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Interdisciplinary perspectives on historical ecology and environmental policy in Papua New Guinea

THEMATIC SECTION
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COLIN FILER*
Resource Management in Asia Pacific Program, Coombs Building Australian National University, Canberra ACT 0200, Australia

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SUMMARY

Papua New Guinea (PNG) has been the site of a great deal of scientific work, and a fair amount of interdisciplinary debate, within the broad field of historical ecology, which encompasses the study of indigenous society-environment relationships over different time periods. However, this in itself provides no guarantee that scientists engaged in such debate will have a greater influence on the formulation of environmental conservation policies in a state where indigenous decision makers now hold the levers of political power. Five environmental policy paradigms which have emerged in the course of public debate about environmental conservation in PNG over the past half century; the wildlife management, environmental planning, biodiversity conservation, ecosystem assessment, and carbon sequestration paradigms. Each paradigm has framed a distinctive form of interdisciplinary debate about indigenous society-environment relationships within a contemporary political framework. However, a further connection can be drawn between the role of interdisciplinary debate in an evolving national policy framework and the history of scientific debate about the nature of indigenous society-environment relationships in the pre-colonial era. This connection places a distinctive emphasis on the relationship between indigenous agricultural practices and management of the national forest estate for reasons which are themselves a contingent effect of the nature of European colonial intervention over the course of the last century and a half. This particular bias in the relationship between historical ecology and environmental policy has lasted down to the present day. PNG's environmental policy problems are unlikely to have any rational or sensible solution in the absence of a better scientific understanding of the complexity of indigenous society-environment relationships. Scientists need to understand the complexity of the environmental policy process as a historical process in its own right in order to work out which policy problems offer both the scope and the incentive to sustain specific forms of interdisciplinary debate that are likely to produce better policy outcomes.

Keywords: interdisciplinarity, historical ecology, environmental policy, Papua New Guinea

INTRODUCTION

Papua New Guinea (PNG) is globally renowned as a site of multi-dimensional megadiversity. Compressed within its borders is a stunning multitude of physical environments, biological communities, plant and animal species, indigenous languages and cultures. For this reason alone, it has been a magnet for natural and social scientists since Britain and Germany claimed ownership of it in the late nineteenth century. If anthropology is defined in the broad (North American) sense, to include the four fields of archaeology, linguistics, cultural and biological anthropology, then anthropological publications about PNG probably contain more words per head of native population than those about any other of the world's contemporary nation-states. The same could well be true in some branches of natural science.

However, megadiversity alone does not completely explain the country's scientific magnetism. When the whole of its territory became subject to Australian colonial administration at the end of the First World War, PNG became even more attractive and accessible to the rapidly expanding community of English-speaking scientists, even while much of the territory remained quite inaccessible to the colonial authorities. The densely populated valleys of the central highlands on the main island of New Guinea, together with many parts of the lowland interior, were not subject to effective colonial rule until the 1950s. Even in 1975, when the country gained its independence from Australia, there were still some isolated communities around the fringes of the central highlands and the least accessible parts of the lowland interior of the main island who had barely been contacted by the colonial administration. As a result, anthropologists (and other scientists) were able to follow the colonial frontier like a ragged troop of camp followers, repeatedly discovering an ethnographic present which had yet to be contaminated by the forces of modernity. Furthermore, the Australian government invested heavily in the conduct of all kinds of scientific research in the aftermath of the Second World War as part of a wider effort to 'reconstruct' and then to 'develop' its only colonial possession.

*Correspondence: Colin Filer colin.filer@anu.edu.au

For these reasons, it might be expected that PNG, of all developing countries, should have environmental policies that are based on a solid body of scientific evidence, that some of this evidence should have been the result of interdisciplinary debate, and that this debate should therefore have had a positive effect on the policy-making process. This paper sets out to explore the connections which actually do exist between the scientific study of indigenous society-environment relationships and the formulation of environmental conservation policies in what is now an independent state controlled by indigenous politicians and public servants. The primary aim of the paper is to show that the accumulation and exchange of information by the practitioners of different scientific disciplines may or may not have distinctive policy impacts, but an understanding of the contribution of interdisciplinary scientific debate to national policy debate requires a prior understanding of the national policy process as a distinctive historical process in its own right. Only then is it possible to establish the points at which the prospect of better policy outcomes might serve to motivate additional interdisciplinary debate about indigenous society-environment relationships.

FROM ANCIENT HISTORY TO MODERN POLICY

For all the scientific work that has been done in PNG, there have been relatively few attempts to achieve a synthesis of the findings that relate to what William Balée (2006) described as the broad interdisciplinary field of historical ecology, that is to say, the entire history and prehistory of society-environment relationships. Some notable examples are found in the writings of archaeologists or prehistorians, which should come as no surprise, since most of the evidence with which they deal can be construed as evidence of past human impact on the biophysical environment. However, much of this synthetic effort revolves around a distinction first drawn by linguists, between the people of the broad Indo-Pacific region, who speak Austronesian languages, and the people of the smaller New Guinea region (including West Papua and Solomon Islands as well as PNG), who speak 'non-Austronesian', 'pre-Austronesian' or 'Papuan' languages (Blust 1995; Pawley 2006). What has emerged over the past 50 years is a sort of interdisciplinary orthodoxy that combines evidence from all four fields of anthropology (in the North American sense) to claim that the smaller islands of the New Guinea region (especially in the Bismarck and Solomon archipelagoes) were first colonized by Austronesian migrants from Eastern Indonesia around 3400 years ago, and within a few hundred years, some of their descendants had gone on to colonize many other Pacific islands that were previously uninhabited (Bellwood 1978; Bellwood *et al.* 1995; Kirch 1997; Spriggs 1997). By this account, most of the indigenous people of the New Guinea region who do not speak Austronesian languages (about 80% of the total indigenous population) are descended from ancestors who were already living there before the Austronesians first arrived, and could well have been living there or thereabouts since the ancient Pleistocene continent of Sahul was first occupied by human beings more than 40 000 years ago (Pawley *et al.* 2005).

