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# Faunal collapse, landscape change and settlement history in Remote Oceania

Atholl Anderson

## Abstract

Substantial anthropogenic environmental change occurred in Remote Oceania following the first arrival of people at 3000 BP and their spread throughout the region by 700 BP. It included numerous faunal extinctions, widespread deforestation and the erosion and re-deposition of sediments, to which are attributed various consequences for cultural development. The issue considered here is whether an explanation of anthropogenic change could extend to variations in settlement history between Remote Oceanic islands. Most of those were inhabited continuously, especially in the older settled area, but in East Polynesia settlement is thought to have declined on several islands and it was abandoned in many others. Consideration of the type and scale of anthropogenic changes indicates no correlation with variations in settlement history. Anthropogenic changes might be regarded as constants of the settlement process. Late Holocene climatic patterns, ecological complexity and isolation with its effect on the availability of subsistence choices, may have been more influential variables.

## Keywords

Remote Oceania; faunal collapse; landscape transformation; settlement history; isolation; subsistence choices; ecological complexity; aridity.

## Introduction

Dramatic environmental changes accompanied the first arrival of people in Remote Oceania (Fig. 1), but within the prehistoric era, beginning at 3000 BP, these changes did not constitute, for them, an 'ecodisaster'. The 'dreadful syncopation' (Martin and Steadman 1999: 50) of human arrival and faunal extinction on Oceanic islands certainly created a biological catastrophe. Yet, if this was ecodisaster measured by the loss of island avifaunas, in particular, it was at the same time a kind of 'ecotriumph' measured by the success of human colonization. The first imperative of colonization is to survive by creating a viable population. Overkill of flightless birds and other large animals was the optimal

strategy of initial survival and lineage fitness on islands (Anderson 1997). Efficiently gathered resources of high nutritive value got small colonizing populations of people past the demographic danger point as quickly as possible. Likewise, an accompanying or subsequent assault on the forest, with consequential re-deposition of upland sediments, opened for most communities the possibility of long-term demographic success by intensive agriculture.

In short, without significant anthropogenic environmental modification Remote Oceania could hardly have been inhabited successfully at all. Had prehistory extended another millennium, the ultimate case might have looked decidedly different, but that is only to concede the temporal contingency of all environmental relationships, to the analysis of which terms like ‘ecodisaster’, or indeed ‘ecotriumph’, add little useful meaning.

Widespread evidence of substantial anthropogenic environmental change in Remote Oceania raises other issues, including the question of whether variations in its kind or severity of impact were critical in shaping the regional diversity of settlement histories. By the time of European arrival, many island populations throughout the region were showing signs of stress, marked by strict territoriality and a proliferation of fortifications, and by endemic warfare and cannibalism. Some island populations seem to have declined

