PACIFIC PRODUCTION SYSTEMS

APPROACHES TO ECONOMIC PREHISTORY

Papers from a Symposium at the XV Pacific Science Congress, Dunedin, New Zealand, 1983
PACIFIC PRODUCTION SYSTEMS: Approaches to economic prehistory

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To the memory of
Brenda Bishop

Secretary
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FOREWORD

This volume is loosely based on the presentations given at a symposium of the same title organised by Doug Yen for the 15th Pacific Science Congress in Dunedin, New Zealand, in February 1983. The symposium formed part of the archaeological sessions of the Congress, which also constituted the 11th Congress of the Indo-Pacific Prehistory Association. I know that Doug would want to thank Foss Leach who was Scientific Programme Convener for Social Sciences and Humanities, of which the archaeological sessions formed part, and Charles Higham who was Chairman and Secretary-General of the Organising Committee of the Congress overall.

Some papers were prepared for publication shortly after the Congress, others were substantially revised and a few are essentially new. They are here offered as an acknowledgement of the major contributions made by Doug to the study of cultivated plants and agricultural systems, especially in Southeast Asia and the Pacific.

Jack Golson
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SECTION I

THE HUNTERS AND THE FISHERMEN
This paper explores the structural differences which exist between the Naskapi of central-northern Labrador and the Strait Salish of southwestern British Columbia. The sociocultural differences noted involve population density, sociopolitical organisation and both the utilitarian and decorative aspects of material culture. It is suggested that these variables are interrelated and that the differences noted in this paper reflect cultural responses to fundamentally different medium-high latitude environments. The critical difference between these environments lies in their potentials for economic intensification of production. Intensification is defined here as comprising favourable, discrete or processual adjustments of the labour:product ratio in production. In the Naskapi case the potential for economic intensification is small indeed. In Strait Salish territory, on the other hand, the potential for economic intensification is small indeed. In Strait Salish territory, on the other hand, the potential for economic intensification is considerable.

The suggestion is made here that where such potential exists it is likely to be realised and that if so a process of escalating change is then set in motion. In this process sociopolitical organisation and material culture are interdependent, so that change in one will precede or parallel change in the other. As sociopolitical organisation increases in structural complexity, so material culture will tend to diversify, so that more and more items of material culture are in use and there will be an increase in the use of decoration. As this trend proceeds the numerical ratio of utilitarian items: decorative items will decrease and there will be an increased tendency towards decoration of utilitarian items.

These changes are reversible and will reverse if potential for economic intensification is diminished or negated. Many instances of this kind of reversal are apparent in the archaeological literature (see for example Sutton 1982). Sociopolitical organisation and material culture can be shown to interact in the manner of a bi-directional causal chain. To use Goody's phrase here,

... we not only recognise an association between two or more factors but we also impute, however tentatively, a vectorial element, a direction [Goody 1976:25 (emphasis mine)].

The emphasis in this paper is not on Newtonian causality of the form associated with unicausal and highly deterministic explanations. Instead the variables being discussed are thought to share effective interrelationships so that change in one will effect, through complex and subtle process of sociopolitical interaction, change in others. The nett effect of such change can be predicted if one is aware of the mode of economic intensification being developed. If the mode of intensification is based upon resource control, increased cultural complexity will result through a process of diversification. If resource control is not involved, cultural simplification will proceed. It is recognised, however, that while these generalisations appear to apply the morphological, or if you wish syntactical, content of changes in material culture will be very difficult to predict. This unpredictability of changes of form in art styles is demonstrated in the Origins of Maori Art (Mead 1975). Although a very few ancestral motifs are known, the rate of inclusion of new elements and their polymorphs is, although not quantified at present, very considerable; this is especially so given the short time scale of New Zealand prehistory.

In the final section of this paper it is noted that the concept of economic intensification is most commonly applied to cultivators and seldom used in discussions of hunters, gatherers or foragers. This conceptual one-sidedness is unjustified and has detrimental consequences. Second, criticisms are made of unicausal prime-mover explanations of the origins of social stratification. Models of change and causality which emphasise homoeostasis are also criticised. The argument is made that further clarification of the vectorial and dynamic relationship which exists between resource ecology, sociopolitical organisation and material culture is overdue.
THE ETHNOGRAPHIC DATA

The Strait Salish

The information presented below is based on Wayne Suttles' (1974) ethnoarchaeological study of the Strait Salish of the Haro and Rosario Straits in southwestern British Columbia (Fig. 1). Suttles began his archaeological site surveys in the San Juan Islands in 1946. He contacted Salish elders who were born in the 1860s and 1870s and asked them about the age, function and inhabitants of the sites found during surveys. Relevant accounts of Indian groups in this region (Boas 1890; Barnett 1938, 1955) were used to complement the oral evidence. The purpose of the study was to provide a full account of the Strait Salish in 'traditional times', by which is meant just prior to, or soon after, the time of first European contact (Suttles 1974).

The total Strait Salish population just prior to contact with Europeans was probably in the range 5000-10,000. This estimate is based on information presented by Kroeber (1939), Taylor (1963) and Duff (1964; see also Suttles 1968:56 ff). The Strait Salish lived in six regional groups which shared a common language (reviewed by Thompson 1979) and a common adaptation to their environment. The distribution of these regional groups is shown in Figure 1. They are Sooke, Songish, Saamich, Semiahmoo, Lummi and Samish. There was considerable intermarriage between these groups, at least by the 1890s. For instance in discussing a village which was established on Juines Island soon after 1875, in

Figure 1 Strait Salish territory, after Suttles (1974:Map 8)
the centre of Samish territory (Fig.1; for more detail see Suttles 1974:97, Map 7), soon after 1875 Suttles notes that of a total of 55 people present only 18 were not outsiders in some sense (Suttles 1974:337-42, Tables 1, 2). Women came into the group from areas to the north and south. Only six of the 29 adult women and 12 of the 26 men present were Samish. It is not possible to establish the extent to which this particular situation was typical of the pre-European period. It is particularly interesting to note that non-Samish individuals resident in the Juemes Island Village went on speaking their own language, although 'Probably all of those people understood the Samish language if they were not truly bilingual' (Suttles 1974:337). Some comments will be made later in this paper concerning language diversity and rates of language change to which this apparently very high level of bilingualism is relevant.

The Strait Salish had a stratified social system within which an upper class, lower class and slave caste were 'recognisable social strata ...' (Suttles 1974:327). Not unexpectedly there has been some move away from the use of the terms class and caste in the northwest coast context (see for example Ames 1981; Donald and Mitchell 1975). The present author is content to focus attention upon the degree of stratification present and the manner in which movement towards high-status positions within this system was achieved; rather than pursuing the controversy over anthropological expression of this stratification.

Stratification in Strait Salish society followed from the operation of 'rules of property' (Goddier 1978:404) under which all possessions and privileges were unevenly distributed. The operation of these rules of property will be described below.

There was significant craft specialisation amongst Strait Salish and a bilateral kinship system based on the recognition of strong relationships by common descent or marriage, through male or female lines, with an emphasis on seniority. Although the nuclear family was the economic unit among Strait Salish, these kin ties were important in the formulation of second or permanent household groups. There is thought to have been some preference for patrilocal residence and levirate and sororal marriage practises operated (Suttles 1974:345-47).

Crucially, a family preferred to marry its sons and daughters to the children of families of other communities and of a status at least equal to its own [Suttles 1974:345]. The degree of social stratification present, at least in reconstructed Strait Salish society, is clear from the following two passages:

Slaves were owned outright by their masters. They were regarded as a form of wealth, and marriage between free men and slaves was not approved.

Second, ...

Low-class people were people without 'advise', and therefore they did not know how to behave properly. They were people who had lost their histories [Suttles 1974:358 (emphasis mine)].

Within each regional group of Strait Salish the family was the basic unit of social organisation. These families moved seasonally forming different aggregates at different times of the year. The distribution of resources and settlements within Songish territory is shown in Figure 2. The 12 winter villages identified and named by Suttles' informants are shown with their Songish names. Resource zones are shown and the resource found at each is identified. The most important of these, as will be demonstrated below, are zones at which sockeye salmon (Onchorinctues nerka) were taken using reef nets. Twelve reef-net sites were located along the west coast of San Juan Island. Some of the routes along which Songish groups moved from winter village to sockeye salmon reef-netting locations are shown in Figure 2.

Most Strait Salish families spent the summer months of July and August at salmon fishing camps. Large reef nets were used to catch sockeye salmon as they migrated through Salish territory en route to spawning grounds in the Fraser River. The nets were set on kelp-covered reefs in the path of the salmon. They were frequently set near headlands where there was a back swing of the current. This helped to concentrate the fish and thereby maximise the catch. Each of the reef-net locations was privately owned and inherited (see Suttles 1974:211 ff).

Each net was held between two canoes which formed a rectangle normally about 30-40
feet long and 20-30 feet wide. Each net was held in place by four large sea anchors and two canoes from which the sides of the nets were suspended. The salmon were guided into the entrance and retained there by a system of rope and blinds which comprised the sides and front of the net (ibid). Kew (1976) argued that the reef net is an indigenous device which was developed as an enlargement and modification of the trawl net form to be used most commonly in the lower Fraser region where the river is broad, deep, slow and laden with silt. At present it is not possible to date the development precisely. However, it was clearly not an historic introduction.

Reef-netting catches were often very large. Rathburn describes two reef net locations. Of one,

... it is said that under exceptionally favourable conditions, a haul can be made every two or three minutes, and a single large catch may fill the canoes. With fishing at the best a single net may secure as many as 2,000 salmon in a day .... [Rathburn 1900:314-15].

The other location described was a small reef net in Samish territory where with a ‘few’ nets ‘daily catches of 3,000 to 2,000 salmon were sometimes made ...’ (ibid). The reef netting is an example of mass capture of a resource in optimum conditions. The total calorific value of a sockeye salmon captured just before entering the spawning river will be reduced to nearly one half by the time it spawns inland (Idler and Clemens 1959).

A crew of perhaps 12-14 men with their families were used in the operation of each of these giant nets. The nets were manufactured and set in position each year. The catch was divided among the crew, apparently until each man had 20 fish for himself and his family. The remainder belonged to the owner (Suttles 1974). The crew, captain and owner lived in a ‘village’ near the net location for the duration of the fishing season. In pre-European times the owner lived in a large ‘permanent’ house covered with plants or mats. This was positioned at the front of the village, as shown in Figure 3. The crew members were housed in much smaller and simpler mat dwellings, which were arranged alongside the drying racks where the fish were preserved for winter food or use in potlatch. The wives of the crew members helped to preserve the owners’ fish.

In the autumn, families dispersed from the reef-netting locations to a number of discrete resource zones (see Fig.2). Late berries were collected and bear and black-tailed deer were hunted in the forest while small spawning fish were raked out of the shallows en masse. The most productive of these resources zones were privately owned and inherited. The ways in

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**Figure 2** Resources and settlements in Songish territory (after Suttles 1974:Map 3)
which inheritance operated in these situations are discussed in the final section of this paper.

In winter the Strait Salish congregated in large plank houses capable of holding at least four families and often more. The people who occupied each of these houses could be related, either through parents of the husband or the wife, although residence did tend to be patrilocal. Families within each winter house cooked separately but commonly shared meals. They always cooperated in intra-community feasting and potlatch but did not necessarily cooperate in subsistence activities.

Spring was spent in a range of hunting and gathering activities, again at discrete resource zones during short periods of resource availability. Vegetable foods were collected in the spring. The most important species, known as *camas*, were taken during a three-week period in May-June. *Camas* was found on the prairies and on some islands (Fig. 2). Some of the most productive beds were owned and inherited. Shellfish were also collected in spring. Ducks were captured using several methods including upright and submerged nets. Seals and porpoises were hunted. Halibut were taken on large hooks and sturgeon were harpooned. Fishermen trolled for salmon and used gill nets in shallow bays and rivermouths. Spring ended with the completion of preparations for the reef-netting season.

It is important to note that in Strait Salish society, leadership roles were not inherited. Those who inherited ownership of salmon-fishing locations and other strategic resources became the initiators of feasting and potlatch. They then competed through these institutions for recognition as leaders.

Strait Salish material culture was complex and highly decorative. This is evident from Farrand’s (1900) descriptions of the basketry, Wells’ (1969) discussion of weaving methods and the raw material used, and from several descriptions of the wide variety of tools, traps, weirs and nets the Strait Salish used in procuring their food (Suttles 1974; Stewart 1973).

The Naskapi

Ethnographic data on the Naskapi Indians of central-northern Labrador are presented below. Naskapi were chosen for inclusion because, in contradistinction to the Strait Salish of Suttles’ (1974) ‘traditional times’, when studied they lived (at the time of data collection) in an unstable environment which lacked the potential for resource control. The information presented below is based on Hendriksen’s (1973) ethnographic research amongst the Naskapi of Davis Inlet between 1966-68. Additional works on Naskapi and related groups by Speck (1935), Leacock (1969) and Tanner (1979), were considered during...
the development of this section of the present paper but these did not affect selection of the substantive description of Naskapi society offered below. Hendriksen's (1973) work is used throughout because it clarifies the sociopolitical context of hunting and travelling on the Barrens in towns which are particularly suitable to this present analysis.

The Naskapi occupy an area of 15,000 square miles in central northern Labrador (Fig.4). In 1968 the Naskapi population of that area totalled 145 individuals organised into 33 households, each of which consisted of a man, his wife, their children and a small number of dependant relatives. These families are the fundamental unit of Naskapi social organisation. Thirty-one of the families present during Hendriksen’s fieldwork spent at least some part of the winter inland hunting caribou on the Barren’s. While there they lived in camps consisting of 2-15 families. These camps may last from 1-2 months. Division of labour within the families is according to sex but it can be reversed and often is *ad hoc* and when the need arises. There is very little craft specialisation and no division by rank. The families are the basic units of production and consumption. Each is led by an active hunter who is entitled to use any part of Naskapi territory. However, solitary hunting is most uncommon. Instead the men hunt in groups which are led. On this subject,

The Naskapi say that they must always have *wotshimao* [first man or leader]. If they do not have one, they cannot jointly leave or move camp for any serious undertaking [Hendriksen 1973:45 (parentheses mine)].
Leadership roles are not inherited. They are the object of continuous competition between the men. The choice of leader is made after a lot of informal deliberation and gossip. Those chosen are able to travel efficiently on the Barrens and to lead others to success in the hunt. Leadership positions are never held for long because they are task and performance specific and are closely scrutinised by all.

Social organisation on the Barrens is amorphous, as individual households constantly join groups with changing memberships. There is no authority structure outside of the nuclear family and there is strong emphasis on common sharing, in which an individual with goods is obliged to share them equally with any other individual. The receiver is not obligated in any way except to give equally to the original giver, just as he is obliged to share with everyone else.

There is no social centre or quasi market-place in Naskapi society where goods converge and are then redistributed. There are no kin-based or other corporate groups, although there is some tendency towards matrilocality, evident in resident patterns at Davis Inlet during the summer months.

The Naskapi return to the coast in March and hunt seals on the land pasture. They also hunt caribou, black bear, geese, ptarmigan and several marine birds and waterfowl. They have some cash income from the sale of trout and salmon but the main source is the monthly welfare cheques sent to the woman of each family by the Canadian Government. Life in Davis Inlet involves heavy drinking and domestic violence. Hendriksen (1973) argues that this is due to the conflicts which arise between the traditional Naskapi values of the Barrens and those which apply on the 'edge of the white man's world'.

Naskapi material culture at the time of Hendriksen's study was simple and undecorated. The tents and houses occupied by the Naskapi were uniform. The clothes worn distinguished male from female but there were very few distinctions beyond that level. There was almost no personal decoration. The tools transported into the Barrens were few in number, simple in design and undecorated. Naskapi material culture of Hendriksen's experience was characterised by the use of a limited number of relatively simple but highly versatile multi-purpose tools. Jordon (pers. comm. 1982) sees this as the result of a normalisation of Naskapi technology which followed from the introduction of European mass-produced and undecorated clothes, tents and other equipment. He notes that while traces of strongly decorated Naskapi material culture, such as red ochre painting of clothes and elaborate bead working are recorded in the historic descriptions of the Naskapi, these faded out as Europeanisation of the technology proceeded. This opinion overlooks the distinction between received and applied decoration. Granted that the goods received were not decorated, decoration could still have been applied but it was not. This suggests that they felt the need to decorate items of material culture, which we know from Speck (1935) to have been present at least until the first decade of this century, was not effective much after that date. Interestingly, this demise of indigenous Naskapi decoration occurred during the period of a substantial reduction in the size and reliability of the central Labrador caribou herd. It was to a degree, a controllable resource and changes in that condition can be suggested here, albeit tentatively, as a factor relevant to the changes in Naskapi material culture (see Spiess 1979 for information on caribou ecology).

INTERPRETATION

The structural differences between Naskapi and Strait Salish outlined above are seen here as the consequence of different modes of intensification of subsistence activity. It is proposed that there is a common, if not universal, tendency for subsistence activities to be intensified within small societies. This process may or may not be discernible archaeologically; it is nevertheless fundamentally important. This tendency towards intensification applies to hunter-gatherer groups as well as to cultivators. At the elementary level this tendency is made up of the sum of individual and specific changes in the way things are done in behavioural terms and the technological means by which actions are completed. These changes therefore can be either behavioural or technological or both. They are here termed devices for the favourable adjustment of the labour:product ratio or intensifying devices.

An analogy is drawn between the ongoing and spontaneous generation of these intensifying devices and the notion of linguistic creativity as used by Noam Chomsky and others. In Chomsky's view (1965) a natural language is an infinite, or at least indefinitely
large set of sentences. Sentences which have not been spoken previously are created from within the set of possibilities all the time. This creativity is either rule-governed or rule-breaking. The former does not modify the form of the language but adds 'new' grammatical sentences (Chomsky 1966:29). While rule-breaking language creativity breaks or bends rules of language in order to achieve special effects such as puns, metaphors etc. (for a discussion of this and other aspects of linguistic creativity see Pawley 1985). This kind of innovation may lead to modification of the grammatical structure of the language.

Only a small proportion of linguistic innovations remain in use to become part of a natural language in everyday use. In Chomsky's strict sense (1957), non-grammatical sentences are not included in the language but the laws of grammaticality can and do change over time, through the operation of rule-breaking linguistic innovation. Other linguists agree that while language creativity will result in a great many small and spontaneous adjustments of the spoken language, few of these will persist. They are arguing then that some kind of filter or selective process operates between linguistic creativity and everyday use in natural languages. Unlike Chomsky (1957), Grace (1981, 1984) and Pawley (Pawley and Hodgetts Syder 1983; Pawley 1985:68-88) contend that 'nativelike fluency' involves much more than the speaker-hearer's competent use of a generative grammar. Whether or not linguistic innovations are retained depends, in a view evidently shared by Grace (1984) and Pawley (1985), on the idiomaticity of a language use; that is 'the degree to which it is a familiar, nativelike way (...) of saying things to the native speaker' (Pawley 1985; Grace 1984:131 ff); Pawley (1985:87) in fact lists no fewer than 11 attributes of language use which 'a proper speaker should show nativelike standards in respect of ...'. Grammatically is just one of these and, although the first listed, it is not necessarily the first in order of importance. The need to match the 11 attributes listed, taken either individually or in any combination, comprises the filter mentioned above.

The view shared by each of the linguists mentioned here is that language usage is continually and spontaneously creative and that complex formulae or processes of selection; either Chomsky's generative grammars or Pawley's 11 attributes, effect what 'new' usages are lost, retained or rapidly incorporated into everyday speech and elaborated.

By analogy, changes in economic usage; that is, the day-to-day conduct of subsistence economics, occur continually and spontaneously as people seek to lighten their daily burdens by doing necessary tasks or achieving required objectives more simply, easily or safely. In small-scale societies these changes or intensifying devices occur initially at the level of individual practitioner. Many such changes are created. Some are trivial and as such have no nett effect on the degree of economic intensification in operation. These changes are the equivalent of rule-governed linguistic innovations which form 'new' combinations of linguistic elements but do not change language structure. In the terms of our analogy there are many possible 'new' combinations of behavioural and/or technological elements involved in subsistence economics which will have no impact on sociocultural structures.

Changes of economic usage which do have potential to cause structural change are analogous to rule-breaking linguistic innovations. They can be divided into two groups on the basis of their acceptability and consequences. First to be considered here are the innovations which, although potentially powerful, are unacceptable and cannot be implemented by individuals wishing to retain ethnic group membership.

The operation of such rules of exclusion are very common. One sees for instance in the contemporary ethnographic literature a lot of societies, like the Naskapi, living in effect 'on the edge' of urban and commercial centres. In these groups ethnicity is maintained by the rejection or avoidance of influences of the centres, albeit most strongly by a core group of individuals.

Similarly, in stratified and segmented societies these internal divisions are maintained and expressed through the use of rules of property (Godelier 1978). These rules affect the generation and redistribution of property. They imply control and limitation of access. Breaking these rules involves risk of sanction, even rejection, by other members of society.

The second group of changes in economic usage which can cause structural changes are made within the boundaries of acceptable intra-group behaviour. In terms of our linguistic analogy these conform with the rules of grammaticality. The acceptance and development of these intensifying devices bring about 'a greater concentration of production' (Brookfield 1972:31). In any habitable environment there are many ways of doing this. Some of the
most salient of the methods used by food producers have been widely discussed. These include the domestication of plants and animals, crop and livestock improvement, irrigation, some uses of storage and the use of commercial or tax systems which stimulate production.

The methods of intensification available to hunters and gatherers have received much less attention, although some ethnographic descriptions contain rich and detailed documentation of intensifying devices used by such societies, (e.g. Meehan 1982; Binford 1978). Many of the more subtle intensifying devices will leave no visible trace in the archaeological record. In fact, it can be argued that only a very small proportion of effective intensifying devices are recognised by archaeologists and that most of these are end-point; that is, elaborated or derived forms of initial intensifications, for example, the discussion by Lourandos (1985) of intensification and Australian prehistory. The apparent invisibility of initial change is not to be taken as evidence of their unimportance. Indeed it is important to be aware of these, at least as possibilities, and to develop middle-range theory (Binford 1981) through which they can be inferred and positively involved in archaeological interpretation.

The intensifying devices, which were or are still used by hunter-gatherers and recognised by archaeologists, include resource control (a condition which is implicit in all trade and most cultivation through either food production or storage), identification of optimum resources and selective predation (Higgs and Jarman 1972), modification of the physical environment in ways which concentrate potential resources (Jones 1975), changing procurement technology to increase yields (see Lazenby and McCormack 1985 for a review of the development of salmon capture and storage technologies on the northwest coast over 8000 years), and redeployment of the labour force either in terms of its spatial and seasonal distribution or its internal organisation (Johnson 1978; Mellars 1985).

The degree to which any one of these devices will concentrate production depends on a range of factors, including the environmental context in which it is applied. For instance, in highly diversified complex and stable ecosystems, control of one resource from amongst a number which are similar in their essential characteristics, will be of limited value. Whereas in specialised ecosystems with few accessible and high yield resources, control will be very effective. In these contexts resource control considered generically as a range of measures, is potentially the most effective of the intensifying devices. It involves control of the supply to others of a major resource by a specific and small sociopolitical group. This device is characteristic of modern and ancient state societies. It is also fundamental to the development of the state where coercive ‘rules of property’ and conduct vest control of resource production and redistribution in a rule-making elite.

In medium-high latitude hunter-gatherer contexts, the potential for resource control depends on the spatial and seasonal concentration and quantity of naturally occurring resources (see Schalk 1982; Ames 1981, 1985).

The general statement of this proposition is as follows:

When a resource is available only at widely separated locations and for short periods of the year control of supply to others is possible. The more reliable and concentrated such seasonal occurrence is the more suitable the resource will be for control [Sutton 1982:84-85].

Major controllable resources are those which contribute an exceptionally high proportion of the accessible resource base. Control of a major resource was possible in the Strait Salish situation. A substantial number of the 40 or more Salish resources described by Suttles (1974) occurred only in small, discrete areas and several of those could be taken only during short seasons. This potential for resource control was realised for the most productive of the controllable resources in two ways. These were the private, as opposed to corporate, ownership of strategic resource zones and the ownership of ‘essential’ procurement technology.

This ownership facilitated socially sanctioned and coercive control, the owners who controlled resource supply through either one or both of those means had access to much larger amounts of food than others. This was because, although in principle food belonged to those who procured it, as with the reef-netting example given above, the owners were allotted much more than the labourers.

The owner’s surplus food could be converted into wealth; that is, status goods or ‘those articles which could be used as potlatch goods, articles which were acceptable in the payment of debts’ (Suttles 1974:381). These can be divided into three categories:
1. those produced locally with a lot of unskilled or semi-skilled labour input;
2. those produced locally but by skilled craft specialists such as weavers and seamstresses. These could also involve high labour input; and
3. imported goods usually made from very uncommon materials.

Those who controlled strategic resource zones had surplus food with which they could purchase the labour necessary to the production of Categories 1 and 2 above. Further they could initiate potlatches which were the principal means of intercommunity trade and exchange and therefore control the redistribution of incoming foreign goods. They could also trade outside the potlatch system, particularly for the very uncommon materials used in the manufacture of status goods.

The possession of items of wealth enabled owners to increase and preserve their social status. In Strait Salish society status changes were marked by feasting. Feasts were held when an infant was introduced to his or her family, to mark a girl's pubescence, at weddings, funerals and public gatherings where inherited names were bestowed. The use of these names validated (Rappaport 1977) private ownership of resource zones, procurement technology and other privileges.

In the case of a feast held to mark a girl's pubescence the father would invite as many important people as he could afford in order to assure that an alliance with an upper class family would be formed through the marriage of his daughter. At the feast everyone would be fed and the more important guests would be presented with items of wealth. This distribution of gifts established strong and reciprocal bonds between host and guest. This reciprocity could be used to increase the status of either party, depending on the value of the gifts and who gave them to whom (see Codère 1950 on host-guest relationships in Kwakiutl potlatching).

Those who did not have access to large quantities of surplus had greatly reduced access to wealth. Therefore they could potlatch very infrequently and then only in cooperation with several others. Owners, by comparison, potlatched more frequently, in greater volume and depended on their kinsmen less acutely. The feasting initiated by non-owners was limited in terms of the number and prestige of the guests present and consequently restricted in its political value.

The relationship between primary production and status for those who controlled resources in the Strait Salish society reconstructed by Suttles (1974) is shown in Figure 5. The term primary production is used here to refer to resources which are primary or major in importance relative to other accessible resources. Primary also indicates mass capture of a natural resource. The control of a reef-netting location normally would leave the owner

\[ \text{Surplus food} \rightarrow \text{Control of primary production} \rightarrow \text{Inheritance of privileges} \rightarrow \text{Wealth} \rightarrow \text{Feasting and potlatching} \rightarrow \text{Status} \rightarrow \text{Control of labour} \]

Figure 5 Production and status in Strait Salish society
with surplus food with which skilled or unskilled labour can be 'bought' and controlled for use in the production of status goods; that is, wealth. Status is accrued through the political practices involved in feasting and potlatch. This status is validated, or even sanctified, through the institutions of marriage, naming and warfare, although the role of the last is not clear in the Strait Salish case. Control of primary production, finally, was ratified through ceremonially endorsed inheritance of privileges, in which names were bestowed at potlatches to which guests were invited and at which they were bound to accept the rules of property ownership which following from the naming they were 'made prisoners through gifting' (Codère 1950).

Escalation is inherent in this system. The driving force behind the escalation is the competition for relatively high and, ultimately, highest possible status positions. The level of status an owner commanded was dependent upon the quantity of primary production which occurred under his control. Because there is no limit to the degree to which status can be elevated there would be continuous and ever-increasing pressure on owners and those who depended upon them to concentrate production. The apparently rapid pre-contact development of salmon mass capture technology in the lower Fraser region and its environs (see Lazenby and McCormack 1985) may reflect this process of politically-based intensification. Due recognition of political competition as a cause of intensification is now widespread. For instance, Earle (1978), Kirch (1984) and Schilt (1984) accept the importance of this process to the origin and operation of the Hawaiian chiefdoms. Mellars (1985:289) discusses 'purely internal social mechanisms as a potential source of change' in his recent discussion of social complexity in upper Palaeolithic southwest France, following Bender's (1978, 1981) work and Lourandos' (1980, 1985) discussion of this concept in the Australian context.

Here it is suggested that the origin of the Strait Salish system is implied in the way in which it operated. The direction of escalation in Strait Salish society indicates the course of development of the basis of that system. A statement of origin and a model of development can be proposed on that basis. Notwithstanding Rubel and Rosman's (1983) suggestions that northwest coast ranked societies are developments from a prototype similar in key respects to contemporary Athapaskan society, the origin of Strait Salish society in recognisable form is likely to lie in the beginnings of exploitable salmon runs in the northwest coast rivers, dated by indirect means to within the last 6000 years (Fladmark 1983; Matson 1976).

The runs would then become foci of the seasonal rounds in a previously diversified subsistence economy based on both marine and terrestrial resources which were accessible at lower levels of density than occurred in the salmon runs. Run salmon exploitation, like other subsistence tasks in the hypothetical proto-Strait Salish economy, would be undertaken by small kin-based familial groups where leadership roles and authority were bestowed according to seniority by age, gender and descent.

At some point in the past, and possibly not long ago, this kin-based economy changed towards an emphasis on non-kin political allegiances in which family heads sought to optimise their status and privileges by working for, and potlatching with, the most successful of the owners, rather than the owners to whom they were most closely related by kin. Although individuals for whom one worked could be both these things at once they need not be kin.

What is suggested here is that the potential for and of resource control on the Strait of Juan de Fuca - Georgia Strait region after 5000 BP led to specialisation within an initially generalised subsistence economy and that escalation of the intensity of competition for status led to the spread of control over all major exploitable resources.

The escalation inherent in the Strait Salish system (Fig.5:ff) led to increases in the scale of salmon mass capture technology and control of other resources, both marine and terrestrial, to the point at which Suttles (1974) is describing a situation in which all resources with potential to cause change in sociopolitical structures or bestow power upon those who controlled them were owned and regarded as 'privileges'.

Just over 40 exploited resources are listed by Suttles (1974). These can be ranked in a relative order for each of the following three parameters; extent of spatial and seasonality (where the most restricted distribution is given the highest score), predictability of occurrence, and potential food yield. The six resources which were subject to private ownership and which were the foci of Strait Salish subsistence have the highest total rankings. These are in ascending order by ranking: camas collection, shellfishing, mass
The cycle of escalation shown in Figure 5 had another important consequence apart from increasing production and productivity. It also acted to produce increased and increasingly permanent non-kin or only partially kin-based differentiation between individuals and classes of individuals. This permanent differentiation would be accompanied by the use of symbols or 'insignia of rank' (Earle 1978). These items of decoration of clothing, personal effects, housing et alia are a regular accompaniment of stratified and state level societies.

The suggestion is made here that at some time within the last 5000 years of the northwest coast sequence, individuals from within and between specific regional or linguistic groups became distinguishable on the basis of the items of material culture which they wore and in other ways used. Simply, those in positions of resource control possessed, by inheritance and control of labour, more status goods including 'insignia of rank' than those who did not 'inherit privileges'. Such insignia would also have been used to separate individuals belonging to different groups. The most conspicuous of these symbols of allegiance were the carved totemic figures (see Oberg 1973:45 on the social function of primary emblems).

In summary, the contention here is that increased differentiation of both the utilitarian and decorative aspects of material culture occur as corollaries of competition where there is a systematic and sustained relationship between the distribution of items of wealth and social status. Such a relationship is only possible where resources with outstanding potential yield can be controlled. The sociocultural consequences of resource control are represented in Figure 6.

![Figure 6](image_url)

**Figure 6**  The consequences of resource control

Whereas Figure 5 deals only with individuals or small groups who are in positions of ownership or resource control, Figure 6 deals with all individuals in a social group. The starting point in fact and in effect is at differential access to primary production. The development of this differential was discussed above. It leads to and is the causal basis of Strait Salish social stratification. The development of social strata within groups and boundaries between stratified groups leads to differentiation of material culture due to two causes. First, because those with privileges used decorative items as 'insignia of rank' and allegiance. Second, because of the need to increase production in order to compete successfully in the escalating relationships between production and status. This need is met through the development of procurement technology which will maximise yields.

The vectorial or causal relationships expressed in Figures 5 and 6 are supported in the converse by the Naskapi case. The caribou, upon which the Naskapi base their winter subsistence, are highly mobile and unpredictable. After two seasons on the Barrens with
the hunters, Hendriksen (1973:8) wrote of the 'near impossibility of predicting the time and place of [caribou] occurrence'. Therefore subsistence activity does not produce long-term or reliable differences in the access individuals or groups have to primary production. Wealth, whether as status goods or in any other form, cannot be accumulated. The common sharing principle is a necessary part of life on the Barrens because of the risks which follow from the unpredictability of the caribou. Common sharing provides insurance against illness or other short-term disability and therefore means that almost everyone is fit to travel and hunt at any time. It also facilitates mobility, and therefore information gathering, because travellers know that those in the camps will offer them food.

In Naskapi society of Hendriksen's experience (1973), leadership roles are temporary and corporate groups cannot be maintained. There is therefore very little demand for insignia of individual rank or group allegiance. For this reason decoration and decorative items are most uncommon. Essentially then the unpredictability of the caribou prohibits the use of resource control which is identified here as the most potent method of intensification. The caribou became the basis of Naskapi economy in prehistoric times (see Fitzhugh 1972 for a discussion of the subsistence-settlement systems of Point Revenge and related complexes when caribou comprised the largest, most aggregated and reliable resource on the Barrens). In fact, caribou may still occupy this position but at least since the failure of the Indian House Lake herd about 1916 (Strong 1930) the strength of the resource has declined to the point at which it is now no longer controllable. However, as argued above, Naskapi sociocultural structure and material culture would have been more complex before the turn of the century than they have become since. This greater complexity would have involved larger camps on the Barrens, more fixed leadership roles, a greater range of decorative items, and possibly more tool types. The consequences of the absence of resource control are expressed for the general case in Figure 7.

Figure 7 The consequences of the absence of potential for resource control

The point of commencement is found in the resource ecology which allows no permanent differentials to be established in access to primary production for Naskapi individuals or groups. This leads to unstratified sociopolitical organisation and through an emphasis on common identity and sharing there is little tendency towards the formation of corporate groups. There is in this situation of commonality no need for insignia of rank and, as a consequence, material culture is relatively undifferentiated. The absence of individual or corporate fixed leadership and the emphasis on shared identity and commonality leads to a situation in which technological experimentation leading to indigenous development of new intensifying devices occurs slowly rather than quickly. It is closely limited by the constraints of group membership. In this situation, culture change
measured archaeologically would occur at a relatively low rate by comparison with the Strait Salish situation.

CONCLUSION

The Naskapi and Strait Salish may be regarded as two different outcomes of a single chain of causality in which people-resource relationships influence and may even effect sociopolitical organisation, which in turn prefigures the degree of differentiation present in material culture. In the view offered here the potential for resource control is of fundamental importance. If it is present as in the Strait Salish case, a systematic relationship can be developed between production and status. This can be achieved through the use of a range of intensifying devices. Social stratification may then develop through time and both decorative and utilitarian aspects of material culture will become more complex.

If the potential for resource control is absent, as in the case with the Naskapi of Davis Inlet (Hendriksen 1973), social stratification will not develop and concomitantly material culture will become or remain less complex through time.

This thesis, if accepted, has several consequences. First, concerning language diversity and rates of change it is noted that the Naskapi belongs within a very extensive, old and relatively slow-changing language group (Goddard 1979; Scherzer 1976) whereas the Salish languages are much more diversified (in the sense of Pawley 1981:271), reflecting amongst other things higher rates of language change and segmentation of previously common proto-languages into contiguous but discrete descendant languages. Explanations of language change tend to depend upon migration, contact borrowings, culture contact, linguistic borrowings and descent from a common base language.

However, at least in the case of Melanesian-Polynesian historical linguistics it is maintained that:

... socio-economic changes played a part. Kin and marriage ties weakened between widely separated sister communities and diminution of the social as well as the economic importance of trade exchanges with remote sister communities led in turn to an impairment of the traditional skills of canoe-building and sailing, even in coastal communities. In many regions other cultural losses [or substitutions] went along with these changes - whether as cause or effect cannot be discovered: loss of pottery-making tradition, loss of hereditary chieftainship and the concomitant system of hierarchically ranked kin and lineages that placed the highest-ranking chief as the head of a group of dispersed descent groups [Pawley 1981:296].

Due point made here is that a vectorial and causal chain of events can be seen to underlie linguistic heterogeneity in the Salish region and the language homogeneity of the Naskapi case. Rather than concurring with the view expressed above that 'whether as cause or affect cannot be discovered' this paper contends that modelling modes of intensification and their consequences may help to explain processes of language change in Oceania and elsewhere. In brief, rates and degree of language diversification will be higher in regions with realised potential for resource control than elsewhere.

On another point there is now very considerable need for a middle-range theory of intensification and its consequences which can be applied in the archaeological study of hunter-gatherers. The emphasis in such theory must be on continuous change at the level of individual or collective adjustments of the labour:product ratio, because this is believed to be the initialising step from which change begins. The use of homoeostasis by Clark (1972) is one of the many instances in which far too much credence has been given to the possibility of little change through time in hunter-gatherer societies, as a general category. Equilibrium is assumed to be the normal condition. The argument is made here that ongoing change and not stasis is a fundamental attribute of human societies. Many of the trend-setting changes in people-resource relationships are very difficult to observe archaeologically. However, this unfortunate condition does not justify the assumption of equilibrium.

Further to this point, the present paper is, in part, an attempt to clarify the future which operates so as to select some new intensifying devices and reject others. Those selected become rule-breaking, in the terms of this argument, and effect change in sociopolitical structures. The devices which are rejected, on the other hand, will remain trivial or be peripheralised.
The nature of this filter is crucial. Three points are made about it here: first, it is not environmentally-determined; second, it is not unicausal; and third, it is non-evolutionary. For the first of these it is now clear that intensifying devices occur, and can be rule-breaking in all habitable environments. Therefore their occurrence is not tied to single environmental factors or specific kinds of environments. As for causality, the argument made above assumes complex not unifactorial, causality. The creation of new intensifying devices is said here to be intrinsic, a very ancient attribute to members of our species. The acceptance or rejection of these devices takes place in the sociocultural realm of ethnicity and 'rules of property' (Godelier 1978). If a device contravenes elements of group identity or the internal operation of that group, it is unlikely to be widely adopted. Escalation, identified here, is a major factor leading to the development of new technology in particular which occurs within and through political competitiveness whether inter-personal or inter-group. Explicit non-kin based political activity may only develop where there is sustainable potential for resource control and the structural and vitally differential access to primary production which is then possible. Finally, the explanation of sociocultural change proposed here is non-evolutionary. The traditional archaeological practice of expressing evidence of cultural change, as if the grand explanation lay in biological theory, ought to be discontinued. Notably, the nomenclature of biological evolution can be done without. This allows one to proceed unencumbered by the strain of having to describe a sociocultural phenomenon in biological terms - effectively, as if biological and culture change were indivisible. However, certain parts of the process of sociocultural change are quintessentially about culture and society and not at all about biology. Ethnicity, rules of property and political imperatives can be understood culturally. They cannot on the other hand, be satisfactorily explained using the central concept of biological evolution. They are, however, the key cultural concepts in the explanation of change offered in this paper. Notably, that explanation is based on analyses of a cultural process; everyday language acquisition and use. It is not based on a biological model.

After all, as Sahlins (1976:xi) has written, 'biology is absolutely necessary for life and equally absolutely insufficient to explain it'.

REFERENCES

Bender, B. 1978 Gatherer-hunter to farmer: a social perspective. World Archaeology 110:204-22
Chomsky, N. 1965 Aspects of the Theory of Syntax. Massachusetts Institute of Technology: Cambridge, Massachusetts


Godelier, M. 1978 *Territory and property in primitive society*. *Social Science Information* 17(3):399-426


Grace, G.W. 1984 *The linguistic construction of reality*. Linguistics Department, University of Hawaii: Honolulu, Hawaii (typescript 235 pp)


Kew, M. 1976 *Salmon abundance, technology and human population density on the Fraser River watershed*. Department of Anthropology and Sociology, University of British Columbia: Vancouver, Canada (unpublished manuscript dated 23.4.76)


Kroober, A.L. 1939 *Cultural and Natural Areas of Native North America*. University of California Press: Berkeley, California


Meehan, B. 1982 *Shell Bed to Shell Midden*. Australian Institute of Aboriginal Studies: Canberra


Strong, W.D. 1930 A stone culture from northern Labrador and its relation to the Eskimo-like cultures of the northeast. American Anthropologist 32 (n.s.):126-44


Sutton, D.G. 1982 Towards the recognition of convergent cultural adaptation in the subantarctic zone. Current Anthropology 23(1):77-87


THE ABORIGINAL HUNTER IN AN UNSTABLE ECOSYSTEM: A VIEW FROM SUBARCTIC PACIFIC

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The main theme running through the whole line of recent investigations in subarctic ecology is the idea of extreme ecosystems' fragility and instability which are now postulated as main features of subarctic environment. All arctic and subarctic (tundra and forest) tundra biomes share a number of common characteristics: general climatic extremity, complex ecological cyclicity and periodic fluctuations in the numbers of animal populations (cf. Banfield 1975; Dunbar 1973). This causes permanent oscillations in the availability of game which varies from brief periods of abundance to real 'life crises' and scarcity of all subsistence resources, following each other successively (Vibe 1967). Such instability is attributed mostly to inland subarctic ecosystems; but sometimes it is likely to be a markable determinant for the coastal marine biomes influenced by annual migrations of sea mammal stocks, Pacific salmon species and colonial sea-birds.

There is no question that such an ecological background formed highly specific environments for early and traditional human populations - hunters and fishermen of the tundra zone in Eurasia and North America. One cannot fix any 'mean' level of game availability on to unstable subarctic ecosystems, as any 'mean' situation was, in these regions, only a short transitional phase from 'good' to 'bad' life conditions, and vice versa. The history of subarctic aboriginal hunters - known through narratives and archival sources from the 17-18th centuries and archaeologically during the last few millennia - arises before surprised historians as an unbroken testimony of ecological crises, reductions in areas and numbers of game stocks, mass human starvations and dispersions. Every individual human life here was not more than a routine succession of scarcity and prosperity; and each inhabitant of the subarctic, upon reaching old age, had to pass inevitably through the whole set of biological catastrophes in the course of regular five, 10-12 and 20-25-year game cycles. But more profound ecological changes forced by broader environmental fluctuations were moreover beyond the individual human memory. They caused, however, even more radical, epochal variations in human resource base, reducing numbers and areas of some game species and favouring life conditions for the others.

Due to these general peculiarities of the environment, special ecological strategies were necessary for permanent and successful occupation by the traditional hunter of all the subarctic biomes: from inland tundra plains to icy sea coasts and ocean archipelagos. Some of these strategies, seen as social or cultural adaptations, have been so widely cited in the literature that they now exist more as scientific stereotypes. The latter include: (a) maintaining of 'optimal population density' far below the average ecosystems' carrying capacity through developed methods of artificial population control (Carr-Saunders 1922; Weyer 1932); (b) general slowing in the process of human cultural evolution which contributes to the conservation of most archaic types of technological, economic and social organisation; (c) forming of specific types of ecological behaviour and ethics of the northern hunter, who demonstrates his highly rational strategy of resource utilisation and strict tendency to maintain an 'equilibrium' in local ecosystems. The widely cited examples of exotic infanticide and senilicide practices among Eskimos and some other Arctic groups, followed by exceptional thrift of all the northern hunters for food products they produced, or their evaluated hunting ceremonialism and ritual care for animals killed and game-host spirits etc., are generally used as the main arguments for such a view on aboriginal hunter's behaviour in subarctic ecosystems (see Birdsell 1968; Birket-Smith 1929, 1959; Bogoras 1904; Jochelson 1898; Popov 1948; Weyer 1932; Zolotaryov and Levin 1940).

This stereotypic, 'textbook' view on a traditional subarctic hunter has been widely criticised, however, in the recent anthropological literature (cf. Yesner 1980:727). Modern studies, based on far more sophisticated methods of data collection and analysis, present other forms of cultural and/or ecological adaptations to unstable subarctic environment.
One can list here: (a) maximal flexibility and complexity ('omnivorous character') in the utilisation of all the available resources (Laughlin 1963; Taylor 1966); (b) minimisation of time and labour expenditures through optimal procurement strategies (Foote 1970; Binford 1980; Sharp 1977); (c) developed storage techniques (Testart 1982); (d) 'increased tension' of economic and demographic activity, aggressiveness of ecological ethics and permanent attitudes of human collectives to expansion and enlarged reproduction (Krupnik 1976, 1984) and a few others (cf. Fitzhugh 1975; Nelson 1980; Yesner 1980). Latest archaeological investigations discovered remnants of developed forms of social life which had formerly flourished in the subarctic in some mostly productive niches on the sea coast. These enclaves of social activity were attributed to large aggregations of sedental subarctic maritime hunters with their social and labour stratification, evaluated ceremonial life and practice of ritual construction (Arutyunov et al. 1981, 1982; Chlenov and Krupnik 1984). Until recently all these social traits are seen as a prerogative of traditional agricultural societies in higher latitudes, or of aboriginal fishermen and hunters exploiting most productive ecological niches along the northwest coast of temperate North America and Aleutian chain.

Anthropological studies on the adaptive process of the aboriginal hunter to his hard subarctic environment are usually done, however, with prime interest given to two main subsistence strategies or ecological models. The first model - coastal sedentary - was based on the extensive exploitation of relatively small and specially selected hunting grounds with simultaneous concentration on many available subsistence resources. The optimal ecotopes for this model were the richest niches along the mainland sea coasts and on the subarctic archipelagoes (with exploitation of migratory large sea mammals’ stocks, local pagophytic pinnipeds, sea-bird colonies) or in the estuaries and lower reaches of subarctic rivers, where these resources were supplemented by migratory populations of Pacific salmon and other fish species, and seasonal concentrations of caribou/wild reindeer herds crossing large water flows on their regular migrating routes. This type of complex hunting and fishing economy was the base of subsistence for all the seashore hunters in the northern Pacific - Eskimos, Kereks, Maritime Chukchis and Koryaks in the subarctic; and more or less also for Aleuts, Nivkhs, Ainu and Indians of the American northwest coast on the northern extremities of the temperate zone.

Another adaptive model - inland nomadic - was oriented just to the opposite procurement strategy. Its main task was to minimise the human population press on the exploited resources of the unstable subarctic environment through regular annual interchange of vast seasonal hunting grounds (or later - reindeer pastures in subarctic Eurasia). The territory used by nomadic collective thus tended to incorporate not only the most productive ecological niches in the rivers’ or lakes’ valleys with their abundant fish, fowl and terrestrial fauna resources, but even the vast watershed uplands (which were widely used as short-term hunting grounds or pastures) and even some parts of the sea coasts. The 'sine qua non' for survival of such an adaptive model was its tendency to enlarge the hunting territory of every group and to lower its population density which, in reality, fluctuated highly throughout the annual cycle. Inland Eskimos and Athapaskans in Alaska, Yukaghirs - fishermen and caribou hunters in northeast Siberia and nomadic Chukchis and Koryaks (successful reindeer-breeders from the 17-18th centuries) were the main representatives of this strategy in the Pacific subarctic.

One may certainly treat both of the adaptive models described above as ‘ideal’ ecological constructions. In ethnographic reality they were represented by a vague continuum of tens of concrete historical variants, transitional or intermediate forms. But these main models of the aboriginal subarctic economy were characterised - which is far more important - by different modes of reaction to the same environmental changes. Historical data from subarctic Eurasia systematised elsewhere (Krupnik 1976, 1989) - narrative and archaeological sources, archival materials, local oral traditions etc. - show that warming climate phases in the subarctic tended to be generally more favourable for the seashore sedentary population exploiting coastal and marine ecosystems. Following the start of the warming phase the usual routes of all migratory sea mammals and fish (mainly salmon) stocks began to move northward (Vibe 1967; McGhee 1969-70). The most productive boat-hunting season was lengthened and the weather conditions generally ameliorated with the simultaneous shortening of the most severe winter time due to earlier start of ice-lead spring hunting.
The same warming phases in the subarctic were on the contrary far less favourable to the inland nomadic population, oriented primarily to caribou hunting or tundra reindeer-breeding in Eurasia. Oral tradition and accumulated experience of native reindeer-breeders, both with recent biological literature blame the reindeer/caribou of tundra ecotopes (*Rangifer tarandus* spp.) for his low adaptability to heating stress and the slightest rise in the summer temperatures. Even a few years with warmer summer months and winter thaws may force a catastrophic reduction in domestic reindeer and caribou herds due to animal weakening, epizootics, lowering of reproductive rates, pasture degradation and fires (see Krupnik 1976, 1989).

The cooling climate phases in the subarctic were followed on the opposite by sharp increases in caribou and domestic reindeer herds and amelioration of inland tundra nomads' subsistence base. Generally they brought a simultaneous deterioration in ice and weather conditions on the sea coasts and narrowing of the coastal-marine subsistence base, which was usually followed by starvation and cultural decline to the permanent seashore settlements of sedental maritime hunters. In this context every environmental change in subarctic ecosystems was inevitably unfavourable to one of the main aboriginal subsistence strategies, but simultaneously enlarged productivity and resource base for the other. This situation gave aboriginal hunting populations in the subarctic their chance to transfer from the old to the new and then more productive procurement strategy. General complexity and flexibility in a resource utilisation system favoured such a reorientation and made the necessary break in traditional year cycle and activity distribution less harmful.

Thus, the process of historical evolution of aboriginal subarctic economies may be present as a constant population flux from inland to seashore adaptive models (i.e. from nomad hunting and reindeer-breeding to sedentary maritime subsistence) and back again due to the current line of environmental trends. We can easily find a number of such population shifts in the recent history of Eurasian and north American subarctic aborigines. The following examples seem to be mostly cited in the literature: (a) mass flux of the reindeer Chukchis losing their herds to semi-sedentary maritime hunting and fishing in Chukotka in the late 19th to the early 20th century (Buturlin 1907; Leontyev 1973); (b) the same exodus of northwestern Alaskan inland Eskimos to the seashore in the late 19th century and their amalgamation with coastal dwellers (Burch 1972, 1976; Amsden 1979); (c) the opposite mass movement of Chukotka coastal inhabitants to an inland tundra lifestyle followed by their quick assimilation by reindeer breeders in the late 18-19th centuries (echoed in folklore, genealogies and local oral tradition); (d) transfer of some Canadian Thule Eskimo groups from coastal subsistence to highly specialised nomad inland caribou hunting in the 16-17th centuries (for Caribou Eskimo origin, see Burch 1978); (e) analogous process on the opposite side of the subarctic on the coasts of the Barentz and Kara Seas (Krupnik 1981, 1989). It is highly doubtful whether a number of well-known examples of such a radical change in economic strategy could be so easily found in the history of native populations in the temperate or tropical zones, with the sole exception for semi-arid regions exhibiting the same ecological instability as in the subarctic ecosystems.

Through this permanent flux of subarctic aborigines from nomadic to sedentary subsistence strategies and back again, a specific adaptive model of dual, coupled economy had to develop. This highly efficient mechanism of a coupled ecological model permitted to subarctic aborigines to sustain every change in their hostile environment. Its sine qua non, however, was its permanent existence in both initial forms - even if one of these forms was then in a degrading, crisis-ridden or rudimental stage. This rudimental or degrading economy presented, however, the necessary refuge - technological, demographical and territorial nucleus for further development of its maternal ecological model when (and whether) the environmental trend reversed, following the curve of climatic fluctuations. In those areas where this adaptive principle is sustained - i.e. in the subarctic Pacific on both sides of the North Bering seashores - we can generally trace the unbroken line of cultural continuity and flourishing of both economies in the wide historical perspective. But if one from the dual strategies totally degraded due to most severe ecological or social conditions the above scenario was destroyed and the coupled model disappeared. Even a short time span was enough for a distinguishable gap in aboriginal cultural continuity and for a brief loss of many technological advances - specific hunting implements, procurement practices and subsistence experimentation.

An example for the latter provides the history of aboriginal maritime hunting culture in the western part of subarctic Eurasia. It is traced archaeologically from Neolithic up to
direct folklore and narrative evidence from the 16-17th centuries (Chernetsov 1935). But in the 17th to the early 18th century the maritime-oriented sedental strategy on the coasts of the Barents and Kara Seas became extinct due to environmental changes and extermination of local sea mammal stocks by European whalers and Russian Pomor walrus hunters (Krupnik 1981, 1989). Although in the late 19th to the early 20th centuries, or less than two hundred years later, the sea-oriented economy revitalised in the western Arctic among some coastal Nenet (Samoyed) groups on Yugor Peninsula, Novaya Zemlya and Kolguyev Islands, it was technologically far inferior to aboriginal maritime subsistence in the northern Pacific. Nenet procurement strategy was then primarily oriented to the commercial sale of skins, blubber and walrus tusks for European commodities and foodstuffs. With its rifles and wooden boats, Nenet hunting was far less efficient than Eskimo or Maritime Chukchi aboriginal subsistence. In less than 200 years a number of aboriginal technological advances were lost in the western Arctic: carcass skin boats, complex harpoon heads, pottering, collective whaling for large and white (belukha) whales from boats with lances and nets; semi-subterranean dwellings with log and/or whale rib carcasses (Krupnik 1976). All of these advances were formerly registered or reconstructed here by archaeological data, early narratives and folklore sources.

In this context one would hypothesise that the widely cited 'slowing' in the tempo of aboriginal social evolution in the hard subarctic environment was attributed mainly to this permanent population flux from one procurement strategy to another. One thing is certain: the 'waving' development model with phases of growth and decline following each other in succession was the common line of evolution for every human economy in any type of environment. But the rate and frequency of these historical undulations was deeply influenced by specificity of certain ecological or social conditions. Thus the difference in ecosystem stability in subarctic, temperate or tropical environments forms an uneven background for human cultural evolution.

From these considerations, the extreme instability of the subarctic environment - combined with the general climatic extremity and scarcity of resource base - appears as the specific obstacle to human evolution. Phases of crises and declines tended to be far more frequent and profound here, than in other parts of the aboriginal world more favourable to human subsistence. The usual 'undulation' of cultural development here are defined as alternations of periods of growth and deep crises, declines and further recoveries. We may present it graphically not as the usual 'historical sinusoid', but as a jagged, pulsing curve with its highs and lows smoothing the positive effect of cultural accumulation. In a broad historical perspective, such a type of historical evolution gives to a historian a false view of slowing and masks the actual rate of cultural and demographic changes.

One could hypothesise that in such a specific environment the increased variability and 'leaping' development tends to be a more successful adaptation than the tendency to maintain the ecosystems' equilibrium through the limitation of subsistence activity and human population growth. As postulated in the biological literature, those species able to sustain ecological calamities, and recover quickly with the succeeding ameliorations of life conditions, are better adapted to unstable subarctic environments. Thus the human group strategy in the subarctic was oriented to - as I have called elsewhere (Krupnik 1976, 1984) - 'increased tension' of demographic and economic development. It was actualised through a constant attitude to group expansion, broadening of exploited territory, active hunting pressure on the utilised resources and rather high level of fertility, which, combined with high and early human mortality, tend to accelerate the succession of generations. It was this very tendency to enlarged group reproduction, more visible in short favourable phases, which provided the aboriginal subarctic populations with their increased 'margin of safety', so necessary to survive times of scarcity, starvation and cultural regress and to recover quickly with the minor favourable changes in natural and social environment.

In recognising the active model of aboriginal hunter's behaviour in his unstable subarctic ecosystems one should not be surprised by examples of his active and sometimes even disastrous impact on the utilised biological resources. His subsistence base was seemingly in deep contrast to that of the northern temperate forest hunters (Tungus or Athapaskans) with their more even distribution of game catch along the year cycle; or that of the coastal fishermen and hunters in the temperate northern Pacific (northwest coast, Kamchatka, Sakhalin, Aleutians etc.), who exploited far more abundant and more stable salmon's and sea mammals' populations. Unlike the latter the subarctic hunter may rely only upon the shortest rushes of abundance of game in the whole annual cycle. These few days, even a
few hours of highly efficient catch had to provide him and his family with the bulk of food and raw materials for a fairly long period. The subarctic hunter was even more dependent on making surplus food storage (Testart 1982:527) in order to be prepared for any further eventuality, as he could never be sure of game availability and repeated success in the next hunting season.

Thus, a number of aboriginal hunting methods widely used throughout the whole subarctic zone in the catch of migratory sea mammals, caribou herds crossing the water-flows, moulting waterfowl etc. were oriented to the procurement of maximum game products available. Therefore the final amount of food obtained often exceeded the known yearly needs of the human group, or in any instance the possibilities for food transportation and conservation. Examples of a 'non-rational' waste of excessive game obtained are well-documented through aboriginal subarctic both in Eurasia (Jochelson 1898; Bogoras 1904; Portenko 1941) and North America. According to the author's estimates and field data, traditional Siberian Eskimo sea mammal hunters killed and accumulated in a 'good' year in the 1920-30s twice as much game as they usually consumed, although the amount of food necessary for group survival was well fixed in routine experience (Krupnik 1978, 1989). But this 'excessive' production in a time of plenty was regularly interchanged with periods of scarcity in the 'bad' years or during some parts of the year cycle.

Furthermore, a number of ancient procurement practices of subarctic aboriginal hunters increased objectively their predator press on the utilised resources compared to their low numbers and population densities. The latter includes: orientation to the easiest and most accessible prey; slaughter of the whole herd or large group of animals; selective catch for immature animals, females with sucklers etc., or even the special pursuit of kids and pregnant females. Some data stress the direct responsibility of ancient and traditional subarctic hunters for a number of local ecological crises, seen in reduction in areas and animal numbers and mass extermination of local game populations (Burch 1977; Campbell 1978; Stanford 1976; Vibe 1967; Yesner 1980). One ominous memorial of such an aggressiveness of the traditional subarctic hunter was discovered recently on the Asiatic side of the Bering Strait (Chlenov and Krupnik 1984), where more than 1500(!) skulls of grey whale calves - mostly sucklers and yearlings - were found at one historic site alone. The same abundance of archaeological whale bones - remnants of bowhead, whale calves and juveniles, killed and butchered by native hunters - is presented at Thule Eskimo prehistoric sites in the central Canadian Arctic (McCartney and Savelle 1985).

From these considerations, it follows that the widespread anthropological stereotypes presented a picture of the aboriginal hunter's integration in his ecosystem and his tendency to maintain the 'equilibrium' and 'harmony' with his environment appear is a recent ecological idealisation. In analysing the role of traditional hunter in his ecosystem one must distinguish his ecological experience (i.e. the whole system of accumulated ideas and knowledge of the environment) and his ecological behaviour, or the real mode of natural resources' utilisation. The ecological experience of subarctic hunters is surely the priceless part of all human knowledge on the nature of the north. It includes innumerable and all-round data on all the aspects of natural life fairly exceeding the limits of routine necessities of human existence (cf. Nelson 1969, 1973, 1980). But the documented ecological behaviour of some aboriginal subarctic groups tends to be equivocal and even negative. It therefore needs special and unbiased appraisement regarding modern views on rational environment utilisation.

In comparing both the ecological experience and ecological behaviour of different aboriginal hunting societies one must constantly keep in mind that they bear specific imprints of their certain environments. Thus we may attribute the documented differences in ecological behaviour and experience of aboriginal hunters from subarctic tundra and northern temperate forest zones (i.e. Eskimos compared to Tungus or Athapaskans) to the visible opposition in ecological rhythmics of both biomes. The northern forest hunter in his more stable ecosystem was adapted to a relatively constant level of resource availability which was violated by fairly rare and though mostly unprecedented periods of game scarcity in the years of weather hostility or in the 'lows' of biological cycles. Here, in my view, we may seek the reasons for more conservative and at the same time - far more ritualised ecological behaviour of aboriginal forest hunters (cf. Martin 1978; Nelson 1973, 1980). In an unstable subarctic environment with an oscillating level of subsistence resources, aboriginal hunters were forced to adapt to a more active, more aggressive mode
of ecological behaviour. Their ecological 'aggressiveness' increased moreover in the years of scarcity and deterioration of hunting conditions. But when game availability was restored in a time of abundance their ecological behaviour tended to reverse and become again both more conservative and ritualised.

