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3 Local and Scientific Understanding of Forest Diversity on Seram, Eastern Indonesia

Roy Ellen

Introduction

Foresters, biogeographers and tropical forest ecologists have devised increasingly sophisticated classifications of forest types (e.g. Eyre 1980). Forest 'types' and their more localised and discrete components, which might variously be described as 'habitats', 'niches', 'biotopes' and 'ecotones', constitute what ecologists understand by 'secondary biodiversity': that is diversity in terms of associations of species rather than the ('primary') diversity measured in terms of the numbers of species (or other taxanomic categories). Although the classifications of foresters in particular have been largely determined by the practical considerations of the industry, during the latter part of the twentieth century they have been much influenced by the developing science of forest ecology, and the technologies of remote sensing (Howard 1991) and Global Information Systems (GIS) (C.A. Johnston 1998). The typologies of forest ecologists, while originally rooted in those of foresters, have become increasingly distanced from them in an attempt to model more accurately the dynamic character of forest diversity.

Although the pragmatic schemes used by national forest departments have often responded to local situations by incorporating categories which anthropologists would describe as 'folk', 'emic' or 'indigenous', on the whole the practice of modern forestry has markedly diverged from the representations of secondary biodiversity which these imply (see e.g. Muraille 2000: 74–77). I shall show in this chapter how the categories and coordinates applied by Nuaulu in eastern Indonesia contrast with most official functional classifications of tropical forest type in being dynamic, multidimensional, not tied to complex nomenclatures, and unashamedly *local*. I will also show how they anticipate recent modelling attempts in scientific ecology which emphasise the 'patchiness' of tropical rainforest.[1] Studies of tropical forest peoples have revealed not only an extensive native knowledge of trees, but also local recognition of forest diversity and the existence of coherent vernacular classifications of forest types. The evidence suggests some variation in nomenclatural and classificatory patterns. Work in the Amazon region, for example, has reported folk classifications of considerable complexity (e.g. Fleck and Harder 2000: 1–3; Shepard et al. 2001; Shepard et al. 2004), which do not appear to be matched by comparable data from, for example, southeast Asia and New Guinea (Sillitoe 1998; Ellen, unpubl.). However, my concern here is with the commonalities which such studies yield, using Nuaulu data as a point of departure; and with a comparison between ethnoecological classifications of tropical forest in general and those offered by scientists and officials. Thus, we are dealing with issues of *scale*, which as Sillitoe (2002a, 2002b) has shown, have increasingly become critical in judging the appropriateness of local and global knowledge respectively in the context of development practices.

There is one further important point which needs to be registered before embarking on this specific analysis, which is that technical forestry practice, especially including the typologies it has devised, was first formalised and institutionalised, and indeed continues, within an overt political context, which has shaped its underlying assumptions. Thus, in Indonesia, as in many other places, the definition and demarcation of land as 'forest' during the colonial period can be seen as a very concrete 'territorialisation strategy' in which first the colonial state (Boomgard 1994) and then an independent republic manifested its existence and legitimated its jurisdiction. Through the 'adminstrative ordering of nature' the remit of the state was made 'legible' (Scott 1998: 2, 4). Thus, forestry departments became one of the most important agencies in territorialising state power, and inevitably in doing so had the effect of simplifying the 'illegible' cacophony of local property regulations and communal tenure, which presented itself as an administrative nightmare (Scott 1998: 35, 37). But the process of simplification and of inscribing legibility had the consequence of excluding and including people within particular geographic boundaries and of controlling their access to natural resources; it provided the inevitable grounds for conflicts with local perceptions and values. In such a situation 'tribal' peoples, already a 'problem' because of their administrative peripherality, became additionally so through a forestry policy defined in such a way as to deny any merit in forms of extraction other than for timber, and which especially demonised swiddening or long fallow forms of agriculture (Dove 1983, Dove et al., this volume; Persoon et al. 2004: 26). And whereby the forested territory of the modern state could be understood in basically linear, abstract and homogenous terms, as the monothetic management of wood, this is quite the opposite of how local people experience forest, or indeed any other kind of space (Vandergeest and Peluso 1995: 388–89; c.f. Sivaramakrishnan 2000).

The main evidence which legitimated this new control, and therefore the problems that subsequently arose, were maps (c.f. Dove et al., this volume). In other words, the 'territorialisation strategy' only effectively became a reality as competent cartographic surveys were conducted, especially, but not exclusively, those which remapped forest on the basis of scientific criteria, such as soil type, slope, vegetation and timber utility, or what Vandergeest and Peluso (1995: 408) call 'functional territorialization'. In the context of Indonesia, this emergence of an ideology of state forestry and of state and scientific classifications of land, as well as the very idea of the 'management' of natural resources (Ellen 2003), happened first in colonial Java, with the establishment in 1808 of the 'Dienst van het [Ost-Indische] Boschwezen' and the 'Administratie der Houtbosschen' (Anon. 1917: 390; Departemen Kehutanan 1986; Peluso 1992: 6–8, 44–45; Boomgard 1994: 119). In the distant Moluccas, and on Seram in particular, such practices did not become a reality until the Topografische Dienst survey of 1917, which I shall return to in the final section of this chapter. But the conceptions of forest space which accompany this strategy are differentiated from pre-existing local conceptions, again in terms of scale.

Methods for Studying Local Representations and Understandings of Forest Diversity

In order to understand how Nuaulu conceive and use their classification of types of forest it is important to show in detail the composition and ecological character of the kinds of forest which they label. This entails the use of a plot methodology, in which all flora above a certain size and other features occurring in a specified area are logged, mapped and named with the help of local people. But one of the problems of comparing different compositional studies of tropical forest on a global scale has been inconsistency in the size of the plots, or quadrats, employed. The majority of ecological studies have relied upon plots of between 0.63 and 1.2 ha, most commonly 1 ha (e.g. Valencia et al. 1994; Richards 1996). While the problems of quadrat surveys generally have been widely discussed (e.g. Kershaw 1973; Kent and Coker 1992), in ethnobotany the problems are, if anything, greater, despite there being a smaller number of studies to which to refer (Martin 1995: 157–59). Rectangular plots, where one side is considerably longer than the other, have been used by Boom (1989), for example belt transects of 10 m by 1,000 m in his work amongst the Chácobo of northern Brazil, and 40 m by 10 m plots have been used by Puri (2005), working among Penan Benalui in east Kalimantan. But most plots have conventionally been square, for example the use by Salick (1989: 191) of stratified random 5 m by 5 m plots to sample Amuesha swiddens. Bernstein et al. (1997) used 0.23 ha (48 m by 48 m) plots divided into four quadrats in their work amongst the Brunei Dusun. Allan (2002: 137), in her Guyana work, used a plot size of 0.25

ha (50 m by 50 m) because the locally defined (largely Makushi) forest types often did not extend over areas large enough or symmetrical enough to allow a larger plot to be established within the forest type. Sillitoe (1998) has even used 10 m by 10 m quadrats to measure differences in tree flora.

Although the size of a plot must ultimately be determined by research objectives and practicalities, Greig-Smith (1964: 28–29) identifies two problems with smaller quadrats: that there is a greater chance of significant edge effects (due to an observer consistently including individuals which ought to be excluded); and that the frequency distribution for individuals is more likely to be Poisson than normal, with the magnitude of the variance related to the mean. This latter makes it difficult to apply some of the usual statistical procedures for comparing populations. The first effect can be corrected by including individual trees which fall on the edge of the plot only if 50 percent or more of their canopy area is judged to fall within the plot; otherwise they are excluded. But although fieldworkers may make every effort to apply this rule consistently, it is inevitably a subjective assessment, and there will always be an unknown level of observer error. This must be acknowledged as a limitation of the data collected in plots of this size. This second problem identified by Greig-Smith can be tested for and potentially corrected using data transformation.

In 1996 the Nuaulu were a group of some 2,000 individuals, engaged in swidden cultivation, sago extraction, hunting and forest extraction in lowland central Seram in the Indonesian province of Maluku, the Moluccas (Figure 3.1). In that year I conducted eleven plot surveys in forest which Nuaulu exploited and which was acknowledged as belonging to them. The intention was to sample from as wide a range of mixed forest vegetation as possible with which Nuaulu were actively interacting. Deliberately excluded from the sample area were mangrove, littoral biotopes, groves and plantations, recently abandoned garden land, and swamp forest predominantly covered in sago (*Metroxylon sagu*). Also, because Nuaulu seldom extract from forest above 1,000 metres above sea level, mountain habitats above this altitude were excluded. As in some earlier studies (Allan 2002, 1995; M. Johnston 1998; Sillitoe 1998), the object of the surveys was to obtain botanical composition data for locally recognised forest types, and for this reason plots were placed within areas identified by local informants as indicative of a particularly salient forest type, and within the range of that type, in locations which were relatively accessible. This inevitably resulted in a non-random, non-systematic distribution, which limited the quantitative analysis that could be performed on the data, and reduced their value as sources for a general ecological survey of the forest. It must, therefore, be borne in mind that the aim was an analysis of ethnoecological knowledge of different emically defined areas and not a study of forest ecology. The general characteristics of the plots surveyed and their geographic location are indicated in Table 3.1 and Figure 3.2 respectively.