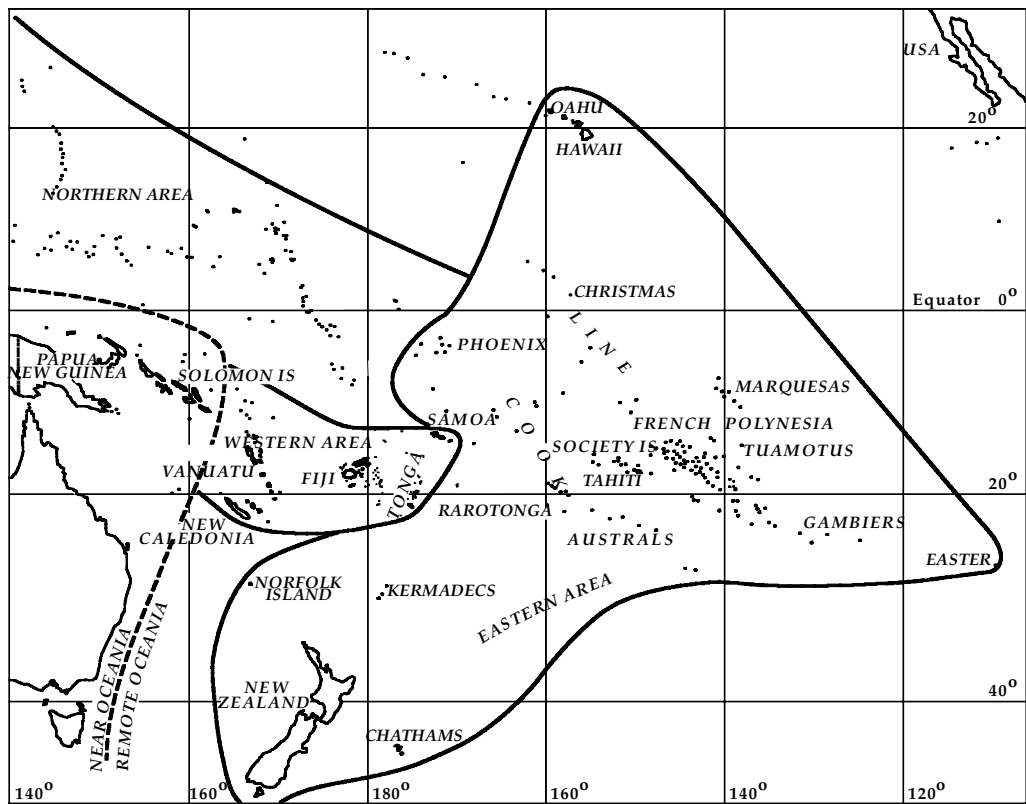


Figure 1 Remote Oceania showing the main areas and island groups.

and others had disappeared. Are these phenomena largely attributable to anthropogenic environmental change?

Certainly, numerous cases of change in vegetation, sedimentary deposition and faunal diversity have been documented (see Fosberg 1963; Dodson 1992; Kirch and Hunt 1997) and some proposed as significant in shaping cultural sequences. Among those are propositions that early settlement patterns in southern New Zealand were re-directed by over-exploitation of megafauna (Anderson and Smith 1996), that mobilization of hill-country sediments enabled intensive lowland agriculture on Māngia (Kirch 1997), and that deforestation in Easter Island produced a cascade of demographic and social calamity (Flenley 1993).

If the latter case has taken on allegorical proportions (Bahn and Flenley 1992) then it serves to highlight the general question of how far an explanation of cultural change by anthropogenic environmental devastation might be usefully extended. One way of examining this issue is to ask whether there is a correlation between different types or scales of anthropogenic change and differentially successful settlement histories in Remote Oceania, as measured by inferred relative population growth. That is the matter considered here.

### **Anthropogenic environmental change**

Remote Oceania consists of three broad areas. The north (Micronesia) is the least known in terms of environmental change and it is not considered here. The west consists of the large islands of eastern Melanesia and West Polynesia, first settled during the Lapita expansion 3000–2700 BP. They have complex biogeographic histories that extend to Gondwanan origins in New Caledonia and to the mid-Eocene in Vanuatu, Fiji, and Tonga. The eastern islands were settled by East Polynesians, probably after 1000 BP (below). With the exception of New Zealand, geologically within the western group, they are mostly small and of Pliocene or younger volcanic formation, or low islands of coral.

In the west, settlement histories are almost exclusively continuous since first colonization and that is also true of the larger, high islands in the east. Population growth on a logistic curve is assumed (Kirch 2000). In the east, however, some islands are believed to have suffered stagnation or decline in population growth, as in Kahoolawe (Hawaii, Kirch 1985), Easter Island (Bahn and Flenley 1992) and southern New Zealand (Anderson and Smith 1996). In addition, twenty-five islands (Fig. 2) show evidence of prehistoric settlement and abandonment (Kirch 1988; Anderson 2001). Could anthropogenic environmental change account significantly for these differences?

My approach to considering this question is, first, to see whether there are different overall patterns of faunal collapse and landscape transformation between west and east, then whether the anomalous settlement histories in the east have any distinctive pattern of anthropogenic change in common, and finally to consider alternative explanations. For the sake of simplicity, I assume that the environmental changes in question were primarily anthropogenic. This is not to deny the fact of continuing natural environmental change during the late Holocene, as initiated by an increasing intensity of El Niño–Southern Oscillation phenomena after 3000 BP (Markgraf and Diaz 1999: 475) and