REFERENCES


Birket-Smith, K. 1959 The Eskimos. Methuen and Co.: London


Buturlin, S.A. 1907 Report of the representative of the Department of Interior on the food supply for Kolyma and Gifziga areas in the year 1905. Sanct-Petersbourg (in Russian)


Dunbar, M. 1973 Stability and fragility in Arctic ecosystems. Arctic 26:179-85


Jochelson, W.I. 1898 Essay on hunting economy and fur-trade in Kolyma district. St Petersburg (in Russian)


Krupnik, I.I. 1984 Le chasseur aborigène dans les écosystèmes subarctiques (L’exemple des Eskimaux Asiatiques). Inter-Nord 18:105-10


McGhee, R. 1969-70 Speculations on climatic changes and Thule culture development. Folk 11-12:173-84


HUNTERS OF THE DREAMING: SOME IDEATIONAL, ECONOMIC AND ECOLOGICAL PARAMETERS OF THE AUSTRALIAN ABORIGINAL PRODUCTIVE SYSTEM

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...few civilisations seem to equal the Australian (Aborigines) in their taste for erudition and speculation and what sometimes looks like intellectual dandyism, odd as this expression may offer when it is applied to people with so rudimentary a level of material life [Levi Strauss 1966:89].

Aborigines conceived of the real world as existing within two domains, one the world of ordinary experience and the other the world of spirits and of primal forces. To refer to this duality by the terms 'natural' and 'supernatural' gives a false dichotomy, since Aboriginal thought did not conceive of a fundamental split between one manifestation and the other; entities having the capacity to express themselves in either mode depending upon the natural, social or religious context. Aboriginal powers of observation of the natural world were keen, and ethnographic studies in those areas where Aboriginal linguistic virtuosity is still preserved, have revealed a wealth of concepts about the taxonomy and the behaviour of plants and animals, and about other natural phenomena, which has resulted from an intimate and profound knowledge of their environment (e.g. Meehan 1982:48-56; Scarlett et al. 1983; Russell-Smith 1985; Warlpiri Lexicography Group 1986; Waddy 1988). Yet at the same time, their explanation of these phenomena, could move indissolubly from what we, with an objectivist unitary theory of nature, would refer to as 'rational' as opposed to 'religious' modes of thought (Hiatt and Jones 1988:10-11). Linguists analysing the conceptual system of the Warlpiri-speaking Aborigines of the northern desert region of central Australia have written that:

All flora, like fauna and other natural phenomena are linked into the Warlpiri cosmography by their relationships which are referred to as "jukurrpa"1 and which we will refer to by Dreaming. Thus each species of flora "belongs" to individuals as a function of their inherited kinship ties. The ownership can be viewed in a more abstract or less individualised way as being vested in a pair of "subsections" ... related by the patrilineal relation ... and, even more broadly by a pair of pairs of subsections ... referred to as a "moiety"2 [Warlpiri Lexicography Group 1986:i-ii].

This unbroken web, relating people to landscape and its resources, and predicated by an all-encompassing ideology lay at the heart of the Aboriginal subsistence and economic system. To attempt to analyse the structure of the economy, one needs some understanding of the underlying ideology.

DJUKURR: STONE, FAT, POWER, RELIGIOUS ESSENCE, BRILLIANCE

To illustrate this, I wish to refer to various levels of meaning, attached to the word Djukurr by Ritharrngu speakers of northeastern Arnhem Land, and how these concepts impinged onto their economic, political and religious realms. Their country consisted mostly of stony plateaux and low rocky hills clothed with open eucalypt woodland swamps. This was a tough landscape, described, using body-part terminology, as being diltji or 'back country'. Small stream valleys and isolated swamps formed the main foci for food foraging and camps site location. The average population density in this region was low, with a figure of about one person per 20 km2 (Thomson 1983; White 1978; White et al. in press). Within this territory, however, was a place called Ngilipitji the most important stone quarry in eastern Arnhem Land. Here were manufactured long quartzite blades called ngambi for hafting as spear points.

1In my orthography - Djukurrpa.
2From the French word Moité - 'half'.

The first recorded visit by an European to this quarry was that of Donald Thomson in 1935 when most of inland eastern Arnhem Land was almost entirely uncontacted by whites, and the area was remote and imbued with ritual danger to the coastal Aborigines. Thomson described travelling on foot through this area and of meeting with people of the Ritharrngu and other groups of the inland; sometimes in little hordes, at other times in family parties consisting of a man and his wives and their children; occasionally just a hunter or two, their faces and bodies smeared with grey mud or clay so that their quarry - red kangaroo or wallaroo - would not "smell" them .... In their right hands these hunters carried a spear-thrower and a bundle of spears - hooked wooden spears with villainous looking barbs, perfectly carved from ironwood, or stone-headed spears called *ngambi* from the famous quarry at Ngillipidji in the hills of the blue distance [1983:67].

This place was so remote, that very few, even of the oldest men on the northern coastline, who had told me about it, had even been there although they knew and cherished, lovingly, the flint spear-heads from it, each wrapped in its sheath of fine soft paper-bark, tied neatly with fibre string' [*op. cit.*:68].

The complex of quarries is located within the estate of the *Marra-larr-mirri* patrilineal clan, the name being translated literally as 'head-stone flake - belonging to'. Sometimes the clan was referred to as *Gurrka-larr-mirri*; the word gurrka is 'penis', having an allegorical meaning here, of the very essence of a man. The analogy of the shape and penetration of spearpoint and penis is probably also involved. This clan is one of the Dhuwa moiety Wagilak clans, and the men from it 'own' the quarry and its associated totemic beings called *Wangarr*. However, access to the quarry and its resources, and expiation of potentially hostile influences of these beings and other inherent forces of the place, may depend on acquiescence from men of the opposite Yirritja moiety, Ritharrngu clans, to whom men of the Wagilak patricians bestow their sisters' daughters as wives (Jones and White 1988:55). These Yirritja moiety men act as 'managers' of the site (Maddock 1974:36) and have the power to carry out ceremonial acts allowing access. The marriage relationship between these clans of both moieties have a reciprocal direction and over a cycle of several generations, theoretically can achieve parity (cf. Hiatt 1968a:169; Maddock 1974:68).

To gain a further feeling of the degree of complex structure within the social relationships of these people, it must be appreciated that the exogamous Wagilak and Ritharrngu groups, spoke different dialects of a broader Yolngu language complex; yet no less than 75% of all marriages occurred between them (White 1978:45). The linguistic differences were subtle, but had great self-identifying significance to the speakers themselves. All of this social complexity was developed and maintained amongst only about 500 people, sparsely located in small, mobile communities over a terrain of 10,000 km², and supporting themselves with what might to the outside observer appear to be a minimalist technology. Thomson wrote poetically about them that:

> There is something indefinable, a quality, a permanence, about the nomadic hunters that abides with one. They are so much part of the landscape; they fit in without a single note of discord and I for one cannot bear to think of their passing, these lithe, splendid, unspoiled men, from their last stronghold in the oldest continent. They came out of the bush, they appeared from nowhere, they did not need to speak .... [1983:67].

In 1981, I was part of a small party which visited the Ngilipitji site in order to study and film the stone tool manufacturing process (McKenzie 1983; McKenzie *et al.* 1983; Jones and White 1988). The Aboriginal members included two senior men, one from each moiety representing the clans most directly associated with the site, and who had been near the quarry as boys during Thomson's visit (Jones and White 1988:55). Three younger men from one of the patricians who had lived all of their lives on their traditional lands; in their youths had hunted solely with iron-tipped spears; and until their early adulthood had spoken no English; yet they had never previously been at the quarry when stone tools had been quarried and manufactured there.

The quarries of Ngilipitji are situated on the gentle slopes of low, eucalypt-wooded hills. These are sand mantled, and within this regolith are boulders of quartzite, the outer surfaces of which are heavily weathered. These boulders were systematically sought, by probing with digging sticks and then dug out. They were carefully inspected by the old men who commented on their qualities. It was said that the weathering was an indication

3D. Thomson's orthography.
that the stone was not ‘raw’ but had been ‘cooked’, and that they were looking for stones which were both of a suitable shape and which had not been ‘overcooked’, i.e. with too thick weathering zones. Stones with fine cracks or having broken-off facets on their surfaces were rejected, being referred to as *yuuthu mirri*, literally meaning ‘consisting of young ones’, as in the case of a pregnant woman. Such stones on being struck would shatter into tiny pieces, the latter being seen as equivalent to eggs or ‘baby stones’ which would eventually grow into full-sized ones within the ground. Such forces of growth for *larr*, or stone flakes, were said only to occur at Ngilipitji.

All the while, stones were being tested by being struck with heavy hammer cobbles and the resulting flake scars closely inspected; the latter work being done by the senior men. The outer hydrated layer was referred to as the ‘cooked skin’. Inside this was a thin crystalline layer called *militji*, a word meaning ‘white’, but especially in the context of a respected ‘elder’ and having reference to white hair. Finally within the best stones was a fine siliceous quartzite having a translucent pinkish-grey colour. This rock was called *larr djukurr*, literally ‘fat flaking stone’. The term *djukurr* has many meanings. At the most secular level it means ‘fat’, especially the highly valued fat within and around the kidneys. This is the first part of the body of an animal (like a wallaby) to be cooked and eaten, while the rest of the carcass is being slowly cooked within an earth oven. Fat and ‘sugar-bag’ honey are the two foods most prized by Arnhem Landers.

The cross-section of a flaked core was seen as being similar to that of a kidney, the inorganic mimicking the organic. Yet within the ritual realm, the inorganic was seen as being the quintessence of the organic, containing its true being. In this sense, *djukurr* was seen as ‘power’, and it was this intrinsic power within the *ngambi* spear blades that caused such a searing burning pain; it was this which made the blood flow freely and which sapped away the life of any animal or man hit by one. A blade made from Ngilipitji quartzite was referred to as being *djukurr mirri*, i.e. consisting of fat; whereas blades of coarser-grained material from other, less prestigious quarries in Arnhem Land were said to be *djukurr miriw*, or lacking in fat.

There were higher, more restricted meanings to this concept of ‘power’, to which I was not privy, except in a general sense. In the neighbourhood of Ngilipitji were located a series of what the Aborigines considered to be ritually dangerous places, the loci of powerful *Wangarr* or ancestral spirits. Arousal of these forces through unauthorised entry or disturbance of the ground or trees was believed to run the risk of terrible consequences; ‘in the ground in these parts is dangerous sickness .... We couldn’t cope. There is no cure or no doctor who could treat it’ (cf. Jones and White 1988:56). Senior men of the Marra-larr-mirri clan could, through their own presence and their knowledge of the correct ritual responses, mediate these forces so that they were quiescent, but they could never totally control them. People’s behaviour at the quarry and in its general vicinity was subdued and showed a high degree of consciousness of these issues.

Some of these sites were associated with the *Djan’kawu* (Djanggawul) myth cycle (Berndt 1952) and the important cult figures of the Wawilak Sisters, two key elements in the cosmology of ancestral beings in Arnhem Land. The Wawilak sisters were said to exist at the beginning of the world, and at that time they possessed the knowledge of how to make fire. They also carried stone *ngambi* blades and other ritual paraphernalia; the blades being associated with the Ngilipitji area (Warner 1937:238-41). Because of the breaking of certain incest laws, the sisters were swallowed by the Rainbow Serpent, and after a while they were regurgitated, but in this new form had lost all knowledge of fire and other ritual matters which henceforth became the exclusive property of men. Reenactment of key elements of this myth, forms the central place within the secret male cult of Kunapipi (Berndt 1951), the greatest of all the religious ceremonies of 20th century Arnhem Land (it is said by the Arnhem Landers that Kunapipi ‘came into’ their country from the southeast, and that it has largely replaced the older, more locally based Mardajyan ceremonies). At its height, with its themes of death and rebirth; seclusion of women; assertion by men of exclusive deep ritual knowledge; and of the reincarnation of the ancestral forces; participants, both within the ritual ground, and more generally in the secular camp outside, feel themselves briefly to be in the presence of the primal creative forces of the world. Somewhere in this hidden realm lies the true meaning of *Djukurr* (the Yolngu dialects form one of the languages of the Pama-Nyungan language phylum, spoken on over three-quarters of the Australian landmass. It is probable that *djukurr*, is cognate with various forms such as *djukurrpa* (Warlpiri), *djugar* (Mardudjara, Western Desert), meaning ‘Dream-time’ (Tonkinson 1978:16)).
Production

The technology of stone point manufacture at Ngilipitji has been described elsewhere (Jones and White 1988). Most work on core preparation and the detachment of primary flakes was done by the senior men, whose control of the inherent power of the stone was said to protect them from cutting their hands. Thin blades were then selected, for their edges to be trimmed back to form finished ngambi points by the young men. In the past, these spear points were wrapped individually in paper-bark sheaths, and then packed together in bundles of about 6-10 for transport away from the site. Our observations suggested a rate of production of some 12-15 finished points per man-hour, with perhaps some 50-100 points being manufactured by a small, well-experienced team during a day. This included travelling to the quarry from the nearest base camp adjacent to the floodplain of the Walker River some 5 km away. These figures accord reasonably well with the memories of the older men who said that some 10-15 trading bundles, or 70-130 separate points, weighing a total of some 25 kg would be produced during a full day's work. Whereas the quarry was worked exclusively by men, it was women's work to carry the bundles away from the site.

These were distributed over most of eastern Arnhem Land and beyond, a total area of some 60,000 km$^2$ (Thomson 1949:70). They formed one of the essential trade items or gerri, within an exchange network which included most of the clans of this entire region. In the reverse direction from the south, came items such as boomerangs, for use as ritual percussion instruments, macropod scapula yam-slicers, public coverings and hafted adzes; from the Blyth River region to the northwest came woven headbands, chaplets of wallaby incisors and carved, barbed wooden spears ('hook spears'); and from the east coast came emu-feather flywhisks, ceremonial string for the Rom ceremony and tightly woven Pandanus fibre bags (op cit.: Fig.2). It can be appreciated from this list, that the importance of the various items were mostly symbolic or religious rather than being essential to subsistence. Nevertheless, this trade constituted a higher level of integration of society than that of the local group, and organised a web of reciprocal obligations and responsibilities between people, many of whom may never actually have met face to face, even during their entire lifetimes. The articulation of this trade was made possible by the ritual associations inherent in the organisation of the ceremonial life, and in particular the Kunapipi; which for short periods brought together hundreds of men into highly structured, totemically based relations.

It could be argued from a point of view of political economy, that the ritual stranglehold which the Marra-larr-mirri and related clans had over the source of the most highly prized stone points set up a monopoly, which gave them a great advantage within the trading cycle. I am sure that this, to some extent, underlay their own assertion of the ritual dangers of the place to unauthorised trespass. Indeed there may have been conflict over access to the Ngilipitji area in the past, since it lies at the very southeastern edge of Ritharrngu-Wagilak lands (White 1978:50), and there were some competing claims from coastal clans from the western shores of the Gulf of Carpentaria. The Aboriginal folklore about Ngilipitji is replete with its own share of bloody violence; of clan feuds, mortal duels and of sorcery killings and pay-backs (cf. Thomson 1983:87-89). One of our 1981 companions, Dhulutarrama, had himself, when a young man been engaged in a duel near Ngilipitji and had been speared in the left breast, just above the heart by a stone-tipped, spear and for a period was close to death (see McKenzie 1983, for his testimony). His assailant from the inland country to the northwest was believed to have been killed later by sorcery in retaliation. It must be borne in mind, Warner's estimate (1937:147), that some 25% of the original cohort of men that he encountered at the Milingimbi Mission in the late 1920s had been killed by homicidal violence. In this deadly game, Ngilipitji spears had exacted their own percentage toll.

**Marr**

Yet, such a reductionist economic analysis is not sufficient. For the Marra-larr-mirri people, there was an extra dimension to their trade, encapsulated by their concept of marr. This postulated that there was a need, indeed an imperative, to distribute in small bundles the fat from certain species, in case one was overwhelmed or harmed by its accumulated marr or spiritual essence. This concept was similar to that of bir'yun, namely 'brilliance', or the sensation of shimmering light that could sometimes be created by an artist when he
painted the cross-hatching designs, *rrark* on a bark sheet or a hollow log coffin (Morphy 1989). This *bir’yun* was seen to be an emanation of the inherent power of the design itself, which since it depicted ancestral beings or elements associated with them, was imbued with their essence: which is what gave it its shining and sometimes blinding quality. Such paintings were referred to as being *mali Wangarr* - literally 'shades of the ancestral world'. Ritualy weak members of society, such as women, uninitiated men, or men afflicted by some travail such as illness or being under threat of sorcery, were said to be particularly vulnerable, which is why some paintings or other entities with *bir’yun* characteristics had to be made dull or shaded in their presence.

In the same way, men returning from the secret ground of the Kunapipi to the secular camp, would casually smear the designs on their bodies which had been made from red and white cotton, adhered by human blood, so as to reduce their inherent ritual power and thus render them safe to uncomprehending and unprotected members of society.

Some natural products also contained this shining essence, such as a highly prized purple haematite, mined from near Elcho Island and traded throughout Arnhem Land (Jones and Meehan 1978:32; Morphy 1989:31). This had a lustrous micaceous streak which when applied to the human body or on artefacts such as tobacco pipes, bark sheets or spear shafts, could be burnished to a brilliant sheen. Blood and fat quintessentially also had this quality, and both were applied to the bodies of key actors in the great ceremonies, and were said to imbue these men with the essential internal *marr* power appropriate to their proximity to the *Wangarr* forces.

Whereas *marr* was generally associated with well-being and health, it also had its dangerous and destructive qualities. A man who was sleek and plump was said to have it in a moderate quantity; yet one too fat engendered both jealousy and also fear. Men engaged on an avenging homicidal raid sought to gain *marr*, in order to give them strength and to better their chances of success. Yet to hold on to too much was considered dangerous, since the inherent power would accumulate and destroy them.

At the time of my visit to Ngilipitji, I had neither read Thomson’s field notes nor had any knowledge of the concept of *bir’yun*. Yet I would guess that, had I asked, my companions would have referred to it as exemplifying the very quality of the translucent siliceous quartzite which was found in the centre of cores. This was the material, which when struck, rang like a bell, and from which the deadly, sharp-edged flakes sprang. Within their shining semi-transparent appearance, existed the very manifestation of *marr* or power. Yet this, because of its inherent danger when concentrated within a confined space, needed to be distributed. In addition to any aspects of economic self interest, the trade was also driven by an imperative to spread this power in *ngambi* points as widely as possible.

One of the key Dhuwa moiety songs of the Djan’kawu myth refers to the Wawilak Sisters hanging their ‘power’ dilly bags, decorated with green and orange-red feathers obtained from the breasts of Rainbow-lorikeet parrots, on the branches of a casuarina tree. The colours of the feathers are intensified by the red light of the setting sun. This image has a series of associations, one of which has been translated by a Yirrkala man, the late Wandjuk Marika, as

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Rainbow lorikeet climbing
the Djuta (casuarina, sacred digging-stick)
Drying its feathers in the rays of the sun,
Children of the Djan’kawu ... shining
[Keen 1977; Morphy 1989:31].
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Near the end of their wanderings, the sisters were said to have dropped these bags at the coast near Milingimbi, where they were changed into stone. These rocks still radiate blue and red colours in the evening sunlight, which is reflected in the waters of the swamps below them.

I have concentrated on various levels of analysis and of meaning associated with the ownership, production and distribution of stone spearpoints from Ngilipitji as an exemplar of the complexity, as viewed by the Aborigines themselves of their own economic and ritual activities. It is obvious from the above, that they saw both realms as integrated into a single entity. Also, it can be appreciated that this construct was superimposed by them across a wide range of levels of ‘social complexity’ as might be measured by such parameters as population density, relative proximity of local groups, sedentism, or other socioeconomic characteristics dependent upon the underlying ‘productive capacity’ of the land itself. This apparent independence of the social or intellectual life over ecological constraints is a theme to which I will return later in this paper.
COSMOLOGY OF THE DREAMTIME

Aboriginal life was dominated by a set of religious ideas concerning the nature of the creation of the world, the relationship of people to the landscape, and of each person to every other, which is subsumed under the English term 'Dreamtime'. This was a direct translation of the central Australian Aranda (Arrente) word Ulchurringa⁴, recorded by F.J. Gillen in 1896 (Hiatt and Jones 1988:21). This was derived from the word altjerri meaning dream (Spencer and Gillen 1904:210). The concept has been further analysed and made accessible to non-Aboriginal audiences by such works as Stanner's illuminating monograph On Aboriginal Religion (1966) and by Strehlow (1971) and Tonkinson (1978).

According to this doctrine, there once was a period when the earth was flat and featureless and no animals nor humans existed except in a mythical, half-formed state. Ancestral beings or Wangarr (in Arnhem Land languages), then travelled across this landscape and at various loci performed acts of creation to make the world as we now know it. These loci were conceived of as being wells, either actual or symbolic in which some of the essence of the creative force still resides. Physical features such as hills, rocks or waterways were formed and were said to be related to specific events in the Dreaming which also involved the formation of different species of animals and to a lesser extent plants, which are forever linked with their ancestral wells. It is of interest that, in many cases, these loci marked some anomaly - for example, a fossil sand-dune, an unusually deep river billabong, a dolerite dyke, or a geological fault line; the physical peculiarities of the feature sometimes being incorporated into the myth of its founding. A white recrystallised mineral on the face of Mt Brockman in the Kakadu region of the Northern Territory was seen as being the semen of the greatest ancestral being, the Rainbow Serpent. A similar physical feature in the Wingate Mountains, west of Katherine at Tjundakin (Jinduckin) was said to be the poison serum from the mythical brown snake, and used in the past for ritual sorcery killings (Chase and Meehan 1983).

In other cases these named localities were not especially distinctive, being a particular patch of trees in the forest, or an area in the spinifex sand-field, which derived their importance purely from their ascribed mythic associations. Sets of sites were associated by reference to the tracks of the founding spirits; the concept of these spirits as travellers, Djilganggadja (in the Pintubi language spoken in the Western Desert [Tonkinson 1978:15]), being deeply engrained. These tracks could cover vast areas and intercrossed each other, some even spanning the continent from the northwest Kimberley coast and south to the Great Australian Bight.

During this phase of creation, mankind was also said to have been formed and individual groups of people given languages and assigned to specific sets of wells within the totemic landscape. It was believed that women were directly impregnated by this ancestral force, emanating out of the wells and thus the child was directly fathered by it (Hiatt 1965:22-23). On death, in a reverse process, the spirit of the person sank back into the wells to meld with the residual power of the place. Each set of wells belonging to a group of related Wangarr were indissolubly linked with descent groups predominantly related through the male line. Every person not only had a unique relationship to the land, but also through a complex set of kinship categories to every other human being. Marriage was with a person (or persons) from the opposite moiety and ideally from within a specific subsection. As we have seen in the case of the Ngilipitji clans, analysis of kinship relations over the span of many generations, reveals the ideal of reciprocal marriage exchange between clans, such as cross-cousin exchange which returns to its initial configuration only after the passage of several generations (Hiatt 1968a:169). These exchanges of wives not only symbolised a permanent pattern of relation between clans but they also formalised the ownership of, and access to, the resources of the landscape.

Specific detailed genealogical studies have shown that these forms were not always followed, and that inherent structural tensions existed between the ideal and the real (Hiatt 1962, 1965:71, 1968a:168-74). This was partly due to inherent problems with the Aboriginal model itself when it could not be reconciled with the demographic statistics of small population units. Also, individuals sometimes ignored or deliberately broke the codes. The creative and destructive imperatives resulting from the emotions of love or of the thirst for power were as strong within Aboriginal society as they were within that of the ancient

⁴In my orthography Altjerringa.
Greeks; the tragedies of Oedipus or of Medea were also enacted on the harsh savanna landscape. Penalties for non-conformity with marriage or ritual rules were often severe, with death and post-mortem mutilation sometimes being exacted. Yet occasionally individuals successfully defied or escaped these penalties. The imbalances caused by some of these personal assertions could have ramifications, generations into the future.

Hiatt (1968b:211) showed that amongst the Gidjingarli of northern Arnhem Land, some 90% of all marriages were in accordance with the rules, but that there was a distinction made by the Aborigines between rules expressed in terms of broad kinship categories and those that specified particular women within these to whom a man had marriage rights. Within the latter realm, there was considerable scope for competition; with the older, ritually powerful men tending to acquire several wives at the expense of other potential and usually younger husbands. This gerontocratic tendency may have been an expression of political dominance, or even of sociobiological imperatives, being based 'more on man's animal nature than his spirit' (Hiatt 1968a:175); but also according to Rose's Marxian analysis of Groote Eylandt and adjacent eastern Arnhem Land society, the acquisition of plural wives resulted in a man gaining control over the economic products of their labour (Rose 1960, 1968, 1987).

These explanations within the realm of political economy and of personal action irritated Lévi Strauss (1968a), who considered Australian marriage customs as exemplifying a perfect structure of communication between men, organised around the exchange of wives. As empiricism got in the way of the model, he made an attempt to discredit the recent detailed ethnography, as being that of 'what is left of a collapsing tribe' and that if this should 'carry more weight than the bulk of the older literature, then let us burn the books' (op cit.:211).

Another suggestion less drastic, was that at some distant time in the past, a completed and perfectly geometrical theory of kinship and of exchange had been devised by Aboriginal philosophers, and that since then, their descendants had not been able to conform to the rules. Thus 'what we are doing is not building a theory with which to interpret the facts, but rather trying to get back to the older native theory at the origin of the facts we are trying to explain' (Lévi Strauss 1968b:351). Hiatt, with a touch of irony, being faced with this proposal of 'perfect Forms and imperfect Particulars' (1968a:166), suggested 'Plato' as the name for this putative originator of the rules. More seriously, he defended the integrity of his own fieldwork in Arnhem Land and that of Meggitt amongst the Warlpiri, pointing out that these peoples had at least as much coherence in their traditional life as any studied during the so called 'classic period' from Taplin, Howitt, Spencer or Gillen in the middle and end of the last century to Radcliffe-Brown or Warner in the first two decades of the present one. Anthropology has almost always been behind the frontier of the colonial advance. Even in the case of Radcliffe-Brown, one of the doyens of the Platonic model, it has been said by one of his most distinguished students, the late Ian Hogbin (1989:19), that he 'never did fieldwork in our sense, anywhere at all. In Australia, he worked exclusively in hospitals and jails and places of that kind'.

Religious curation

These events of the Dreamtime were said to have occurred in some distant past, but in a different sense they are timeless; the forces still existing now and the events themselves, capable of being reached by present-day humans both in a mundane way through a dream, but also in a more profound sense via the medium of ceremonial. Each set of Wangarr had a series of songs - Manikay (in Arnhem Land languages), which not only reflected some of the events of the Dreamtime but by being performed in the correct manner became the very essence of that event - a form of super reality. The Manikay, for example Djambitj or Goyulan (Morning Star) song cycles (Clunies-Ross and Wild 1982) with their associated dances (bunggul), the ritual paraphernalia, and totemic emblems (rrark) were seen not only as commemorating the time of life-giving creation but also in a profound sense, as participating in its continuation.

In central Australia, amongst the Aranda, some of these ceremonies were called intichiuma, sometimes referred to in English as 'increase' ceremonies (Spencer and Gillen

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5There may be some confusion in the literature, between the earlier spelling of the name as 'Gidjingali'. This was an error corrected in the mid-1980s. The core meaning of the word revolves around ngarl meaning tongue, or language. The Gidjingarli define themselves as those who share this tongue.
1899:206), in which ritually prepared human actors reenacted events of the Dreamtime, and by so-doing believed that they were direct actors within the continuation of the essence of life (Hiatt and Jones 1988:12-14). Strehlow’s (1971: 293-94) translation of an Aranda song from a grass-seed increase ceremony has the incantation which can be rendered as:

Let the ilbritjilbira bird grind the grain;
Tall like a grass stalk, let him grind the grain!
Let the tall grass stalks stand in full seed;
Let the tall grass stalks sprout upwards!

The songs of a particular clan were linked with those of others, the analogy being formalised by the Arnhem Land word Rom meaning at one level ‘string’ but at a more profound level the ceremonial of the relationship between clans (Meehan and Jones 1986; Hiatt 1986:10-13). These song cycles were named and jointly owned by clans, often located hundreds of kilometres apart but through this relationship were said to have a common stake in the life-continuing ritual power embodied within their correct performance. Some of the song cycles referred directly to the travels of the ancestral beings; and of the linking of men, animals and land. They also offered a means of memorising the geographical distribution of wells, their associated food resources; and of their ownership by various clans. The performance of these song cycles formed the central structure of mourning rituals and of the great ceremonies which restated the events of the Dreaming and of peoples’ relationship to it and to each other. They also had considerable political significance (Keen 1984). The anthropologist Robert Tonkinson (1978:14-15) has referred to a ‘spiritual imperative’ that

The Aborigines ground their entire existence firmly in a conception of spiritual beings as holders of life-giving and life-sustaining power that is automatically accorded those who act out the life design formulated by these beings. The living conform to the dictates of a culture transmitted by their forefathers but attributed to spiritual, not human, actions. By denying the human innovatory component in their cultural development and by cleaving to a cosmic rather than chronological notion of history, the Aborigines are in effect claiming primacy for religious conceptions of causation, being, and purpose.

One great paradox which the Australian Aborigines presented to the progressionist mind of the mid-19th century was the contrast, within the context of a harsh and uncompromising environment, of their minimal material technology and a foraging mode of subsistence; with the complexity in their social relations and the beauty of their religious concepts.

A second irony was that within the continent of hunters and gatherers, Aborigines profoundly believed that they curated the natural environment; that through their actions, they sustained the life forces which allowed the renewal of species; that without their intervention, the land might return to its pre-dreaming chaos. In this ritual sense they saw themselves as managers of the landscape and of its essential forces. My experiences in Arnhem Land have reinforced my view, that my Aboriginal companions saw no distinction between what I might call direct maintenance activities, such as burning the grass or clearing out the wells, and the ritual activities in performing the Mardaiyan ceremonies and singing the Manikay. The landscape was perceived as being an ordered, humanised one through the medium of ritual.

The Dreaming was also a powerful system for conformity and the rejection of new ideas. In its purest form, all knowledge was derived from the Dreaming period and access to it was only available via the existing, well-tried methods and residing within the revealed truth available only to the most senior men. Meggitt (1966:64), recording his experience among the Warlpiri, wrote that:

As the mythical ancestors and culture heroes of the long past Dreamtime had defined the characteristics of the totality once and for all when they had participated in its creation and shaping, any subsequent change in any variable would inevitably affect the whole - and that for the worse.

His analysis (1966:64) of the implications of this world view within the realm of culture change are stark and have profound implications for our understanding of Australian prehistory. Because it was the duty of people to ensure the continuation of the interlocked system - the Law (Djabor in Gidjingarli) - this also ‘ruled out most possibilities of cultural innovation whether in the sphere of technology or of law’ (ibid.).
**TERRITORIAL ORGANISATION**

The key social unit of analysis of territorial ownership and consequently, the geographical distribution of people vis-à-vis natural resources, was the patrilineal clan, epitomised by the Arnhem Land *barparu*. This consisted of a line of men and women claiming descent through their fathers who corporately owned a set of related named sites and the surrounding territory (Hiatt 1965:24-31; Rose 1987:133-47). This is referred to in the literature as the ‘estate’ of the clan (Stanner 1965). Since descent was along the male line, a man’s sons continued to belong to the same clan, whereas a woman’s children belong to the clan of her husband. Analysis of such clans amongst the Gidjingarli of the northern coast of Arnhem Land by Hiatt (1965:19) showed a mean membership of 15 people with a range of between two and 35. In a study of directly observed ethnographic data from across the entire continent, Peterson (1986:69) has presented a detailed analysis of the size distribution of such patrilineal groups. The average size in almost all regions, ranged from 11-40 people, there being no systematic correlation with ecological environment. Thus the Worora of northwestern Australia (data 1912), had an average clan membership of 15, approximately the same as those from the rich tropical coasts of northern Australia such as amongst the Gidjingarli already described, and the Yir-Yoront of Cape York (data 1933-35); but also amongst the Kurintj of the semi-arid inland Northern Territory (data 1982). The Warlpiri of the central desert (data 1979) had an average clan membership of 38, similar to those both of the tropical Carpentarian coast near Borroloola (data 1977), and on the other side of the continent, amongst the Kurmai of the temperate Gippsland coast of Victoria (data 1879).

If the membership of patrilineal clans showed such remarkable similarity to each other within regions, having vastly different rates of basic biological production, it follows that the estates owned by these groups also varied enormously, being basically inversely proportional to rates of primary production. Let me illustrate this tendency by reference to the Arnhem Land data. At Djunawunya within Gidjingarli territory, on the Blyth River, a series of coastal dunes and swales, supported a highly diverse pattern of vegetation, including monsoonal jungle thickets and highly-productive small swamps with associated waterholes (Jones 1980). Here, Hiatt (1982) has recorded no fewer than 15 named totemic sites, belonging to the Galamagondija land-owning unit - within an estate of only 2 km² in area (Jones 1985:202). Some of these sites were situated as close as 100 m away from each other, and were typically not more than 250 m away; with areas surrounding them, ranging from less than 0.01-0.07 km². Neighbouring estates along the rich floodplain coast, had similar, small, tightly-bounded estates with closely-packed totemic sites on them (Hiatt 1965:18).

In contrast, the estates of other and closely related Gidjingarli-speaking clans in the open woodland only 10 km to the south, had estates typically measuring 30-40 km² in area (Hiatt 1965:18). These named totemic sites were often associated with small swampy depressions within the woodland, and were typically located a kilometre or two from each other. Further inland, amongst the Rembarrnga or Ritharrngu-speaking peoples, estates were even larger, being up to 300-500 km² in area and having named sites often separated by distances of tens of kilometres (White 1978:50). Within these extensive estates, the key zones were again the banks of streams or small swamps which tended to have a concentration of named sites separated by virtually unnamed stretches of open *ditjii* (back) woodland. Such country in a similar ecological zone, west of Katherine in the southern tropical savanna belt of the Northern Territory was referred to in English as ‘desert’ by the Wagiman people (Chase and Meehan 1983).

The population density for the Anbarra community of clans on the estuarine plains at the mouth of the Blyth River, was about two people per km², amongst the highest recorded in Australia but it must be stressed that this high density pertained only to the estates occupying a tiny area of the richest land (Meehan 1982:12-15; Jones 1984:42-43; White *et al.* in press). The Matai in the woodlands immediately back from the floodplains, had densities of about one person per 6-8 km². Further inland, the Rembarrnga and Ritharrngu-speaking peoples had densities as low as one person per 25 km² (White 1978; White *et al.* in press). It can thus be seen, that along this north-south transect from the coast to inland Arnhem Land, measuring only 150 km, there was a population density gradient of the order of 50 to one; yet despite this, the fundamental social structure of those people living at the highest densities was precisely the same as those living at the lowest. All peoples participated on equivalent terms within the Kunapipi. There was no transformation of social structure, but
rather a tighter packing of smaller estates in the richer areas. The core social unit, the patriclan, tended to remain constant. This was a key characteristic of Aboriginal territoriality throughout the continent (cf. Rose 1987:133-49).

As has been discussed above, for each individual person, membership of their clan was indissoluble from their own identity as a person. This was the ideal situation, the Platonic model presented by the Aboriginal mind, yet in practice there was some degree of fluidity in clan membership. For example, men had considerable rights over their mother’s country, which they could exercise in certain circumstances; adoption of individuals into a clan also occurred. In a converse process, demographic statistics of such small groups meant that occasionally, clans became extinct due to the lack of descendants. The way in which such estates could be claimed by neighbouring clans were complex and involved political processes perhaps over several generations. Genealogical studies by Hiatt (1965) and Meehan (pers. comm.) have shown the ways by which individual people have gradually gained territorial ownership and occupation over newly-formed lands of the prograding Blyth River estuarine plain, while at the same time, weakening their links with the silted-up back country with their diminishing resources; a social process that has been taking place over several generations. Modern detailed ethnographic work associated with the preparation of land claims in the Northern Territory has tended to emphasise these flexibilities, giving opportunities for political action and sometimes conflict within the confines of the old rules (Hiatt 1984:1-2).

LAND-USING BANDS

Perhaps one of the most difficult issues to resolve in Aboriginal territoriality has been the relationship between the formally defined land-owning clan and the real compositions of land-using foraging groups. The early literature, particularly that of Radcliffe-Brown (1918:222-23, 1931), posed a rigid model that the two were identical. What he called the ‘horde’ consisted of a single patriclan and in-married wives, and he postulated that these formed the group which foraged together in exclusive isolation: Peterson has shown that in his original formulations, when he was closest to his field experience, Radcliffe-Brown did in fact depict a relatively flexible situation, but that later he modelled his data into the realm of a formal construction, and that

This view became solidified in the literature and was influential in the formulation of Julian Steward’s concept of the patrilineal band as the corner-stone of the social and ecological organisation of hunter-gatherers (1936). It was eventually challenged by Meggitt (1962) and in particular by Hiatt in 1962, who argued for much more fluid composition of groups on the ground. This provoked a flourried defence of the rigid model by Stanner (1965) and Birdsell (1968, 1970). The latter, perhaps perturbed that the ethnographic detail of flexibility might undermine his own ecological modelling of the fundamental structure of hunting societies (1958:197), sought to render invalid the status of almost all fieldwork done in Australia since 1930; as being carried out with Aboriginal societies which had been affected by ‘degenerative change’ (1970:117). Hiatt (1968c:147) responded, pointing out that his own fieldwork amongst the Gidjingarli had been done with people who had been living a nomadic existence entirely from foraging, up until only a year before his study; and that the Warlpiri had been living under traditional economic circumstances in the Western Desert less than a decade before Meggitt’s analysis.

It is convenient to refer to those groups of people actually seen living and foraging together, as ‘bands’. The most comprehensive study of the composition of such bands observed as functional foraging units in the field under ‘traditional’ situations beyond the ‘white frontier’ has been made by Peterson (1986). His sources spanned observations ranging from accounts of primary maritime explorers, through to reports of patrol officers and other officials carrying out census surveys in Arnhem Land before and after World War II, and in the Western Desert in the 1960s. A remarkably consistent pattern emerges, despite the heterogeneous nature of the data sources. In Arnhem Land, band sizes typically numbered some 20-33 people, with a range of between 11 and 63. In the desert, there were somewhat smaller groups, averaging 14 people with a range of between four and 28; similar
figures to those from Cape York (ap cit.:135). These figures conform well with more general accounts of band sizes from the ethnohistoric literature in southeastern Australia and Tasmania (Jones 1974; Kohen 1988).

While the bands usually had a core membership of people related to each other along clan lines, they were often joined by people from other clans. Some of these were close relatives, such as the husbands of the daughters of senior patrician men; widows and also sometimes, men with ritual trading connections, and their families who for a period had come together to forage for a particular period of time. Details of such membership within functioning bands have been documented by Peterson (1986:74-134). Thus membership of the foraging band was fluid, sometimes agglomerating into larger units in favourable seasons, and at other times splitting up into smaller groups for a variety of reasons. An individual person in their lifetime, would thus forage over the estates of many other clans, apart from their own. How this was done was subject to social and political ties as well as the flux of seasonal change.

Taking a continental view, band sizes were more fluid and their mobility greatest, in the harshest part of the continent which had the greatest uncertainty of resource availability - such as the desert regions. It is from here that we have the quintessential portrait of the hunter armed only with weapons and tools that he can carry, accompanied by his wives and children, mobile, residing in temporary camps and foraging over a range of hundreds of square kilometres. At the other end of the ecological scale, in the richest regions, such as the estuarine plains of the tropical and semi-tropical rivers, and along the swamplands of major rivers, especially those of the Murray, the situation may have been closer to that described for the Blyth River Gidjingarli by Hiatt (1965). Here were ‘communities’ which consisted of agglomerations of members of several related and intermarrying clans who had semi-sedentary residential groupings numbering up to 120 people at certain times of the year. Members of such communities had the customary rights to forage over the estates of all of the co-resident clans, though there were rules and etiquette surrounding such access. However, even in the case of the Gidjingarli communities, it must be stressed that these co-resident groups were only loosely associated and did, in fact, split up into smaller, separate bands foraging on their own clan estates at certain times of the year. Meehan and I, who lived with the Anbarra Gidjingarli-speaking community during 1972-73, observed that the actual foraging group with which we were intimately associated had a remarkably constant core membership of about 25-30 people (Meehan 1982), though on occasions they agglomerated into larger groups numbering up to 100 people occupying the same base camp for several weeks.

**LANGUAGE AND THE DEMOGRAPHIC UNIT**

Contiguous bands who habitually, had close exchange links and intermarry, also spoke the same language. A remarkable feature of Aboriginal social life was the small size of the group of people speaking any particular language; and the regularity in the sizes of each language community. As Wurm (1972) has recognised, the north coast of Arnhem Land is one of the most linguistically diverse in Australia (or indeed, the world). Along an extent of coastline measuring only 100 km from the mouth of the Goyder River in the east, to that of the King River in the west, six different languages were spoken, namely, Kopapingu, Djinang, Gidjingarli, Nakara, Gunavidji, and Gunwinggu. Some of these languages had great structural linguistic differences from each other; in at least one case at the family level. In 1960, only a year or two after the Maningrida government post had been established, primary Nakara speakers numbered only 71 people (Hiatt 1965:2) with a territory consisting of their pooled estates measuring only 350 km². The neighbouring Gidjingarli numbered almost 300 people on a total area of only 800 km² including the pooled estates of their four constituent ‘communities’; Anbarra, Matai, Marauwurapa and Gulala - all of whom spoke distinctively different dialects to each other (Meehan 1982:12-13).

It might be thought that the residential ‘community’, consisting of members of clans of opposite moieties, and thus containing individuals within the category of potential spouse, regularly living close to each other, might have been the effective demographic or genetic unit (White et al. in press). However, detailed genealogies for the Anbarra, covering six generations within the time period from ca. 1875-1975, show that only about 60% were endogenous, i.e. with other Anbarra. Some 18% were with other Gidjingarli-speaking clans from other communities; while nearly 22% of Anbarra marriages involved spouses from
different languages - indeed language families. However, analysed in a different way, the vast majority of Gidjingarli marriages - about 90%, were with people from other coastal groups. The population unit through marriage, incorporated a number of territorially-based social units, which extended across major linguistic boundaries, but which involved people living in similar environments along a maximum range of only about 20 km of the coast (White et al. in press).

Within the various closely-related dialects of the Yolngu of northeastern Arnhem Land there was some 95% endogamy. However, within this area the patterns of marriage followed the same coast/inland division which one can deduce from the Gidjingarli data (White and Parsons 1976). Concerning the Yirritja moiety Ritharrngu speakers and the Dua moiety Wagilak speakers, 75% of all marriages were contracted between these two groups. Only 5% involved groups having coastal territories. These inland Aborigines also had their linguistic communities numbering some 200-500 people but with the areas corresponding to such language groups measuring some 10,000 km² in area (White 1978).

Despite the complexities exposed by the detailed genealogical information from this part of Arnhem Land, which is unequalled elsewhere in Australia, a general pattern emerges: that the linguistic group closely approximated to the demographic unit. Where leakage occurred outside, as was the case with the neighbouring Anbarra and Nakara; this was usually reciprocated through marriage links within the next one or two generations. In any case, the coast of northern Arnhem Land is also distinguished by its linguistic diversity and close-packaging of speakers from quite different languages.

The language groups, usually called 'tribes' in the Australian ethnography (Tindale 1974), tended to be similar to each other in population, i.e. numbering in most cases over the continent, units of some 200-600 people. Within the more productive zones, with high population densities, we have seen that the areas occupied by clans speaking the same language were small - less than 1000 km². In contrast to this, tribes occupying resource-poor regions had extensive lands up to 20,000 km² in area (Tindale 1974:maps).

On the continental scale, the ratio of tribal areas could be as much as 100:1. Even on the scale of a region, such as Arnhem Land, with people being parts of the same trading communication network, the ratio could be as high as 20:1. Yet in all cases, there was a powerful tendency for the population sizes of the language tribes to conform to a single value. Here, once more, at this highest level of Aboriginal social and demographic integration, was an indication of the primacy of the same social imperatives as we saw operating at the level of constituent clans.

Birdsell (1958:197) has set up an interesting spatial model of how a boundary of communication can develop in a packing matrix of hexagons. Based on his observation that the inland tribes, mapped by Tindale (1940), had approximately polygonal shapes, with an average number of 5.5 neighbours, he postulated that a hexagonal model would also be a good representation of the shape of the constituent bands. A single hexagon has of course no internal contacts and six external ones. Adding a 'ring' of six hexagons onto the original one to make a new group of seven, will result in a total of 12 internal contacts and 18 external ones. Adding a further 'ring', forms a group of 19 hexagons, and suddenly the balance of total internal to external contacts has been reversed; with 42 of the former and only 30 of the latter. Somewhere at about this scale, the internal network has a 'gravitational' tendency as opposed to links outside. If one multiplies 19 by the range of patrician membership figures discussed above, namely 11-46, one gets figures ranging from 200-800; which are in fact, close approximations to the linguistic tribal population estimates. If one were to place such a hypothetic hexagonal network onto a real landscape (Tindale 1974:55-63; Peterson 1976:67-68), with geographical barriers of various degrees of difficulty, then one can see how linguistic and genetic polities of the sort described by the ethnographic data could arise.

POPULATION DENSITIES

Birdsell (1953, 1957) also considered the apparent inverse relationship between tribal area, as mapped by Tindale (1940), and average rainfall on their territories. On an initial sample of about 400 tribes distributed over the continent, he found a curvilinear correlation satisfied by an exponential equation of the form: \( Y = a X^b \); where \( Y \) was the tribal area and \( X \) was the mean annual rainfall (op cit.:178). The coefficient of curvilinear correlation \( \rho \) was 0.6. Much of the unexplained variance seemed to be derived from two sources. Firstly,
there were tribes whose territories abutted onto the coast with its extra resources, or which were fed by rivers and their wetlands, whose water had initially been derived from elsewhere. The second source of variance was sociological. Birdsell, working from the available demographic material and aided by the kind of modelling indicated in the previous section, made an assumption that the Australian linguistic tribe corresponded to a statistical mean of 500 individuals (Kryzwicki 1934). He noted that those tribes situated geographically on either side of the boundaries of the initiation customs of circumcision and subincision were smaller in number than his putative norm. Conversely a few larger polities (matrilineal), such as the Kamilaroi and Wiradjuri of the slopes and plains of southern New South Wales were also excluded (Birdsell 1953:180).

Whatever the virtues or otherwise of these exclusions, they were at least systematic. His remaining sample of 123 linguistic tribes, had entirely inland territories and were widely distributed across a representative sample of continental ecological zones. These included much of inland Queensland (including rainforest areas), the eastern tablelands of New South Wales, southern Victoria to the South Australian border, and a north-south swathe through the centre of the continent from the Barkly Tableland to the northern Nullarbor Plain (op. cit.:174). Again he found a similar inverse logarithmic relationship; but this time with an r value of 0.8, indicating that 65% of the variance was accounted for by the two variables of population density and average rainfall. The less rain, the less people per unit area according to an empirical formula of:

\[ D = 0.07 \times 1.6^X \]

where D was the density in population per 100 square miles, and X was the rainfall in inches (op. cit.:206).

In the sample from which this was derived, there were 38 linguistic tribes for which reasonable direct demographic data were available. In order to check the general validity of his assumption that the ‘tribe’ in his sample approximated to 500 people, Birdsell then used his formula to calculate from the rainfall, the expected density of population and compared this result with the direct demographic data. In this sample of 38 cases, he found a coefficient of correlation, \( r = 0.51 \) (op. cit.:198-99; which I calculate as being significant at better than \( p < 0.1; t = 3.8 \)). Given the difficult nature of all of the demographic data, this is a reasonable result.

A region not considered by Birdsell, because it had not then been ethnographically mapped, was central and eastern Arnhem Land, where White, Meehan and I have done most of our own direct work (White et al. in press). It is of interest that directly counted population densities in inland Arnhem Land, plotted against rainfall, show a highly significant correlation (White 1979); indicating at a regional level, the same ecological relationships that, using less ‘hard’ data, Birdsell had been able to suggest at a continental scale.

**THE MURRAY RIVER VALLEY**

Some parts of the continent had densities much higher than those predicted by Birdsell’s formula. As discussed above, these were rich coastal areas and those abutting rivers with wetlands, ultimately fed by rainfall emanating from elsewhere. A key case in point was the middle and lower Murray River Valley, where the densities were between 20 and 40 times the expected values derived from local rainfall alone. The greatest diversion from the predicted values occurred towards its mouth and its confluence with the semi-saline and ecologically rich, Lake Alexandria (Birdsell 1953:187-88). This was due to two factors; firstly that the river valley itself had productive, seasonally flooded wetlands; and secondly that in its lower reaches, it (and its major tributary, the Darling) flowed as a narrow riverine corridor, through semi-desert country, with an annual rainfall of only about 250 mm (Maher 1973), and with no other permanent sources of fresh water within 100 km (Kefous 1988:228). Even at the confluence of the Murray and the Darling, a region of great ecological richness locally, the rivers are located within a trench only 30 km wide at its widest point at Lake Victoria (op. cit.:229). Away from this is desert mallee steppe, of extremely low productive capacity.

At Morgan, on the great bend of the lower Murray, the river flows in a sharply defined trench which is only a kilometre or two wide. Moving up the steep scarp, onto the surface of the plain into which the river is cut, one quite literally passes into genuine desert country with salt-bush shrub, as arid as any along a 500 km transect to the north towards the Flinders Ranges and the southern edge of Lake Eyre. In addition, the supply of water
within the lower Darling-Murray Rivers themselves is subject to frequent and unpredictable severe shortages, which would have affected the peripheral wetland systems. Kefous (1988:231) has shown that records over the past 50 years have indicated at least 10 river-drought episodes, each lasting in excess of 24 months; the one of 1943-46 resulting in the Murray downstream from its confluence with the Darling, being reduced to a string of salt-affected pools. Taking a geographical perspective, that also considers the history of the landscape features according to the time scale of Pleistocene climatic changes, one may consider a triangle, one side of which being the lower 200 km of the Darling and the other, an equivalent distance of the middle Murray as they approach their confluence with each other. Within this is located the downstream vestige of the Willandra Creek. During the time period between 25,000 and 50,000 years ago, this fed a series of huge, now fossil lakes, including Lake Mungo. Detailed geomorphological work has shown that these began to dry up about 20,000 years ago, corresponding to the last glacial maximum, and they have remained dry and inactive for the last 15,000 years (Bowler et al. 1970).

Concerning the Aboriginal population along the lower Murray River corridor, this may have been as high as two persons per km of river (Sturt 1833; Maddock 1974:23), with small clan estates packed every 15-20 km along it. The direct observations of densities are difficult to estimate since a smallpox epidemic had ravaged the people there a short time before Sturt’s exploratory journey in 1830-31. Perhaps a more profitable approach is to consider the evidence for language groups and their constituent dialect and patriclan subsets, for which we have considerable sociological information (Schurmann 1844; Taplin 1873, 1879; Berndt 1940; Tindale 1974:23-25, 212). Along the lower Murray downstream from Morgan and within 160 km of the sea, including Lake Alexandrina and the Coorong Lagoon system, there were seven language or dialect units divided into two groups, depending on their words for ‘man’. One of these groups was referred to in the general literature (e.g. Taplin 1873, 1879) as ‘Narrinyeri’ after narrindyeri - ‘belonging to men’ (Radcliffe-Brown 1930:690; Tindale 1974:212). These linguistic social units occupied small territories, ranging from 550-1600 km2 in area (Tindale 1974:212-19). From internal evidence concerning constituent patriclans, they must have varied somewhat in population sizes, but one of the main ones, the Djaralde (-kaldώ) (alternate spelling Yaralde), consisted of 22 large clans and may have numbered some 800 people; giving a population density of approximately one person per 1.5 km2 (Radcliffe-Brown 1930:690; Tindale 1974:212). The linguistically related Tanganekald occupied the northwestern portion of a geomorphologically remarkable sand spit, 150 km long, parallel to the coast and forming the seaward barrier to the brackish water Coorong Lagoon and to Lake Alexandrina. The people had access to this back-lagoon and to some of the resources of the mainland coast immediately opposite the sand spit; a region of great ecological richness. Tindale (1974:25) was able to map in detail the estates of 22 named patriclans of this language-tribe; giving an average area per clan estate of 90 km2. The actual area of land per estate was somewhat less, because the areas of the adjacent lagoon had been included in Tindale’s calculation. An estimate of the population density of these people would be of the order of one person per 2.5-5.0 km2.

In contrast to these high figures, the densities of people immediately away from the river, would have been as low as one person per 50-100 km2. There is good evidence that people from the back country belonging to tribal groups having ritual relations with the river people, used to fall back on the resources of the river during times of stress in the outlying countryside. Sometimes flood-events in the river, whose water was derived from the Great Dividing Range, 1000 km away, did not correspond with the local rainfall/drought regime, so there was a complex interaction between agglomeration of people onto core resources during times of stress and their dispersal in good seasons (cf. Kefous 1988:232-35).

If we were to take a transect of say 100 km either side at right angles to the middle and lower Murray Valley, one might have found a population density gradient of 50:1. The genetic effects which such a large variation might be expected to produce, have been considered by Pardoe (1984), who has argued that the Murray Valley populations may have constituted an effective ‘isolate’, relatively unaffected by the much more sparse populations surrounding them. Considering evidence for periodic stress, Webb (1984), analysing Harris lines in bones of recent prehistoric populations on the Murray, has been able to show a

6Kald means language.
pattern of numerous episodes of considerable nutrition stresses. These may have been due to stochastic collapses in river-flow regimes, and they emphasise the fundamental ecological limitations on the size of the permanent human population in this region.

It can be seen within the Darling-lower Murray Valley region, that the organisation and the orders of magnitude of key social, ecological and genetic parameters were remarkably similar to those of Arnhem Land, discussed above, and from which we have first-class ethnographic data. Other estimates of population densities from a variety of ecological zones across the continent also indicate a coherent relationship between population and the degree of ecological richness of the landscape (Yengoyan 1968:188-91; Meggitt 1966:60-63; Maddock 1974:21-23; Rose 1987:17-23). Birdsell's equation of population density against rainfall may be seen as only a specific case of a more general proposition, namely that of population density against some measure of primary biological productivity. The latter is obviously difficult to calculate, especially in coastal or wetland ecosystems. One may note, however, basic research into rates of primary productivity in a variety of ecosystems (e.g. Whittaker and Likens 1975; Head 1987). A comparison of these rates with good estimates of Aboriginal population densities and the structure of their foraging strategies is obviously a key area for future research (cf. Jochim 1976). An implication derived from these ecological relationships is that within each zone the Aboriginal population tended to remain constant according to different density levels. Some of the mechanisms controlling population growth amongst hunters and gatherers have been discussed in Lee and De Vore (1968:221-49), and a further analysis is beyond the scope of this paper. It is worth noting, however, that Aboriginal groups have the same inherent capacity for rapid population growth as any other. The Aboriginal population of Groote Eylandt, for example, has doubled during the past 30 years, after the Aborigines have become largely settled, with access to European carbohydrate food sources, and reduction of their rate of infant mortality due to medical care.

**BUTLIN'S CHALLENGE**

A broad challenge to some of the key ecological facts and assumptions about Aboriginal population densities implicit in the above discussion has been made by the economic historian N.G. Butlin (1983), and needs to be assessed. Briefly, Butlin has proposed that because of smallpox epidemics, the first in 1789 and the second around 1829-30, Aboriginal populations throughout southeastern Australia were so severely affected in their fundamental demographic parameters, that all ethnographic observations are fatally compromised:

- substantially all white description of blacks may need to be treated as conveying the characteristics of radically disturbed societies and may be seriously misleading in relation to "1788" conditions [Butlin 1983:175].

Here indeed is another call for 'burning the books'! The 1829-30 epidemic has been well recorded in the culture-contact exploration literature (e.g. Sturt 1833), and at least some of its effects monitored in terms of assessing pre-epidemic population levels (Radcliffe-Brown 1930:691). The epidemic of April 1789 is more enigmatic. There is no doubt that a disease resembling smallpox severely reduced the Aboriginal population around Sydney Harbour. Butlin's argument is that this disease spread far beyond the frontier and affected most groups of Aborigines throughout southeastern Australia. Thus all ethnographic accounts after this period are dealing with societies which may in their core demographic characteristics, have had little resemblance to those which pertained in the period immediately prior to the British colony. Using projections based on mortality rates from other studies of smallpox on unprotected populations, he attempted to calculate the hypothetical original populations. He also attempted to arrive at such estimates by considering the available food resources and his own analysis of their optimal exploitation (but see Kefous 1988). Butlin proposed that the Aboriginal population of southeastern Australia at 1788 numbered some 250,000 people; an estimate four times the previous one by Radcliffe-Brown (1930) and roughly equivalent to Radcliffe-Brown's estimate for the whole continent. Butlin's proposal entailed an average population density over the whole of southeastern Australia of one person per 3.9 km². Given that there were extensive areas of low productivity, the densities in the core ecological zones such as the coastline, or the Murray-Darling riverine plains would have to have been quite literally, a different order of magnitude to those discussed in the previous section. Indeed Butlin (1983:157) considered that the Murray-Darling River system was the 'heartland' of his putative population.
Although Butlin's estimates have been somewhat uncritically accepted in some quarters (e.g. White and Mulvaney 1987), there are serious problems with this analysis. Firstly, it is not entirely proven that the 1789 epidemic was in fact smallpox, as opposed to some other viral infection with symptoms of heavily infected vesicular eruptions, such as chickenpox (Watt 1988:145). Anomalous clinical features can occur when a non-immune population is exposed to a new disease (Thomson 1967; Fenner 1985; Watt 1988:145, 146). It is of significance to note that none of the colonists' children caught the disease even though they had not been inoculated and also despite the fact of frequent contact between the British and the Aboriginal population (Watt 1988:146). While there is no argument as to the tragic effects of the disease on the Sydney Aborigines, if it were not in fact smallpox then its aetiology may have been significantly different. Perhaps further research is needed on this question. Butlin assumed that the disease was transmitted across the sparsely occupied Blue Mountains or along the northern and southern coasts of New South Wales to infect most of the population of the southeastern part of the continent at least. Since these proposed events would have occurred at least 25 years before the first European entry, we have no way of knowing whether or not they actually happened; and that is the problem.

We may make some general observations. The pattern of transmission of infectious diseases amongst sparsely distributed hunting and gathering peoples may be fundamentally different to that amongst more densely settled sedentary populations. The situation with malaria on the south Papuan coast as opposed to northern Australia is a case in point. In the former situation, malaria was endemic, with evidence from immunological markers for malaria having been a major disease vector for a long period in the past. On the other hand, malaria was practically non-existent amongst the Aboriginal populations of the north coast of Australia, despite the presence of the mosquito carriers and sporadic episodes of local introduction of the disease. Using such arguments, it is by no means certain how a disease such as the virus of 1789, or even the confirmed smallpox of 1829, would have spread amongst hunting populations of greatly differing densities and in many cases effectively separated from each other by ecological or social barriers.