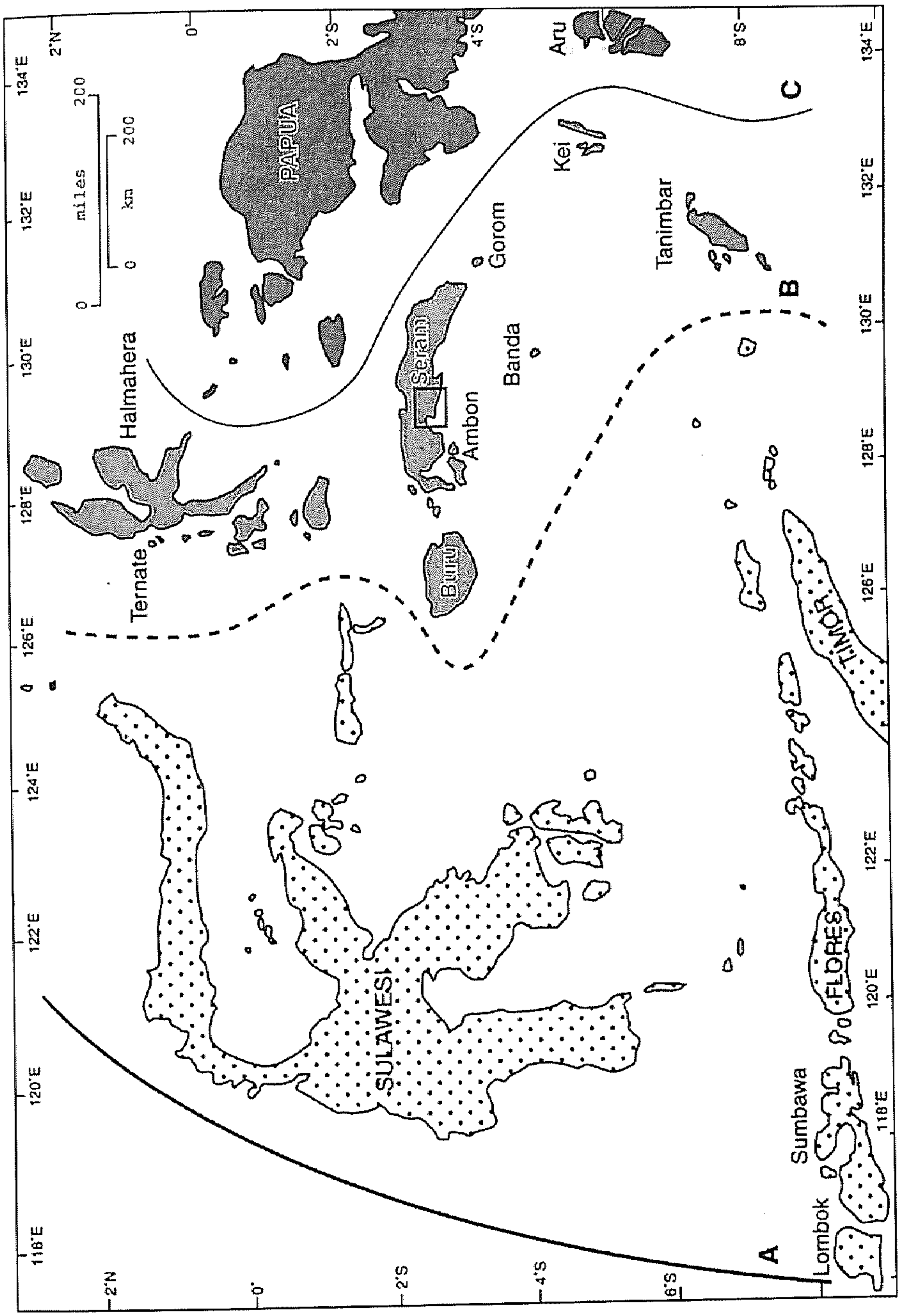

Figure 3.1 Seram in the context of the eastern Indonesian archipelago, showing places mentioned in the text. Line A represents Wallace's Line of Faunal balance. Line B is Weber's Line, and Line C is the western boundary of the Australo-Pacific region. The box indicates the area enlarged in Figure 3.2.

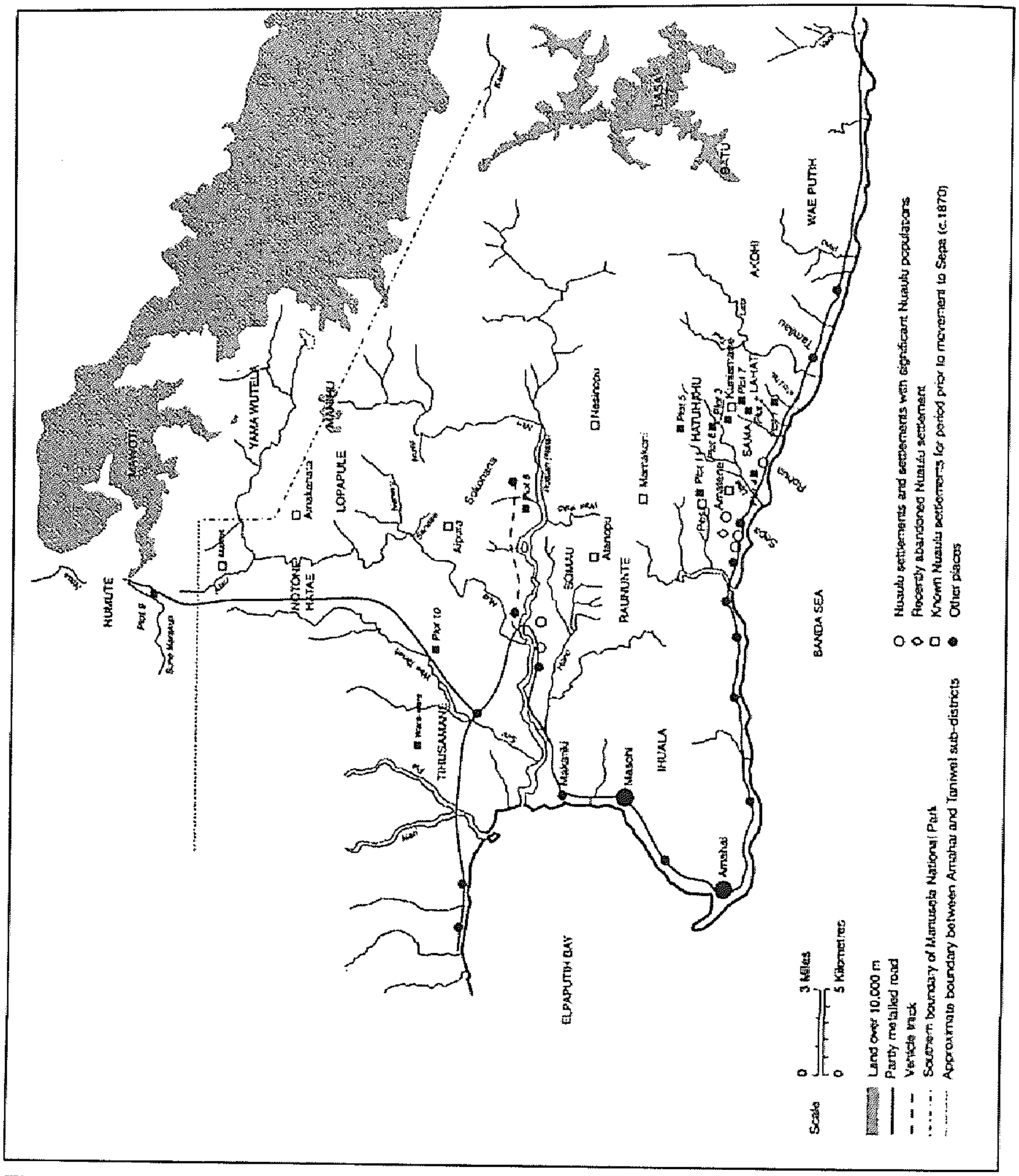

Figure 3.2 South Seram, showing former and current Nuaulu settlements and plot locations mentioned in the text, as of 1996.

Table 3.1 Basic data on location and description of plots.

