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Native forest management in Papua New Guinea: advances in assessment, modelling and decision-making

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2011

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Fox J.C., Keenan R.J., Brack C.L. and Saulei S. (eds) 2011. Native forest management in Papua New Guinea: advances in assessment, modelling and decision-making. ACIAR Proceedings No. 135. Australian Centre for International Agricultural Research: Canberra. 201 pp.

ACIAR Proceedings - ISSN 1038-6920 (print), ISSN 1447-0837 (online)

ISBN 978 1 921962 10 3 (print)

ISBN 978 1 921962 11 0 (online)

Technical editing by Mason Edit, Adelaide, Australia

Design by Clarus Design Pty Ltd, Canberra, Australia

Printing by Blue Star Print

Cover: Large-scale harvesting offers temporary employment for communities, but monetary returns to the community and ongoing benefits can be limited.

(Photo: Joe Pokana)

Assessing the importance of local biodiversity to communities in Madang province, Papua New Guinea

Dalia Bastyte^{1*}, Julian C. Fox² and Brandon P. Anthony³

Abstract

The biodiversity of Papua New Guinea's tropical rainforests is utilised by local communities in diverse and often unrecognised ways. Aside from the high commercial value of some rainforest trees, forests provide a number of other goods and services to these communities that are more difficult to quantify; for example, construction, food, medicinal, spiritual, ornamental and recreational values. In addition to being of importance to livelihoods, the forests of Papua New Guinea are among the world's most biodiverse; hence, their valuation, and recognition by local communities, may contribute to their preservation. Our research was carried out in two villages (Yagi and Ohu) in Madang province. The relative value of different components of biodiversity for villagers was estimated according to the pebble distribution method, based on village and gender. The focus groups attributed the highest value for wild plants, in comparison with cultivated plants, wild animals and domestic animals. Interestingly, Ohu focus groups valued wild plants from forests significantly higher than Yagi focus groups. However, there were no significant differences between the opinions of men's and women's focus groups from Ohu and Yagi. Yagi focus groups named 57 taxa as the most important, including *Casuarium* spp. and *Licuala lauterbachii* as those used most commonly. Out of 40 taxa identified by Ohu focus groups, three species (*Pterocarpus indicus*, *Gnetum gnemon* and *Intsia bijuga*) were considered the most valuable, and had a combined relative importance higher than 6%. Some species identified as valuable are common, while others are classified as threatened. Information on rare or threatened biodiversity should be communicated to villagers, coupled with the development of options for sustaining indigenous livelihoods that limit the exploitation of rare local biodiversity.

Introduction

The global value of Papua New Guinea's (PNG's) biodiversity is often emphasised for the global environmental services it provides (Sekhran et al. 1994; Hunt 2002). It has existence and production value for many people in developed countries, who

appreciate the high richness of species and the levels of endemism (e.g. Miller et al. 1994; Telesetsky 2001). Its role is also emphasised in the development of pharmaceuticals and utilisation in fundamental scientific research (e.g. Telesetsky 2001). However, what value does PNG's biodiversity have for the people who live among it?

Inhabitants of Yagi and Ohu villages, located in Madang province of PNG, agreed to participate in research about the value of local biodiversity for indigenous people. These two villages were chosen as a case study in PNG, a country naturally endowed with high biodiversity that is currently experiencing difficulties in managing its forests, where much of this biodiversity exists. Local communities and biodiversity are interdependent in PNG, and an

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understanding of the importance of different biodiversity components for resource-dependent communities is significant not only for the wellbeing of these people, but also for the conservation of unique PNG biodiversity.

However, literature on the value of biodiversity for subsistence and social activities of indigenous Papuans was published a few decades ago, with no publications (to the authors' knowledge) appearing recently. Since PNG is a developing country, a few decades is a significant period of time for changes in the lifestyles of local people. Furthermore, there is no consensus in opinions about the value of the wild biodiversity for the local communities of PNG. Furthermore, there are few numeric evaluations of the value of biodiversity in the literature.

Methodology

Study area

The field research was carried out in two villages (Yagi and Ohu) in Madang province, located on the northern coast of PNG (Figure 1). Yagi village is a case study area for the Australian Centre for International Agricultural Research (ACIAR) project FST/2004/061. It is described as 'moderately accessible' by a Village Development Trust (VDT) Activity Report (2008b). It is situated in primary rainforest approximately 90 km south-west of the main town (Madang) in Madang province. The level of literacy in the village is low because there is a lack of basic education services. There is no health facility in the village and most villagers are subsistence farmers. To earn cash income they sell vegetables, betel nut and the meat of wild animals, as well as coffee, cocoa and vanilla (VDT 2008a). The average income earned by a family per year is K21–50 (kina) (VDT 2008a).

Ohu village is situated approximately 15 km west of Madang. There is an elementary school in the village and the literacy rate is around 80%; however, there is no health facility. The main occupation in the village is subsistence farming and, according to V. Novotny (pers. comm. 2009), annual household income is around K700. The village is proximal (<5 km) to primary (undisturbed) forest; however, local people consider the primary forest to be far away. Wiad Wildlife Management Area (WMA) lies 2 km from the village. This area was established in the customary land owned by the Ohu villagers in the 1990s. It is 322 ha in area with a main purpose

of protecting primary forest. In addition, this WMA supports the villagers with cash income collected from tourists and biologists (V. Novotny, pers. comm. 2009; WWF n.d.). Biological research undertaken by The New Guinea Binatang Research Centre in the area also facilitates the villagers' education about nature conservation.