By this same account, ancestral Papuan societies evolved in relative isolation from their Australian Aboriginal counterparts, even before rising sea levels separated the current island of New Guinea from the current Australian mainland around 7000 years ago. The emergent orthodoxy therefore retains the longstanding European perception of Aboriginal Australians as a 'race apart' from the other prehistoric populations of Oceania, but challenges the other part of nineteenth century cultural (or racial) geography, which divided the rest between Melanesia (the 'black islands'), Micronesia (the 'small islands'), and Polynesia (the 'many islands') (Douglas & Ballard 2008). Instead, it posits three distinct historical ecologies in Oceania, with some room for debate about the form and extent of interaction between (southern) Papuans and (northern) Australians over a period of more than 40 000 years, and between Papuans and Austronesians (in the New Guinea region) over a period of less than 4000 years.

Scholars of the New Guinea region have taken issue with this account of regional prehistory on both theoretical and methodological grounds. If the only thing that 'Papuans' have in common is the fact of not being Austronesian, there is no reason to assume that they have ever had much else in common apart from the fact of living in the New Guinea region, and such an assumption can only defeat the task of explaining the megadiversity of the region as a whole, including the parts now occupied by the putative descendants of the Austronesian invaders (Pawley *et al.* 2005). But some scholars go further than this and challenge the very idea of an 'Austronesian invasion' as the figment of an illegitimate interdisciplinary imagination that uses evidence from one or other of the four fields of anthropology to fill the holes which no one discipline can cover with its own distinctive methods of inquiry (Terrell & Welsch 1997; Terrell *et al.* 2001).

These are interesting debates, but they do not enable a better understanding of the relevance of prehistory to the more recent history of society-environment relationships in the New Guinea region or the very recent history of environmental policy formation in PNG. For this purpose, it is informative to consider the work of two zoologists, Jared Diamond and Tim Flannery, whose respective scientific reputations were originally founded on their study of the region's birds and mammals (Flannery 1990; Mayr & Diamond 2001),. The long experience of fieldwork in PNG has evidently inspired both scholars to develop some grand Oceanic (and in Diamond's case global) narratives, whose poetic licence goes well beyond the limits normally set by the prehistorians whose work they seek to interpret (Flannery 1994; Diamond 1998, 2005). Whether or not they have told a set of mutually consistent stories, Diamond and Flannery both use regional evidence to attack the myth of the 'ecologically noble savage' (Hames 2007), to elide the distinction between 'traditional' and 'modern' forms of

environmental management, and to make the humanist case that we are all in the same boat, and always have been, when it comes to matters of environmental policy.

Needless to say, both authors have attracted a good deal of collegial criticism for failing to get their prehistoric facts right, but it is their social theory (or the lack of it) that has been even more contentious. Diamond's (2005) attempt to explain 'how societies choose to fail or succeed' has become the primary target of such attacks, but these have come from two different quarters. On one side are historical ecologists (for example Tainter 2008), who complain about the lack of any systematic explanation of long-term change in the complexity of social (or social-ecological) systems, whether in Oceania or anywhere else. On the other side are cultural (or social) anthropologists (for example McAnany & Yoffee 2009), who condemn the substitution of a popular psychology of social choice for a serious sociology of globalization, whether in PNG or in other countries of the Global South. Some of this criticism may well be justified, but the point which most of the critics overlook is that Diamond and Flannery are appealing to a popular audience as part of an effort to change the terms of engagement between environmental science and environmental policy, not just in the countries of their critics, but also in the country which inspired their zoological research.

In the first draft of this article, I asked how the practitioners of different scientific disciplines had not only collaborated to achieve a common understanding of the relationship between indigenous societies and their natural environments in PNG, but how they had extended this collaboration to the development of policies, programmes or projects to protect the natural environment in a contemporary political setting. However, I was rightly castigated by reviewers for begging an important question about the relationship between two different forms of complexity that both need to be distinguished from the complexity of social-ecological systems considered as historical entities in their own right. The first is the complexity of indigenous society-environment relationships as represented by scientific investigation conducted in the wake of the relatively recent distortion of these relationships by the twin forces of colonialism and capitalism. The second is the complexity of the environmental policy process in a country where indigenous people now hold the levers of political power, but foreigners still dominate the scientific representation of indigenous people's relationship with the natural environment. In this context, foreign scientists may be tempted to think (or perhaps to hope) that interdisciplinary contributions to environmental policy have somehow followed from interdisciplinary debates about historical ecology. But why make this assumption? A review of the history of interdisciplinary debate about the first form of complexity might well lead to a distorted picture of the second form of complexity, or to the rather trivial conclusion that indigenous policy makers can now make better policies because foreign scientists have come to understand the benefits of interdisciplinary communication. Much more has been written about the first form of complexity than about the second, but since I am more familiar with the second form of complexity, I shall now discuss the recent history of environmental policy in PNG with a view to asking whether it has or has not been informed by interdisciplinary debate that may or may not belong to the field of historical ecology.