Plot number	Toponym	Location	Nuaulu description	Summary ecology	Altitude (m)	Distance from Rohua (km)
1	Nahati sanai	Near river Makoihiru	*nisi ahue*	Edge of cultivated area, depleted mixed forest	200	3.75
2	Mon	On river Mon, near Rohua	*wesie*	Edge of cultivated area, depleted mixed forest	150	4.25
3	Nahane hukune	Sama, north of Rohua	*wesie*	Depleted, near logging road	200	2.00
4	Ratipanisa	On river Yoko, near Rohua	*nisi ahue*	20-year-old regrowth garden land	100	0.75
5	Besi	Between Iana Ikine and Iana Onate	*nia monai*	Old settlement site	300	3.00
6	Iana onate matai	near river Upa	*nisi ahue*	30-year-old regrowth garden site	50	2.50
7	Mon sanae	Head of river Mon, near Rohua	*sin wesie*	Protected sacred forest (clan Peinisa)	300	4.50
8	Sokonana	Near transmigration site on river Ruatan	*wesie*	debris of cut trees, far from gardens near new road	100	25.0
9	Rohnesi	W of trans-Seram highway near Wae Sune Maraputi	*wesie*	High-altitude undisturbed forest	900	70.0
10	Wae Pia	E of trans-Seram highway near Tihasamane, Tanaa valley	*wesie*	Lowland forest	200	55.0
11	Amatene	Above headwaters of Iana river, trib. of Upa	*nia monai*	Old village site	400	5.00

Plots 1 to 6 were each 400 m^2 (20 × 20 m), and plots 7, 8, 9 and 11 were each 900 m^2 (30 × 30 m). Plot 10 was 430 m^2. The four large 900 m^2 plots were surveyed because particular features of the plot were judged to be intrinsically interesting: plot 7 being sacred protected forest, plot 8 an area on the fringe of recent settlement, plot 9 a high-altitude site traditionally used for collecting *Agathis* resin, and plot 11 an old village site. All measurements were of surface areas, but surfaces which were often on steep slopes. Although angle of slope was measured, plot maps (e.g. those in Ellen, unpubl.) and density data were accordingly distorted: the steeper the slope the greater the distortion. Another problem associated with plot size was that small plots tended to underestimate species richness compared with larger plots in the same area. Figure 3.3 shows the relationship between the number of species and size of plot, from 0.05 to 0.5 ha, as used in a number of Moluccan studies. The inclination of the species–area curve is roughly consistent with species-area curves obtained in other studies of lowland rainforest in island southeast Asia, though Edwards et al. (1990: 168, fig. 15.2 (a)) found that curves in the Manusela National Park generally flattened out at 0.25 ha, suggesting that enlarging plot size further would not have added more species. I shall return to a consideration of the implications of this pattern in the next section.

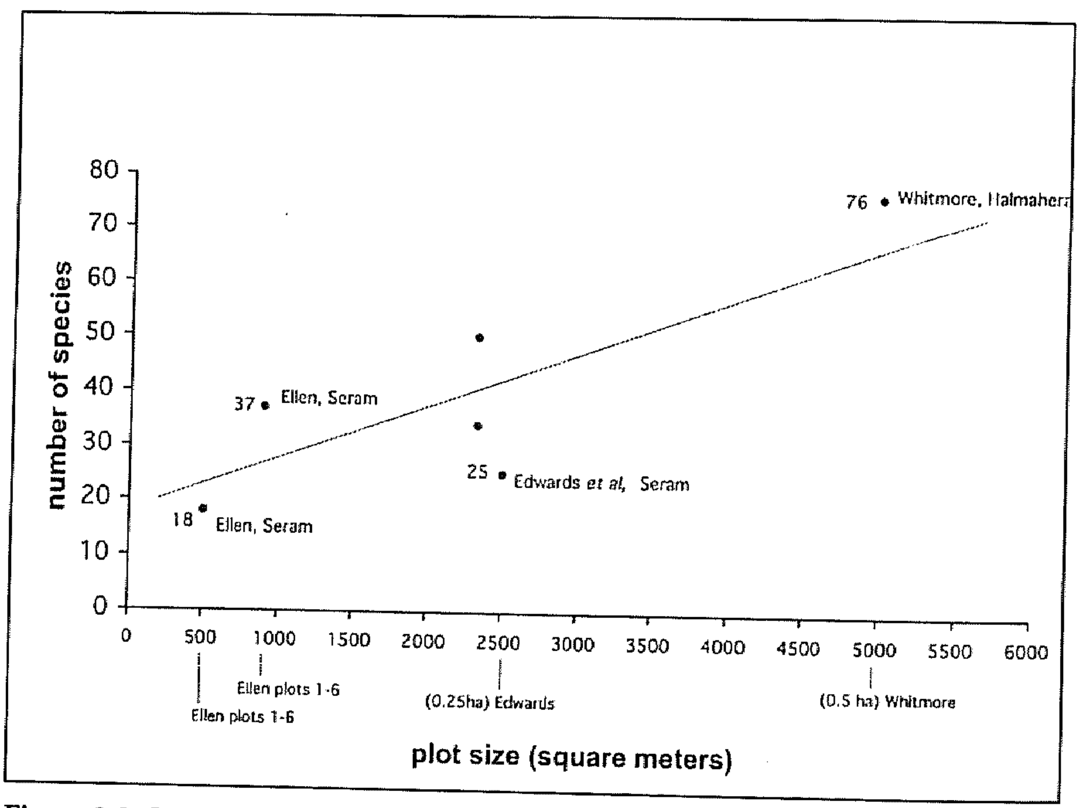

Figure 3.3 Species numbers in relation to plot size for various forest composition studies in the Moluccas.

Each plot was surveyed with a minimum team of three adult males. They were not always the same persons, but there was a marked overlap in membership. All team members were trained in the use of measuring, marking and enumeration techniques before each survey. Plots identified by me were first measured and marked up using a 30 m fibreglass retractable tape and spray paint. Plants were included in the survey if they were 10 cm dbh (diameter at breast height) or above, effectively restricting the census to trees and large lianas. The 10 cm threshold has become standard practice, although it has been demonstrated (Valencia et al. 1994) that only counting trees over 10 cm dbh can underestimate the diversity of woody species present as saplings. The location of each tree above 10 cm dbh was marked on prepared graph paper and an independent Nuaulu identification sought from each field assistant present. If there was any disagreement, discussion was allowed to see whether agreement might be reached or whether informants would agree to disagree. Where possible, voucher specimens were collected, including bark, but seldom (for tall trees) fertile specimens. We would then move on to the next tree, and the same sequence would be repeated. Back in the village, voucher specimens would be further discussed, fully documented, preserved by drying or in alcohol-soaked newspaper. All specimens, collected in triplicate where possible, were checked and sorted at the Herbarium Bogoriense. One set was retained in Bogor, a second was sent to Kew, and the third set retained in the Ethnobiology Laboratory of the University of Kent. All systematic data were entered into the Nuaulu Ethnobotanical Database (NED). In the field, local names obtained during plot surveys were checked against earlier data entered into the NED, and revisions made as necessary, often involving further consultation with informants. Where voucher specimens were absent or insufficient, photographs, drawings and visual descriptions were used in combination with standard reference manuals. Where Nuaulu were also able to provide Ambonese Malay terms, these were matched where possible against standard lists of Moluccan tree species with vernacular glosses (e.g. Whitmore et al. 1989), but always back-translated several times in different contexts to minimise erroneous determinations. Table 3.2 lists the total number of standing trees recorded for each plot compared with: (a) numbers of trees for which Nuaulu informants could provide names, and (b) botanical identifications to different levels of taxonomic specificity obtained from the various authorities consulted. Although phylogenetic identifications have not been obtained for all vouchers (in some cases even to generic level), and there are some plot trees for which vouchers were not obtained, the general pattern of identifications demonstrates a strong correlation between vernacular names provided and scientific species, suggesting that measures of species density, for example, might reasonably rely on vernacular names as proxies where determinations are unavailable.

Table 3.2 Summary of selected 1996 plot data: levels of identification.

	Plot	1	2	3	4	5	6	7	8	9	10	11
1	N	34	30	37	26	28	54	124	116	80	35	68
2	N with Nuaulu name[a]	34[b]	28	37	26	28	54	124[b]	115	74	35	68[b]
3	Percentage N identified with agreed Nuaulu name	100	93	100	100	100	100	100	99	94	100	100
4	N Identified to family level	30	25	35	25	16	50	108	98	54	25	68
5	N identified to generic level	20	21	32	24	16	49	103	90	37	25	58
6	N identified to species level	5	12	19	24	1	38	46	41	29	12	40

Key: N= number of standing trees 10 dbh or above; [a] = name agreed by minimum of three adult male field assistants; [b] = one doubtful

The Ecology of Lowland Rainforest on Seram and the Classification of Vegetation Types

If we compare the forest composition of Seram with that of the large islands of western Indonesia (Borneo and Sumatra) and New Guinea, it is clear that Seram lies in a zone of transition (Wallacea) between the predominantly Dipterocarp forests of Sunda (Asia) and the Australo-Pacific tree flora of Sahul (Oceania) (Figure 3.1). As we move eastwards Dipterocarpaceae fade out and are replaced by other characteristic families, such as (in lowland areas) Myrtaceae (particularly the distinctive Eucalypts), Myristicaceae, Lauraceae and Guttiferae (Glatzel 1992: 17–18; Edwards et al. 1993: 66, table 2a). This same pattern is confirmed by my own data (Table 3.3), with the most numerous families represented in the Nuaulu plots being Myrtaceae, Myristicaceae and Guttiferae.