Pebble distribution method

The field research methodology was based on the pebble distribution method (PDM), a weighted ranking exercise (Sheil et al. 2002). This method helps to identify patterns in the importance of local biodiversity, and stimulates dialogue between participants about their perceptions of biodiversity and its importance to sustaining livelihoods (Anthony and Bellinger 2007). PDM is ideally suited to instances where the illiteracy rate is high, people are not used to complex exercises and the environment is unpredictable (Lynam et al. 2007).

The method uses focus groups of between 6 and 10 people. This size allows one to perform a group exercise and involve all participants in the decision-making (Anthony 2006). It also allows a cross-section of the community to be involved (Sassen and Jum 2007). The people for the groups are chosen either according to the advice of local authorities or simply on a voluntary basis (Anthony 2006; Sassen and Jum 2007). In each stage of the exercise, the group participants are asked to distribute 100 pebbles among labelled cards according to their importance (Sheil et al. 2002). Careful introduction is required to ensure that the participants understand the nature and requirements of the exercise (Lynam et al. 2007).

Data collection

Two focus groups (men and women) of approximately 10 participants were engaged in the PDM exercise in each of the villages. The participants were divided into men's and women's groups because of the distinct roles of the genders in terms of using biodiversity (Fereday et al. 1994; Petir et al. 1996). Hence, this division allowed differences of opinions between the genders. Figure 2 shows the women's group and Figure 3 the men's group from Yagi village. The informants were chosen on a voluntary basis—all people who wanted to participate were welcome.

First, the importance of domesticated biodiversity was compared with wild biodiversity. The cards were labelled as shown in Table 1. The categories, which were defined according to which environment the

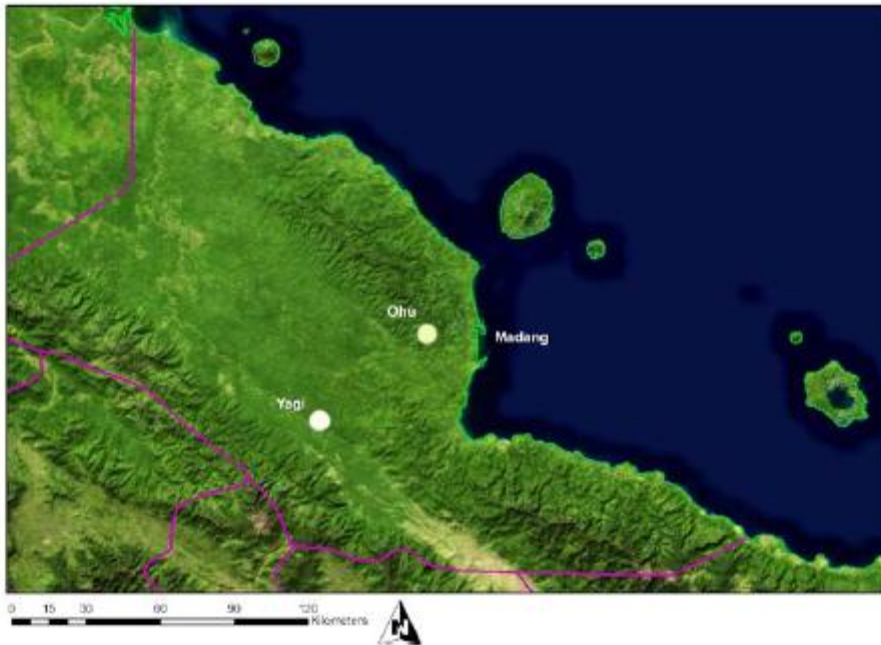


Figure 1. Ohu and Yagi villages in Madang province; map background is a Landsat image.



Figure 2. Women's group from Yagi village distributing pebbles among use categories (Photo: Dalia Bastyte).



Figure 3. Men's group from Yagi village distributing pebbles among use categories (Photo: Dalia Bastyte).

parts of animals, plants or mushrooms were taken, were called 'source categories', adopted from Sassen and Jum (2007) with modifications. This example was used because their research was carried out with people dependent on the goods and services of lowland tropical rainforest, which is similar to the situation in PNG. The categories were modified so that they would cover as much biodiversity as possible but would not overlap.

The use categories for the wild biodiversity were defined according to discussions with the participants. Seven use categories were defined in Yagi village (Table 2). These were arbitrary, chosen to facilitate communication with the participants. The use categories were not compared with one another according to their relative value for the participants;

therefore, an assumption was made that they had equal value. The importance of taxa value was based on this assumption.

According to discussions with the participants, the uses of wild biodiversity were grouped differently in Ohu village. Figure 4 shows the women's group from Ohu village, where four use categories were defined (Table 3).

