Article

Tim Bayliss-Smith, Edvard Hviding and Tim Whitmore

Rainforest Composition and Histories of Human Disturbance in Solomon Islands

On the basis of a Solomon Islands case study, we report that tropical rainforests hitherto perceived as untouched, pristine, virgin, etc., are actually sites of former settlement, extensive forest clearance, and irrigated/swidden agriculture. An unusually wide range of sources—rainforest ecology, forest classification and mapping, ethnobotany, land-use history, oral traditions, ethnographic and archaeological observations—supports our conclusions. These observations have bearings for contemporary perspectives on scenarios for rainforest regeneration after logging. They also force a revision of certain assumptions concerning Melanesian prehistory and historical demography, and indicate that interdisciplinary links between botany, archaeology and social anthropology are needed to achieve a better appreciation of rainforest dynamics.

INTRODUCTION

Writing 250 years ago, the Swedish naturalist Peter Kalm observed how natural disturbance from occasional storms was an integral part of the cycle of regeneration in North American forests (1). Knowledge of this kind was undoubtedly shared by many indigenous peoples living in forests all over the world, especially those whose swidden agriculture created a mosaic of disturbed areas in various stages of recovery back towards mature forest (2, 3). Yet in contrast, as late as the 1960s forest ecologists were still unwilling to accept a role for random disturbances within their ecological theories. In the words of George Peterken, "blinded, unlike foresters, by the concept of vegetation as a stable climax, most ecologists and conservationists recognized only recently that wind, fire, disease and other disturbances are widespread determinants of stand structure, the longevity of trees, and the balance between species" (4).

As a result of research efforts in the last 30 years a new paradigm for forest ecology has now emerged in which natural disturbance plays a central role. Gaps in the forest canopy are seen as providing a range of different micro-habitats, while tree species can be classified along a continuum from light-demanding to shade-tolerant, according to how much solar radiation they require for regeneration. Two broad classes can be recognized: pioneer species and climax species. The essential difference is that pioneer species germinate and establish only in full light in a gap after its creation, so their seedlings are not found growing below a full and undisturbed canopy (5, 6). Forests reach their highest levels of species-richness when they are in an intermediate stage of recovery from disturbance, or when disturbance is at an intermediate intensity or frequency. In such intermediate states the forest will contain the full spectrum from pioneer to climax species, and so will maximize its biodiversity (7).

Rainforests and Swidden

Slash-and-burn, shifting or swidden cultivation creates gaps in the forest canopy not much larger than those produced by some natural hazards. Swidden was once demonized by colonial officials as primitive, destructive and inefficient; as it still is by some developing nation politicians eager to obfuscate serious forest damage by logging which they condone. In the mid-20th century a more liberal interpretation began to emerge, and was summarized in the conclusion reached by Lord Hailey in his *African Survey* of 1936. Shifting cultivation, he wrote, was "not the relic of barbarism, but it is in fact rather ... a concession to the character of the soils" (8). Research did indeed show that despite its remarkably high growth rate, the tropical rainforest was rooted in soils that were generally deficient in nutrients. Nye and Greenland (9) found that if a period of cultivation lasted only 1 to 3 years and was followed by about 15 years of bush and forest fallow, then soil degradation could be avoided. After a brief episode of swidden cultivation there was no serious decrease in available cations, except perhaps phosphorus, and the rapid build-up of biomass in the fallow produced a pioneer forest stand that could be the basis for a sustainable system of land use (9, 10). It was, moreover, a system of land use that required less labor and produced better returns than short-fallow or zero-fallow alternatives (11). So, increasingly, swidden cultivation could be represented as being a rational, benign, and even efficient land-use practice. In any case, European contact with the indigenous peoples of the humid tropics between c. 1500–1800 had generally been adverse in its effects, dislocating societies and introducing disease. Areas previously settled were largely abandoned (12), and only after 1940 did economic changes and medical advances permit a new wave of forest colonization.

The rapid rate of deforestation in the last 40 or so years has resulted in a further switch in the dominant narrative. Slash-and-burn cultivation, although potentially sustainable, was increasingly seen as being the first stage in a more permanent clearance of forest (13). Now, in an era of mounting concern about biodiversity conservation, forest fires, climate change, and sustainable development, sharper conceptual boundaries are being drawn between the natural 'undisturbed' forest and the inhabited, mismanaged, degraded, and perhaps doomed landscapes of swidden cultivation. Some conservationists might reluctantly accept a new paradigm in which natural disturbance and gap phase play their part in forest regeneration, but increasingly they see any form of human presence as merely a threat. In the Western mind nature and culture must be kept separate, even if in reality most lowland forests, perhaps all, are to some extent, cultural artefacts, and are recognized as such in the eyes of their human inhabitants.