The Manusela National Park study, conducted in 1987 (Edwards et al. 1993), was primarily concerned with altitudinal variation. It was based on nine 0.25 ha (i.e. 50 m by 50 m) permanent sample plots at a range of altitudes from sea level to 2,500 m asl (above sea level) south of Gunung Binaia on the central mountain spine. There were two sequences, one over calcareous rocks and the other over non-calcareous rocks. Both show that soil pH decreases with altitude while organic carbon increases. In addition to a lowland zone (the primary focus of the present analysis) the Manusela study yielded data distinguishing alpine, subalpine (characterised by shrubby *Rhododendron*), montane (high-altitude tree fern grassland), and lower montane zones, the latter with an upper band dominated by Myrtaceae and Lauraceae, and a lower band by Fagaceae. The dominant species of lowland and lower montane forest (which occurs at a lower altitude on smaller mountains, and is therefore of some interest to us here) are reported for four plots as, respectively: *Drypetes longifolia, Planchonella nitida* and *Astronia macrophylla; Lithocarpus* sp., *Litsea robusta* and *Shorea* sp.; *Lithocarpus* sp. and *Weinmannia*; and *Phyllocladus hypophyllus*, Myrtaceae and *Trimenia*. By comparison, in the eleven Nuaulu plots (Table 3.3, Table 3.4), there are 39 families represented overall. There are no clear dominants in one, and in the others the dominants are Euphorbs and *Syzygium*; *Shorea selanica*; *Artocarpus integer*, Myrtaceae and *Mallotus*; *Areca catechu*; Myrtaceae and *Annona reticulata, Polymatodes nigrescens* and *Myristica*; *Calophyllum inophyllum*; *Syzygium* and *Myristica*; and finally Myrtaceae and *Macaranga involucrata*. In other words, despite a strong similarity between the Manusela data and my own at the family level, the only overlap of dominants at the generic level is with respect to *Shorea* (a genus which is numerically quite untypical of the Moluccas) and the important Myrtaceae genera, no doubt including *Syzygium* and *Eugenia*. The explanation for this difference may in part lie in the deliberate bias in the Nuaulu plots in favour of anthropogenic vegetation, but it also reflects the general diversity and patchiness of species composition of lowland rainforest on Seram below 1,000 m (mostly on low hill land), which had been evident from my work in 1970–71, at a time

Table 3.3 Family frequencies for individual trees in 1996 plots.

Family	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10	Plot 11	Total
MYRTACEAE	6	1	4	1	6	1	16	17	11	8	15	86
MYRISTICACEAE		2	2		2	7	6	21		6		46
EUPHORBIACEAE	13	2		1	5	2	7		3	1	11	46
GUTTIFERAE	1		5				5	8	17	4		40
PALMAE		4				21	4		2	1	3	35
MORACEAE	1			17	1		8	1		2	3	33
LEGUMINOSAE	1	1	1	1		3	4	3	4		7	25
POLYPODIACEAE								23				23
LAURACEAE	1	2	1	1			7	2	4			18
BURSERACEAE			4	2		1	7	3			1	18
ANNONACEAE		2				1	11	3				17
EBENACEAE	2		1		1	1	8	1				14
LEEACEAE		3				3	5					12
RUBIACEAE	3	2					4		1		1	11
ROSACEAE			3			1	2	1	3			10
DIPTEROCARPACEAE			10									10
LOGANIACEAE						1					7	8
OLEACEAE			2					6				8
VERBENACEAE	2			1			2		2		1	8
STERCULIACEAE						3		1		1	2	7
MELIACEAE		3			1	1	2					7
LECYTHIDACEAE			1					5				6
APOCYNACEAE							2				3	5
PANDANACEAE						2					3	5
ARAUCARIACEAE									4			4
MELASTOMACEAE							1	2		1		4
GRAMINAE						1					3	4
ELAEOCARPACEAE			1								3	4
MALVACEAE											3	3
ANACARDIACEAE							1				2	3
FLACOURTACEAE							3					3
Eight families with two or less trees 3		1		1	3	1	3	1		13		
Unidentified		4	5	2	1	12	4	16	18	27	10	108

when there were no detailed studies of forest ecology for Seram (Ellen 1978: 67–68). Table 3.4 provides a summary of 1996 Nuaulu plot data for floristics and forest structure (see also Figures 3.4, 3.5 and 3.7).

Both montane and lowland plots surveyed on Seram display low species diversity compared with many rainforests in the far east (Whitmore 1984), species declining with altitude above 600 m. If we take the mean of all plots (n = 4) within the altitude range 0–1900 reported by Edwards et al. (1993) – that is, covering approximately the same altitudinal range as the Nuaulu plots, and including both lowland and sub-montane areas – the number of species per plot is 25. Species number for the Nuaulu plots was higher, even though plot size was smaller. Assuming an approximately proportionate increase in species number with plot size (Figure 3.3), Nuaulu species numbers for a 0.25 ha plot would likely be between 35 and 50, and projected to 0.5 ha then around 75. In terms of the index of species richness ($d = S/\sqrt{N}$), the Manusela data give a mean of 2.14 (range = 1.44 > 2.99, where N = 4) and the Nuaulu data a mean of 3.32 (range = 1.7 > 5.6, where N = 11). Whitmore et al. (1987), in an enumeration study carried out on Halmahera at 630 m asl, recorded 76 species > 10 cm dbh, from 31 families within a 0.5 ha plot, giving a species richness index of 3.94, slightly higher than both the Manusela and Nuaulu data. Sidiyasa and Tantra

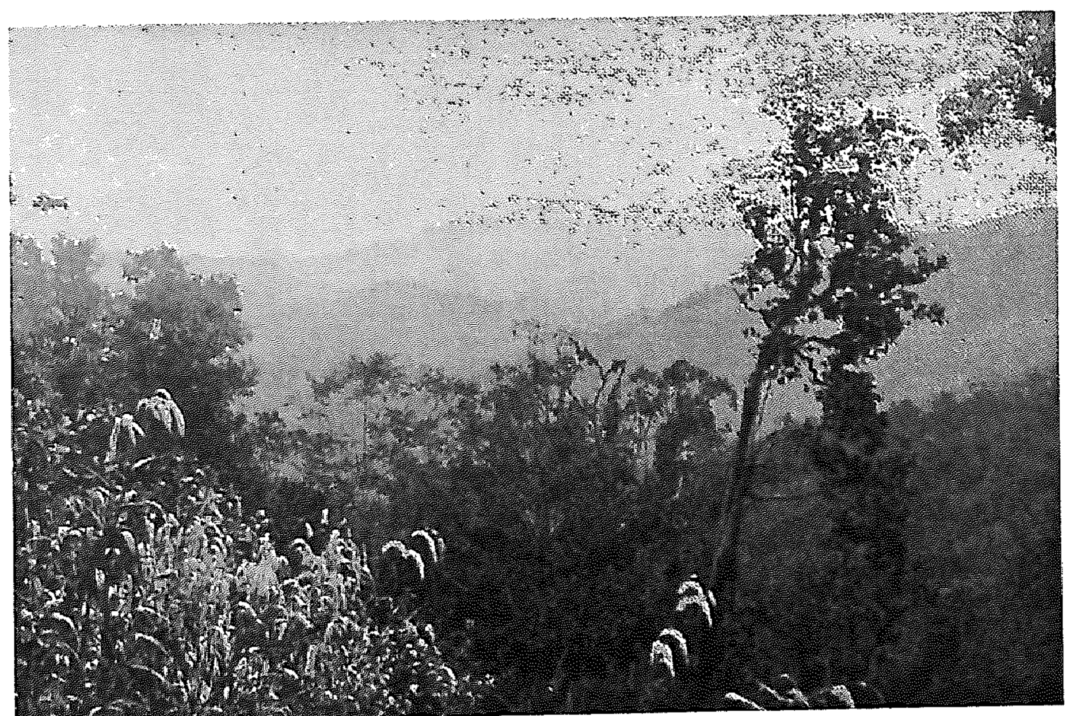

Figure 3.4 Looking eastwards along the Nua valley towards Mount Binaiya from Notone Hatae on the Trans-Seram Highway; midway between the south coast and Sawai on the north coast, but on the southern watershed. Apart from the roadside strip, all forest here is described simply as *wesie*, and consists of long-term regenerated forest and forest which has not obviosuly been modified by humans. March 1996 (96-11-20).

Table 3.4 Summary of plot data: floristics and forest structure.