In a critique of Butlin's methodology, the demographer A. Gray (1985) has pointed out that even in the cases of the impact of smallpox on American Indians, or of bubonic/pneumonic plague in 14th century Europe, there was great variation in the impact; some populations being severely affected and others escaping more or less unscathed. Gray points out that Butlin (1983:69) assumes a more or less uniform mortality of greater than 50% for all of the Aboriginal population of southeastern Australia. Such a figure was barely achieved and only on a local scale in the worst cases of the mediaeval plague. Butlin in his age-specific mortality modelling, based on a smallpox epidemic amongst unvaccinated people in India during 1974-75, arbitrarily increased his proposed rates for the Aborigines by between 60-120%. For children under five, this implied mortality rates of 70-90%, figures which Gray (1985:4) considered to be both extreme and also unsupported by any coherent epidemiological data.

It is more likely that a disease like smallpox would have had a selective and regionally diverse impact. Perhaps it would have had its greatest effects in areas of greatest sedentism and highest population density, such as along the Murray River corridor. Indeed, the very concentrating effects of the British settlement at Sydney Cove upon the Aboriginal population in the region, may have accelerated the effects of the 1789 disease. Had traditional patterns of seasonal geographic locations been observed, many Aboriginal groups may have been spared exposure to infected kin during the height of the epidemic. We have evidence for such geographical and social barriers in the case of the 1829 epidemic. McBryde (1984:277) has shown a total absence of any observations of pock-marked individuals amongst the Kurnai group of Aboriginal tribes of Gippsland in southeastern Victoria, compared with the riverine region and central Victoria situated the other side of the southeastern mountain ranges. Butlin (1983:8) has argued that

much anthropological description of aboriginal society relates to populations that were radically de-stabilised and possibly with their practices and values deeply disturbed.

It is likely that whereas some societies might have been in this condition, others would still be largely intact according to some 'pre-epidemic norm'. We might therefore have expected the ethnography to have documented societies that were highly variable in their social structure, and which in their demographic characteristics showed no coherence with any ecological parameters. In fact, this was not the case, since not only in southeastern...
Australia, but also across the continent, a clear and consistent pattern emerges, both as to the nature of Aboriginal society in its various regional manifestations, and also concerning a predictable relationship between land ownership, use and basic demographic characteristics vis-à-vis ecological factors.

Even if all of these arguments were to be discounted, we still have some descriptions of Aboriginal societies prior to April 1798. The key location is of course the Sydney district, where from the pens of such perceptive observers as Dawes, Collins and Tench, we have a detailed picture of a society which is totally understandable in terms of an Arnhem Land model as discussed earlier in this essay. It is worth noting further that in the journals of Cook and other maritime explorers of the 18th century, there was a consistent assessment of the Aborigines whom they saw, as living in small mobile groups at low densities. In this argument, I am not of necessity locked into any specific defence of Radcliffe-Brown's figures (1930); of which concerning Victoria and the Murray district, he himself admitted were probably underestimates. I also do not at this stage care to make my own estimate as to the 1788 Aboriginal population of the entire continent, since I think that this will depend on detailed regional studies; taking into account the historical circumstances and the variable quality of the evidence case by case. Assessments of the Tasmanian demographic structure (Jones 1974) illustrate some of the difficulties in this area of enquiry. However, my aim here has been to argue that despite the interpretive problems due to the historical circumstances of the colonial advance, our knowledge about Aboriginal society has not been fatally corrupted.

**SEASONALITY: VARIABILITY AND PREDICTABILITY**

Some of the basic parameters of Aboriginal subsistence strategies have been discussed elsewhere, and will not be repeated here. These include analyses of the budgets of the food quest; calculations of the rates of production in obtaining various foods; the division of labour; targeting strategies in terms of predictability as opposed to energy yield of foraged and hunted foods; the composition of the foraging groups and the relative contribution of vegetable as opposed to animal food to the total diet (McCarthy and McArthur 1960; Jones 1980; Meehan 1982; Meehan and Jones 1986; O'Connell and Hawkes 1981, 1984; O'Connell et al. 1983; Altman 1987; Cane 1987; Devitt 1988).

For most parts of Australia, the temporal distribution of resources is highly varied and we may consider two factors. Firstly, there is the regular passage of the seasons which have a different expression in the tropical and subtropical regions with its summer monsoon rains, as opposed to the southern part of the continent dominated by winter rain-bearing westeries. Secondly, onto this seasonal pattern one must also add the element of uncertainty, particularly in the frequency of rainfall occurring at its normal time. The scale for these unpredictable events may be within the seasonal cycle and also over much longer periods. The great drought events were times when rainfall was far below long-term average in a succession of years, sometimes extending over a decade or more, and may have been the result of major global climatic oscillations such as the El Nino effect. Coping with such variability was inherent in the Aboriginal economic system. These periodic but difficult to predict episodes of drought stress may have been the key determinants of population sizes and the structure of seasonal territorial movements.

**Arnhem Land coast**

The climate of Arnhem Land is characteristically both a high seasonal variability but also a relatively high predictability. Aborigines had a well-developed concept of the seasonal calendar expressed through the medium of the combination of prevailing winds, temperature regime, available plants and animals, and some of their own key economic activities (Jones 1980). For the Gidjingarli, the key event was the arrival and the intensity of the northwest monsoon called *barra*, usually in December (in most Arnhem Land languages the names of the prevailing winds derived from Macassan terms for the cardinal points of the compass, *'barra'* from *'barat'* (west); *'djimurr'* from *'timur'* (east); *'djalata'* from *'selatan'* (south)). This was conceived to be a manifestation of the Rainbow Serpent, in some contexts visualised as an armed spear-man rushing into a fight, his ritual 'power' dilly-bag clenched between his teeth (Hiatt and Hiatt 1965). People built well-constructed wet-season houses and lived in dispersed clan-sized groups on locations above the floodwaters. In the case of the coastal clans, they occupied exposed windswept sandspits to try and gain some relief
from mosquitoes. Movement was difficult due to rapid growth of shoulder-high grass and flooding over much of the wetlands and coastal plains. Hunting was difficult and the subsistence of coastal clans concentrated on shellfish and fish (Meehan 1982), supplemented with some tree-fruits (Morinda citrifolia sp.). In the past, this was a time of stress and of low activity, due both to the shortage of food and the high humidity. Receding floodwaters in March and April allowed much greater mobility away from base camps; fish could be found in large pools, and water lilies (Nymphaea spp.) began to make significant contributions to the carbohydrate diet.

The early dry season when the wind started to shift to the southeast, heralded the beginning of the most productive time of the year; with diet dominated by yams (Dioscorea spp.), other tubers, together with geese and other waterbirds feeding and congregating at the swamps. Fixed fish traps were set up to catch fish leaving the wetlands for the sea. These were operated by senior men who had them located at key points on their estates. Further drying of the country allowed the greatest mobility, when the grass was burnt off over extensive parts of the entire territory. People shifted their residence into small foraging units sited for relatively short periods near key food resources. Large bodies of water and wet ground were now confined to the main swamps and these became the foci both for collection of spike-rush corms (Eleocharis dulcis) and for the hunting of geese. Easy access across the country allowed hunting of large game, such as macropod and emu, and the digging out of aestivating goannas (Varanus spp.).

The mid-dry season was the time of major ceremonies, when large numbers of people from related clans came together at key camping locations adjacent to ceremonial grounds. Groups of several hundred people might be supported for periods ranging from a few weeks to a month or two, subsisting on seasonally abundant resources, usually derived from these core wetland areas.

The late dry season with its high solar radiation, known as 'hot sand time', resulted in surface water evaporating away from most of the country except in the deepest swamps. Wells became too deep to dig or salty, and people fell back on key campsite locations characterised by having the most dependable source of water. Vegetable foods were now hard to get, with yam tendrils having dried off and the swampland muds too hard to dig. Animals, such as wallabies and goannas, were in poor condition. This late dry season was, by far, the hardest time of year and in the past, was the occasion of considerable nutritional stress.

A good wet season meant that resources during the following late dry, remained sufficient to support the population. But a poor wet, could result in a long dry season ending with failure of freshwater sources and severe shortage of available food. It was said that vulnerable people such as the elderly, babies and nursing mothers sometimes died of starvation stress at these times. On such occasions, knowledge of ephemeral foods, not normally eaten, would have had high survival value.

Older people, with their memories of such resources, obtained during previous stress events, had an especially important role in the transmission of this arcane knowledge during such episodes of crisis. However harsh this season could be, the people could also plan their subsistence activities with some security afforded them, by the visual signs of the impending Wet, such as the build-up of cloud banks in the northwest sky and the late dry-season lightning storms. The sudden fruiting of trees, such as Vitex, Syzygium and Planchonia, was keenly noted by the Aborigines as a signal that the essential replenishing of the landscape would once more occur with the early wet-season rains. The period at the very beginning of the full Wet, offered a variety of fruits and tubers, gave opportunities for hunting game, and also for catching fish as they migrated from the estuaries to the inland swamps.

It can be seen that, in the case of the Anbarra, whose clans occupied only small estates, relocation was carried out only three or four times during the year. From each of these camps the entire territory could theoretically be reached, by walking, during a foraging day. However, in the different seasons of the year, from a hunting point of view, individual areas, such as an ephemeral wetland, would have quite different ecological characteristics. Thus the pattern and location of foraging over this small area was quite different in the various seasons of the annual round. For the other Gidjingarli communities living inland, with their lower population densities and much larger estates, people moved their camps more often and over further distances; for example, from a river edge to an isolated swamp.
in the woodland. Foraging patterns were not only directed towards different resources in different seasons, but also were usually located in separated parts of the total territory. The less naturally productive the landscape, also resulted in the most widely dispersed pattern of mobility of the people according to seasonal changes. However, I wish to stress that, amongst the Anbarra who might be termed semi-sedentary, the structure of the food quest, according both to social organisation and seasonal patterns, was not different from that practised by their more dispersed and domestically mobile neighbours living immediately inland.

**Western Desert**

At the other extreme to the Arnhem Land coast, in terms of availability and predictability of resources, would be the hard core of the Western Desert region, spanning the Tanami and the Great Sandy Deserts, occupied by Pintubi and related speakers (Cane 1987; Tonkinson 1978; Thomson 1964). Here, the highest average temperature ranges from 24°C in winter to 39°C in summer; with many summer days having shade temperatures of 50°C. Annual evaporation is about 4500 mm, whereas average rainfall is only 270 mm and is highly unpredictable; ranging from 900 mm in wet years, but dropping to only 90 mm in drought periods. This negative budget, in terms of evaporation and precipitation, results in some of the most desertic conditions in Australia, the vegetation being dominated by an *Acacia* shrub steppe and spinifex, giving a stark and desolate impression to European explorers.

The Aborigines of the region had a population density of only about one person per 150-200 km² (Cane 1987:396) and generally lived in small family groups. Previous accounts had tended to see the subsistence as characterised by a non-structured opportunistic utilisation of scarce, and fundamentally unreliable, resources. Recent detailed field studies by Cane (1984, 1987) with people who had lived a totally traditional foraging life until the mid-1960s7, and which involved returning to the actual terrain and to campsites which the Aboriginal people had last abandoned when they moved to the mission settlement, has shown a regular underlying structure to their seasonal foraging strategies.

The seasonal round can be analysed as starting with a wet season between December and February with rain coming in the form of scattered large thunderstorms which leave water sources in the beds of ephemeral streams and claypans. People spread across the country in small groups to these water points from which they could forage. No new plant growth had yet occurred and game was also widely dispersed and difficult to encounter, so food was scarce and people had to move from water source to water source. All members of the community contributed to the food quest, which was characterised by an eclectic range of whatever foods could be obtained. This was the time of year when people were the most widely dispersed across their terrain. Men availed themselves of the opportunity to travel great distances to quarries, in order to obtain suitable stone for their tools; and to areas containing groves of hardwood for making spear-shafts and other wooden implements.

A few months after the first rainstorms, plant growth had been stimulated and this season, called 'green grass time' from March to May, extending to 'cold time' June to July, saw the Aborigines congregating around large surface waterholes on the sand plains. Migrating water birds also came into the desert and could be caught near these same waterholes. However, the main focus of the foraging economy was on vegetable foods, in particular the tubers of *Ipomoea costata* and *Vigna lanceolata* together with *Acacia*, grass seeds and *Solanum* fruits. New tubers of *Ipomoea* tended to be obtained at the beginning of the season, but later in the season, the women concentrated on seeking the deeper and larger tubers of the main root stock. These were large, often being found close to 1 m under ground but had swelled enough to reveal tell-tale cracks on the surface of the ground during the middle of the old season and thus could be dug out with the greatest efficiency of yield to effort. Cane (1987:407) has recorded rates of production of energy from these tubers from a sample of 24 foraging episodes carried out in sand-sheet localities. I have calculated that these resulted in a mean rate of production of 1830 ± 1456 (N = 24) kcals/hour; actually at the foraging locations. These values do not take into account

7Some Aborigines of this group were still living on their own in the desert until 1984 and it is rumoured that a few individuals continue to practice their traditional life having no contact with European institutions (Oram 1984; Robson 1989; Cane pers. comm. 1990).
women, who during this phase of the annual cycle, may have contributed some 60-80% of the total diet. It was a time of surplus, and the men availed themselves of the opportunity to engage in their main ceremonial activities. Settlements were semi-permanent around the major soaks and people, drawn by kin and ceremonial relations, formed the largest residential communities during their annual cycle.

Warm westerly winds from August to October resulted in the open soaks and the surface vegetation of the plains slowly drying out. The social units broke up into smaller family units, which retreated back from the plains towards the permanent sources of water in large rockholes along escarpments and ranges adjacent to the plains. The country was systematically fired both to encourage small patches of green growth attracting game, such as macropods and bustard birds, and to stimulate the growth of tubers and seeds during the next season. Subsistence was now much more generalised, with the vegetable base coming from *Vigna* tubers and *Cyperus* bulbs which at productivity rates of 250-400 kcal per hour and 600-1000 kcal per hour: respectively (op. cit. 406-408) were significantly less productive than in the case with *Ipomoea*. Seeds, of grasses, *Acacia* and *Eucalyptus* were also gathered and processed, and caches of seeds stored for the coming hardest time of the year. This was the time during the annual cycle when kangaroos, hunted by men, made their biggest contribution to the diet. Despite the importance which people ascribed to this food, both in terms of size of catch and quality of meat, it is likely that in actual dietary values, kangaroos only contributed to a small proportion of the diet, since they were not often killed. Even with firearms and the use of a vehicle, during Cane's 10 month study, only eight were shot (op. cit. 422). The major animal food during this period were reptiles, especially goannas and lizards which emerged from hibernation due to the onset of warm weather.

As the season progressed into full summer, with temperatures rising sometimes to 50°C, most waterholes dried up and food supplies dwindled throughout the entire territory. People retreated to their core rockholes which had deliberately been left during the rest of the year as a reserve for this critical period referred to as 'hungry time'. Vegetable foods became restricted to stored *Acacia* and *Eucalyptus* seeds, and to the poor-quality fibrous tubers of the drought season, *Cassia* and *Clerodendrum*. The main resource, during these hard episodes, however, were goannas collected by men, working to the extreme of their physical capacity, but often only producing semi-starvation food intakes, such as 800 kcal per head per day. Due to dietary and heat stress, those people not foraging, usually women, children and old people, tried to conserve energy and water by reducing their physical activity. Cane has likened this situation to people being 'trapped on foraging "islands" around large water holes' (op cit:395).

Within the entire study area of 18,000 km², there were only two truly permanent springs which have never been known to dry up. If the rain season was delayed, then people began to starve and there are accounts of healthier members feeding blood from veins in their arms to weaker members, that they might survive the final stresses of this harshest time of year (op cit.:396). It can be seen, that according to a simple demonstration of Liebig's Law of the Minimum, that it was the duration of the hot season and in particular, the time of arrival of the wet-season storms, which set a limit onto the Aboriginal population of this region; even though at other times of the year, there was a major surplus of predictable and easily available food resources.

**Comparative remarks**

Despite the ecological differences between the Western Desert and the coast of Arnhem Land, what is striking, is the structural similarities of the two foraging systems summarised here; in terms of group mobility, variations in sedentism, fission and agglomeration of social groups vis-à-vis the availability of local food supplies, variable contribution of plant and animal foods, the foraging role of men and women in different seasons, and the alternating periods of abundance and of stress. Despite the fact that in one case, the average population density was about one person per km² with a foraging range confined to 50 km², and the other had an average density of one person per 150 km² and a range of 18,000 km², there were no fundamental differences between the two. The first displayed no elements of intensification in its social institutions compared with the latter. This single system of foraging strategy had the capacity to be deployed over this extreme range of environments without trans®rmination. Returning to the central theme of this essay, one may note that in their ritual/ceremonial life, trading systems, and integration of kin groups within far-flung
social systems extending well beyond the primary foraging units, the Aborigines of the Western Desert were in all ways as 'complex' as their distant counterparts living in one of the richest and ecologically most dependable parts of the continent.

**SURPLUS**

In any analysis concerning social or economic 'evolution', comes the question of surplus and of the nature of its investment as an agent of social change. It can be seen from the two case studies used here, that during parts of the year, there was a substantial surplus of production in terms of availability of food in excess of immediate needs, thus releasing a large amount of labour for other potentially productive activities. In both cases this period of surplus coincided with the time of greatest ceremonial activities. This was a general feature of Australian societies right across the continent. In some cases, great ceremonial events involving the coming together for short periods, of most members of a language group, together with kin and ritual relations from neighbouring languages, were timed to coincide with a seasonal glut of food. This was the case with the summer aestivation of the Bogong moth in the southern highlands of New South Wales and Victoria, which attracted people from as far as the New South Wales coast to the east and the southwest slopes of the Murrumbidgee to the west, over a lateral distance of 300 km (Flood 1980). Similarly, the fruiting of the Bunya nut in certain restricted localised places in southeast Queensland forests, was a trigger for congregations of people from a wide region, to these areas, when major ceremonial activities were carried out.

As has been stressed at the beginning of this paper, the carrying out of ceremonial was not regarded as some sort of entertainment or casual social activity, but was driven by an overriding sense of obligation to fulfil the human part of the contract with the supernatural powers. At the most general level, the ceremonials were controlled by senior men, and within the rituals there was an institutionalisation of the subservient nature of young men, who did not yet possess the knowledge. To gain this, they were expected to forgo the years of their youth in an unmarried state as acolytes; with a flow of resources, such as prime hunted food and other goods and services, moving to the senior men. Most of the ceremonies revolved around secret male cults with women restricted to a peripheral role. The fact that key elements of the ritual often reenacted fundamental aspects of procreation and female functions of birth, has led psychoanalysts to interpret them as representing the annexation of female reproductive powers into the male ritual domain. Aggregations of men into a single location at the same time, also allowed the exchange of goods, wives and information necessary for the cohesion of Aboriginal society on a regional scale.

These activities had considerable economic consequences (Altman 1987). At a Kunapipi held at Ngaladjebama on the east bank of the Blyth River in the dry season of 1972, Meehan and I were able to document some of these at the scale of the local community. The seclusion of men away from the secular world meant that they made no contribution to the diet of women and children, and little of their own. The influx of other men for ritual activities also increased the number of people who needed to be fed. This was met by the women increasing their workload by a considerable degree. The site was located close to beds of shellfish and groves of cycad trees, both of which were exploited heavily by the women. Cycad bread was made; one woman making 90 kg of it in a period of 4-5 days; and this was transferred to the men's secluded camp. During the last few weeks of the finale of the ceremony there were several hundred people at this camp. I have estimated that some 400 man-weeks of potential work was directed to the rituals and could potentially have been deployed to other tasks had the ideology of the society been different (Jones 1973).

When the end of the ceremony occurred, Ngaladjebama had the look of a small busy town. During the last few weeks of the finale of the ceremony there were several hundred people at this camp. I have estimated that some 400 man-weeks of potential work was directed to the rituals and could potentially have been deployed to other tasks had the ideology of the society been different (Jones 1973). When the end of the ceremony occurred, Ngaladjebama had the look of a small busy town, yet only weeks later, it was deserted; the people having dispersed back onto their own estates. The men returned to the food quest, operating generally at the top of trophic levels of the ecosystem obtaining meat and fish. The women greatly reduced their work; again tending to shift from their previous almost total concentration on vegetable food and shellfish, to a much more mixed foraging pattern, which also involved small game. For the next 15 years, the site of Ngaladjebama was entirely deserted, until a new Kunapipi ceremony was held there in 1987. Again for a period of a few months, it became the central location for the economic and social life of the people of the entire central, north Arnhem Land coasts.
THE ABORIGINAL CULTURE: A CONTINENTAL PERSPECTIVE

Given the vast diversity of small local groups of people distributed across a continent, it might seem a priori that there would be little chance of perceiving any unifying features in the nature of their society. Yet underlying all was a deep unity, that they belonged to a single culture (cf. also Meggitt 1966:68). This conundrum was powerfully expressed by the explorer and first Premier of Western Australia, John Forrest (1890:161) that

One might reasonably have expected that in an immense continent the people of the different portions might have been found to differ largely in their customs and manners, and in their state of civilization, and that an altogether different state of things would exist on the east coast from that existing on the west coast, separated by more than 2,000 miles... but strange to say, the same habits, customs, and manners were found to exist throughout this great continent. Although there were no means of inter-communication, although the languages or dialects were altogether different; although they were separated by immense distances; although no sympathy, or even knowledge of one another existed, it is still a fact that they were found to be the same people, with the same laws, customs, and manners, and to a very large extent, with the same ideas and traditions.

At the level of technology, one can point to the same set of implements, that although there were regional variations in tool kits, they were drawn from some common pool. A comparison of the material cultures depicted in the ethnographies of Sydney Aborigines in the late 18th century; those of the mouth of the Murray River in 1850; and those of Arnhem Land, from Port Essington in the 1840s to the present day, show both great similarities and also subtle variations. There were some interesting elaborations which might give pause to those who wish to interpret the material technology of hunters in strictly utilitarian terms (Jones 1977:192-93). Why did the Gidjingarli have 10 different named types of spears, some with elaborate tips, when a simple hardwood spike could do the killing just as effectively? Why have different designs to the bases of the handles of spearthrowers made and used by Yirritja, as opposed to Dua men? Why the fundamental differences in shape of spearthrowers from Arnhem Land, Cape York and the Western Desert, the latter also used sometimes to carry babies and seeds? Why end-hafted tula adze flakes in central and southern Australia, and not in the Top End of the Northern Territory and in Cape York, where burren side-hafted flakes were used for the same functions? These questions are probably to be resolved in the realm of cultural self definition; material analogues to those of kinship and ritual. Hunting boomerangs from the central desert, when traded into Arnhem Land, became transformed into the red-ochred ritual clapsticks of the great ceremonies. Bifacially flaked, serrated-edged, silcrete spear-points from the Kimberley, when traded southeastwards into the heart of the Western Desert, became elevated into the cutting implements for the circumcision of boys, enabling their entry into the world of men and of knowledge.

Similarities also occurred at higher levels of social life than that of the implements of the chase. At the beginning of this essay, I have tried to give some insight into the interrelated nature of production, ownership, access, trade, conceptual categories, and religious beliefs, surrounding the mining and manufacturing of quartzite blades at Ngilipitji. From the other end of the continent, there is the scholarly analysis by McBryde (1984) on the greenstone, ground-stone axe quarry at Mt William in central Victoria, mined by the Kulin people. The ethnography for this pertained to the middle and late 19th century, when already, the society had been massively affected by the processes of depopulation and of colonisation. Using direct archaeological evidence based on petrological analyses of axes, McBryde and her co-worker A. Watchman, have been able to demonstrate a trading network of these axes over an area of about 60,000 km², some specimens being found 600 km away from the quarry. Using difficult ethnohistorical sources, including that of Howitt, a picture emerges of the ownership, rules of kinship, access, and of distribution, uncannily similar to that which pertained at Ngilipitji a century later and a continent apart. Similar long-distance trading systems also extended across the arid heartland, with commodities exchanged, ranging from the narcotic nicotine-bearing plant pituri (Duboisia hopwoodii), to baler and pearlshell ornaments (Watson 1983; Mulvaney 1976; McEntee 1988). These served to set up social links between small groups of people, sparsely located across distances of hundreds of kilometres.

At the level of the highest religious cults, Meggitt considered the Bora ceremonies of southeastern Australia and stated that
when we examine (these) rituals ... more closely, the correspondence between them and the rituals of the Northern Territory and the Kimberleys even in minor detail is most striking ... the evidence supports fairly well the hypothesis that all these major ceremonial complexes are best viewed as particular local developments or manifestations of a more general configuration of Australian Aboriginal initiation ritual [Meggitt 1957:34].

A close inspection of the descriptions and photographs of ceremonial regalia and performance amongst the central Australian tribes in the 1890s (Spencer and Gillen 1899, 1904); or those of Arnhem Land from the 1920s to the present day (e.g. Warner 1937; Berndt 1951; Wild 1986), compared with similar ceremonies described for the Sydney Aborigines in the 1790s by David Collins (1798:544-80), will amply illustrate this point; especially remembering that they pertained to societies living several thousand kilometres away from each other in space, and were made over a period, separated by 200 years in time.

This cultural system, however loosely defined, was deployed over an entire continent, with vastly different ecological parameters in different regions. These included the tropical savanna, the deserts, the temperate grasslands and even small areas of semi-Alpine highlands. Yet Aboriginal society in its key social, technical and ideational aspects, remained remarkably similar across this entire terrain. This is what I think was the most salient characteristic of their culture, and it has great implications for our understanding of their prehistory. They were able to maintain this similarity of core cultural behaviour in demographic contexts which at the extremes, could range from one or two persons per km\(^2\) to one person per 100-150 km\(^2\); a scale, taking the square root of area, in order to obtain a linear dimension, being 10 or 14.1. Yet there is no suggestion in the serious ethnographic literature that the cultural complexity of the desert dwellers was any less than those of their countrymen; sometimes specific trading partners, who lived semi-sedentary lives in the richest estuarine or riverine ‘islands’ of high primary biological productivity.

We may go back to Birdsell’s curve (1953), but this time consider three variables and carry out a partial correlation analysis. To Birdsell’s two variables, namely an index of primary production and population density, let us add a third - some index of social complexity. Carrying out these equations would show that, keeping social complexity constant, there was a highly significant correlation between primary production and population density. However, carrying out the other two equations of the triad, would show no significant correlation between social complexity and either the ecological parameters or those of the demographic structure. Social complexity in Aboriginal society was surprisingly independent of these other core variables.

This neatly encapsulates the essential challenge - the surprise - that Aboriginal society has always posed to the European mind, as exemplified in the opening quote to this paper from Lévi Strauss in his La Pensée Sauvage. European concepts about the nature of hunting societies are deeply embedded in the history of social enquiry, and reflect fundamental debates from the mid-17th century onwards, about the nature and development of social institutions. John Locke (1690 [1965]), considered that in his Two Treatises on Government, any meaningful ownership of land could only occur if a person had ‘mixed his labour’ with it and thus, those societies which lived by hunting and gathering for their subsistence were seen as being outside this contract of labour and of possession;

Before the Appropriation of land, he who gathered as much of the wild fruit, killed, caught, or tamed, as many of the Beasts as he could; he that so employed his Pains about any of the Spontaneous Products of Nature as in any way to alter them, from the state in which Nature put them in, by placing any of his Labour on them, did thereby acquire a Property in them [Locke 1690 (1965:336-37)].

Hunting societies were seen as lacking concepts of property, territoriality, government and any organised structures of society greater than that of the immediate primary family. They were people as a French aphorism put it;

\[
\text{sans roi, sans loi, sans foi' (without king, law or faith)}
\]

wandering at random in their un-owned terrae nulliis.

In the mid-18th century, these concepts were placed within a powerful theoretical construct of the history of human society, that there had been an unilineal development through a series of stages defined by the cardinal characteristics of their means of subsistence. During the mid-1750s, both Adam Smith in his lectures to the University of Glasgow (1759), and Turgot at the Sorbonne, independently proposed a similar progressionist theory (Meek 1971, 1976), that mankind has passed through ‘four distinct stages’
First the Age of Hunters, Secondly the Age of Shepherds, Thirdly the Age of Agriculture; and Fourthly the Age of Commerce (Smith in Meek 1976:117).

This four-stage theory, later reinforced by archaeological constructs such as the four-age technological system characterised by artefacts of flaked stone, ground stone, bronze and iron and borrowings from biological evolutionary theory, is essentially still with us. They were refined and placed within a broader social context in Gordon Childe's *Social Evolution* (1951).

Captain Cook in his observations of the Aborigines of the east coast of Australia, brought with him the essential concepts of Locke, tinged with some romantic indulgence from Rousseau. When direct and relatively intimate contact was made with Aboriginal groups at Sydney, following the 1788 settlement, a totally different picture emerged. Dawes described sophisticated linguistic grammatical features and a complex structure of marriage and local group affiliations; Collins (1798) gave detailed accounts of land ownership and of marriage and ceremonial rites. Despite the wide readership of Collins' work, its essential message seemed to fall on barren ground. Malthus (1798), though quoting extensively from it, nevertheless employed the construct of trying to place the Australian Aborigines within a hierarchical structure based upon an assessment of the degree of complexity of their society; the Andaman Islanders and the Tasmanians occupying the lowest rung. Marx considered the nature of the relationship between the labour of people subsisting by hunting, and what he referred to as one of the 'raw materials' for that labour, namely land;

All raw material is the subject of labour, but not every subject of labour is raw material; it can become so, after it has undergone some alteration by means of labour [Marx 1867 (1954:178)].

There are shades here of Locke, and it is likely that Marx had only a superficial knowledge of the then existing Australian Aboriginal ethnographic literature, preferring instead to rely on secondary sources such as Malthus and Morgan (Spriggs in press).

The question still exists, whether or not the land of hunters had 'undergone some alteration by means of labour' (cf. Rose 1987:43). This is a key question over which I have pondered for many years. I have argued that through the use of fire, Aborigines were able to manage their landscapes (Jones 1969, 1973). In their own concepts, they were 'cleaning' the country, and were fully aware that by doing so, they locally increased the food supply, by creating fresh regrowth and increasing the mosaic diversity of their landscape. Other activities of the same implications are changes to the soil at campsites produced by the dumping of food, shells and other refuse. This can create a favourable soil, highly conducive to the growth of fruit trees and edible tubers, which were themselves distributed onto these places by the people, who discarded the seeds in amongst the leaf litter. They were conscious that by so doing, new plants might grow there (Jones 1973; Chase 1989), yet the Aboriginal people whom I knew, were curiously passive about it all. Yen (1989), has argued that the long-term effects of such behaviour could be profound; both in widening the distribution of favoured edible plants and also in creating microenvironments by digging and aerating the soil. Over the time scale of 30,000-40,000 years, which we have now established for the human occupation of most ecosystems of the Australian continent, these small but cumulative effects may have had important effects. However, I wish to stress that this behaviour was inherent within that of hunting and gathering foraging strategies as were the manufacture and maintenance of such 'facilities' (cf. Lourandos 1985) as fish traps, earth dams, channels for eels, large nets for bird or fish, dug-out canoes (north coast); or indeed the preparation and exploitation of stone quarries, with which I began this essay. But I do not think that there was of necessity any teleological, incipient directions towards some 'higher stage'.

Within Australia, there was established a human society perhaps 50,000 years ago (Roberts *et al.* 1990). The archaeological record shows that many elements of what might be called the 'Australian Aboriginal culture' were already extant during the late Pleistocene. Such evidence relies not only on stone and wooden tools or evidence of subsistence behaviour, but more importantly on art. Art can encode symbolic systems; concepts of perception and of organisation of the external world. The application of new physical dating techniques may establish that some of this art, and therefore the concepts behind it, date back to the late Pleistocene, say 20,000-30,000 years ago. Maybe this is the antiquity of the 'Dreaming'. In western Europe, the earliest Aurignacians, at 32,000 years ago, had a degree of complexity in terms of their art and social organisation, as did their distant descendants of the late Magdaleni, 20,000 years later. They lived as 'hunters in a world of
hunters'. So did the Australians until 1788. Aboriginal society was locked into a particular world view. They had an adequate response to the ecological challenges posed by the variability of the Australian continent. Other peoples, with different ideas might have created different solutions.

Hunting and gathering societies were not of necessity on some track to a 'higher' stage of social or economic life. The archaeological records of western Europe from 35,000 years to 8000 years ago; and that of Australia from 40,000 years, to close to the present, shows how societies of modern humans operating under hunting and gathering regimes, could remain remarkably stable; while at the same time, flexibly responding to broad ecological changes in their environments. Perhaps the development of an agricultural subsistence base depended upon particular historical and ecological circumstances. Once this had been achieved, then there might have been great increase in the populations of the agriculturalists at the local level; and they would then have been able to out-compete, or genetically swamp the hunter-gatherers at the peripheries of their expanding world. This is what happened in western Europe during the 6th millennium BC, with the expansion of wheat growing, and sheep and goat-herding peoples, moving up the middle Danube into the heartland of a previous world of hunters. This is also of course, what happened in Australia, within the span of a single generation, from 1817 to the late 1880s, when almost the whole of the continent was colonised by agriculturalists and herders, themselves articulated to a broader industrial system. Perhaps at the core of our archaeological theory, should be a reexamination of some of the fundamental, though hidden, assumptions that hunters are in some structural evolutionary or developmental relationship to other modes of subsistence, in particular agriculture.

The archaeological record shows that at the broad scale, societies of hunters could, and did remain stable over periods of tens of millennia. To understand the reasons why some hunters and gatherers at certain places and times, changed their subsistence towards different ecological relationships with plants and animals, requires specific investigations of these particular circumstances. We need to reassess the primacy of the direct archaeological records, rather than relying on the putative workings of vaguely defined cultural 'processes'. This is not a call towards historical particularism, but rather one to free us from the progressionist legacy of the 18th century Enlightenment, itself a product of a particular place and a time.

REFERENCES


Berndt, R.M. 1940 Some aspects of Jaralidi culture, South Australia. Oceania 11:164-85


Birdsell, J.B. 1953 Some environmental and cultural factors influencing the structure of Australian Aboriginal populations. The American Naturalist 87:171-207


Birdsell, J.B. 1970 Local group composition among the Australian Aborigines: a critique of the evidence from fieldwork conducted since 1930. Current Anthropology 11:115-41


Gray, A. 1985 Some myths in the demography of Aboriginal Australians. Seminar, Department of Demography, Research School of Social Science, Australian National University: Canberra (unpublished manuscript).


Hiatt, L.R. 1962 Local organisation among the Australian Aborigines. Oceania 32:267-86.


McEntee, J.C. 1988 Arthropods of the northern Flinders Ranges and adjacent plains with Aboriginal names. Privately printed, ISBN No. 0 959 6644 2 4, Sheidow Park, South Australia


Meehan, B. 1982 Shell Bed to Shell Midden. Australian Institute of Aboriginal Studies: Canberra


Meggitt, M.J. 1962 Desert People. Angus and Robertson: Sydney


Morphy, H. 1989 From dull to brilliant: the aesthetics of spiritual power among the Yolngu. Man 24:21-40


Oram, J. 1984 Like travellers in time ... what they missed over 25 years. Daily Mirror: Sydney 25:10-84


Peterson, N. 1976 The natural and cultural areas of Aboriginal Australia. In N. Peterson (ed.) Tribes and Boundaries in Australia, pp.50-71. Australian Institute of Aboriginal Studies: Canberra


Radcliffe-Brown, A.R. 1931 Social Organisation of Australian Tribes. University of Sydney: Sydney, Oceania Monographs 1


Rose, F.G.G. 1960 Classification of the Kin, Age Structure and Marriage Amongst the Groote Eylandt Aborigines. Akademie - Verlag: Berlin


Rose, F.G.G. 1987 The Traditional Mode of Production of the Australian Aborigines. Angus and Robertson: Sydney


Schurmann, C.W. 1844 Vocabulary of the Parnkalla Language. Adelaide

Smith, A. 1759 The Theory of Moral Sentiments. Edinburgh

Spencer, W.B. and F.J. Gillen 1899 The Native Tribes of Central Australia. Macmillan: London

Spencer, W.B. and F.J. Gillen 1904 The Northern Tribes of Central Australia. Macmillan: London


Strehlow, T.G.H. 1971 Songs of Central Australia. Angus and Robertson: Sydney

Sturt, C. 1833 Two Expeditions into the Interior of Southern Australia. 2 vols. Smith, Elder and Co.: London

Taplin, G. 1873 Narrinyeri. Adelaide

Taplin, G. 1879 Folklore, Manners, Customs and Languages of the South Australian Aborigines. Adelaide


Tindale, N.B. 1940 Distribution of Australian Aboriginal tribes: a field survey. Transactions of the Royal Society of South Australia 64:140-231


Waddy, J.A. 1988 Classification of Plants and Animals from a Groote Eylandt Aboriginal Point of View. North Australia Research Unit, Australian National University: Darwin


Watson, P. 1983 This Precious Foliage. University of Sydney: Sydney, Oceania Monograph 26


White, N.G. 1979 Tribes, genes and habitats: genetic diversity among Aboriginal populations in the Northern Territory of Australia. Unpublished PhD thesis. La Trobe University: Melbourne


SECTION II

INTEGRATIONS WITH AGRICULTURE
ATOLL PRODUCTION SYSTEMS: FISH AND FISHING ON ONTONG JAVA ATOLL, SOLOMON ISLANDS

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ATOLL ADAPTATION

Atolls are usually portrayed as difficult environments for human settlement. The limited quantity of land resources is always emphasised, with tiny land areas and unproductive soils which severely limit agricultural production. Following on from this restriction is the limited variety of resources: the only carbohydrate foods capable of being produced on a significant scale, as supplements to the ubiquitous coconut and fish, are breadfruit (Artocarpus altilis), pandanus and aroids (Cyrtosperma, Alocasia and, with difficulty, Colocasia taro). Thirdly, observers have stressed the fluctuating availability of resources as a result of their vulnerability to damage by hurricanes and droughts. Finally, as well as limited means, atolls may also provide limited incentive for the production of a surplus, since the main foods other than coconuts are perishable (unlike yams or pigs, for example), and moreover the communities are typically isolated and have as nearest neighbours other atolls producing an identical set of products. Only where atolls are in close juxtaposition to high islands that have a contrasted resource base, as in Tahiti and the Caroline Islands (Oliver 1974:853; Alkire 1981), does the distinctive nature of atoll resources constitute an incentive to surplus production for trade purposes.

In response to these problems atoll communities in the Pacific are thought to have developed several distinctive characteristics: 'coral island colonists were consistently faced with problems of adapting their technology and social system to a context of limited land where cultivation was often difficult ....' (Alkire 1978:40). The populations of many atolls seem to have been regulated within the limits of the environment’s carrying capacity, yet on occasions these populations also needed to recover from the effects of catastrophic mortality (Vayda 1959; Bayliss-Smith 1974b; Carroll 1975). Social adaptations have also been identified, notably by Sahlins (1958) in his comparison of the social organisation of high islands and atolls in Polynesia, and by Alkire (1977) in studies of the Caroline Islands of Micronesia. According to Sahlins, atoll societies are distinctive, firstly because the limited nature of the resources encouraged a tendency towards a relatively egalitarian social organisation, and secondly because the fluctuating nature of the resource base encouraged the emergence of a complex interlocking social structure, in which the members of each household participated in a range of different kin-based groups, thus maximising access to resources. This latter feature would be a particularly valuable adaptation if some people or some resources were wiped out because of natural disasters. Alkire (1978:94) points out that these interlocking groups operated in many cases to enable food transfers to take place between atolls, thus enabling populations to avert the worst effects of drought or hurricane.

There are other generalisations to be made about how the traditional production systems of atolls have adapted to the modern world. As Connell (1982:1) has shown, not only is it a truism that new aspirations can be less easily satisfied in atoll environments than on high islands, but also ‘it is equally a truism that, as these aspirations increase, the degree to which they can be satisfied on atolls falls’. This problem can only be exacerbated by the global climatic trend that is now predicted as a consequence of changes in atmospheric composition. The sea level rise of 0.2-1.4 m that is expected in the next 50 years following a global warming of between 1° and 4.5°C will inevitably destabilise the shorelines of atoll islands. Although the sediment dynamics of coral islands are controlled in the long term more by storm events than by sea level (Bayliss-Smith 1988), the short-term effects of such a rapid sea level rise can only be erosive. Indeed, one prediction is that in the Indian Ocean the low lying atolls of the Maldives will disappear altogether (Radford 1988).
Figure 1  Relationship between land area and population density on 86 Pacific atolls
However, in this paper rather than attempt an exhaustive treatment of atoll adaptation, my intention is more restricted. Because atolls are distinctive landforms, there has been a tendency to ignore the variations that exist in their resource base. In this paper I discuss first a classification of atolls, extending the typology proposed by Alkire (1978:15), and secondly, I show that the marine resources of atolls, particularly fisheries, do not conform to many of the stereotypes outlined above. This point is illustrated by means of quantitative data for Ontong Java Atoll, Solomon Islands.

LAND AREA, RAINFALL AND NATURAL HAZARDS

Pacific atolls vary considerably in size and population density (Fig.1). A sample of 86 inhabited atolls have land areas that range between 0.2 and 40 km² and gross population densities that reach a maximum of around 700 persons per km². There is a tendency for the smaller atolls to be more densely settled, but as Wiens (1962:459) has pointed out, gross population density takes no account of the marine ecosystems which may greatly extend the resource base of some atolls whose actual land area is tiny.

In any case the area of each constituent island of an atoll is more important than aggregate land area. One important reason is that islands smaller than 1.2 ha do not provide conditions in which a lens of fresh water can be maintained, no matter how adequate the rainfall. As a result only medium-sized to large islands can provide a water supply from wells, and only the largest islands will support the freshwater swamps suitable for taro cultivation. Larger islands are also less vulnerable to storm overwash, and support a larger number of species of plants and animals, as studies on Kapingamarangi, Ontong Java and the Cook Islands have shown (Whitehead and Jones 1969; Bayliss-Smith 1974a; Stoddart 1975).

Variations in the amount and seasonality of rainfall is a second important cause of ecological variation among atolls. Within an atoll, differences in the size of islands and in the extent of human intervention can explain most of the variations in species richness, but variations between atolls can be attributed mainly to climate. On the driest atolls, with less than 900 mm annual rainfall, the total flora will not exceed 20-30 species, of which only coconut and pandanus have any importance as subsistence foods. On atolls that are seasonally wet and have a total rainfall of 900-2000 mm, the aroids Cyrtosperma and Alocasia can also be grown, and the total flora of 40-60 species will include other plants with some economic value. With more than about 2000 mm of rainfall a flora of up to 150 species can be anticipated, and Colocasia taro, bananas, breadfruit and sweet potatoes can all be grown in addition to those plants already mentioned (Wiens 1962; Alkire 1978; Stoddart and Fosberg 1982).

Inversely correlated with rainfall amount is drought probability. The reason that dry atolls such as the Phoenix and Line Islands have been such difficult habitats for Polynesians is not so much the low annual rainfall as the recurrent drought conditions that are associated with El Nino phenomena. Hurricanes are another hazard that vary in frequency, being very rare events in northern Kiribati and the central outliers but much more frequent elsewhere. Atolls in the northwest Carolines experience on average more than one hurricane per decade, making the smaller islands there (e.g. Olimarao) non-viable for permanent settlement (Wiens 1962). In general the very small atolls in the Pacific are only inhabited if they receive an adequate rainfall and have a low frequency of droughts and hurricanes, as in the central outliers and Marshall Islands.

ONTONG JAVA ATOLL

An exceptional combination of large land area, high rainfall, low drought frequency and few hurricanes occurs on the atoll of Ontong Java (Luangiua), a central Polynesian outlier in the Solomon Islands. The largest of the outlier atolls, Ontong Java had a population of around 2000 people in the late 19th century occupying at least six permanent village sites. There are 122 islands widely scattered around and within a lagoon. Estimation from air photographs shows that submerged reefs and reef flats (the main fishing grounds) cover 122 km², compared to a vegetated land area of only 7.8 km² of which almost half is accounted for by four islands. The largest island is Luangiua (178 ha) in the southeast, and the second largest Pelau (80 ha) in the north. These two settlements are about 70 km distant from each other by canoe, and were the centres of two separate polities in the 19th century (Bayliss-Smith 1974b, 1975, 1978).
Figure 2  An ecological classification of atolls
Table 1  Summary estimates for work, output and dietary contribution of the major subsistence activities, per annum, Ontong Java 1970-71

<table>
<thead>
<tr>
<th>Activity</th>
<th>Work input (hours)</th>
<th>Estimated total food yield (gross weight)</th>
<th>Proportion of energy in diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pondfield cultivation</td>
<td>26,000</td>
<td>69 t Cyrtosperma corms</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>51,300</td>
<td>40 t Colocasia corms and 1.3 to Colocasia leaves</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>9,200</td>
<td>Turmeric</td>
<td>0.1</td>
</tr>
<tr>
<td>Coconut collecting</td>
<td>8,800</td>
<td>121,000 ripe nuts</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>272,000 unripe nuts</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>104,000 germinating nuts</td>
<td>3.5</td>
</tr>
<tr>
<td>Fishing</td>
<td>59,300</td>
<td>81.2 t fish</td>
<td>19</td>
</tr>
<tr>
<td>Shellfish diving</td>
<td>3,800</td>
<td>1.3 t shellfish meat, mainly clams and Trochus</td>
<td>0.2</td>
</tr>
<tr>
<td>Turtle hunting</td>
<td>9,700</td>
<td>60 turtles and 60 clutches of eggs</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Sources: Bayliss-Smith (1974a: Tables 66, 94; 1977:342; 1982:Fig.5.5; and calculations)

Table 2  Data on time spent in marine exploitation, Ontong Java Atoll 1970-71

<table>
<thead>
<tr>
<th>Activity</th>
<th>Number of hours spent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fish</td>
</tr>
<tr>
<td>Sample of adult males</td>
<td></td>
</tr>
<tr>
<td>Luangia Village</td>
<td>958</td>
</tr>
<tr>
<td>Pelau Village</td>
<td>554</td>
</tr>
<tr>
<td>Outlying islands</td>
<td>190</td>
</tr>
<tr>
<td>Sample of adult females</td>
<td></td>
</tr>
<tr>
<td>Luangia Village</td>
<td>-</td>
</tr>
<tr>
<td>Pelau Village</td>
<td>2</td>
</tr>
<tr>
<td>Outlying islands</td>
<td>-</td>
</tr>
<tr>
<td>Estimate for population, per person per year</td>
<td></td>
</tr>
<tr>
<td>Adult males</td>
<td>345</td>
</tr>
<tr>
<td>Adult females</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes: 1 Fish - all kinds of fishing; Trochus - diving for Trochus and cleaning the shells; shellfish - diving and collecting; turtles - hunting the animals and searching for eggs
3 Total sample was 1157 person-days at Luangia, 464 at Pelau and 191 on outlying islands
4 Total sample was 2205 person-days at Luangia, 595 at Pelau and 252 on outlying islands
5 Calculated using average resident populations of adult males as follows: Luangia Village 98.6, Luangia outlying islands 27.3, Pelau Village 40.5, Pelau outlying islands 5.4
6 Calculated as (5), with adult female populations as follows: 148.7, 15.7, 34.6, 7.4 respectively.

Source: Bayliss Smith (1974a: Tables 51-52, 55-57)
In 1970-71 the atoll supported 850 inhabitants, partially dependent on the imported foods that supplied 25% of their diet, but mainly consuming the traditional staples of taro, coconuts and fish (Table 1). Data on the economics of subsistence suggest that atolls such as Ontong Java do not at the present day constitute particularly difficult habitats for survival. Detailed surveys of the work carried out by adults in sample households, combined with data on household food consumption, production and imports, showed that the major food-gaining activities produced substantial contributions to the diet in return for relatively moderate work inputs. Men spent on average 23 hours per week in food-gaining activities, and women 14 hours (Bayliss-Smith 1982). Of the major activities only shellfish collecting (by women) and turtle hunting (by men) occupy significant amounts of time, yet on average yield rather little, but in these cases the motivation is not primarily the supply of food energy.

Fishing, on the other hand, is a remarkably productive activity. Data from activity surveys (Tables 1, 2) suggest that fishing involves an annual work input of around 59,000 hours (345 hours per man). This input is scarcely greater than that involved in the cultivation of taro (Colocasia esculenta) by women, yet it supplies 19% of the total dietary energy compared to only 11% from taro. Calculations from the data in Table 1 suggest that one hour of work in taro cultivation produces 0.78 kg of Colocasia corms and cormels, yielding only about 0.45 kg net edible matter, whereas an hour's work in fishing generates on average 1.29 kg of fish. In terms of energy gain per unit of energy expended, fishing has a ratio of 8.6:1 compared to 6:0:1 for Colocasia cultivation. Cyrtosperma tardo cultivation is less labour intensive than Colocasia, as the plants require no mulching and almost no weeding. This activity has an estimated output/input ratio of 19.3:1 (Bayliss-Smith 1977). Nevertheless the high average productivity of fishing is remarkable, and raises some interesting questions concerning the reliability of this resource and its importance in prehistory.

Optimal foraging theory suggests that subsistence producers will maximise the output of those resources that offer the most favourable returns to labour (Winterhalder and Smith 1981; Harris 1982). The above data suggest that this model leaves unexplained a large amount of economic activity, so that factors other than output/input ratios must be invoked. On Ontong Java these factors obviously include the need to devote time to the market economy. More fundamentally, however, we must consider the reliability of subsistence resources as well as their average productivity. Jones (1980) has shown for the Anbarra Aborigines that their overall food-gaining strategy combines two kinds of foraging activities, ones offering a high yield but low probability of success, such as wallaby hunting and fishing, and also ones giving a low yield but a high probability of success, such as yam digging, cycad preparation and the collection of shellfish.

Men concentrated on the highly athletic hunting and fishing activities which involve physical power and skill, while women, who gathered and sometimes fished, obtained a low yield per unit of effort invested, but their work was highly reliable and the yield was almost directly proportional to the effort invested .... The target of the Anbarra economy was to be able to maintain their food intake at a point of balance between minimising effort and maximising the certainty of a regular and high-quality food supply [Jones 1980:136].

Turtle hunting on Ontong Java would certainly appear to conform to the high payoff/high risk type of activity whereas agriculture is generally very predictable but not always very productive. But where does fishing lie on this scale?

SEVEN HUNDRED AND THIRTY-SEVEN FISHERMENS' TRIPS

On Ontong Java systematic observations were made on fishing by means of surveys carried out in three different locations and covering seven different fishing techniques (Table 3). Altogether the survey covered fishing trips by 737 people in 327 different groups, ranging from individuals fishing in small outrigger canoes to groups of up to 36 men operating nets on a communal basis. Almost 5000 manhours of fishing were monitored, yielding a total catch of over six tonnes of fish.

For each trip the following information was recorded: number of persons, time of departure from village, time of return, principal fishing technique used, number and weight of fish caught (by species). During fieldwork the Ontong Java fish taxonomy was used, with over 100 named taxa being recorded. Specimens were collected of the 30 most important species, but they were unfortunately lost in transit to the Australian Museum in
Sydney, so that at present it is not possible to relate the ethnotaxonomy to a zoological classification. However, some species can be identified from an earlier published collection (Whitley 1929), and also from vernacular names from elsewhere in Polynesia (Leach and Ward 1981; Kirch and Dye 1979).

Complete data are available for 737 person-trips, and for a further 20 person-trips, not shown in Table 3, information on the catch is incomplete but the fishing technique is known. The percentage figures shown below relate to the grand total of 757 person-trips, and should give a quite accurate picture of the relative importance of each technique in 1970-71.

Nine principal methods of fishing are recognised on Ontong Java, of which two were not recorded at the time of fieldwork but are still occasionally practiced. Makau (56% of person-trips): the commonest method in use is fishing with a nylon line and baited hook over coral heads, patch reefs or fringing reefs in either lagoon, ocean or passages. The hook is placed within two coral stones (Acropora branches) around which the line is loosely wrapped; these stones act as a sinker which can be jettisoned once the baited hook reaches the bottom. In 98% of all makau trips observed, the trip took place during the daytime, and in all but two instances the fishermen used canoes, generally sailing canoes.

Hakale (2%): shark fishing with baited hooks, in the ocean or lagoon passages. Sharks are not eaten very often, and deliberate fishing for them is very much a minority occupation. Uu (not recorded): bait fishing in deep waters offshore of ocean reefs, in the daytime.

Hasolo (not recorded): bait fishing in deep waters, at night, for the huge Ruvettus oil fish. Sii (9%): live bait fishing in the ocean or main passages, the bait being kept alive in a basket beneath the canoe and then released slowly to attract feeding shoals of tuna and bonito. According to Lazarus and Beasley (1937) the technique was introduced from Takuu, another Polynesian outlier to the west of Ontong Java, earlier this century. In 1970-71 sii fishing was particularly popular at Pelau.

Table 3 Fishing surveys carried out on Ontong Java Atoll

<table>
<thead>
<tr>
<th>Survey site and technique</th>
<th>SAMPLE SIZE</th>
<th>WORK INPUT</th>
<th>FISH OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Groups</td>
<td>Person-trips</td>
<td>Total hours</td>
</tr>
<tr>
<td>Luangiu Village</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line fishing (makau)</td>
<td>232</td>
<td>386</td>
<td>2848</td>
</tr>
<tr>
<td>Spearfishing (vangevanga)</td>
<td>11</td>
<td>12</td>
<td>56</td>
</tr>
<tr>
<td>(hullhulli)</td>
<td>5</td>
<td>124</td>
<td>1123</td>
</tr>
<tr>
<td>Net fishing (pupui)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keila Island</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line fishing and trolling (makau/paka‘e)</td>
<td>8</td>
<td>21</td>
<td>116</td>
</tr>
<tr>
<td>Pelau Village</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live bait fishing (sii)</td>
<td>14</td>
<td>71</td>
<td>396</td>
</tr>
<tr>
<td>Line fishing (makau)</td>
<td>20</td>
<td>36</td>
<td>243</td>
</tr>
<tr>
<td>Shark fishing (hakale)</td>
<td>4</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>Trolling (paka‘e)</td>
<td>10</td>
<td>14</td>
<td>41</td>
</tr>
<tr>
<td>All methods</td>
<td>327</td>
<td>737</td>
<td>4974</td>
</tr>
</tbody>
</table>

2 For explanation of techniques, see text.
3 Out of the 327 fishing groups only 10 groups (16 person-trips) were unsuccessful - i.e. yielded less than 1 kg fish per fisherman: Luangiu makau (2 groups), Pelau sii (1), Pelau hakale (2), Pelau paka‘e (5).

Source: Bayliss-Smith (field notes)
Paka'e (5%): trolling with a lure from a moving canoe for pelagic species such as spanish mackerel, etc..
Pupui (16%): net fishing on reef flats or sand flats, either with a rope of plaited coconut leaves or with a nylon seine net, which is usually jointly owned.
Vangavanga (2%): spearfishing on reefs with spears, goggles and hand nets, an activity often combined with collecting clams and Trochus shells.
Hulihuli (10%): spearfishing on foot at night in shallow pools exposed on the reef flat or along the reef front, using torches and spears or machetes. This is the only fishing activity in which women participated, although they were predominant in shellfish collecting (usually clams).

PRODUCTIVITY AND UNCERTAINTY

Out of 327 fishing trips that were fully monitored, only 10 were unsuccessful, i.e. yielded no fish or a negligible catch of less than 1 kg of fish per fisherman (see Table 3). Eight of these unsuccessful trips were by fishermen using specialised equipment to try to catch particular species, by trolling, shark fishing or using live bait. These techniques offer the chance of a very large catch, but appear to be less dependable. On average such methods yield 1.6-3.1 kg of fish per manhour, but with a 28% probability of failure.

All other techniques appear to provide almost guaranteed success but a somewhat lower average return. One reason for the high success rate is that fishermen tend to be both flexible and persistent. If one location is unrewarding they move somewhere else or try a different technique, and continue (weather permitting) until a sufficient catch has been achieved. For line fishing (makau) sailing canoes are normally used - indeed such trips are not normally undertaken unless the wind is favourable. Fishermen travel singly or in groups of two or three, with men generally sharing with their brothers, sons or brothers' sons (Fig.3).

![Ontong Java Atoll 1970-71](image)

Figure 3  Number of persons per canoe in 232 makau fishing groups at Luangiua

The sailing canoe makes accessible destinations up to 20 km away for a day's return trip, and even further under optimum conditions. In 1970 there were 163 outrigger canoes on the atoll, of which 147 were seaworthy, for a population of 164 males aged 15-59 years (Bayliss-Smith 1978). Sailing time is not altogether wasted time, since trolling can be carried out en route. The average fishing trip by canoe from the main villages lasts between 6-8 hours, but for people on islands like Keila which are beyond the normal range of village-based fishermen, good fishing grounds are close at hand and a trip usually takes only 5-6 hours. Yields per manhour from makau averaged 1.1 kg at Luangiua, 1.5 kg at Pelau, and 1.7
kg at Keila, the differences attributable mainly to the greater distances to be travelled from Luangiua and a greater pressure on fish populations, closer to the larger villages. For *makau* the modal class of fish catch per canoe per trip is 7.5-10.0 kg, and the modal catch rate is 0.8-1.0 kg per manhour (Figs 4, 5).

![Figure 4](image-url)  
**Figure 4** Total catch per canoe for 232 makau fishing groups at Luangiua

![Figure 5](image-url)  
**Figure 5** Mean productivity per manhour for 232 makau fishing groups at Luangiua
Nets are used in two different ways. Kin-based or residential groups having common ownership of nets will use them along sheltered lagoon shores during calm or rough weather when canoe sailing is not feasible. Secondly, large-scale communal fish drives occasionally take place, particularly around the New Year, with up to 40 men and 12 canoes involved. Only five net-fishing trips were monitored (see Table 3), but in all cases they were successful and enabled a sizeable catch to be equally shared out among the households of participants. On these five occasions the average productivity was 1.4 kg per manhour (range 0.8-1.7 kg), but there were other occasions seen but not measured that were less successful. A larger sample of days might well show a rate of return similar to that of line fishing, and we must look to other reasons for the increasing popularity of seine net fishing. These include the possibility of very large catches, the unlikelihood of complete failure (because of equal sharing), and the enjoyment of an occasional communal activity in a society where commercial pressures have somewhat diminished opportunities for cooperative activity in recent years.

CONTRIBUTION OF FISH TO THE DIET

As shown in Table 1, it is estimated that the total annual catch of fish on Ontong Java amounted to 81.2 tonnes, which represents about 19% of the diet. Two different procedures were used to produce this figure. The first method involves an estimate of the total work input, derived from activity surveys in three locations, Luangiua Village, Pelau Village, and outlying islands, i.e. Keila and nearby islands (see Table 2). This figure is then multiplied by the mean productivity of fishing in each location, which for all techniques averages 1.1, 1.6 and 1.7 kg per manhour respectively (see Table 3). The total output figure thus derived amounts to 81.2 tonnes over a 12-month period, of which 32.8 tonnes were caught and consumed at Luangiua Village.

For Luangiua a check is available using an alternative method of estimation. During the Luangiua fishing survey, which occupied seven consecutive weeks in September, October and November 1970, 532 persons making fishing trips were observed and timed (all makau, vangavanga and hulihuli). For all except 65 persons the catch was weighed and is shown in Table 3. The catch for the 65 missing person-trips was estimated using mean productivity data for the technique in use. The result is an estimate of total fish consumption, over seven weeks of 3630 kg, which when multiplied to give a year's consumption gives a figure of 27.0 tonnes. This estimate is 21% less than the figure derived from the first procedure, and the difference can probably be explained by seasonal factors in the September-November period.

In nutritional terms these output data imply a per capita daily consumption of 0.25 kg of fish, representing about 46 gm of animal protein. Average consumption figures are not meaningful unless it can be shown that food is distributed more or less equally among households and between all household members, but in the Ontong Java case, social organisation does tend to ensure an equitable distribution, and for fish this tendency is reinforced by the nature of the product. On nine occasions during the seven-week survey over 150 kg of fish per day were arriving in Luangiua Village (on three occasions over 400 kg); all this food must be cleaned and cooked at once and consumed within a day or so by a population of 350-400 people. Normally every village household received fish on a Saturday, the main fishing day, and most households can also expect a second distribution midweek.

