu* areas within the same village are. As a result of the activity of a non-government organisation (NGO), The Nature Conservancy, engaging with the Tipu-u clan, a land-use plan has been developed in which the periodic *tambu* area's role and boundary have been recognised. Six signboards have been erected around the wider area to warn other neighbouring communities of the regulation of the forest and prohibitions being enforced. The Tipu-u clan is currently in the process of getting its land-use management plan ratified by the Local Level Government and passed into law. Under such a law poachers will face an initial warning penalty involving community service, but after three warnings will be taken to court. Charles sees this as a necessary step as he sees the traditional management practices waning, and believes the customary laws are not being respected as a consequence of modern culture undermining the authority of the clan leaders.

Plausibility of sustainability

Periodic *tambu* areas are not perpetual reserves, nor are they subject to a prolonged hunting season, but rather they are characterised by a long cycle of closure followed by an instantaneous harvest. Understanding the rate of recovery from an instantaneous harvest is clearly imperative to determine the efficacy of the periodic *tambu* area as a management technique. Population projection matrices provide a method of determining such viability analytically (Caswell 2001). While scientific studies on the Admiralty cuscus are currently in their infancy, with good estimates of survival and reproductive rates (that would be required to accurately assess the effectiveness of the periodic *tambu* areas) several years away, good surrogates do exist in the phalangerid literature. While we are cognisant that the use of surrogate rates is less than ideal they can be used to develop hypothetical population trajectories under differing harvesting intensity and frequency regimes.

We used surrogate survival rates derived from the closely related brush-tailed possum *Trichosurus vulpecula* on the basis of it being a comparable sized (1.5–4 kg) arboreal phalangerid occupying a similar generalist folivore niche (including tropical habitats) (Menkhorst and Knight 2011) and the closest related species for which survival rates were available. We derived surrogate female survival values for adults (S_a) and juvenile (S_j) of 0.82 and 0.65, respectively, from adult and yearling seasonal rates reported by Efford (1998) for a detailed New Zealand–based study. These derived rates closely mirrored the female age-specific survival rates obtained by Isaac (2005) for brush-tailed possum from a tropical Australian study. We constructed a female-only two-stage matrix no-migration model (**A**) based on the life history of *Spilocuscus maculatus*, a congener of which *S. kraemeri* was long considered to be a subspecies (Helgen and Flannery 2004), under the assumption of one year to maturity, and a single birth annually (Sinery *et al.* 2013). We then back-calculated the adult fecundity (F_a) to ensure that the dominant eigenvalue of the matrix **A** matched the population growth rate described by Sinery *et al.* (2013) for a translocated *S. maculatus* population (equivalent to 14.4% annual population growth over an interval of four years from last introduction 2008−12).

We assumed that the introduced population of Sinery *et al.* (2013) had a stable-state age distribution and that no mortality occurred from a prior translocation in 2007. This led to a fecundity rate estimate of 0.58.

To estimate the possible recovery rates of a harvested population inside a periodic *tambu* area we constructed a harvest matrix ($\mathbf{H}_m$) for each of three proportionate rates of instantaneous harvest mortality (where $h_m = 0.5$, 0.3 and 0.1):

$$\mathbf{H}_m = \begin{bmatrix} 1 - h_m & 0 \\ 0 & 1 - h_m \end{bmatrix}$$

The simulated harvest was then followed by a recovery interval (i) of 1–8 years of unharvested population growth based on our surrogate two-stage population projection matrix ($\mathbf{A}$):

$$\mathbf{A} = \begin{bmatrix} 0 & F_a \\ S_j & S_a \end{bmatrix}$$

The overall population growth rate within each interval at a particular harvest mortality rate was then calculable as the dominant eigenvalue (λ) of the resultant matrix ($\mathbf{G}_{im}$):

$$\mathbf{G}_{im} = \mathbf{A}^i \mathbf{H}_m$$

The value of λ indicates the expected proportionate growth rate of the population: $\lambda < 1$ indicates that the population would not be expected to recover from the harvest given the recovery interval, $\lambda = 1$ indicates that the population has recovered back to its preharvest baseline, $\lambda > 1$ indicates that the population has grown beyond its baseline.

The population projection matrix mathematics were undertaken in Program R ver. 3.1.2 (R Core Team 2014) with additional functionality from package 'popbio' (Stubben and Milligan 2007).