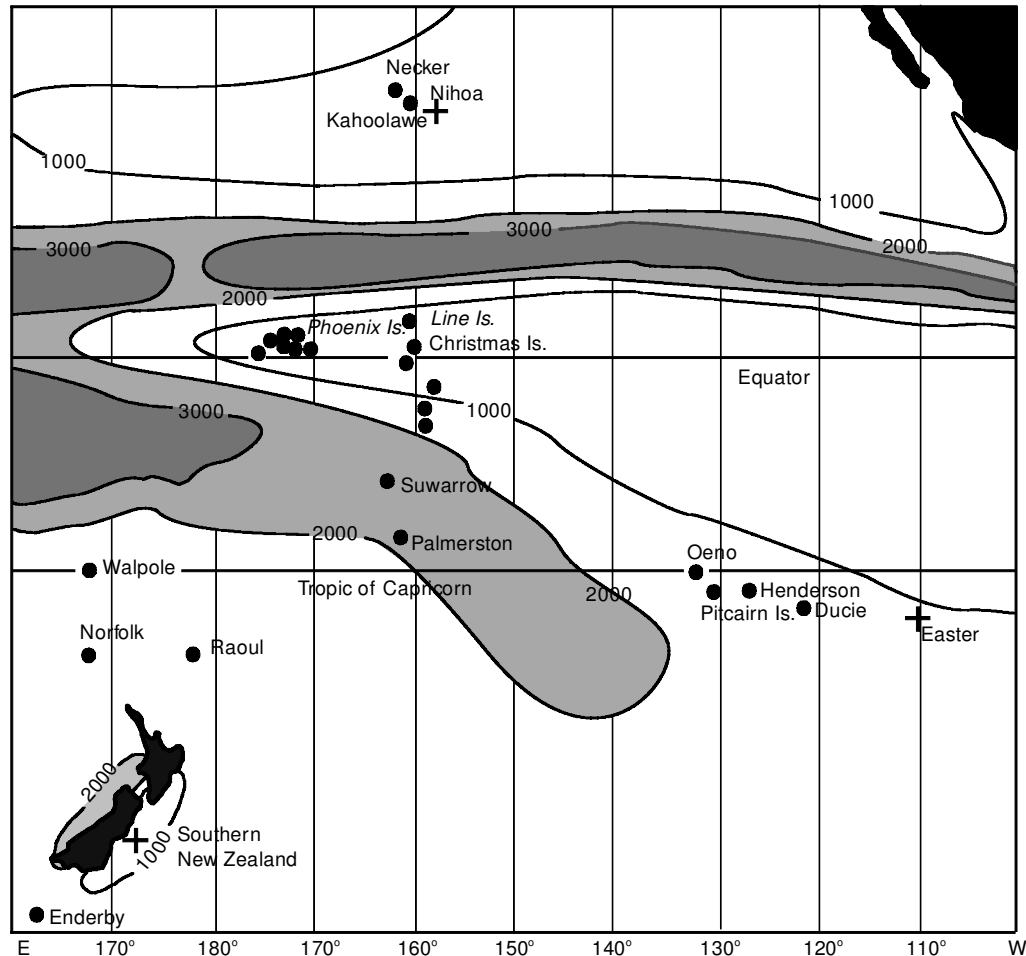


Figure 2 The distribution of islands with anomalous settlement histories (+ = population decline, • = settled and abandoned prehistorically), in relation to annual precipitation at sea level.

changes in sea level, such as retreat from the 4000 BP highstand – not to mention exceptional storms, earthquakes, drought, tsunamis and volcanism. These clearly impacted on Oceanic landscapes (Nunn 1999a; Anderson 1995; Hunter-Anderson 1998). Human disturbance could produce effects similar in character, but significant anthropogenic change involving a continuous fire record associated with unreversed deforestation, the two most usual features, is generally unmistakable in the sedimentary record and it is mostly that evidence which is reviewed here.

Faunal collapse

Late Holocene extinction of terrestrial vertebrate taxa is widely documented in the region, but until recently the evidence was patchy. In the west, it included extinction of a giant megapode *Sylviornis neocaledoniae*, some small birds, a crocodilian *Mekosuchus*

*inexpectatus*, and a horned tortoise *Meiolania* sp. in New Caledonia (Balouet and Olson 1989; Balouet 1991), plus a large iguana, a megapode and some other birds in early Tongan sites (Pregill 1993; Pregill and Dye 1989; Steadman 1993). Other archipelagos had no comparable record.