Forests in Solomon Islands

This is the context in which we examine the remarkably intact forest cover of the western Solomon Islands in the Southwest Pacific. The high volcanic islands of the New Georgia Group are among the few places on earth where large tracts of coastal rainforest cover remain at the start of the 21st century. Although modified over much of the archipelago by logging during the 1990s, in places the New Georgian forest still extends from coast to coast across plateaus and mountain peaks 800–1000 m a.s.l. How useful is the new paradigm of gap phase when we come to interpret the floristics of these forests, which can so easily be constructed as 'natural', 'climax' or 'virgin' by outsiders? (14). The Marovo Lagoon area, comprising the southeastern parts of the New Georgia Group, lends itself well to such a discussion due to some inherent contradictions. On the one hand, it has a history of agricultural intensification, interisland contacts and sociopolitical transformations, yet on the other hand the lagoon's catchments and its forested islands have in recent decades figured in international media as a prominent example of pristine tropical wilderness (15). As such Marovo has been proposed for permanent conservation, and even as a possible UNESCO World Heritage Area (16–18).

The climate is this area is normally wet. On the island of Vangunu the annual rainfall in sites 80–90 m a.s.l. ranges from 4.2–4.9 m, and rainfalls are double this amount at higher altitudes (19). Most of the forests below 300 m are lowland evergreen tropical rainforests *sensu* Whitmore (6), and are basically similar to Malesian forests but are lower in height, have fewer emergent trees, more epiphytes and climbers, and are impoverished in species diversity (20). The canopy, which is 30–45 m tall, but less on steep slopes and at higher altitudes, is locally broken by gaps filled with climbers and by thickets of smaller trees 6–8 m tall. The forest type varies somewhat according to soils, slopes and altitude (21). Landforms range from coastal mangroves and swamps, to extensive rolling plateaus around 200–400 m a.s.l., higher ridges, and some volcanic peaks that reach 1040 m on Mt Vangunu (22). On Vangunu and elsewhere the soils are mostly young, acidic oxisols derived from deep weathering of basaltic lavas (23).

The only detailed studies of forest ecology come from nearby Kolombangara island. Here, in the lowland forests, 12 common tree species account for 72% of the basal area of the larger trees >10 cm dbh. When classified according to the shade tolerance of their seedlings, these 12 common trees can be divided into 4 categories: *i*) the completely shade tolerant trees (4 climax spp.); *ii*) the shade tolerant trees that benefit from gaps (3 spp.); *iii*) the light-demanding trees that require gaps in order to grow up into the canopy (2 spp., including *Campnosperma brevipetiolata* Volkens); and *iv*) the pioneers that require gaps both to germinate and to grow up (3 spp.) (6, 24). The high frequency of light-demanding trees in these forests reflects a situation of relatively frequent disturbance to the canopy, and this was attributed to massive canopy disturbance, probably from tropical cyclones (25). On a regional scale, variations in species composition could therefore reflect the protection of certain sites from storm damage. However, the tracks of recent cyclones and monitoring studies of tree mortality and recruitment over 30 years suggest instead that variations in species composition might result from other sources of disturbance (24, 26, 27). Species like *Campnosperma* are particularly abundant on the north coast of Kolombangara. In this area, there are traces of settlements on ridge tops and the local oral tradition confirms the existence of inland villages, until warfare, disease and missionary influence in the late 19th century persuaded the surviving population to move down to coastal sites (27, 28). From available evidence it seems likely that anthropogenic disturbances were on a larger scale than previously imagined.

FOREST DISTURBANCE IN NEW GEORGIA

19th Century Agroforestry

Apart from a few brief accounts of visiting ships, there are no written sources available for us to reconstruct the pattern and intensity of forest management in the New Georgia Group until after the onset of colonial rule. The British Solomon Islands Protectorate was declared in 1893, but there is good reason to suppose that the process of 'contact' had begun much earlier in the century. For example, in February 1844 Captain Andew Cheyne was at New Georgia Island trading tomahawks for turtle shell, and gaining fresh supplies of coconuts, bananas, breadfruit, yams and sweet potato (29). Through transactions such as these, steel tools were introduced making swidden cultivation less labor intensive, while the newly-adopted sweet potato meant it was possible to cultivate swiddens for longer periods and with shorter fallows (15, 30). A heightened mortality from introduced diseases and the escalation of warfare were other consequences of European contact (31, 32). Reconstructing the history of New Georgian rainforests is therefore by no means a straightforward task, but it is a necessary one if we are to establish the context for forest regeneration more than 100 years ago. For example, to what extent did the apparently 'virgin' forests that were mapped from air photographs in the 1960s always have an undisturbed canopy, virtually from coast to coast? Can we reconstruct the disturbance regime on New Georgia from the floristics of the forest, and how far does the inferred history of gap-phase forest match other kinds of evidence, such as archaeology and oral history?