On the outlying islands fish consumption tends to be much more frequent, averaging, for example, 0.38 kg per person per day during a 30-day survey of food consumption by 30 people living on Keila (Bayliss-Smith 1974b:399, 1974a:278). This consumption represents 25% of the energy in the Keila population's diet, and if we add to it turtle meat and eggs, crabs and shellfish, the contribution of marine foods is little short of 30%. I have argued elsewhere that the limiting factor in atoll carrying capacity is the proportion of starch in the diet, which in extreme circumstances can fall to about 25% provided that coconuts and fish are abundant (Bayliss-Smith 1974a). On Ontong Java with present technology there seems to be no reason why fish consumption should not contribute at least 30% of calories, but to what extent can this level be applied to the pre-contact period?
IMPLICATIONS FOR ETHNOARCHAEOLOGY

All the fishing techniques now in use were recorded by Sarfert in 1910, but in addition he noted techniques such as stone traps, eel baskets, flying fish nets and poisoning which are no longer used (Sarfert and Damm 1929:109-30). Some of the technology has been transformed, in particular by the availability of nylon lines, seine nets and steel hooks, and it must therefore remain an open question as to how far the yield and productivity data reported here can be translated into a pre-European context. To my knowledge experiments have not been conducted into the performance of traditional Polynesian fishing gear, although it is clear that in pre-contact times the manufacture and maintenance of lines, nets, hooks and canoes would have involved substantially more work than at present.

Figure 6  Distribution of catch by taxa: Kapingamarangi and Ontong Java

On Kapingamarangi Atoll Leach and Ward (1981:57-65) identified a minimum of 1214 fish specimens from archaeological contexts, belonging to 24 families. As on Ontong Java a few species dominate the catch (Fig.6), but the most common fish in the prehistoric catch are not the same as those in the modern collection from Ontong Java. On Kapingamarangi the most commonly represented families are Epinephelidae, Scaridae, Anguilliformes and Balistidae, which account for more than half of the bone assemblage. On Ontong Java Lutjanidae are by far the commonest species caught by line fishing, and Siganidae species are the commonest caught with nets. More work needs to be done to determine whether these are real differences between the two atolls or between past and present, or whether they reflect differential deposition, survival or identification of fish bones belonging to different species. However, by comparison with the very different modern fish catches reported for the high island of Niuatoputapu (Kirch and Dye 1979), the Ontong Java and Kapingamarangi catches are relatively similar in species composition, apart from the absence on Ontong Java of eels, which were reported as being caught in 1910 (Sarfert and Damm 1929:129) but are no longer eaten. About 96 named taxa were recorded in the modern Kapingamarangi catch, which compares to the 94 named taxa recorded on Ontong Java during the seven-week Luangiua survey.

The 1214 minimum number of fish specimens on Kapingamarangi can be compared with 6495 shellfish, 27 birds, 10 turtles and a few fragments of crustacea and pigs that were recovered. Yet despite the prominence of molluscs in the archaeological record, at the present day 'shellfish does not appear to be a very significant food resource to contemporary people on Kapingamarangi' (Leach and Ward 1981:112). The same is true of Ontong Java, where shellfish account for only 0.3% of the modern diet, or 0.2% if Trochus is
excluded as being harvested primarily for commercial reasons (see Table 1). A further reason for not inferring from the Kapingamarangi data that the prehistoric diet of atolls was dominated by shellfish rather than fish relates again to the question of the survival of archaeological evidence. Kirch and Yen (1982:303) suggest that on Tikopia both discarding behaviour and differential decay mean that molluscs are proportionately overrepresented in archaeological deposits, and conclude that amongst animal foods fish was dominant in the diet throughout the prehistoric sequence.

If this interpretation applies also to atolls, then the data from Ontong Java should be regarded as giving a basically faithful representation of prehistoric subsistence patterns, with productivity improved but not revolutionised by the adoption of industrial technology. It thus appears realistic to characterise the marine resources of the atoll as being abundant, varied and dependable. This is in such contrast to the normal image of atoll resources as few, scarce and unreliable, that it suggests a need for some revision of accepted views concerning atoll production systems and their cultural correlates.

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REFERENCES


Whitley, G.P. 1929 Fishes from Ontong Java, Melanesia. Proceeding of the Linnaean Society of New South Wales 54:91-95


THE CAUSES AND CONSEQUENCES OF A DECLINE IN THE PREHISTORIC MARQUESAN FISHING INDUSTRY

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The relatively static nature of Polynesia's prehistoric archaeological record ought to make for uninteresting accounts of the region's past. Fortunately, two circumstances coincide to forestall this fate. The first is ecological. The small size of most Polynesian islands, their obvious boundaries, simple geologic histories, and tendency toward ecological entropy when perturbed all make the environmental impact of man's activities fairly easy to detect and assess. These ecological circumstances have led to the active pursuit and development of ecologically oriented archaeological projects over the last two decades. By studying the nature and dynamics of man/land or man/sea relationships, such studies have yielded great insight into the processes at work as Polynesian peoples wrested a living from, and prospered in, their island homes. As the insights from ecological archaeology have accumulated, however, it has become increasingly clear that ecological interpretations of archaeological data are by themselves insufficient to understand fully the changes in Polynesia's past, that the causes and consequences of prehistoric change in Polynesia have a social dimension as well as an ecological one. The understanding spawned by an ecological approach thus prompts a closer look at another set of circumstances that can aid in the interpretation of the archaeological record, this one historical in nature rather than ecological.

The initial settlement of Polynesia, while obviously a complex process, was accomplished by the descendants of a single group of people in the not too distant past. Once established on an island, societies developed in substantial, though by no means complete, isolation, giving rise in time to a number of distinct societies that appear, in the light of comparative ethnology, as permutations on several common themes. What is more, these island societies remained relatively unaffected by contact with the European world until the arrival, in the 18th century, of missionaries, naturalists, and seamen who not only observed closely what went on around them, but took the time to write down what they saw.

These historical circumstances provide a nearly ideal opportunity for applying the direct historical method in the search for social factors at work in past change. But despite the availability of a lively ethnological literature (Sahlins 1958; Goldman 1970) and the increasing number of published first-hand reports of Europeans who lived with unacculturated Polynesian peoples, archaeologists have tended to take less advantage of the direct historical method than they have of the compliant island ecology, with the result that causes and consequences of changes detected in the archaeological record are often presented in strictly environmental, or ecological terms.

Interpretations offered for changes over time in the fishing gear employed by prehistoric Marquesan peoples are good examples of this tendency to stress ecological over social factors. The changes, which involve a shift from an early varied fish-hook kit to a later kit dominated by small jabbing hooks, was first noted by Suggs (1961:80, Fig.27), and later substantiated by the work of Sinoto (Sinoto and Kellum 1965; Sinoto 1966, 1970, 1979) and Skjølsvold (1972). The shift to a simple fish-hook kit has been interpreted by both Suggs and Kirch as a reflection of man's adaptation to the rocky, steeply shelving coastal waters found in the Marquesas. Suggs (1961:157) felt that

... the absence or infrequency in the Marquesas of certain fish types known to the Marquesan settlers from their home island may have occasioned the obsolescence

of several hook types. Kirch expanded on this interpretation and brought it up to date with archaeological discoveries that post-dated Suggs' work. In Kirch's view (1980:45), the first Marquesan settlers to arrive from the Tonga-Samoa region
... were confronted with a new set of environmental constraints [rocky coasts, absence of developed reefs and lagoons] not suited to the fishing strategies that had been selected for in the western, tropical islands. Given this situation of adaptive stress, it is not surprising that the early Marquesan archaeological sites yield an especially varied assemblage of one piece fishing gear, reflecting experimentation with angling techniques. Later Marquesan sites demonstrate that, through a process of selective retention, the Marquesan fisherman had settled upon a highly standardized form of jabbing hook, which presumably had proved to be more effective in exploiting fish along the archipelago's rocky coasts and headlands.

Both Suggs' and Kirch's interpretations are stimulating contributions to the literature on Polynesian prehistory. Both, however, rest on the assumption that the Marquesans were well adapted to the constraints of the Marquesan marine environment during the latter part of their prehistory. Observations by Europeans in the early historic period, prior to the massive cultural changes that transformed Marquesan society in the 19th century, do not support this assumption, revealing instead a society sharply divided into classes, the lowest of which was left to perish in times of extended drought. A general example that testifies to this maladaptation, rather than one drawn from the literature on Marquesan fishing, will serve here, as the data on fishing are fragmentary, and the task of piecing them together occupies the main body of this paper.

SOME OBSERVATIONS ON THE MARQUESAS DURING A PERIOD OF DROUGHT

Edward Robarts, an Englishman about 30 years old, had lived in the Marquesas for a little over two years in the last decade of the 18th century when the effects of an unusually severe drought began to be felt (Dening 1974:121-23, 274-75; see Adamson 1936 for data on the frequency and duration of droughts in the Marquesas). Robarts was living at the time in the valley of Taiohae on the south coast of Nuku Hiva Island with the permission of the valley's chief, Keattonue. As the staple breadfruit crop failed for lack of water, Robarts and his Marquesan neighbours turned increasingly to ma (a fermented breadfruit paste stored in underground pits) for sustenance. Soon, however, the ma held in the small pits of individual households was exhausted, leaving only that stored in massive communal pits farther up the valley (Linton 1925:102 describes similar pits). This had been prepared over the preceding decades by the people of Taiohae, under the direction of their chief, so that it would be available at a time like this when the breadfruit crop failed. But now that the ma was needed, not just anyone could hike up the valley and dig out his or her share. The chief, backed by the mana of departed ancestors and a coterie of faithful armed warriors, reserved the right to distribute the communal ma. One consequence of this centralised redistributive network was that, when push came to shove, not everyone shared in the ma.

The results were not pretty. In one Taiohae Valley household Robarts found 11 corpses rotting in the house and around the yard, while the household's lone surviving member, an elderly woman, wandered about the bush in the back of the valley eating the roots of plants that grew wild there. Robarts himself was growing weak from incessant hunger and had taken to boiling, mashing and straining the trunks of banana trees to make a food that he found 'lay cold on the stomach'. When a chief from nearby Ua Pou Island arrived with the news that the drought had broken there and that the meagre population spared by the famine could not make full use of the breadfruit now ripening on the trees, Robarts quit Taiohae for Ua Pou. Recovery was not instantaneous, but after a month of rehabilitation he was able to walk well again. After a short time spent exploring Ua Pou, he returned to Taiohae. There he found that 200-300 of the valley's inhabitants had perished from hunger, perhaps a quarter of the total pre-famine population. The chief's family had done quite a bit better than average, and Robarts, eager to make the proper preparations for the next drought, wasted little time in proposing marriage to Keattonue's sister. With the marriage and a ritual chest tattoo Robarts formally joined Keattonue's retinue. As Robarts explained his full entrance to Marquesan society, 'I well knew a poor man had but little for himself, when the great man had to spare' (Dening 1974:274).

Robarts had lived, albeit barely, through a severe drought. The suffering that he had experienced and the death that he had witnessed were recurrent features of life in these drought-ridden islands. The social response to the famine was not ad hoc, but an institutionalised feature of society. It is clear that the Marquesans as a whole were not at all

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1See Anell (1955:177) for another environmental perspective on Marquesan fishing.
well adapted. But the question at hand has to do with fishing. With terrestrial production crippled by the drought why could not the labour of fishermen and the products of the sea hold the famine at bay? Were the Marquesan waters too poor to provide sufficient food, despite the concerted efforts of skilful fishermen? Or did contact-era fishermen, with their caches of small jabbing hooks, leave unexploited some potentially rich fishing grounds while they and their neighbours perished?

THE ARCHAEOLOGICAL DATA IN ECOLOGICAL PERSPECTIVE

A thousand years ago, when a Marquesan fixed his line for fishing he faced many choices. More likely than not, his fishing kit contained a wide selection of pearl-shell hooks and a few of bone (Sinoto 1979:112-17; Suggs 1961:78-89). There were jabbing hooks of various sizes, small ones for hand-lining little fish inshore and big ones for bottom-fishing the deeper waters offshore. With an unconstricted gap between the point and the shank, these jabbing hooks, set by a sharp tug on the line, would only hold a fish if constant tension on the line could be maintained. Bottom fish, whose swim bladders overinflate without the great pressure of the ocean's depths, and who put up little struggle once hooked, were easily landed with these hooks.

The fishermen also found a variety of rotating hooks, capable of setting themselves with the force of the fish strike, and able to hold the fish securely once set. These properties made them preferable for fishing strategies that left the line unattended, and for landing stronger, hard-fighting fish. A particular form of rotating hook is one of the few Polynesian hooks for which a specific target prey is noted in the literature. This is the ulua hook (Nordhoff 1930) designed to land members of the hard-fighting jackfish family (Carangidae).

If the fisherman had access to a canoe he could make use of a composite bonito lure hook to troll for pelagic fish offshore. Though the name given to this lure/hook combination suggests that the skipjack tuna was its primary quarry there can be little doubt that other species of pelagic fish were taken as well. Certainly, the size of some of these bonito lure hooks suggests that their manufacturers may have had in mind a fish larger and stronger than the skipjack.

The final hook type from which the fisherman could choose, the compound shank hook, has long been considered unique to the Marquesas, an invention developed and perfected in these islands (Suggs 1961:82; Sinoto 1979:117). Recently, however, similar hooks have been recovered from excavation contexts dating to about 500 BC on Santa Cruz and Tikopia in the Solomon Islands (Kirch and Yen 1982:243-44; McCoy pers. comm.) and recorded in ethnographic collections from the western Solomons (Cummings 1973:14, Fig.1, Type E), thus raising the possibility that the compound shank hook, or its precursor, arrived in the Marquesas with the first settlers. Independent invention remains a strong possibility, of course, given the 5000 odd kilometres of ocean that separate the Solomons from the Marquesas. The point here is that the hook's presence in the Marquesas is not evidence in itself of experimentation with angling techniques. But whatever the ultimate origin of this unusual hook type, the more important question has to do with the hook's function. What types of fish did its makers hope to catch? A possible clue comes from the Solomon Islands where similar hooks may have been used to cast for skipjack tuna from the bow of a stationary canoe2. If this was indeed the function of the compound shank hook then it would have served as a substitute for, and supplement to, the more common bonito lure hook.

In contrast to the early Marquesan fisherman, his counterpart some 600 years later faced only a few choices when fitting a line (Sinoto 1979:119-20; Suggs 1961:78-89; Skjelsvold 1972:24-28). He could still choose jabbing hooks, though the largest of these was a mere 27 mm long (Skjelsvold 1972:28; cf. Beasley 1928:47). Rotating hooks, once a dominant component of the kit, were now fairly rare. The fishermen who ate their meals in Hanapete'o Cave at this time apparently had no rotating hooks at all (Skjelsvold 1972:26). Bonito lure shanks could still be had, though fewer of them appear to have been produced,

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2This is an inference based on information in Ivens (1927:134), and the descriptive material in Cummings (1973) and Kaschko (1976). See Ivens (1927:131) for a drawing of a fisherman casting from the bow of a canoe. It is unclear whether the fishermen in the drawing are chumming to attract fish. If they are, this fishing method would be similar to the Hawaiian practice of lawai'a hi aku, for which see Kamakau (1976:71-74).
and the compound shank hook remained popular (Sinoto 1979:119-20).

The angler at the end of Marquesan prehistory thus seems ill-equipped in comparison with his ancestors, especially for fishing offshore, where the decline in rotating hooks and bonito lure hooks would have been most keenly felt (Sinoto 1970). But tools are only one component of any productive task and it would be unfair to conclude solely from changes in the form of fish hooks that the fisherman’s quarry changed as well. The best test of whether changes in tools were accompanied by changes in technique is in the products of the Marquesan fisherman’s labour, as revealed in the fish-bone midden from archaeological sites.

Figure 1  The Marquesas Islands, showing places and archaeological sites mentioned in the text

All of the fish-bone midden from Marquesan sites stored in the B.P. Bishop Museum, including major collections made independently by Sinoto and Skjølsvold in 1964, was analysed. Sites represented are located in Figure 1. Excavation units assigned to the early and late phases of Marquesan prehistory are noted in Table 1. For periodisation terminology used in this paper and its relationship to Suggs’ and Sinoto’s sequences see Figure 2. Over 1000 bones, primarily premaxilla, dentaries and various unusual spines, were identified to family level with the aid of over 160 reference skeletons in the Department of Anthropology, B.P. Bishop Museum, and with reference to the published works of Fowler (1955) and Barnett (1978). Positive identification to the genus level is rarely possible, due to gaps in the reference collection. The 350-odd identified bones that are not listed in Table 1 are from sites and excavation units that cannot be confidently dated.

There are two reasons why the fish-bone data in Table 1 should be interpreted with caution. Angling was undoubtedly one among many fishing strategies practiced in the prehistoric Marquesas (Handy 1923:167-80). Changes in catch composition, and hence the fish-bone midden of a site, may be due, in part, to changes in the practice of strategies other than angling. The effect of changes due to strategies other than angling should be most appreciable inshore, since the level of technological development in traditional Polynesian fisheries restricted the bulk of offshore fishing to some form of angling, with the possible addition of a minor component of strategies associated with the use of the harpoon. If changes in fish hooks do reflect changes in fishing practice, then these should be most evident in the catch of offshore taxa.
<table>
<thead>
<tr>
<th>Taxon</th>
<th>MUH-1A</th>
<th>Early sites</th>
<th>Late sites</th>
<th>Subtotal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MUH-1B</td>
<td>MH-10</td>
<td>Hanape-te'o</td>
<td></td>
</tr>
<tr>
<td></td>
<td>V-VI</td>
<td>IV-VI</td>
<td>I-IV</td>
<td>Subtotal</td>
</tr>
<tr>
<td>Bottom-dwelling and inshore</td>
<td></td>
<td></td>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>Acanthuridae (surgeonfish)</td>
<td>3</td>
<td>6</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Balistidae (triggerfish)</td>
<td>2</td>
<td>-</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Cirrhitidae (hawkfish)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Diodontidae (porcupinefish)</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Eel</td>
<td>2</td>
<td>-</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Holocentridae (squirrelfish)</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Kyphosidae (rudderfish)</td>
<td>3</td>
<td>3</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td>Labridae (wrasse)</td>
<td>2</td>
<td>5</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td>Lethrinidae (emperor)</td>
<td>8</td>
<td>4</td>
<td>-</td>
<td>12</td>
</tr>
<tr>
<td>Lutjanidae (snapperfish)</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Mullidae (goatfish)</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Ostraciidae (boxfish)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Polynemidae (threadfin)</td>
<td>14</td>
<td>2</td>
<td>-</td>
<td>16</td>
</tr>
<tr>
<td>Scaridae (parrotfish)</td>
<td>5</td>
<td>3</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>Serranidae (groupers)</td>
<td>30</td>
<td>34</td>
<td>1</td>
<td>65</td>
</tr>
<tr>
<td>Tetraodontidae (ballonfish)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Subtotal</td>
<td>75</td>
<td>74</td>
<td>16</td>
<td>165</td>
</tr>
<tr>
<td>Free-ranging and pelagic</td>
<td></td>
<td></td>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>Belonidae (needlefish)</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>Carangidae (runnerfish)</td>
<td>5</td>
<td>1</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td>Carangidae (scadfish)</td>
<td>-</td>
<td>5</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Carangidae (caudal scutes)</td>
<td>10</td>
<td>4</td>
<td>-</td>
<td>14</td>
</tr>
<tr>
<td>Carangidae (jackfish)</td>
<td>24</td>
<td>6</td>
<td>-</td>
<td>30</td>
</tr>
<tr>
<td>Elasmobranch (shark/ray)</td>
<td>4</td>
<td>3</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Shark (teeth)</td>
<td>52</td>
<td>23</td>
<td>-</td>
<td>75</td>
</tr>
<tr>
<td>Scombridae (skipjack)</td>
<td>9</td>
<td>5</td>
<td>-</td>
<td>14</td>
</tr>
<tr>
<td>Subtotal</td>
<td>104</td>
<td>51</td>
<td>8</td>
<td>163</td>
</tr>
</tbody>
</table>

| Total                                | 179     | 125         | 24         | 328      |

Table 1  Fish bone identified from archaeological sites in the Marquesas Islands. Figures indicate the number of identified bones. Parenthetical information in the taxon column is either the common English name of the taxon, or the identified bone.
A second cause for caution is the size of the fish-bone sample. Given a prehistoric sequence of about 1500 years the bones identified in Table 1 constitute a sample of one bone for every two years and four months of prehistory. The errors possibly introduced by this rather ludicrous sample are mitigated somewhat by the fact that the intent here is not to discover the precise species composition of fish in the diet at any point in time, but to look for broad trends in the fish component of the diet through time. The outline of one such trend, the abandonment of offshore fishing for inshore waters, stands out clearly.

In the early layers of the Hane Dune site on Ua Huka Island (MUH-1) and the Hanatakua site on Hiva Oa (MH-10), bones from free ranging and pelagic taxa are found in nearly equal numbers with those of bottom-dwelling and inshore taxa. By far the greatest number of bones come from the Elasmobranchs, a class of cartilaginous fish that includes the sharks and the rays. The bones of the jackfishes, including the ulua and related taxa, outnumber those of all families of bottom-dwelling and inshore fishes save the groupers (Serranidae). The impression gained from Table 1 is that of a marine production system actively and successfully exploiting a wide range of available marine environments.

Fish bones from the Hanapete’o Cave site and late layers at the Hane Dune site show a completely different emphasis. Now it is the inshore and bottom-dwelling taxa that make up the bulk of the catch, while offshore taxa are only barely represented. The jackfishes, for whom the obsolete rotating ulua hook was designed, drop out almost entirely, while inshore fishes of rather dubious desirability, such as the balloonfish or the porcupinefish, come to the fore. It thus seems safe to conclude that changes in the Marquesan fish-hook kit went hand in hand with a profound qualitative shift in the kinds of fish actually caught by Marquesan fishermen.

This qualitative shift, striking as it seems, does not rule out the possibility that Marquesan fishermen were in fact becoming more productive because inshore fishing provided greater returns on labour than did offshore angling. Unfortunately, this rather straightforward conjecture is extremely difficult to address with archaeological data. A precise answer would require fairly thorough knowledge of the quantity of fish-bone midden per unit volume of excavated material and of the exact rates at which deposition and erosion had proceeded at each site, as well as a sample large enough to mitigate some of the uncertainty surrounding estimation of these variables. None of these conditions are
met with the Marquesan data, so it is necessary to attack the problem from a different angle to see if another line of evidence might cast some light on possible changes in fishing productivity. One way to do this would be to assess the changing importance of fish relative to the other flesh foods with which Marquesans supplemented the vegetable portion of their diet (see Table 2).

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Phase I nos</th>
<th>%</th>
<th>Phase II nos</th>
<th>%</th>
<th>Phase IV nos</th>
<th>%</th>
<th>Hanapete’o nos</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell</td>
<td>294</td>
<td>1.1</td>
<td>532</td>
<td>29.1</td>
<td>1,275</td>
<td>21.6</td>
<td>1,312</td>
<td>15.7</td>
</tr>
<tr>
<td>Bird</td>
<td>23,207</td>
<td>89.8</td>
<td>747</td>
<td>40.8</td>
<td>59</td>
<td>100</td>
<td>40</td>
<td>0.5</td>
</tr>
<tr>
<td>Pig</td>
<td>588</td>
<td>2.3</td>
<td>5</td>
<td>0.3</td>
<td>2,868</td>
<td>48.5</td>
<td>2,599</td>
<td>31.1</td>
</tr>
<tr>
<td>Fish</td>
<td>1,705</td>
<td>6.6</td>
<td>524</td>
<td>28.6</td>
<td>1,762</td>
<td>29.8</td>
<td>4,392</td>
<td>52.6</td>
</tr>
<tr>
<td>Turtle</td>
<td>46</td>
<td>0.2</td>
<td>22</td>
<td>1.2</td>
<td>5</td>
<td>0.1</td>
<td>13</td>
<td>0.2</td>
</tr>
<tr>
<td>Total</td>
<td>25,840</td>
<td>100</td>
<td>1,830</td>
<td>100</td>
<td>5,910</td>
<td>100</td>
<td>8,356</td>
<td>100.1</td>
</tr>
</tbody>
</table>

Table 2 Contribution of various flesh foods to the diet of prehistoric Marquesan peoples. Figures are estimated meat weights expressed in gm. Hanapete’o is a Phase IV site. It is set apart here due to its probable special purpose nature, i.e. Fisherman’s Cave. Note the absence of data from Phase III sites

The data for this exercise are taken from faunal analyses carried out by Kirch (1973) and by Kellum (Skjølsvold 1972:46-50), with the raw shell and bone weights presented by these authors transformed into estimates of edible meat weights following a procedure employed by Kirch (Kirch and Yen 1982:304-5). Transformed in this way the data show some striking trends.

During Phase I the residents of the Hane Dune site ate about 14 meals of sea-bird for every meal of fish, about 39 for every meal of pig, and about 69 for every meal of shellfish and turtle. By Phase II the proportion of sea-bird in the diet had fallen considerably, due most probably to the overexploitation of this once abundant, but extremely vulnerable prey. Shellfish and fish replaced bird on the menu, while turtle and pig were still seldom eaten. There are no data that may be confidently assigned to Phase III, but by Phase IV it is clear that much had changed. The bulk of flesh foods were provided by the long-neglected pig. Bird meat was now an unusual treat. Shellfish and fish continued their secondary roles, and an occasional turtle was captured and cooked. Even at the Fisherman’s Cave at Hanapete’o, where fish was the dominant flesh food in the diet, pig was eaten in considerable quantities.

These data indicate that fish played a secondary role in the diet compared to bird and pig. A better idea of the historical role played by the fishing industry can be gained by comparing trends in the yields from fishing with those from shellfishing and pig husbandry, the two other flesh-food production techniques that were important at the end of Marquesan prehistory. This comparison is made in Table 3, which uses data from Kirch (1973). Kellum’s data from Hanapete’o Cave are excluded due to the probable special-purpose nature of this site and the relatively short temporal duration of its prehistoric use.

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Phase I nos</th>
<th>%</th>
<th>Phase II nos</th>
<th>%</th>
<th>Phase IV nos</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell</td>
<td>294</td>
<td>11.4</td>
<td>532</td>
<td>50.1</td>
<td>1,275</td>
<td>21.6</td>
</tr>
<tr>
<td>Pig</td>
<td>588</td>
<td>22.7</td>
<td>5</td>
<td>0.5</td>
<td>2,868</td>
<td>48.6</td>
</tr>
<tr>
<td>Fish</td>
<td>1,705</td>
<td>65.9</td>
<td>524</td>
<td>49.4</td>
<td>1,762</td>
<td>29.8</td>
</tr>
<tr>
<td>Total</td>
<td>2587</td>
<td>100</td>
<td>1,061</td>
<td>100</td>
<td>5,905</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 3 A comparison of the yields from shellfishing, fishing and pig husbandry through Marquesan prehistory. Figures are estimated meat weights expressed in gm. Data are from Table 2

Phase III was represented at the Hane Dune site (MUH-1) by burials in otherwise culturally sterile sand (Sinoto and Kellum 1965:6-28). Several other sites investigated by Sinoto, but as yet undated, may belong to this phase. Faunal data from Phase III sites are sorely needed. A well-stratified Phase III site ought to yield striking data on changes in diet.
Comparison of the three production techniques reveals a strong development of shellfishing in Phase II and an equally strong intensification of pig husbandry by Phase IV, plainly indicating the crucial roles played by these two industries as bird yields declined and human population grew. By comparison the fishing industry appears not to have experienced a similar period of development, its yields declining steadily against those of shellfishing and pig husbandry. When this lack of development is combined with the data presented earlier for a growing neglect of offshore fishing, it seems clear that Marquesan fishing did indeed suffer a decline over time.

The ecological arguments of Suggs and Kirch appear unable to accommodate data that indicate a decline in the fishing industry. Certainly the proposition that free-ranging and pelagic fisheries were exhausted prehistorically seems extremely unlikely. But why, then, did fisherman restrict their activities so thoroughly to inshore waters? Were social factors at work?

SOCIAL ORGANISATION OF MARQUESAN FISHING

In the late 18th century, when sustained contact with European peoples began, the Marquesans were organised into small, politically autonomous groups known in the literature as tribes (Handy 1923; Dening 1974, 1980). Tribal boundaries occasionally encompassed an entire island. More often they coincided with the natural boundaries of a valley and its bay, while in the larger valleys two or more tribes might live side by side (Delmas 1927; Handy 1923:25-31). Warfare between tribes was endemic and alliances shifted continually. Two tribes in adjacent valleys might be at war one year, then find themselves allied against the people of a third valley the next year. Warfare in the early-contact period was not highly organised, but relied for success on individual exploits, both on the field of battle and during surprise raids by land or by sea against an enemy who had strayed too far from the relative safety of home.

The members of any tribe may be classified according to a number of different criteria, and with each criterion a different grouping of the populace will result. The typical Marquesan tribe had a *tapu* class composed of religious specialists, priests, the chief and certain of his relatives whose access to *mana* gave them various decision-making rights. Each tribe had a propertied class who owned land and fruit trees, as well as a group of *tuhuna*, recognised specialists in ritual, chant, handicrafts, house-building, canoe construction, fishing and other activities. A single person might meet the criteria for inclusion in all three of these classes, as in the case of a chief whose *mana*, extensive breadfruit groves, and skill in manufacturing ornaments from human bone would make him *tapu*, propertied, and a *tuhuna*. On the other end of the social scale would be one who met none of the criteria, dying as he was probably born, with no *mana*, major property, or socially recognised skills. Such an unfortunate person would have been called *kikino* by other Marquesans. In between these two extremes were probably the majority of the tribe's members, who, at one time or another, could lay claim to either *mana*, property, or special skill.

People of the *tapu* class and well-known *tuhuna* appear to have led social lives that transcended tribal boundaries (Handy 1923:144-46; Linton 1923:268; Dening 1974:331-33, 1980:83-84). Sons and daughters of rival chiefs married, cementing alliances that were almost certainly temporary, and the services of renowned *tuhuna* were widely sought. The *kikino* appear to have spent their lives within the confines of a single tribe, for in the ebb and flow of enmity that characterised Marquesan social life, *kikino* were the objects of raids designed to procure victims for sacrifice to the gods. Marquesans referred to these raids metaphorically as fishing (*e ika*) (Dening 1974:255, fn.56, 1980:55; Handy 1923:138).

The early-contact sources all agree that most fishermen belonged to the *kikino* class. Krusenstern, on Robarts' authority, and Langsdorff, who seems to have established a rapport with the Frenchman Kabri (or Cabris), went so far as to claim that fishermen formed their own 'despised' class (Langsdorff 1813:14-120; Krusenstern 1813:163), though this is almost certainly an overstatement. The missionary Crook, perhaps the best 18th century source on both property relations and fishing, gives a few examples of the fisherman's standing within Marquesan society, two of which are considered here.

The first example is Crook's portrait of the fishing village of 'Vennua Tahha' on the inhospitable western end of Nukuhiva Island. The small valley in which the fishermen and their families lived:
... affords neither breadfruit, Cocoa Nuts, nor water, except after rain. The Fishermen, who live in caves that swarm with Musketoes, sometimes climb the neighboring hills to get fern root; but they depend, for everything else beside fish, upon supplies which they obtain at Hakouwe whither they carry their fish to barter, mostly after having baked it, to preserve it from putrefaction [Sheahan 1955:Appendix IV, 1xxi].

The opportunity for establishing a remote fishing village such as Vennua Tahha may not have existed on the smaller or more heavily populated islands, so that this uncomfortable situation may not be typical of the Marquesas as a whole.

The second example, which may more closely describe a recurrent pattern, was recorded by Crook at Taiohae Valley on the south coast of Nukuhiva Island (op cit.:xxii ff.). Here Tahueinue, a younger brother of the valley’s chief, and Pahouahetu, whose own younger brother was married to one of the chief’s sisters, were the tribe’s principal fishermen, with authority to control much of the fishing activity on the bay. This they managed by three means. First was their control over canoes, a piece of equipment vitally important to fishing success along the steeply shelving Marquesan coast. Though Crook provides no exact statistics, he did note that together Tahueinue and Pahouahetu ‘own more canoes than the chief himself’ (ibid), a choice of words that suggests that the chief and the principal fishermen each owned several canoes. This in itself is not too surprising, but how many canoes were there at Taiohae? Krusenstern, who was there for 10 days in May 1804, counted only eight canoes (Krusenstern 1813:110), which, if correct, would give the chief and the principal fishermen with their small fleets a virtual monopoly.

This conclusion is supported by several other lines of evidence. Crook described the regular lot of fishermen as labouring:

... under the control of Persons of Property, who furnish them with Canoes for the purpose of fishing, and barter the fish thus obtained for other needful Articles, out of which they supply the fishermen as they find occasion [Sheahan 1955:Appendix IV, viii].

Thomson, writing in the 1840s, described the act of appropriating the fisherman's catch in rather stark terms. '[N]o sooner is their canoe drawn up [on shore] ... than their fish are seized and but a small portion rewards the labours of the fisherman' (Craig 1978:27). On Tahuata Island Crook himself often angled with a hook and line while swimming because he was unable to secure a canoe (Sheahan 1955:Appendix IV, lxiii), an apparently widespread practice (Dening 1974:133; Krusenstern 1813:110).

The posited scarcity of canoes is indirectly supported by evidence that indicates that Marquesan canoe building was a decadent industry. Robarts, who lived in the Marquesas for nine years, complained frequently about the dearth of seaworthy vessels, and was nearly lost at sea in a dilapidated canoe (Dening 1974:52, 93, 241). Crook stated that:

Marquesan canoes seem to be their worst [productive] performance and are generally acknowledged to be inferior in their construction to those of any group of the Ocean, hitherto discovered [Sheahan 1955:Appendix IV, xxxvii].

an opinion shared by others (Craig 1978:28; Langsdorff 1813-14:173). He noted that the 'Seams of their Canoes open, so as to require constant bailing' (Sheahan 1955:Appendix IV, xxix) and admired the distance from shore that Marquesans dared venture in their small craft. War canoes, with their elaborately carved prows, excited more admiration from Europeans than did the fishing canoes, but the decadent nature of the canoe-building industry was apparently manifest in these top of the line models as well. Porter, who dealt frequently with the local war canoes in attempts to further his imperialistic designs, found them 'not so fleet as might be expected, as our whaleboats could beat them with great ease' (Porter 1823:102).

In addition to their monopoly on canoes, Tahueinue and Pahouahetu controlled fishing on the bay through the exercise of ownership rights over portions of the bay fronting their homes. When they wished to keep others from fishing their waters they merely flew a white flag from a pole stuck in the beach or the nearby shallow waters. The rest of the bay was controlled in this way by Chief Keattonue’s sister and his mother (Sheahan 1955:Appendix IV, xcii ff.), giving the chief’s close family a monopoly on these ownership rights.

The final means by which fishing on the bay was controlled was through the enforcement of tapu against the eating of certain fishes by some members of the tribe. Crook notes the jackfish, skipjack tuna and two unidentified taxa in this regard, while Delmas,
who draws on slightly later sources, lists the eagle ray, freshwater eels, a parrotfish and a jackfish (Sheahan 1955:Appendix IV, ix; Delmas 1927). The tapu against free-ranging and pelagic fishes should come as no surprise given the unequal distribution of canoes within the population. Most kikino fishermen would have had few chances to breach these tapu. Similarly, the tapu against freshwater eels can be seen as the formal expression of existing property relations. Kikino, with no land of their own, would have lived far from the choice riverfront property of their more fortunate tribesmen. The tapu against parrotfish must have been onerous for the kikino fisherman, though, as he would certainly have had the occasion to capture and covet these tasty fish. In general, the tapu against the taking of various fish just reinforced that which was already determined by ownership of the bay and by the monopoly on canoes held by the chief and a close circle of relatives.

Thus, three classes of fishermen plied the waters of Taiohae Bay during the early-contact period. At the top were the two principal fishermen, related by blood and marriage to the valley’s chief, who exercised ownership rights over a substantial portion of the bay and had their own fleet of fishing canoes. These men specialised in the more adventuresome fishing ventures and were said to excel in harpooning rays (Sheahan 1955:Appendix IV, xcii). Beneath this class were the tuhuna avaika, a class of master fishermen without high-placed relatives, some minor property holders who occasionally fished, and perhaps a few kikino, all of whom had forged some sort of alliance with persons of property, thereby gaining access to the scarcer tools of the trade, such as canoes or large nets (Dening 1974:253). At the bottom were the kikino fishermen who, for one reason or another, had no alliance with a property holder and thus were left to make do as best they could. Such fishermen lived at the very edges of tribal society and must have enjoyed few of the benefits accruing to members of the tribe. Often the lives of kikino fishermen must have ended rather ironically at the hands of an enemy out fishing for men.

The ethnographic data support the picture of a poorly developed Marquesan fishing industry, a curious state of affairs in a place where drought frequently crippled terrestrial food production. There can be little question about the ready availability of manpower for fishing projects, but the lopsided distribution of tools and ownership rights kept this labour underutilised. The fishing that did take place must have been hindered by the inferiority of the typical fishing canoe and the restricted range and size of fish hooks, two tools of crucial importance in the Marquesan marine environment. Instead of designing and manufacturing a fine fleet of fishing vessels and employing an underutilised labour force to harvest the spontaneous products of the sea, a small group of influential men apparently monopolised a paltry collection of leaky dugout canoes for their own use and enjoyment. When the droughts came people starved.

A BRIEF COMPARISON

The organisation and decadence of the Marquesan fishing industry contrast strongly with other Polynesian island groups, where chiefs and other men of influence worked to support the development of fishing tools, facilities and techniques. The Hawaiian Islands provide a particularly vivid contrast to the Marquesas in this respect.

In Hawaii the role of chiefs in the fishing industry was felt most keenly in two areas: (a) the development of coastal fish ponds and (b) the active pursuit of schooling pelagic fish such as the tuna. At the time of Cook’s visit in 1778 there were about 360 productive fish ponds in the Hawaiian Islands (Summers 1964; Kikuchi 1976). While some of these were relatively small and easily maintained, many were large enough to have required the labour of thousands under the direction of a chief for their construction. The Hawaiian historian Kamakau lists several fish ponds where Kamehameha I directed repairs and reconstruction (Kamakau 1976:47). Stocked primarily with mullet, tenpounder and milkfish, Hawaiian fish ponds were capable of producing over 1,000,000 kg of fish each year. The bulk of the yield went to feed the chiefs and their burgeoning retinues, a practice reminiscent of fish distribution in the Marquesas, but which actually had the effect of protecting the viability of the inshore fisheries upon which the common people depended.

The organisational requirements and expenses involved in outfitting and completing a successful pelagic fishing sortie made it difficult for the common man to take a leading role. The proper tools had to be manufactured, the most time-consuming and difficult of which was undoubtedly the open ocean canoe. In Hawaii the entire manufacturing process, from choosing the proper tree from which to hew the hull, to launching the completed vessel,
was attended and presided over by one or more *kahuna* who excelled in the various tasks to be performed. The labour of these skilled specialists did not come cheaply. Tasks such as shaping the hull and assembling the canoe were ‘a great deal of work, and many pigs, dogs, tapas, nets and other articles had to be given in return’ for labour (op cit.:121). These payments were beyond the means of most men, but those who could afford them shouldered the burden with pleasure for the prestige it offered. ‘Fishing for *aku* [skipjack tuna] was greatly enjoyed by the chiefs and rulers in the old days ... Kamehameha I was accustomed to fishing for these fishes’ (op cit.:75). The catch from these sortsies was often so great that there was no question of it all being appropriated by the chief and his followers. When canoes loaded with *aku* came in,

... there would be trading, peddling, and paying for *poi*, for pounded taro, sweet potatoes, bananas, sugar cane, breadfruit, and other kinds of food; for *awa* [Piper *methysticum*], tapa, *piʻu* [woman’s skirt], *malo* [man’s loincloth], and mats (op cit.:73).

In this way fish were distributed throughout the community.

Regardless of the great pleasure that many Hawaiian chiefs found in fishing, and the great quantities of wealth that they must have invested in fishing tools and facilities, they did not monopolise access to the tools of the fisherman’s trade as did Marquesan chiefs. Early European visitors to Hawaii were impressed by the number of canoes that gathered about their ships (Beaglehole 1967:489, 1158). No dearth of seaworthy vessels here, and as the following quote from Kamakau suggests, there were few institutionalised obstacles to obtaining either a canoe or some other piece of fishing equipment.

If a fisherman were a landholder or a chief, or a descendant of a fisherman, or a son in a family which had ‘*aumakua* [family gods] of fishing, then he could be a true fisherman with no lack of long canoes, short canoes, light, swift canoes, large and small nets, and long and short fishing lines. He would have everything he needed, and there would be nothing to stop him [Kamakau 1976:59].

This comparison between Hawaii and the Marquesas is unfair in the respect that the Marquesas offered extremely limited areas in which fish ponds could be constructed. Aquaculture was not really a viable alternative in the Marquesas. The obstacles facing a Marquesan chief and his people who wished to go fishing for free-ranging and pelagic species are not so obvious, though. Why did this sector of the industry decline in the Marquesas? Several factors may have played a role; the fragmented social and political climate may have meant chiefs were unable to ensure that fishermen would be safe from attack at sea, or that the services of a skilful canoe-building *tuhuna* were difficult to procure. Perhaps breadfruit trees were too important as food producers to sacrifice for canoe wood. But whatever the causes, the backward nature of the contact-era Marquesan fishing industry remains a puzzling fact. How did things get this way?

**SOCIAL PREHISTORY AND THE MARQUESAN FISHING INDUSTRY**

Two features of contact-era Marquesan fishing stand out in bold relief; the concentration of tools and access to resources in the hands of a select few, and the severe limitations imposed by the crudity and lack of diversity in fishing tools. A consideration of how these features developed will take the discussion beyond the fishing industry proper to certain facets of the terrestrial production system. This is unavoidable. Marine and terrestrial production in the Marquesas, as elsewhere, were integrated by a set of social relations whose development was not restricted to either land or sea matters. These developments in social relations were uniquely Marquesan in character and provide one example of the myriad possible developmental pathways open to Polynesian societies.

The first step in this development took place during Suggs’ long developmental period with the establishment of extensive breadfruit groves in the valleys (Suggs 1961:181-82). Extensive breadfruit groves were a necessary precondition for the high level of *ma* production that characterised the islands in the contact era. Late Phase II is probably the earliest time that communal *ma* pits could have been an important component of the subsistence strategy. The excavation and use of communal *ma* pits would have had two major social effects. First, the *ma* would have served to buffer the effects of drought, thereby helping to sustain population increases. Second, creation of a novel resource of such crucial importance would have posed problems of how to organise its production, maintenance and distribution. Any number of different forms of decision-making body
could have handled these tasks. But more important than the successive forms that such a body took, is the opportunity that ma pits offered for abusing their control by turning their use to personal, rather than community, ends. This kind of abuse, so apparent at the time of Roberts' visit, is easier to perpetrate with a spatially restricted, long-lasting resource like ma, than it is with a resource like ripe, unprocessed breadfruit which is widely distributed and rots quickly if not harvested on schedule.

As the Marquesans expanded their breadfruit groves the yield of sea-birds began to decline, due perhaps in part to the loss of valley forest roosting grounds. The slack in the diet caused by this decline appears to have been taken up by increased attention to the shellfishing industry, which expanded rapidly in Phase II. Offshore fishing was still a viable industry and the general impression left by the faunal data is that the quest for food at this time was both efficient and sufficient to meet the needs of the people. Once again, however, the possibilities for controlling a valuable resource increased, as the shallow water habitat of shellfish was much more areally restricted, and thus easier to control, than were sea-bird nesting grounds.

Faunal data from Phase III are nonexistent, but given the magnitude of changes between Phase II and Phase IV it is easy to speculate on what must have happened at this time. Two trends stand out; pig husbandry experienced a period of intense development while the fishing industry's offshore component underwent a startling decline. With the rise in pig husbandry a trend that had begun with the decline of sea-birds in Phase II culminated, for among the Marquesan flesh foods the production of pigs is certainly the easiest to monopolise. One might attempt to argue that the development of pig husbandry in the Marquesas was akin to the development of fish ponds in Hawaii. Such an argument would contend that pig production would have eased the level of predation on other resources, enabling kikino to gather richer harvests than otherwise would have been the case. But this argument would have to ignore the fact that pigs, in contrast to pond fishes, compete with man for food (Rappaport 1968). There can be little doubt that the development of pig husbandry in the Marquesas was not an efficient solution to the imbalances between food supply and population brought on by droughts, but rather served to benefit a privileged few. When future excavations in the Marquesas gather faunal data from Phase III sites the rising importance of pig in the diet will provide a good index to the growth of marked material differences within Marquesan society.

Future research should also provide better temporal definition for the decline in offshore fishing, and with it the demise of the Marquesan canoe. The two undoubtedly went hand in hand, with social and political obstacles to offshore fishing sapping incentives to build seaworthy canoes and slumps in canoe performance crippling yields of pelagic fishing sorts. At some point in Marquesan prehistory pelagic fishing represented a losing proposition, with risks far outstripping possible gains. This is the situation represented by the faunal figures for late sites in Table 1.

The decline in offshore fishing by Phase IV is clear, but two questions remain. First, why did harpoon heads, a tool linked in Western minds with the capture of whales and sea mammals, and requiring a seaworthy canoe for its application, persist throughout the prehistoric sequence (Sinoto 1979:123-25; Suggs 1961:95)? If canoes had indeed deteriorated, why did not harpoon heads go the way of the rotating hook? The answer appears to lie in the fact that Marquesan harpoons were used not only for capturing marine mammals, such as the porpoise whose bones are found primarily in early deposits (Kirch 1973:37, Fig.3.), but also for taking sharks and rays inside the bay (Craig 1978:14). At Taiohae Bay, according to Crook, this type of fishing was carried out by the principal fishermen, a piece of information that fits well with the widespread practice on Nukuhiva of placing a tapu on the capture of rays (Delmas 1927)4. Putting these data together it seems reasonable to suggest that by Phase IV harpoons were restricted to use by the upper classes. If this were so then the sharks and rays that made up the bulk of free-ranging and pelagic taxa in the Phase IV catch would not be evidence for continued strength in offshore fishing, but more an indication that the principal fishermen monopolised access to canoes. The fact that no shark or ray bones could be identified from the deposits of the Fisherman's Cave at Hanapete'o adds further support to this interpretation.

4The ray in question is the heheimanu, or heheimanu (Aetobatis narinari) (see Lavondes and Randall 1978:82).
The second question has to do with another case of persistence, this time of the compound shank hook. If the functional interpretation of the compound shank hook as a lure for skipjack fishing from the bow of a canoe is correct, then its persistence and the decline of the bonito lure hook may be bound up with the demise of the Marquesan canoe. As canoes became less and less seaworthy it would have become increasingly difficult to troll for pelagic fish. These fish would have continued to frequent the Marquesan waters, occasionally venturing into the deep bays where they may have surprised fishermen engaged in bottom-fishing. Lacking the means to chase after the quick-swimming schools, fishermen would have had to content themselves with casting a compound shank hook into the midst of a passing school from their near stationary canoes. Such a scenario could well account for the small numbers of schooling pelagic fish identified from late-period sites.

Changes in the Marquesan fish hook sequence were thus due to a variety of social and ecological factors. Soon after initial settlement, Marquesan fishermen experimented with, and developed, a wide range of fish hooks in order to exploit fully a marine environment sorely lacking both in reefs and broad expanses of shoal water. The wide range of fish taxa recovered from early period sites strongly suggests that this phase of experimentation yielded a number of successful hook types. In the early portion of Marquesan prehistory fishermen were productive members of society, harvesting seafood in what was, for Polynesia, an unfavourable marine environment. At some time during Phase III the fisherman's lot became more tenuous. The exact sequence of events is not yet apparent, but several mutually reinforcing trends began to cripple the fishing industry. Enemy tribesmen, out fishing for men, began to capture fishermen who had strayed too far from the relatively safe confines of their own bay. The deteriorating political conditions indicated by such brazen acts of aggression made it difficult to find a friendly tuhuna truly skilled in the art of canoe construction. Adding to these difficulties, local chiefs and their close relatives began to exercise increasing control over the relatively safe nearshore waters and to use their relative social freedom to gain privileged access to competent tuhuna. As the material differences within Marquesan society widened, and the consequences of membership in one class or another came to spell the difference between life and death during a drought, it became nearly impossible for the average fisherman to find a decent canoe from which to fish. The rotating hooks that had once landed powerful jackfishes were of little use now. Small jabbing hooks were sufficient to land the weak little inshore fish that made up the bulk of the catch. Fishermen, whose catch was now but a shadow of that reaped by their forefathers, could no longer produce food for their society, and lacking the perquisites of chiefs were mistakenly regarded as a despised class. The change in Marquesan fish hooks witnessed in the archaeological record does not reflect a process of adaptation to the marine environment. It documents instead the rise of a class system that, in the end, came to define who would live and who would die when droughts ravaged the land.

These conclusions accord well with Suggs' contention, based partially on construction sequences of ridge-top fortifications, that the Marquesan political system began to develop its contact-era form during the Expansion period (Suggs 1960:120, 1961:183). His suggestion that the Classic period represented an 'efflorescence' of Marquesan culture based upon optimal productivity, large population and efficient political organisation (Suggs 1960:128) must certainly be rejected in the light of the faunal and ethnographic data presented above. Instead, these data point to the more interesting conclusion that Marquesan culture, especially in its artistic expression, flowered at a time when small valley societies turned increasingly in upon themselves, and people of power exercised ever greater control over the means by which Marquesans produced their livelihood.

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REFERENCES


Anell, B. 1955 *Contribution to the History of Fishing in the Southern Seas*. Studia Ethnographica Upsaliensia, IX: Uppsala


Cummings, H. 1973 *The Distribution of Compound Fishhook Types as a Gauge of Population Interaction in the Solomon Islands*. Field Museum of Natural History: Chicago, Solomon Island Studies in Human Biogeography, No.1

Delmas, S. 1927 *La religion ou le Paganisme des Marquisiens*. Beauchesne: Paris


Fowler, H.W. 1955 *Archaeological Fish bones Collected by E.W. Gifford in Fiji*. Bishop Museum: Honolulu, Bulletin 214


Handy, E.S.C. 1923 *The Native Culture in the Marquesas*. Bishop Museum: Honolulu, Bulletin 9


Kirch, P.V. 1973 Prehistoric subsistence patterns in the northern Marquesas Islands, French Polynesia. *Archaeology and Physical Anthropology in Oceania* 8:24-40


Linton, R. 1925 *Archaeology of the Marquesas Islands*. Bishop Museum: Honolulu, Bulletin 23


Porter, D. 1823 *Journal of a Cruise made to the Pacific Ocean ... in the Years 1812, 1813 and 1814*. Sir Richard Phillips: London


Sinoto, Y.H and M.J. Kellum 1965 Preliminary report on excavations in the Marquesas Islands, French Polynesia. Department of Anthropology, B.P. Bishop Museum, Honolulu (mimeo)

Skjølsvold, A. 1972 *Excavations of a Habitation Cave, Hanapete'o, Hiva Oa, Marquesas Islands.* Department of Anthropology, Bishop Museum: Honolulu, Pacific Anthropological Records 16


Summers, C.C. 1964 *Hawaiian Fish Ponds.* Bishop Museum: Honolulu, Special Publication 52
Humans, in the process of reordering nature to make appendages of the parts that are relevant to their existence (Murphy 1970:169), commonly embrace harsh and inhospitable environments at the margins of the earth. Some of these 'regions of difficulty' (Fleure 1919) are by definition 'non-subsistence' environments, at least in the way that the term is still commonly used to refer to survival in the provision of food, clothing and shelter. Of the relatively few such environments in the Pacific, the summit region of Mauna Kea (White Mountain), the highest (4205 m) and second largest of five massive shield volcanoes that form the island of Hawaii (Fig.1), is one of the most interesting and significant. The centre of interest is a large adze quarry which has been the subject of ongoing archaeological investigations since 1975 (McCoy 1976, 1977, ms.f; McCoy and Gould 1977; Allen 1981; Cleghorn 1982).

The purpose of this paper is to discuss natural and cultural factors of production in this quarry industry. My primary concern is with 'giving meaning to the archaeological record' in terms of what can be inferred regarding the internal dynamics of the manufacturing process and the quarry industry as a social process. The discussion begins with a consideration of the environmental setting and definition of the 'effective environment' as a 'non-subsistence environment'. The second part of the paper is devoted to interpreting selected aspects of the archaeological record relating to production strategies, site structure, activity pattern differentiation, and settlement and subsistence patterns. The focus of attention is on natural and cultural constraints, beginning with a characterisation of the raw material source as a series of 'patches' which are then defined in archaeological terms as 'production zones'. The several different analyses of intersite assemblage variability that follow employ the production zone concept. The paper concludes with a brief consideration of the sociopolitical context of the quarry industry viewed in terms of (a) the probable relationships between the quarry and other production systems, canoe manufacture and the development of agricultural systems in particular; and (b) a rather unconventional perspective on 'origins' and some of the implications that a knowledge of antecedent historical conditions and 'social facts' have in interpreting the structure and practice of the quarry industry.

Subsistence and the natural/cultural dichotomy

In equating subsistence with production in the title of this paper I am arguing like many other anthropologists that 'subsistence' should not be thought of in terms of food alone, but instead should be broadened to include aspects of the appropriation of nature such as tool manufacture (Ellen 1982:174; Ingold 1987). In maintaining the neo-Kantian distinction between natural and cultural systems I am following in the footsteps of any number of social thinkers, including Victor Turner, who himself acknowledged a debt to the Polish sociologist Znaniecki in expressing the difference between the two systems:

Natural systems, Znaniecki always argued, are objectively given and exist independently of the experience and activity of men. Cultural systems, on the contrary, depend not only for their meaning but also for their existence upon the participation of conscious, volitional human agents and upon men's continuing and potentially changing relations with one another [Turner 1974:32].

There are, of course, any number of difficulties in employing this dichotomy because As Claude Levi-Strauss has pointed out, we live at the edge of a paradox: we

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belong both to Nature and Culture, and we perpetually struggle to announce and renounce that ambivalent condition ... [Myerhoff 1982:109].

I find the natural/cultural distinction useful if for no other reason than drawing attention to the fact that the environment can never be taken for granted (Butzer 1982:4) or left out of account (Gellner 1973:198). There are, for example, different types of 'material realities', including some like climate, which 'remains outside the direct or indirect sway of humankind, but never ceases to affect it' (Godelier 1986:4).
I do not mean to imply in the use of the natural/cultural dichotomy the separation of the material and the social, or the material and the ideal (see Sahlins 1976:205-6, 1985b:154; Godelier 1986:5). All of these exist simultaneously and yet it is clear that a quarry has an 'earthly basis' as well as a 'cultural basis', and that the first is not totally encompassed in the latter as with, for example, climate and the constraints of raw material properties on tool morphology (Isaac 1972, 1977a). Contrary to the opinion of some I do not think it possible to factor out so much 'natural' and so much 'cultural'.

Quarry production systems

The extent to which the archaeological record imposes itself on archaeological concepts (Clarke 1973:14) is perhaps nowhere more apparent than in the case of stone tool quarries (Ericson and Purdy 1984; Torrence 1986) which often tend to be viewed, I think, in narrow utilitarian terms as: (a) adaptive responses to a pervasive environmental 'selection pressure' in the uneven and oftentimes highly localised occurrence of tool-quality stone (Crabtree 1975:108); and (b) nothing more than 'special purpose' sites related to the fulfilment of basic functional needs and 'embedded' in the logistics of food-getting activities (see Gould and Saggers 1985; Binford and Stone 1985). The reasons for such views are easy to understand, since the archaeological record of many quarries consists of little more than manufacturing by-products and tools, thus making social inferences extremely difficult. Isaac was correct to emphasise in this regard that:

... archaeology is not well served by unrealistic attempts to squeeze too much blood from stones alone. We need to concentrate our efforts on situations where the stones are only part of a diverse record of mutually related traces of behaviour and adaptation [Isaac 1977b:11].

One such 'situation' is the Mauna Kea adze quarry where there are mutually related traces of extractive and maintenance activities, including food residues and personal gear items. Work residues are not limited to manufacturing by-products, but also include the remains of ritual behaviour, thus providing an opportunity rarely afforded in quarries to elucidate the place of ritual in the production process (Firth 1965:168-86). In the process of attempting to give meaning to these various residues I have taken issue with some claims regarding the degree of standardisation in the manufacturing process and the extent to which standardisation can be accepted as an unambiguous signature of craft specialisation. I do not doubt that the adze makers were craft specialists, but I do have hesitations concerning norms and rule-bound behaviour. In this I side with Bourdieu (1977) and Giddens (1979, 1981) in the view that there is a recursive relationship between structure and practice (see Hodder 1986:70-71; Shanks and Tilley 1987:45). Stone tool production systems such as the Mauna Kea adze quarry industry represent in my view a preeminent form of social action, and as such they cannot be completely understood in static structural-functional terms. Turner expressed it best in saying that 'The social world is a world in becoming, not a world in being ...' (Turner 1974:24), though he in fact recognised the need for both 'being' and 'becoming' vocabularies in the study of social dynamics.

ENVIRONMENTAL SETTING

The environment on the upper slopes of Mauna Kea evinces similarities to other high mountains, including the marked interdependency of biotic and abiotic processes that has given rise to the term geoecology in the recent literature on arctic and alpine environments (Troll 1972; Winterhalder and Thomas 1978; Webber 1979). The complexities that the term geoecology engenders prevent a total environmental analysis in a paper of this length. I have thus chosen to focus attention on the description of what I believe to be the most relevant biogeoclimatic characteristics for understanding the archaeological record of the quarry industry. The discussion begins with an overview of general environmental characteristics, followed by an equally brief consideration of altitudinal variability in topography, hydrology, vegetation and animal life within the quarry complex. The discussion concludes with a summary of the 'effective environment' and a set of predictions regarding coping behaviours and environmental influences on the organisation of work.

General environmental characteristics

Mauna Kea is the only known mountain in the tropical mid-Pacific with evidence of Pleistocene glaciation (Daly 1910; Porter 1975, 1979b, 1979c, 1987). A succession of glacial
drift sheets is exposed between the ca. 2800 and 4200 m elevations (Porter 1972:1459). The presence of fossil ice (permafrost) in the summit region is further testimony to earlier glacial conditions (Woodcock et al. 1970; Woodcock 1974). The summit now lies below snowline and as a result there are no extant glaciers.

The climate of the higher elevations on Mauna Kea is like all mountain climates, kaleidoscopic, consisting of a great number of individual elements that are continually changing through space and time. It exhibits all of the universal changes that occur in the atmosphere with increasing altitude (e.g. decreasing temperature, air density and water vapour) in addition to local effects directly related to latitude and the 'mountain mass effect' (Barry 1981; Price 1981). At this latitude (19-20°N) there is little difference in the mean minimum and mean maximum temperature ranges throughout the year in contrast to pronounced diurnal variation. Precipitation at the higher elevations frequently averages less than 25 mm in every month of the year, primarily in the form of sleet, hail and snow, which rarely accumulates below the 3050 m elevation, however. The prevailing winds are from the east-northeast. Fog and other forms of ground condensation are not uncommon and appear to be generally associated with increased cloudiness at midday (Powers and Wentworth 1941).

The biota is predictably impoverished in this oceanic, high mountain ecosystem as the result of extreme isolation which is reflected in a high degree of endemism among a few closely related taxa. The alpine ecosystem on Mauna Kea, as with all high mountain ecosystems, is 'at the upper ends of environmental and evolutionary gradients that originate in the surrounding lowlands' (Billings 1979:101).