Now, however, land crocodile remains are reported from an early Lapita site in Vanuatu (Bedford pers. comm.) and a whole extinct fauna from Fiji. Though still largely undescribed, it includes another land crocodile species, a giant iguana, a meiolanian tortoise, a giant frog, remains of fruit pigeon, rail and two large megapode species, a giant megapode, *Megavitiornis altirostris* (Worthy 2000), comparable to *Sylviornis*, and a giant flightless pigeon, similar to the dodo and solitaire of the Mascarenes (Worthy et al. 1999). The age of disappearance of this fauna is still uncertain. The best assemblage of remains is bracketed by late Pleistocene radiocarbon dates and uranium series ages of about 4500 BP on post-depositional stalagmites (Anderson et al. 2001). Nevertheless, extinct megapodes, including *Megavitiornis*, are represented in Lapita sites, and possibly also the giant iguana (Anderson et al. 2000a), so it is a fair working assumption that the new taxa became extinct by human agency.

In East Polynesia some cases of late Holocene extinction are well-known, as in New Zealand, where nearly forty species of birds (including twelve of the moas), a bat, three to five species of frogs and an unknown number of lizard taxa disappeared (Anderson 1989, 1997; Worthy 1997). This represented a 50 per cent decline in the number of bird taxa breeding on the mainland, and similar losses were sustained on Hawaii and elsewhere in East Polynesia from the central archipelagos to the margins (Steadman 1989; Weisler 1995; Steadman et al. 1994). Wherever data can be obtained they show that extinctions occurred within the period of human colonization. For example, remains of all prehistorically extinct species of late Holocene birds in New Zealand have been found in at least one archaeological site, apart from two tiny wrens and two recently recognized species (the moa *Pachyornis australis* and a petrel *Puffinus spelaesus*) which might yet be found in re-examination of archaeological collections (Worthy 1997).

With few possible exceptions, the extinctions occurred rapidly, although perhaps not as quickly on large islands as the fifty years after human colonization preferred for moa extinction by Holdaway and Jacomb (2000). Radiocarbon dates on moa bone gelatin, ranging in median age up to the fifteenth century, and other radiocarbon data, suggest that small populations survived for several hundred years (Anderson 2000a; Schmidt 2000).

Martin and Steadman (1999: 30) think extinction was slowed on Mangaia by complex topography but the avifaunal remains in question come from the base of the oldest known archaeological site and it is only belief in a preceding phase of human occupation, undocumented archaeologically, which sustains the suggestion of delay. The more convincing case seemed to be in New Zealand, where radiocarbon ages of up to 2200 BP on introduced Pacific rat bones encouraged Holdaway (1999: 216) to propose that, since human colonization on any scale did not begin until 800 BP, 'many of the extinctions and extirpations occurred when the Pacific rat was the only widespread novel factor in the environment'. In other words, avifaunal extinction was a relatively lengthy and two-stage process (rat only, then rat and people). However, there is no evidence of vertebrate extinctions occurring in the period 2000–800 BP in New Zealand and, in addition, the early radiocarbon dates on rat bone show an unfortunate correlation between sample age and the

sequence of laboratory processing. Thirty of the first thirty-two dates from the Rafter Laboratory, New Zealand (including both archaeological and predator-site specimens) ranged from 1100 to 2200 BP, whereas twenty-five of the next twenty-eight dates were younger than 900 BP, even although many of them were from the same provenances. It is unclear how the problem arose, but there is no case remaining for early rat colonization in New Zealand (Anderson 2000b).

As well as extinction, there was also widespread depletion or range contraction among other taxa. For example, remains of New Zealand fur seal, and elephant seal in one case, have been found in early archaeological sites on the Cook Islands, Kermadecs and Norfolk Island, well beyond current ranges. Within New Zealand, the fur-seal- and sea-lion-breeding ranges, marked by pup bone in archaeological sites, retreated southward from the Northland coast at AD 1300, to Cook Strait by about AD 1600 and to East Otago by AD 1800 (Smith 1989; Walter 1998).

These data suggest two useful points about faunal collapse in Remote Oceania. First, that it was rapid and early. The typical pattern is for remains of extinct taxa to be found in sites that date to the initial century or two of human settlement and thereafter to be absent. This pattern indicates that extinction, at least among the larger-bodied taxa, was in some degree density independent, i.e. small human populations of widely varying density distributions could still devastate indigenous faunas very quickly. Second, it is now clear that the process was virtually universal. So much so, that Steadman (1995) estimates a loss of 8000 species or populations within Oceania generally and Martin and Steadman (1999: 29) comment that 'on any remote Pacific island with a respectable fossil record, one can expect to find at least two to three times the number of land bird taxa before [human] contact than after'. A general conclusion may be drawn that early faunal collapse in Remote Oceania was a common factor throughout the region.