POST-COLONIAL POLICY PARADIGMS

Historical ecologists may take a broad view of environmental policy, to encompass any form of public policy that has an intended or unintended effect on society-environment relationships. But in PNG, as in most other countries, there is a more conservative definition of this policy domain that links it to the activities of a single government agency, which in PNG is the Department of Environment and Conservation. For the sake of brevity, my focus here will be the specific domain of environmental conservation policy, and not the broader domain of sustainable development policy, which is, in any case, a hard animal to track down in PNG's political jungle. To tell the story of environmental conservation policy, I distinguish five policy paradigms which have made their first appearance at different moments in recent history, each adding a new form of relationship between national and international institutions in this policy domain. I call these, in order of appearance, the wildlife management, environmental planning, biodiversity conservation, ecosystem assessment, and carbon sequestration paradigms. In each case, I shall try to establish whether there is a distinctive form of interdisciplinary debate associated with the design or implementation of environmental conservation policies in the post-colonial state. I then return to the question of how this debate might be related to more general scientific debate about the history and prehistory of society-environment relationships in PNG.

Wildlife management

The wildlife management paradigm has its origins in the Fauna (Protection and Control) Act (see http://www.paclii.org/pg/legis/consol_act/faca1966290/ for recent versions of all PNG laws) which was originally enacted as an 'ordinance' by the Australian colonial administration in 1966. This followed a decision to licence the use of shotguns by a few specialized hunters in each local community to boost the amount of protein in the local diet. Government officials were concerned that hunters in some parts of the country were using their new weapons to target rare and endangered bird species, especially the iconic birds of paradise, to meet the demand for feathers created by an escalation of traditional ceremonial activity, especially in the central highlands (Healey 1986). This concern echoed the earlier Western campaign against the Western fashion for wearing hats adorned with bird-of-paradise plumes from the New Guinea region before the First World War (Swadling 1996), a campaign that marked one of the first steps along the road that would eventually lead to the Convention on the International Trade in Endangered Species

(CITES), which the PNG government ratified in 1976. The Fauna (Protection and Control) Act not only became part of a national regime of compliance with CITES, but was also amended to conceal its origins as an act of colonial paternalism and to reflect the constitutional recognition of 'custom' in the management of local affairs (Eaton 1997). In its present form, the Act enables the PNG government to authorize the establishment of wildlife management areas by customary landowners who are then responsible for protecting the wildlife which they contain. The great majority of protected areas officially established since Independence have been authorized under this regime, and together these account for roughly 3% of PNG's total landmass. However, most of these areas are relatively small, and local communities have generally been unable to maintain an effective management system without the dedicated support of non-government organizations (Chatterton *et al.* 2006).

In the early years of national independence, traditional hunting practices and local ideas about 'wildlife' became the focal point of an interdisciplinary debate about the motivation of indigenous communities to conserve endangered species. Natural scientists were by no means blind to the importance of conserving flora as well as fauna, and habitats as well as species (Gressitt 1982), but the faunal bias of the wildlife management paradigm was reinforced by the elaborate forms of animal and bird symbolism that cultural anthropologists discovered amongst their 'native informants' (for example Bulmer 1979). Despite the evident complexity of these local knowledge systems, the anthropologists were generally inclined to discount the existence of a 'traditional conservation ethic' that would motivate local people to preserve (rather than consume) the objects of such knowledge (Bulmer 1982; Dwyer 1982). On this account, the maintenance of biological diversity would have to be seen as the unintended (or epiphenomenal) effect of traditional practices which had other motivations, so customary institutions did not provide solid ground for the implementation of environmental conservation policies. However, the argument was already diluted to some extent by the emergence of a nationalist counter-narrative that regarded Western institutions and technologies as the main threat to biological and cultural diversity alike (Waiko & Jiregari 1982). A generation of Papua New Guineans who had themselves been trained in the natural sciences by Western conservationists were therefore inclined to reinstate the 'myth of the ecologically noble savage' as a valid representation of indigenous knowledge.

Environmental planning

The environmental planning paradigm also has its origins in a specific piece of national legislation, the Environmental Planning Act of 1978. PNG was one of the first developing countries to follow the example set by the USA in its National Environmental Policy Act of 1970, by demanding a process of impact assessment, monitoring and mitigation for development projects that pose a major threat to the natural environment (Hughes & Sullivan 1989). The reasons for PNG's early adoption of such legislation can be found in an interdisciplinary debate about the likely impacts of big mining and logging projects that took place around the time of independence (Winslow 1977). In some respects, PNG's environmental planning legislation was already foreshadowed in the Mining (Ok Tedi Agreement) Act of 1976, which made very detailed provision for the conduct of social and environmental baseline studies in the area to be affected by what would later come to be known as one of the world's great mining disasters. However, the temporal relationship between the two laws had two peculiar effects: first, the Ok Tedi mine (whose construction did not actually start until 1982) was exempt from the provisions of the Environmental Planning Act; and second, the Mining (Ok Tedi Agreement) Act was framed in a way that split responsibility for the assessment of social and environmental impacts between the government and the project proponent. Government control of social impact assessment in the extractive industry sector lasted until 1988, when the Department of Environment and Conservation was able to reassert the primacy of the user-pays principle and make project proponents in all sectors responsible for both types of assessment (Filer 2005).