Altitudinal variability

The quarry encompasses within an altitudinal range of some 1340 m (or more, depending on how the boundaries are defined) two major ecosystems, a stony alpine desert and a subalpine forest. The boundary between the two is treeline which varies between the roughly 2900 and 3050 m elevations. The alpine desert as presently defined corresponds to what Allen refers to as the alpine tundra and subalpine scrub zones, while the subalpine forest is equivalent to her mountain parkland (Allen 1981:45). Given the problems in defining altitudinal zonation in tropical high mountain environments (Whiteaker 1978), I have opted to describe environmental variability in terms of what I generally refer to as the 'lower' quarry area and the 'upper' or 'main' quarry area. The boundary that separates the two is a major topographic break between steep slopes and a broad summit plateau on which the majority of sites are located (Figs 2-3). Most of the few known sites in the lower area are concentrated just above treeline in the alpine desert.

Upper quarry environment

Above the 3353 m elevation the slopes decrease to form a gently domed summit plateau (Gregory and Wentworth 1937:1724) on which is found a number of massive volcanic cones (Fig. 2). Lake Waiau (Fig. 3), the only permanent body of water on the plateau and one of the few lakes in Hawaii (Maciolek 1982), is perched in a glacially scoured cone. Two intermittent streams, Pohakuloa Gulch and Waikahalulu Gulch (Fig. 3), originate in the environs of the lake which contains in the bottom sediments a fossil diatom flora showing possible human influences (Massey 1978). Both gulches are narrow and shallow on the plateau. The effects of glaciation on the topography of the summit plateau is clear in this description by Porter of the landscape above the limits of the latest ice-cap:

> Behind the belt of end moraines lies a broad zone of dominantly erosional topography irregularly mantled by thin patches of drift. Within this zone, lava-flow surfaces have been abraded into stoss-and-lee forms and are extensively striated, and the flanks of cinder cones have been oversteepened by glacial erosion so they stand at angles of 30 to 34°, instead of the more typical 24 to 26° (Porter 1972) [Porter 1975:247].

The stoss-and-lee forms to which Porter refers are roches moutonées (Davies 1972:171), also commonly known as 'whaleback ridges' (Porter 1975:247) and 'muttonback ridges'. The soils in the summit region, like those in alpine environments generally, are poorly developed (Ugolini n.d.). In the absence of a vegetative cover and, thus, a surface organic layer, the ground surface in many places is a desert pavement (Ugolini 1974:189).

The climate on the upper slopes of the mountain is periglacial, a term that is inconsistently used with reference to a variety of cold climates as well as geomorphological
regimes (Davies 1972:9; Embleton and King 1975:2). Mauna Kea is an example of what Tricart (1970) has called the 'low latitude mountain variety' of periglacial climate. There are frequent frosts but they are of low magnitude or intensity, penetrating to only shallow depths (Davies 1972:13).

Mechanical weathering by frost is the most important mass-movement process in the periglacial regime and attains real significance in landscape evolution in the absence of trees (Caine 1974; Davies 1972:11). On current evidence the effective lower limit of this regime on Mauna Kea is treeline (Ugolini n.d.). The primary evidence of a periglacial climate and geomorphic processes is the occurrence of diverse forms of patterned ground, such as stone stripes and polygons, that are widespread in the cold regions of the world (Washburn 1956, 1979). The most common type of mass-movement landform in the summit region of Mauna Kea is the stone-banked terrace or lobe (Davies 1972:49-51) which myself and others have inconsistently called either solifluction or gelifluction terraces and lobes. Here I follow Washburn (1979) and Embleton and King (1975:97) who have noted the advantage of the term gelifluction in clearly denoting a periglacial regime as opposed to other climatic regimes, including low elevation deserts, where similar forms of patterned ground are also found (Cooke and Warren 1973:129).

The vegetation above the 3000 m elevation has been classified as a semi-arid, barren alpine tundra (Krajina 1963). It consists of lichens, mosses, and a few bunch grasses such as *Trisetum glomeratum* and *Agrostis sandwicensis* (Hartt and Neal 1940; Krajina 1963; Mueller-Dombois and Krajina 1968; Smith et al. ms.). A lower xerophytic scrub zone, extending down as far as the 2100 m elevation, is characterised by the presence of *Styphelia douglasii*, *Vaccinium peleanum* and *Coprosma* spp. In addition to the higher elevation species. There is some evidence, including our own discovery, in the quarry of the remains of a silversword.
colony (*Argyroxyphium sandwicense*) at the 3475-3658 m elevation, that this zone formerly contained a much richer flora such as the arborescent Dubautias (Allen 1981:46).

In the summit region there is an 'aeolian zone' occupied by a variety of insects (Howarth and Montgomery 1980; Papp 1981) that are believed to have been the only resident fauna in the alpine desert prior to European contact.

**Lower quarry environment**

The lower reaches of the quarry is an area of predominantly steep topography. In one of the early reports on the glacial geology of Mauna Kea, Gregory and Wentworth (1937:1724) wrote ‘between 11,000 and 7,000 feet, the general gradient is 1,600 feet, with a few small areas as steep as 2,000 feet, a mile’. The general lack of deep radial valleys on slopes that average nearly 40% in many places has been attributed to a combination of low rainfall and porous soils. Pohakuloa and Waikahalulu, the only substantial gulches on the southwest flank of the mountain, attain a maximum depth of roughly 30-90 m between the 2438-3353 m elevations (Wentworth and Powers 1941:1198). Water is not totally lacking and in fact...
there are a number of springs and seeps perched in glacial drift deposits above and below
treeline (Wentworth and Powers 1943).

*Sophora chrysophylla* (Hawaiian mamane) and *Myoporum sandwicense* (Hawaiian naio) are
the dominant species of the treeline vegetation on the southwest flank of the mountain. Herbaceous fog-drip communities comprised of mostly introduced species occur beneath
the larger, scattered mamane trees which form a distinctive mountain parkland (Mueller-
Dombois and Krajina 1968). There are clear indications that this dryland forest at one time
contained many more species, such as *Santalum ellipticum*, *Euphorbia olowaluana* and
*Dubautia arbores*, which are presently confined to small pockets or refugia away from the

Two species of birds, the Hawaiian goose (*Nesochen sandvicensis*; Hawaiian nene) and the
dark-rumped petrel (*Pterodroma phaeopygia sandwichensis*; Hawaiian ‘ua’u) are reported as
having been seasonally abundant in the interior uplands. Henshaw (1902:102) was told that
the ‘ua’u formerly nested in great numbers in the saddle between Mauna Kea and Mauna
Loa. The nene is described as having moved between the lowlands and uplands in response
to seasonal changes in the availability of certain foods. According to Baldwin (1945, 1947:108) the Hawaiian goose spent the summer months above the 1525 m elevation feeding
on grasses and berries. The Hawaiian honeycreepers (*Drepanidinae*), some of which are
found in the dryland forest on the south flank of Mauna Kea (Scott et al. 1986), also
appeared to have moved between the lowlands and uplands in response to the flowering of
the ‘ohi’a tree (*Metrosideros macropus*; Hawaiian lehua). Emerson (1894:104) claims that they
were in the uplands from August to October and possibly into November.

The effective environment

A discussion of the 'effective environment' (Netting 1971; Smith and Winterhalder
1981:8) of the main quarry area is hampered to some extent by the lack of
palaeoenvironmental data on climate and vegetation. Porter has noted the lack of evidence
for renewed glaciation since the disappearance of the last ice cap more than 9100 years ago,
while simultaneously suggesting the possibility of a recent change to a colder and/or wetter
climate during the last 1000 years based on his interpretation of the chronology of
gelifluction lobe development in the main quarry area (Porter 1975:250, 1979b:184-85). The
excavation of several gelifluction lobes in 1975 and 1976 (McCoy and Ugolini field notes)
provided additional evidence in support of Porter's conclusion while also indicating cyclical
periods of gelifluction throughout what we believe to be the whole of the Holocene.

On current evidence the 'effective environment' of the main quarry area has been,
throughout its known history, a periglacial environment. For humans it is a particularly
difficult environment in which to work and live because of the physiological effects of high
altitude (Van Wie 1974), low temperatures and biotic impoverishment. It is at the same time
a highly predictable environment in terms of the probable effects of these and other stresses
on work organisation and subsistence, leading to the expectation of a major concern with
time-budgeting and efficiency (Torrence 1983).

Apart from the fact that most forms of Hawaiian craft specialisation were probably part-
time professions, there are a variety of ecological reasons to predict that: (a) the operation of
this particular quarry industry was short-term seasonal work; and (b) the rhythm,
sequencing and duration of work in a single season were constrained in a manner and to a
degree quite unlike the situation that would have obtained in any other Hawaiian adze
quarry.

Of all the known stresses that would have affected the organisation of work perhaps the
most important is the condition known as high altitude hypoxia produced by the reduction
in partial atmospheric pressure. The effect is a significant decrease in aerobic working
capacity and, thus, output (Grover 1974, 1979). Within the boundaries of the quarry the
aerobic working capacity, which is reduced 10% with each 1000 m increase in altitude above
1500 m, varies between 82-77% of the value at sea level. One consequence is impaired
mental and mechanical functions, which may have been one causal factor of a seemingly
rapid debitage accumulation rate. The predictable response to hypoxic stress is obviously
minimal energy expenditure - short periods of sustained hard work and longer periods of
low activity.

While weather is without a doubt the great condition of human existence, standing for
all other conditions (Glassie 1982:325), it is the degree of biotic impoverishment that stands
out here as the most obvious conditioning factor of production. The quarry environment is
above all else a 'non-subsistence' environment, incapable of supporting a population of any size for any length of time without the introduction of food, clothing and firewood. The only sources of fuel above treeline are the few arborescent plants and silverswords (Westervelt 1902:15) which would have been hardly adequate or sufficient in terms of the amount of heat they give off and their long-term availability. The biotic environment is an undependable resource and in fact the only subsistence requirement that this environment afforded in any abundance were the margins of lava flows that could be utilised as shelters.

THE ARCHAEOLOGICAL RECORD

Quarry size and chronology

The first systematic archaeological investigations of the Mauna Kea adze quarry, in 1975-76, defined a site complex encompassing an area of some 12 km$^2$ between the 2620-3962 m elevations (McCoy 1977; McCoy and Gould 1977). Recent fieldwork indicates an area well in excess of this figure (McCoy ms.f). The boundaries of the quarry have become increasingly blurred over time with the discovery of new sites. Some, like the Pu'u Kalepeamoa site (McCoy ms.e, in prep.), contain adze manufacturing by-products but are located well beyond the source of raw material and other known sites, most of which are found within the screened area in Figure 3. On present evidence the Mauna Kea adze quarry covers more area and contains a larger volume of debitage than all of the other known adze quarries in the Hawaiian Islands combined (Cleghorn et al. 1985).

A suite of 23 radiocarbon dates from eight excavated sites (Fig.3) indicate that the quarry industry spanned a period of some 700 years between ca. AD 1100-1800 (Fig.4). A lower limiting date of perhaps AD 800-1000 seems likely based on the interpretation of stratigraphic evidence from several of the excavated rockshelters. The basal layer of Ko'oko'olau rockshelter no. 1, for example, is undated and where test excavations have been undertaken exterior of the dripline there is an indication of earlier activity. With regard to an upper limiting or terminal date, there is archaeological as well as ethnohistoric evidence (McEldowney ms.7) suggesting that the quarry may have been abandoned prior to first known European contact in 1778 and the ensuing rapid replacement of stone adzes with...
metal counterparts. In any event, by 1793-94 there was a surplus of metal and the chiefs were apparently no longer interested in trading for iron tools such as adzes (Sahlins 1981:44).

The raw material source

The most obvious materialistic ‘explanation’ for the vast areal extent of this quarry and chronology of long-term repeated use is the quality and quantity of the raw material. The boundaries of the quarry, as presently known, coincide with the occurrence of a fine-grained rock called hawaiite, which is the dominant lithology in all of the younger lavas on Mauna Kea (Porter 1979c). The primary source of this material is what Porter (1979c, 1987) believes to be the front margin of a subglacially erupted flow that forms an escarpment at the 3720-3780 m elevation in the vicinity of Pu‘u Ko‘oko‘olau (Figs 2, 5). Porter has described this flow, referred to as the Puu Waiau flow in his 1987 paper, as follows:

- Its downslope margin forms a discontinuous but abrupt cliff, locally embayed and commonly 15 to 25 m high (Fig.15). The flow consists of a dark-gray dense nonporphyritic and nonvesicular hawaiite with well-developed intersecting joint planes that result in distinctive and rather symmetrical blocks of various sizes. The early Hawaiians quarried this flow extensively for adze blanks, because the dense aphanitic nature of the rock and its prominent jointing were ideally suited for their lithic industry (Fig.4, loc.10, Table 1). The large concentration of quarry sites along the steep flow margin suggests that the special properties of the rock that the Hawaiians found so desirable may be due, in part, to the unique eruptive conditions and cooling history of the flows [Porter 1979c:1034].

- The flow, which is very fine-grained and hard, fractures into slabs appropriate for such artifacts [adzes] and apparently was ideal for stone working. Its glassy groundmass contains randomly oriented microlites of plagioclase, rather than fully developed crystals, making the rock tougher than other flows and therefore easier to shape [Porter 1987:592].

Porter’s interpretation of the escarpment as the ice-contact terminus of a subglacially erupted flow has been recently questioned by Wolfe (ms.:30) who believes that it is an eruptive centre rather than the front of a flow. New potassium-argon (K/Ar) dates indicate that this and other flows are more recent than earlier reported (Porter et al. ms.:10 -11). The escarpment, whatever its origin, is according to Wolfe (ms.) the upper elevation limit of a series of older mafic hawaiite flows which are distinguished from younger felsic hawaiite flows. There is no evidence that the Hawaiians exploited the younger flows for adze-quality material.

The quarry is not localised to the escarpment, however, contra the impression given in Porter’s descriptions and maps (Porter 1979c, 1987:592, Fig.21.3). Secondary sources of tool-quality hawaiite are found in other flows and in glacial drift deposits below the escarpment (McCoy ms.d, ms.f; Wolfe ms.). The large area of the quarry is in fact directly related to the distribution of these glacial drift deposits which include moraines and outwash deposits of different ages. The older drift, labelled the Waihu Glacial Member, is exposed mainly below the 3350 m elevation. The younger Makanaka Glacial Member is comprised of two bodies of drift (Fig.5) which as a whole is less indurated than the Waihu deposits (Porter 1987:588-89). All three drifts contain hawaiite clasts of predominantly subangular to subrounded shape.

Production strategies

Significant variability exists within each of the two ‘sources’ (lava flows and glacial deposits) in terms of the quantity and density of ‘tool-quality material’, defined here as the combination of major raw material properties: (a) grain-size or texture; (b) shape (sphericity and rounding); and (c) size. What exists in fact are a large number of variable size ‘patches’ (Winterhalder 1981:23) of tool-quality material unevenly distributed over a large area of the southwest flank of Mauna Kea. There are large ‘patches’ which I propose to call ‘production zones’. These include in descending order of probable importance: (a) Zone 1 - the escarpment (Fig.6); (b) Zone 2 - a ‘middle-ground’ of whaleback ridges covered with a thin mantle of glacial drift and, in the same area, Late Makanaka glacial moraines; and (c) Zone 3 - lower elevation slopes discontinuously covered with Early and Late Makanaka and Waihu glacial moraine and outwash deposits (Fig.7). Within each of these zones are smaller ‘patches’ of differential quality material.

The extent to which ‘patchiness’ is a predictable source of behavioural variability (Kirch
Figure 5  Locations of dated sites in relation to the primary source of raw material in a series of higher elevation lava flows and secondary sources in lower elevation glacial moraines and outwash deposits

Geologic base map from Porter (1979a, 1987:Fig.21.3, 21.9).
Production Zone 1. The escarpment 'Ua'U rockshelter (arrow) is located on the edge of the flow.

Production Zone 3. View down Pohakuloa Gulch toward Mauna Loa from the terminus of a Late Makanaka end moraine at Hopukani Spring. A career made on glacial drift deposits such as this would have differed greatly from those of craftsmen working at the primary source higher on the mountain.
1980:124) is evident in procurement strategy variability in space and over time. An optimal, mixed strategy of initial surface collecting and later bedrock extraction (mining) characterises the long-term, continuous exploitation of the primary source along the escarpment. This is in sharp contrast to the almost pure collecting strategy employed in the somewhat later exploitation of the glacial drift deposits in Zones 2 and 3, which on current evidence was coeval with the former between ca. AD 1300-1600 and possibly as early as AD 1000 (Fig.4). The material correlates of this spatio-temporal sequence are similar, yet contrastive, blank-preform assemblages given the inherent limitations of raw material form and size on the shape and dimensions of the final product (Isaac 1972, 1977a), which in this particular quarry context may have meant not only differential exchange-value, but the differential potential to build a personal reputation as well (see Shanks and Tilley 1987:95).

The predominance of thick quadrangular (rectangular and trapezoidal) cross-section blanks and preforms (Cleghorn 1982) supports the unstated assumption that a higher value was placed on tabular material, which is virtually localised to the escarpment and nearby flows in Zone 2. It is here that the vast majority of the larger adzes used in felling trees for canoes and land clearance would have been made. Maximisation of raw material form is obvious, yet there is also clear evidence throughout the history of the quarry of multiple reduction strategies in the manufacture of a range of adze types and sizes from core blanks and flake blanks (McCoy 1977, ms.a, ms.f; Cleghorn 1982).

Activity remains

The structure of this quarry industry is inferred to have been correspondingly more complex than any other Hawaiian adze quarry based on a consideration of the number, diversity, spatial distribution and formal-functional variability within different classes of activity remains that include2:

Workshops

Recent investigations in the Pohakuloa Gulch region of the quarry (McCoy ms.f) indicate a number well in excess of the 264 workshops and 1566 constituent features (physically discrete ‘chipping stations’) identified in the 1975-76 fieldwork. There is considerable variability in the size of individual workshops defined in terms of the area and volume of debitage. Assemblage variability is also evident in both the number of manufacturing stages that are represented and their position in the sequence (e.g. early or late stages).

Rockshelters

In the original classification of activity remains a distinction was made between rockshelters and what I called ‘overhang shelters’ based on differences in surface characteristics of the interior floor area. Rockshelters were noted as containing a variety of residues indicating their use as camps. The ‘overhang shelters’ were described as lacking midden deposits and containing only small quantities of adze manufacturing debitage (McCoy 1977:229). Most of these were presumed to have been used for the storage of food, firewood and other bulky items. A test excavation of one of these ‘overhang shelters’ at Hopukani Spring (Fig.3) in 1985 revealed a buried occupation layer with a fire hearth, faunal remains and flake debitage (McCoy ms.f). As a result, I have combined all natural shelters into one category and renamed this site Hopukani rockshelter no. 2. Six of some 50 known rockshelters in the quarry have been test excavated.

Open-air shelters

There are two varieties of walled ‘enclosures’ in the quarry that have been classified as open-air shelters. The simplest form is a low windbreak wall. The second variety is a full enclosure. Both varieties are found singly on workshops and aggregated into clusters where they are associated with shrines in what appear to be religious compounds. Nearly 200 of these structural remains have been recorded to date.

Shrines

One of the clearest signs that adze manufacture in this quarry was, like Hawaiian canoe manufacture, ‘an affair of religion’ (Malo 1951:126), is the presence of some 45 shrines. All

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2The number of remains per class in the descriptions that follow is a minimal number, reflecting the need for additional survey to establish new boundaries for the quarry.
of the structures in the quarry that can be classified with confidence as shrines have one or more upright stones which Emory (1938:22) has made clear are stone gods ('eho). There is a wide range of variability in the number of uprights as well as the manner in which they are arranged. The vast majority of shrines are conspicuously sighted in the landscape on workshops (Fig.8) and above the entrances to rockshelters. A smaller number are found in isolated contexts. The surfaces of many shrines mimic workshops in the presence of a variety of adze manufacturing by-products which are interpreted as offerings to the gods (McCoy and Gould 1977; McCoy ms.a). A lock of human hair was found beneath one upright at one of the roof-top shrines in the main quarry area.

Rock art

The rock art in the quarry is limited to one and possibly two panels of petroglyphs and a single panel of pictographs. The latter, which is located on the interior southern rim of a large pit crater below Pu‘u Ko‘oko‘olau (Figs 2, 5), includes a shark and what appear to be other sea animals or creatures. It is possible that all of them are depictions of ‘aumakua, a class of deities, some of whom are related to professional groups (Valeri 1985:19-30).

Volcanic glass source/workshop

At the foot of the escarpment, directly below Ko‘oko‘olau rockshelter no. 1, is one of several known local sources of volcanic glass. A 1 m² test excavation at this locale in 1976 yielded evidence of a small workshop in the presence of a number of cores and flakes which have also been recovered from several rockshelters. The quantity of cores and flakes at the workshop suggests the possibility of export even though the material is of generally poor quality.

SITE STRUCTURE AND ACTIVITY PATTERN DIFFERENTIATION

The largest and most complex sites, defined in terms of the number and variety of constituent activity remains, are located on and just below the escarpment, in Zones 1 and 2 where there also exists the best evidence for activity pattern differentiation. Virtually all of the ‘built environment’ of the quarry, consisting of walls, enclosures and shrines, is found in these two zones (McCoy 1977; Cleghorn 1982:Table 2.1, Fig.2.4). It is here, too, that the greatest difficult is encountered in giving meaning to the archaeological record in terms of distinguishing natural from cultural influences on the ‘built environment’ and workshop assemblage formation processes.
Figure 9  Crescent-shaped windbreak wall on a workshop located on the rim of the pit crater downslope from the escarpment and Ko'oko'olau rockshelter no. 1 (arrow)

Workshop assemblage variability

One behavioural response to the vicissitudes of changing weather during the day is manifested in a number of low windbreak walls constructed in part of recycled debitage and reflecting in their variable orientations changed wind directions. The situational behaviour embodied in these structures is restricted to the higher elevations, but it is not as common as might be expected, probably due to the proximity of so many natural rockshelters (Fig.9).

A better indication of spatio-temporal discontinuity in the manufacturing process can be seen in workshop assemblage variability. There appears to be a higher frequency of partial or incomplete stage assemblages everywhere, with evidence for separation and aggregation phases of work in the movement from: (a) one workshop to another workshop; (b) workshops to base camps; and (c) the special case of carrying debitage from a workshop or camp to a shrine where some symbolic manufacture also appears to have taken place. Much of this patterned variability, which initially suggested the possibility of a factory approach, is probably related to daily fluctuations in sun and cloud cover and the rapid drop in temperature that comes with the onset of cloudy weather. It is a well known fact that open areas that are exposed to the sun are subject to much greater and more frequent temperature changes than areas in shade and that such differences are more pronounced at altitude because the thin air does not hold heat well (Price 1981:57-58).

The rockshelter camps constitute one of the most important expressions of activity pattern differentiation since they functioned as places of residence in addition to workshops. In contrast to some other workshops where there are by-products representative of the complete manufacturing sequence, the debitage associated with rockshelters is primarily restricted to the final stages of blank and preform shaping and thinning, thus indicating a shift in work location. Elsewhere (McCoy ms.d) I argued that these particular workshops constituted one node in a behavioural chain of events directly linked to a multiplicity of different climatic stresses, including cold, wind, fog, and solar radiation. The relative volumes of debitage present at all of the major camps, both inside and outside of the rockshelter, was assumed to be a clear indication, moreover, of the frequency and intensity of these variable stresses as well as the duration of the 'adaptive response' in which the magnitude of the debitage piles was seen as mirroring the
magnitude of the stress. Though weather is an obvious factor, it does not provide the only or even the best explanation for the formation of these mounds. As Binford (1987:19) has noted, 'Dense aggregations of materials may be understood in several ways'. In the present context large volumes of debitage are best understood as the accumulated waste of generations of large aggregate groups working under both optimal and adverse conditions.

The spatio-temporal discontinuities in the manufacturing process associated with the shift from open-air workshops to the confines of the better protected, warmer rockshelter environment is not a static phenomenon in terms of the expected proportions of different stage by-products at the base camp. The process is inferred to have varied spatially and changed through time with, for example, the depletion of surface material that would have required either going farther afield or engaging in the more labour intensive process of mining subsurface material. The delimiting factors are distance and portability as exemplified in an isolated rockshelter referred to in several early accounts (e.g. Alexander 1892; Arning 1931) as Keanakako'i (Cave of the Adze). Keanakako'i is of great interest for several reasons, not least is that it is farther removed from the source of raw material than any other major camp. The material correlate is a more uniformly size graded heap of waste flakes, reflecting energy minimisation in the transport of prepared blanks rather than blanks and cores. There are no dates for this camp but the size of the associated debitage pile (Fig.10) indicates an extended period of use, thus suggesting that this particular natural shelter was selected as a base camp because of its isolation from other workshops and camps. The extent to which separation may imply 'sacredness' and high rank seems especially clear in this case because of the presence of a roof-top shrine and the fact that this is the rockshelter from which a 'curious idol' was collected in the last century (Alexander 1892).

**Ritual compounds**

The epitome of site complexity occurs in two unique compounds of associated shrines and enclosures. One of these is an isolated site located at the 3719-3749 m elevation, 0.5 km distant from the nearest source of raw material. It consists of 20 enclosures, five shrines and

![Figure 10](image.jpg)

Debitage mound fronting a rockshelter known as Keanakako'o (Cave of the Adzes) located alongside the Humuula Trail

This is the site from which a 'curious idol' was collected last century: Arning (1931) published a photograph of this campsite which is almost certainly the same one he describes as containing broken calabashes, small pieces of tapa, 'awa root and 'opihi shells.
a small quantity but diverse range of adze manufacturing by-products and hammerstones. The structural remains are arranged in two separate groups that suggests a division based on occupational status and/or group membership at the community or chiefdom level. What we may in fact see here in the site structure is a symbolic linkage and opposition between different communities and/or polities.

The second compound is located on top of the escarpment in the heart of the quarry. A total of 39 enclosures have been identified beneath and adjacent to a massive mound of debitage situated directly below two shrines on the lee side of a prominent ridge. One of the shrines, which is comprised of five and possibly six dispersed uprights positioned on the top of boulders, is believed to be a territorial 'map' of the island political organisation with each upright symbolising a district or polity. One possible explanation for the enclosures is that they represent the shelters of a collective labour force comprised of workers from various task groups and sectors of the quarry who assembled during the day to mine and reduce large blocks of material into blanks and preforms, some of which may have been transported back to other camps to be finished. The deliberate burial of these structures with tons of debitage suggests quite a different interpretation, especially when viewed in relation to the evidence of similar 'backgrounding' behaviours (Douglas 1975:3) from other contexts in the quarry. The alternative view is that these structures were occupied by a collective labour force that assembled on various occasions to participate in public rituals, perhaps rites of passage, marking the change from one 'state' to another (Turner 1967:93), such as initiation rites.

A short distance away from this compound is a large extraction pit that is partially surrounded with a wall of debitage. There is no obvious utilitarian or pragmatic function for this wall which is thus inferred to represent yet another kind of ritual behaviour.

**ORGANISATION OF WORK**

This brief discussion of activity pattern differentiation indicates that the workaday reality of the adze makers was one of coping with fluctuations in sun and cloud cover. It is clear from our own field experience that the old adage, 'night is the winter of the tropics', frequently applies to the day as well. Though variable, the weather at the higher elevations is not totally unpredictable. Midday fog and drizzle occur with such regularity in fact that this weather pattern can be regarded as a 'statistical regularity' (Butzer 1982:22-23). The effect of such conditions is, to quote Glassie (1982:460), that 'Work is organically ordered. Wild weather prevents its cycles from cracking into exclusive periods, and no season, no day, can be filled with work of but one kind'.

Environmental constraints notwithstanding, there is circumstantial evidence that the several different spatio-temporal discontinuities in the archaeological record of the manufacturing process are primarily related to cultural factors that mediated the organisation of work in the separation and aggregation of task groups. While there is much that is unknown regarding the actual social interactions between workers, including the transmission of technical knowledge and ideology (Cook 1982:53-55), it is difficult to accept Cleghorn's (1986:385-86) thesis that experts and novices spent part of each season working in different sectors of the quarry because of an increasing scarcity of quality raw material which he assumes would have been wasted on apprentices. On current evidence the exploitation of the patchy bedrock exposures and glacial drift deposits in Zones 2 and 3 reflects a period of intensification and not the imminence of diminishing returns as might be conjectured in terms of the inherently higher cost:lower yield ratio in working these smaller 'patches'.

The evidence described here also contradicts Cleghorn's (1982:343) conclusions regarding standardisation of tool form and manufacturing procedures which he and others (e.g. Arnold 1987) seem to accept as unambiguous signatures of craft specialisation. Craft specialisation is clearly indicated in the archaeological record of this quarry industry in terms of the degree of ritual investment, but the emphasis on standardisation is somewhat
misleading given the evidence for a multiplicity of reduction strategies and tool forms throughout the history of the quarry. There is ample evidence that ritual performance, too, was not standardised (McCoy ms.a), even though it might have conformed in theory with the usual characterisation of ritual as highly structured and with specific role expectations.

The assumption of specific role expectations and standardisation in the context of craft specialisation is problematical for a number of reasons (see Hodder 1986:70-71, 148-49; Shanks and Tilley 1987:44-45). Merrill (1968:585) is correct in noting in this regard that the 'tendency to think of technologies as fixed sequences of standardized acts yielding standardized results' is misleading because 'Desired technical results are not obtained automatically. Materials vary, circumstances differ, and manipulations are hard to control'. Rather than assuming that craft specialisation is everywhere synonymous with a high degree of standardisation and homogeneity, we would be far better of to begin with the view advocated by Merrill that 'A more adequate conception of a technology is that it is a flexible repertoire of skills, knowledge, and methods for attaining desired results and avoiding failures under varying circumstances ....' (Merrill 1968:585).

SETTLEMENT AND SUBSISTENCE PATTERNS

Many of the primary questions regarding the structure of this quarry industry have to do not with the manufacturing technology but with other mundane matters such as shelter, clothing and food. Brigham (1902:75-76) and Emory (1938), for example, were both led to question the practicality of actually living in the quarry. Emory's thoughts on this matter are worth quoting in full because they are the first to be based on actual field observations:

The floors of the caves and shelters contain grass-padding and some fragments of sea shells, but no accumulation of shells or bones such as would indicate use as living quarters. On calm nights the temperature drops well below freezing. On rainy and windy nights, water drips through the roofs of the caves. During the winter months, snow frequently covers the ground, and the bitterly cold winds sweeping over the work shops would be unendurable to the workers. In two hours of easy walking one may reach the work shops from timber line. So, it is my conviction that the adz makers lived at warmer altitudes, walking daily to their work during favourable weather in the summer months [Emory 1938:22].

The validity of many of his observations is not at issue, but the conclusions he derived are in many instances wrong, such as the assertion that there are no indications that any of the rockshelters were actually inhabited, and the implication that treeline is below the zone of freezing night-time temperatures.

The objection to Emory's primary conclusion regarding settlement and subsistence patterns is based on evidence obtained in the test excavations of six rockshelters. A brief summary of some of the evidence recovered in these excavations is presented for the purpose of developing a camp typology as the first step in comprehending social relations of production. The focus is on the description and determination of the possible meanings of intersite variability in features, artefacts and faunal and plant assemblages.

Rockshelter characteristics

The six rockshelters are all located above treeline in the alpine desert environment. The sample is small, but it does include sites in all three of the production zones as earlier defined. Locational and other general characteristics are summarised in Table 1. With the exception of Hopukani rockshelter no. 2 all of the rockshelters are multi-component habitations with well-stratified deposits. The interiors of these rockshelters indicate minimal maintenance. The occurrence of adze blanks and preforms and hammerstones, for example, suggest that they were rarely if hardly ever cleaned out. In the case of Ko'oko'o'olau rockshelter no. 1, which is one of the smaller habitations in the whole quarry (Table 1), the effect of the accumulating fill was a significant reduction over time in the floor area. The finite limits on group size in the floor areas provide one explanation for the large number of rockshelters in the quarry. Intersite variability in the residues of work and food consumption suggest a social reason. It is important to note that there is no general correlation between floor area, debitage mound volume, assemblage diversity and the length of the sequence in these rockshelters.

Features

A variety of features have been found in surface and subsurface contexts at the rockshelters. They include enclosing walls, roof-top shrines, fire pits and ash lenses, and
concentrations of artefacts and midden that I earlier interpreted as living surfaces (McCoy 1977:232). At Ko’oko’olau rockshelter no. 1 there is an unique surface feature comprised of dispersed stone uprights, including one large adze blank, located on the exterior debitage mound. The uprights may be the functional equivalent of Maori rahui posts (Best 1982:185-91) that were erected in religious rites during the occupation of the rockshelter and possibly just before it was abandoned. The features of primary interest in this paper are the enclosing walls and fire pits.

**Enclosing walls**

The entrances to many, but not all, of the higher elevation rockshelters in Zones 1 and 2 are partially to almost totally enclosed by a wall constructed beneath the dripline (Fig.11). Where such walls exist they are assumed to have functioned to retain heat and retard wind and cold, but these are constants of the local environment which means that the presence/absence of walls must signify some additional purpose and meaning. While they may also have served to retain accumulating debitage from inundating the interior living area at the back of the dripline, the degree of closure suggests a social use. There is some evidence to suggest that the enclosing walls at many of the larger camps were social barriers.
that functioned to control, and possibly even prevent, the movement of low-ranking
individuals across these barriers, which are thus conceived as symbolic boundaries
(Douglas 1966) of exclusion and inclusion. The purpose is inferred to have been the
exclusion of the uninitiated from access to secret ritual knowledge (Childe 1942:85, 87).

On present evidence, enclosing walls are late features in the quarry sequence. At 'Ua’u
rockshelter, the enclosing wall (McCoy 1977:Fig.3) is bracketed by dates (see Fig.4) of 190 ±
80 BP (AD 1490-1950) and 490 ± 80 BP (AD 1315-1520).

Fire pits

Fire pits and ash concentrations are understandably common features. With the
exception of a couple of pieces of fire-cracked rock from the Pu‘u Kalepeamoa site there is
no evidence that any of the pits in the quarry proper were used as earth ovens. Rather, all
of them appear to have been hearths over which some food might have been roasted. Some
are stone-lined while others are nothing more than shallow basins. The majority of these
features are located in the interior living area, yet at the three rockshelters where test
evacuations have been undertaken in more exterior contexts, additional fire pits have been
found. At 'Ua’u and Waikahalulu rockshelters fire pits were found below the dripline, and
at Hopukani rockshelter no. 1 several were uncovered even farther out from the dripline on
the debitage mound. The exterior hearths in all three sites have either yielded older dates or
have been found in earlier stratigraphic contexts than the interior hearths. The location of
the earliest habitation layers outside of these shelters is further evidence that an enclosing
wall is not an absolute necessity in occupying this high altitude, cold environment.

Artefacts

Artefacts, other than the ubiquitous debitage and manufacturing tools, include objects
made of stone, bone, tooth, shell and other organic materials. The only shell artefacts are
modified 'opihia shells (Cellana sp.) interpreted as taro corm peelers. They were found in the
two upper elevation rockshelters only. The only ornament recovered in the excavations is a
single perforated dog tooth from Ko‘oko‘olau rockshelter no. 1 that would appear to have
been a pendant or part of a necklace. The recovery at 'Ua’u and Ko‘oko‘olau rockshelters of
bird bone awls and volcanic glass flakes, presumed to have been used for cutting and
scraping wood and fibre, has elsewhere been interpreted as indicating the high probability
of maintenance activities (McCoy 1977:234). The co-occurrence of these same artefacts with
pandanus leaves in Ko‘oko‘olau rockshelter no. 1 formed the basis for conjecturing that
personal gear, such as mats and carrying baskets had been repaired in the quarry, thereby
suggesting that the duration of work was greater than a week or two (McCoy 1976:140).

The repair of personal gear now seems unlikely. It is more probable that the pandanus
leaves and many other items were offerings to the gods. All but a few of the perishable
artefacts that have been collected from the quarry are from Ko‘oko‘olau rockshelter no. 1.
They include such items as fire ploughs, pandanus matting, tapa cloth, fragments of a
possible ti-leaf rain cape, sandal fragments (?), twisted cordage and braided sennit (McCoy
1977:Fig.4; Allen 1981:103-5, Figs 18-20, Appendix B). The bulk of this material was
recovered in a compacted mass from two proveniences in a stratified deposit in the corner
of Ko‘oko‘olau rockshelter no. 1 that led me to conjecture that it had been purposefully
placed there as a cushion beneath sleeping mats (McCoy 1977:234). Allen (1981:130) noted
some of the difficulties with this simplistic interpretation, but offered no explanation for this
‘feature’, which also contains bone and shell. The stratigraphic context of these particular
residues suggest something more specific and meaningful than the use of the rear wall of
the rockshelter for the discard of food remains and personal gear. All of this material is
from a deposit in which there are no fire hearths. The absence of fire hearths, which are
taken for granted as a functional necessity in overnight stays in this environment, is an
indication of a non-habitation fill deposit and a different kind of site formation process.
This deposit and possibly several other layers in this and other rockshelters are interpreted
as ritual fill deposits that were intended to cap and thus remove from view the accumulated
residues of meals and offerings to the gods that are polluting and thus dangerous to man in

3The ritual fill hypothesis is addressed in a recently completed MA thesis by Scott Williams, ‘A
technological analysis of the debitage assemblage from Ko‘oko‘olau rockshelter no. 1, Mauna Kea adze
quarry, Hawai‘i’. (Department of Anthropology, Washington State University, 1989).
Two other artefacts deserve to be briefly mentioned. One is a silversword (Hawaiian 'āhinahina) wrapped with pieces of tapa cloth, pandanus leaf and a wooden bottle gourd stopper with the sennit cord attached (Allen 1981:Fig.11), which was found beneath an overhang at 'Āhinahina rockshelter (Fig.11) for which the site was named. It is thought to be a god image. As already noted, a 'curious idol' was found at Keanakako'i rockshelter some years ago. Unfortunately there is no description of this object and efforts to relocate it have been unsuccessful.

**Faunal assemblages**

The faunal assemblages from the six excavated rockshelters include a mixture of invertebrate and vertebrate remains which in almost every instance are believed to represent a combination of food and non-food remains.

The invertebrates are represented by small quantities of: (a) marine molluscs, including eight species of gastropods and one species of bivalve; (b) two species of echinoderms; (c) one species of barnacle; and (d) five species of land snails. The only taxon that is common to all of the excavated sites is a limpet (*Cellana* spp.; Hawaiian 'ōpīhi) and the only sites where it occurs in any numbers are Ko'oko'olau (MNI = 119) and 'Ua‘u (MNI = 100) rockshelters from which all of the other taxa were recovered. All of the marine invertebrates appear to have been collected from a rocky shore habitat.

The vertebrate fauna includes fish, bird and mammal (Table 2). The 'small vertebrate' category (Table 2) represents essentially unidentifiable material that was recovered in small screens in a matrix analysis of selected soil samples from surface proveniences and features in the two Hopukani rockshelters (McCoy 1986:15-17). In calculating the number of identified specimens (NISP) I have followed Grayson (1984:16) in defining a specimen as 'a bone or tooth, or fragment thereof'. The analysis of the fish and bird bones is incomplete and the number of taxa is consequently a minimum number.

**Fish**

A total of 16 species of fish have been identified at this time by Dr W.I. Follett of the California Academy of Sciences. Figures are not yet available for the number of taxa per site, but there are only 42 fish bones from the three lower elevation camps (Table 2) which

<table>
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<th>%T</th>
<th>Taxa</th>
<th>Mammal NISP</th>
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**Table 2**   Vertebrate fauna assemblage composition
Threadfins
Inshore/sandy bottom
Jacks
Inshore and deep water/semi-pelagic
Snappers
Deep water/benthic
Wrasses
Inshore/reef
Parrotfishes
Inshore/reef
Surgeonfishes
Inshore/reef
Mackerels
Pelagic
Gobies
Freshwater

Table 3 List of identified fish

means that essentially all of the 16 species are from the three camps in Zones 1 and 2. The 16 species represent a wide range of habitats, including both marine and freshwater (Table 3). The distribution is clearly uneven, however, with a better representation of inshore reef species, especially wrasses and parrotfishes.

Birds
A total of 20 taxa, including three taxa identified to a general size class (Table 3), have been identified by Dr Alan Ziegler and Sara Collins. The large number of bones assigned to only a size class (Fig.12) is due to the high degree of fragmentation (92-98%) in all of the assemblages. According to Ziegler, there is reason to believe that most of the bones in both the ‘small’ and ‘medium’ Procellariid category are probably those of the dark-rumped petrel (cf. *Pterodroma phaeopygia sandwichensis*). The same opinion is held with regard to the large number of bones in the ‘medium bird’ category (petrel, duck, crow, size range) which is probably 90% or more dark-rumped petrel. The petrel bone includes skeletal elements of immature birds. The other 10-20% or so of the bird bones are distributed among six families (Table 4). The small passeriform material probably includes both thrushes and honeycreepers, which are probably also well represented in the otherwise unidentifiable material in the ‘small bird’ category that might also include fragments of two or more taxa in the Rallidae family. The ‘small rallid’ and coot (*Fulica americana alai*) from the recently excavated Hopukani rockshelter no. 1 (Fig.12) represent yet two more newly reported members of the family Rallidae in the quarry avifauna, which also includes *Porzana sandwichensis* and an extinct ‘medium rallid’ (Olson and James 1982).

A comparison of the six assemblages (Fig.12) shows a high degree of redundancy in the large percentage of bones in the ‘medium’ bird category with the exception of ‘Ahinahina rockshelter. There is at the same time clear evidence of intersite variability in species diversity, much of which is probably due, however, to sample size effects (Fig.12). On present evidence goose is restricted to Ko’oko’olau rockshelter no. 1, and the rail material to earlier stratigraphic contexts.

Mammals
A total of only 32 mammal bones, representing 0.37% of the total bones of all classes, was recovered in the excavations. Of the 32 bones there are a total of only 10 that fall into the dog and pig size range (‘medium’ mammal) and of these only three could be positively identified as pig (*Sus scrofa*) and two as dog (*Canis familiaris*). The remainder of the bones
are those of the Pacific rat (*Rattus exulans*), or in that size range ('small' mammal).

With the exception of the single 'medium' mammal bone from Waikahalulu rockshelter, all of the dog and pig bone was recovered from the two upper elevation sites. The two dog bones, a cranial fragment and radius, were recovered from a late stratigraphic context in Ko’oko’olau rockshelter no. 1. The pig bone from ‘Ua’u rockshelter includes: (a) two matching fragments of a lower incisor from an individual of uncertain age, but almost surely older than a 2-3 month old piglet; and (b) matching fragments of a lower 4th milk premolar estimated to be from a piglet 8 ± 2 months old, both from Layer II. The one fragment from Ko’oko’olau rockshelter no. 1 is a parietal, that according to Dr Alan Ziegler,
The excavations yielded a diverse array and quantity of plant remains. Some 51 taxa have been identified to at least the family level, of which 39 (76%) are wild species and 12 (24%) are cultigens. The number of taxa, which includes organic artefact raw materials, is a minimum number. There are a sizeable number of unidentified samples, primarily seeds, woods and fibres, exemplifying a common problem in research on Pacific subsistence systems in the insufficient attention given to wild species in ethnobotanical studies (Yen 1985). The general neglect of wild species, especially in studies of agricultural societies (Yen 1985:315), makes it extremely difficult to not only identify the raw materials of many artefacts, but to determine the cultural significance of wild plants in terms of their practical uses and symbolic meanings. The problem is evident in Allen's efforts to determine plant use in the quarry (Allen 1981:Table 11). Of the known species the number of taxa common to all sites is only five, including fragmentary material identified only as grass and wood (Allen 1981:86-87, Tables 12, 13). A number of species diversity is represented in the Ko'oko'olau rockshelter no. 1 assemblage which contains taxa from every major vegetation zone on the island (Allen 1981:Table 16), including everything from seaweeds to alpine mosses.

Wild species

A number of the wild species identifications were made on small fruits and seeds which were recovered in sizeable numbers from the previously mentioned stratified deposit at the rear wall of Ko'oko'olau rockshelter no. 1 (Allen 1981:86-87, Tables 12, 13). A number of species appear to be derived from the subalpine forest and xerophytic scrub zone, including several probable food plants - Chenopodium oahuense and Solanum nigrum leaves and one or more species of ferns (Allen 1981:118-19). Identifications of a small number of charcoal samples from Ko'oko'olau rockshelter no. 1, Hopukani rockshelters no. 1 and 2 suggest a preference for three high elevation species that could be readily procured for firewood in these two vegetation communities: (a) Railliardia sp.; (b) Sophora chrysophylla; and (c) Coprosma montana (Murakami 1986).
Domesticated species

There is a wide variety of domesticated species represented (Allen 1981:Tables 10, 17; ms.:Table 2) but the only cultigens that occur with any frequency are taro (*Colocasia esculenta*), ti (*Cordyline terminalis*), sugarcane (*Saccharum sp.*) and gourd (*Lagenaria siceraria*). Small quantities of all of the major Hawaiian food plants have been found with the exception of yam (*Artocarpus altilis*) for which Allen (1981:116) has offered a plausible explanation. The questionable presence of sweet potato (*Ipomoea batatas*) remains in the quarry, tentatively identified from only Ko'oko'olau rockshelter no. 1, suggests that the adze makers did not consume much, if any, of this food which is claimed to have been 'particularly the food of the common people' (Handy and Handy 1972:14). Taro, which has been identified from a layer near the base of the deposits in Ko'oko'olau rockshelter no. 1 dated to AD 1045-1340 (Fig.4), would appear to have been one of the staples of the adze makers' diet based on the abundance of corms from several sites.

Assemblage variability

The faunal and plant assemblages taken as a whole are more complex than those from any known Hawaiian coastal settlement in terms of the number and diversity of taxa. Small sample sizes preclude any definitive statements regarding taxonomic abundance and the meaning of species diversity.

Species diversity at the site level is to some degree time dependent given the natural propensity for changes in taste and the necessity of substituting one food for another at some times. Diversity also reflects a combination of purposeful and accidental human behaviours. The epitome of adventiveness and transported landscapes are the land snails in Ko'oko'olau rockshelter no. 1 at the 3780 m elevation. The problem of distinguishing cultural behaviours and natural site formation processes is much more of an issue in the case of some of the plant remains where the identifications were based on seeds. Allen (1981) has discussed this problem, noting the probability of mixed formation processes in purposeful human introductions and aeolian transport.

Diet: men and gods

Viewed at the level of the quarry complex the potential and actual diet of the adze makers would appear to have been essentially one and the same based on the diversity of foods, which include marine and terrestrial, and domesticated and wild categories. While the total variety or richness of the combined site assemblages is an obvious indication of a 'broad spectrum economy', it is also clear that there is considerable intersite variability in both richness and evenness. With the exception of the two upper elevation sites, the evenness appears to have been low in terms of the greater dependence on just a few foods.

The marine foods, which include fish, shellfish and seaweeds, are of particular interest in this inland context. The fish fauna is somewhat unusual in the presence of the freshwater gobie and certain benthic and pelagic species that appear to be either rare and/or found in a restricted number of archaeological contexts (Goto 1986). Notably absent are any of the species raised in fishponds. The predominance of inshore species is predictable given what is known of Hawaiian fishing strategies (Goto 1986). The presence of the threadfins, which are reported to have been taken in large numbers during the spawning season from March to August, are of interest not only as a possible indicator of seasonality but as a status marker as well. They are said to have been reserved for the chiefs (Goto 1986:422). The only regularly occurring species of shellfish in the quarry is the 'opihi. It was found at all of the camps but there are too few in any one place to interpret the shells as food remains alone, thus leading to the speculation that they were offerings to the gods.

Of the birds, there is clear-cut evidence that the dark-rumped petrel was consumed in disproportionate numbers compared to other species. The abundance of this species is believed to reflect availability and cultural factors such as taste and nutritional value (Handy and Handy 1972:259). Ethnohistoric sources indicate that the lower flanks of Mauna Kea and the adjoining plain were the most probable source for most, if not all, of the petrels and geese, which as earlier noted show indications of seasonality in nesting and feeding habits. Henshaw (1902:120), for example, was told that the dark-rumped petrel formerly nested in great numbers in the saddle between Mauna Kea and Mauna Loa, and that the nestlings were considered a great delicacy and were tabooed for the exclusive use of the chiefs. According to one historic account the young were taken in the downy stage from
their burrows in late September and October (Bryan 1914:156). The presence of immature petrel bones in several of the rockshelter assemblages is of great significance then in providing clear-cut evidence of seasonality and social rank. If the petrels in this upland region were under a taboo that was lifted after the birth of the young, there is reason to suspect that these same bones are those of young birds that were offered to the gods in first-fruits rites at the beginning of the hunting season. The different meanings given to these bones exemplifies the simultaneity of different ecological, economic, and sociopolitical facts and processes. Sahlins (1981:45) has drawn attention to the same thing in the observation that 'Even the so-called economic or conservational tabus had a divine finality: they were consecrations of foods to be used in honor of the gods, thus organized in the first place in a system of sacrifice'.

The small number of mammal bones precludes any definitive statements regarding the meaning of the dog and pig, but it does appear significant that the meagre remains of both of these domesticated species were recovered from late contexts and are, with the exception of a single dog forelimb, the cranial elements of young individuals. Ethnographically, both of these species were used in sacrifices as mediators between men and gods (Valeri 1985:119). The heads of both dogs and pigs were the share of chiefs and even though both of these animals were suitable offerings to the gods, pigs are more frequently mentioned. Dogs are said to have been a more appropriate offering in the case of female deities (Titcomb 1969:14, 18).

It is clear that the material provisioning of the adze makers was conditioned by factors other than basic human needs of survival, if such ever exist separate from cultural standards (Gellner 1973:140-41). The archaeological evidence indicates that there were in fact dual needs and cultural standards, one for men and one for gods, and that these were met in a variety of different ways and places. The diverse range, but small quantities, of many of the inferred offerings could be interpreted as evidence that the gods had 'broad tastes but small appetites'. More likely is the simple fact that symbolic foods, as tokens, are sometimes 'expensive', which means that they cannot always be deployed to the fullest degree (Gellner 1985:161). It is highly probable, for example, that certain plants and marine foods were substituted for pigs (see Valeri 1985:395, Note 156 on 'leaf pigs' and 'sea pigs').

Camp variability

Perhaps no area of archaeological research has caused such difficulties as developing an operational definition of the base camp or residential base concept. As Thomas has noted it is easy to assign behavioural meaning to this concept as, for example, the 'hub of all subsistence activities' (Binford 1980:9) or, more specifically, as 'the locus of most processing, manufacturing, and maintenance' (Thomas 1986:238). The problem is taking these behavioural definitions and linking them to archaeological observations, a process that requires the use of unambiguous signatures to be successful (Thomas 1986:238).

A convenient starting point in the development of a camp typology for this quarry is the use of simple criteria such as the presence/absence of fire hearths and food remains to distinguish camps from rockshelters used exclusively for storage. All six excavated rockshelters can be regarded as camps on the basis of these two criteria. To proceed any further is difficult because of the uncertainties regarding the behavioural meaning of assemblage diversity, due for example, to sampling error problems related to small test excavations.

Waikahalulu rockshelter and Hopukani rockshelter no. 1 are especially difficult to interpret in terms of determining whether they:

1. were utilised as transient camps, which would imply a gradual ascent to the main quarry and conform to the expectation of a short period for acclimatising to altitude and collecting provisions; or
2. functioned as permanent base camps for individuals and groups who did not have access to the primary source of material, which would imply rank differentiation and, as noted earlier, the differential potential to build a reputation.

There are no unambiguous criteria to make such a distinction, but the paucity of shellfish, fish, food plants and personal gear from all of the lower elevation sites is striking compared to the richness of the higher elevation camps. The contrast cannot be attributed in my view to differential preservation, thus suggesting that the first alternative is the most likely explanation for the assemblage characteristics of the lower elevation sites. In this regard, there is as yet no archaeological evidence in support of my earlier conjecture that these
lower elevation sites were occupied by support groups whose task was to provision the adze makers with firewood, cooked food, birds and water from the treeline ecotone. ‘Ahinahina rockshelter, the only mid-elevation site in the present sample, would appear to represent a base camp given the size of the associated debitage mound, but it is clearly different from the ‘Ua’u and Ko’oko’olau no. 1 camps in the size and diversity of the faunal and plant assemblages. On current evidence the difference cannot be attributed solely to the shorter chronology of ‘Ahinahina rockshelter. The ‘Ua’u and Ko’oko’olau no. 1 camps are by any standard of comparison exceptionally rich and internally complex habitation sites. The presence of roof-top shrines, enclosing walls, and rich assemblages of food remains and personal gear suggest that they were akin to ‘club houses’. The roof-top shrines are inferred to have made plain and visible the identity of the group, while the rich assemblages of food offerings and personal gear in the interiors are interpreted as dramatising the activities that were performed behind the enclosing walls at these two camps. Both of these camps would appear to have functioned as daytime work centres for a collective labour force that, with the exception of the few permanent and presumably high ranking occupants, dispersed to other camps at night. A consideration of lighting conditions and floor area constraints, especially in the case of Ko’oko’olau rockshelter no. 1, casts some doubt on the amount of work that was actually undertaken in the interiors of these rockshelters. There is, as earlier noted, reason to believe that at least part of the fill is the result of ritual action rather than in situ manufacture.

THE SOCIOPOLITICAL CONTEXT OF THE MAUNA KEA ADZE QUARRY INDUSTRY

The remote location, size, and chronology of this quarry together have a number of implications when viewed in the larger context of the island economy and political organisation. Some of these are discussed below as the first step in comprehending the place of this quarry in the larger scheme of things, what Sahlins (1985b:34) refers to as ‘the general cultural practice of heroic history’. The discussion begins with an examination of some of the more obvious or probable integrations. This is followed by a brief consideration of the more speculative subject of quarry origins and the implications that ‘origins’ have for understanding the ritual process in this particular quarry industry.

Socioeconomic relationships

The Mauna Kea adze quarry presupposes a condition of raw material scarcity and, indeed, there are only two other known major adze quarries on the island (Fig.1). It would be wrong to conclude, however, that this quarry is nothing more than an adaptation to that condition. The report of a source of material for adzes and god images at a boulder beach near Ninole (Fig.1) is instructive in pointing to the high probability of a large number of unknown sources containing relatively small quantities of tool-quality material (Ellis 1969:212-14). A larger number of sources, notwithstanding, it is also highly probable that a large part of the population did not have direct access to the primary sources of raw material and must therefore have made do with inferior grades of stone.

The raw material on Mauna Kea is not necessarily better than that found at some other sources, but there is, as already implied in the comparison with other quarries, much more of it. The volume of waste material is a clear indication, moreover, of a sustainable yield. Mauna Kea is the only known source with the inherent potential to sustain over a period of more than perhaps a few centuries an institutional practice such as the legitimation of chiefly authority and power based on the production for exchange by a group of attached specialists (Brumfiel and Earle 1987:5-6). The opportunities for the growth of personal identities, of ‘becoming’ an acknowledged expert, are similarly constrained or circumscribed.

The large volume of material available for exchange also implies broader social relationships with other communities, but there is, as just suggested, much more than exchange value or economics per se involved here. As Sahlins has noted:

\[\text{Since the first draft of this paper was completed the results of a petrographic analysis have confirmed the prediction of a number of unknown sources of adze material on the island of Hawai'i and provided independent support for the interpretation that the first activity in the Mauna Kea quarry pre-dated AD} 1000 \text{(Barbara Withrow pers. comm.)}\]
An "economic basis" is a symbolic scheme of practical activity - not just the practical scheme in symbolic activity. It is the realization of a given meaningful order in the relations and finalities of production, in valuations of goods and determinations of resources [Sahlins 1976:37].

Figure 13 Ethnographic period sociopolitical context of the Mauna Kea adze quarry in Ka‘ohe Ahupua‘a, Hamakua district

The ethnographic period sociopolitical context of the quarry implies another set of 'social facts'. The quarry is located in an ahupua‘a (a territorial unit generally equated with the community) called Ka‘ohe in the Hamakua district (Fig.13). Ka‘ohe is perhaps the classic example of the unusually large ahupua‘a found in what Lyons referred to as the 'almost worthless wastes of interior Hawaii' in the following account:

Then there are the large ahupuaas which are wider in the open country than the others, and on entering the woods expand laterally so as to cut off the smaller ones, and extend toward the mountain till they emerge into the open interior country; not however to converge to a point at the tops of the respective mountains. Only a rare few reach those elevations, sweeping past the upper ends of all the others, and by virtue of some privilege in bird-catching, or some analogous right, taking the whole mountain to themselves .... The whole main body of Mauna Kea belongs to one land from Hamakua, viz., Ka‘ohe, to whose owners belonged the sole privilege of capturing the ua‘u, a mountain-inhabiting but sea-fishing bird.

These same lands generally had the more extended sea privileges. While the smaller ahupuaas had to content themselves with the immediate shore fishery extending out not further than a man could touch bottom with his toes, the larger
ones swept around outside of these, taking to themselves the main fisheries much in the same way as that in which the forests were appropriated. Concerning the latter, it should here be remarked that it was by virtue of some valuable product of said forests that the extension of territory took place. For instance, out of a dozen lands, only one possessed the right to kalai waa, hew out canoes from the koa forest. Another land embraced the wauke and olona grounds, the former for kapa, the latter for fish-line [Lyons 1875:2:111].

Ka‘ohe is unusual in several other important respects. It encompasses both wet and dry environments, in contrast to most other ahupua‘a (Hommon 1986:55), and land on the summits of two mountains (Fig.13), which also happen to be the homes of two rival goddesses - Pele (the fire goddess) and Poli‘ahu (the snow goddess whose home was Mauna Kea). The population of Ka‘ohe was undoubtedly small given the little arable land on the coast and may have been less than the approximate average figure for the island of Hawaii of 215 individuals per ahupua‘a (Hommon 1976:Table 1). The ratio of people to land points to a great inequality (McGuire 1983:102), especially when viewed in relation to proprietary rights to adze material, birds and other important forest resources (McEldowney 1983), and the summits of two sacred mountains5.

The importance of these inland resources is obvious in the accounts of conflict over the location of the Hilo-Hamakua district boundary (McEldowney ms.:7, 14). One of the major koa (Acacia koa) forests from which canoe logs were procured is located on the slopes of Mauna Kea above Hilo. The koa forests on Mauna Kea, Mauna Loa and Hualalai (Fig.14) and one on the upper slopes of Haleakala on Maui, described as having once covered tens of thousands of acres (see McEldowney 1983 regarding earlier vegetation patterns), are said to have produced a disproportionate number of the total number of canoes in Hawaii (Holmes 1981:19-20). The same can be said for adze manufacture on the higher slopes of Mauna Kea where a disproportionate number of adzes must have been made, especially the larger adzes called ko‘i lipi used in felling trees (Handy and Handy 1972:28), but also including all of the other adze types that comprised the diversified tool-kit of canoe makers (Holmes 1981:27). The Mauna Kea quarry is in fact probably one of the few quarries in Hawaii where it would have been possible to manufacture a complete tool-kit.

In contrast to the clear link between adze manufacture and canoe manufacture, the use of the adze in forest clearance is more problematical, even though the axe/adze was commonly used for this purpose in many parts of the world (Clark 1945, 1947). There are several references in the ethnographic literature to the use of fire in clearing land (Handy and Handy 1972:28; McEldowney 1983:421), but only one vague reference with which I am familiar to the use of the adze in connection with agriculture. Kamakau (1961:237) wrote, ‘With their hands alone, assisted by tools made of hard wood from the mountains and by stone adzes, they tilled large fields ....’. The use of adzes in clearing land for planting in the valley bottoms (Tuggle and Tomonari-Tuggle 1980) and wet forests on the windward coast (Fig.14) is especially doubtful. According to one source the Hawaiians rarely cleared the candlenut (Aleurites moluccana; Hawaiian kukui) forests (Handy and Handy 1972:283). If there is a link it is most likely with the development of the leeward field systems (Fig.14; Schilt 1984:292-94). A direct relationship between adze manufacture and the inland expansion of dryland agricultural field systems after AD 1400 has been suggested by Hommon (1986:64) who has argued that the need for such tools in clearing the land must have required an intensified level of adze production.