Afterwards, the participants were asked to name the most important wild species according to the use categories. However, some species were identified only to the level of genus and some to even higher taxa (e.g. bamboo), and it was not possible to put a value on a certain species. The names of species were then recorded in both local language and Latin on the cards, and the participants were asked to

Table 1. Source categories used for the comparison of wild and domesticated biodiversity

Category	Description
Wild plant from forest	Autochthonous plant growing in the native forest
Wild plant, not from forest	Autochthonous plant taken from the native forest and planted in a village
Cultivated plant	Plant grown in the gardens—fenced areas outside a village
Wild animal from forest	Animal inhabiting native forest, i.e. native species and alien species, for instance, wild pig
Wild animal, not from forest	First-generation wild animal caught in a native forest and kept in a village
Domestic animal	Animal bred in a village
Wild mushroom	Mushroom collected in a native forest (a category of cultivated mushroom in Madang province does not exist)

Table 2. Use categories of wild biodiversity defined in Yagi village

Category	Description
Food and drink	Wild plants, animals and mushrooms used for primary and secondary daily food as well as food used for festivals and ceremonies, and drinks made from wild plants
Construction	Parts of wild plants used for building houses and fences
Medicine	Wild plants, animals and mushrooms used for treating diseases
Ornaments	Wild plants and animals used for planting in the village as aesthetic plants, shade trees; and for making clothes, adornments and decorations for everyday life, festivals and traditional dances
Recreation	Wild plants and animals used for leisure and recreation
Magic	Wild plants and animals used for coping with inimical spirits and malevolent people
Tools	Parts of wild animals and plants used as household and garden utensils

Table 3. Use categories of wild biodiversity defined in Ohu village

Category	Description
Food and drink, daily uses	Wild plants, animals and mushrooms used for primary and secondary daily food, and drinks made from wild plants
Ceremonies	Anything made from wild biodiversity and used for special occasions: wild plants, animals and mushrooms used for food and drinks for festivals and ceremonies; parts of animals and plants used for adornment and decorations during festivals and traditional dances; parts of animals and plants used for musical instruments; wild biodiversity used for magic
Medicine	Wild plants, animals and mushrooms used for treating diseases
Construction	Parts of animals and plants used for building houses and fences, and making tools

distribute the pebbles according to the value that each species had for the community in the use category under consideration. The first village in which the exercise was performed, Yagi, refused to do this part of the exercise, explaining that they already felt tired. Hence, evaluation of numeric importance of particular species was given only by Ohu people, which reduced the dataset for the most detailed part of the research.

Data analysis

The source categories

Data were analysed using SPSS statistical package, Microsoft® Excel and the descriptive discourse method. The value that people put on the source categories was compared according to their mean percentages. Independent sample t-tests were used to compare the mean values across gender and village. Descriptive



Figure 4. Women's group in Ohu village distributing pebbles (Photo: Dalia Bastyte).

discourse was used to compare the opinions of the men's and women's groups about the source categories in Ohu and Yagi.

The use categories

The taxa that Yagi people identified as the most important were put into a matrix according to the use categories, and compared with one another according to the number of use categories to which they belonged. The taxa that Ohu people named as the most important for use categories were put into a matrix, and individual use value (IUV) was calculated by summing up the values attributed for that species in all the categories. Combined relative importance (CRI) for each taxon was calculated by dividing IUV by the total possible value (TPV). TPV was calculated by summing the values that both groups put on all four categories (in this case it was 800).

Results

Comparison of the villagers' opinions about wild and cultivated biodiversity value

The mean relative value of the four source categories was compared. Mean relative value was calculated using data from all four groups (men's

and women's groups in Yagi and Ohu). The category of wild plants clearly has the highest value for the villagers, being assigned almost half (48.75%) the mean value for all source categories combined (Table 4).

Comparison of Ohu and Yagi

Comparing opinions about the value of wild and cultivated biodiversity between Ohu and Yagi indicated a significant difference for one source category. An independent sample t-test showed that opinions about wild plants from the forest were significantly different ($t = 8.497$, $df = 2$, mean difference $= 9.50$, $p < 0.05$)—Ohu groups attributed significantly greater importance to the category of wild plants from the forest than Yagi groups (Figure 5). Comparing opinions about the value of wild and cultivated biodiversity of different gender groups indicated no statistically significant differences (Figure 6).

Men's and women's opinions about wild and cultivated biodiversity value

Looking in more detail, men's and women's groups' opinions about seven local biodiversity source categories (Figures 7 and 8) can be described.

Table 4. Mean value of local biodiversity source categories for Ohu and Yagi groups

Source category	Composition of the category	Mean relative value (%)
Wild plants	Wild plants from the forest, wild plants grown in the villages, and mushrooms	48.75
Cultivated plants	Plants grown in the gardens (subsistence farming areas outside a village)	25
Wild animals	Wild animals either from the forest or not from forest (i.e. first-generation wild animals that were tamed)	18.25
Domestic animals	Domesticated animals	8