As in other parts of the world, the scientific effort absorbed in the conduct of social and environmental impact studies has generally depended on the scale of the threat posed to the natural environment and the amount of money that is consequently allocated to such studies. But even when the effort is substantial, and many scientific disciplines are involved, there is no guarantee of interdisciplinary dialogue in a process typically managed by professional consulting companies who are paid by project proponents to satisfy the needs of government agencies or financial institutions. In the early years of national independence, the direct involvement of the PNG government in commissioning this kind of work did succeed in promoting such dialogue, not only in respect of the Ok Tedi mine (for example: Swadling 1983; Hyndman *et al.* 1989), but also in respect of a major hydroelectric scheme that was never constructed (Petr 1983). Over a period of more than 30 years, the Ok Tedi mine alone has spawned a more substantial body of scientific literature than any other mining project in the world, but even in this instance, there has not been much in the way of interdisciplinary dialogue between natural and social scientists because the former have been exclusively concerned with measures of environmental change in the Fly River catchment (Bolton 2009). It is the social scientists who have debated the relationship between the social and environmental impacts of large-scale extractive industry projects in PNG, especially since this relationship was first placed in the spotlight by the forced closure of the Panguna copper mine in 1989 (Filer 1990; Banks 2002; Macintyre & Foale 2004; Kirsch 2006). However, this debate has not been replicated in other sectors of the national economy, where project proponents only pay lip service to the environmental planning paradigm, nor has it made any

obvious contribution to the design or implementation of environmental conservation policies.

Biodiversity conservation

A greater contribution has been made by interdisciplinary debate around the biodiversity conservation paradigm, whose origins do not lie in any specific piece of national legislation, but in the National Forestry and Conservation Action Programme initiated under the auspices of the World Bank in 1990, and in the PNG government's subsequent ratification of the Convention on Biological Diversity in 1993. This last act served to release a substantial grant from the Global Environment Facility for the 'execution' of a Biodiversity Conservation and Resource Management Programme (BCRMP) by the Department of Environment and Conservation over a five-year period from 1993 to 1998. This programme was designed to undertake two experimental integrated conservation and development projects (ICDPs) in different parts of the country, and apply the lessons learned from these experiments to the production of a Biodiversity Country Strategy and reform of the country's conservation policy regime (Sekhran & Miller 1994; McCallum & Sekhran 1997). In practice, this involved a further effort to integrate and coordinate the activities of several non-government organizations that also had access to new foreign money to experiment with ICDPs in the wake of the Rio Earth Summit.

As in other parts of the world, the dramatic increase in funding for biodiversity conservation created a new forum for debate between the natural and social scientists who were involved in the design and implementation of conservation policies, programmes and projects in PNG. It also created the space for economists and lawyers to join in debates about environmental conservation from which they had largely been absent before. The debates were substantially documented in a series of reports associated with meetings of policy makers, expert advisers, conservation practitioners and even some local landowners, during the course of the 1990s (Alcorn & Beehler 1993; Sekhran & Miller 1994; Saulei & Ellis 1998). The common thread running through these debates was an economic reformulation of the questions previously addressed in the wildlife management paradigm. What mix of moral and material incentives would persuade local landowners to look after biodiversity values and resist the temptations of unsustainable resource development, and how could this mix of incentives achieve the protection of areas big enough to satisfy the demands of conservation biologists? However, the amount of money spent on this conundrum was, if anything, a disincentive to its resolution. On one hand, the conservation biologists developed new techniques for determining which large areas ought to be protected because of their biodiversity values, regardless of the wishes of local landowners (Nix *et al.* 2000; Faith *et al.* 2001). On the other hand, the 'myth of the ecologically noble savage' gained new traction in the hands of conservation practitioners who challenged the very idea of 'integrating conservation and development', and sought instead to protect local landowners from both scientific and economic forms of neocolonialism (Anderson 2005). Anthropologists engaged in the ethnographic study of conservation projects have been attracted to this populist narrative, not because they have changed their minds about the existence of a 'traditional conservation ethic', but rather because they have observed that natural scientists who promote and manage these projects are themselves often guilty of misrepresenting and misunderstanding the motivations of local landowners (van Helden 1998; Filer 2004; West 2006; Wagner 2007).

Ecosystem assessment

And where did that leave the economists? An economic evaluation of the BCRMP came to the conclusion that moral incentives alone would not suffice to persuade poor people in remote forest areas with high biodiversity values to resist the temptations of unsustainable resource development. If the radical conservationists could claim a measure of success in the use of such incentives in the second of the BCRMP's two experimental conservation projects, that was mainly because the temptations were not yet present. Environmental conservation policy was beset by a problem of moral hazard: the easiest way to show a positive return on foreign investment in biodiversity conservation is to spend the money on areas where biodiversity values are not under any immediate threat. The response of the Global Environment Facility was to leave the rainforest people to their own devices, and instead fund the design of a 'community-based marine conservation project', with no explicit development component, in a coastal province which had relatively high levels of formal education and labour mobility, but where local communities were exerting unsustainable fishing pressure on coral reef ecosystems (van Helden 2004; Foale 2005). While the primary aim of this project was to protect marine ecosystems with high biodiversity values, the need to establish local community support for a network of marine protected areas entailed another dialogue between social and natural scientists in the design and implementation of the project. The net result was a project component linked to the Millennium Ecosystem Assessment as a sub-global assessment of Coastal, Small Island and Coral Reef Ecosystems (Filer *et al.* 2004).