If we accept Hommon’s model then the earlier part of the quarry chronology must reflect either an earlier date for the ‘inland expansion’, perhaps correlating more closely with the posited rapid increase in the population of west Hawaii beginning at ca. AD 1200 (Kirch 1984:107, 1985:286-89), and/or other motives or intentions unrelated to population pressure and the economics of canoe manufacture and subsistence agriculture. One such intention is posited to have been the manufacture of ritual adzes, which does not necessarily imply the existence of two separate classes of adzes - utilitarian and ritual - however. Little is known of the ritual uses of adzes in Hawaii in comparison to many other islands in the Pacific (e.g.  

5The difficult question of quarry ‘ownership’ has not been raised, but some of the archaeological evidence presented in this paper leads to the conclusion that the quarry was a common resource exploited by all of the chiefdoms on the island under an agreement that restricted access to a privileged few members of each district. No effort has been made to reconcile this interpretation with conflicting references throughout the text to production for exchange-value or the ethnographic ‘model’ of Hawaiian land tenure with its emphasis on proprietary rights to resources within the boundaries of the ahupua‘a.
Figure 14  Geographic distribution of known adze quarries, remnant *koa* forests and major agricultural field systems

*Koa* forest distribution map from Holmes (1981:21) based on data compiled in 1979; field system locations based on Allen (1981:Fig.2; Schilt 1984:Fig.1.1).

Firth 1959), but that they existed as symbols of power is clear in a legend in which two famous adzes inherited from two gods were used to 'cut asunder the government [*aupuni*] so that it fell' (Beckwith 1940:49).

**Quarry origins**

The existing chronology indicates that the Mauna Kea adze quarry is rather late in the Hawaiian cultural sequence (Kirch 1985:298-308), a fact which should probably occasion little surprise given the remote location in a stressful environment. At the same time there is good reason to believe that the quarry does not represent the first human activity in the summit region of the mountain. A large shrine complex located above the quarry (McCoy ms.b, ms.c) suggests that the earliest activity on the top of the mountain was related to the worship of local gods and goddesses. This complex, which is interpreted as a 'pilgrimage centre', is inferred to have had its origins in what would have been for the first colonists from east Polynesia a natural history anomaly - snow - which because it was 'matter out of place' must have been regarded as mystically dangerous. As Lewis (1976:109) points out, 'anomalies are always situational and relative, never, or very rarely, absolute'. The shrine
complex, though undated, suggests that this anomaly was not avoided, but rather that it
was quickly given a place in the local cosmology (Douglas 1966:38).

The relevance of the shrine complex to the origins and structure of the quarry industry is
twofold, on the assumption that the 'pilgrimage centre' is indeed earlier. Pilgrimages to the
top of the mountain provide a likely 'explanation' for the discovery of the primary source of
raw material just below the summit. Secondly, in the process of the cosmology seeking to
make sense of the local ecology (Lewis 1976:105) in the worship of newly created gods and
goddesses, there is the development of a religious domain that essentially sets the stage for
future actions in this high mountain cultural setting which is at the crossroads of the earth
and sky. The cosmology not only makes sense of the ecology, but because it is antecedent to
the beginnings of the quarry industry it conditions to some extent the organisation of work,
especially the ritual process, which must have encompassed not only the tutelary gods of
the adze-makers, but many of the major and minor Hawaiian gods as well. 'Expropriation'
may be a more proper term than appropriation (Sahlins 1985a:195) in describing Polynesian
production systems where the work of the people was the 'Work of the Gods' (Firth 1967),
but as Firth showed, and the quarry evidence also demonstrates, the prescriptive and
performative behaviours of work are situationally patterned.

The notion that 'The social structure in a particular environmental setting creates, as it
were, religious expectations' (Lewis 1976:104) finds considerable support in the
archaeological record of this particular quarry. The same must have held true in the ascent
to the quarry which in the terms just defined was a walk upward and backward in time to
cosmological origins. Little is known of the actual movement to and from the quarry, of
course, but there is reason to suspect that this phase, a 'betwixt and between' or liminal
phase (Turner 1967), involved a series of religious rites in the process of passing through
across the boundaries of a number of different environmental zones perceived in
cultural terms as wildernesses and known by the general term wao (Malo 1951:17). The
expropriation of a bit of nature in each of these zones for human use and offerings to the
gods would contribute over time to the 'Maussian totalisation' character of the quarry
faunal and plant assemblages. Finally, in the passage from a permanent home at sea level in
a subtropical environment to a temporary home in a 'non-subsistence' alpine desert and
back again, one can begin to apprehend what is meant in statements such as 'Life's center,
work, is a prayer and a mode of becoming' (Glassie 1982:311) and the extent to which non-
agricultural production systems are an integral part of the social construction of reality.

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or the lack of it, in trying to say too much.
REFERENCES

Alexander, W.D. 1892 The ascent of Mauna Kea, Hawaii. The Hawaiian Gazette 27(38):7 (20 September 1892)


Arning, E. 1931 Ethnographische notizen aus Hawaii 1883-86. Mitteilungen aus dem Museum für Völkerkunde in Hamburg XVI


Baldwin, P.H. 1945 The Hawaiian goose, its distribution and reduction in numbers. Condor 47:27-37


Binford, L.R. 1980 Willow smoke and dogs' tails: hunter-gatherer settlement systems and archaeological site formation. American Antiquity 45:4-20


Bryan, W.A. 1914 Hunting the Uau on Molokai. Mid-Pacific Magazine 8(2):152-57


Clark, G. 1945 Farmers and forests in Neolithic Europe. Antiquity 19:57-71

Clark, G. 1947 Forest clearance and prehistoric farming. The Economic History Review 17:45-51


Daly, R.A. 1910 Pleistocene glaciation and the coral reef problem. American Journal of Science 208:297-308


Ellis, W. 1969 Polynesian Researches Hawaii. Charles E. Tuttle: Japan


Emerson, N.B. 1894 The bird-hunters of ancient Hawaii. Hawaiian Annual


Lyons, C. 1875 Land matters in Hawaii. *The Islander* 1(1-33)
Netting, R.M. 1971 *The Ecological Approach in Cultural Study.* Addison-Wesley, Module in Anthropology No.6
Olson, S.L. and H.F. James 1982 *Prometheus of the Fossil Avifauna of the Hawaiian Islands*. Smithsonian Institution: Washington, DC, Smithsonian Contributions to Zoology No.365


Schilt, R. 1984 *Subsistence and Conflict in Kona, Hawai'i: an archaeological study of the Kuakini Highway realignment corridor*. Department of Anthropology, Bishop Museum: Honolulu, Departmental Report 84-1


TRADING FOR SUBSISTENCE: THE CASE FROM THE SOUTHERN MASSIM

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SUBSISTENCE TRADING

The concept of subsistence trading invokes the notion that many coastal and insular Melanesian groups consciously expand their reproductive bases beyond the productive bases of what they regard as their own physical territories. Put more simply, the population densities of certain locations exceed the ability of the local natural environment plus the achieved levels of technology to provide the necessary subsistence for such densities. Instead, by developing specialised trading skills and importing the means of subsistence, these groups create a wider economic catchment within which particular groups specialise in the production of particular food items or manufactured goods, or the conveying of both. This shapes, and is shaped by, the particular forms of settlement and their locations, together with the concomitant social patternings which are found in the region today.

The concept of subsistence trading is not new, being implicit in the works of anthropologists working in the area since and including Malinowski, and explicit in the works of Sahlins, particularly in *Stone Age Economics*. We feel, however, that social anthropologists, with particular interests in social organisation, symbolism and ceremonial have perhaps paid insufficient attention to the economic organisation required to underwrite these other aspects of Melanesian behaviour. We find it difficult to separate ceremonial and secular activities, arguing instead that they are interlocking. Thus we avoid the question, or more accurately, the non-question of which is more ‘important’. In the following analysis we do separate goods into the categories of prestige and utilitarian goods, for pragmatic reasons which will become clearer later.

While adhering to the term throughout this paper, subsistence trading thus implies an activity not concerned with the disposal of surplus production for profit, but instead with the practice of a basic subsistence mode which is central to a wide range of social activities and vice versa.

Finally there is, of course, no uniformity in the degree to which various groups participated in subsistence trading, either as specialist middlemen or as suppliers/recipients. Participation in, as well as the configurations of subsistence trading depend upon a wide range of variables including location, local ecology, marriage patterns, warfare, sorcery, other trade partnerships and so on. What needs to be made clear is that the discussion here is not predicated upon a model of environmental determinism, although environmental factors are obviously important as one aspect determining the configurations of trade.

PROPOSITIONS ABOUT SUBSISTENCE TRADING

The central purpose of this paper is to test a number of propositions about subsistence trading that have been put forward by one of us (Allen), using several clear cut Melanesian examples of highly specialised middleman trading groups, by examining them against a large database collected by the other (Macintyre) for an area which is much more geographically complex and where middleman trading is a less specialised occupation, if no less time consuming.

The theoretical contribution has evolved from an examination of both ethnographic and archaeological data from the Motu of the Port Moresby area, which has and is appearing elsewhere in print and will not be considered here in any detail. To this have been added observations by Saville (1926), Malinowski (1915, 1922), Irwin (1985) and others for the Mailu, Harding (1967) for the Siassi, and Mead (1937) for the Titan of Manus. From this investigation these specialised systems appear to hold in common a number of
characteristics which have led to the general propositions to be tested. These characteristics are:

Location

Specialised middleman traders appear frequently to occupy locations which, while marginal in terms of local subsistence, are often strategically placed to take advantage of other locational factors. In the case of the western Motu, the highly pronounced wet/dry seasons, with the wet being short and unpredictable, lead to marginal agricultural production. This is offset by the advantage of a secure harbour and a protecting reef corridor for local canoe travel, as well as a central geographical position in the western Motu trading system which allowed them to prevent, if necessary, direct communication between peripheral areas of the network. Mailu is a small offshore island which confers defensive potential (important when large numbers of the male population are absent on trading expeditions) as well as, in Irwin's words (1978a:406-7), 'a distinct locational advantage' in respect of communications, but whose 'carrying capacity was too small for its population'. The Siassi occupy tiny islands between the landmass of New Guinea and New Britain, a dominant trading location although, as Sahlins (1972:282-84) pointed out, 'naturally impoverished'. The Titan traditionally owned no land, and perched in houses in lagoons along the south coast of Manus and other islands in the southern part of the Admiralties. Thus the proposition: specialised middleman traders are likely to be located in marginal zones between agricultural or other resource-rich areas, but in places conferring alternative advantages in terms of a trading regime.

Pottery for food exchanges

There is, in the cases examined, a correlation between specialist traders and the manufacture and/or distribution of pottery. At contact, both the western Motu and the Mailu held a monopoly of pot making and distribution in their areas. In the southern Admiralties all pottery was made by Titan, although not all Titan made pots. The Siassi did not pot but monopolised pottery distribution from New Guinea to New Britain across the Vitiaz Straits. Further south, the Amphlett islanders preferred to maintain themselves on their locationally advantageous but resource-poor island, importing food against the pots they made, even though they had to sail for a day to get suitable clay from Fergusson Island.

In these cases pottery provided a basis not only for food exchanges, although this was the primary item exchanged, but also for more prestigious goods, either in a direct exchange or by conversion to another medium. The proposition here is that among specialist trader groups, pottery provides an important item of subsistence exchange and that capturing a monopoly on its manufacture and/or its distribution provides a strong basis for increasing such specialised economic activities.

Population

Mead's (1937:212) observation, that the Titan, although 'most disadvantageously placed of all the tribes in that part of the archipelago, are nevertheless the richest and have the highest standard of living' has been echoed on a more general level for Melanesian specialist traders as a whole by Sahlins. While this does not mean (nor do we argue) that non-trading Melanesian communities cannot be prosperous, it does suggest that specialised trading is one pathway to prosperity. If we assume that population density is a general measure of prosperity, then we can examine the cases before us.

For the Siassi in the Umboi subdistrict, 25% of the population is clustered on 3% of the available land. Mailu Island Village in 1889 contained 80 houses compared with a range of 6-36 houses in the surrounding mainland villages. At the end of the 19th century, population in the western Motu domain averaged 50 people per kilometre of coast compared with 20 per kilometre of coast along the adjacent and more fertile area occupied by the eastern Motu. The largest western Motu village, Hanuabada (more correctly a contiguous cluster of villages) in Port Moresby harbour, and centrally located, was, depending on various sources, 2-4 times larger than its neighbouring villages.

Here the proposition which emerges is that specialist trading groups, whether villages or groups of villages, increase in size and density of population. Both natural increase and immigration are assumed. For the western Motu it has been suggested that the documented prehistoric but recent shift of inland Koita to the coast, where they established their own
villages and also joined Motu villages, may be explained in terms of the attraction of the prosperity of the specialised trading western Motu. In other cases the fusion of tribally-related villages or lineal descent groups within villages can be documented.

**Transport**

The proposition is self-evident that efficient sea-going canoes and associated technology, as the most viable available way to move bulk and weight over long distances, is a prerequisite to the development of these specialised trading systems. However, several further aspects can be noted. None of the four groups considered here had access to suitable trees for canoe hulls in their own territories, and this vital commodity had to be procured by trade. Despite this, there is evidence that both the Titan and the Mailu preserved a monopoly on ocean-going canoes, probably by force.

**Metastasis**

The final, general characteristic to be considered involves the changing configurations of systems, their longevity, changing locations of specialist trading communities and producer-partners and changing items of trade. A varied set of factors, many of them interactive, impinge on the consideration of change. Some of the following have been considered elsewhere (Allen 1984; Macintyre 1983) and none of them can be argued in detail here. Instead we seek merely to outline them for brief consideration.

*The embedded conservatism of egalitarian social and political organisation*

Prestige acquisition and competitive status rivalry may promote the development of specialised trade. Trading itself confers prestige on the successful, apart from the acquisition of food and other items to be used to promote status. Paradoxically, however, while this form of status acquisition may initially foster growth in trade, it may also be fundamental through the inflexibility of the social system, in preventing the continued growth of a trading system. The argument is that successful trading systems have a strong tendency to expand, but that such expansion demands more centralised forms of political organisation than are available. A transformation of the egalitarian forms of organisation in Melanesia, into hierarchical forms necessary for centralisation, while not impossible, does not seem to have happened.

*The control of supply and demand*

Related to the previous point, Sahlins has argued that supply and demand regulate the systems of Melanesian trade, at least to some degree, but that whereas, in western economic systems, imbalances are regulated by the market price mechanism. In Melanesia this mechanism is replaced by controlling social aspect of exchange; in his words (Sahlins 1972:311), what is important is not ‘the customary exchange rate; it is the customary exchange relation’.

The standard mechanism of exchange in Melanesian systems is the individual trade partnership, which imposes obvious physical limitations to expansion. There are limits on the number of partnerships an entrepreneur can handle. While increased population might increase the number of entrepreneurs, concomitant increases need not necessarily occur in the producer villages. Either new markets would have to be tapped, that is, an expansion of the system in space, or the system would likely become unstable at the centre as per capita inflow of food and prestige goods decreased. Well-known examples of buffering, involving seemingly uneconomic, if not irrational exchanges, illustrate the effort employed to keep trading ‘roads’ open.

*Marriage alliances*

In Melanesia generally there is a strong correlation between marriage alliances and trade. Institutional exchanges associated directly with marriage help maintain other more pragmatic trading relationships. Breakdowns in existing patterns of exogamy between particular groups, or even the physical relocation of particular villages might cut traditional supply lines of certain items, or open up others which create new competitions; such perturbations might affect an entire system, and require readjustments in otherwise unaffected areas of a system.
Warfare

The relationship between warfare and trade is extremely complex. Among the variety of situations where these two factors interact we can nominate warfare which is a reaction to trade, where trading partners might fail to respond with goods of sufficient quality or quantity, or might form new trading partnerships with competitors; warfare intended to initiate or intensify trade through the subsequent pacification process; warfare to maintain trading monopolies; warfare to redress sorcery to which an unsuccessful trading venture is attributed, and so on. What is clear is that hostilities and trade were not opposite ends of the perceived economic spectrum among specialist Melanesian traders, but that warfare was a factor in the changing configuration of trade.

To summarise the theoretical side of this paper, we believe that while the policy of subsistence trading held out the promise of prosperity, the brittleness of the structures made the promise tenuous. Thus, while stressing the primacy of the traders within the various systems, this does not imply any domination of the client villages by the traders, other than the overall economic control afforded by the monopolies of location and transport, themselves often only monopolies existing by the grace of other groups within the system not attempting to interfere.

Figure 1  Model of cyclical patterns of trading intensity

*A priori* constant change in the nature and configurations of any defined trading system are readily predicted under such conditions and the total breakdown of systems is a likely possibility. From our scanty historical and archaeological knowledge, where no defined system seems more than a few hundred years old, such a view is suggested but far from confirmed. Figure 1, a model of past trading activities on the south Papuan coast illustrates this. The nuances of this model cannot be taken up here, but overall it is intended to suggest a cyclical patterning to periods of trade intensity increasing, becoming unstable and subsequently breaking down. Over a period there is a growth in the complexity of trading systems complemented by a reduction in their geographical size. I would argue that this can be seen in archaeological evidence and offer one example only (Fig.2).

One of us (Allen) has argued elsewhere that of all the factors causing change and breakdown in these subsistence trading systems, the inability of the existing social and political organisations to accommodate rapid growth may be most fundamental amongst a
variety of what Flannery called 'systemic pathologies' (Rappaport 1969; Flannery 1972).

One final point is that this model is explanatory rather than predictive, in that it implies no predetermined trajectory. Without going into the variety of possibilities it is possible to predict, however, that if such development continued along an evolutionary pathway we might expect systems to become spatially smaller and trade items more diversified. This point will be taken up after reviewing the southern Massim data.

TUBETUBE AND THE SOUTHERN MASSIM

This section concentrates on an examination of Tubetube's trading role in the Massim. Tubetube is one of a group of eight islands, the inhabitants of these islands are interrelated, speak the same language and refer to themselves as Bwanabwana (island people) (Fig. 3). At contact there were 400 people on Tubetube, which means a population density of 176 per km². The missionar y's census (confirmed by government ones) indicates that Ware had then 350 people, Naluwaluwali ca. 60, Kwaiwa ca. 90; during the pre-contact and early colonial period the smaller islands were not permanently inhabited. Ware and Tubetube were centres of trade, with Tubetube dominating. When Seligman (1910:526) visited the island in 1904 he observed that 'everything in common use, including food, was imported'. Field (letter dated August [no year]), the resident missionary there for eight years commented also on the prolonged absences of the men, their 'appalling sloth' when it came to gardening and their obsession for 'sailing about'. His letters provided the basis for much of the reconstruction offered here.

Genealogical evidence reveals that during the late 19th century there had been an influx of immigrants from Panaeati, South Cape, Logea, Dobu and Duau.

Social organisation

Bwanabwana social organisation is essentially the same as that Fortune (1932) describes for Dobu. The basic social unit is the susu, a matrilineage comprising brothers and sisters and the children of the women. The senior man of the susu (guayau) was the guardian of the susu's wealth, his sisters the controllers of its land. As owners of large sea-going canoes, the
Figure 3  Map of the Massim
guyau directed interisland trade: their more common title on Tubetube was Tanuwaga which means 'owner of the boat' and by extension, 'leader'.

Each susu was politically autonomous and at contact there were 14 distinct susu, with separate hamlets and territories. There was no hierarchical differentiation between susu (cf. the Trobriands) although internally a strict generational hierarchy was observed.

There are two points which should be made in this context:

1. Each susu had distinctive trading alliances with hamlets on other islands, usually based on an affinal or totemic clan relationship. This means that, for example, one group of people imported yams from Nuakata, while another got the bulk of theirs from a trading partner on Dobu. One effect of this, of course, is to diversify trade contacts.

2. In the Bwanabwana, there were (and still are) regulations which require that at least for the first 4-6 years following marriage, the couple alternately reside in each other's hamlet. With interisland marriages, this entailed annual voyaging between each place, affinal visiting and large exchanges of food and other goods. Until missionisation, practices of child betrothal between trade allies were one of many customs which preserved or established patterns of trade over generations.

Table 1  

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type A: items which are used primarily as a medium of exchange, but are worn or displayed in ceremonies.</strong></td>
<td></td>
</tr>
<tr>
<td>Kilam</td>
<td>axe blades mounted in carved handles</td>
</tr>
<tr>
<td>Palelesalu</td>
<td>polished stone axe blades</td>
</tr>
<tr>
<td>Mwali</td>
<td>conus armshells</td>
</tr>
<tr>
<td>Bagi</td>
<td>necklaces made from chama pacifica or spondylus shell beads</td>
</tr>
<tr>
<td>Dona</td>
<td>boar's tusk ornament</td>
</tr>
<tr>
<td>Wanepa</td>
<td>nosesticks</td>
</tr>
<tr>
<td>Wakisowa</td>
<td>fibre belts decorated with shell beads</td>
</tr>
<tr>
<td>Kenelobulobu</td>
<td>large, non-functional limesticks, carved wood or turtleshell, used as a mount for bagi</td>
</tr>
</tbody>
</table>

| **Type B: items which are functional but also constitute media of exchange.** |
| Kepo | gold lip shell implements, used to cut seed yams and in some areas, as an ornament carried during soi large feasting pots |
| Gulewa lalakina | large carved wooden platters with decorated rims |
| Gaebu | carved wooden drums |
| Sidai | roughly out or unpolished stone for axe blades |
| Veku | carved wooden sword-shaped weapons |
| Kelepa | elaborately carved paddles used to stir sago |

| **Type C: Polo - pigs** |

| **Type D: Waga - sea-going canoes** |

| **Type E: items which are given as subsidiary or accompany gifts to Type A valuable. These all fall into the indigenous category 'pasa' - 'decoration'. This designation refers to their function in the exchange, not their later use.** |
| Kene | lime spatulae |
| Kauli | lime gourds |
| Bosim | whalebone spatulae, decorated with shell beads |
| Dunali | cowrie shell leg ornaments |

All of the above are part of the regalia of guyau. Other types of pasa are given as gifts and retained by the recipient for his own use.

| Komwakomwa | earrings |
| Nipuna | armbands of woven fibre |
| Wakisowa | belts made of woven fibre with minimal decoration |
| Gulugulu | necklaces made of black banana seeds |
| Kepata | bone daggers |
| Beda | betel (areca) nut, given either as a large bunch or made into a garland and draped over the kune gift |
Kune

All interisland trade involved kune (kula) partnerships. In the southern Massim, kune transactions are not confined to the valuables mwali and bagi (Trob. soulava). They include all items which can be classed as scarce but essential commodities: canoes, large feasting pots, stone tools in various stages of manufacture, and formerly obsidian. The shell valuables constitute flexible exchange media for these goods. Table 1 is a list of all items exchanged in kune (up to about 1920). All kune goods were used as media of exchange for appeasement and compensation payments; for land, marriage and mortuary payments.

The neat distinction between ceremonial/utilitarian exchange cannot be maintained for the southern region for the following reasons:

1. All exchanges were performed with ceremony.
2. Although the rituals for the direct exchange of commodities such as food, pots and mats were less elaborate, many of these goods were transacted in marriage and mortuary ceremonies which were highly ceremonial affairs.
3. All items have some utility. Shell valuables as a medium of exchange, pigs as food etc. Tubetube traders acquired their greatest economic asset - canoes - in kune.

Pali

Table 2 lists all goods which Tubetube transacted as pali, trade or visiting gifts. Goods acquired in pali transactions with one group of producers were later traded with others. Production for trade on Tubetube was confined to the following items:

Nose bones; pots; upgrading of stone tools by polishing; upgrading of shell valuables by grinding and polishing; refurbishing hulls of canoes; string manufacture; fishing and smoking fish; manufacturing shell implements; diving for giant clam shells; making turtle-shell ornaments. All of these items were also imported - Tubetube people traded pots made on other Bwanabwana islands; they even imported fish from Panamoti.

Pali operates according to fixed rates of exchange and does not involve barter or haggling. One major distinction between kune and pali is that leaders derived prestige from ownership and exchange of kune items, whereas pali goods were valued primarily as items of common utility. (The complicating factor in this distinction is the prestige derived from yam exchanges - yams acquired as pali from producers could be given as affinal prestations or as kune payments for canoes, in which case they were ‘revalued’ and became prestige goods in the system. This applies only to Dioscorea alata). From an economic stance the movement of goods from pali to kune spheres is functionally related to the scarcity of the product in a particular region, e.g. pots coming into Tubetube come as pali, but count as kune in non-pottery producing communities; roughed out stones were given as pali by Muruans, but moved everywhere else as kune.

Table 2  Pali goods

Type A: food.
Yams, sago, leafy vegetables and ferns, turtles, dogs, taro, bananas, fruit, fish and coconuts.

Type B: raw materials.
Fibres  pandanus, sago leaves, vines for making string, rope, fishing nets, etc. A flax-like substance, possibly from a grass called imo, used for lashing and hafting
Stone  whetstones for grinding shells, drill tips, veku, nabuka - obsidian, waia sand for polishing
Glass  from late 19th century until about 1930, bottles and glass fragments for use as cutting implements
Building materials  sago palm branches and leaves
Wood  fine-quality wood used to carve decorations for canoes and houses, musical instruments and weapons
Ochre  used as a dye for decorating canoes, house-posts, and for body decoration
Clay
Turtleshell
Feathers  a pitch-like substance used to blacken teeth used as hair ornaments and on war canoes
Type C: finished goods.

- Pots
- Mats
- Baskets
- Fibre skirts
- Rope and twine
- Wooden dishes
- Waila patuna
- Giant clam shells
- Pwaupwaum
- Spears
- Gune
- Combs
- Lime gourds and lime spatulae

Highly polished water containers made from exceptionally large coconut shells used as receptacles and as food dishes for pigs finely woven basket-like head coverings, worn during mourning shells made into cutting and peeling implements, fishing lines

Type D: plants and plant products

- Sprouting coconuts
- Seedlings, cuttings and seed pods
- Scented oils
- Plants used for magic and healing
- Resinous substances used for caulking, hafting and in tool manufacture
- Tobacco
- Areca nuts and ‘mustard’ - betel pepper leaf and catkins

Location

Irwin (1978b, 1985) has demonstrated Tubetube's geographical advantages as a base for a community of traders. This will not be further elaborated here, but will become more obvious later.

Strategies

Having observed that canoes are a prerequisite for the development of specialised trade systems we begin by looking at the ways in which Tubetube controlled (or attempted to control) canoe exchanges (Fig.4).

There are three major producers - Murua, Misima, Panaeati - all east of Tubetube. Although some canoes came from these places direct to Tubetube, the majority did not (until pacification). Between the afforested islands lay smaller islands, strategically located so that their inhabitants could interpose themselves between producers and purchasers - Egom/Yanaba, Panamoti, Nasikwabu, Gawa and Brooker. These people obtained hulls from the larger islands and fitted them out before trading them to Bwanabwana people, and then acted as agents or intermediaries between producers and consumers. All of these islands are small, drought prone (Panamoti and Nasikwabu have no water for long periods of each year) and entirely dependent on imported food. Although they traded, they were also major producers of fibre products. At contact, Tubetube's most important kune partnerships to the east were with people on these ecologically marginal islands. Alliances with these groups for warfare, reinforced trade links and presumably limited competition.

Tubetube traded canoes to the west. In this case its strategic location is obvious, note also that it did not trade canoes to Basilaki, Duau and Sideia (maybe because they could have challenged Bwanabwana dominance by establishing alternate routes?). According to oral testimony, most canoes traded west were refurbished hulls - Bwanabwana's secondhand canoes. Most canoes were acquired for their own use, the map (Fig.4) does not indicate volume, just trade routes.

But there was another crucial commodity involved in all this - stone tools.

There is little archaeological data available from which to draw conclusions about the nature and extent of trade in this item. The map (Fig.5) is conjectural, derived mainly from oral testimony about the past and observations by Seligman (1910) in the early years of colonial intrusion. Preliminary work in the Louisiade region suggests that the greenstone axe trade may only have flourished in the recent past, in the years immediately preceding and during European colonisation (G. Irwin pers. comm.).
Figure 4  Trade routes for canoes

Figure 5  Trade routes for axe blades
The only source of high grade stone in the region is Suloga on Murua. The stone workers traded their product to coastal villagers (who were also canoe manufacturers) and stone tools reached Tubetube along the same routes as canoes. Misimans traded directly with Murua for stone, and so the Panaeati/Brooker route provided another major source. (It might be relevant here to note that the Tubetube people still believe that Misima is a major source of stone, and they distinguish between axes of Louisiade and Muruan manufacture. Even today many people believe that the monopoly over axe blades was not environmentally determined but due to the producers' secret knowledge of the reproductive habits of stones. They grow them in streams and harvest them).

All oral history attests to the Louisiade connection preceding the northeast links via the small islands. At least three 'legends' attribute the rise of Tubetube's trading power to their alliances with Panamoti and Nasikwabu which enabled them to establish alternate routes for canoes and stone.

The productive capacities of the smaller islands depended on a stable food supply. Tubetube supplied the sustenance which enabled their partners to deliver the goods.

**Yams, sago and pots**

At contact, trading networks indicate that the southeastern Massim, from a Tubetube viewpoint, was divided into two regions. The D'Entrecasteaux Islands provided yams, while the western region from Basilaki to Suau provided sago. Tubetube traded pots and sago north, and pots and yams west. Both areas were specialising their agricultural production in ways that provided a subsistence base of one crop but in sufficient quantities to trade against pots and other foods. The value of the imported foodstuff is high in relation to the staple; to the west of Tubetube yams were exchanged as cooked food at ceremonial feasts; in the Bwanabwana and to the north, cooked sago (*mone*) was the ceremonial food.

The variation in the status of foods between the two regions reflects relative scarcity. Although environmental determinants can be invoked to explain this phenomenon, they do not offer a sufficient explanation as both crops grow well throughout the region. (Indeed, as trading for subsistence has declined, people have diversified their crops).

Oral accounts and the recorded observations of Europeans suggest that Dobu exported enormous quantities of yams. Seligman (1910:526-28) speaks of tons; the visiting missionary on Tubetube recorded five separate voyages between 1918-24, when Tubetube canoes returned with between 80 and 100 large baskets of yams. Reverend Guy observed that in 1921 they had departed Tubetube with two pigs, six dogs, eight baskets of dried fish, 'a pile of grass skirts from Sudest' (i.e. ones for ceremonial wear) about 50 pots and 'other mysterious packages' (Guy 1918-48). The relationship between Dobu and Tubetube was uniquely focused, as at this time all Tubetube hamlets had alliances on Dobu. The concentration of trading alliances in that direction was probably recent, however, and most voyages to food producers did not entail vast quantities of food. Rather they traded a wide range of goods with one staple product predominating in each case (see Table 3).

Clearly, however, we are dealing with a developed system of interdependence, in which trade not only moved one type of food against another but encouraged specialisation in the production of non-food items to the extent that whole communities could subsist without gardens. Figure 6 shows that food was the major commodity traded to these small islands. We can interpret this on the one hand as maintaining vital trade routes to canoes and stone tools, on the other as providing the means whereby stone tool and canoe manufacturers can maximise production of their own resources. So, the movement of axes and other tools from east to west must be viewed in terms of the movement of food in the other direction.

Tubetube did not monopolise pottery production and trade. Pottery was produced on Panaeati, Brooker, Duau, and East Cape. The only places which were entirely dependent on Tubetube pots were Basilaki, Nuakata and possibly Sideia, Sariba and Logea. Pots were traded in all directions, but never as the sole item of trade, and always in conjunction with a staple food. The only places where vegetable staples were not conveyed by Tubetube as major trade items were to the yam-producing communities to the north. These communities imported dogs, fish and pigs.

Pig exchange between communities was (and remains) a very complicated business. Oral testimony from people who traded with Tubetube suggests that Tubetube traders transported pigs everywhere. Informants from Gawa, Murua, Duau, four Milne Bay villages and Logea insisted that Tubetube people were rich because they grew many pigs. This reputation sits uneasily with other data. Tubetube informants, when confronted by
<table>
<thead>
<tr>
<th>Place</th>
<th>Tubetube imports</th>
<th>Tubetube exports</th>
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</thead>
<tbody>
<tr>
<td>Suau</td>
<td>Bangi, pigs, ceremonial limesticks, Waga (sea-going canoes from Murua)</td>
<td>Hafted axes, stone tools, bangi, carved wooden bowls</td>
</tr>
<tr>
<td>Logea</td>
<td>Stone tools, hafted axes, pigs, Mwali</td>
<td>Bangi, pigs, canoes</td>
</tr>
<tr>
<td>Sariba</td>
<td>Stone tools, pigs, Mwali</td>
<td>Bangi, pigs, shell belts, nosesticks</td>
</tr>
<tr>
<td>Sideia</td>
<td>Mwali, pigs</td>
<td>Bangi, canoes, pigs, Mwali</td>
</tr>
<tr>
<td>Basilaki</td>
<td>Mwali, pigs</td>
<td>Bangi, canoes, pigs, Mwali</td>
</tr>
<tr>
<td>Panaeati</td>
<td>Bagi, ceremonial limesticks, pigs, canoes</td>
<td>Hafted axes, pigs, nosesticks, stone tools</td>
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<tr>
<td>Brooker Island</td>
<td>Bagi, pigs, canoes, ceremonial limesticks</td>
<td>Pigs, hafted axes, stone tools</td>
</tr>
<tr>
<td>Moturina</td>
<td>Bagi, ceremonial limesticks</td>
<td>Pigs, stone tools, nosesticks</td>
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<tr>
<td>Location</td>
<td>Items</td>
<td>Bagi Items</td>
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<td>----------------</td>
<td>--------------------------------------------</td>
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<tr>
<td>Misima</td>
<td>Taro, Areca Nuts, Basketware, Wooden Utensils, Sago, Limesticks</td>
<td>Bagi, Canoes, Ceremonial Limesticks</td>
</tr>
<tr>
<td>Sudest</td>
<td>Sago, Taro, Pearl-Shells, Basketware, Areca Nuts</td>
<td>Bagi, Pigs, Shell Belts, Boar's Tooth Necklaces, Carved Bowls</td>
</tr>
<tr>
<td>Egom</td>
<td>Pots, Yams, Mats, Skirts (via Panaeati, via Murua), Boat Building Materials</td>
<td>Canoes, Bagi, Sapi-Sapi</td>
</tr>
<tr>
<td>Nasikwabu</td>
<td>Mats, Skirts, Pandanus</td>
<td>Canoes, Bagi, Pigs</td>
</tr>
<tr>
<td>Gawa</td>
<td>Mats, Rainmats, Skirts</td>
<td>Bagi, Canoes, Pigs</td>
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<tr>
<td>Panamoti</td>
<td>Mats, Skirts, Coconuts</td>
<td>Bagi, Canoes</td>
</tr>
<tr>
<td>Milne Bay (Wagawaga/Maivara)</td>
<td>Taro, Areca Nuts, Baskets</td>
<td>Pigs, Hafted Axes</td>
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<tr>
<td>Murua</td>
<td>Mats, Skirts (Roughed Out Stone, Axes - Pre-Contact)</td>
<td>Bagi, Canoes, Pigs</td>
</tr>
<tr>
<td>Duau</td>
<td>Yams, Taro, Baskets, Bananas</td>
<td>Mwali, Pigs</td>
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<tr>
<td>Location</td>
<td>Items Listed</td>
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<tr>
<td>Dobu</td>
<td>Yams, basketware, ochre</td>
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<td></td>
<td>Bagi, belts, dona, pigs</td>
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<td></td>
<td>Pots, dried and fresh fish, areca nuts</td>
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<tr>
<td>Nuakata</td>
<td>Yams, bananas, taro</td>
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<td></td>
<td>Mwali, pigs, stone tools</td>
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<td></td>
<td>Bagi, canoes, nosesticks</td>
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<td></td>
<td>Pots, dried and fresh fish</td>
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<tr>
<td>East Cape</td>
<td>Yams, taro, sago, areca nuts, breadfruit</td>
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<tr>
<td></td>
<td>Mwali, pigs</td>
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<tr>
<td></td>
<td>Bagi, canoes</td>
<td></td>
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<tr>
<td></td>
<td>Pots, dogs, carved wooden utensils</td>
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<tr>
<td>Ware</td>
<td>Pots</td>
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<tr>
<td></td>
<td>Canoes, bagi, stone tools, pigs, Mwali</td>
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<tr>
<td></td>
<td>Stone tools, lime-sticks, pigs, bagi, Mwali, canoes</td>
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</tr>
<tr>
<td></td>
<td>Yams, bananas, taro, sago, areca nuts, basketware</td>
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<tr>
<td>Kwalaiwa</td>
<td>Polynesian chest-nuts, bananas</td>
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<tr>
<td></td>
<td>Bagi, pigs</td>
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<tr>
<td></td>
<td>Mwali, hafted axes, pigs</td>
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</tr>
<tr>
<td></td>
<td>Areca nuts, sago, yams</td>
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</table>
this, suggested that their trade partners thought that all pigs they brought had been bred on Tubetube, whereas they were brought in and fattened. According to them, many small pigs were exchanged for stone tools and the centre for pig production was on the southern mainland coast. All pigs are bred for exchange and the maxim 'your own pig you may not eat' holds throughout the region. Table 2 shows that the only places where pigs were not exchanged for pigs were Milne Bay villages, East Cape, and islands in the Louisiades - in these cases pigs from the mainland were moving against bagi of Louisiade manufacture and stone tools.

Specialised production is one form of specialisation. Specialised manufacture of goods from ubiquitous resources was another. Pandanus and coconuts grow throughout the Massim and every community manufactures fibre products for local consumption as well as for export. Food producers made baskets in which they packed all food given as pali, the sizes standardised according to the rates of exchange, so that each community produced three sizes of basket which were then exchanged for pots of matching size. So, from Dobu for example, a small basket containing five yams is equivalent to a small pot, a large basket of 20 yams can be exchanged for four small pots or one very large one. The etiquette of pali required that Tubetube traders offered their goods in baskets of exotic origin. Imported baskets are valued more highly than the local item and are therefore chosen as receptacles for ceremonial prestations. Only in-marrying women made baskets on Tubetube and even today most baskets are imported. Photographs and drawings of baskets from various museum collections were recognised and provenanced by informants from several areas. Bwanabwana informants identified 40 distinct types of basketware from 17 different places of manufacture; Dobuan informants attributed 10 of these to Tubetube; Basilaki people recognised baskets made by their immediate neighbours but were unable to specify sources for nine from the eastern area. Tubetube informants did not rank food baskets, but simply gave each its value in pots (assuming it was filled with yams). Their trading partners ranked them according to a scale which put their own product at the bottom and that of the islanders most distant at the top, (e.g. an old woman from Logea smiled at a picture of a standard yam basket from Sudest and said 'Oh yes, that's from Panaeati side, an excellent basket. If they gave a pot in that then I'd find some extra betel nut for them'). Clearly Tubetube traders were able to capitalise on their role as transporters.
Food baskets vary in shape and weaving patterns but not in basic utility or durability. The people of Panaeati, Egom, Nasikwabu and Misima, however, produced fine basketware which was highly valued throughout the southern region. Louisiade islanders made small round basket-shaped head coverings which were worn by women in deep mourning; they made small round baskets used to carry skulls and other relics of the dead at mortuary feasts and three-tiered baskets for storing personal possessions. Skirts made of coconut leaves were given as marriage and mortuary payments and Tubetube traders acquired these as *pali* from their manufacturers and exchanged them within the Bwanabwana and to the western islands where the same mourning customs obtained.

Until missionisation, when Samoan mat weaving was introduced as a standard domestic accomplishment, almost all mats were imported to Tubetube from Nasikwabu, Egom and Panamoti.

Bwanabwana people imported rolls of prepared pandanus for sail-making and repairs, and for making the long skirts for widows. They made a soft but coarse string from a flax-like plant and traded this to the people of the mainland coast, along with shiny rattan which was then used for hafting tools. The *kilam* or 'ceremonial' axe of the southern region is an excellent case of specialised manufacture made possible by trade - Tubetube supplied the axe-blades from Murua, string and shiny rattan for hafting and binding, ochre came from Dobu and the people of South Cape made the axe handles and hafted them. These hafted blades then moved back along the trade routes as highly valued *kune* items. (The majority of hafted blades in museum collections are provenanced incorrectly 'Trobiand'; e.g. of those in the Australian Museum, five collected on Woodlark marked 'Trob.' were made in the southeast; in the British Museum, out of 30 axe handles marked Trobriand, 12 were indubitably of Suau/South Cape manufacture and four from Misima).

This hasty and far from exhaustive review of the evidence from Tubetube has omitted a number of items (plants, where the evidence is piecemeal, wooden bowls, where the evidence is very complex) but still demonstrates very clearly, the complexity of subsistence trading. Among a wide variety of conclusions emerging from these data only a few can be considered.

Starting with the earlier propositions we can observe:

1. That the centrality of Tubetube in terms of its trading location outweighs the local subsistence potential of the island.
2. That the population density of Tubetube at contact far exceeded its subsistence potential. Migration to this island shortly before this time is documented, and since contact a decline in specialised subsistence trading has been accompanied by out-migration and more generalised subsistence economies (less specialised gardens, increased effort towards local rather than imported subsistence activities etc.). On the model previously discussed this would be a phase of rapidly dropping 'trading complexity'.
3. That an emphasis on procuring canoes, and therefore the wherewithal to trade is emphasised in the oral history of Tubetube. We noted that canoes were not traded to Tubetube's nearest western neighbours, which may reflect a monopolistic intent remarked upon for other specialist traders such as the Mailu.
4. That like other specialist trading groups the Tubetube system appears to have no great antiquity. A number of the conditions likely to promote change are present in Tubetube, paramount among their potential competitors on other islands, a point to which we will return.

In these characteristics Tubetube seems to fit quite closely the earlier propositions. In one other it does not. Tubetube, while it made some pottery and traded other peoples' pots, had neither a monopoly on its manufacture nor its distribution. Only in its most local geographical sphere did Tubetube approach any sort of pottery distribution monopoly.

The geographical complexity of the southern Massim offers an explanation for this discrepancy and also broadens our understanding of specialised subsistence trading. Tubetube was centrally located in the broad east-west movement of items such as canoes and stone tools and the movement west of Fergusson Island obsidian, but poorly situated to prevent the multidirectional flow of goods east-west to their north or north-south to their east. As they themselves acted as middlemen locally, they in turn had to deal with smaller islands strategically located between them and the suppliers of goods and materials which had restricted sources, such as stone axes, canoes and obsidian - goods which took on a greater prestige value than those which could be produced in a number of places.

This is exemplified with pottery in particular. In the southern Massim, pottery manufacture and distribution conforms to the model only in very localised areas as a craft
specialisation enabling certain groups to emerge as middlemen traders.

Elsewhere (Allen 1984) it has been suggested that if the model presented here for the other systems has a predictive value, one pathway might be that systems become spatially smaller, trading more intense and the range of specialised trade items more diversified, with the closed nature of systems decreasing (i.e. interlocking of systems increasing). In viewing the southern Massim data it would appear that either this transformation had occurred by the end of the 19th century or that the developmental stage of one or a few specialisations, such as pottery, provided the springboard for the emergence of specialised traders had been bypassed. Only future archaeological research will solve this problem.

Clearly, however, the general importance of the coastal Melanesian strategy of trading for subsistence is amply demonstrated in the southern Massim and the general propositions developed elsewhere are substantiated by these data.

REFERENCES


Field, J.T. Rev. 1891-97 Unpublished letters to Lorimer Fison. In the private collection of Alan Tippett, Canberra


Guy, A. Rev. 1918-48 Unpublished diaries and papers. In the private collection of Mrs Brockhurst, his daughter


Irwin, G.J. 1985 The Emergence of Mailu as a Central Place in Coastal Papuan Prehistory. Department of Prehistory, Research School of Pacific Studies, Australian National University: Canberra, Terra Australis 10

Macintyre, M. 1983 Changing paths: an historical ethnography of the traders of Tubetube. Australian National University: Canberra


Rappaport, R.A. 1969 Sanctity and adaptation. The CoEvolution Quarterly, pp.54-68


SECTION III

THE AGRICULTURALISTS
The reclamation of swampland through drainage for use in cultivation is one of the options available to some New Guinea Highlands agricultural societies inhabiting the premier agricultural zone between 1400 and 2000 m altitude. At the time of contact, everywhere within the last 60 years, a number of communities was observed exercising that option (for general surveys Brookfield 1961, 1962, 1964; d. Brookfield with Hart 1971:94-116). The most extensive and most complex systems were being operated by the Dani on the swampy bottomlands of the Grand Baliem Valley of Dutch New Guinea (now Irian Jaya) (Brass 1941; Gardner and Heider 1969:Chapter 3; Heider 1970:31-42; Yen 1974:117-26). Further west, the Kapauku were draining the margins of lakes and swamps in limestone basins at the Wissel (now Paniai) Lakes (Pospisil 1963:Part IV). Similar practices in Australian New Guinea (now Papua New Guinea) were on a smaller scale. Those of the Huli in swampy limestone basins of the Tari district of the Southern Highlands have recently been described by Powell and Harrison (1982:31-42), while Bayliss-Smith (1985:296-98) notes the situation in the upper Kaugel Valley, near Mt Hagen, in the context of a study of high-altitude cultivation of taro.

In other parts of the Highlands there were wetlands not being systematically exploited. One of the most conspicuous examples is provided by the extensive swamps of the upper Wahgi Valley, where the topographic and hydrologic situation seems to parallel that of the Grand Baliem Valley (Brookfield 1964:22). Indeed, so unimportant were the Wahgi swamps in the traditional economy that with the end of World War II and the establishment of effective Australian administration they were sold to the Government by their traditional owners, to be subsequently developed for European plantations and as resettlement areas for people from overpopulated parts of the Highlands.

It was in the course of the aerial photography and large-scale drainage required by these developments that evidence emerged for the Wahgi swamps having once been the locus of swampland agriculture, just like the Baliem (Golson et al. 1967; Lampert 1967). Investigations which colleagues and I have been carrying out since 1972 in the upper Wahgi, primarily in the swamp at Kuk Agricultural (formerly Tea) Research Station, were initially directed to the questions of at what date and under what circumstances the option of systematic swamp drainage for agriculture had been taken up by the Wahgi people, and at what date and under what circumstances it had been given up. Particular attention was to be paid to the role of the sweet potato, the present staple of New Guinea Highlands communities, whose arrival in New Guinea was, in the accepted view, less than 500 years ago.

The project at Kuk has been prolonged because the investigations revealed that the option of drainage was exercised not once, but on a number of occasions, over an agricultural past of 9000 years, while there were long periods during which it was not exercised at all. The bare details are set out below:

<table>
<thead>
<tr>
<th>Drainage phase</th>
<th>Approximate dates BP</th>
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<tbody>
<tr>
<td>6</td>
<td>250-?100</td>
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<tr>
<td>5</td>
<td>?400- 250</td>
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<td>4</td>
<td>?2000-1200</td>
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<td>?4000-2500</td>
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<td>?6000-5500</td>
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<td>9000</td>
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Each episode of reclamation and exploitation, abandonment and non-use had obviously to be documented in its own right before soundly based hypotheses could be advanced, and this work of documentation is not yet complete. Inevitably, however, a series of provisional statements of a general nature has been made and it is with the genesis and modification of these that this paper is in the main concerned. The literature I used in this process is not referenced here, but is to be found in the bibliographies of the articles I shall pass explicitly or implicitly under review, which were written in the following order: Golson 1976; Powell et al. 1975:40-52; Golson 1977a, 1977c, 1977b; Golson and Hughes 1977, 1980; Golson 1981a, 1981b, 1981c, 1980, 1980/81, 1982a, 1982b. Of these Golson 1976, 1977b, 1981a, 1981b, 1981c and 1982a are the most important for our purposes. For the sake of completeness I add the following papers written subsequent to the assessment of the Kuk evidence made in this paper: Golson and Steensberg 1985, Golson 1989, Golson and Gardner in press and Golson in press. Wilson 1985 deals with a specific aspect of the investigations (phytolith analysis) and Golson 1985 (written in 1980) considers their implications as a whole for the consideration of agricultural origins in Southeast Asia.

ETHNOGRAPHIC AND ARCHAEOLOGICAL CONTINUITIES

Basic to early thinking (Golson 1976, 1977b) were the observations of ethnographers, human geographers and agricultural botanists on the technology of Highlands agriculture as a whole and the status of the existing swamp systems within it. Three general statements could be made on the basis of their studies.

1. Swamp agriculture is only a part, and not necessarily the major part, of the total agricultural system to which it belongs. For example, in 1955 Pospisil (1963:180-81) recorded that the village of Botukebo in the Kamu Valley of the Paniai Lakes had four times as much land under cultivation in swiddens on the mountain slopes as in two types of drained cultivation on the swampy flatlands, though he also noted swamp gardens as being more important with other communities in the region (1963:123). Ninety per cent of all Botukebo cultivations were planted to sweet potato (1963:182) and 82% of sweet-potato yields came from the mountain gardens (1963:444, Table 24).

2. Swamp cultivation is the intensive part of the agricultural system, with labour inputs greater, land kept under cultivation for longer periods and yields higher per unit of land, if not necessarily per unit of labour. The dry land component overall differs in all these respects and in some cases, as at Botukebo, is classic swiddening, with one crop only taken before abandonment. At Botukebo (Pospisil 1963:126-27) sweet-potato cultivation on the valley floor requires twice the labour input of the hillslope swiddens but gives twice and sometimes three times the yield for the same area of land. The villagers cannot rely on valley cultivations, however, since, despite drainage, the lowlands are susceptible to flood in very wet years and the sweet potato crop liable to be totally destroyed (1963:86). At the same time other crops of the villagers, like taro, banana and sugarcane, cannot be successfully grown on the rocky mountain slopes and must be cultivated in gardens on the valley floor (1963:87). The full interdependence of the two subsystems is explored by Pospisil (1963:82-83).

3. In respect of this dichotomy between intensive and extensive components, systems with swamp agriculture share the characteristics of some other New Guinea Highlands agricultural systems, where an intensive sector is located on other types of deep-soiled land, such as river terraces or volcanic ashes. Indeed, the agricultural techniques used in these intensive sectors are the same, whether swampland is involved or not. They include tillage of the soil to provide the planting medium, disposition of the tilled soil in regionally different types of raised bed, which form the gardening units, and sometimes mulching with green or decayed vegetable matter.

These techniques, together with the widespread though not universal practice of tree fallowing - the deliberate planting or conservation of seedlings of particular species of trees of rapid growth - on plots going into long fallow, have been characterised by students of Highlands agriculture as representing two things: (a) an answer to the problems posed for the practice of productive agriculture in grassland conditions, where the tough sod and associated conditions of soil acidity and low biomass renders the techniques of slash and burn agriculture ineffective; and (b) an ability to allow the prolonged and more productive cultivation of the same area of ground, something which becomes vitally important in circumstances of large populations of people and of pigs.

The historical evidence recorded by the mid-1970s from Kuk and elsewhere seemed highly compatible with this characterisation of the technology of Highlands agriculture.
Pollen diagrams showed substantial inroads into Highlands forests by 5000 BP, putting the region on the way to its present state of open grassland, bushy regrowth and localised forest. Stratigraphic change in the Kuk sediments at 2500 BP, from deposition in the form of clay particles to deposition in that of soil aggregates, could be interpreted as signalling the appearance of soil tillage in the agricultural system. Pollen diagrams over a wide area of the Papua New Guinea Highlands exhibited striking and sustained increases from 1200 BP in the representation of those tree species utilised in the practice of tree fallowing - *Casuarina*, *Trena*, *Dodonaea*. Finally, archaeological evidence at Kuk indicated the appearance of raised-bed gardening probably from 400 BP, certainly from 250 BP.

**THE INTERPRETATION OF PHASE 6: DIRECT ETHNOGRAPHY**

These indications of continuity between the archaeological and the ethnographic situations, together with the short time span separating the end of one and the beginning of the other, inspired confidence in using the evidence from New Guinea ethnography to interpret the latest phase, Phase 6, in the Kuk swamp. At first (e.g. Golson 1976, 1977b) this was attempted in a fairly limited fashion. Phase 6 was seen as an intensive phase of the local agricultural system, a view supported by the location during this phase, as during no other, of men’s and women’s houses in the swamp, identical in type with those described by the first European observers and built today.

Other components of the agricultural system, it was proposed, would have been located on the neighbouring dry land, from which by this stage any forest would effectively have been cleared and replaced by natural regrowth of degraded secondary communities and grass, with managed plantings of *Casuarina* and other trees. The system would have been associated with at least moderate densities of population. This conclusion seemed justified by the demonstration by a number of students, including particularly a quantified exercise by Brown and Podolefsky (1976), that the association between population density and agricultural intensity is very strong for the Highlands as a whole.

These interpretations were incorporated into and extended by subsequent publications (e.g. Golson 1981c, 1982a). It was apparent from the ethnographies that by no means all sweet potato was grown to support human populations and that at all times a proportion, and at times a considerable proportion, of the produce was meant for pigs. In the deforested environments of the Highlands, where wild fauna is scarce or remote, pigs are a major source of protein. Because in the circumstances of deforestation their opportunities for foraging are restricted, their upkeep becomes a charge on agriculture.

Pigs therefore are expensive and their possession is a mark of wealth and authority, since only men able to command the labour of a number of wives and attract that of bachelors and other unattached members of the community can keep pigs in quantity. Their disposal in any form, especially their killing for food, is strictly regulated. It takes place only on occasions that involve people beyond the immediate family group, such as birth, marriage, sickness, injury and death, which are occasions of acquitting obligations to kinsmen and affines. It reaches its apogee in the complex ceremonies characteristic of the Western Highlands from Chimbu to Enga, where in some areas the maximal political units serially play host to each other and in others big men sponsor the occasions where debts are repaid and credits created between men and their exchange partners. These occasions are attended by thousands and pigs disposed of in hundreds, while the pigs themselves grease the wheels for the movement of other valuables: products from the distant bush like feathers and fur, items of localised occurrence like specialised axes and salt, and exotics from beyond the region like marine shells.

We may feel confident, therefore, in suggesting that the produce of the drained swamp at Kuk went partly to the support of pigs, and through them, of elaborate exchange systems of the sort I have mentioned. After all, such an exchange system, known as *moka*, was characteristic of the upper Wahgi when Europeans arrived there in the 1930s (Strathern 1971).

There is, however, a problem in this use of the ethnographic situation in the upper Wahgi around contact to interpret the final drainage period at Kuk, because at contact there was no swamp drainage.

It can consequently be argued that swamp drainage was given up without traumatic effects on the pattern of upper Wahgi society as a whole, as distinct from the fortunes of individual upper Wahgi communities (cf. Golson 1976:218-19). I have elsewhere suggested...
(Golson 1977b:629-30) that the particular variety of raised-bed sweet-potato cultivation which sustains communities in the upper Wahgi today was learned in the swamp, and that its transference from the swamp to the dry land enabled dryland agricultural productivity to be increased to the point that swamp cultivation was unnecessary. These suggestions were prompted on the one hand by the fact that the chequer-board pattern of plots and dividing ditches in dryland sweet-potato agriculture looks as though it derives from wet ground management and that the sizes and shapes of ditches and beds are very similar, on the other by the agronomic advantages of adding nutrients from the subsoil to the garden surface and renewing them whenever the garden ditches are remade. This transference theory I still think has some validity, but there are other factors to be considered.

There is some evidence that in its latest phase swamp cultivation was less important than it had been. The area of drained land in Phase 6 at Kuk was barely 25% of what it was in Phase 5, which precedes it, with no appreciable break, about 250 years BP. This dramatic contraction I have suggested, with fewer qualifications in later publications (cf. Golson 1977b:627-28 with Golson 1982a:132), was due to the entry of the sweet potato into the Highlands and its replacement of taro as the staple. Initially adopted perhaps because of its superiority as pig fodder, it would have further recommended itself by its greater productivity and quicker maturation at altitude and by its greater tolerance of naturally poor and agriculturally degraded soils. There is some independent evidence, related to more intensive use of dryland soils (apparent in the study of lake-bottom sediments) and high altitude forest clearance (revealed through pollen analysis), which support the proposition that the sweet potato made its entry at this stage (references in Golson 1982a:131).

A point to remember when considering the geographical extent of Phase 6 drainage at Kuk is that even this reduced area of drained swamp, intensively cultivated though it may have been, is hardly likely to have all been under cultivation at the same time. Pospisil for the Paniai Lakes region and Heider and Yen for the Baliem Valley testify to the fact that large areas of drained land are under fallow at any one time. For the settlement where he lived in the Baliem, Heider (1970:40-41) suggests 50% (cf. Yen 1974:125), while Pospisil, making a return trip to the Kapauku after an absence of four years, saw only nine drained gardens out of a total of 67 which he had mapped in 1954-55 still in whole or partial use (Pospisil 1963:175, Figs 21-25).

Wood (pers. comm.) reports another kind of situation at the Haiyapugwa Swamp, near Tari, in the Southern Highlands. Here there is a dense zone of gardens around the swamp margin, but only few and isolated gardens in the swamp proper, though aerial photographs here, as at Kuk and in the upper Wahgi generally, show fossil-field systems apparently continuous over a large area. The evidence of Haiyapugwa raises the possibility that this could be a palimpsest effect, the result of an at any one time small number of often individual undertakings repeated on different occasions in different parts of the swamp. The practice today is for the actual or aspiring big man to mobilise the labour to establish a compact garden far out in the swamp, cleaning out and reactivating one or other of the main drainage channels which are abiding features of the swamp and are named after the big man who sponsored their construction. By these means the entrepreneur reaps the well-authenticated benefits of increased yields, which largely go to the increase of his pig herd.

All of the above considerations could be interpreted to suggest a minor role for swamp cultivation during Phase 6, the sweet potato phase at Kuk. This would certainly help to explain the total ignorance of the older inhabitants there of the drained gardens and associated home sites archaeologically revealed in their swamp, which seem to be, according to radiocarbon dating, no more than 100 years old (Golson 1976:214). This lack of memory of large-scale swamp drainage extends to the upper Wahgi Valley as a whole (Golson 1976:216).

There is, moreover, an element of instability in the total cultural system as it affects the subsistence subsystem, particularly the drainage aspect with which we are concerned. Yen has characterised this as technology outstripping the ability of the social structure to control

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1This is a point that Doug Yen has repeatedly urged in our discussions about Kuk and its interpretation. I should like to take this opportunity of acknowledging the importance of those discussions for my thinking about Kuk in general, of which this exercise in academic self-analysis, which he suggested I undertake, is a partial record. More specific acknowledgements, too numerous to mention here, are made in the various articles to which the reader is referred in the text.
it. Despite the considerable populations speaking the same languages over large areas of the Highlands, the size of the maximal political units is nowhere great and they themselves are divided into often antagonistic segments which combine on few occasions. There is no ascribed leadership at any level of the segmentary structure and positions of power are competed for between big men and their would-be usurpers. The operation of drainage systems is particularly vulnerable to upsets consequent upon circumstances where internal rivalry and external warfare are endemic.

The situation is well exemplified for the Balem Valley, where the highest degree of political integration has been achieved. This consists of fairly stable 'confederations' numbering in one case about 1000 people which are grouped into rather unstable 'alliances', with a population in one instance of around 5000 (Heider 1970:77-81). Heider (1970:118-21) describes how one of these alliances fell apart in 1966 when some ambitious confederation leaders attacked the most important man in their alliance after some years of intra-alliance friction. The result was the subsequent incorporation of the warring partners into other alliances of different composition and geographical location. Brookfield (1961:443), drawing on Dutch sources, describes how between 1938, when the Grand Balem was first seen and photographed by the Archbold Expedition, and 1960, when the Dutch were beginning to extend administrative control, large tracts of the valley floor were depopulated due to heavy fighting, with wide areas of vacant land left between hostile groups amongst the populations who remained.