Plot	Size (m^2)	Alt.	N	S	N/m^2	S/m^2	H	E	1/D	Most frequent family/genus (N reported for taxon)
1. Nahati	400	200	34	20	0.085	0.05	2.75	0.92	18.10	EUPHORBIACEAE (13) MYRTACEAE, *Syzygium sp* (6)
2. Mon	400	150	30	21	0.075	0.053	3.01	0.99	48.33	PALMAE (4) –
3. Nahane hukune	400	200	37	16	0.093	0.04	2.47	0.89	10.74	DIPTEROCARPACEAE *Shorea selanica* (10) GUTTIFERAE *Calophyllum inophyllum* (5)
4. Yoko	400	100	26	9	0.065	0.023	1.41	0.64	2.39	MORACEAE *Artocarpus integer* (17) –
5. Benteng	400	300	28	9	0.07	0.023	1.77	0.80	4.97	MYRTACEAE (6) EUPHORBIACEAE *Mallotus sp.* (5)
6. Yana Onate	400	50	54	22	0.14	0.055	2.79	0.90	13.25	PALMAE (mainly *Areca catechu*) (21) MYRISTICACEAE (7)
7. Mon sanae	900	300	124	47	0.14	0.052	3.62	0.94	38.32	MYRTACEAE (16) ANNONACEAE *Annona reticulata* (11)
8. Sokonana	900	100	116	33	0.13	0.037	3.05	0.87	15.02	POLYPODIACEAE *Polymatodes nigrescens* (23) MYRTACEAE *Myristica* (17)
9. Rohnesi	900	900	80	28	0.089	0.031	2.92	0.88	14.77	GUTTIFERAE *Calophyllum inophyllum* (17) –
10. Wae Pia	430	200	35	21	0.081	0.05	2.88	0.94	23.8	MYRTACEAE *Syzygium sp.* (8) MYRISTACEAE (Mainly *Myristica sp.*) (6)
11. Amatene	900	400	68	26	0.076	0.03	2.98	0.91	18.67	MYRTACEAE (15) EUPHORBIACEAE *Macaranga involucrata* (11)

Key: N = number of trees, S = number of species (see *Note*) = species richness, N/m^2 = tree density, S/m^2 = species density. H = Shannon diversity index $\Sigma P_i(\ln P_i)$, where P_i = the proportion of individuals in the *i*th species. The value of H increases with both species richness and equitability (evenness with which individuals are distributed among the species). E = equitability H/lnS, 1 being where individuals are most evenly distributed amongst the species, and 0 being the least. D = Simpson's index of dominance, $\Sigma(n_i(n_i-1) / N(N-1))$ (gives probability of any two individuals drawn at random from an infinitely large community belonging to different species, where n_i = the number of individuals in the *i*th species. As D increases, diversity decreases. Simpson's index is therefore expressed as 1/D.
Note: S and formulae incorporating S are derived from Nuaulu vernacular terms for trees, and therefore an assumed equivalence between Nuaulu terms and taxonomic species.

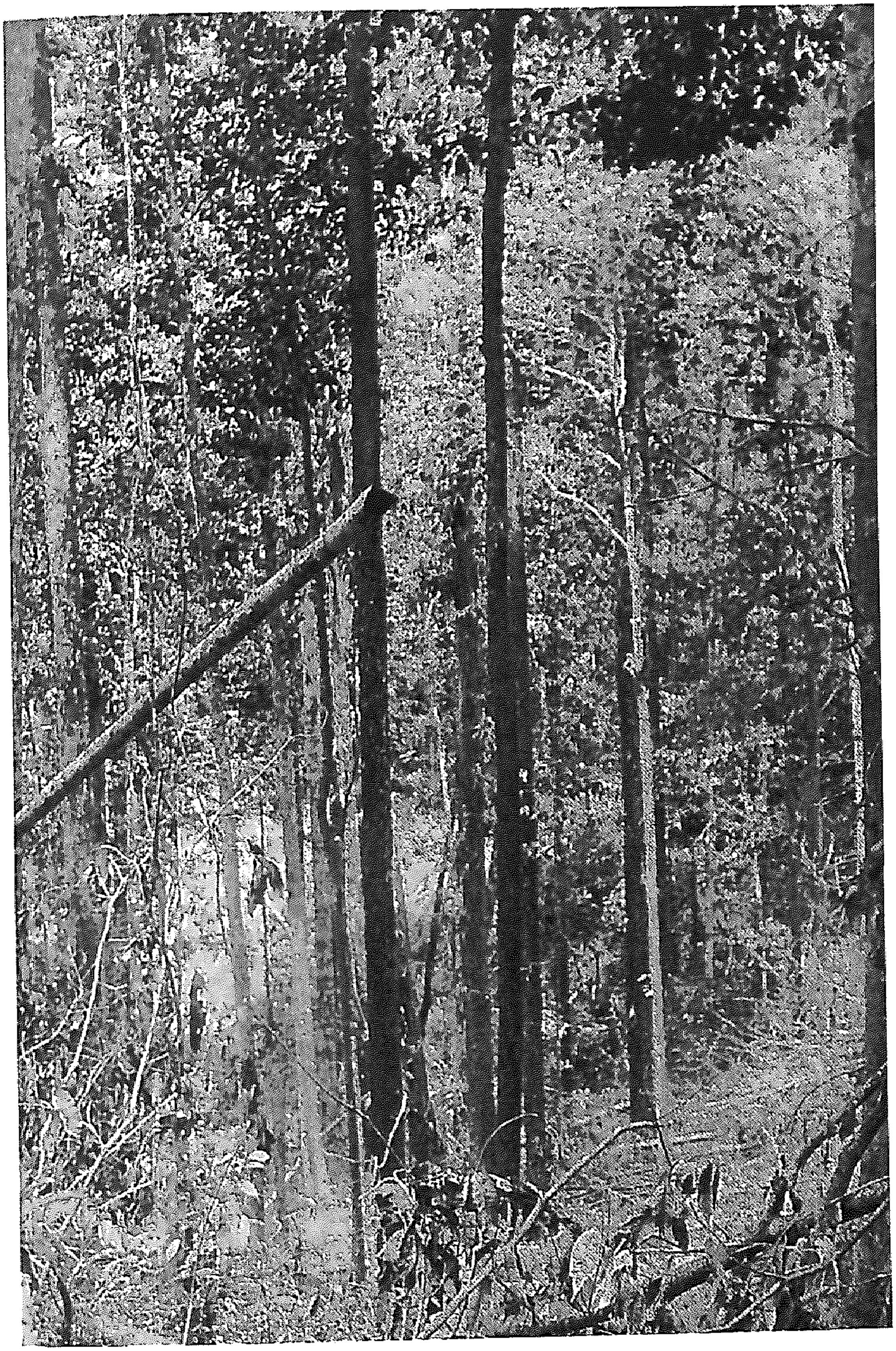

Figure 3.5 Plot 8, riparian forest at Sokonana, north of the Ruatan river. February 1996 (96-08-25).

(1984), working in the northern part of the Manusela National Park (Wae Mual), provide a very low species richness index of 0.97 for lowland rainforest, even for Seram. In contrast, a 1 ha plot in Brunei (Poulsen et al. 1996) had 550 trees, 231 species and an index of species richness of 9.85. The low species richness values reported for Seram, compared with Borneo (see also Proctor et al. 1983) or New Guinea (Paijmans 1970), appear to be related to the recent geological emergence of the island and the varying levels of isolation over a six million year period (Audley-Charles 1993).

There have been various attempts to distinguish distinct forest types for Seram, beginning with the colonial forestry department, and its successor in independent Indonesia (Departemen Kehutanan). Figure 3.6, for example, shows superimposed official forestry categories on a map of South Seram. More instructive, from an ecological standpoint, is the typology presented by Glatzel (1992: 17–18), based on work conducted in West Seram by the Agricultural Faculty of Pattimura University, in the same area in which the ethnobotanical work of Suharno (1997) was subsequently conducted (Table 3.5). What is significant about these official typologies, as we shall see, is their general lack of congruence with local folk classifications.

We now know that tropical rainforest is a less stable and more diverse vegetational regime than once thought, and that a great deal of forest, especially lowland forest, is relatively recent regrowth, much of it following human interventions. Little was known about the time-scale of secondary successions at the time of Richard's classic benchmark study (1996: 400), and it was generally accepted that *primary* forest could be taken as mature old forest which had reached a fairly stable equilibrium or ecological succession (Spencer 1966: 39). The certainties of these older equilibrium and functional models, and the static pristine rainforest concept are no longer accepted in their entirety, and a single forest ecosystem type concept based on notions of a stereotypical or 'essentialised' climax forest are inappropriate (Johns 1990: 144; see also Blumler 1996: 31). Instead, contemporary models of lowland forest ecology emphasise more the patchiness, historicity and diversity of composition. Moreover, measures of what is understood by diversity have become more sophisticated. For example, it is now usual to distinguish alpha diversity (the number of locally occurring species) from beta diversity (diversity at the level of species communities). Some argue that alpha and beta diversity are related, alpha diversity resulting from a mosaic of juxtaposed niches and microhabitats. Consequently, to attempt to measure empirically the number of different 'types' of vegetation in a tropical rainforest may seem so time-consuming and ultimately subjective as to be hardly worth the effort (Condit 1996). This makes establishing simple typologies difficult, though there may be good practical reasons (in connection with forest management), to devise and recommend them. Thus, the authoritative classification of Pires and Prance (1985: 112–13), which draws extensively on ethnically diverse local ethnoecologies, distinguishes about twenty-two separate vegetation types for the