It can hardly be said that this marked a new stage in the development of PNG's national policy framework, because responsibility for executing the project was vested in a non-government organization working in partnership with the relevant provincial government. The ecosystem assessment paradigm should therefore be seen as an international step beyond the biodiversity conservation paradigm, which had some ramifications at a national and sub-national level in PNG because of a general recognition of the need to link conservation priorities with a better understanding of the relationship between ecosystems and livelihoods. While a new focus on the health of coral reef ecosystems was also part of a wider regional and global trend, the five years spent on

the design of PNG's flagship marine conservation project was followed by only three years of implementation before the project was terminated after a mid-term evaluation in 2006. As a result, there was little opportunity to internalize or domesticate the interdisciplinary debate which had taken place in the Sub-Global Working Group of the Millennium Ecosystem Assessment, most notably between economists and ecologists (Filer 2009). The new focus on the health of coral reef ecosystems did spark a fresh debate about the role of indigenous knowledge and traditional social institutions in the design of locally managed marine protected areas (Foale & Manele 2004; Cinner 2007), but this was essentially a continuation of earlier debate about local fishing practices under the terms of the wildlife management paradigm (Johannes 1978; Polunin 1984; Carrier 1987).

Carbon sequestration

The disruption of PNG's flagship marine conservation project in 2006 was soon followed by a new type of policy focus on the country's forest ecosystems. This stemmed from the key role of the PNG government in the Coalition for Rainforest Nations, an organization established to seek compensation from developed countries for reducing greenhouse gas emissions from deforestation and forest degradation under the terms of the UN Framework Convention on Climate Change. It could be argued that PNG's ratification of this convention in 1993 had already inaugurated a new phase in the country's environmental policy framework, but so far as environmental conservation is concerned, the problem of mitigation is quite distinct from the problem of adaptation (Sullivan 1991). In PNG, unlike most other Pacific island countries, the first problem has attracted more attention from policy makers than the second problem, because PNG is thought to have very high rates of carbon dioxide emissions from land use change and forestry. Economic advisers to the BCRMP made an early attempt to secure forest conservation funding through the clean development mechanism (Stuart & Sekhran 1996), but the failure of this mechanism to provide material incentives for native forest conservation in developing countries is what ultimately led to the demand for an entirely different global policy instrument to achieve reduced emissions from deforestation and forest degradation (REDD). The carbon sequestration paradigm only began to generate a new form of interdisciplinary debate about native forest conservation after the Coalition for Rainforest Nations was established in the lead-up to the Bali climate change conference at the end of 2007.

Scientific debate on this subject still bears some of the hallmarks of the biodiversity conservation paradigm, because some of the participants see REDD schemes as a new way to finance the conservation of biodiversity values in forest ecosystems. Ecologists and conservation biologists have busied themselves with the use of satellite imagery and geographical information systems to make new estimates of recent, current and future rates of deforestation and forest degradation, and the extent of the contribution made by different direct drivers of this double process (Shearman *et al.* 2009). However, these estimates have proven to be highly contentious. The idea of PNG as a 'rainforest nation' has opened up a new gap between the representation of customary landowners as 'forest-dependent people' and their role as subsistence farmers clearing the very forests on which they are meant to depend. The earlier debate about moral and material incentives has also taken a new turn, because public debate about REDD projects has provoked what some observers call a 'carbon cargo cult' (Kelola 2010), as landowners are led to believe that a huge financial windfall is about to come their way. Finally, the scientific and political debates on this subject are both inflected by new forms of moral hazard, because the size of the prospective windfall for many stakeholders, including members of the scientific community, may be a function of their capacity to overstate the severity of the threat for which compensation needs to be paid by the international community (Filer *et al.* 2009). In the lead-up to the Copenhagen climate change conference at the end of 2009, I teamed up with an economist, an agronomist and two forest ecologists to advise the PNG Department of Environment and Conservation on these issues. At the time of writing, the results of this work have yet to be published, but have already informed the adoption of a new climate change policy by the PNG government.

CONNECTIONS TO HISTORICAL ECOLOGY

While it may be true to say that PNG's current array of environmental conservation policies originated in the last ten years of colonial rule, interdisciplinary debate about these policies is closely connected with a longer history of debate about indigenous society-environment relationships. However, I argue that this connection places a quite distinctive emphasis on the relationship between indigenous agricultural practices and management of the national forest estate. One of the first scientific foresters to survey the country's vegetation found it hard to explain the existence of many sparsely populated areas of grassland except by supposing 'that a large population existed in the past, and it has migrated to other parts of the Territory for various causes, possibly the most urgent being that it had exhausted the land, created the grass, and could no longer farm it' (Lane Poole 1925, p. 35). Like many of his contemporaries, Lane Poole thought that shifting cultivators would eventually turn all forests into grassland if their population kept growing and no action were taken to change their methods of cultivation, an argument which recently reappeared in scientific debate about the current drivers of deforestation (Shearman *et al.* 2009).

However, colonial forestry officials had already adopted a different point of view by the 1950s, seeing much of the territory's forest cover as a 'mosaic or patchwork quilt the components of which include a large number of seral stages of which the production garden is one extreme and at the other is a community approaching but doubtfully reaching

the climatic climax' (Womersley & McAdam 1957, p. 21). From this quotation alone, it should be evident that PNG was not only one of the first countries to accommodate an anthropological critique of the 'myth of the ecologically noble savage', but also one of the first to accommodate another kind of critique which has become a foundational tenet of historical ecology; the argument that much of what appears to some Western scientific eyes as virgin tropical rainforest is an artefact of past human activity (Balée 2006). So if indeed there are some areas of anthropogenic grassland in PNG, there are also huge swathes of primary and secondary forest that are also part of the man-made patchwork quilt.