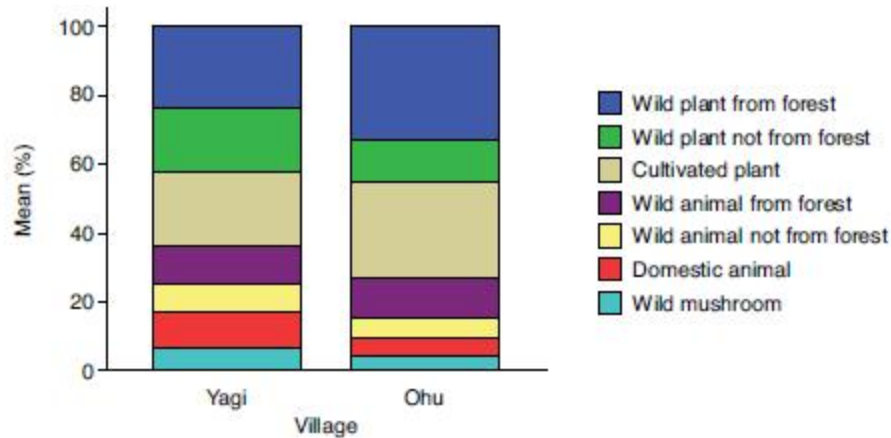


Figure 5. Mean values of weighted ranks for biodiversity source categories in Yagi and Ohu villages

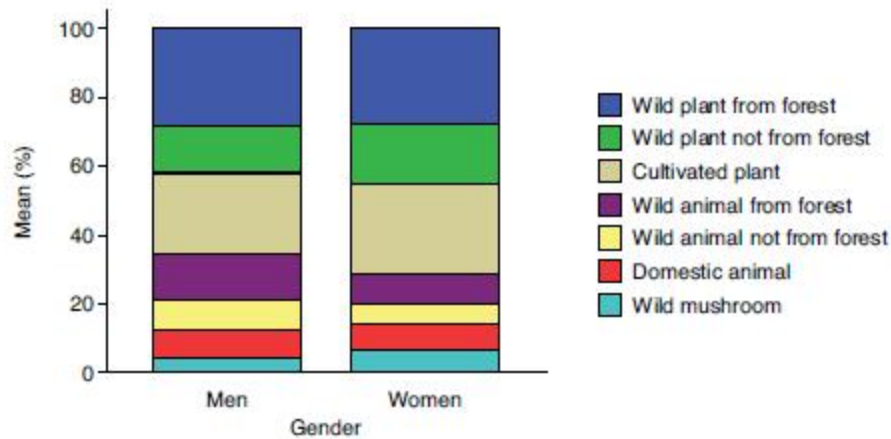


Figure 6. Mean values of weighted ranks for biodiversity source categories for men's and women's groups

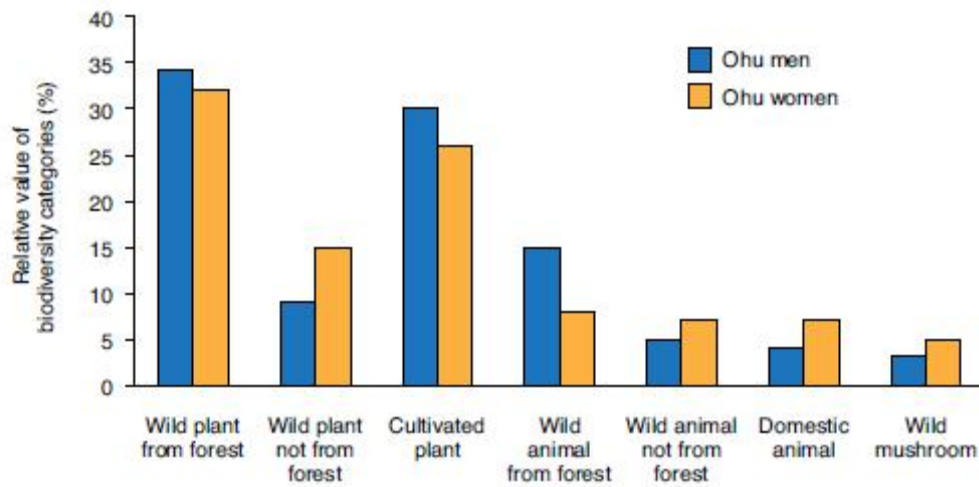


Figure 7. Value attributed by Ohu men's and women's groups for biodiversity use categories

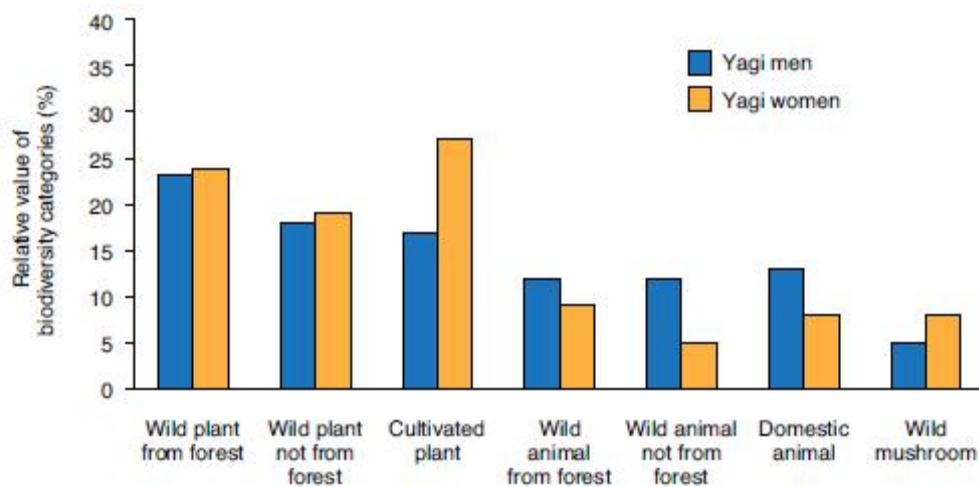


Figure 8. Value attributed by Yagi men's and women's groups for biodiversity use categories