The resulting graphical representation of the three instantaneous harvest mortality rates (Fig. 3) suggests that harvest rates of 10% or less should be sustainable on an annual basis, while harvest rates of 30% would require a recovery period nearing three years. Larger harvests of 50% would require a recovery period of more than 5 years. Such an outcome suggests that the annual harvest conducted by the Tipu-u clan could be sustainable in their *tambu* area so long as the harvest rate does not exceed 10%. Similarly, the sustainability of the harvests for the 1000-day Manusian mourning ceremony in such areas (e.g. the Welei clan's 2013 harvest) appear plausible if not more than ~30% of the population is harvested and the area is maintained in a perpetual cycle of periodic *tambu*.

While a surrogate fecundity rate of 0.58 appears high for an annual breeder reported with an assumed birth-pulse dynamic we have found that, contrary to speculation of a July–August annual breeding cycle (Flannery 1995), small naked pouch young have been found throughout the year whenever Admiralty cuscus have been sampled (i.e. March, June, September, November, and December: WCS unpubl. data). Consequently, the Admiralty cuscus would appear to have a birth-flow dynamic that results in higher fecundity rates rather than birth-pulse dynamics (Caswell 2001). Additionally, testimony of local hunters and the observations of Cohn (1914) that the Admiralty cuscus has a skewed sex ratio in favour of females are now backed up by a canopy camera trapping study (sex ratio ~60 : 40: WCS unpubl. data). Combined, these life-history characteristics would be expected to result in a high fecundity rate.

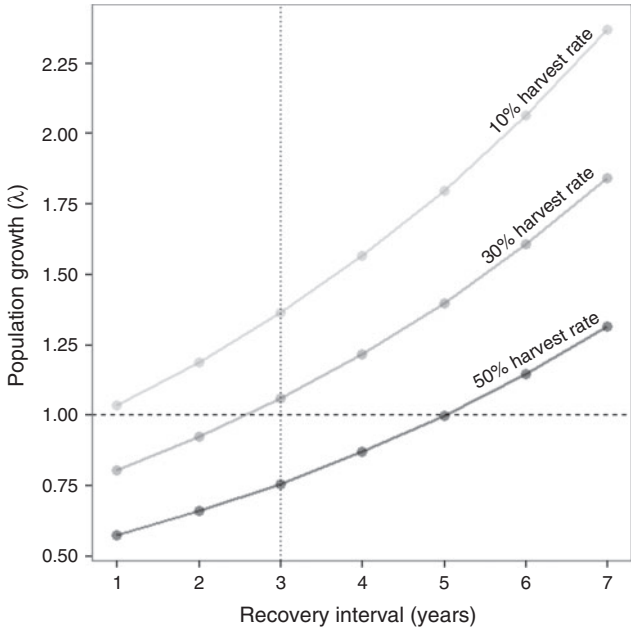

Fig. 3. Predicted variation in population growth (λ) with recovery interval since harvest for three harvest rates. Key: dashed horizontal line = threshold for sustainability, dotted vertical line = expected recovery after three years.

The influence of external actors

It is clear from the examples above that while the core motivation of the clans is similar, the periodic *tambu* system itself is culturally dynamic and across Manus Island it exhibits differing characteristics regarding purpose, adherence to tradition, and hybridisation with modern land governance practices. Furthermore, the existence and creation of periodic *tambu* areas is being influenced, often entirely inadvertently, by the presence of NGOs (including WCS). In some instances while NGOs are acting as a catalyst (reinforcing widespread and preheld concerns about the decline of Admiralty cuscus) it is highly likely that in some situations they are being engaged because a clan wishes to strengthen their relationship with an agency that is seen as having the potential to bring opportunity and development (*sensu* Novotny 2010). This interplay suggests that attempts by outside agencies (such as NGOs) to understand the cultural aspects of the periodic *tambu* system without influencing them may not be particularly realistic. Consequently, outside agencies (like WCS) need to be cognisant of this conundrum and the often counter-initiative impact they may have on local culture.

Despite the growing recognition of traditional practices in sustainable resource management, feedback received by WCS suggests that there is a Papua New Guinean contingent of staff

within donor agencies (tasked with development in PNG) who see the use of traditional management techniques and reliance on wildlife as food as backward and anachronistic, and advocate adoption of western approaches to land and food management (echoing the 'cultural cringe' in Melanesia identified by Foale 2006). Such actors are in a particularly strong position to influence the funding of projects and potentially could curtail practical conservation initiatives founded on traditional natural resource management.