The precocious enlightenment of Australian foresters was not an isolated event. Part of the Australian government's investment in post-war scientific research funded the work of a multi-disciplinary team of environmental scientists associated with the Division of Land Use Research in the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO). This work involved a variety of field surveys carried out over a period of 20 years (1953–1972), covering 40% of the total land area of PNG, supplemented by analysis of two sets aerial photographs with national coverage. The ultimate purpose of the whole exercise was to assess the environmental constraints on land use to assist the Australian colonial administration in its plans to develop what was then known as native agriculture (Trangmar *et al.* 1995).

Members of the CSIRO team published the results of this work in books and articles representing the interest of different disciplines in different types of environmental constraint (Löffler 1977; Paijmans 1976; Bleeker 1983; McAlpine *et al.* 1983). In the 1980s, the results were integrated in the form of a spatial database known as the PNG Resource Information System (PNGRIS), in which 4566 'resource mapping units' were distinguished from neighbouring polygons by one or more of six 'physical resource attributes': landform, rock type, altitude (treated as a proxy for temperature), relief, inundation and mean annual rainfall (Bellamy & McAlpine 1995). These physical environments were defined in such a way that their boundaries could only change very slowly in the absence of major tectonic disturbances (or rapid climate change). The variable element of the database included the attribution of one or more forest types or other vegetation types to each polygon, an estimate of the extent of human disturbance in each type of forest, and a separate estimate of the percentage of land which showed signs of having recently been used by human beings. These descriptions were summarized in hard-copy maps of agricultural land use and forest resources (Saunders 1993*a*, *b*). The patches in the patchwork quilt had thus been defined, classified and counted in ways that provided the basic foundation for a systematic historical ecology.

In the 1990s, some members of the CSIRO team refined their analysis of primary forests (where there was no visible evidence of disturbance by shifting cultivators) to produce a second database, known as the Forest Inventory Mapping System, which provided the scientific foundation for a sustainable forest management policy (essentially a selective logging policy) that was the second main component of the National Forestry and Conservation Action Programme. At the same time, a second multi-disciplinary team of scientists, from the Australian National University and the PNG National Agricultural Research Institute , embarked on a nationwide field survey of all those areas, including areas of secondary forest, which the CSIRO team had designated as areas of agricultural land use (Saunders 1993*a*), leaving aside the commercial farms or plantations designated as areas of very high land use intensity with tree crops. In the database produced by this Mapping Agricultural Systems Project (MASP), these areas of indigenous land use are grouped into a total of 287 local agricultural systems or food-cropping systems distinguished from each other by one or more of four variables: cultivation period, crop types, fallow period and type of fallow vegetation (Bourke *et al.* 1998).

The MASP database was not only intended to complement the contribution of the PNGRIS database to agricultural and rural development plans at different levels of political organization; it was also meant to provide an empirical test of Boserup's (1965) general theory of agricultural intensification, and a methodological tool for the analysis of poverty-environment relationships in rural areas. Since the basic rationale behind the MASP database emerged from the discipline of human geography rather than the natural sciences, there has been a greater effort to link a range of socioeconomic variables to the description of local agricultural systems. Conclusions can therefore be drawn about the relationship between population pressure, rural poverty, land degradation and agricultural innovation.

The main conclusion has been that there are relatively few places (or systems) which exhibit the 'vicious downwards spiral' described in the Brundtland Report (World Commission on Environment and Development 1987), where rural poverty and environmental degradation are joined in a positive feedback loop. In the more densely populated agricultural systems, people have generally responded to additional population pressure with some form of agricultural innovation or by moving out of the system altogether (Bourke 2001). In general, forms of agricultural intensification that raise the productivity of land already in use are far more widespread than forms of agricultural expansion that entail the cultivation of land which has not previously been used for this purpose (Allen *et al.* 2001). Most of the rural poverty in PNG is thus associated with agricultural systems that have low population densities and low levels of agricultural intensity, where people do not have the technical capacity or economic opportunity to change what are essentially poor physical environments (Hanson *et al.* 2001).

All this spatial analysis might seem to take us some distance from prehistory, as well as from environmental conservation policy, but this would be a false impression. In the last ten years of colonial rule, when members of the CSIRO team were still at work on their national survey of PNG's physical environments, a separate group of anthropologists, geographers and botanists were already

debating the causes and consequences of a sweet potato 'revolution' in the densely populated inter-montane valleys of the central highlands (Watson 1965, 1977; Brookfield & White 1968; Yen 1974). Sweet potato was already the staple crop in these highland agricultural systems, but was thought to have arrived there from its South American homeland after European navigators began their exploration of the Pacific Ocean in the sixteenth century. The consequent transformation of society-environment relationships was not only said to be revolutionary because of the speed with which it occurred, or the rapid rate of human population growth that was literally fed by the intensification of agricultural production, but also because of a sort of positive feedback loop between both of these processes and the elaboration of complex social institutions through which highlanders produced, exchanged and consumed a growing population of pigs that also lived on a diet of sweet potato (Feil 1987; Golson & Gardner 1990). Scientists involved in production of the PNGRIS and MASP databases have since made important contributions to the historical ecology of this phenomenon (Allen & Ballard 2001), as have other scholars who bring the evidence of indigenous oral history to bear on the timing of its phases in different parts of the central highlands (Ballard *et al.* 2005). Although there are still some question marks about the long-term sustainability of this sweet potato revolution, which does seem to have involved a significant amount of deforestation (Bowers 1968; Manner 1976; Humphreys & Brookfield 1991), the scientific evidence persuaded Diamond (2005) to portray the central highlanders as a society (or group of societies) that 'chose to succeed'.