Ohu village

We found no significant differences between men's and women's groups' opinions in Ohu village. Ohu men noticed that wild plants from the forest can be used for multiple purposes: for medicine against a runny nose, a fruit to eat, a plant containing water to drink, bark of a tree to get rid of the spirits that

affect people or to treat a snake bite, materials for drums used for local communication, bird feathers for traditional dances, ginger to improve the taste of food, plants to fence a garden or a vine for construction. Moreover, people are even more dependent on these plants in unfavourable conditions, for example in periods of drought. The Ohu women's group



Hunting of local fauna is an important source of protein in remote areas but can have significant impacts on local biodiversity. Here, youths from the Kiriwa tribe of Simbu province, Papua New Guinea, have caught a cuscus (family Phalangeridae) (Photo: Julian Fox).

confirmed the men's opinion—wild plants from the forest are used for many purposes.

It was agreed that wild plants not from the forest were not as important as the ones from the forest. It was explained that some of these plants are used for food; for example, the leaves of *Gnetum gnemon* are often used as greens in the staple food. Also, some of the wild plants are used decoratively in the village. Cultivated plants were explained to be important because they are used for daily consumption as food, and in festivals and as a bride price.

Ohu people explained that wild animals are hunted in the forest on occasions. Pigs, cuscuses and wallabies are hunted for festivals and ceremonies. For example, before harvesting food from a new garden, people go to hunt a wild pig or catch crabs, fish, prawns and lobsters from a river. Also, wild animals are used for cultural ceremonies called 'sing-sing'; for example, birds of paradise are a key item for traditional dancing—without their feathers, traditional dancing cannot happen. Lizards are also important for cultural ceremonies because their skin is used for kundu drums, which are the main traditional musical instruments in Madang province. Since these animals are not used every day, the value they were given was not as high as

for the plants. Offspring of some animals can be taken from the forest and kept in the village, for example pigs, cuscuses and hornbills. However, it does not happen very often, and the category of wild animals not from the forest was therefore not highly valued.

Domestic animals were not attributed with a very high value because they were not employed very often. Itemising why they attributed a low value for domestic animals, Ohu people explained that dogs are used for guarding a house and hunting, pigs mainly for a bride price and sometimes sold for cash income, chickens for food, and cats for protecting houses against rats.

Mushrooms were valued the least of all the categories. It was explained that they are used only for food and as a medicine, but not for a wide range of diseases. Moreover, they can be used only in season, which is a short period.

Yagi village

The opinions of men's and women's groups in Yagi diverged more than in Ohu. In particular, the women's group seemed to value cultivated plants more than the men's. In explanation, Yagi women answered: 'This is what we use from the morning till the night every day'. However, the men explained that, even

though cultivated plants are used for food, as building materials and as medicine, their seedlings have to be bought in a market, making it difficult to access them. Furthermore, because people have used wild plants from the forest for longer than cultivated plants, they became more accustomed to those plants, and therefore they have more uses. Moreover, only wild plants from the forest are used for magic and this is a very important purpose. (It has to be mentioned here that magic is practised only among men, while gardens are usually worked by women in Madang province.)

Yagi people named quite a few uses for wild plants not from the forest: for food, medicine, as building materials, as aesthetic ornamental plants, as trees providing shade in the village and for selling in a market. Wild mushrooms in Yagi village are used only for food and only in season, so they have less value for the people than other categories.

Wild animals from the forest were used for many purposes; for example, for food, exchange, selling in markets, and for kundu drums and headdresses. However, people explained that wild plants from the forest were much easier to access than animals. Hence, the animals are caught when people find them, but it does not happen often. Therefore, the people usually use plants. It is interesting to notice that, even though Yagi people specified that they use wild animals rarely, they also listed that they use domestic animals even more rarely than wild animals. The lack of substitution increased the value of wild animals from forest.

The importance of the wild animals not from the forest category was explained similarly as for the wild animals from the forest. Various animals are caught and kept in the village for different purposes: as pets, used for food, as bride price payment, sold in the markets, and their feathers used for headdresses and their bones as utensils. The value of domestic animals in Yagi village was explained similarly as in Ohu village: they are used for bride price payment, for food, as pets, cats for chasing rats, dogs for security and hunting, and buffaloes for pulling a carriage. In addition, their feathers are used for decorations and chasing mosquitoes, and parts of the animals are used for necklaces. However, they are used relatively rarely.

Uses of wild biodiversity in Yagi

According to conversations with the villagers, uses for wild biodiversity in Yagi village were grouped into seven categories (Table 2). The participants were asked to name the most important species in each use category. It was found that *Casuarina* species

and *Licuala lauterbachii* have many uses, with these species belonging to four use categories. Six taxa belong to three use categories, namely *Artocarpus communis*, bamboo, cuscus, *Intsia bijuga*, *Mucuna* sp. and *Pometia pinnata*. There were 20 taxa named that belong to two use categories and 29 taxa that belong to one use category in Yagi village.

Uses of wild biodiversity in Ohu

According to conversations with the villagers, uses for wild biodiversity in Ohu village were grouped into four categories (Table 3). CRI for all taxa are presented in Table 5.