### *Landscape transformation*

In the west, sites of initial colonization are easily discriminated by decorated Lapita pottery, which provides a fixed point in time for the initiation of anthropogenic change. In New Caledonia, where early Lapita sites date to about 3000–2900 BP (Sand 1997), two sedimentary cores show that charcoal levels rose substantially after 3000 BP and there was some loss of diversity in arboreal taxa, but massive deforestation did not occur until after 2500 BP (Stevenson 1999). Cores from the interior of Viti Levu, the main island of Fiji show substantial deforestation beginning about 2100 BP, although Lapita colonization had begun about 2900 BP (Anderson and Clark 1999). A core from the Rewa delta (windward coast of Viti Levu) exhibited significant levels of fine charcoal extending back to about 4400 BP but these are almost certainly from natural firing. Forest decline begins at a point dated to 2700 BP, but other signs of anthropogenic disturbance, including a rapid increase in charcoal frequency, do not occur until about 2300 BP (Hope et al. n.d.). A core from Navatu swamp on the leeward coast shows substantial forest disturbance and a sustained charcoal incidence beginning at about 1600 BP. Delayed deforestation and accelerated erosion is also apparent on Totoya Island and in other cores from Fiji (Hope et al. n.d.) which are producing comparable results.

There is a broad pattern of change evident in these data from the western area. There



was relatively little initial impact on the landscape. Massive changes in sediment distribution and vegetation patterns developed as population density increased and settlement expanded inland. Landscape transformation shifted sediment from the hills to the coast and valleys which 'both increased island area and provided opportunities for agricultural development of these fertile lowlands' (Enright and Gosden 1992: 192, citing other western cases).

The situation is more difficult to comprehend in the eastern area, largely because of uncertainties about the timing of initial human colonization. Acercamic East Polynesian archaeology lacks any horizon marker of initial colonization comparable to Lapita pottery in the west. Some adzes and ornaments are characteristic of the earliest radiocarbon dated sites, but none can be traced back to western Oceanic antecedents sufficiently precisely to set a *terminus post quem* for East Polynesian colonization. The orthodox chronology has appealed, instead, to continuity of eastward voyaging (Irwin 1992) and a potential loss of the earliest sites to argue for initial occupation 2500–3000 years ago. This position is supported by older radiocarbon dates of up to about 2000 BP (Kirch 1986) on sites in Hawaii and the Marquesas. Later archaeological research has returned consistently younger radiocarbon ages: South Point, Hawaii, goes to 500 BP (Dye 1992), Ha'atuatua, Hane and other early Marquesan sites to 900 BP or later (Rolett and Conte 1995; Rolett 1998; Anderson and Sinoto n.d.) and Anakena, Easter Island (Steadman et al. 1994), along with colonization sites in the Society Islands, to 1000 BP (Anderson et al. 1999; Anderson and Sinoto n.d.). Wairau Bar in New Zealand dates to about 700 BP (Higham et al. 1999) and there are similar ages for Norfolk Island (Anderson and White 2001), Raoul Island (Johnson 1995) and the Subantarctic islands (Anderson and O'Regan 2000). In short, human advent was late.

Questions are raised, consequently, about the dating of apparently anthropogenic landscape changes to 2500 BP in Mangaia, Cook Islands (a much debated proposition – Anderson 1994, 1995; Spriggs and Anderson 1993; Kirch and Ellison 1994; Kirch 1997), to 1500–2000 BP in New Zealand (Sutton 1987), and to 1200–1500 BP in Easter Island and the Societies (Parkes and Flenley 1990; Flenley 1993; Parkes 1997). Further, there are significant dating inconsistencies on disturbance horizons between comparable cores. One cause of the difficulty might now have been isolated. Using New Zealand examples, McGlone and Wilmshurst (1999) showed that, whereas the inception of continuous deforestation recorded in ombrogenous peat bog strata dated characteristically late (younger than 900 BP), the same horizon produced dates older than 1500 BP in sediments recovered in lakes and swamps which are susceptible to inwashing of old soil carbons. A parallel project using a 600-year-old tephra as the chronological marker showed that in all cases significant disturbance horizons were located above it (Newnham et al. 1998). There is, consequently, a strong case for late anthropogenic change consistent with the archaeological chronology.