We present first an outline of the general features of the agroforestry system in the Marovo Lagoon area around 1800, prior to escalated European contact (15). The system had 3 major components, reflected in indigenous categories: *i*) irrigated, terraced taro pond-fields (*ruta*), *ii*) mixed bush fallow swiddens, producing mainly dryland taro and yams (*chigo*); and *iii*) the fallow of well-developed secondary forest, enriched in particular with groves of *Canarium* nut trees (*buruburuani*). Also important was the gathering of edible leafy greens, ferns, and wild yams in the forest, as well as many medicinal plants. All these plants are more abundant in secondary forest. Some of the hunting also depended on the agroforestry system, in that fruit bats and many birds prefer to feed on cultivated trees and in the surrounding secondary forest.

Today, we can only speculate about this agroforestry system's ecological character. However, if our reconstruction is correct, then it has all the hallmarks of a stable and ecologically sound land-use system. Wetland cultivation of taro is inherently productive and sustainable. Yams and taro under dryland conditions both require high levels of soil fertility, and these crops are not normally grown more than once or twice before a site is abandoned to bush fallow. The regeneration of secondary forest is thus assured, since plots are recycled quickly to bush through a stage of luxuriant ginger growth that shuts out light, and so excludes the grasses and herbaceous weeds, characteristic of degraded soils, before they have a chance to get established. The ecological stability of the system and its economic value are further increased by the fruit, nut, and timber trees that form an integral part of the bush fallow and subsequent intercropping.

This indigenous agroforestry system started to be modified at a rapidly increasing rate by the direct and indirect effects of regular European contact from the mid-19th century. Population decline and sociopolitical upheaval led to a collapse of the regional exchange systems in which taro was a pivot. By c. 1900 most inland-dwelling groups had migrated to the coast and abandoned their taro pondfields. Only a few remote groups in north New Georgia continued to practice irrigated taro cultivation, in some places until the 1940s. Because they mostly fell into disuse soon after regular European contact, taro pondfield systems have generally been neglected by those studying indigenous agriculture in Melanesia, and their role in forest modification and regeneration have certainly been overlooked. Existing knowledge among elders of the Marovo Lagoon area indicates that the pondfield systems there were quite similar to those documented from nearby Kusaghe (33), Kolombangara (28, 34) and Viru Harbour (35). Although covered in forest today, traces of these systems can still be found. People travelling today in Marovo's inland river valleys searching for feral pigs or marking sacred sites for protection against logging machinery often encounter the over-grown remains of settlement sites and ceremonial grounds with their associated stone-walled pondfield terraces. Very few such sites have yet been formally mapped.

Pondfields in the Marovo area have been surveyed by the authors through brief inland excursions to inland crater rims and river basins. These are places that are mentioned in New Georgian oral history, in connection with the size, importance and precise locations of major inland settlements of olden times (Fig. 1). A number of regionally important settlements, some spoken of as 'abodes of seven thousand people', had large populations whose lifestyle was structured by the requirements of intensive cultivation, feasting cycles, and tribute requirements (36). Activities in these great settlements centered on the cultivation of huge crops, particularly taro, the annual harvesting of *Canarium* nuts, regular feasting involving the participation of friends and allies from near and far, and—for some with a more coastal orientation—overseas trading journeys, as well as warfare and raiding sometimes in regional alliances involving virtual navies of war canoes (37).

Floristic Evidence for Disturbance

Although neither archaeology nor oral history were documented in colonial times, the Solomon Islands Land Resources Study (LRS), using 1962 and 1969 aerial photography, appears to provide reliable indicators of the location of the larger pondfield systems of former centuries. The LRS maps of Wall and Hansell (22) reveal many locations where the forest was dominated by conspicuous stands of *Campnosperma brevipetiolata*, a light-demanding tree typical of sites where the canopy has been severely disturbed in the past. For example, one LRS forest type, the Tirua Land System, was found on low ridges forming hilly plateaus, and consisted of an even-canopied forest dominated by *Campnosperma*. An association between this system and anthropogenic disturbance is implied by Wall and Hansell's remark that within Tirua areas "many ridge tops show signs of former habitation with trees such as *Canarium* spp., *Prunus* spp. and *Ixora* sp. around abandoned village sites" (22). The same connection was noted by one of us on Santa Isabel, a large island east of New Georgia. Here vast tracts were covered in the 1960s by a forest in which 45% of large trees were *Campnosperma*, suggesting that "this particular area may well date from the abandonment of cultivations following the decimation of the local people by raiding parties from New Georgia across the Sound, which is known to have occurred within living memory late last century" (20). In New Georgia itself dense *Campnosperma* stands occur today in upland river valleys precisely in places where oral traditions locate old centers of inland settlement with associated taro pondfields and swiddens. The close correspondence between botany, archaeology, and oral history suggest that measuring the areas under *Campnosperma* could be a useful way to estimate the former extent of intensive agriculture and inland settlement more generally. To the *Campnosperma*-dominated stands, we can add inland tracts of *Terminalia brassii*, which observations suggest have grown up along wet valley floors in areas once used for taro pondfields.