Though the Kawelka people of the upper Wahgi, on whose traditional land Kuk stands, know nothing of prehistoric agriculture in the swamp, they have a highly circumstantial story (Strathern 1972:37-38; cf. Gorecki 1979b:25) of how they were forced as a group from the Kuk area through warfare about 80 years ago and had to take refuge until pacification with friendly communities in the mountains some 25 km away. There are archaeological features of the drainage pattern of the final phase in the Kuk swamp which can be plausibly interpreted as showing the effects of such political instability (Golson 1976:214-15, though the statements about Creek 2 there have now been superseded).

It is interesting that with the Kawelka there was total abandonment of their territories in the valley bottom, swamp and dryland alike. It has been argued that because at European arrival not only was there no swamp agriculture in the Wahgi, but the valley floor as a whole was sparsely inhabited, with populations concentrated in side valleys and on the hillslopes above, we must look for a more general explanation than any of the factors so far discussed. The advent of malaria is one such general cause that has been proposed (Brookfield 1961:445; Gorecki 1979a; cf. Brookfield 1964:34).

THE INTERPRETATIONS OF PHASES 4-6: SYSTEMIC CONSIDERATIONS

The further we go back in the Kuk sequence, the further we are from any ethnographic referent, such as I have drawn on extensively above. As a result, in earlier publications (especially Golson 1977b, but also see 1981c, 1982a), I have sought explanations for the onset and abandonment of swamp cultivation strictly in terms of the data of the archaeological, geomorphological and palaeobotanical record and of correlations between them. The palaeobotanical record is a general one for the Western Highlands. The archaeological/geomorphological record is for the most part restricted to Kuk, but there is evidence from a few other sites of swamp drainage to suggest that the Kuk sequence is reflecting processes of a general character (Golson 1982a:120-21).

Some early statements could be made, relevant to an assessment of the drainage episodes in the swamp: about the deteriorating nature of the swamp over time, about the elaboration of major disposal channels to cope with this, and about the progressive enlargement of the area (up till Phase 6, the sweet-potato phase, already discussed) under coordinated drainage, though, of course, as we have seen, not necessarily simultaneous production.

Particularly important has been the effort to characterise the gardening systems of the different drainage phases, for it is these which the major disposal channels were meant to serve. These gardening systems are made up of trenches and runnels which differ in morphology and/or organisation from phase to phase. They articulate with different drainage networks. They and the disposal drains which they partner belong to distinct horizons in the stratigraphy of the swamp, this stratigraphic integrity being confirmed by their association with distinctive air-fall volcanic ashes coming from sources outside the Highlands.
The beginnings and/or ends of some of the drainage phases have been seen as correlating with events in the general environmental record: the beginning of Phase 3 with a low point for forest values in the pollen diagrams about 4000 BP; the end of Phase 3 with the stratigraphic change (from clay particles to soil aggregates) in the Kuk deposits about 2500 BP interpreted as due to the advent of soil tillage in the agricultural technology; and the end of Phase 4 with the beginning of tree fallowing around 1200 BP.

These correlations fostered the view (most fully set out in Golson 1977b) that swamp drainage was undertaken only when the productivity of dryland agriculture with the existing technology was threatened by the environmental changes revealed in the pollen record, the destruction of primary forest and its replacement by more and more degraded secondary growth. As the argument then went on, swamp cultivation was given up whenever some innovation in the realm of dryland agricultural technology re-established productivity in the dryland sphere. The agricultural innovations concerned were those of the intensive sector of contemporary Highlands agriculture already discussed, soil tillage, tree fallowing and finally raised-bed cultivation. The assumption was that increased labour inputs were required by swamp drainage and system maintenance and that these were only worthwhile when dryland agriculture was under stress.

While I am loath at this stage to abandon the thought that the correlations suggested between the periodicity of swamp drainage and man-induced changes in the environment have some significance, I have been made conscious by colleagues of the weakness of some of the conclusions based on them. The proffered interpretation takes no account of the real productivity of swampland agriculture and ignores the possibility that real incentives might have existed to undertake whatever extra labour inputs were required by swamp cultivation.

As a result I have recently offered a revised interpretation of the evidence (Golson 1982a, cf. 1981c). If the stratigraphic break at Kuk from deposition in the form of clays to deposition in the form of soil aggregates really does represent the appearance of soil tillage in the agricultural technology, this would indicate that stabilised grasslands had become established in the valley bottom by 2500 BP. As I have stressed above, the replacement of forest by grassland means the disappearance of wild sources of protein and sets the stage for an intensification of pig husbandry in replacement. Insofar as this husbandry has, as we have seen, to be partly at least supported from the produce of gardens, there is an advantage for those communities able to expand production by intensive cultivation of richer soils, of which drained swampland would be an outstanding example. If, as may be proposed for pre-sweet potato times, taro was a major crop, swamp cultivation would be particularly appropriate. It may be no coincidence then that the three drainage phases spanning the period with which we are now concerned - Phases 4-6, with sweet potato replacing taro in Phase 6 - have in common, and in contrast to the three preceding phases, gardening systems characterised by a repetitive pattern of straight-line trenches or runnels intersecting at right angles, the morphology of the trenches and their spacing differing between phases.

It could well be then that with Phase 4 we are seeing the genesis of Wahgi society as we know it ethnographically. The character of that society, defined by the role of the pig as a symbol of wealth and the key to exchanges of every kind, would have been determined by the particular ecological developments that I have suggested began 2500 years ago, the permanent replacement of woody regrowth by grassland. Differential access to land of high quality and the opportunities for some individuals to advance themselves through pig breeding could in the fullness of time lead to those inequalities between clans and between persons that are described in the documents of the contact period.

Satisfying as this reconstruction may be, it does not account for the long gap in the Kuk drainage sequence between Phases 4 and 5. In the circumstances it is tempting to rehabilitate a hypothesis I contemplated for some years and finally abandoned in an unpublished, because unfinished state, (Golson 1977c:50-52, 54-55). This is that the sweet potato came into New Guinea, not within the past 500 years as the orthodox theory has it, but about 1200 years ago, by which time, of course, the hypothesis requires that the plant be already not only well established in the central Pacific but present in island Melanesia as well. This is not the place to repeat all of the arguments that initially influenced me to propose an earlier introduction of the sweet potato. All I would say is that an abandonment of swamp cultivation would fulfil the predictions made for the initial effects of the new crop by a number of scholars, that of the replacement of agricultural intensification based on the

**THE INTERPRETATION OF PHASES 1-3: THE TRANSFORMATIONAL APPROACH**

In interpreting Phases 4-6 at Kuk as representing the development of the pig-centred societies of modern times, I have continued to make large drafts on the ethnographic present and am disinclined to do so further back into the Wahgi past. The earlier drainage phases at Kuk are significantly different from those I have already dealt with (Golson 1977b:612-23, 1981c:57-58, 1982a:120). They are simpler in drainage organisation and they appear to be separated by long periods of inactivity in the swamp. Most importantly, their structural features are not linear and uniform but consist in part of small basins and interconnecting runnels which can admit and circulate water, as well as dispose of its excess. In contrast to the monoculture of taro and subsequently sweet potato proposed for Phases 4-6, these earlier systems are thought to represent mixed gardening with the intercropping of different plant species and allowance for their varying soil and moisture requirements.

We are probably safe in proposing for the communities operating these systems that populations were smaller and less dense than in subsequent times and the environment less impacted. From this environment it would have still been possible to obtain wild plants and animals, including, perhaps, wild pigs, so that pig husbandry is not likely to have been very systematic.

These are all conditions that apply to the people fringing the communities of the Highlands core, to whom they bear a varying degree of linguistic and cultural relationship (Brown 1978:28-39). There has been a considerable amount of anthropological interest shown in these communities of late. This is not least the case because some commentators (Brown 1978:14, 26, 28, 30; Rubel and Rosman 1978:Chapter 18) believe that they represent in some ways a lifestyle and cultural type from which the complex societies of the Highlands proper have developed, through a series of transformations to an explanation of which the prehistoric data we have been discussing would be relevant.

Yen (1982:292) has characterised the Kuk drainage record as revealing an evolutionary sequence of intensification in the sphere of production, following on independent origins for agriculture in New Guinea, based on the domestication of a suite of plants that included basic staples, vegetables and fruits able to sustain populations in various environments. Such domestication, he suggests, might have begun in the ‘variable ecologies of mid-altitude regions’, with the development of ‘simpler regimes of swidden modes of agriculture’ following ‘the long hunter-gatherer “phase”’. This directs attention by another route to the Highlands fringe, where indeed from recent investigations in the lower Jimi Valley in the mid-montane zone (ca. 500 m altitude) north of Mount Hagen Gillieson et al. (1985 and subsequent unpublished revisions, Gorecki pers. comm.) report agricultural features back to 5000 BP which bear a satisfactory resemblance to gardening systems at Kuk of a broadly similar age (Phase 2).

From this perspective the evolutionary sequence of intensification in agriculture seen by Yen at Kuk may well symbolise the cultural evolution of Highlands societies postulated by some ethnographers.

**REFERENCES**


Pospisil, L. 1963 Kapsauk Papuan Economy. Yale University: New Haven, Publications in Anthropology No.67


Wilson, S.M. 1985 Phytolith evidence from Kuk, an early agricultural site in Papua New Guinea. Archaeology in Oceania 20:90-97


SUBSISTENCE FOOD PRODUCTION SYSTEMS IN PAPUA NEW GUINEA: OLD CHANGES AND NEW CHANGES

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ABSTRACT

Changes in subsistence food production systems are considered prior to European settlement (before about 1870) ('old changes') and since then ('new changes'). Changes since 1940 receive most attention as the rate of change has accelerated greatly since this date. The sequence of introduction of a number of important food crops is covered. Crops are grouped as follows: very ancient introductions, ancient ones, more recent introductions, those introduced post-Columbus but before 1870, and post-1870 introductions. Major changes in the cropping base have occurred since 1940, in particular the rise in importance of sweet potato and Xanthosoma taro and the decline of Colocasia taro. The latter is covered in more detail. The adoption of more productive staple crops has offset the effect of declining soil fertility as land use has intensified. It has also reduced the significance of seasonality of food supply.

Other recent changes in cropping systems include the trend towards more intensive land use; the conversion of forest into grassland and the greater use of grassland for cropping, particularly in the Highlands. The soil fertility maintenance techniques used in the Highlands of composting sweet potato mounds, the use of a legume/sweet potato rotation and the use of planted tree fallows are expanding in significance. The effect of cash cropping is discussed briefly as are non-agricultural changes that are affecting food production systems, particularly the large increases in imported food since 1960.

It is concluded that changes have always occurred in subsistence agricultural systems but the rate of change has greatly accelerated since 1940. The country is experiencing a rapid adjustment in agriculture following European settlement. The factors responsible for the changes are now mostly in position, although new factors, including non-agricultural ones, could alter the direction of change.

INTRODUCTION

In Papua New Guinea (PNG) people live and practise subsistence agriculture over a wide range of altitudes (sea level to 2850 m), climatic regimes (1000 to over 7000 mm of rainfall per year), soil types and topographic relief. There are major differences in cultural traditions of various groups of people and in population density. Hence it is not surprising that subsistence food production systems are very diverse. In pre-contact Papua New Guinea most people were dependent on horticultural products with the major exceptions being the processing of sago (Metroxylon sagu) stands, hunting and fishing. The common denominators are dependence on high starch staple foods (sweet potato, taro, yams, sago and bananas) and the absence of grain crops.

There is great diversity in most of the components of the farming systems: that is, staple crops, fallow types, intensity of cropping, dependence on animal products, soil fertility maintenance techniques and cultural practices. At one extreme are low input, low intensity, shifting cultivation-based systems. At the other extreme are the intensive systems used in parts of the Highlands which feature permanent cropping; the differentiation of agriculture into several garden types which occupy different microenvironments and are managed differently; and various fertility controlling techniques.

The theme of this paper is change in these subsistence systems. Changes have always occurred in subsistence food production. Golson's work at Kuk in the Western Highlands shows changes in land occupation and agricultural technology that can be traced back as far as 9000 years (Golson 1981). I will concentrate on some of the changes that have occurred at
an accelerated rate since European settlement and in particular since 1940 ('new changes'). Much of the information presented is based on my field observations of subsistence agriculture in all parts of the country over the past 13 years, and on detailed field mapping of subsistence farming systems that has now covered about half of the nation.

The theme of rapid change in Papua New Guinea subsistence agriculture is not a new one. In the early 1950s Spate visited Papua New Guinea and wrote about changing agriculture (Spate 1953). His main interest was with cash cropping but he touched on forest clearing and soil erosion. Lea (1972) reviewed recent changes in subsistence agriculture in Melanesia, concentrating on the Abelam people where he had done fieldwork. A third geographer, Ward (1982) has also reviewed recent changes in subsistence agriculture in Melanesia, focusing on the loss of diversity.

CHANGES IN CROP SPECIES

Crop introductions

At the time of European settlement in Papua New Guinea in the late 19th century, numerous plant species were exploited as food. The antiquity of usage of these species may vary greatly. Barrau (1965) suggests that a number of species grown in the Papua New Guinea Highlands were probably important incipient products of agriculture. That is, they were important food sources prior to the arrival of the major Asian-Pacific staple crops (taro and yams) which were dominant when Europeans reached the islands. Barrau's 'witnesses of the past' include Cordyline fruticosa, Dioscorea nummularia and Pueraria lobata.

Some of the staple crops at the time of European settlement in Papua New Guinea are likely to have been introduced many thousands of years ago, but more recently than the species named above. These include taro (Colocasia esculenta), some yams (Dioscoria alata, D. bulbifera) and diploid bananas. More recent introductions would include the lesser yam (D. esculenta) (Bourke 1982), winged bean (Psophocarpus tetragonolobus) (Powell 1974), swamp taro (Cyrtosperma chamissonis) and kava (Piper methysticum). I will expand briefly on my reasoning in suggesting that two of these species, swamp taro and kava, are more recent introductions. Swamp taro is used as a food on Manus Island, New Ireland and the atolls inhabited by Polynesian people west of Manus and east of New Ireland and Bougainville Islands. Wild forms are present in New Guinea, but are not eaten on the mainland. This distribution suggests that the edible forms have been introduced into the atolls, New Ireland and Manus relatively recently, perhaps by Polynesians arriving from the east.

Kava also had a very limited distribution in Papua New Guinea at the time of contact. It was used by the Kabiri, Mawata, Masingara and Kiwai people who live near the mouth of the Fly River in Western Province (Haddon 1916). Haddon suggests that the Mawata people may have learnt the use of kava from the Masingara and that it is not an indigenous custom amongst the Kiwai. Kava was also used by the Rai coast people in Madang Province (Miklouho-Maclay 1886) and in the Admiralty Islands (Bühler 1935). Miklouho-Maclay notes that the custom was probably a recent introduction on the Madang coast. This very limited distribution of kava within Papua New Guinea suggests that it is a comparatively recent introduction into the country or has been recently domesticated in a limited number of locations only.

Following European exploration in the Americas, a number of crops of American origin arrived in Papua New Guinea prior to 1870 and permanent European settlement. These crops include tobacco (Nicotiana tabacum) (Feinhandler et al. 1979), sweet potato (Ipomoea batatas) (Yen 1974), lima bean (Phaseolus lunatus) (Powell 1974) and probably bixa (Bixa orellana) (R.M. Bourke unpublished field data).

Since European settlement in Papua New Guinea from 1870, as many as 200 species of food crops have been introduced there. Many of these have not been adopted by village growers. Some are used as minor food items and some have become significant staple or supplementary foods. The last group includes Xanthosoma taro (Xanthosoma sagittifolium), potato (Solanum tuberosum), corn (Zea mays), pumpkin (Cucurbita moschata), choko (Sechium edule), pawpaw (Carica papaya), mango (Mangifera indica), pineapple (Ananas comosus), cabbage (Brassica oleracea), pak choi (Brassica chinensis), peanuts (Arachis hypogaea), common bean (Phaseolus vulgaris), spring onion (Allium cepa), orange (Citrus sinensis), watermelon (Citrullus lanatus) and guava (Psidium guajava).

The rate and time of adoption of the different introduced species has not been even.
Miklouho-Maclay (1886) recorded that pawpaw, watermelon and corn were quickly adopted by the villagers on the Maclay coast soon after he introduced them in 1871. On the Gazelle Peninsula of New Britain the widespread adoption of *Xanthosoma* taro and peanuts occurred from 1950 onwards (Bourke 1976). Seed potatoes were widely distributed in the Highlands following the 1972 frosts which destroyed much of the staple sweet potato crop at higher altitudes in Enga, Western and Southern Highlands. Potatoes were present in the Highlands prior to 1972, but they increased significantly in importance at high altitudes (above 1900 m) after the frost rehabilitation programme. Cassava is now a staple food on Manus Island but prior to the taro blight epidemic there in 1974-77 it was only a minor food item (Rooney 1982).

As well as the introduction of new species, the expansion of existing food crops has also been significant. Coconuts (*Cocos nucifera*), for example, are now being grown at higher altitudes, as outsiders such as missionaries plant them at locations where they were not traditionally grown. Triploid clones of bananas, including recently introduced ones such as Yava and various Cavendish types, have increased in importance greatly since 1950, for example on the Gazelle Peninsula of New Britain.

The most significant expansion of an existing crop since 1940 has been that of sweet potato. By the time Europeans had penetrated the Central Highlands in the 1920s, sweet potato was well established there as the staple food crop. It was not grown extensively in the lowlands at this time. Since 1940 the crop has expanded widely in the lowlands. It is now the staple food on Bougainville Island and most of New Ireland as well as being a co-staple in the Oksapmin area, and parts of East and West New Britain, Madang, Morobe, Oro and Central Provinces. (Bourke (1985) presents a map of the distribution of sweet potato in different farming systems in Papua New Guinea).

The recent spread of new cultivars of existing crops has also been very significant. Cultivars of some existing crops, especially bananas and sweet potato, have been introduced into Papua New Guinea since European colonisation. With the cessation of warfare, improved transport and the great increase of people’s mobility, movement of germplasm of the major crops between locations within Papua New Guinea has increased greatly. Cultivars of all the major food crops are regularly introduced into gardens from other locations in Papua New Guinea. The names of some of the sweet potato cultivars in the Highlands illustrate this pattern - Balus (aircraft), Koroka (Goroka), Erave (a township in the Southern Highlands), Merikan (American), Markham (the Markham Valley), SDA (Seventh Day Adventist Mission).

**Decline of crops**

A number of species of food crops have declined in importance over the centuries, including Barrau’s ‘witnesses of the past’. In recent decades there has been a decline in importance of some of the traditional staples including the greater yam (*D. alata*), sago and taro. The decline in importance of taro as a staple food has been particularly dramatic and this decline is still continuing. Prior to about 1941, when taro blight first occurred on Bougainville, taro was the main staple food on Bougainville, almost all of New Britain, most of New Ireland (yams were a co-staple in the Namatanai area), in inland Manus, the Madang area, the Yangoru area of the Sepik, parts of the Huon Peninsula, the coastal and inland areas southeast of Lae to Collingwood Bay, parts of inland Gulf Province (Kaintiba-Kanabea area), the Oksapmin-Telefomin-Star Mountains area west of the Strickland River, and on some of the smaller islands (see Fig.1). In other places in the lowlands and intermediate zone between the lowlands and highlands, taro was a co-staple with yams and bananas.

Forty years later taro remains the main staple food only in limited areas of central New Britain and parts of the south coast of New Britain, parts of Oro (Northern) Province and the Telefomin-Star Mountains area (Fig.1). In the Highlands where it was generally a minor food at the time of European contact, production is declining. In locations where it was a co-staple with other crops, it is often being replaced by *Xanthosoma* taro and sweet potato. The crop’s status is clearly reflected in market prices gathered for the Consumer Price Index. Over the past 12 years the price of taro has risen steeply (Spencer and Heywood 1983), and it is now much more expensive than all other staple crops in most urban centres. This is shown in Figure 2 where the prices of sweet potato and taro in Goroka and Lae over a 12 year period are plotted. A similar pattern occurs in other urban areas.
Figure 1  Areas in Papua New Guinea where *Colocasia* taro was the *major* staple crop (1940 and 1983)

Figure 2   Monthly price (toea/kg) of sweet potato and taro in Lae and Goroka markets for the period 1971-82. (Source: National Statistical Office data)
In some places, the decline of taro has been dramatically fast. Elsewhere the decline has been more steady. Taro blight caused by the fungus *Phytophthora colocasiae* arrived on Bougainville several years before the Pacific War (Packard 1975). Over the period from just before the war (1941) to the years just after the war, sweet potato replaced taro as the staple food on Bougainville. On the Gazelle Peninsula of New Britain, taro declined in significance from about 1950 onwards and it has been replaced by *Xanthosoma* taro, sweet potato and banana (Bourke 1976). The decline of taro in the mountainous part of the peninsula continued throughout the 1970s. In 1971 taro was still a co-staple with sweet potato on the northeast coast of New Ireland between Konos and Kavieng, but a decade later sweet potato had completely replaced taro. Taro was the sole staple food on the Lelet Plateau (950 m above sea level) of New Ireland up to 1976. By 1981 sweet potato had become a secondary staple after taro.

In 1978 taro blight became a serious problem in inland parts of Oro Province near Popondetta and along the coast southeast of Lae. Following the blight epidemic, sweet potato has replaced or supplemented taro in these areas. Blight reached the Hotmin area of West Sepik Province in 1977 (but possibly in 1971) and has caused considerable damage to taro crops since (Pearson and Thistleton 1981).

In an earlier paper (Bourke 1982) I suggested a number of reasons for the decline of taro in Papua New Guinea. These were unavailability of land of adequate soil fertility, high labour inputs relative to yield returns, virus diseases, taro beetle (*Papuana* spp.), taro blight, unavailability of planting material, decline in spiritual values associated with the crop and the availability of alternative easier to grow staples. I would now accord the effects of taro blight more emphasis, especially in areas at low altitude with high rainfall evenly distributed throughout the year.

**Effects of new crops**

Some of the crops that are increasing in significance are more tolerant of lower soil fertility conditions than the ones they are displacing. Sweet potato and cassava yield better on poorer soil than does *Colocasia* taro, yams or diploid bananas. *Xanthosoma* taro is more tolerant of reduced soil fertility than *Colocasia* taro, and can be grown successfully under the shade of other crops. Peanuts will grow and produce in soil too infertile for *winged bean*. Thus the effects of reduced fallow periods and declining soil fertility (see below) are being offset by the changeover to more productive crops, especially sweet potato.

The other major effect has been to reduce the effect of seasonality of food supply and irregular disruptions in the continuous supply of food. Sweet potato, corn and beans mature faster than existing staples such as taro and yams. In the Highlands, corn and potato mature before sweet potato. *Xanthosoma* taro and cassava mature later than most other energy crops. More importantly they can be stored in the ground after maturity until they are needed, giving flexibility and security by filling in gaps in the food supply. (On the other hand the decline of taro in the Highlands in recent decades has made the food systems more susceptible to disruption as they become more dependent on sweet potato).

Some commentators have noted that introduced species of food plants have had only a marginal effect on food production systems. Lea (1972:255) for example, in considering the 1960s, states that introduced crops are still considered mainly as supplementary foods or relishes. I suggest that the impact of introduced crops is being underestimated. In the Central Highlands, the traditional staple sweet potato continues to dominate subsistence agriculture and the traditional vegetables are still important. However, many of the important supplementary crops grown in the gardens and sold in the markets are recent introductions. These include common bean, pak choi, pumpkin, choko, corn, cabbage, potatoes and peanuts. At very high altitudes where the tropical crops were pushed to their limits (2400-2800 m), the impact of introduced crops such as potato, cabbage, peas and broad beans is pronounced.

**CHANGES IN FARMING SYSTEMS**

The other important components of a farming system are the intensity of cropping (relationship between cropping and fallow periods), fallow types, soil fertility maintenance techniques, significance of animals and special cultural techniques such as irrigation or soil erosion control. Changes that have occurred in these components are now discussed.
Intensity of systems

The intensity of subsistence farming systems and human population densities in Papua New Guinea are widely variable. The large number of discrete farming systems in Papua New Guinea indicates that significant changes have occurred in prehistoric times, although there is still little evidence to indicate the rate of change and when it occurred in different places. In particular, the impact of the introduction of sweet potato in the Highlands has been controversial (Watson 1965; Brookfield and White 1968; Go1son 1982).

The trend in recent decades has been towards greater intensification of land use, that is the ratio of cropping to fallow period is increasing. In many parts of Papua New Guinea people have moved towards roads and government settlements. At the same time the population is increasing rapidly and land is being tied up by permanent cash crops (especially coffee, cocoa and coconuts). One consequence is that fallow periods are being reduced. This happened for example in the Mt Elimbari area between 1952 and 1961. Following the cessation of fighting, people moved their gardens to the valley bottoms and reduced the fallow period from 11-15 years to less than eight years (Salisbury 1964).

My field observations that fallow periods are being reduced are in accord with the interpretation of air photographs taken in the 1950s and 1970s. Examination of photographs from eight lowland and highland provinces show that in general there has not been an extension of land under cultivation over this period, suggesting that land is being used more intensively (Jo McAlpine pers. comm.). The introduction of sweet potato in lowland systems has also allowed the cropping period to be extended. Previously a single crop of taro or yams only would have been taken off the land before falling in a lowland forest area. Nowadays the taro or yams may be followed by a sweet potato crop before falling or two sweet potato crops may replace the taro. Many older subsistence gardeners claim that yields of sweet potato, taro and yams are not as great as when they were children or in their grandparents’ time. This is documented for the Maprik area (Lea 1972) and the Kaironk Valley (Bulmer 1982). I have heard this said by subsistence gardeners in many parts of the country from Bougainville and New Britain to the Highlands. I interpret this as a possible reflection of shorter fallow periods and consequently reduced soil fertility. Wood and Humphreys (1982) attribute the reported reduction of crop yields to soil erosion and fertility decline.

Most grasslands in Papua New Guinea have been created from forest by subsistence agriculture and fire (Robbins 1962). This process is continuing. It has been documented, for example, in the Tari Basin (Wood 1982), the Sirunki Plateau (Allen 1982), the Kaugel Valley (Bowers 1968), the Okapa area (Sorenson 1976), the Wau Valley (Allen 1981) and the Port Moresby area (Eden 1974). If there is a choice between forest and grassland, villagers almost always choose forest land. As the area of available forest is reduced, people are forced back into the grasslands. This process can be seen on the fringes of the Central Highlands, for example, in the Okapa area. A change to grassland fallows generally results in an increase in cropping intensity because grassland gardens are almost always cropped for a longer period before fallow than forest gardens in the same geographical area. Grassland soils are usually tilled. This additional labour input enhances their fertility (Clarke and Street 1967) and allows a longer cropping period. Overall the change from forest to grassland fallows is not as significant as the shortening of fallow periods which is very widespread.

In contrast to grassland formation that is occurring elsewhere, in the northern part of the Eastern Highlands, grasslands have been reforested in recent decades. Early photographs of this region show large tracts of treeless grasslands. Groves of trees, especially Casuarina oligodon are now common on the lower sides and bottom of these valleys.

Male/female labour inputs

An important side effect of a shift from forest fallows to grassland fallows and an extension of the cropping period may be a shift in the balance of men's and women's input into gardening. In most gardening systems, men make substantial inputs into establishing new gardens, for activities such as forest clearance, drainage and fencing. Women usually provide more labour for crop planting, weeding, harvesting and replanting. As the cropping period is extended, because of a change from a forest to a grassland fallow or because of intensification, activities usually performed by women occupy a greater proportion of all garden work. Hence the labour input of women is likely to increase relative to those of men.
No long-term studies of labour inputs in a single village have been done to document this, but there is indirect evidence. In lowland forest fallow systems, men provide much of the labour for gardening, as for example in Pavaere Village in Bougainville (Lea 1970) or Sivepe Village near Popondetta (Waddell and Krinks 1968:101). On the other hand in highland grassland fallow systems, women provide a much greater proportion of labour input for gardening (Lea 1970; Bourke and Lea 1982; Modjeska 1982). As the level of pig production increases, the division of labour moves towards a heavier workload for women (Modjeska 1982). Boyd (1981) studied the effect of male migration in a village in the Eastern Highlands that had access to both grassland and forest land. He found that male-headed households rely more heavily on forest gardens, whereas female-headed households were more dependent on grassland gardens. In this case, tillage of the soil in grasslands is exclusively women’s work, whereas pollarding of large trees in making forest gardens is exclusively men’s work. One of the responses to male absenteeism by female-headed households was to reduce the area of crops in forest gardens in favour of grassland gardens.

**Soil fertility maintenance techniques**

In the Central Highlands a number of special techniques are used to increase soil fertility. These are composting, use of a legume/sweet potato rotation, use of controlled tree fallows and the application of soil from drainage ditches onto garden beds. Composting is confined to much of Enga and the Southern Highlands Provinces and a small portion of the Western Highlands (D’Souza and Bourke 1982). With this technique, people place grass, weeds, sweet potato vines etc. in a pile and form a soil mound over it. The sweet potato vines and supplementary crops are then planted in the mound. Application rates of 17, 29 and 5 t/ha of fresh organic matter have been measured by Waddell (1972), Wohlt (pers. comm.) and Bourke (1988:41) respectively. Bayliss-Smith (1982) suggests that yams rather than taro appear to be the more likely pre-Ipomoean mounded crop. However, yams are rarely, if ever, grown in sweet potato mounds in the zone where large mounds and associated composting are used. Much of the large-mound/composting zone is above the altitudinal limit of all yam species (Diocreas alata, D. nummularia and D. bulbifera usually grow up to 1850-1900 m above sea level). For these reasons I suggest that the use of large mounds and composting was adopted subsequent to the introduction of sweet potato into the Highlands.

Composting and the associated large sweet potato mounds are now used as far west as the Strickland River in both grassland and forest soils. It is likely that the spread of the technique to its western extremity has only occurred within the past century and probably more recently. The eastern extremity of the technique occurs to the east of Pangia in the Southern Highlands. It was adopted in this area subsequent to the arrival of the mission and government in about 1961. Unlike legume rotation and controlled tree fallows, composting has a discrete geographical distribution. The technique appears to have been expanding at the time of European contact. Composting is still displacing less intensive gardening techniques at the western, eastern and northern extremities of the composting zone.

The use of a peanut/sweet potato and winged bean/sweet potato rotation is widespread in the Nebilyer, Wahgi and Baiyer Valleys of the Western Highlands and the main valleys of the northern half of the Eastern Highlands (Ramu, Dunantina, Benabena and Asaro). The rotation is confined to flatter land, altitudes below 1900 m, deeper soils and is usually associated with grass fallows. Villagers are adamant that the technique results in higher sweet potato yields than a sweet potato monoculture, although three trials in the Southern Highlands have failed to substantiate this (D’Souza and Bourke 1986).

Peanuts are much more important than winged bean in the areas where the rotation is practised. It is likely that peanuts only became a significant crop in the Highlands after 1950 as European influence intensified. People claim that the winged bean/sweet potato rotation is a traditional one and the introduced peanuts have been adapted into the same rotation. I suggest that the traditional winged bean/sweet potato rotation was a relatively minor technique for maintaining soil fertility prior to 1950. Since then the technique has been used more widely, with the adoption of peanuts into the cropping system.

A third fertility maintenance technique in the Highlands is the use of a controlled tree fallow. Casuarina oligodon is the species that is generally used, but self-sown stands of Parasponia rigida are sometimes managed in the same way. Self-sown casuarina seedlings are transplanted into sweet potato gardens or are protected within the garden as the garden
approaches the fallow phase. Dense stands of casuarina thus replace a grass or scrub fallow. At the end of the fallow period, the side branches are trimmed and the sweet potato is planted among the standing live trees.

The technique is commonly used between Lufa (Eastern Highlands Province) and the western end of the Porol Range in Simbu Province. It is also used throughout the Highlands in limited areas in locations as scattered as Oksapmin, Lagaip Valley (Enga Province), and Lamari Valley (Eastern Highlands Province). With sweet potato it is mostly confined to slopes with shallow soil, although the technique is also used for mixed vegetable gardens which are located on heavier, deeper and wetter soils on flatter land. A number of observers have noted that the use of planted casuarina fallows has increased since the 1930s, for example, Brookfield and Brown (1963:51) in Simbu, and Waddell (1972:193) in Enga. In the Mt Elimbari area of Simbu, the area under casuarinas increased significantly between 1952 and 1961 (Salisbury 1964). The technique was adopted in the upper Kaironk Valley only during the lifetime of fathers of living men (Bulmer 1982).

Irrigation of taro was a minor but widely scattered cultural technique in a few subsistence systems in Papua New Guinea. Taro irrigation has declined since European contact (Spriggs 1982), although some people still practise it.

Sequences of change in systems

A number of changes in cropping systems can be identified as they become more intensive. These are:
1. a decrease in the period of the fallow;
2. a reduction in the diversity of cultivars and a greater reliance on a limited number of cultivars;
3. adoption of new staples;
4. extension of the cropping period before fallowing;
5. use of more intensive cultural techniques, such as controlled tree fallows or composting.

There is little direct evidence for the loss of cultivar diversity. However, a characteristic of some intensive agricultural systems is a reliance on a very limited number of cultivars, for example, mami (Dioscorea esculenta) in the Wosera, East Sepik Province, and sweet potato on the Gazelle Peninsula and on the Nembi Plateau. The upper Kaironk Valley is one area where we do have evidence of loss of cultivars over time. Between 1963-64 and 1980, Bulmer (1982) recorded a loss of 24 sweet potato cultivars. Meggitt (1962:103-4) notes that between 1955 and 1960, the average number of sweet potato cultivars in gardens near Wabag declined from 8-10 to 2-3.

The sequence of adoption of these changes varies with the environment and the existing cropping system. In the lowlands a decrease in the period of forest fallow often occurs first. There may be a reduction in cultivar diversity of the staple crops or new staples may be adopted. The adoption of sweet potato, in particular, facilitates extension of the cropping period. In the Highlands the change to sweet potato as the major staple has now been made in most locations. As intensification becomes necessary, there is reliance on fewer cultivars of sweet potato and more intensive cultural techniques are adopted.

Effect of cash cropping

The increase in smallholder cash cropping since 1950 has forced changes in subsistence food production systems. The first effect has been a direct one by removing land from the food garden fallow cycle. This has increased pressure on land in a number of locations. Cash crops have been planted near villages in many places and in some this has forced people to make food gardens several kilometres from the village. This is noticeable on Bougainville, the Gazelle Peninsula of New Britain and Karkar Island. In a village in the Kainantu area of the Eastern Highlands, the establishment of four cattle projects in early 1975 pushed gardens further from the hamlets, resulting in an increased burden in transporting food, poorer garden maintenance and the location of more gardens in the zone of primary danger from sorcery (Grossman 1981). This resulted in a decrease in planting food gardens, increased damage to gardens by pigs, and a subsequent food shortage later in the year.

The consequences of adoption of coffee as a cash crop by people in parts of Simbu Province have been documented by Brookfield (1968, 1973, pers. comm.). Coffee had numerous effects on peoples' lives, including a reduction in the cultivation of
supplementary crop foods in mixed gardens. Between 1958 and 1967, the area under coffee increased from 0.01 to 0.06 ha/person and the area of mixed vegetable gardens declined from 0.07 to 0.03 ha/person. Sweet potato production increased over this period as pig numbers increased as part of the regular pig cycle. The net result was that the area under food crops remained constant at 0.18 ha/person. Almost all of the coffee was planted in the central part of the study area and the net increase in food crop area was almost wholly in the outlying region.

Cash cropping has also resulted in innovations in food crop farming systems. On the Gazelle Peninsula cocoa and coconuts have been integrated into food gardens (Bourke 1976). Sophisticated crop sequences sometimes result. Diploid bananas provide temporary shade for cocoa and have increased in importance. Early coffee plantings in the Highlands in the 1950s and 1960s were often made on better drained soils near hamlets. More recent plantings are often made on wetter sites and in integrated food crop/coffee gardens. The coffee is shaded initially by short-term food crops and then bananas or cassava before permanent casuarina shade is established. These new systems may result in changes in the crop base. In the Asaro Valley (Eastern Highlands Province) cassava has become an important shade for young coffee, whereas in the Wahgi Valley (Western Highlands Province) banana plantings have increased as a consequence of adoption of the new system.

Pig husbandry

Pigs are kept in large herds in the Central Highlands and there is some evidence that pig numbers have expanded since European contact. In Enga, Waddell (1972:197) records that pig populations are substantially larger since contact and tend to be maintained at a high level for longer. Among the Siane people, there was a 'real increase' in the pig population of about 30% between 1952 and 1961 (Salisbury 1964). Brookfield's (1973) long-term study of pig cycles in Simbu finds some evidence that successive pig cycles between 1940 and 1972 imposed more strain on resources at the peak of the cycle, that is, pig numbers increased faster than the human population. It is possible, however, that people migrated into Brookfield's study area and pig numbers did not increase faster than the human population. Hide (1981), who has conducted the most intensive study of village pigs in Papua New Guinea, records that in the Sinasina area of Simbu, the importance of pigs in bride payments increased between 1925-33 and 1959-63, and then declined somewhat (Hide 1981:161-80). Hide does not necessarily accept that the pig population per person has increased over this period, as there is inadequate long-term data to support this. A special case are members of the Seventh Day Adventist Church, many of whom have abandoned pig husbandry since conversion.

NON-AGRICULTURAL CHANGE

The introduction and acceptance of new food and cash crops have brought change to subsistence agriculture. A number of non-agricultural features of colonisation have resulted in changes in subsistence food production systems. These include the cessation of warfare and the consequent fixing of clan land boundaries and ability of people to garden safely at greater distances from the village; the influx of massive quantities of trading currency such as shells and the resultant devaluation of traditional currency and inflation of the value of pigs; the introduction of steel tools; and the movement of people to roads and peri-urban areas. One of the most significant changes has been in people's attitudes to gardening, especially of the more difficult to grow crops such as the greater yam (D. alata).

Steel tools have been widely and quickly accepted. The spade has largely replaced the digging stick for soil tillage, although this process is still occurring in places where cash is limited, such as around Telefomin. In the Highlands the traditional digging stick is still considered superior to the spade for harvesting crops. The introduction of steel axes reduced labour inputs in garden clearing (Salisbury 1962), although subsequent studies have suggested that Salisbury probably overstated the case, as a small proportion of time was spent in cutting activities (Lea 1972). In the lowlands, steel 'bush knives' are now very important in garden work.

Another non-agricultural change affecting village agriculture is urbanisation. For one peri-urban village at least, we have data on the effect of land alienation and urban employment. In 1948, Vicary (1960) recorded that people at Yabob Village near Madang gardened 440 m² of land per person per year. A follow-up study in 1959-60 by Johnston
found that the area had declined to 275 m² (reported in Vicary 1960). A third study in 1982 found that the area of garden per person per year had further reduced to 204 m² (Spencer and Heywood pers. comm.). Spencer and Heywood recorded that taro has been largely displaced by mami (*D. esculenta*) and the fallow periods have declined. Over this period urban employment had risen as a significant factor in the village economy. A large increase in the village population had placed pressure on the remaining unalienated land.

The significant imports of cereal grains into the country suggest that subsistence production per person is declining as a source of food in the rural areas. Imports of rice and flour have risen rapidly over the past two decades (see Fig.3). The National Government estimated that in 1976 about a quarter of the food eaten by nationals was imported (Lepani 1977). In 1981 the value of all imports (K130 million) was not much less than the value of all export crops combined (K168 million). Bourke *et al.* (1981) have shown that about half of all imported rice is consumed outside the urban areas. In a village in Simbu Province, Harvey and Heywood (1983) found that between 1956 and 1981 the contribution of the traditional staple (sweet potato) to diet had declined, whereas imported cereals had risen dramatically. Energy intake of adults in 1981 was similar to those in 1956, whilst those of younger groups appeared to have increased. Morauta (1982) reported a similar phenomenon from a village in the Malalaua area in Gulf Province where sago was the traditional staple. In 1979 the villagers received a third of their energy needs from imported food and they purchased, rather than produced, most of the sago they ate. Extrapolation of these findings suggests that imported grains are displacing the traditional staple foods in diets elsewhere in Papua New Guinea and that the area of subsistence gardens per person may be declining.

![Figure 3](image-url)  
**Figure 3** Imports of rice and flour/wheat into Papua New Guinea for the period 1961-81. (Source: National Statistical Office data)
DISCUSSION AND CONCLUSIONS

Changes have been occurring in subsistence food production systems in Papua New Guinea over a long period and at different rates. There is still little information on changes in the cropping base and the agricultural practices in prehistoric times. The great diversity of systems used within the country now indicate that the systems have not been static. Since 1940 the rate of change has accelerated. A large number of new crop species have been introduced and many of these have been adopted by subsistence farmers. Some species, such as sweet potato and Xanthosoma taro, have increased rapidly in importance and now constitute the major staple foods in some places. There has been a decline in the importance of some species, particularly Colocasia taro, but also yams and sago.

Subsistence agriculture in Papua New Guinea is in a transition period as the new energy crops from the Americas (sweet potato, Xanthosoma taro, cassava and potato) are displacing the older Asian/Pacific staples. Many of the supplementary crops that are rapidly becoming important also originate in the New World. These include corn, peanut, pumpkin, choko, pawpaw and pineapple. The rapid adjustment that is now occurring in Papua New Guinea is repeating a process that has occurred earlier in the Old World (Europe and Africa) in earlier times.

Other aspects of the farming systems are also changing. In general an intensification of land use is occurring throughout Papua New Guinea. Deleterious effects of this have been offset by the adoption of more productive crops, especially sweet potato and Xanthosoma taro in the lowlands and intermediate altitude zone. In the Highlands the use of soil fertility maintenance techniques is becoming more widespread. This includes the technique of composting sweet potato mounds, the use of a controlled tree fallow with Casuarina oligodon and a peanut/sweet potato rotation. Of the cultural techniques considered here, only irrigation of taro has declined since contact.

Numerous other changes are affecting subsistence agriculture. The adoption of cash cropping, usually with perennial tree crops, is a major one. This has stimulated direct changes in subsistence systems, such as innovations in crop sequences and shade crops where cocoa and Arabica coffee have been adopted. As well, cash cropping has caused a diversion of resources of land and labour from food production. Other changes are occurring that affect subsistence food production. Rapidly increasing imports of food from outside the country and incorporation of this food into the village diet is likely to be responsible for a decline in subsistence production per person. New tools, changes in attitudes, urbanisation and the cessation of warfare are factors that indirectly affect subsistence food production.

The rate of change is particularly rapid in much of the lowlands and on the highland fringe as new staple crops are adopted. For any location the period of rapid change lasts for perhaps several decades. For the entire nation, the rapid changes commenced after 1940 and are likely to continue until at least the end of the century. The factors responsible for change are now mostly in operation within Papua New Guinea. These include the new crops, new plant diseases, population increase, cash cropping and the cash economy. New factors, such as coffee rust on coffee or a serious sweet potato disease, could result in further major changes in food production systems. A decline in coffee production caused by rust, for example, could make subsistence food production more attractive for many highlanders. Other factors which could alter the rate and direction of change in subsistence farming systems include the relative prices for imported food grains and the major export crops as affected, for example, by changes in the value of the kina; government action in providing food hand-outs after frost, flood or drought; and technical advances developed by agricultural research projects.

In observing subsistence food production systems in Papua New Guinea, I am impressed by the changes that are occurring and their rapid rate of adoption rather than by the static nature of the systems. Papua New Guinean subsistence farmers are adaptive and receptive to change. Since 1940 Papua New Guinea subsistence farmers have experienced some of the most dramatic changes in their basic economy since people first settled these islands.

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REFERENCES

Allen, B.J. 1981 Spontaneous resettlement and environmental damage in the Wau area. Office of Environment and Conservation, Port Moresby (unpublished typescript)


Brookfield, H.C. 1968 The money that grows on trees. The consequences of an innovation within a man-environment system. Australian Geographical Studies 6(2):97-119


Eden, M.J. 1974 The origin and status of savannah and grassland in southern Papua. Institute of British Geographic Transactions 63:97-110


Haddon, A.C. 1916 Kava drinking in New Guinea. Man 16:145-52


Pearson, M. and B.M. Thistleton 1981 Taro diseases in the Hotmin area (East Sepik Province) and Telefomin area (West Sepik Province) of Papua New Guinea. Department of Primary Industry: Port Moresby (mimeo, 13 pp)


TRADITIONAL MELANESIAN AGRICULTURE IN NEW CALEDONIA AND PRE-CONTACT POPULATION DISTRIBUTION

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The study which follows is the result of extensive research carried out in 1981 and 1982 in the Territory of New Caledonia.

One of our objectives was to determine as precisely as possible on a map (to a scale of 1/25,000), and with the assistance of the most objective scientific techniques, the sites of pre-colonial Melanesian agriculture on the one hand, and the villages in existence at the time of colonisation on the other.

The base map chosen was the 1/25,000 scale used by the Institut Geographic-National (IGN), which allowed sufficient resolution, and totalled 135 sheets for the Grande Terre.

The following methods were utilised:

1. Study of the earliest maps made by the Mapping Department of the Service Topographique du Territoire de Nouvelle-Calédonie, after 1860. These were cadastral maps, or sketch maps drawn to scales of 1/10,000 and 1/20,000, and sometimes 1/5000. By 1900, 530 maps had been made, covering 530,000 ha (about a third of the land surface of the Grande Terre, principally the economically useful areas). These maps give place names, the positions of Melanesian villages or the remains of villages, areas of cultivation, paths linking villages and irrigation canals.

2. All available documents of a historical nature were consulted, whether from public archives (at the Ministries of the Navy, the Army, of Overseas Departments and Territories, and at the National Library) or from private collections: the archives of the Marist Fathers in Rome, the Protestant archives, and the collection of Maurice Leenhardt. Contemporary newspapers (Moniteur de la Nouvelle-Calédonie, and the Journal Officiel) were systematically used.

3. In close collaboration with a team from the Service Topographique de Nouvelle-Calédonie, a systematic analysis of aerial photographs was undertaken (the IGN mission of 1976), which permitted us to verify and complete the information we already had from old sources, and to extend our research of sites giving evidence of pre-contact Melanesian settlement in areas not covered by the old maps.

We do not claim to have read everything, nor seen everything insofar as interpretation of the aerial photographs is concerned, but it is probable that the study has helped to accumulate certain data and observations, which were then catalogued, to an unprecedented degree. Figure 1 is a map of locations mentioned in the text.

If there remain some areas lacking in information, although they were populated in pre-contact times, this is the result of a lack of contemporary documents, or because of irreparable loss or destruction in the colonial archives. All information given in the maps which are analysed in this article has been catalogued; there remain a few villages for which the exact site has not been determined, although their existence was absolutely certain. They have been localised to within 1 or 2 km, but their exact site could give rise to local differences of opinion.

We hope that, following on from this general inventory, archaeological work and further research in dating the old tarodièrre systems (hillside terraces for taro cultivation) will give us information which will enable us to analyse changes in the population of the Grande Terre over time (see for example, Spriggs 1981; Frimigacci et al. 1981).

DISTRIBUTION OF THE PRE-CONTACT KANAK SETTLEMENT

The question of the pre-colonial Melanesian population of the Grande Terre, both in terms of numbers and settlement pattern, remains little understood. For a long while censuses were limited, and by the time more reliable statistics were available, the decline of the Kanak population on the Grande Terre had started (1878). Similarly, the sites of native village settlements remained difficult to locate for some time.
Figure 1 New Caledonian locations

The map presented as Figure 2 shows any settlements whose existence is attested by any form of historical documentation. In this manner, we obtained a total of 2363 villages (Belep Islands and Isle of Pines not included). We must point out that this number includes in fact 1783 villages with a known place name, and 580 villages which have been rediscovered and located by means of various documents and maps, but the names of which were not noted in contemporary chronicles, and remain unknown. To this number must be added those villages which disappeared suddenly as a result of epidemics or tribal wars, or were abandoned before the invading livestock of the colonists, or whose inhabitants were ousted (either by the authorities or individuals). Thus, in the Diatot region in the north of New Caledonia, a series of military operations was carried out (between 1862 and 1870) against the Ouebias, causing the disappearance of several dozen villages or hamlets whose populations regrouped elsewhere (Pouébo, Ougoa) or dispersed (see the Moniteurs and the reports of the Colonial Secretary, Mathieu). The same happened in Voh-Temala and in Poindimie, especially at the time of the 1878 revolt which extended from Koné to Bouloupari and Thio, when perhaps several hundred settlements disappeared (Rivière 1879 [1980]). Thus the settlement maps we produce here (Figs 1-4), at least for certain regions, probably greatly underestimate the former numbers (327 villages or hamlets must be added to those on the maps, but this could not be done for lack of precise information concerning their location).

Nevertheless, the results of this study, compared to the documents of the early colonial period known to date, which are too few and too limited in scope, allow us to understand for the first time the situation of a large part of the pre-colonial Melanesian population distribution, systematically and in its entirety.

The general map (Fig.2) of the distribution of settlement leads us to note several things:

1. Most of the land surface of the Grande Terre was settled, with the exception of the southern part of the central mountain range and the south of the island, where regional conditions did not seem suitable for permanent settlement even in the simplest form.
2. Settlement seems to have varied in density from region to region.

3. It would seem too speculative to establish a scale of Melanesian village-size with any scientific rigour. Most of the information analysed says little or nothing on this subject. Some villages seem to have been quite large according to the descriptions (Koumac and its surrounding area, for example). Others, and these are numerous, such as the Central Highlands region near Kone and Hienghène, were in fact only a few huts sheltering on occasions just one family.

Distribution of settlement

In 131 maps (not including the Belep Islands or Isle of Pines) we noted the following results (see Table 1).

<table>
<thead>
<tr>
<th>No. of villages</th>
<th>No. of maps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>32</td>
</tr>
<tr>
<td>6-10</td>
<td>21</td>
</tr>
<tr>
<td>11-20</td>
<td>29</td>
</tr>
<tr>
<td>21-40</td>
<td>17</td>
</tr>
<tr>
<td>41-80</td>
<td>12</td>
</tr>
<tr>
<td>81-160</td>
<td>4</td>
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<tr>
<td>More than 160</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>116</strong></td>
</tr>
</tbody>
</table>

1 15 maps show no village at all

Source: series of historical maps, ORSTOM 1981

Table 1  Number of pre-contact villages (in sections, to a scale of 1/25,000)
Generally speaking, this distribution seems to show several types of situations:

**Areas which are virtually empty**

No human settlement is marked. Nevertheless some of these areas are crossed by 'Kanak' paths, or contain old place names indicating the role that these inhospitable places could have played in communication. In effect, these are vast areas of the interior of the peridotite plateau in the south, starting at Thio and extending to Yaté-Goro. Due to natural conditions, this area has probably never sustained other than precarious, nomadic habitation.

**Very sparsely populated areas**

We find a significant number of individual grid maps (32) which show only 1-5 villages. Let us state also that 12 of these are maps of the Southern Caledonian Plateau mentioned above; which was almost devoid of habitation, so it is not surprising that the population which was settled along the coast from Thio to Yaté and from Goro to Noumea was sparse.

There is an exception in the Mt Dore region, for which we lack precise documentation, and cannot therefore state with any certainty the original situation (although imprecise sources mention a sizeable settlement near Plum and Les Rekes).

Others areas of sparse population appear elsewhere, such as the area round the Baie de St Vincent, a dry region where water supply was probably a problem. However, this was a good fishing area, which probably led to coastal settlements (in the form of temporary fishing villages) which are shown on the maps. Other regions of the same ecological type are found to the south of Poya (Plaine des Gaiacs), between Pouembout and Paewa, and on the west coast some of the map sections suggest low population density between Voh and Tiêbaghi. However, Koumac and Gomen were heavily populated, probably with a greater density than was shown on the maps, if we are to believe the first official reports.

**Regions with a large number of villages**

Here we could cite the Canala-Thio region, a notable example of high population density, with 178 villages in one section and 101 in the neighbouring section. Another heavily settled area extends from Hienghène to Poindimie. In the Diahot region and in the La Foa area, high population density is to be found on the maps; the Voh-Pouembout region falls into the same category.

In the rest of the territory, it is interesting to note that settlement is generalised throughout the Highlands, even if population density varies from section to section.

Taking into account the strictures of methodology, we can postulate the following ideas:

1. It seems clear that all of the New Caledonian territory providing a minimum of favourable conditions, was to some degree settled.
2. Unpopulated regions (the south, and parts of the west coast) represented a considerable percentage of the island (approximately one third).
3. The mountain regions, and in particular the higher areas, were not in fact free of settlement as early writers concluded somewhat hastily. On the contrary, a civilisation of 'mountain people' lived there, although perhaps, settlement was less dense than elsewhere, and villages were smaller.
4. On the east coast, for reasons both of climate and landform, settlements tended to be localised on the coast and at the mouths of the rivers. The latter generally extended up the river valleys, and were established on the mountain slopes. They were of high density within small areas (Hienghène-Touho-Poindimie).

This study of settlement patterns therefore shows that, apart from the inhospitable areas, the whole of the Grande Terre was populated in a manner that closely followed the ecological possibilities of the surroundings, and that population density varied according to the potential of each area for agriculture.

The data presented here, considering its general nature, must be carefully weighed. We therefore give another series of results pertaining to the question of size of settlements and their distribution in the Grande Terre. The results are those from a study carried out by a team of anthropologists from ORSTOM (Frimigacci et al. 1981) who, through onsite research have tried to transcribe onto a map any and all information concerning the traditional organisation of Melanesian lands, and adapted as Figure 3. In 104 individual grid maps studied, we find the distribution as summarised in Table 2.

This distribution shows the same geographical tendencies as those previously given where taken from purely historical sources (Figure 2). A considerable part of the territory
was either deserted or very lightly settled (approximately 30% of the area of the island). On the other hand, a similar pre-proportion of the island, centred on the north (Diahot), the east coast (from Hienghêne to Houailou) and the west coast (Sarraméa, La Foa/Goyetta, Poum, Pouembout, Gomen/Koumac) had a relatively dense population.

According to Kanak tradition, the number of villages in existence was about one-third higher than the number indicated by contemporary historical sources. Without going into a comparative analysis or a critique of the results obtained from the two sources, we can see...
that there are common factors between the two approaches to population measurement. We should note, however, that if the paper (Frimigacci et al. 1981) on Kanak oral traditions gives for some areas, such as Bourail-La Foa-Bouloupari, lower figures than those found in the historical study, this could be explained as being the result of the disappearance of many of the old clans and the regrouping of the villages and tribes (when Governor Feillet restructured village organisation in 1897-98).

Elsewhere, very large population estimates can sometimes be explained as the exaggeration of ancestral memories, which increase the reality over a period of time, or under pressure of the current political situation.

Apart from these reservations concerning data, one fact clearly stands out: the population of the Territory at the time of colonisation was distributed over a number of settlement units of varying size, and which covered more or less densely all parts of the Grande Terre where living or subsistence conditions were normal. This brings us to discuss another aspect of Melanesian life which is closely linked to the question of settlement: that of the areas which were under cultivation.

THE EXTENT OF PRE-COLONIAL MELANESIAN AGRICULTURE

Like all Oceanians, New Caledonian Melanesians had an agricultural civilisation based on root crops: taros and yams. Added to these were sweet potatoes, coconuts, bananas and domesticated and wild fruits. The absence of large fauna for hunting, and of any domestic animals (the deer was introduced, as was the pig, by Europeans) meant that fishing played a major role, with the hunting of fruit bats (an edible species of bat) and birds, in providing a much-appreciated element of protein. The basic crops were taro, and yams of a number of species (Bourret 1979), which required a level of agricultural technology that has impressed many observers (Glaumont 1953), with the extensiveness of the terraces and the complexity of the hydraulic engineering.

Taro is cultivated on hillsides, with a system of artificial terraces or steps, irrigated with water which was often brought over several hundred metres. At that time this was done with ‘pipes’ made of the trunks of coconut trees split in half lengthwise. These ‘tarodieres’ (taro terraces) can still be seen today. Yam cultivation was practised more on the plains and at the base of the hillsides and required the construction of yam ridges (or addos) which, like tarodieres, had to be regularly maintained.

Thus, as we have mentioned previously, many vestiges of old forms of cultivation remain visible to the naked eye, or in aerial photographs, despite the fact that they have long been abandoned. Others were found on the numerous topographic department maps. These can therefore be seen on the maps reproduced here (Figs 1-4), and they constitute an essential part of our approach to pre-colonial human settlement in the Grande Terre. The reconstruction of population density using planimetric methods is one of the main methods confirming the results shown above on the subject of pre-colonial settlement patterns.

Figure 4 helps us to envisage, for the Territory as a whole as well as for each of the IGN sections, the extent in hectares of the pre-colonial cultivation of taro and yams, for which the terraces or ridges are still visible. The results of the survey show that 56,982 ha were under cultivation in the Grande Terre alone. This figure is interesting in itself, if we take into account the fact that today the total land surface under cultivation is something less than 10,000 ha for all cultivation (Bourret 1976)! This figure indicates the existence of previously large-scale Kanak agriculture (mutatis mutandis), and therefore direct implications for the situation of the pre-colonial population become obvious.

The cartographical survey of the distribution and size of these agricultural zones, which are now abandoned for the most part, allows us to come to the following conclusions:

1. Nearly one-third of the island (16 maps) shows no trace of pre-colonial agriculture. This is mainly in the south (a peridotite mineral outcrop) and in a few parts of the west coast where there is little arable land and where it is otherwise unsuitable for permanent human settlement. In this respect, there is close correspondence with the maps of traditional villages, cf. Figures 2 and 3.

2. On 28 maps the pre-colonial cultivation was less than 50 ha. These mainly concern the discontinuous coastal plain on the west coast, which extends from Dumbea to Poum. The inhospitable nature of the terrain is clearly shown by the low figures for the area under cultivation, although there are small areas of richer land in valleys and irrigated plains.

Similarly, the northern region from Paagoumène to Boat-Pass does not seem to have been much used for cultivation, apart from Baaba and Arama. In this same
category we find some areas of the east coast, between Oubatche and Hienghène, and from the Bogota Peninsula to Yaté. Finally, some maps of the eastern slopes of the Highlands show few traces of pre-colonial agriculture.

3. Those map sections showing 50-100 ha of cultivated land also suggest that man was settled on the land to a limited extent, and in this category we find only 15 maps. The category of 100-200 ha is perhaps more significant, but only concerns 14 maps.

4. In the category of 200-500 ha under cultivation we find greater representation with a geographical distribution over 24 map areas.

5. The group of maps (16) showing 500-1000 ha of cultivated land cover the regions of intense pre-colonial agriculture.

6. Finally, the map section 1000-5000 ha under cultivation represent what we could call the Kanak granaries of the Grande Terre. Note that the Azareu-Pote region had 5000 ha under cultivation and the neighbouring area of Canala and the Nakety River had 3340 ha.

Table 3 leads us to two conclusions.

On a total of 17 maps we find 32,883 ha of cultivated land, which shows a marked concentration of cultivation in a limited area, often at higher altitudes (sections of 1000-5000 ha).

On the other hand, on a total of 59 maps we find only 1849 ha of cultivated land (sections from 0-100 ha). It should be noted that we find the same geographical distribution of extremes on both the historical maps of settlement and the maps of cultivation. This is shown in the comparative table (Table 4) which follows.