The tropical Polynesian data come mainly from lake and swamp cores (ombrogenous bogs are absent in lowlands). If the dates are correct, there may have been substantial natural disturbance prior to human arrival. If the dates are too old, then there was a higher rate of early landscape change in the east than to the west. Perhaps both are true in part. On small eastern islands with steep volcanic slopes and subject to periodic drought, relatively high rates of natural disturbance could be expected, and Parkes and Flenley (1990)

note this possibility for much of the change recorded in cores from the Society Islands. However, in flat eastern landscapes, significant disturbance is relatively late (e.g. about 950 BP in leeward Oahu, Hawaii – Athens et al. 1999).

Landscape change in Remote Oceania appears to divide, therefore, into two patterns. In the large western islands it was often slow to start and took up to a millennium to assume major proportions. This seems to be a density-dependent pattern which was tracking the progressive expansion of agriculture. In the eastern islands, there was a stronger early impact. It is probable that anthropogenic change was more prominent early on small, young islands with very steep slopes and relatively fragile soils, and that it was supplemented by increased climatic volatility in the second millennium AD. The question now is whether that eastern pattern was even more pronounced on islands with anomalous settlement histories (Fig. 2).

### **Environmental change and settlement history**

As concluded, above, faunal extinctions can be regarded as a common phenomenon which was broadly scaled to island size and complexity. Numerous species, many of large body size, disappeared in southern New Zealand, there were several extinctions or extirpations of small birds in Norfolk, Henderson and Easter islands, and the native goose disappeared from Kahoolawe (Anderson 1997; Anderson and White 2001; Steadman et al. 1994, Weisler 1995). No prehistoric losses have yet been recorded on Enderby, Raoul, Pitcairn, Ducie, Oeno, Nihoa, Necker or any of the Line and Phoenix islands. There is nothing about these data to suggest that faunal extinctions were more influential in creating the anomalous demographic histories than elsewhere, even in southern New Zealand (below).

On the three islands for which population decline is proposed, there was certainly extensive deforestation. There is no pollen record for Kahoolawe so the rate of change is unknown, but by European contact it was well-denuded and considerably eroded (Kirch 1985). In the eastern South Island of New Zealand, a natural fire-return interval of 200 years in the mid-Holocene had dropped to only ten years by 1300 BP (McSaveney and Whitehouse 1989), and forest was largely replaced by secondary shrubland, fern and tussock grassland within two centuries of human arrival. However, large-scale erosion was confined to the alpine fringe and large patches of forest remained in some areas (McGlone 1989).

Easter Island presents a problem because the case for demographic decline caused by anthropogenic environmental devastation is insufficiently documented at critical points (Bahn and Flenley 1992). The frequency distribution of obsidian hydration and radiocarbon dates suggests a population peak at AD 1400–1650 and Flenley (1998) dates the population decline to within the next fifty years, an interval too narrow to document archaeologically. Europeans arrived only twenty years after that (AD 1722) and there is no evidence of a population crash in historical observations. The social upheaval that toppled the statues occurred mainly in the late eighteenth century (statue toppling had probably occurred throughout prehistory as lineage competitions were won and lost). Recorded population decline occurred in the nineteenth century. All estimates of the peak size of the prehistoric population are entirely speculative; it might never have

exceeded the 2000–3000 that can be estimated from early historical records. Warfare was endemic on most Polynesian islands and does not indicate demographic collapse.

The course of environmental change is also disputed. Flenley (1993, 1998) dates the period of forest decline to about 1600–900 BP, but most of that period was probably before human colonization (above). Hunter-Anderson (1998) notes the long prehuman record of vegetation change on Easter Island and suggests that the forest had begun to disappear with a mid-Holocene onset of climatic volatility, presenting a largely open landscape to initial settlers, and one which declined further by drought during the Little Ice Age. Yet it should be noted that there was forest decline but not disappearance. Orliac and Orliac (1998) found a predominance of wood charcoals in cooking fires up to at least the mid-seventeenth century, and, while the native palm was gone before European contact, the other main tree, *Sophora*, survived until the mid-twentieth century.