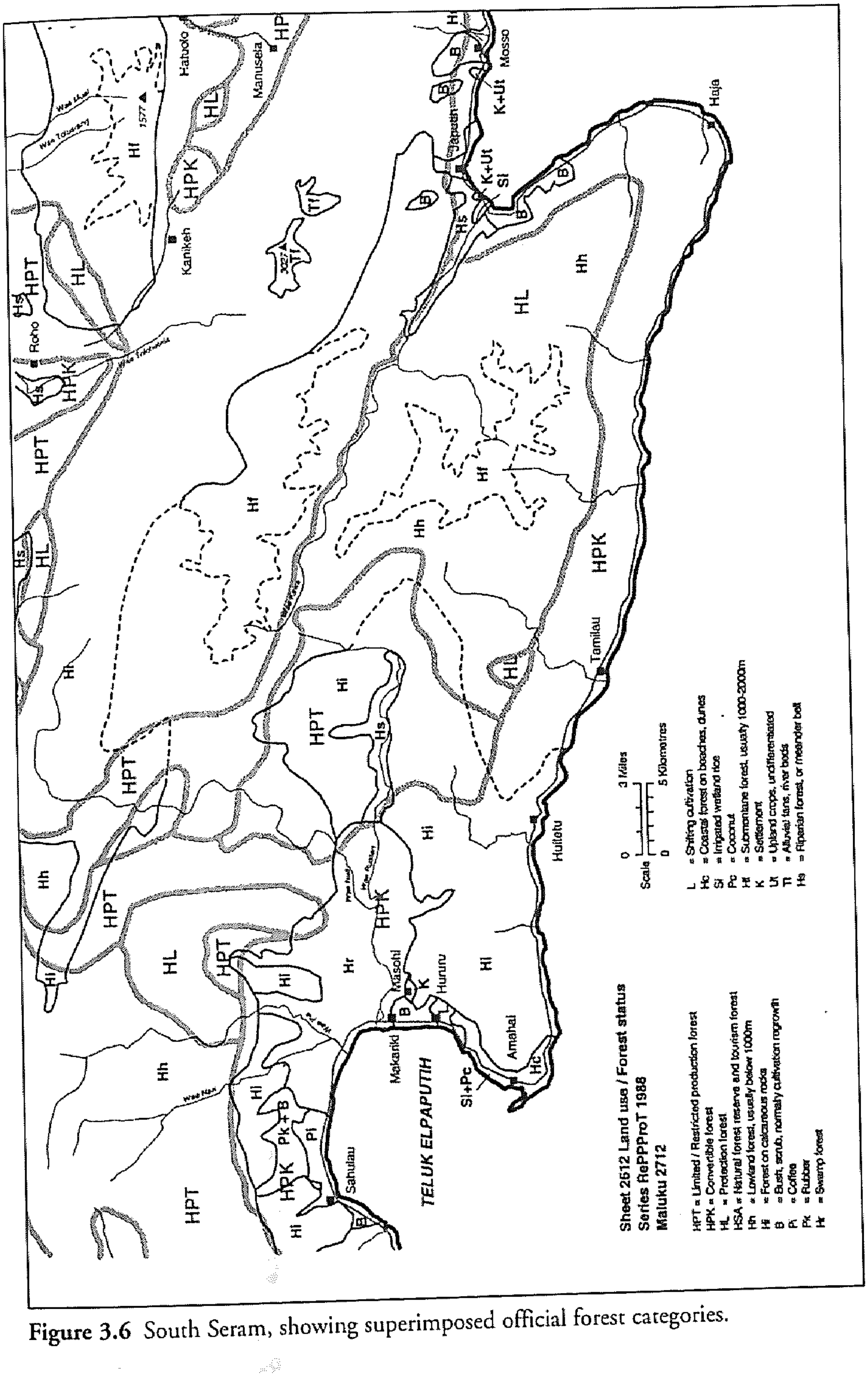

Figure 3.6 South Seram, showing superimposed official forest categories.

Table 3.5 Forest types distinguished by Pattimura University Agricultural Faculty survey team and utilised by Glatzel (1992)

	Species association	Notes
1.	*Imperata – Melaleuca* grassland	
2.	*Melaleuca – Imperata* woodland	As 1, but *Pteridium* also charactersistic
3.	*Strombosia phillipensis* dense evergreen forest	*Anthocephalus macrophyllus, Vitex cofassus, Octomeles sumatrana, Macaranga* sp. Pandanus on disturbed sites
4.	*Vitex – Pterocarpus* dense evergreen forest	No pronounced dominants. Most common species: *Vitex cofassus, Myristica insipia, Pterocarpus indicus, Eleaocarpus sphaericus.*
5.	*Anthocephalus – Intsia* dense evergreen forest	
6.	*Intsia – Pterocarpus* dense evergreen forest	
7.	*Canarium – Myristica* dense evergreen forest	Easy to walk in: dominants include *Canarium indicum, Myristica insipida and Pterocarpus indicus*
8.	*Puteria – Metrosideros* dense evergreen forest	No real dominants, but common species include *Puteria obovata, Metrosideros vera, Calophyllum inophyllum, Litsea* sp., *Elaeocarpus sphaericus, Cananga odorata, Dysoxilum cautostachyum* and *Octomeles sumatrana.*
9.	*Metrosideros vera* dense evergreen forest	Almost exclusively monospecific
10.	*Octomeles – Arenga* evergreen forest	Dominants are *Octomeles sumatrana, Ficus* sp., *Pinanga* sp., *Nauclea orientalis* and *Bambusa* sp. (*Arenga* very characteristic)
11.	*Metroxylon – Bambusa* evergreen forest	*Metroxylon, Bambusa* and *Arenga*
12.	*Sonneratia – Bruguira* evergreen forest.	Coastal and estuarine mangrove

Brazilian Amazon. However, it appears to make increasing sense to interpret forest composition in terms of the distinguishable kinds of process which lead to variation (Sprugel 1991; Fairhead and Leach 1998: 186). Rainforest, it is now widely acknowledged, is a mosaic of patches of different sizes, whether looked at in terms of different silvigenic stages of development (Torquebiau 1987), or differences based on substrate, altitude and aspect, soil water content, or dynamics arising from species dispersion.

Human Use and Modification of Forest

Much tropical lowland rainforest – in Indonesia as elsewhere – is now seen as the product of many generations of selective human interaction and modification (deliberate and inadvertent), optimising its usefulness and enhancing local diversity. The outcome is a coevolutionary process in which human activity is essential. Indeed, particular patterns of forest extraction and modification are often seen as integral to its sustainable future. For some authorities, the evidence for intentional rather than serendipitous human influence is so compelling as to invite the description of 'managed' forest (Clay 1988; Schmink et al. 1992: 7–8).

The empirical work supporting these claims comes mainly from the Amazon (e.g. Balée 1989, 1992, 1994; Anderson and Posey 1989); but more recently also from Africa (Fairhead and Leach 1996), and increasingly from large parts of Malaysia and the Western Indonesian archipelago (Rambo 1979; Dove 1983; Maloney 1993; Padoch and Peluso 1996; Aumeeruddy and Bakels 1994; Brookfield et al. 1996; Padoch and Peters 1993; Peluso 1996; Colfer et al. 1997; Puri 2005). On Seram, the generally low tree diversity is much influenced by disturbance, and there is abundant evidence that human agency has had consequences for forest ecology. This has been largely through the long-term direct impact of small-scale long forest-fallow swiddening, the extraction of palm sago (mainly *Metroxylon sagu*), and arboriculture over many hundreds of years, featuring a small number of crucial nut- and seed-yielding trees, most notably *Canarium*, *Aleurites*, *Pandanus* and *Celtis* (Ellen 1988, 2001). For example, the mature mixed forests of central Seram contain a higher proportion of *Canarium* than would be expected without human encouragement (Edwards 1994; Latinis 2000), and the high proportion of *Canarium* to other genera in the Nuaulu plot 7 (a protected area) is worth noting in this respect (Figure 3.8). The selective felling of large trees allows for small patches of characteristically secondary forest species (e.g. *Trevesia sundaica*, *Macaranga hispida*, *Artocarpus elasticus* and *Bombax* spp.), while species which are often regarded as being characterically 'secondary' – *Prunea arborea*, *Platea excelsa* and *Chisocheton sandoricarpus* – have become characteristic of primary rainforest (Edwards et al. 1990: 171). In addition, the introduction through human agency of the pig (and almost certainly the cassowary), and in more recent centuries, deer too, has had a marked impact on forest dynamics, both in terms of the feeding patterns of these megafauna, and also through systematic human predation. Extraction of a wide range of useful products, including timber for local use, selective logging and collection for exchange (resins, rattan, birds) has also been significant (Ellen 1985: 563; Ellen 1999: 137). In addition to *Canarium*, among the endemic tree species whose distribution have been significantly affected by their importance in exchange are *Agathis dammara* (for its resin) at sub-montane altitude and *Melaleuca leucodendron* (for medicinal oil) in drier more open areas.