To follow this interesting lead, we used the LRS Map 4h Forest Types to measure the areas in the main inland zones of Marovo (Gatokae, Vangunu, and New Georgia excluding Roviana) that have a disturbed forest with the dominant presence of *Campnosperma* or *Terminalia brassii* at canopy level. Those forest types that interest us, all indicative of vegetation disturbance at least 50 years prior to the air photography of 1962–1969, are defined on Map 4h as:

– **Flm**: Lowland closed-canopy forest with "*Campnosperma* commonly occurring";
– **Fld**: Lowland disturbed forest having a broken irregular canopy with "*Campnosperma* commonly occurring" as "scattered individuals amidst smaller often secondary trees";
– **Flk**: Lowland forest with a dense canopy of large-crowned trees, mainly *Campnosperma*;
– **Fhd**: Medium-height to tall hill forest having a broken, irregular canopy resulting from recent disturbance giving rise to gaps in the canopy and many small crowned probably secondary trees; "*Campnosperma* commonly occurring";
– **Fhk**: Hill forest "with a dense canopy dominated by large-crowned trees mainly *Campnosperma brevipetiolata*";
– **St**: "Stands of *Terminalia brassii* with a closed, even canopy", excluding coastal tracts.

C. brevipetiolata and *T. brassii* are unusual among rain-forest tree species in being readily identifiable from aerial photographs. At the time of the 1969 photography, the forest types in question covered 393 ha on Gatokae, 3948 ha on Vangunu, and 6136 ha on the 'Marovo' portion of inland New Georgia. The aggregate area of all these types of disturbance forest amounts to 105 km^2 in the study region, or 6% of the total land area.

Evidence from Oral History

These figures become more informative when we consider these islands as social spaces rather than an empty wilderness, and realize that the **Fhk** and **Fhd** types in particular are concentrated in hill locations where once existed the most important settlement-and-*ruta* complexes of the bush people. Table 1 shows the history of forest use in 6 sociopolitical regions of old Marovo, and the estimated human population c. 1800. The interpretation combines our evidence from oral history, aerial mapping, and ethnographic, archaeological and botanical fieldwork (38).

One example is the Chubiuru peninsula of Gatokae, where oral history locates the legendary twin settlements of Tige Ulu and Tige Peka ('Upper and Lower Tige (cut nut, *Barringtonia edulis*)'). This combined abode of 7000 people led a life of abundance and splendour with great feast-giving of regional importance (37). The people there are reckoned to have produced extraordinary volumes of irrigated and dryland taro. Furthermore, the Chubiuru area was renowned as a key location for taro cultivation well into historical times, even though the Tige polity was long gone. In exactly this location, on gentle slopes immediately behind stony beaches and coastal cliffs, 1962 aerial photography showed a continuous 4 km wide band of broken **Fhd** forest, reaching a large plateau at some 100 m elevation and comprising 238 ha of lands highly suited for both irrigated and dryland taro cultivation.

Whereas the Chubiuru area appears not to have sustained populations of the sizes implied by a legendary abode of 7000 people, a different pattern appears from a view of forest types and oral traditions for southern Vangunu. Here, another legendary abode of 7000 was located around the inland crater core, and adjacent southern slopes have large tracts of **Fhk** forest indicating locations of former swiddens, as well as conspicuous channels of **Fhd** forest along upper river reaches near the old settlement center, indicating locations of *ruta*. A total for southern and central Vangunu of 35 km^2 of relevant disturbed forest gives a population estimate in the range 4420–8300; such numbers support oral traditions about large precolonial populations.

ESTIMATED PAST POPULATIONS

The population estimates shown in Table 1 are derived from 2 alternative models. Model 1 is the Taro Carrying Capacity Model which assumes that 25% of the potentially arable land, i.e. the area under disturbance forest today, was in cultivation at any one time (33), this land supporting on average 5 persons ha^{-1} (39). These assumptions are reasonable for a swidden economy, but take no account of the much higher yields that can be obtained from intensive irrigated taro systems such as the New Georgia *ruta* (35, 40).

We believe that Model 2 is more realistic. The Mixed Taro

Figure 1. Map of the Marovo Lagoon area, with locations of centers of inland settlement and coastal strongholds c. 1800, and major forest areas with dominant *Campnosperma bevipetiolatum* c. 1960.