For the islands colonized and abandoned, vegetation histories are uneven and generally poor. Enderby Island has a pollen record, and it shows no clear evidence of human impact (Anderson and O'Regan 2000). On Norfolk Island, pollen records for the period 800–200 BP are essentially absent, but full forest cover at European discovery in the eighteenth century suggests that the prehistoric impact, concluding several centuries earlier, had not been devastating (Anderson and White 2001); the same is true of Raoul (Johnson 1995). Pitcairn was partly deforested and eroded at European contact (Weisler 1995, 1996), while Henderson retained much of its forest cover, despite extensive burning in the north and east (Weisler 1995).

Christmas Island, in the Line group, was grass and shrub-covered, with a few coconut palms, when discovered by Captain Cook in 1777. Initial analysis of sediment cores, as yet undated but regarded as prehistoric, shows a predominance of non-arboreal pollen (Anderson et al. 2000b). Nihoa, though modified by prehistoric settlement, retained its endemic palm and some shrubs (Kirch 1985). The other islands have no vegetation history beyond historical observations of dry forest and shrubs (Emory 1934) which indicate, at least, that they had probably not been denuded of trees by prehistoric colonization 300–500 years earlier.

While these records for the Remote Oceanic islands with anomalous settlement histories are patchy and incomplete, taken together they do not suggest that landscape change upon them was in any way distinctive or significantly more devastating than on many continuously occupied eastern islands. The coastal lowlands of Hawaii and Tahiti were largely deforested during the prehistoric era (Kirch 1982; Lepofsky et al. 1996) as were Rapa and Mangareva (Weisler 1996). The same may be said of Aneityum (Spriggs 1997), Tikopia (Kirch and Yen 1982) and other western islands, to which may be added the reduction to grassland of much of interior Fiji and New Caledonia (Enright and Gosden 1992). The anomalous settlement histories do not seem to reflect a different character or greater extent of anthropogenic environmental change, either in faunal collapse or in landscape transformation, than is evident elsewhere in Remote Oceania.

## Discussion

Taking anthropogenic environmental change as common to the regional settlement histories, which other factors may have been especially influential in creating the

anomalous cases? Three have been discussed by Kirch (1988), Irwin (1992), Weisler (1996) and Anderson (2001) among others. Their combined impact on Remote Oceanic islands is sketched in Figure 3.

First, cultural factors of isolation were almost certainly involved. Most of the islands at issue are particularly isolated, as demonstrated by Irwin (1992: fig. 67) and therefore had relatively low chances of population replenishment if a small initial colony failed because of environmental calamity or stochastic demographic disaster (Williamson and Sabath 1984). This is true whether or not voyaging activity decreased over time in Polynesia, a proposition offered frequently but one which it is exceedingly difficult to document (Anderson 2000c). A recent approach to measuring relative isolation, or interaction, in East Polynesia, has been through elemental source characterization of basalt and obsidian artefacts distributed by long-distance voyaging (e.g. Weisler 1997; Anderson 2000d). The results, so far, validate the expectation that interaction occurred throughout the central archipelagos but to no extent beyond that. No exotic lithics are reported from the three marginal groups (Hawaii, Easter Island, New Zealand), and where they do occur on small, isolated islands such as Raoul, Norfolk and Christmas (Anderson 2000d; Anderson et al. 2000b), they are in contexts and quantities indicative of transport with the initial colonists.

Isolation, operating through the hazards of long ocean passages, probably induced social pressures to abandon very isolated islands, especially once the easy resources were severely depleted. Most importantly, isolation was also expressed in a reduction of variety among the introduced cultigens and domestic animals which were available as subsistence alternatives when local faunal resources became severely depleted. Anderson (2001)