In earlier work (Ellen 1978: 67, map 8, p. 117) I have described the distribution of mature regrowth and 'primary' forest for 1970–71 in the vicinity of the Nuaulu settlement of Rohua. The distribution showed a striking visual distinction between (a), the bulk of forest stretching from a very minimum of around 100 m from the coast northwards and mountainwards, and (b) isolated patches apart from the major block of forest and forming barriers between cultivated areas. This latter residual distribution tends to be along ridges and around steep

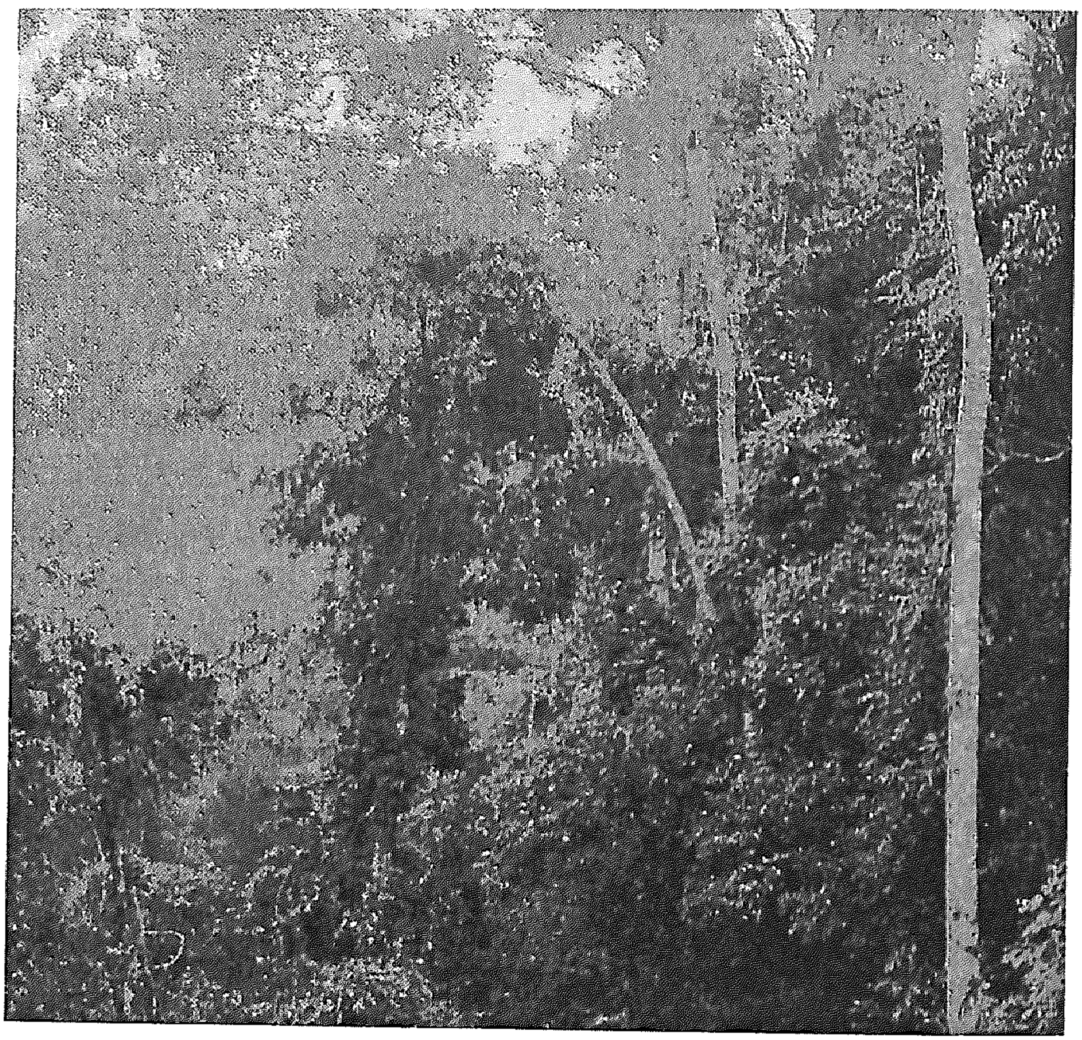

Figure 3.7 Upland forest with *Agathis dammara*, near plot 9 (Rohnesi), west of Trans-Seram Highway near Wae Sune Maraputi. March 1996 (96-11-21b).

Figure 3.8 *Canarium commune* below the old village site of Amatene (plot 11). March 1996 (96-12-21).

knolls, unsuitable for cultivation under normal circumstances. As a result, these areas (together with the margins of the main forest block) within easy access of the village, are an important source of construction timbers and certain other products, leading to gradual thinning and denudation. Different kinds and degrees of extraction lead to different kinds of secondary regrowth, some directed (that is managed) and some arising by default (c.f. Sillitoe 1996: 216–24). These include: (1) young secondary growth: recently deserted clearings with rapidly growing herbs, shrubs and small trees of a relatively few number of genera – for example, *Trema orientalis, Euphorbia hirta, Homalanthus populifolius* and many kinds of pteridophyte; (2) medium secondary regrowth: one to ten years, with small trees gradually becoming dominant, for example, *Aleurites moluccana* and *Melastoma malabathricum*; (3) mature secondary forest, with a great variety of small and medium-sized trees, shrubs and vines in areas with over ten years of secondary growth; and finally (4) bamboo thicket, also found in combination with the three above associations.

The tendency to procure a wide variety of products, in particular rattans, timber and bamboo from secondary and mature forest as near to the village as possible, and adjacent cultivated land, leads inevitably to the depletion of more stable associations of forest the nearer one is to the main loci of settlement. Consequently, when mature forest is cut for gardens it has almost always been considerably modified already and contains plant associations more typical of regenerated secondary forest, tends to lack rattan and is considerably thinned on account of the cutting of timber for construction purposes. Such depleted but ecologically distinctive areas, such as open secondary associations often subject to marginal cultivation as well as complete clearance (Ellen 1978: 76, 85, map 9; 1999), were originally termed by Richards (1996: 379, 400) *depleted* forest and by Fosberg *altered* forest (1962: 257). Ecologically, these contain a combination of the properties of both mature and secondary forest growth. It is now widely acknowledged that the edges of garden land, swidden regrowth and disturbed and other secondary forest commonly represent the most important patches for hunting (e.g. Linares 1976), and sites of intensive extraction of plant extraction (Grenand 1992).

Nuaulu Terms and Categories Applied to Forest: Concepts and Plots

Nuaulu categorisation and general understanding of forest reflect: (a) disturbance history, (b) topography and substrate, and (c) salient species associations, nuanced in terms of (d) land ownership and (e) toponyms. I argue elsewhere (Ellen, unpubl.) that this is a broad and flexible framework, which although employing a limited set of fixed and shared lexically-labelled concepts, accommodates knowledge of wide-ranging ecological differences in forest type, and indeed constitutes a pragmatic response to the recognition of its complexity. The Nuaulu term *wesie* broadly indicates all forest, but narrowly and prototypically is understood as mature forest, far away from human settlement, which has not been modified in recent times. Once cut, individual areas of cultivation are known as *nisi*, 'gardens', which in turn can be divided into three basic types: (1) *nisi honue*, recently cleared garden plots up until the end of the first year; (2) *nisi monai*, gardens after the first year; and (3) *nisi ahue*, secondary growth of various kinds. One special category based on disturbance history is indicated by the term *nia monai* (literally, 'old village'), which refers to an old village that is still inhabited, but also to old village sites at different stages following abandonment.

In addition to disturbance history, Nuaulu describe forest locations in terms of four categories based on topography and altitude (Ellen 1978: 114, map 10): (1) *watane*: flat areas (the coastal margins, valley floors, alluvium); (2) *sanene*: valley sides; (3) *pupue*: ridge land, crests, the higher reaches of valley walls: (4) *tinete, pupue tinete*: mountains, peaks; or combinations of these terms, sometimes in conjunction with some reference to their underlying substrates. Shared labelled categories referring to areas dominated by a particular species are rare in Nuaulu, though any patch where a particularly salient species is dominant may be described with a term such as *wesi mukune* (tree-fern forest), *wesi iane* (*Canarium commune* forest), or *oni-oni* (*Cylindrica exaltata*, alang-alang grassland), but we should not mistake these for fixed terms, even though their use evokes widely shared meanings and knowledge. Where there are special terms these tend to be for deliberate anthropogenic patches, groves or plantations. Thus, strictly ecological criteria elide with cultivation (*nisi*) and ownership (*wasi*) categories. A special case of tenure which intrudes into the lexicon to describe different kinds of forest is *sin wesie*, areas of sacred protected forest (e.g. plot 7). These are not necessarily historically undisturbed or unmanaged, but are generally ecologically mature, resource rich and with a composition which reflects their age and successional stage in the development of long fallow.