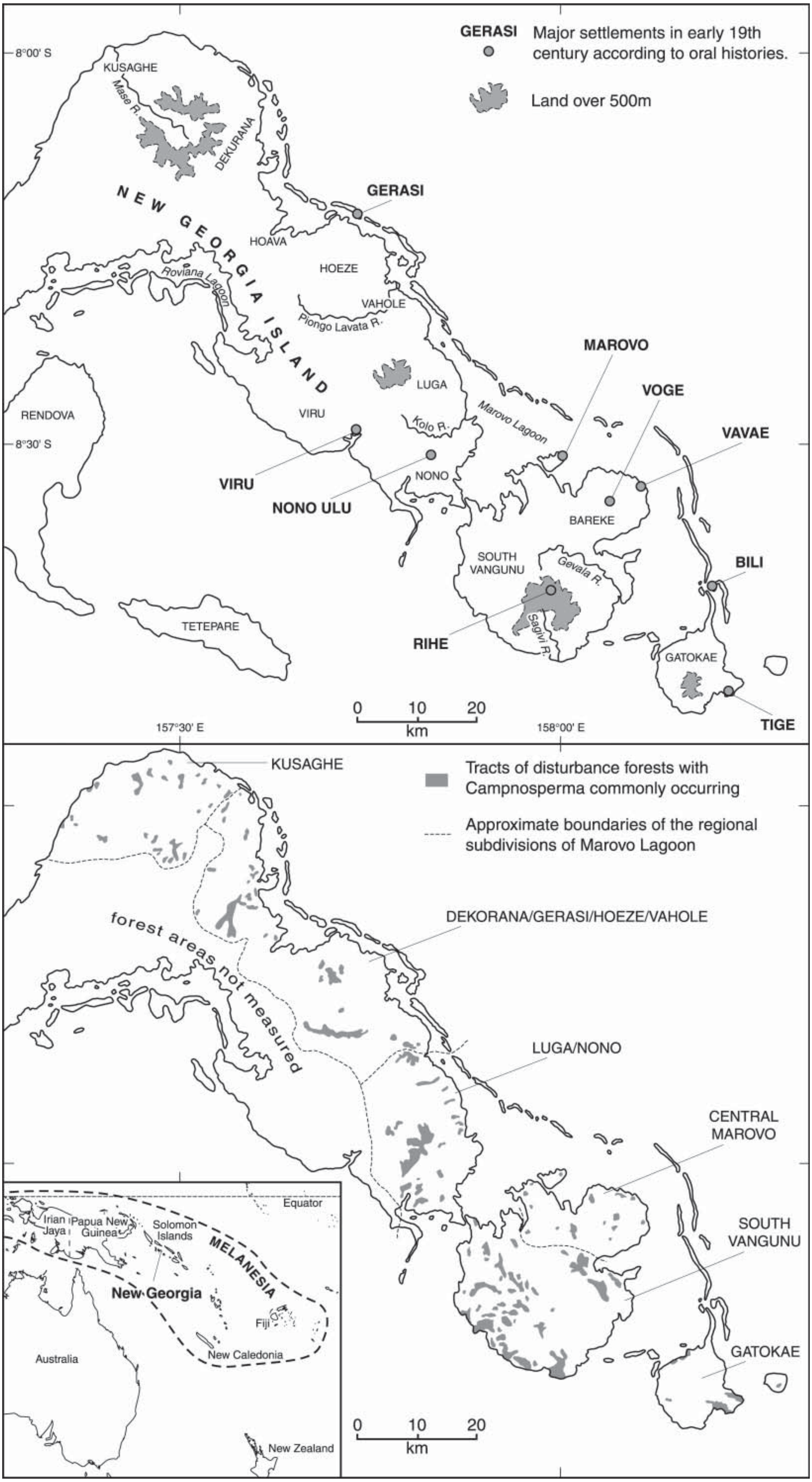

Table 1. The evidence for forest use, social organization and estimated populations in the Marovo Lagoon area, c. 1800.