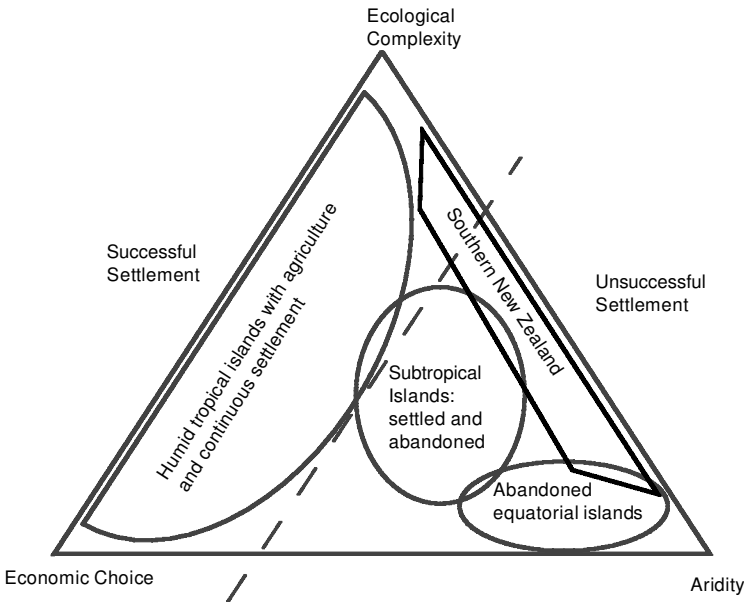


Figure 3 Successful and unsuccessful settlement (divided by dotted line) of Remote Oceanic islands in relation to varying ecological complexity, economic choice and aridity.

argues that, in addition to relatively limited availability of marine resources, this was a very significant factor in the abandonment of the subtropical islands. They received, at best, only one domestic animal and a restricted range of food plants, compared with those available on continuously occupied islands. In southern New Zealand, of course, the choices were even more limited by the climatic impossibility of growing any of the introduced cultigens. It is this factor especially which produced population stagnation in southern compared to northern New Zealand.

Second, relatively limited ecological complexity was probably a factor in many of the cases at issue. Biological diversity provides a buffer against environmental hazard and in the tropical Pacific it declines, broadly speaking, towards the south east, where the islands with anomalous settlement histories are situated. Lowland rainforest with its variety of native food plants is scarce east of Fiji. Landbird diversity declines from 520 species in New Guinea to fifty-four on Fiji, seventeen in the Society Islands and four on Henderson, a trend that was almost certainly in existence before anthropogenic extinctions, although the numbers would have been different. Shore fish diversity declines from more than 3000 species in New Guinea to 1159 in the Society Islands and 133 in Easter Island (data in Green 1991; Anderson 2001). Diversity also declines inversely with island size and altitude (McArthur and Wilson 1967). Most of the islands with anomalous settlement histories are small and low. Of the exceptions, Christmas Island at 321 km<sup>2</sup> is large by East Polynesian standards but entirely flat while Easter Island at 160 km<sup>2</sup> is a relatively high island but very isolated and far to the east. Southern New Zealand, was neither isolated nor low in relief or intrinsic ecological diversity, but, as noted above, it entirely lacked horticultural possibility.

Third, nearly all of the anomalous settlement histories were on islands that are prone to climatic instability, notably drought. They are situated almost exclusively in the low rainfall sectors of the Pacific (Fig. 2). Of course, some of the larger and continuously occupied archipelagos were in the same areas (Fig. 1), but they were able either to produce orographic precipitation (e.g. Societies) or were in sufficiently regular contact with other groups to enable rapid population replenishment following disasters (e.g. Tuamotus). The impact of drought is known to have been particularly serious on low, coral islands, as noted by Maude (in Fosberg 1963: 174) for Ocean Island, where drought reduced the AD 1850 population of 2000–3000 to thirty-five by AD 1880. Drought, or at least climatic instability, could have increased during the mid-second millennium AD with the onset of cooler, often drier and windier conditions that culminated in the Little Ice Age (Nunn 1999b). It is plausibly that instability which accentuated the anthropogenic impact on prehistoric East Polynesian forests and erosional regimes generally.

## Conclusion

Abundant archaeological and palaeoenvironmental data from throughout the region indicate that anthropogenic change was closely implicated, in a variety of ways, in the cultural trajectories of Remote Oceanic islands. Considered from a broader perspective, however, it seems that anthropogenic change was only one of a number of important factors in determining whether early settlements on previously uninhabited islands failed, faltered or succeeded in the long-term. At a regional level, anthropogenic environmental change

can be regarded as almost a constant factor, in both its variety and extent. It was a natural and inescapable concomitant of human dispersal. Differences between settlement histories or other cultural phenomena may need, therefore, to look beyond that common factor towards some others. In Remote Oceania, the narrowing effect of isolation upon population replenishment and plant and animal introductions, geographical variation in ecological complexity, and increased climatic instability and drought eastward across the Pacific and during the Holocene may offer greater explanatory value.

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