These cross-cutting ethnoecological and social categories are integrated and articulated through a detailed toponymic grid. No description of forest can make much sense for Nuaulu without such an annotation. The main components of this grid are named rivers, even small creeks, supplemented by names of peaks, hills, prominent rock outcrops, stones, waterfalls, lakes, swamps, caves and suchlike. In addition there are the transient features – large trees, paths, log bridges, burned patches, patches of grassland; plus the recorded evidence of human activity, gardens belonging to particular individuals, old gardens, abandoned gardens and – most importantly – old village sites, and sites of some other special significance, such as Kamnanai Ukune or Nusi Ukune, in these cases within the sago forest at Somau. The extensive character of participatory mapping exercises elsewhere has shown just how detailed this knowledge is. On the whole, as a reference system, these toponyms begin with the names of particular mountains on the one hand, and large rivers on the other. The mountains or hills are fixed points which also give their names to large areas surrounding them. Similarly, the large rivers indicate extensive riparian and valley areas rather than the rivers themselves. Linking a river name to a mountain, therefore, provides some general coordinates, which can then be refined further by referring to tributaries of the main rivers, and tributaries of tributaries. Only when this set of coordinates are insufficient to locate places will other indicators be introduced. This set of toponyms serves to identify particular patches of forest, which to some extent bypasses the need to identify forest in terms of floristic composition or habitat structure. The toponymic references clearly indicate the investment of history in the description of a particular landscape, no better revealed than through the narrative associations of old village sites. No stretch of vegetation is ever seen as an example of some generic ahistoric type, but rather as a place whose character must be understood through its particular historical associations, and the overall 'cultural density' (Brosius 1986: 175) of the landscape.

If we now look at the plot descriptions in terms of the words Nuaulu use to describe their overall character (Table 1), five are described as *wesie* (forest), two as *nisi ahue* (long-term fallow), two as *niamonai* (old village sites) and one as *sin wesie* (sacred forest). Only a small number of terms are consistently shared by Nuaulu to describe forest habitats, and there is a low degree of lexicalisation compared with what we find in official and scientific classifications, and indeed in the folk classifications of some Amazonian peoples (Ellen, unpubl.). Systematic data on ecological knowledge and linguistic evidence indicate: (1) that the categories *wesie* (forest) and *nisi ahue* (long fallow) absorb a great deal of variation; (2) that disturbance history is the main and unifying basis for local understandings of variation, modified by occasional considerations of topography and substrate; (3) that forest is perceived as being in a constant state of flux, in large part due to interaction with humans; (4) that some stable categories are associated with specific species, but that named categories of this kind are rare; and (4) that ethnoecological understandings of forest are inseparable from categories dividing forest in terms of patterns of ownership and the cultural division of landscape reflected in the use of toponyms.

Discussion

Scientific and folk classifications have coevolved in recent global history, and the relationship between folk knowledge and instituted scientific knowledge can be modelled as two interacting and mutually reinforcing streams: hybridising through mutual borrowings while maintaining permeable boundaries for social and professional reasons, and in the interests of cognitive efficiency (Ellen and Harris 2000; Ellen 2004; Dove et al., this volume). Because tropical forest ecology and forestry are field-based practices, they have absorbed more from local knowledge systems than the other way around, and also compared with some other sciences. Indeed, instituted professional forestry has adopted much from local artisanal forestry practices, nomenclatures and understandings. The precise form this has taken varies from one country to the next, but colonial forestry services certainly appropriated much from indigenous knowledge. Thus, the Brunei Forestry Service today utilises a typology developed by colonial foresters operating in Malaya, Sarawak and British North Borneo (Kathirithamby-Wells 2004) in which 'Peat Swamp Forest' is sub divided using vernacular Malay terminology into, amongst other categories, *atan bunga* and *padang atan* (forms of forest dominated by *Shorea albida*), *padang keruntum* (dominated by *Combretocarpus rotundatus*) and '*padang* forest'; in addition to utilising the category *kerangas* (tropical heath forest) (Brunei 1984). Whatever these terms once meant, they now reflect official categories.

A similar process of knowledge transfer can be identified in colonial map-making traditions. Thus, the maps produced by the Dutch Topographische Dienst in 1917 of Seram, which surveyed in detail the entire island for the first time, show evidence of extensive reliance on Nuaulu (and other indigenous) topographic knowledge, through the use of recognisably Nuaulu toponyms over a large swathe of the central part of the island, approximately corresponding to that area which Nuaulu clans claim as their territory today. These descriptions were obviously generated by the map makers surveying with Nuaulu guides in the first decade of the twentieth century. Conducting research on these issues from 1970 onwards, and particularly in 1996, both Nuaulu co-researchers and myself have been struck by the congruence between current Nuaulu knowledge, as indicated in culturally annotated sketch-maps which Nuaulu produced for me (c.f.Fernandez-Gimenez 1993), and the toponyms provided in the 1917 Dutch map. I have already indicated in the preceeding section how crucial local toponymic knowledge is in providing a framework for understanding vegetational diversity more generally, and it is certainly not a coincidence that as *field-based* practices, colonial cartography and forestry converge in the way they made use of local knowledge.

But while colonial forestry and cartography depended heavily on the inputs of local people, at the same time there was increasing pressure to produce generic typologies of practical value to science and industry which applied over wider geographic areas. The possibilities permitted by new technologies of literary and graphic representation, in addition to the requirement to confirm qualitative intuitions with quantitative measurement, accelerated this tendency: routinising the use of plot surveys and yielding increasingly complex and contrastive typologies of forest habitats, but also raising issues of comparability between timber-type maps using different categories in different places (Avery and Burkhart 1994: 262). Sometimes the process of generalisation encouraged dangerous distortations of local ecological realities, which served to reinforce the 'territorialization strategies' and official prejudice about local forestry practices and their consequences (e.g. Fairhead and Leach 1996). More recent technologies of GIS and remote sensing have had a similar effect, creating new opportunities for distancing official and local representations. The history of attempts by ecologists and foresters to impose overly rigid classifications is reminiscent of Campbell's (2002) instructive demonstration of how the predetermined conceptual assumptions and technical specifications of a GIS package prevented the absorption of relevant data on Namibian agropastoralist land tenure, which, just like Nuaulu forest knowledge and tenure, is informal, flexible and overlapping.

Recent scientific modelling of rainforest in terms of a complex mosaic rather than as an aggregation of discrete types has been a response to the problems generated by the mechanical application of these methodologies and the assumptions associated with stereotypical, overgeneralised and essentialised representations. The diversity patterns we can now read into tropical rainforest make classifications of forest 'types' difficult. All lowland tropical rainforest is heavily influenced by patterns of human settlement and extraction over many thousands of years, and essentialist descriptions which ignore human disturbance are now widely acknowleded as misleading. And paradoxically, the problems of 'ground-truthing' imagery based on remote sensing have led to the revision of just how such data should be interpreted, in some cases involving participatory mapping. We now appreciate much more how grouping secondary biodiversity at different levels of geographic aggregation may result in very different classificatory patterns and require different kinds of analysis and interpretation (Moran 1990), and how much professional forestry can learn from local people (Wiersum 2000). Indeed, what success recent strategies, such as Joint Forest Management (JFM), have had has been grounded in the partial resolution of the opposition between global scientific forestry knowledge and local knowledge (Sivaramakrishnan 2000: 61). Even in Indonesia, the rethinking of forest policies, in the light of the failure of top-down models, made possible by the 'Reformasi' following the end of the Suharto regime in 1998, has given more scope for social forestry, local voices, and for the recognition of local community rights and ecological knowledge.

We can observe, therefore, a convergence between how local tropical forest dwellers perceive and classify forest, in this case the Nuaulu, and how scientists have reacted to the inadequacies of an earlier generation of models. The spatial variation of secondary biodiversity (habitats, biotopes, ecosystems) must, on the whole, be understood very differently from variation at the species level. My data support the claim that a classificatory model composed of large numbers of forest types, analogous to folk taxonomic schemes reported for individual plant species and typified by morphological discontinuity, does not reflect accurately how Nuaulu perceive and encode forest differences. Rather, Nuaulu representation of forest is non-taxonomic, constructed on the basis of the intersection of a number of classificatory dimensions based on different criteria acknowledging its continuous variation, deployed in a flexible and non-mechanical way. Terminologies arising from classificatory stimuli are more likely to be ad hoc descriptions of difference rather than indicating the presence of widely shared and fixed categories. Nuaulu, therefore, seem to experience forest in the same way as those ecologists who have tried to use plots to measure compositional and structural diversity. To describe a 'patch' in terms of a permanent and simple ethnoecological category is to overgeneralise and reify in a way which is not always helpful to the representation and management of resources.

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Note

1. A patchy distribution pattern is one in which values, observations or individuals are more aggregated or clustered than in a random distribution, indicating that the presence of one individual or value increases the probability of another occurring nearby (Lincoln et al. 1982). Alternatively, it might be defined as heterogeneity in the distribution of resources and of the patches themselves. In the context of forest ecology, patchiness reduces the possibility of accurate mapping using a neat classification of forest types.

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