AREA	EVIDENCE (1) Oral history	EVIDENCE (2) Archaeology	EVIDENCE (3) Floristics	INTERPRETATION Regional system, degree of stability	POPULATION Estimated population c. 1800
Kusaghe	There were many smaller settlements of people who grew taro in *ruta* in river valleys and up in the crater basin; they had relations with bush people further to the south and southeast and with coastal people of Roviana. They had no canoes. One language was spoken (Kusaghe).	Settlement sites, taro terraces and ceremonial grounds throughout the crater basin and in valleys behind the coast.	*Campnosperma* commonly occurring throughout the area from coast to coast; patches of **Fhk** forest near rivers at 50–200 m; St forest patches along upper river system in locations of documented pondfields; tract of broken **Fld** forest in centre of crater basin.	An internally homogeneous system of inland-dwelling taro cultivating groups related through kinship, exchange and feasts, and with a shared language. A likely source of taro for the Roviana coastal polity. Long-term stability, some inland population remaining until migration to coast in late 1920s.	10.20 km^2 of disturbance forest covering 3.2% of total area. POPULATIONS: Model 1 1100 (3.4 km^{-2}) Model 2 2400 (7.5 km^{-2})
Dekurana/ Hoava/ Hoeze/ Vahole	Several contiguous bush groups spoke several languages; they grew taro in *ruta* and maintained feasting, exchange and marriage with each other and more widely with Kusaghe, Marovo and Roviana. This was the northern part of Kalikolo. A large group by the Niva river was associated with '7000' coastal people at Gerasi. There was seafaring by Vahole raiders.	Settlement sites, hill forts, ceremonial grounds and taro terraces found throughout entire area, especially in Piongo Lavata river valley, Hoeze ridges and Vahole hills. *Canarium* nut groves only in interior.	**Flm** forest along Piongo Lavata and some way into its tributaries; **Fhd** forest around upper reaches of rivers in Hoeze mountains; **Fhk**, **Fhd** and **Flm** forest in upper reaches and valleys of rivers in Vahole hills, and further north a large **Flm** area along the Niva river adjacent to Gerasi.	An internally differentiated system of ranked, inland-dwelling, taro cultivating groups; a regional system of feasting, exchange and raiding, with internal migrations and inter-marriage; integration with Kusaghe and Kalikolo; some groups with direct links (including taro supply) to powerful coastal polities. Long-term instability; some settlement on coast by bush groups pre-1800, a few developing their own maritime raiding mainly to north and east	26.34 km^2 of disturbance forest covering 4.8% of total area. POPULATIONS: Model 1 3300 (6.0 km^{-2}) Model 2 6200 (11.3 km^{-2})
Luga/ Nono	Many settlements, some large, most small, all related as kin and speaking the Marovo language, and dispersed from coast to ridges. Taro was grown in *ruta* in the Kolo river valley. This southern part of Kalikolo had ties to Vahole, Viru, Choe, Marovo, and also had seafaring raiders operating west from Nono Lagoon.	Large fortified settlements and ceremonial grounds on mountain ridges; smaller settlement sites with associated taro terraces along rivers facing Marovo Lagoon. Reputedly large areas of settlement and taro terraces in upper reaches of Kolo river valley.	**Fhk** (and some **Flm**) forest in well-defined channels along middle parts of rivers facing Marovo Lagoon; very large areas of **Flm** forest in upper Kolo valley and over mountain ridges across to rivers facing Nono Lagoon.	An internally heterogeneous yet well-integrated system with taro cultivating groups in river valleys and hills, seafaring raiding groups based in hill forts, and smaller coastal settlements by Marovo and Nono lagoons; internal supply of taro surplus; kin connections and shared language. For raids to west there was collaboration with central Marovo . Long-term stability; coastal migration to both lagoons from c. 1900.	24.82 km^2 of disturbance forest covering 8.9% of total area. POPULATIONS: Model 1 1960 (7.1 km^{-2}) Model 2 3530 (12.8 km^{-2})
Central Marovo	Many smaller groups cultivated taro in ruta and swiddens in the foothills and ridges of Bareke; at Vavae near the sea there was 'an abode of 7000'; bush groups could not use the sea but each had its own exchange relations with a coastal raiding group for both barter and tribute, as well as being tied to South Vangunu. Bush people and coastal people have their own two languages (Bareke, Marovo).	Settlement sites, taro terraces and nut groves throughout lower hills with some in interior; no agricultural terraces in seafaring settlements (but dense nut groves); large settlement site and ceremonial ground at Vavae.	Well-defined patches of broken **Fhd** forest in locations known as sites of 19th-century settlement and agriculture, and lying adjacent to coastal sites of regular barter; most of Bareke peninsula with much *Campno-sperma*; **Fhk** patches around old hill fort at Mt. Voge.	An intensified inequality-based system with taro surplus extracted as tribute by coastal raiding polities from internally related inland cultivators; differentiation through history and language into bush people and coastal people, the latter with ties to Gerasi in the north and Gatokae in the south and with wide-ranging overseas contact to the east, north and west. Medium-term stability; collapse of lagoon-wide system in late 19th century with mass migrations to the coast.	4.10 km^2 of disturbance forest covering 2.8% of total area. POPULATIONS: Model 1 510 (3.4 km^{-2}) Model 2 960 (6.5 km^{-2})
South Vangunu	Around Rihe crater were many small-to-medium settlements constituting 'an abode of 7000'; *ruta* were tended by extended families and larger groups all related through the six ancestresses at Rihe; they had feasting cycles which also involved Bareke and Gevala people. They had no canoes but were tied to 'sea people' of Tetepare and Rendova. One language (Vangunu).	Extensive settlement sites and ceremonial grounds all around the Rihe crater; *ruta* remains and nut groves in upper river valleys; some coastal ceremonial sites associated with death and interisland connections.	Large tracts of **Fhk** forest in river valleys along 200-m contour on SW slopes, indicating 19th-century agricultural areas (swiddens); conspicuous channels of broken **Fhd** forest along upper river reaches near the old centre of Rihe.	An internally homogeneous system of group relations through largely egalitarian clan structure and shared language; all groups cultivating *ruta*; regular feasting cycles involving the entire area as well as related groups from Bareke and Gevala, reaffirming Vangunu-wide ties; some surplus taro channelled into lagoon polities of Nono and Marovo and to Gatokae (Bili). Long-term stability; migrations to coast c. 1910.	35.38 km^2 of disturbance forest covering 9.8% of total area. POPULATIONS: Model 1 4420 (12.3 km^{-2}) Model 2 8300 (23.1 km^{-2})
Gatokae	Many closely related hill settlements had *ruta* on lower slopes, but not in the NW part of the island where malevolent powers reign; at Tige Ulu/Tige Peka was 'an abode of 7000'; after warleaders immigrated from Viru about 1750 the Gatokae people also became seafarers, with Bili as their 18th- and 19th-C. coastal stronghold. By the late 1800s Chipuru language had been replaced by Marovo.	Fortified hill sites; *ruta* scattered through river valleys including some near the coast; nut groves mostly near the coast; early 19th-century coastal fortifications.	Large tract of broken **Fhd** forest around location of legendary 'abode of 7000'; scattered **Fhk** forest along lower reaches of river valleys on south coast. Notably, little or no occurrence of the relevant forest types on northwestern slopes, indicating lack of settlement and agriculture here.	An internally heterogeneous system yet with close integration of taro cultivation and maritime raiding; 18th-century immigration by Marovo-speaking groups with ties to central Marovo and Viru; internal feasting as well as participation in systems of central lagoon and much overseas contact to north and east; probable additional taro supply from Gevala on southeast Vangunu. Long-term instability, migrations to coast and language displacement.	3.93 km^2 of disturbance forest covering 3.8% of total area. POPULATIONS: Model 1 490 (4.8 km^{-2}) Model 2 920 (9.0 km^{-2})