Table 5 shows that the CRI of the 40 taxa that the participants from Ohu village indicated as the most valuable range from 0.6% to 7.1%. Some species have high CRI because they are used in several categories, and others because they are highly valued in just one or two use categories. The most valuable species, *Pterocarpus indicus*, was not only present in all use categories, but was also given high value in each of the categories. The second most valued species, *Gnetum gnemon*, was used in two use categories, but was given higher value in the categories it was used in than the majority of the other taxa.

Discussion

Wild and cultivated biodiversity value

Economic variables are an imperative factor defining the value of biodiversity for indigenous people. The gross domestic product per capita of PNG is estimated as K2,586.25, but the income is distributed very unequally (National Statistical Office of PNG 2000; Forest Trends 2006). Less than 10% of PNG's population over the age of 10 years works in salaried employment; therefore, for the majority of Papuans, subsistence activities, which are occasionally supplemented by market sales, are the only means of survival. The sources of subsistence named in the literature are: agriculture, hunting, gathering and fishing (Fereday et al. 1994). Observing day-to-day life in PNG, it is not difficult to notice that the sources for market sales are the same as for subsistence. There is no doubt that subsistence activities are vital to sustain livelihoods in PNG, but opinions diverge about the value of each subsistence activity for local communities.

It is generally accepted that agriculture is the main source for sustaining livelihoods in PNG villages, where 84% of the population lives. The importance

of agriculture is stressed because it provides the people with staple food (Fereday et al. 1994; National Statistical Office of PNG 2000), while hunting and gathering is claimed to be only a subsidiary activity (Bulmer 1972). However, while emphasising the

need to secure a supply of staple food, other needs of indigenous people are often unvalued.

According to Ohu and Yagi people, local biodiversity is used for multiple purposes. Most noticeably, wild biodiversity has a wide range of uses because

Table 5. Combined relative importance for the wild biodiversity taxa in Ohu village

Taxon	Food and drink, daily uses	Ceremonial	Medicine	Construction	Total
<i>Pterocarpus indicus</i>	0.0125	0.0125	0.0225	0.02375	0.07125
<i>Gnetum gnemon</i>	0.0375		0.02875		0.06625
<i>Intsia bijuga</i>	0.0175	0.01125		0.03375	0.0625
<i>Vitex cofasus</i>	0.0075	0.025		0.0225	0.055
<i>Pometia pinnata</i>	0.02		0.00875	0.02375	0.0525
<i>Cinnamomum grandiflora</i>	0.0125	0.01375	0.025		0.05125
<i>Arenga microcarpa</i>	0.0175	0.0275			0.045
<i>Ficus copiosa</i>	0.0275		0.0125		0.04
<i>Cordyline terminalis</i>			0.0325		0.0325
<i>Caryota rumphiana</i>	0.01375	0.00875		0.00875	0.03125
<i>Metroxylon sagu</i>		0.03125			0.03125
<i>Alphitonia incana</i>				0.02875	0.02875
<i>Amomum aculeatum</i>			0.02625		0.02625
<i>Melanolepis multiglandulosa</i>			0.02625		0.02625
<i>Paradisaea sp.</i>		0.02625			0.02625
<i>Flagellaria indica</i>				0.025	0.025
<i>Ficus dammaropsis</i>	0.02375				0.02375
<i>Ficus wassa</i>	0.0225				0.0225
<i>Calamus aruensis</i>				0.02125	0.02125
<i>Premna obtusifolia</i>			0.02125		0.02125
Bamboo				0.02	0.02
<i>Sus scrofa papuensis</i>		0.02			0.02
<i>Rhyticeros plicatus</i>		0.015			0.015
<i>Ficus nodosa</i>		0.01375			0.01375
<i>Tabernaemontana aurantiaca</i>		0.01375			0.01375
<i>Hydriastele costata</i>				0.0125	0.0125
<i>Mucuna sp.</i>	0.0125				0.0125
<i>Musa sp.</i>			0.0125		0.0125
<i>Piper betle</i>			0.0125		0.0125
<i>Zingiber officinale</i>			0.0125		0.0125
<i>Calopogonium sp.</i>	0.01125				0.01125
<i>Donax canniformis</i>				0.01125	0.01125
Lizard		0.01125			0.01125
<i>Cacatua galerita</i>		0.01			0.01
Cuscus		0.01			0.01
<i>Randia decora</i>				0.01	0.01
<i>Cassia alata</i>			0.00875		0.00875
<i>Celtis latifolia</i>				0.00875	0.00875
<i>Sterculia sp.</i>	0.0075				0.0075
<i>Uncaria sp.</i>	0.00625				0.00625

the people are more accustomed to it. The first example of the direct use value of local biodiversity for indigenous people is enrichment of the diet with proteins and vitamins. Another example is medicinal purposes. There are no health facilities in these villages, so the people depend principally on local plants for the treatment of diseases. Even though cultivated plants are sometimes used for medicine, wild species are used much more often. One more important example is construction materials. Houses and fences protecting the gardens in Yagi and Ohu are built from local plants, again mainly of wild origin.