At the time when debate about this agricultural revolution first began, archaeologists and cultural anthropologists were still speculating about the existence of an earlier phase in the agricultural prehistory of the central highlands, in which a smaller population of people and pigs was supported by the cultivation of taro and other indigenous food crops (Bulmer & Bulmer 1964). In the 1970s, archaeological excavations at the site of the Kuk agricultural station near Mount Hagen began to find evidence of prehistoric agricultural activity dating back as far as 10 000 years, which indicated that central highlanders were among the world's first farmers, and the island of New Guinea was one of the places where plants were first domesticated (Golson 1977; Bayliss-Smith & Golson 1992; Denham *et al.* 2003). Since this discovery was made, prehistorians have found evidence of people using fire to clear substantial areas of montane forest for more than 20 000 years, hence raising the possibility that they may have been responsible for the extinction of some large alpine mammal species around the time of the Last Glacial Maximum (Flannery *et al.* 2002; Haberle 2003; Hope 2007). However, the number of people engaged in such activities must have been limited by the cold climate that prevailed at high altitudes during the late Pleistocene period (Haberle *et al.* 2001; Fairbairn *et al.* 2006) and, despite the evidence of early agricultural activity in the Holocene period, botanists think it very unlikely that any of the so-called Indo-Pacific staple crops (such as taro, yam and banana) would have originally been domesticated in the central highlands (Yen 1995).

Interdisciplinary debate about the parallel prehistory of agriculture beyond the intermontane valleys of the central highlands has been fairly inconclusive (Fairbairn 2005). This is not so surprising given that these other areas are home to the vast majority of the physical environments, vegetation communities and agricultural systems documented in the PNGRIS and MASP databases. Given the diversity of local agricultural and plant management practices that are still in evidence today, it is difficult to conceptualize their mutual relationship in terms of the sort of evolutionary sequence invoked by concepts like domestication (Kennedy & Clarke 2007). Furthermore, the construction of a number of distinct regional sequences remains shrouded in uncertainty because the physical environmental factors documented in the PNGRIS database are not only constraints to indigenous land use, but also constraints to the discovery of new archaeological evidence (Löffler 1977). Even the evidence from plant genetics has been unable to settle the question of which Indo-Pacific plants were first domesticated in the New Guinea region and which were imported after prior domestication in South-east Asia (Lebot 1999).

So what becomes of the idea that Austronesian invaders were responsible for a Neolithic agricultural revolution (Diamond & Bellwood 2003), at a moment in prehistory when there had already been one or more previous episodes of plant domestication on the main island of New Guinea? Even if it is true that a distinctive Austronesian cultural package can be documented from both the linguistic and the archaeological record, it is things like boats, pots, houses and social institutions that seem to be the most distinctive elements of this package, not agricultural practices (Pawley 2007). Leaving aside the question of whether their canoes brought a new suite of domesticated plants to the New Guinea region, there is stronger evidence to suggest that the newcomers brought some pigs, dogs, chickens and Pacific rats (*R. exulans*). If Austronesian invaders were responsible for starting an agricultural revolution in the New Guinea region, part of that revolution would then have consisted in the subsequent incorporation of these four commensal animal species into Papuan society-environment relationships. Although there is no evidence of their presence in the region more than 4000 years ago, the strength of their association with Austronesian archaeological sites is still debatable (Matisoo-Smith 2009), and there is a growing recognition amongst archaeologists that plants, animals and people could have been moving back and forth between the two regions at various points in time before the Austronesian incursion (Denham 2004). In which case, the idea of an agricultural revolution may simply serve as an obstacle to the understanding of regional systems of production and exchange before and after their arrival.

Prehistory has always been a field of great uncertainty, but what is interesting about the Austronesian debate is that, unlike the other debates about the agricultural prehistory of PNG, it has no tangible connection with current policy debates

about resource management or environmental conservation. There are several reasons for this. The PNGRIS and MASP databases are entirely concerned with terrestrial environments and ecosystems, and provide little or no information about the use of marine resources by Austronesian-speaking people who like to live by the seaside. They have also been constructed at a scale which virtually obliterates the large number of very small islands (<10 km^2 in area) which are exclusively occupied by such people, and which may well have been the original stepping stones of the first Austronesians to migrate through the region. In addition, there is virtually no coastal counterpart of the rich oral historical record which has enabled anthropologists to reconstruct the pre-colonial historical ecology of the sweet potato revolution in the central highlands. The reason for this is that the indigenous coastal population (including most of the Austronesian-speaking people) were the first to be brought under colonial rule, and it is thus difficult to establish which aspects of their environmental knowledge or resource management practices (marine or terrestrial) have pre-colonial origins. In the early colonial period, the coastal zone was the area of preference for the development of European plantation agriculture, which had a major impact on indigenous society-environment relationships, and, in the later colonial period, the development of 'native agriculture' took preference over the development of 'native fishing' as a matter of public policy, reinforcing the separation of two branches of resource management which had supposedly been combined in the archetypal Austronesian 'maritime economy' (O'Connor & Veth 2000). In the post-colonial period, industrial logging has taken precedence over industrial fishing as a focus of national economic development policy, and this in turn has framed the progress of environmental conservation policy (Filer 1998). Historical ecology has been drawn towards the relationship between commercial agriculture, shifting cultivation and sustainable forest management, largely neglecting the field of coastal zone management. Even in the field of climate change, the emergence of the carbon sequestration paradigm has put the problem of mitigation before the problem of adaptation, at least for the time being.