Pondfield/Swidden Model assumes that 10% of the area of disturbance forest was under *ruta* pondfields, in which 50% of the land was under perennial cultivation (15), yielding 25 tonnes of taro ha^{-1} (40), and thus supporting on average 17.2 persons ha^{-1} (41). In this model the remaining 90% of the disturbance forest was under long-fallow swiddens supporting 0.7 persons ha^{-1} (42). Model 2 generates higher predicted populations despite its rather conservative assumptions.

To what extent do these calculations accurately represent the populations of the area before contact? Model 2 is more realistic in acknowledging the high productivity obtainable from even small areas of taro pondfields. However, the assumed 10% under *ruta* pondfields may be an underestimate for some areas. In Kusaghe, for example, the forest types found in valley bottoms where *ruta* were often constructed make up 26% of the total area of disturbance forest, suggesting the Kusaghe area could have supported many more people. On the other hand both models assume that all taro production was used for local subsistence, whereas in fact exchange with coastal peoples and wastage were also likely to have occurred, reducing the actual population. Certainly, this is the case for southern Vangunu, which was tied into complex channels of surplus taro export (15). At best, the numbers we have calculated must remain approximations.

How do the model predictions compare to present-day demography? The models generate a total inland population for the mainland area of Marovo Lagoon in the range 11 800–22 300 people. This compares to the 1986 population of less than 7000, increasing to about 11 000 today. In certain respects, however, past and present are not comparable, because after c. 1900 most Marovo people settled on coastal sites and have lived off sweet potatoes, cassava, marine resources, and trade as well as depending on root crops from the inland forests. After the mid-19th century the Marovo population declined, and probably reached a low point of about 4000 around 1930. If we accept the smaller population predicted by Model 1, it nonetheless implies a catastrophic 70% decline in numbers between c. 1850 and 1930. Depopulation was indeed a widespread phenomenon in Island Melanesia in the late 19th century (32), but the pre-contact baseline can seldom be defined with precision. In the New Georgia case, the decline that is implied by the model populations would not, in percentage terms, exceed the disastrous depopulation experiences of smaller islands like Aneityum (43) and Ontong Java (44).

The population densities implied by these models range from 6.7–12.7 persons km^{-2}. Although much higher population densities for New Georgia than today, these are not exceptional levels compared to bush populations elsewhere. In north Malaita in 1985 the inland population of Gwaiau district had reached a density of 13.4 persons km^{-2}, less than one-tenth the density of Malaita coastal populations, but unlike on the coast a population supported almost entirely from forest-fallow swidden cultivation (45). A similar density (34 $mile^{-2}$, or 13.1 km^{-2}) was calculated in 1968 for the Baegu inland population, also in north Malaita, where the forest-fallow swiddens were very similar to those we can reconstruct for New Georgia in the 19th century (46). Finally, the Siuai of south Bougainville numbered 1032 persons in 1938, within a total area of 83 km^2 of settlements, gardens, and secondary forest used for hunting and gathering (47). These data indicate an average density of 12.9 km^{-2}, for a population dependent upon an agroforestry system identical to New Georgia's in its primary reliance on taro. Siuai taro plots were located on alluvial flats close to streams, but unlike in New Georgia apparently they were not irrigated.