Besides economic importance, wild products have a value for other aspects of indigenous life. For example, feathers of the bird of paradise, which are used for traditional dances, were declared as 'not for sale' by Ohu villagers. PNG is famous for its cultural diversity. More than 800 distinct languages exist and a similar number of different cultures are present in the country (Thomas 2003; WWF 2006). According to Yagi and Ohu people, a number of the wild species

are used for traditional festivals and magic, which are key to maintaining local cultures. These species cannot be replaced by market goods.

Because of these two reasons—direct importance for sustaining livelihoods and value for cultural activities—wild plants and animals were highly valued by the Yagi and Ohu focus groups (Table 4). Interestingly, Ohu focus groups valued wild plants from the forest significantly higher than Yagi focus groups. Ohu village is much closer to the main town of the district (Madang) than is Yagi village. This has several implications for the villagers. First, people can more easily commute to the town and therefore have higher income, which means that they become less dependent on local biodiversity. Second, it is easier to maintain a school and get health care closer to the town. Education might have an impact on the people's attitudes about the value of the biodiversity. Third, the environment around Ohu is experiencing larger anthropogenic impacts than around Yagi. Yagi is situated in primary forest and Ohu people



It is common in Papua New Guinea for local biodiversity to be caught and raised in the village. Here, a young cassowary (*Casuaris* sp.) is being raised as a pet in the Sob community, Madang province (Photo: Julian Fox).



Papua New Guinea has a rich diversity of local cultures. At the Goroka Show this diversity is on display, with the many cultures of the highlands exhibiting their tribal dances (Photo: Julian Fox).

perceive that primary forest is far away. However, according to J. Fox (pers. comm. 2009), Papuans are strongly attached to their traditional environments. This attachment to the primary forest that formerly surrounded the village but has become more distant could have exaggerated the value of species contained in primary forest for Ohu villagers.

One more result of this research worthy of discussion was the similarity of opinions between the genders. There were no significant differences between the opinions of men's and women's focus groups. It appears that, despite the different traditional roles in PNG society, men and women tend to have similar opinions on the importance of biodiversity source categories for their communities. One exception were Yagi women, who valued cultivated plants as 27%, while Yagi men valued this source category as only 17%. This result is intuitive because women traditionally spend most of their time in the gardens, whereas men have different occupations. For example, according to research done by Anthony and Bellinger

(2007), people from a traditional society in South Africa valued the landscapes where they themselves spent most of their time as the most important for their community. However, this tendency did not emerge in Ohu village. The current research cannot explain this, but it could be that Ohu villagers are more influenced by urban attitudes and the traditional roles in the village are expressed to a lesser extent.

The value of wild taxa

Yagi village

Yagi focus groups identified *Casuarius* spp. and *Licuala lauterbachii* as the taxa used for most (4) use categories. Two species of genus *Casuarius* (*C. bennetti* and *C. unappendiculatus*) inhabit the forests of Madang province. The exact species was not identified during the discussions with Yagi villagers; therefore, both species are reviewed below.

Casuarius species (cassowary) belong to the order Struthioniformes. They are ratites; that is, large,

flightless birds of archaic origin. Cassowaries need large areas of thick tropical or subtropical forest as their habitat. Because of its important role in the tropical forest ecosystem, cassowary is acknowledged as a keystone species (Wet Tropics Management Authority 2006). However, both *C. bennetti* and *C. unappendiculatus* are included in the International Union for Conservation of Nature and Natural Resources (IUCN) Red List (IUCN 2008).

Casuarius bennetti (dwarf cassowary) is endemic to the island of New Guinea. According to the IUCN Red List, these birds have a status of near threatened. The population of *C. bennetti* is declining mainly because of heavy hunting pressure (IUCN 2008).

Casuarius unappendiculatus (northern cassowary) has a narrower distribution than *C. bennetti*, being restricted to the northern lowlands of New Guinea. Its habitat is rainforests in river floodplains. Northern cassowary constitutes a major food source for subsistence communities, and has a major cultural importance. However, no breeding of domesticated birds exists. Because of its high value for indigenous people and its unsustainable consumption, the species has a status of vulnerable in the IUCN Red List. It is claimed to be 'dependent on the local culture and the availability of weapons and alternative meat-sources' (IUCN 2008).

People from Yagi stated that they use *Casuarius* spp. for food and the manufacture of tools. Parts of these birds are also used for traditional dances and magic. (People from Ohu mentioned several times during the exercises that they would like to include cassowary as a valuable species, but cannot because this species does not live in their forest anymore.) It seems that cassowary is one of the most valuable species for indigenous people. However, the consumption habits seem to be unsustainable and when human populations reach higher density, the species ceases to exist in surrounding forest. According to the researchers from Binatang Research Centre, the animal's density in PNG is inversely proportional to people density. The more villages in the area, the bigger they are and the closer the towns, the fewer animals live in the surroundings.

Licuala lauterbachii is an indigenous palm of PNG and Solomon islands (Riffle and Craft 2003). Yagi people use it for construction, and the stem is split and sharpened into spears for hunting. Leaves are used as decorations for traditional dancing. This tree is not threatened according to IUCN and it is a common tree in the undergrowth of rainforests (Riffle and Craft 2003).

The two species mentioned above illustrate the general situation. Some of the species that Yagi focus groups identified as valuable are common, while others are threatened.