True local ownership of conservation

Mandatory local participation in donor-driven conservation projects is now the norm. Sayer and Wells (2004), however, point out that, in practice, 'ownership' of projects by local people most commonly means an external organisation trying to convince communities to participate in, or at least not oppose, prearranged project activities (determined by institutional agendas) in which they have had little or no input. One alternative model could seek to build upon pre-existing mechanisms within local communities that regulate environmental use, and are administered by the local communities themselves (mirroring the locally managed marine area concept *sensu* Jupiter *et al.* 2014). An extensive network of small-scale periodic *tambu* areas born from motivated communities could well be more effective and face fewer hurdles than establishing equivalent-sized terrestrial protected areas, or ICDP projects in PNG. We hypothesise that the most critical aspect underpinning the compliance of conservation programs in PNG will be whether or not the inception of the program was of endogenous (local) origin.

Customary practice versus cuscus population dynamics

A review by Foale *et al.* (2011) surmised that in Melanesia customary marine tenure and fishing taboos are primarily designed to manage relationships between social groups, and that Melanesian fishing taboos typically follow social cycles, which bear no obvious relation to the population dynamics of fisheries. Similarly, periodic terrestrial *tambu* areas can only function as a sustainable management tool when the life-history characteristics of the population of the particular species they are set up to safeguard are sufficiently matched with the patterns of use to allow recovery from harvest within the timeframes of the social cycle. Our hypothetical trajectories, however, suggest that production dynamics of the Admiralty cuscus could be expected to show potential compatibility with the *tambu* management technique albeit at low to medium harvest rates.

Recent research on Admiralty cuscus (WCS, unpubl. data) also suggests a degree of ecological compatibility with periodic *tambu* management in that recorded home ranges are small (typically <2 ha), stable, and overlapping. However, the efficacy of periodic *tambu* areas will remain largely speculative until detailed empirical data are gathered.

A low-risk conservation investment

In order to gain empirical data WCS launched a transponder-based mark–recapture hunter-recovery study in November 2015 to estimate rates of harvest, dispersal and population growth, as well as survival and reproduction. While the reliance on surrogate values has been criticised in assessments of hunting sustainability for PNG (e.g. Sinclair *et al.* 2012), obtaining accurate estimates of life-history parameters takes many years. Such a scenario, however, should not preclude the development of interim management initiatives based around periodic *tambu* areas, as the fundamental question is about the magnitude of effectiveness rather than concerns over the possibility of a deleterious outcome. Given that periodic *tambu* management is essentially the only pre-existing management alternative to a widespread *laissez faire* approach, the only foreseeable negative scenario would be one in which hunting effort remains the same but is simply transferred to other geographic locations (sometimes referred to as 'leakage', *sensu* Ewers and Rodrigues 2008). Clan-based land tenure in Manus restricts the spatial extent of such leakage, but if periodic *tambu* management was to become standard management an increase in interclan poaching may be anticipated.

Reconciling the supernatural

Supernatural beliefs in Manus, as across much of Papua New Guinea, are widely held (Pauka *et al.* 2005). The compliance power of periodic *tambu* areas is routed in the foundation of this belief system despite Christian indoctrination. Supernatural and religious beliefs underpin many explanations of natural phenomenon in PNG (e.g. Pauka *et al.* 2005). Despite this, many Manusian villagers identify the magnitude of hunting, village population growth, and access to modern hunting equipment as the causative agents resulting in the observed decline of the Admiralty cuscus.

We view it as unwise and potentially counterproductive for outside conservation organisations to try to actively reconcile scientific knowledge with a customary supernatural belief system that is the foundation of a potentially effective management system. As a result, we have opted for a tacit approach in which the landowners of the periodic *tambu* areas gather data on transponder-marked animals in a participatory hunter-return study. Not only should this be a cost-effective way of gathering life-history data but we postulate that villager interpretation of the data will feedback into the management of the periodic *tambu* area. How, and to what extent, their management actions will incorporate supernatural beliefs and science is unclear, but ultimately only the customary landowners and right-holders of Manus have the ability to control the harvest of the Admiralty cuscus and the fate of its habitat.

Conclusion

We suggest that while much of the recent conservation commentary over the last two decades in PNG has revolved around the relative merits of ICDP, protected area, and payment for ecosystem service models, the potential effectiveness of active endogenous systems of resource management in terrestrial systems have been largely overlooked. Given the difficulties of imposing exogenous conservation systems in PNG, we suggest that endogenous systems need to be given serious attention as alternatives before the customs themselves wane out of existence.

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