CONCLUSION: DIVERSITY, COMPLEXITY AND POLICY

The New Guinea region has been home to important theoretical advances in both the social and natural sciences, but these advances have sometimes had the paradoxical effect of hindering the development of interdisciplinary debate about the diversity of relationships between indigenous societies and their natural environments. For example, the theory of island biogeography can only explain the relationship between biodiversity values and island ecosystems if the immigration, evolution and extinction of species are assumed to take place without human interference (MacArthur & Wilson 1967; Mayr & Diamond 2001; Steadman 2006; Simberloff & Collins 2010). The diffusion, evolution or decline of social institutions can be accommodated in a broader theory of historical ecology, but the cultural diversity of the New Guinea region seems to have discouraged anthropologists from making the effort. Instead, the evidence of cultural diversity has inspired the functionalist rejection of evolutionary social theory (Malinowski 1944; Richards 1957) and the subsequent evolution of a theory of social exchange which presents a radical challenge to the Western distinction between 'nature' and 'culture' (Wagner 1975; Strathern 1988; de Coppet & Iteanu 1995). Interdisciplinary debate about society-environment relationships must therefore establish a middle ground between the extremes of ecological fundamentalism and cultural relativism. At one extreme, ecological fundamentalists are inclined to erase the evidence of cultural diversity by treating all human beings as pests, or treating all indigenous people as fallen angels, or entrusting the salvation of endangered species and ecosystems to a single body of enlightened decision makers. At the other extreme, cultural relativists are inclined to challenge the foundations of environmental science by treating all ideas about species and ecosystems as social constructs, and hence treating biological and environmental diversity as a diversity of perceptions grounded in an indeterminate range of social relationships.

If interdisciplinary debate can serve to bridge this theoretical divide, it does not necessarily follow that the same debate creates a body of scientific knowledge about indigenous society-environment relationships which has a straightforward relationship to the formulation of environmental conservation policies in PNG. For example, Jared Diamond and Tim Flannery have recently adopted positions in PNG's national policy process that appear to reflect their role as 'celebrity conservationists' (Brockington 2009) working in alliance with the Worldwide Fund for Nature (WWF). Diamond has endorsed the contractual relationship through which WWF manages an integrated conservation and development project with funding provided by the companies responsible for the development of PNG's oil and gas resources (Diamond 2009). Flannery and WWF have proposed a scheme through which local villagers could be given a financial incentive to protect their local forest ecosystems by auctioning forest carbon credits on the internet (Flannery & WWF 2007). Diamond's position is located with the biodiversity conservation paradigm, Flannery's within the carbon sequestration paradigm, and each might well support the other's position, given that both have been acting in concert with the same conservation organization.

Diamond's position can be explained by reference to his earlier work on the optimal size of protected areas (Diamond 1975), coupled with a belief that extractive industry companies, which now dominate the formal sector of PNG's national economy, are the only stakeholders with the motives and resources to secure such areas for long periods of time. Flannery's position can be explained by reference to the close personal relationships that he developed with local villagers in one part of the country while conducting research on one endangered species of tree kangaroo (Flannery 1998), coupled

with an equally strong distrust of the national government's capacity to protect the interests of either the villagers or the local wildlife. However, there is no obvious way to infer either of these positions from their respective versions of historical ecology.

PNG's anthropological community might have been expected to espouse other policy positions supported by international conservation organizations, like the argument that conservation of biological diversity is best achieved through the conservation of indigenous languages and cultures (Maffi & Woodley 2010). However, the cultural (or social) anthropologists who study indigenous society-environment relationships in PNG have generally shied away from the task of mapping and measuring their systematic transformation in time and space. As a result, there has been no serious effort to produce a sociocultural analogue to the PNGRIS and MASP datasets that does more than show the spatial distribution indigenous languages (Wurm & Hattori 1981) Now that anthropologists are no longer able to discover an ethnographic present that has yet to be contaminated by the forces of modernity, and wary of the accusation that their discipline is little other than the colonizer's science of the colonized, they have been more inclined to accuse other stakeholders in the conservation policy process, whether conservation organizations or mining companies, national government departments or foreign aid agencies, of misrepresenting indigenous society-environment relationships in a futile effort to integrate the forces of environmental conservation and economic development (Kirsch 2006; West 2006). But when anthropologists align their own version of the truth with local voices opposed to all forms of 'government' and 'development', they not only sacrifice the opportunity to make a distinctive scientific impact at the level of national policy debate, but also risk irrelevance because their local allies have no great interest in cultural diversity or historical ecology (see Brosius 2006).

If the outcomes of national policy debate in a country like PNG are determined by global forces beyond national control, then it is hard to see why foreign scientists from any discipline should bother to enter this debate, even if they are welcome to do so. But even if PNG is granted the status of a nation which can 'choose to fail or succeed' in the management of its natural environment, there is no obvious reason to assume that a greater degree of interdisciplinary debate amongst natural and social, as well as national and foreign, scientists will lead to better outcomes in the conservation policy domain. The transaction costs incurred by interdisciplinary collaboration are unlikely to be justified unless the collaboration serves to produce better solutions to specific policy problems that are indeed generated by forces external to science itself (Sillitoe 2004). Most of the disciplines represented in the field of historical ecology (including cultural anthropology) are not well equipped to grasp the complexity of the environmental policy process at any level of political organization (Balée 2006). Conversely, in a country like PNG, environmental policy problems are unlikely to have any rational or sensible solution in the absence of a better scientific understanding of the complexity of indigenous society-environment relationships.

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