Ohu village

Out of 40 taxa Ohu focus groups identified as the most valuable, three species (*Pterocarpus indicus*, *Gnetum gnemon* and *Intsia bijuga*) had a CRI higher than 6%. These species and their uses are described below.

Pterocarpus indicus (red sandalwood), in comparison with abovementioned species, has a wide distribution. It is local in south-eastern Asia, northern Australasia and the western Pacific Ocean islands. This huge (30–40 m tall and up to 2 m in diameter) deciduous tree is used for many purposes. It is a hardwood species and its timber is highly valued because of its resistance to decay and its decorative appearance. The flowers and leaves of the tree are eaten, parts are used for medicine, and the tree itself is used ornamentally (Traditional Tree Initiative 2006a).

Red sandalwood is extinct in some parts of its original range, while in other parts this species is heavily exploited and its population is decreasing. Therefore, its status in the IUCN Red List is defined as vulnerable. The largest remaining subpopulation is in New Guinea (IUCN 2008). Ohu focus groups identified *Pterocarpus indicus* as important for daily food, ceremonies, medicine and construction.

Gnetum gnemon (gnetum – two-leaf) is a native tree in Indo-Malaya and Melanesia, but currently it is also widespread in south-eastern Asia and the Pacific islands. This species is tolerant to various environmental conditions. It is an important agroforestry species—its timber, leaves and nuts are widely used. In Melanesia this tree is used for food, cordage, timber and medicine (Traditional Tree Initiative 2006b). Ohu people identified it as an important species for daily food and medicine.

Intsia bijuga (kwila or Borneo teak) is distributed through south-eastern Asia and the islands of Melanesia, Micronesia and Polynesia. The tree is claimed to be one of the most highly valuable species in its range because of its cultural importance and value as commercial timber. It is used as a timber, medicine and craft wood for high-quality carving (Traditional Tree Initiative 2006c). Because of its immense importance, the tree has been exploited so heavily that only a few large natural stands remain. Therefore, it is classified by IUCN as vulnerable

(IUCN 2008). Ohu people use *Intsia bijuga* for construction, food and ceremonies.

Two out of three of the most valuable species identified by Ohu participants are classified as vulnerable in the IUCN Red List because of overconsumption. Even though one of the participants revealed personally to the researcher after the PDM exercise that the species will never go extinct because indigenous people know the magic spells to invite species back when they are needed, the IUCN Red List suggests that a threat for the most valuable species exists. Some of these species are threatened because of the activities of local people, but others because of the unsustainable harvesting practices. However, 97% of the PNG land area belongs to traditional owners according to customary land tenure, and only traditional owners can decide which actions can be implemented on their land.

Conclusions

It is evident that tropical forests are not only one of the most biologically diverse terrestrial ecosystems, but also one of the most threatened. Growing demand for wood and its derivatives, coupled with demand for land for food production due to population growth, poses an increasing threat to the tropical forest frontiers. As a result, 75% of remaining frontier forest outside the boreal region is threatened (Sizer 2001).

Local communities living in the tropical forests have to be mentioned in a discussion of global threats to tropical forest biodiversity. First, the forests that are threatened have a value for these communities, which is a strong reason for conservation of the forests (Sheil and Wunder 2002). Second, biodiversity to some extent depends on indigenous people. As Toledo (2001) notes, 'they hold a key to successful biodiversity conservation in most of the biologically richest areas of the world'. Therefore, understanding the needs of indigenous people is an essential condition for biodiversity conservation.

The biodiversity of PNG's tropical rainforests is used by local communities in wide-ranging and often unrecognised ways. Aside from the high commercial value of some rainforest trees, forests provide a number of other goods and services to communities that are more difficult to quantify; for example, construction, food, medicinal, spiritual, ornamental and recreational values. The focus groups from Ohu and Yagi villages highly valued local wild biodiversity. They explained that it can be used for more purposes than cultivated biodiversity. Some of the purposes

are very important (e.g. magic), and the species used cannot be replaced. Moreover, people are even more dependent on the wild biodiversity in unfavourable conditions; for example, in periods of drought.

However, some of the species identified by the focus groups as valuable are included in the IUCN Red List (e.g. *Casuarium* spp., *Pterocarpus indicus* and *Intsia bijuga*). Hence, the populations of these species decline, and a risk emerges that the communities will not be able to use them any more in the future. Some of the valuable and threatened species are acknowledged as keystone species; that is, they have a large, stabilising influence throughout an ecosystem and determine the survival of many other species (e.g. *Casuarium* spp.). Communicating the existing situation to the communities could be helpful to reduce the consumption of such species to a sustainable level.

This research showed that different communities value the sources of local biodiversity differently. Ohu groups valued wild plants from the forest significantly more than Yagi groups. The question why there were differences in opinions between Ohu and Yagi focus groups remains unanswered. One more area open for further research is the differences between the opinions of genders. This research does not show significant differences between the mean values of Ohu and Yagi men's groups with Ohu and Yagi women's groups; however, a bigger dataset could show different results.

An understanding of the importance of different species/taxa for resource-dependent communities is significant not only for the wellbeing of these people, but also for the conservation of biodiversity. This understanding is needed for developing biodiversity conservation policies. Policies that recognise and incorporate the needs of local villagers are more likely to be adopted by these people, who have a significant influence on local biodiversity (Anthony and Bellinger 2007).

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