DISCUSSION

These comparisons with inland populations elsewhere in the region provide some support for our conclusion, that in New Georgia island there is unmistakable evidence that substantial populations lived in and exploited the lowland rain forests until about 100 years ago. Across vast areas that have mostly been empty of population since the onset of colonial rule in 1893, those same forests have appeared to outside observers as 'undisturbed', 'virgin', and possibly 'fragile ecosystems'. We have focussed on the distribution of *Campnosperma brevipetiolata* as an indicator of past disturbance because its crown form shows up clearly on aerial photographs, so its spatial extent can be easily mapped and measured. There are several other tree species whose presence would, on the ground, be equally useful as disturbance indicators, for example *Caryota rumphiana*, *Elaeocarpus angustifolia*, *Fagraea racemosa*, *Gmelina moluccana*, and *Macaranga polyadenia*.

A different effect of disturbance was the selective survival of those hardwood species that were difficult to fell with stone axes and so were left standing, later to provide a ready seed source. *Calophyllum neo-ebudicum*, for example, seems to have been favored in this way (48). Extensive stands of this species in north Kolombangara and Gizo islands must result from seed dispersal by birds and fruit bats from mother trees, in areas not cultivated since the late 19th century. A similar process has been suggested for SW Manus island, Papua New Guinea, where dense stands of *Calophyllum urophyllum*, now mostly logged, grow on ridge tops in inland areas now uninhabited, but where there is abundant archaeological evidence for former settlement (49).

Close monitoring of forest stands on Kolombangara over 30 years has demonstrated that gaps produced by tropical cyclones can account for the persistence of light-demanding trees like *Campnosperma*, but these natural disturbances have not led to an increase in the numbers of these trees at the expense of the shade tolerant species (27). Instead, stands of trees like *Campnosperma* have their origin in massive disturbance by humans. These stands then replace themselves through gap phase from windthrow and similar events, provided that enough disturbance events are repeated. Such trees cannot regenerate in their own canopy gaps, so if no disturbance recurs they will give way to shade tolerants in the long term. No cyclones have been experienced in New Georgia since 1963, and if this situation continues the species composition of these forests as mapped 30 years ago is unlikely to remain stable.

Quite a different interpretation has been presented by conservationists, who are reluctant to consider anthropogenic disturbance as a ubiquitous feature of the forests in places like Solomon Islands. For example, a New Zealand conservation organization presented their case to the Australian government, the principal aid donor to Solomon Islands, as follows:

The proposed protected area [i.e. the forests of Marovo Lagoon] has been little disturbed: hurricanes are infrequent and of low intensity, and human impact has been limited to gardened land and some timber removal on Vangunu and Nggatokae. The result is a region of extensive primary forest cover, including undisturbed forest community transitions from the sea to mountain tops (14).

The alternative view would emphasize the resilience of these forests, even in the face of modern logging operations. Our observations indicate successful regeneration of logged forests, even in cases such as north New Georgia where clearfelling by the Levers company has resulted in a long delay while the degraded areas are invaded by creepers such as *Merremia*. Eventually, 14 years after this severe disturbance, *Campnosperma* and *Pometia* pushed their way through the *Merremia* carpet to reach a height of 13 m (50). Eventually, a succession back to mixed forest seems to be assured, unless further anthropogenic disturbance intervenes. Total forest loss through the planting of oil palms in logged areas is a possibility, but is unlikely to happen in most parts of Melanesia because the forests are growing on land that is communally owned.

CONCLUSION

This paper suggests that only interdisciplinary investigations are likely to reveal the true status of tropical rainforests. In many cases what such research reveals is that apparently natural forests are in fact cultural artefacts exhibiting remarkable resilience in the face of both natural disturbance and human use over very long periods. A major research challenge for the tropical rain forests of the world is now to implement modern management programs which acknowledge these aspects of forest resilience.

Larger scale logging, as it has been practiced till recently, undoubtedly causes excessive and unnecessary damage. It is increasingly being replaced by Low Impact Logging (LIL), as concerns for sustainably produced timber, expressed in major markets, become ever more strident. LIL and small-scale logging based on locally-owned technology provide management alternatives that can involve even less disturbance to the forest than was achieved over millennia by the activities of shifting cultivators.

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Tim Bayliss-Smith is a geographer whose research interests include forest management in Solomon Islands and Fiji and the prehistory of Melanesia. His address: Department of Geography, University of Cambridge, Cambridge CB2 3EN, UK.
E-mail: tpb1001@hermes.cam.ac.uk

Edvard Hviding is a social anthropologist with interests in marine tenure, use of forests, and culture history in the western Solomon Islands. His address: Institute for Social Anthropology, University of Bergen, Fosswinckels gate 6, N-5007 Bergen, Norway.
E-mail: Edvard.Hviding@sosantr.uib.no

The late Tim Whitmore was a tropical forest botanist who spent 40 years—starting in Solomon Islands—on research into rain forests. His interests included the impact on forests of rare big disturbances, forest conservation, and sustainable utilization. His last address was Department of Geography, University of Cambridge, Cambridge CB2 3EN, UK. Dr Whitmore died on 14 February 2002.