In Table 4, + and - signs next to certain categories indicate anomalies in the correspondence of numbers. Thus, for example, for the maps in the 3001-5019 ha category with 6-10 villages, we must assume that the number of existing villages has been minimised by our sources (unless they were particularly large villages!?).
### Table 3  Distribution of pre-colonial cultivated land per map

<table>
<thead>
<tr>
<th>Cultivated land surface (ha)</th>
<th>No. of villages</th>
<th>More than 80</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>14</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>1-50</td>
<td>2</td>
<td></td>
<td>29</td>
</tr>
<tr>
<td>51-100</td>
<td>-6</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>101-200</td>
<td>-5</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>201-500</td>
<td>-3</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>501-1000</td>
<td>-</td>
<td></td>
<td>26</td>
</tr>
<tr>
<td>1001-2000</td>
<td>-1</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>2001-3000</td>
<td>-</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>3001-5019</td>
<td>-</td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

Source: ORSTOM (historical maps)

### Table 4  Land surface under cultivation and the number of villages per map

Furthermore, where we have 11-20 villages on maps where only 1-50 ha of cultivated land is shown, we must suppose that the land surface under cultivation has been scaled down from what it really was.

This brings us to another, more general observation: the question of how reliable is the figure we put forward, 56,982 ha. Considering the methods used to obtain this figure, we can only take it to be approximate. Reservation is necessary, insofar as we only included the areas to be seen on the old maps, and those visible through photo-interpretation, which showed much more (with aerial and ground checks). However, it is obvious that these totals are far from exhaustive. For instance, observation of visible traces of cultivation does not take account of cultivated areas which have since been completely hidden by natural vegetation. In some regions such as Thio, mining activity has probably contributed to the obliteration of cultivated areas. Colonisation in parts of the east coast (with coffee growing in particular) and the west coast, destroyed or covered the old Kanak landscape with agriculture, extensive cattle-raising and other land uses. Thus it is possible that areas which today show little evidence of extensive pre-colonial cultivation, were widely cultivated in former times.

Under the conditions mentioned above, and taking into account the limitations of research, a loss of at least 20% seems quite reasonable when measuring land surface previously under cultivation. This only serves to highlight the extent of the Melanesian horticultural civilisation of former times, and the possibilities it suggests in terms of population.

We shall not deal with the types of Kanak agrarian landscapes here; this question has recently been well-developed, and is now widely understood (Doumenge 1982).
It should be pointed out that the organisation of land use depended on the geographical situations, the main types being the coastal areas, the river plains and mouths of river valleys, the sheltered lands of the narrow valleys in the middle level to high mountain areas.

**Coastal landscape**

Different economic combinations were found in these regions, notably groups of fishing villages near rich maritime zones, which offered easy access for outrigger canoes. There was then the possibility of a combination of agricultural activity and fishing (generally on the east coast). Elsewhere, the problem of water supply was of prime importance, and villages tended to be rather small and dependent on fishing and shell collecting. Agricultural produce was either obtained by bartering, or was cultivated in inland fields (e.g. Oundjo), which required a temporary change of residence. This latter system seems to have been quite widespread on the Grande Terre.

**Villages in the plains and at the mouths of river valleys**

These were very common. Often people in such areas practised cultivation. The river valleys (the Iouanga Valley, the lower Diahot, the Tchamba Valley, the La Foa Valley, Nakety, etc.) were probably the most heavily populated, and it was these areas that were the most disrupted by the different phases of colonisation, in particular by the introduction of cattle raising.

**Settlement and cultivation in the Highlands**

Today, there is no Melanesian settlement higher than 600 m above sea level, but it would seem that this was not necessarily the case in pre-colonial times. Even some of the highest mountains sustained a regular population if we are to believe the different sources. This is shown by the extent of taro cultivation in some areas that were a sort of ‘root crop granary’.

**POPULATION DENSITY AND PRE-COLONIAL MELANESIAN DEMOGRAPHY**

**The complexity of the problem**

The questions discussed above have the implicit consequence of a far-reaching revision of the population estimates which were more or less accepted by most authors until now. The estimates ranged from 60,000-100,000 Melanesians for the whole of the New Caledonian Archipelago. These were based on only the localised estimates of the first explorers in the region of Pouto and Balade, and that the generalisation of these figures for the whole of New Caledonia is more hypothetical than an approach based on existing documents. Nor must we forget that the question was soon further complicated by a policy of colonisation by settlement, and that, as a result, some authors felt the need to justify a small Kanak population. Furthermore, some writers based their estimates on the level of population between 1880-90 to conclude that the initial Melanesian population had been small. Nevertheless, tales of voyages and of exploration by missionaries and the military showed, at least locally, the size of population and the extent of rural activities in certain areas (Ratte 1878). With the early military expeditions and the creation of the first reservations, some attempts at counting the population were made.

Thus the population of the Manongoes (the coastal region of Paita) who were settled in the villages of Ennedé, Nanouni, Oé, Tiaré, Téré, Tongouin, Mati and Tanongoe consisted of 87 men, 74 women, and 71 children, a total of 232 people. This was in 1866, before territorial limits were defined (Mathieu 1868 No.440).

In 1869, military operations in the north led to the dispersal of some groups, which later regrouped in designated areas. In this manner we have some population figures (Mathieu 1869 Nos 489, 490); for example, the Tendianous (Ouébias) numbered 122 men, 67 women, and 37 children (only 11 of whom were girls), a total of 226 people.

In the same year (order in the *Journal Officiel* of 28/2/1869), the Maloumes (Ouégoa, Pouto region) were composed of four groups, with a total of 579 people: 277 men, 155 women, and 147 children (only 58 of whom were girls). The villages of the Paiacs (upper Diahot) had a population of 154 men, 105 women and 116 children (50 girls), a total of 375
people. Finally, in the same region (Pouébo), the Mouélébés tribe was ‘constituted’ by the authorities (order in the Journal Officiel of 28/2/1870); it was composed of 748 persons of whom 217 were men, 226 women, and 305 children. But this new tribe included some heterogeneous elements: there were ex-Ouveans, ex-Paiacs and ex-Maloumes, which distorts the demographic data. As for the Diaué tribe, which was an ally of the French, it was ‘reformed’ in 1869 (Mathieu 1869 No.520) with 93 men, 86 women, and 49 children (25 girls). But remnants of other tribes (Taboubaches, Ouimanis) were added, and here too the figure of 228 persons is not very significant. Similarly, in the northeast sector, the total of several localised censuses indicates that at one time there were 2177 people living there, but these figures do not include part of the areas of Pouébo-Balade, Arama, and the lower Diahot, all well-populated regions. Its main interest is in showing that Melanesian hamlets could have populations of up to 100 persons in mountain regions.

In another census of six hamlets near Thio (see the Marist Archives in Rome. A document from the Thio Mission correspondence) organised by the Marist Brothers before 1878, there was a total of 211 persons. We note that in this count there was a great difference in population size in the Thio hamlets: 14 persons in the smallest, and 62 in the largest.

Apart from these few actual counts, we do not have any exact account giving a systematic inventory of the Melanesian population until the first census in 1887 (Métais 1953). This census showed that there were 42,515 Melanesians in the Caledonian Archipelago, a figure that dropped to 30,304 in the 1897 census (18,295 of this population was on the Grande Terre). The tardiness of this census in relation to the beginning of the French settlement is one of the major difficulties in the demographic question.

In fact, by 1887 the impact of colonisation: epidemics, alcohol, the increase in tribal wars with firearms, and a fall in the birth-rate (often voluntary), had had a great effect on most Melanesian groups on the Grande Terre. Some sources imply that it is from the very beginnings of contact with Europeans that consequences for the Melanesian population appear, consequences which have been called ‘the fatal impact’ (Moorehead 1966) of the encounter between Oceanians and Europeans, with the devastating effect of the introduction of certain European maladies. From 1825 onwards, New Caledonia was a rest area for the European whalers who hunted the hump-back whale in the north of the Coral Sea, and spent winters in several places in the Territory (Doumenge 1966). After 1840 came the Sandalwood period which, according to available literature, implied a close relationship between the sandalwood traders and the native tribes, as semi-permanent settlements were established by European traders on the Isle of Pines, the east coast, the Bay of Poom, and in Nouville, where James Paddon set up his trading post and village (first settlement in the Noumea area) (Person 1953; Shineberg 1974). Towards the end of this period we find the first attempts by Catholic missionaries to gain a foothold in Balade, (1844), and in Yaté by the Protestant ‘teachers’ from the London Missionary Society (LMS).

As early as 1843-45 an old tale (see Anon. 1970) bears witness to the introduction of epidemics which decimated the native population in the south of New Caledonia, and led the Melanesians to flee or to repulse strangers, or else to make them submit to purification rites before contact. Later, in 1860, an account of a military exploratory trip (see Mathieu 1860 No.367:179) notes that the Ahoui tribe had been devastated by an epidemic, which had led the natives to refuse to carry the mail between the Canala outpost and Noumea. Other reports elsewhere mention similar occurrences.

The demographic destabilisation of the Melanesians probably appears very early (Nicolas 1928) after the fragile island balance had been damaged. Rural colonisation became more and more extensive, and only served to aggravate a process which had already started. It was further accelerated by other factors, such as alcohol, firearms, capture of the women (see the reactions of the missionaries following the capture of women and children, and that of Pastor Maurice Leenhardt after the 1917 revolt; see also Dousset-Leenhardt n.d.), voluntary infanticide, intermarriage and punitive expeditions.

Table 5 compares the results of three censuses of that period, and shows the evolution of the Melanesian population towards the end of the 19th century. The censuses were divided according to the contemporary administration sectors or ‘arrondissements’, with the first census being in 1887, the second in 1891, and the third probably in 1899. The results were set out on the Agricultural Union Map, on a scale of approximately 1:102,000, by Engler.
Table 5  Evolution of the Melanesian population (1887-99). (Including the Loyalty Islands in the first arrondissement)

We are given the sex-ratio of the Melanesian population only in the 1887 census. In some arrondissements we note a large difference between the numbers of adult males and females (the 3rd, 4th and 5th arrondissements). Over a period of 12 years, the data from these three censuses illustrate the rapidity of the decline in population, with a general total of 18.11% in population decline, with some arrondissements losing up to 29.96% of their numbers.

Some demographic considerations

The question of the settlement factor

The data concerning settlement (2368 villages) as well as for food crops (56,982 ha) are interesting in that they represent a serious research effort in the public and private archives, and an attempt at cartographic reconstruction which had not previously been undertaken, and could only be improved upon by further discovery of hypothetical unedited documents. It therefore seems to us, in all modesty and with due respect to the scientific caution so necessary in this field, that we have redefined the terms of the question, at least in so much as to improve the approach, which has thus far been hazardous.

For the whole of the Grande Terre we found a total of 2695 pre-contact villages (1788 situated on maps, 580 situated but nameless, 327 unsited for lack of sufficiently precise information). Even if a large number of them were no more than small hamlets, or even seasonal settlements in the fields, this figure is important. To this we must of course add a number of unknown villages which disappeared without a trace, but a number which may not be negligible according to military sources (see Mathieu 1868; Rivière 1879). There were perhaps several dozen, or maybe even several hundred. Let us assume, with all methodological reservation, that there were 3000 villages and hamlets; if we also accept a figure of 20 as the minimum average population per unit (Vieillard and Desplanches 1869; they estimated in 1862 that there was a total population of 42,480 Melanesians in the Territory, of whom 16,600 were in the islands, but these naval doctors had not visited the interior, and gave figures only for the coastal populations), we would have a total of 60,000 Melanesians in the Grande Terre (Birdsell 1977 states that in Australia the basic population unit is five families, or a minimum of 25 people. This is an ecologically more rigourous region than New Caledonia). This gives us, in a first minimal estimate, the maximum number suggested by most authors in estimates of the pre-colonial Melanesian population. If we increase the average per unit to 30 inhabitants, which seems to us, quite plausible, we come to 90,000 inhabitants. We shall not carry these calculations any further.

We believe this study shows that the lowest estimate of the initial population corresponds to the highest estimates of the early colonial period. This would mean a

Source: Censuses of the Melanesian population, 1887-99.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
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<td>1st</td>
<td>2nd</td>
<td>3rd</td>
<td>4th</td>
<td>5th</td>
</tr>
<tr>
<td>1887</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>5.035</td>
<td>1.426</td>
<td>2.787</td>
<td>2.805</td>
<td>1.871</td>
</tr>
<tr>
<td>Women</td>
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<td>1.255</td>
<td>2.140</td>
<td>1.982</td>
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</tr>
<tr>
<td>Children</td>
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<td>1.410</td>
<td>2.270</td>
<td>1.858</td>
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</tr>
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<td>4.091</td>
<td>7.197</td>
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</tr>
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<td>3.550</td>
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<td>5.041</td>
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<td>-15.57</td>
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</tr>
</tbody>
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1Union Agricole de Nouvelle-Caledonie. Carte. Scale of approximately 1:102,000. One exemplar was in 1984 in the Topographic Service of the Territor. Map drawing by Engler with order of Governor. Feuillet Engler was the first chief of this board and had a good knowledge of the New Caledonian Bush and his tribes.
minimum of 80,000-100,000 Melanesians living on the Grande Terre at the time of the first contact with Europeans (from about 1825).

Population estimates based on cultivation systems

Another interesting factor which could serve to strengthen the theory of a high level of population is provided by the evaluation of cultivation systems. If we are to believe the early writers and agriculturalists of that time, the tarodièr systems required a large labour force both for construction and for maintenance. Relating a visit to the old village of Téné (7 km from Bourail) Claumont (1953) wrote:

We went there together and counted the sites, today empty, of more than twenty villages and a thousand huts or homes. Immense tarodières furrowed the mountains all round the valley, which could be estimated to be at least 100 km, with the tarodières going from the mountain tops and scoring them to their base, following all the contours of the hills.

By the methods described above, we found 56,982 ha of pre-contact cultivated land, associating taro (in the majority) and yams (the latter probably predominating on the east coast). This figure is, of course, incomplete, and we can probably increase it by 15-20% without risk of exaggeration. However, we also know that the tarodièr terraces needed fallow periods of up to nine years (because of parasites). Custom pertaining to sacred rites or traditional forms of authority were also factors regulating crop rotation (Curry 1959-62). So it seems difficult to extrapolate from the surface under cultivation, to speak of the cycles of rotation or the intensity of cultivation. But we can suppose that the number of man-hours necessary for terrace cultivation and maintenance (Spriggs 1981) was not the result of social practices for prestige, and that a considerable part of the land was generally productive. Spriggs, after studying the tarodières at the Col de la Piroque near Paita, showed that 1 ha of irrigated taro required a minimum of 4816 man-hours of work per year, and up to 5926 man-hours on difficult terrain. These figures indicate, if we accept a minimum of 10 hours labour on each of 300 days, that between 1.5-2 full-time workers would be necessary per hectare. If we further accept that for about 60,000 ha of pre-contact cultivated land found (to which we should add an adjustment of 20%) there was only 1 ha out of a potential six under cultivation at any one time, a total of 10,000 ha, the number of workers required would have been about 20,000 (1.5-2 workers per ha). (Note that 1 ha of irrigated taro can yield an annual harvest of 12 tonnes, and 20-40 tonnes per hectare for yams (Barrau 1962).

Yet we are still speaking of a minimum intensity of cultivation. The number of 20,000 active workers, which is a quite plausible figure, indicates that, counting women, children, old people, regular fishermen, and people dispensed from horticultural work by customary law, there was a population of 80,000-100,000 people (Crocombe 1979) (Crocombe gives this definition of the cultivation/population equation in the average Pacific situation: 3 ha of land, with 0.5 ha under cultivation, is sufficient to sustain a family of five people, and requires between 40 and 50 days of agricultural labour by the father and mother of the family. Using Crocombe’s ratio, we can postulate that 11,000 ha of cultivated land would have provided sufficient food for 100,000 people in New Caledonia).

We believe that these tentative conclusions lend further support to the population estimates suggested by the number of pre-contact Melanesian settlements, and that a higher level of Melanesian population probably existed at the time of colonisation than was then thought.

REFERENCES


Crocombe, R. 1979 The New South Pacific. ANU Press: Canberra

Curry, L. 1959-62 La culture du taro en Nouvelle-Calédonie. Etudes Melanesiennes, Nos 14, 17
Doumenge, J.P. 1982 *Du Terroir à la ville: lesp Mélanesiens et leur eure in Nouvelle-Calédonie.* Travaux et documents du CEGET/CNRS No.46
Glaumont, G. 1953 *La culture de l'igname et du taro en Nouvelle-Calédonie.* *Etudes Mélanesiennes,* No.7. Noumea
Marist Archives 1879 Census of the Marist Brothers of Thio Mission, Roma
Mathieu, A. 1860 See *Moniteur de Nouvelle-Calédonie,* 1860:367
Mathieu, A. 1868 See *Moniteur de Nouvelle-Calédonie,* 1868:440
Mathieu, A. 1869 See *Moniteur de Nouvelle-Calédonie,* 1869:489, 490, 520
Métais, P. 1953 *Démographie des néo-Calédoniens.* *Journal de la Société des Océanistes No.9*
Nicolas, A. 1928 *Les causes de la disparition progressive d'une intéressante race indigène.* *Bulletin de la Société de Pathologie Exotique* 21
Ratte, A. 1878 *Sentiers Canaques.* *Moniteur de Nouvelle-Calédonie* No.999
Vieillard, A. and A. Desplanches 1869 *Essais sur la Nouvelle-Calédonie.* Paris
WHY IRRIGATION MATTERS IN PACIFIC PREHISTORY

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Irrigation is often assumed to represent one of the peaks of intensification in Oceania, but this judgement needs to be examined. This view has come from the presence of easily recognisable structural remains - stone-faced terraces, long canals, raised beds in swamps, and the like - rather than from a study of labour inputs, importance within total production, and environmental and social conditions under which irrigation systems have operated. While it could be argued that all irrigation systems are intensive in Brookfield's (1972) terms, it is equally true from an Orwellian viewpoint that some are more intensive than others. Irrigation cannot be viewed solely within a presence/absence framework and its importance assumed. Similar assumptions could of course be criticised in relation to any intensive technique or array of techniques observed in the Pacific.

Related to the assumption that irrigation necessarily represents one of the peaks of intensification in the Pacific is the much debated view that irrigation is important on a world-wide basis as a factor in social evolution (Downing and Gibson 1974; Earle 1978; Mitchell 1973; Wittfogel 1957).

On occasion, the discovery of the most miserable diversion of a trickle of water into a minute parcel of land has led to pilgrimages of academics from far and wide and assumed some mystical aura as a decisive first step on the road to despotism or, as it is often more quaintly labelled, 'the Rise of Civilisation'.

Other agricultural techniques also found in the Pacific such as yam mounding or genetic selection of tree crops, have not (yet) been invoked by name in similar debates. The question to be considered is one of whether there is something qualitatively different about irrigation that lends it more than a purely technological significance in oceanic prehistory?

Among the most common categories of archaeological remains encountered in the region are those associated with agriculture. Irrigated gardens often leave particularly distinctive archaeological traces, and the range of crops that can be grown in them is severely restricted, as established from the evidence of crop water requirements and from recent historical and ethnographic sources. As one moves out into the Pacific from New Guinea, the number of hydrophytic food plants for which irrigation would be suitable narrows even further. In most cases we can be reasonably sure that the main crop (if not the only one) grown in oceanic irrigation systems is the taro (Colocasia esculenta), or under certain conditions another aroid, the giant swamp taro (Cyrtosperma chamissonis).

Irrigation systems have been reported in an area stretching from the Hawaiian Islands in the east to New Guinea and beyond in the west, in a range of environmental and social contexts. Many of the other intensive techniques have a more restricted distribution within Oceania.

Several early European visitors to the Pacific commented on the irrigation practices associated with the cultivation of taro. The Spaniards of Mendaña's expedition which 'discovered' the Solomon Islands were the first of these, observing irrigation systems in use on Guadalcanal in May 1568 (Amherst and Thomson 1901(I):306). Members of Cook's expeditions in the 1770s commented on and were obviously impressed by taro irrigation systems in the Hawaiian Islands, Tahiti and New Caledonia (Cook [Beaglehole] 1961:538, 1967:269; Forster 1777(I):341-42). Early accounts by visitors to other island groups also mention the presence of taro irrigation. Williams (1838:206-7) described the practice as it was on Rarotonga in 1823, Wilkes (1845(III):42-43) reports it from the Fijian Archipelago during the US expedition of 1838-42, while the missionary John Geddie mentions taro irrigation in an account (Missionary Register:January 1852:8) written soon after he settled on Aneityum in Vanuatu (formerly the New Hebrides) in 1848.

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As well as the evidence from early travellers' accounts and historical sources, archaeologists have also noted widespread remains of irrigation systems in many parts of the Pacific. Abandoned irrigation systems were first reported by Glaumont (1897) from New Caledonia. Pioneering archaeological and ethnographic surveys by the Bishop Museum record the presence of abandoned canals, terraces and other features associated with taro irrigation from the Hawaiian Islands (Bennett 1931; Emory 1924; Handy 1940; McAllister 1933), Mangareva (Buck 1938:226-27), Marquesas Islands (Handy 1923:182-87), Austral Islands (Aitken 1930:16-17, 33-34), Society Islands (Emory 1933:33), Cook Islands (Buck 1944:249-50), and Wallis and Futuna (Burrows 1936:140). From Fiji, Ward (1960:40-42, 47) reports wide-scale abandonment from the 19th century onwards of formerly irrigated terrace systems. Shutler and Shutler (1966:160) reported seeing extensive areas of abandoned agricultural terraces on Aneityum in the first archaeological survey of southern Vanuatu, while Chikamori (1966) reported similar systems from his survey work on New Georgia in the Solomon Islands.

Irrigation is a term which has often been loosely applied to describe a range of wetland agricultural techniques. I use it in a general sense to mean water manipulation for agricultural production where the aim is to maintain a high soil moisture content, rather than to create a ‘dryland’ environment by drainage. The term thus embraces all forms of ‘wetland’ agriculture, from the use of naturally swampy areas to systems whose water supply comes from long supply canals.

Three main categories of irrigation can be identified in the Pacific (Damm 1951): swampland, pit cultivation, and true irrigation. Swampland cultivation techniques generally consist of the management by ditching of freshwater swamps where the aim is not complete drainage to create a dryland environment for planting but is only to control the water-table within required limits. These techniques are widely distributed throughout the Pacific. Pit cultivation is found mainly on coral atolls and other low islands where pits are dug to tap the freshwater lens beneath the ground surface but it is also found on some high islands, particularly in Micronesia.

True irrigation refers to diversion of water from source to fields. Variants of this technique are widespread in the Pacific. There are two basic parts to this technique: a water delivery system of canals or pipes, and a system of water application to the crop. Sometimes water is led almost directly from a stream into the garden area but often unlined (or stone-lined) canals up to several kilometres in length are necessary. In parts of the Pacific, canals are found up to 5 km in length, with one exceptional example in New Caledonia which is 12 km long (Brenchley 1873:347). Found in association with such canals or in place of them are pipelines usually of bamboo, pandanus, or tree fern which again may be some kilometres long.

The methods of water application to the crop include: (a) simple flooding; (b) ‘paddies’ or pondfields; (c) island beds; and (d) furrow irrigation.

In simple flooding water is led to the upper edge of the garden and then circulates down, often with simple wood or stone barriers to slow down the flow, thus helping to trap sediment and control erosion. Simple flooding is essentially a Highlands New Guinea practice. A variant is when rough terraces are constructed directly in small stream beds which is a more widespread practice.

Pondfield systems have planted areas as artificial ponds through which water is kept constantly flowing, to feed other usually terraced pondfields downslope. These systems closely resemble some of the wet-rice paddy systems of southeast Asia, and indeed taro is sometimes interplanted with rice in Southeast Asian paddies or found as a monocrop in paddies adjacent to ones used to grow rice; examples are in Sulawesi (Ian Glover pers. comm.), Java (Ochse 1977:55), the Philippines (Conklin 1980; Peralta 1982; Villanueva and Tupas 1980) and Malaysia (Ghani 1981-82:41). On Botel Tobago, between the Philippines and Taiwan, taro is grown in pondfields and rice is absent (Kano and Segawa 1956). Pondfield taro systems are found widely distributed in Melanesia and Polynesia and occur also on Ponape and Palau in Micronesia (Ayres 1985; Ayres et al. 1979:110; McKnight and Obak 1960).

The island bed system consists of water led round the perimeter of usually rectangular beds and thus resembles the island bed systems found in swamplands. Island bed irrigation systems occur in Papua New Guinea, New Caledonia, Fiji and the Cook Islands. In some parts of the region there is a garden succession from pondfield to island bed as fertility declines, followed by a fallow period and then reactivation of the pondfield.
In *furrow irrigation*, water is applied to the ground in small, shallow furrows from which it soaks laterally through the soil, wetting the area between the furrows. I have seen this system in use only on Aneityum in Vanuatu.

Reports of irrigation systems in some parts of the Pacific do not contain clear information on water-application techniques, and so other techniques of true irrigation may also be present in the region. For instance, agricultural remains of the Waiumea field system on Hawaii Island reported by Clark and Kirch 1983 are aberrant in form and may represent a local innovation utilising a form of simple flooding or even furrow irrigation.

**IRRIGATION: 15 REASONS WHY**

All Pacific irrigation systems share certain advantages:

1. They produce a higher yield per hectare than dryland crops (particularly taro) grown in equivalent soils even when rainfall is adequate for good crop growth. Dryland taro yields in the Pacific are usually from 2.5-15.0 mt/ha/year (Bayliss-Smith 1980). Swampland garden yield figures on Aneityum (Vanuatu) varied from 32.2 (22.7 corms only) mt/ha/year up to 52.1 (44.6 corms) mt/ha/year (Spriggs 1981a:Appendix 5, 1984). In west New Guinea in the Wessel (Papenai) Lakes area, yields of 12.8 mt/ha/year are recorded from unmulched beds (Bayliss-Smith 1980), and from the Western Highlands of Papua New Guinea island bed yields of 12.1-22.3 (mean 17.1) mt/ha/year are reported (Bayliss-Smith 1982), using lowland varieties. One local variety of taro gave a yield of 30.6 mt/ha/year. Pit cultivation yields from Ontong Java Atoll in the Solomon Islands were 21.0 mt/ha/year (Bayliss-Smith 1980).

   The only yield figures for simple flooding I have come across are 18.4-21.0 mt/ha/year (Boyd 1975) and 37.6 mt/ha (growth period unknown) recorded by Conroy and Bridgland (1950) in an area where dryland taro yields are given as 12.5 mt/ha.

   On Maewo in Vanuatu, I recorded yields from pondfield systems of 35 mt/ha/year and above (Spriggs 1981a:Appendix 5, 1984). Commercial Hawaiian farmers today using pondfield techniques, but mostly also using heavy fertiliser and weed-killer inputs, obtain yields of 22-50 mt/ha/year (Bayliss-Smith 1980). Yields of one Cook Islands variety have been reported as 26.7 mt/ha/year (Manarangi 1984).

   For island bed true irrigation systems, yield figures were collected on Lakeba (eastern Fiji) in the aftermath of a major hurricane and Brookfield (1979:138) considers that they 'probably under-represent the potential production'. Yields varied from 12.4-35.3 mt/ha/year (mean 19.4 mt/ha/year). These figures do not separate tilled from untilled beds but the higher figures are presumably from the tilled beds. One variety grown in island beds in the Cook Islands gave a yield of 18.0 mt/ha/year (Manarangi 1984).

   I estimate that *furrow irrigation* yields for untilled gardens on Aneityum are in the region of 26 mt/ha/year (19-20 mt/ha/year corms only) with 29 mt/ha/year (22 mt/ha/year corms only) for tilled gardens (Spriggs 1981a:Appendix 5, 1984).

2. With constant water supply, risk of crop failure is reduced and year round production is possible, thus preventing yield fluctuations and crop shortfalls. This may allow more permanent occupation in an area, and the need for crop storage is often obviated.

3. It is possible with irrigation to use land not otherwise agriculturally productive - either because it is too wet and water level is uncontrolled (some unmanaged swamps) or it is too dry (some leeward or rain-shadow areas).

4. Production certainty in irrigated land allows 'speculative' use of rain-fed land. The production system is buffered against crop failure in the rain-fed sector in particularly dry years.

5. Irrigated taro varieties have different flavours and cooking properties than dryland varieties, giving some variety in the diet.

Various other advantages accrue to some forms of irrigation although not to all -

6. Once built, most irrigation systems form a permanent or semi-permanent infrastructure which can be brought back into use at any time. Thus there is often a better return from 'once built' than in dryland gardens where the garden usually has to be completely recreated at every use: an exception would be the New Caledonian yam mounds which are also semi-permanent structures. There are implications here in terms of the potential for privatisation of land.

7. Irrigation often allows an extension of the number of cropping-cycles before fallowing is necessary, sometimes allowing nearly permanent production from a piece of land. The swampland systems of Aneityum can be reused every year if the subsurface leaf mulch is replaced (Spriggs 1981a:50). In pondfield systems there is a wide variation in the number of cropping cycles dependent on soil type, nutrient supply, availability of land and the labour involved in clearing out the
pondfields. On Maewo on the best soils 8-10 years cropping (six cycles) is normal, followed by 3-4 years fallow. On less fertile soils 3-8 years cropping (2-4 cycles) with five years fallow is typical (1981a:158). Dryland gardens on this island can only be put through a single cropping cycle before falling.

8. Linked to Point 7 is the potential (often present) for further intensification, increased labour inputs to the economic limit, to allow either increased yields or increased number of cropping cycles: practices such as tillage, fertilising and mulching are important in this regard. While such potential also exists in dryland systems it is not usually as great.

9. In all true irrigation systems nutrients are carried in the water to the garden site allowing natural fertilisation by tapping the nutrients of a wider catchment than the garden site itself.

10. In some swampland, pit and true irrigation systems conditions are suitable for blue-green algae to grow on wet surfaces and in the water, considerably increasing nitrogen availability to the plants (Vasey et al. 1984; cf. Ayanaba and Dart 1977 in regard to rice paddies).

11. By flooding the gardens (as in pondfield agriculture) some pests and diseases may be prevented. Taro beetles (Papuana spp.) and rats cannot reach the corms if they are submerged, and the purple swamphen (Porphyrio porphyrio) is discouraged from attacking the corms if sufficient water depth is maintained. While taro grown in wetland conditions is more susceptible to corm rots than dryland taro, it has been claimed that wetland taro is not so susceptible to leaf and petiole diseases (Wang and Otagaki 1980:8). The water in flooded fields acts as a weed-suppressing mulch for weeds intolerant of low oxygen levels (Lambert 1973:45).

12. Water control devices in true irrigation often incorporate slope retention measures such as terracing, which help to prevent washouts and lessen erosion. Slope retention is not usually as developed or effective in dryland systems.

13. True irrigation systems can considerably extend the habitats of fish, eels, shellfish, crustacea and water birds, and allow such resources to be harvested more easily than in their natural habitats. As well as higher root crop yields, animal protein availability becomes more certain. The creation of large pondfield systems in the Hawaiian Islands may have allowed coots, ducks and gallinules to establish permanent colonies there for the first time (Olson and James 1982). These systems may have played a similar role elsewhere in the Pacific.

14. Certain kinds of soil are easier to dig when saturated and this is clearly recognised by irrigation farmers. At Col de la Piroque, New Caledonia, the ground is soaked before pondfield preparation for this reason.

15. Constant irrigation can allow long periods of field storage after maturity without corm rot. On Maewo field storage for periods of up to 18 months was claimed for some pondfield systems. Variation in field-storage potential is accounted for by soil and water conditions and taro varietal differences (Spriggs 1981a:156-57).

These advantages can be summarised as:

1. A greater control over environmental factors.
2. A higher yield per hectare than dryland crops grown in equivalent conditions.
3. A greater potential for further intensification.

If water supply from springs and rivers can be assured, soil moisture content and other growth factors can be controlled. Thus continuous production throughout the year is possible, yield fluctuations per year are reduced and labour inputs may be regulated to avoid a marked seasonal demand. This allows relatively exact planning, with implications too for dryland gardening operations in that speculative use of rain-fed land becomes less risky. This may allow crops to be obtained from land which otherwise might not be used. Absolute yield of taro is higher with irrigation and in some cases relative yield per person-hour increases. The highest yields recorded for taro in both traditional subsistence gardening and commercial production come from irrigated plots. Linked with this factor of higher yields is the third main advantage of irrigation: its potential for further intensification.

IRRIGATION AND ITS IMPLICATIONS: THE ANEITYUM CASE STUDY

Aneityum Island, the southernmost inhabited island of the Republic of Vanuatu (formerly the Franco-British Condominium of the New Hebrides) is a high volcanic island 160 km² in area. Its highest peak is just over 850 m above sea level. I have discussed in detail elsewhere (Spriggs 1981a; Spriggs 1985a) the sociopolitical structure at European contact (ca. 1830) and so will only briefly summarise this information here.

At contact the island was divided into seven major chiefdoms or dominions, each under a high chief and further subdivided into about 50-60 districts under sub-chiefs. These districts generally consist of valleys from shore to mountain top, separated from the next by
eroded ridges radiating from the central spine of the island. Relations between the dominions involved either sporadic warfare and/or competitive feasts, or food exchanges between them. The agricultural economy which supported this ‘fighting with food’ (cf. Young 1971) was based in part on the irrigation of taro, two main methods being practiced. The first was planting in swamplands either on rectangular island beds or hillside terraces directly below springs and the second method was furrow irrigation. Dryland taro and other crops were grown in swiddens, sometimes involving planting on stone-faced terraces.

An archaeological reconnaissance of the whole island, and a detailed settlement pattern study of four of the seven dominions (Anau-unse, Ijipdav, Anetcho and Anau-unjai) were undertaken to examine the archaeological manifestations of this late prehistoric/early historic pattern.

Archaeologically, the dominion or chiefdom level of political organisation is shown most clearly by the long canal irrigation systems, some crossing major watersheds and over 4 km in length. The significance of such substantial engineering works does not lie, however, in the required labour input for these necessitating a chief or equivalent as manager of such enterprises. It lies in there being that area of land under the political control of one unit, of there being in this case a supra-district polity. Initial labour input and labour organisation would not have required the mobilisation of large work teams above the level available in a single district or contiguous districts served by these canals (cf. Earle 1978 for Hawaii). The chief as overseer or manager is clearly not a necessary precondition for the existence of such systems.

Long canals are, however, vulnerable to any interference, and so political control above the district level was necessary to ensure the continuance of water supply. In the period for which we first have documentary evidence on Aneityum, such supra-district organisation was provided by the dominions. These canals never cross dominion boundaries as we know them from this period.

At least two comparative examples showing the vulnerability of water-aided agricultural systems spring to mind. In discussing formative development in the North American southwest, Gledhill (1978:251-52, 271) notes a case where a canal system linking several settlements was in a later phase modified to divert water away from two of them, an event which it is suggested had significant sociopolitical implications. In the Baliem Valley of west New Guinea, the unstable nature of confederations led by Big Men, often leads to sudden political realignments. During such shifts, large areas of cultivated swamp may be abandoned where water supply is no longer securely controlled (Brookfield 1961; Brookfield with Hart 1971:115; Heider 1970:78, 118-21). If the source of water is some distance away (in a different catchment or from further upstream), outside involvement and therefore potential vulnerability to disruption of water supply become significant concerns. There are fewer problems when the water source is immediate, either from an adjacent spring or within a small catchment under the control of a single group.

On Aneityum chiefly prestige was gained by the mobilisation of large quantities of food for presentation at competitive feasts, by creating an obligation of the rival party to produce at least as much food at a future feast, and by demonstrating that the feast-giver had more successfully propitiated the spirits controlling agricultural production. A political system of this kind leads to a cycle of escalation, demanding increasing surplus production and controlled only by the limits of agricultural productivity. These limits are set by the environmental potential for intensification (in this case set by water supply and suitable land) and the labour available for agricultural production. At contact, water supply was limiting only in some areas, the area of irrigable land could have been expanded (and had expanded rapidly in previous centuries), but labour inputs did not perhaps have the same flexibility.

Given the social relations of production on the island and the particular division of labour based on sex which they entailed, increasing development of irrigation meant increasing workloads for women. The limits of agricultural production were largely set by the amount of garden labour women could be forced to undertake (cf. Modjeska 1977). In the case of Aneityum, in Marxist terminology there was clearly an inherent contradiction between the forces and relations of production.

Elsewhere where similar kinds of political systems are found, based on manipulation of surplus agricultural production for political ends, this contradiction is manifested in other ways. For instance, Earle (1978) has discussed the differing degrees of social stratification found within Polynesia in terms of the environmental limits to intensification:
Irrigation, with its potential for intensification, was the ideal economic base for an evolved chiefdom, because capital investment in irrigation technology permitted an expansion of surplus production.

In summary, political rivalry (competition) in Polynesian chiefdoms resulted in a positive feedback maximizing economic system. The expansion of this system was limited either by the size of an island or the environmental potential for irrigation. In Hawaii, the relatively large land mass and extensive alluvium permitted the expansion of the social system and the financing of an elaborate sociopolitical superstructure through intensive agricultural production, especially irrigation [Earle 1978:173].

In Friedman's Burmese example:

The internal logic linking surplus production to genealogical proximity to the gods serves to convert big man status into chieftaincy. We can suggest here that any significant increase in relative, but especially absolute, surplus would merely accentuate this kind of development to a point where vertical relations were everywhere predominant. This could result from the successful intensification that might occur in lowland riverine irrigation [Friedman 1975:193].

Where access to irrigable land is not possible and hillside swiddening remains the agricultural method however, the environmental limits are soon reached, creating an absolute barrier to the internal tendencies of the relations of production. Where ecological degradation occurs... the segmentary hierarchy collapses' (Friedman 1975:97).

A change in land use from dryland to irrigated gardening clearly represents a process of intensification, a process demonstrated by the archaeological record of Aneityum and one which appears to have operated in the past on many other Pacific islands as well (Spriggs 1981a, 1985b). Further intensification of particular techniques of irrigation is also possible. Thus on Aneityum, cropping of swampland gardens can be indefinitely extended by continually renewing the leaf mulch and turning over the soil and yields can be increased in furrow irrigation by tillage. In various parts of Maewo pondfield garden use can be extended by cleaning out the soft mud, applying a mulch, or initially harvesting only the corms and leaving the cormels to grow larger. Elsewhere in the Pacific, exhausted pondfields are converted to island beds to extend the length of cropping. This is reported from Hawaii (Queen Emma ms, quoted in Earle 1978:117) with a variant on Futuna (Kirch 1975:132-33).

The potential for intensification is the potential to increase surplus production to meet the demands of the sociopolitical system (cf. Godelier 1977:110-11). The growth of chiefly power and the expansion of irrigation on Aneityum went hand in hand. As a chief's prestige grew he would become more able to command labour to expand the conditions of agricultural production by the building of new canals and the extension of irrigation systems to the flatter areas of the coastal plains: these represented land which had only recently become usable for agriculture as alluvium accumulated to raise it above the base water-table (Spriggs 1981a:Chapter 5, 1986). It was the chief's power to appropriate surplus production for feasts in order to maintain his prestige, which required the expansion of the irrigation systems. An expansion in one district or dominion would necessitate expansion in the others to match food presentations, taro for taro, up to the limits of the productive capacity of the island. Irrigation is clearly an attractive path to intensify production in such expanding chiefdoms. It is thus not surprising that, on Aneityum, the core of every chiefdom was a large permanent river or series of rivers.

THE WIDER PICTURE

The distribution of irrigation in the Pacific has interested scholars since the early part of this century (Damm 1951; Perry 1916; Riesenfeld 1950; Rivers 1916, 1926). The extent to which irrigation is mainly a response to natural climatic factors can be assessed by comparing its distribution with that of mean annual rainfall and seasonal patterning of rainfall. Taro can be grown in non-irrigated gardens in areas of moderately high rainfall, 2500 mm per year usually being necessary but with 1750 mm sufficient if spread evenly throughout the year (Kay 1973:169). As expected, if we compare the distribution of methods of true irrigation in the Pacific (Table 1) with monthly rainfall figures for nearby stations (Table 2), we find that many areas with irrigation possess less than 2500 mm of yearly rainfall and a marked dry season.
Table 1  The distribution of true irrigation in the Pacific

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Rainfall data can only give us a general impression of the relation between irrigation and climate, however, because of lack of coverage of many areas, local rain-shadow conditions not detectable at the macro-level, and differences in soil moisture storage and evaporation rates in different areas of the Pacific. Of more use, where available, are water balance figures (Keig and McAlpine 1974) which, since they provide information about soil moisture storage, give a much better idea than simple rainfall data, of seasonal effects on plant growth. They thus allow us to assess any island or area of the Pacific in terms of its suitability for year-round non-irrigated production of taro. Generalised water balance figures have been calculated for Papua New Guinea (McAlpine and Short 1974) and are summarised in Figure 1 which also plots known areas of true irrigation. A fairly close relationship between soil moisture drought and incidence of irrigation is clear. It can be predicted that further work using data from more Highlands stations (such as Laiagam) will show further areas of localised soil moisture deficit.

The association of taro irrigation with seasonally dry conditions has been previously pointed out by scholars from Rivers (1926) to Bellwood (1978a:147). However, as with many seemingly snug fits between environment and cultural practice, this is by no means the full story. Irrigation is often found in areas where taro can be grown successfully and on a regular basis under rain-fed conditions - wet islands such as Taveuni, the windward coasts of many islands, and in places such as New Caledonia in the wetter central mountain chain. Here the other advantages of irrigation need to be considered: even in areas of adequate rainfall, yield increases are still to be found with irrigation; with some irrigation
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</table>

Table 2  
Notes

a. Seen operating in June.

b. Terracing observed in stream bed.

c. Seen operating in June.

d. Irrigation in Asal Valley and Jimi tributaries, July to November/December.

e. Irrigation late-February to mid-October/December.

f. Seen operating July to September (Baruya groups).

g. Baruya 'homeland', probable irrigation.

h. Extensive hydraulic technology, not used for irrigation.

i. Assume local rain-shadow effects.

j. On island between Kolombangara and New Georgia.

k. Honiara Station; Irrigation reported north of here.

l. Range of rainfall in areas where irrigation practiced.

m. Lawaqa Station. Irrigation also practiced in wetter areas.

n. Draketi Station. Range of rainfall in areas where irrigation practiced.

o. Wales Station. Range of rainfall in areas where irrigation practiced.

p. Walievo Station (central north coast). Irrigation practiced on this drier coast.

q. Mua Station (northern point). Irrigation practiced on this drier coast.

r. Equivalent climate to Futuna (14°18'8, 178°09'W) where irrigation practiced.

s. Drier side of the island.

u. Irrigation practiced?
### Mean monthly rainfall (mm)

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| 389  | 363  | 332  | 267  | 228 | 222  | 261  | 289  | 249  | 254  | 224  | 195  | 3273 |
| 340  | 341  | 358  | 242  | 240 | 238  | 341  | 315  | 256  | 298  | 248  | 246  | 3462 |
| 228  | 265  | 381  | 231  | 142 | 85   | 95   | 86   | 101  | 146  | 135  | 226  | 2121 |
| 399  | 432  | 406  | 394  | 454 | 278  | 211  | 218  | 366  | 339  | 294  | 314  | 4105 |
| 275  | 238  | 326  | 266  | 198 | 156  | 145  | 153  | 142  | 172  | 234  | 223  | 2530 |
| 392  | 204  | 358  | 209  | 212 | 138  | 145  | 139  | 131  | 109  | 178  | 230  | 2446 |
| 316  | 278  | 393  | 226  | 140 | 146  | 86   | 126  | 89   | 65   | 125  | 131  | 2121 |
| 155  | 130  | 138  | 97   | 98  | 84   | 91   | 77   | 58   | 45   | 32   | 96   | 1101 |

Slight discrepancies in table between totals and sums of the mean monthly figures are because of fractional values which are not indicated.

Sources:
1. Brookfield and Hart (1966)
3. Latham (1979)
4. De la Rue (1963)
5. Her Majesty's Stationery Office (1958)
7. Wernstedt (1972)

Kirch (1977: Table 1) gives details of rainfall for Hawaiian irrigation areas
SEVERE and REGULAR soil moisture storage depleted to below one third capacity for more than 50% of every dry season

MODERATE and IRREGULAR soil moisture storage depleted to below one third of capacity for 10-25% of the length of most dry seasons

LOW and INFREQUENT soil moisture storage depleted to below one third capacity for only 1-10% of the length of occasional dry seasons

RARE levels of moisture soil depletion below one third of capacity extremely rare

* True irrigation

** Possible case of true irrigation

Area where true irrigation concentrated

1. Laiagam
2. Enga/W. Highlands/Madang concentration
3. E. Highlands/Morobe concentration
4. Mount Yule
5. Kabwum
6. Cape King William
7. Wamira area
8. Long Island
9. Blanche Bay, New Britain
10. Cape Laverdie, Bougainville
11. Woodlark Island

Figure 1  Intensity and frequency of soil moisture drought and distribution of true irrigation compared, Papua New Guinea

techniques the number of cropping cycles the land can be put through prior to fallow will still be greater than any dryland gardening techniques. We could go on through all 15 advantages looking for possible factors.

Each occurrence of irrigation needs to be examined at a very specific level; the more obvious generalisations only get us so far. Thus, techniques of simple flooding in the New Guinea Highlands involving impermanent water supply structures, minimal slope retention devices, a shifting garden pattern, small-scale and single cropping cycles cannot be easily compared in terms of significance to Aneityumese interdistrict stone-lined canals and large-scale permanent terrace garden infrastructures. The importance of irrigation should always be investigated rather than assumed. For archaeologists, one part of irrigation's significance clearly is its high archaeological visibility (although again the New Guinea simple flooding systems may prove an exception) and the higher degree of certainty in the identification of the crop grown, compared to other structural evidence for Pacific agriculture. This may lead us, however, to place too much emphasis on its presence and not enough on its place within the total productive system. Even on one island there is considerable variation: 10-
40% of total root crop production on Aneityum was by irrigation techniques depending on which dominion is examined (Spriggs 1986:15).

The mere presence of a particular technique of irrigation on an island is, however, significant if we think in terms of a very old-fashioned kind of culture history: trait comparison. While one could argue that some rare irrigation techniques are local innovations (furrow irrigation on Aneityum is a possible example), others were clearly known prior to the dispersal of Oceanic peoples out from the New Guinea area - pondfield agriculture and swampland island beds. The latter technique is also widespread in Non-Austronesian speaking areas in New Guinea. Pondfield agriculture is nearly exclusively found among Oceanic Austronesian speakers in the Pacific and of course both language and technique point to links with island Southeast Asia (Spriggs 1982). Simple flooding techniques in Melanesia are exclusively found in Highland New Guinea and therefore associated with Non-Austronesian speakers.

The details of water supply, either in a regional framework (long-distance canals, large reticulated systems) or within a single irrigation system, contain sociological clues of interest to archaeologists. How water is distributed within an irrigation system is at least as much a sociopolitical issue as a technological problem. In the Anahulu Valley on Oahu (Hawaii) a one-on-one correspondence was found between historical water distribution structures and social boundaries, suggesting that analysis of canal layout ‘may be a useful tool for the interpretation of social boundaries in systems where sociological data are not independently available in the form of archival or other data’ (Kirch 1979:54, cf. Kirch this volume).

The final point which needs to be raised in discussing the significance of irrigation in Pacific prehistory is in relation to other intensive agricultural techniques with which it is often compared, such as the fixed-plot dryland gardens of Hawaii and New Zealand, and the yam and sweet potato mounds of New Guinea and elsewhere. How comparable are these? Many of the advantages of irrigation which I have outlined are not shared by other techniques. Are there really a wide range of possible intensive strategies which could be chosen in any situation, of which irrigation is just one? Where people had the choice (i.e. a controllable water supply) and the desire to increase production, lengthen cropping cycles and so on, did they often choose not to irrigate? It can be suggested that when people could irrigate they usually did, and intensive dryland systems were adopted very much as a second choice. Was there a more attractive road to agricultural intensification in the Pacific? I think not.

ACKNOWLEDGEMENTS

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REFERENCES

Amherst and B. Thomson (eds) 1901 The Discovery of the Solomon Islands by Alvaro de Mendana in 1568. 2 volumes. Hakluyt Society: London
Anderson, J.W. 1880 Notes of Travel in Fiji and New Caledonia. Ellissen: London


Bellwood, P. 1978a *Man's Conquest of the Pacific: the prehistory of Southeast Asia and Oceania.* Collins: Auckland

Bellwood, P. 1978b *Archaeological Research in the Cook Islands.* Pacific Anthropological Records 27

Bennett, W.C. 1931 *The Archaeology of Kauai.* Bishop Museum: Honolulu, Bulletin 80


Brenchley, J.L. 1873 *Jottings during the Cruise of HMS Curaçoa among the South Sea Islands in 1865.* Longman, Green, and Co.: London


Brookfield, H.C. and D. Hart 1966 *Rainfall in the Tropical Southwest Pacific.* Department of Geography, Research School of Pacific Studies, Australian National University: Canberra


Buck, P. 1944 *Arts and Crafts of the Cook Islands.* Bishop Museum: Honolulu, Bulletin 179

Burnett, R.M. 1963 *Some cultural practices observed in the Simbai administrative area, Madang district.* *Papua and New Guinea Agricultural Journal* 16(1-2):79-84


Damm, H. 1951 Methoden der Feldbewässerung in Ozeanien. *South Sea Studies in Memory of Felix Speiser*, pp.204-34. Museum für Völkerkunde: Basel


Earle, T. 1978 *Economic and Social Organization of a Complex Chiefdom: the Halelea district, Kaua'i, Hawai'i*. Museum of Anthropology, University of Michigan: Michigan, Anthropological Papers 63


Emory, K.P. 1924 *The Island of Lanai*. Bishop Museum: Honolulu, Bulletin 12


Erskine, F.E. 1853 *Journal of a Cruise among the Islands of the Western Pacific in HMS Havannah*. Murray: London


Forster, G. 1777 *A Voyage Round the World ... During the Years 1772, 3, 4 and 5*. 2 vols. Robinson: London


Handy, E.S.C. 1923 *The Native Culture in the Marquesas*. Bishop Museum: Honolulu, Bulletin 9

Handy, E.S.C. 1940 *The Hawaiian Planter*. Bishop Museum: Honolulu, Bulletin 161


Hanson, F.A. 1973 *Rapa: une île Polynésienne hier et aujourd'hui*. Publications de la Société des Océanistes 33


Kellum-Ottino, M. 1971 *Archéologie d'une vallée des îles Marquises: évolution des structures de l'habitat à Hane, Ua Huka*. Publications de la Société des Océanistes 26

PRODUCTION, INTENSIFICATION, AND THE EARLY HAWAIIAN KINGDOM

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Late prehistoric Hawaiian society, carrying economic and political development to the highest levels known to indigenous Pacific cultures, offers strategic theoretical terrain for the investigation of the linkages between island polities and the production systems upon which they ultimately depended for support. Hawaii has long been considered an apogee of political development among Polynesian chiefdoms (Sahlins 1958; Goldman 1970), one which quickly transcended the chiefdom/state boundary in the early years of European contact (ca. AD 1778-1819). Similarly, the islands' production systems represent peaks of agricultural and aquacultural intensification. Valley bottom irrigation of taro, intensive dryland field systems, and large stone-walled ponds for the husbandry of mullet and milkfish are among the notable developments of late prehistoric Hawaiian food production.

This close association between the complex Hawaiian polity and its intensive production base has for some time been fertile ground for anthropological theories of development. In his influential study of social stratification in Polynesia, Sahlins argued along ecological lines that 'the degree of social stratification varies directly with productivity' (1958:5). The most highly stratified of his Group I societies, 'Hawaii with its large-scale irrigation techniques and conscious and effective utilisation of small ecological niches ... stands above the field' (1958:127). Thus, the inherent possibilities for intensive production in an island environment such as Hawaii were seen as decisive to the actual development of highly stratified society. In more recent work, Sahlins (1968, 1972) argued that the historical relations between production and the chieftainship are largely the other way around. 'The development of rank and chieftainship becomes, pari passu, development of the productive forces' (1972:140). Again, Hawaii offered critical support for this hypothesis (1972:141-48).

Goldman, in his major comparative work on Polynesian sociopolitical structures (1970) stressed the significance of chiefly control over and stimulus of the economic base, remarking also on the special place of Hawaii (1970:200-1). Goldman regarded successful economic production as essential to the pursuit of status rivalry among Polynesian chiefs. 'The chiefs who could promote production through terrace irrigation were the most successful, as the Hawaiian traditions tell us' (1970:486).

More recently, Earle (1978) drew upon archaeological and ethnohistoric data from the heavily irrigated Halele'a district of Kaua'i Island, to extend Goldman's thesis, while incorporating current archaeological debates, especially the role of population 'pressure' (cf. Boserup 1965). 'Rather than being caused by population pressure, Hawaiian irrigation and warfare were important aspects of the political economy for which expanded productive capacity was an essential goal' (Earle 1978:192). Agricultural intensification, especially irrigation, was an outcome of political competition.' Indeed, Earle argues that the process had its effect on population, as 'agricultural intensification was a strategy to increase local population as a means to increase surplus production' (1978:183).

The theoretical positions outlined above draw almost exclusively from ethnohistoric and ethnographic accounts, with time depth provided only in sketchiest fashion by oral traditions. Even Earle's work, which incorporated archaeological data, is essentially synchronic, as his observations were confined to surface manifestations lacking in temporal control. In short, arguments concerning the historical development of Hawaiian chieftainship and of intensive food production, and the causative links between these, were based largely on synchronic data.

A spate of archaeological investigations in Hawaii since about 1968 have now produced a wealth of information on changes in prehistoric subsistence production, bringing a much-needed diachronic perspective to the field (Yen et al. 1972; Kirch and Kelly 1975; Riley 1975; Kirch 1977, 1979, 1985; Green 1980; Tuggle and Tomonari-Tuggle 1980; Schilt 1980; Athens 1983). There have been few efforts to integrate ethnographic accounts with the new
archaeological information, however, or to assess these findings in relation to the theoretical positions reviewed above (see, however, Hommon 1976; Kirch 1984). Most of the recent archaeological interpretations of the development of Hawaiian production systems are couched in explicitly ecological, demographic, or technological frameworks, with little account taken of social or political factors (Cordy 1974a, 1974b; Riley 1975; Kirch 1980; Athens 1983). The synchronic comparative ethnographic perspective emphasising linkages between productive forces and the social relations of production has thus been replaced by a diachronic, but strongly materialist archaeological view that largely ignores social and political systems.

THE ANAHULU VALLEY PROJECT

Hawaii stands out among Polynesian societies as a field for anthropological study, not only because of the richness of its ethnohistoric record, but of its archaeology as well. Coordinated application of ethnohistoric and archaeological approaches offers a means to redress the synchronic limitations of the ethnohistoric data, and the materialist bias of the archaeological record. Such a coordinated approach has been the thrust of the Anahulu Valley project, a joint collaboration of the author and Marshall Sahlins, and an outgrowth of Sahlins' long-range study of the historical anthropology of the Hawaiian Kingdom (Sahlins 1971, 1974, 1981).

Penetrating the western axis of the Ko'olau Mountain range on Oahu Island, the Anahulu Valley lies within the fertile and traditionally well-populated district of Waialua (Fig. 1). The region figured prominently in the early post-contact history of Hawaii, in direct association with the chiefly lines responsible for transformation of Hawaii's indigenous chieftainship to a native political state (Fig. 2). At the time of initial European contact, AD 1778, Oahu and Waialua district were under the charge of the independent line of Oahu rulers, with Peleioholani as paramount. In about 1785, the powerful Maui Island paramount, Kahekili, conquered the island. The Maui hegemony lasted only a decade, however, with the rout of the Oahu and Maui forces by the famous Kamehameha I of Hawaii Island at the battle of Nu'uanu in 1795. Kamehameha and his forces did not permanently occupy Oahu until 1804, however, when Kamakau (1961:175) wrote, the lands of Oahu were redistributed by Kamehameha I to his various warrior chiefs and counsellors, as was the custom. Waialua fell in this redistribution to Ke'eaumoku father-in-law of Kamehameha. Ke'eaumoku I died in 1804, at the time of the reoccupation of Oahu, and the...
district passed to his son, who had taken the English name 'Cox', and who held Waialua (often residing there) until his own death in 1824. The lands passed then to Cox's sister, Kaʻahumanu, the kuhina nui ('premier') of the Kingdom and regent over the young king Liholiho. Kaʻahumanu's younger sister Piʻia and her husband Laʻanui were designated representatives of the high chiefess, and residing in Waialua looked after the royal interests in the estate. Laʻanui continued in this position of konohiki after the death of Kaʻahumanu (1832), when the ownership devolved to Kinaʻu and her husband Kekuanaoa (Governor of Oahu), and in 1839 to Victoria Kamamalu (the latter received the ahupuaʻa or land section of Kawailoa, in which Anahulu Valley is situated, in the Great Mahele of 1848).

As suggested by this review of the ruling chiefs who controlled Waialua district and the Anahulu Valley, we are concerned with the time span from late prehistory (before AD 1778) through the completion of the Great Mahele or division of lands between the kings, chiefs, and commoners (AD 1848-54). The post-contact era, which witnessed the development of the early Hawaiian state, can be divided into three periods, with certain major transformations of economy and society as criteria for periodisation. The 'Conquest period' (AD 1778-1810) saw the unification of the archipelago under Kamehameha I, and during the latter half of this span, the first major economic transactions between Hawaiian chiefs and foreigners, primarily fur traders. The sandalwood trade was abruptly terminated in 1829, and the ensuing 'Whaling-trade period' (1830-54) saw increasing commerce in supplying the large Pacific whaling fleet. Throughout all these periods, the direct access of commoners (such as those residing in the Anahulu Valley) to the market was mediated by the chiefly hierarchy. Thus, despite the integration of Hawaii into a larger world economic system, the local production systems continued to operate along largely indigenous lines. Indeed, we would argue that the ways in which the Hawaiian chiefs manipulated the local production systems to achieve their new commercial ends were distinctly Hawaiian in their conception and operation, and thus the study of early historic production systems is of direct relevance to understanding the traditional, prehistoric system as well.

A wealth of ethnohistoric materials pertaining to the Anahulu Valley (situated within the land section or ahupua‘a of Kawailoa) was discovered by Sahlins and his associates during their extensive archival research from 1971-74. This research resulted in a full set of procedures for eliciting social and economic data that permit a reconstruction of local society and economy in the early historic periods. Among the many documentary sources used, the records of the Great Mahele or division of lands, during the reign of Kamehameha
III, from 1846-54 (Chinen 1958) were central. These include native claims concerning lands occupied and cultivated as of 1848, native and foreign testimony relative to claims, and subsequent awards and surveys of land in fee simple. The early records of the Hawaiian government (especially of the Minister of the Interior), journals and letters of resident missionaries (the Waialua Mission Station was established at the mouth of the Anahulu River in 1832), tax and census records, probates, and general accounts of the period all contribute to the ethnohistoric reconstruction of the changing social and economic order of the district and valley in the early 19th century.

Were our investigations to be limited to these documentary sources, however, any analysis of historical process would have to be confined to the decades following European contact. Further, certain aspects of the local production system, such as the details of valley irrigation systems, are not fully recoverable from the ethnohistoric sources. By coupling the results of ethnohistoric reconstruction with archaeological investigation, these constraints are alleviated. The middle and upper reaches of the Anahulu Valley make up a continuous archaeological landscape, with many surface components socially identifiable from archival records of the Mahele and local missionary accounts. Archaeological study thus offers the opportunity to enhance the ethnohistoric reconstructions with specifics of the technical and material correlates of social and economic structure. Moreover, excavation and temporal control permit the projection of the ethnohistoric system back in time, and the tracing of its development across the critical boundary from late prehistory to early history, from indigenous chiefdom to political state.

A pilot archaeological programme carried out in the middle Anahulu Valley in 1974-76 left no doubts as to the potential of this coordinate ethnohistoric-archaeological research strategy (Kirch 1979), and provided the framework for an intensive study with archaeological fieldwork carried out in the summer of 1982. This paper constitutes one preliminary report on the results, with a detailed monograph in preparation (Kirch and Sahlins n.d.). The following section offers an overview of the Anahulu Valley production complex and of the social relations that governed production. This is followed by a review of the archaeological and ethnohistoric evidence for a major expansion of intensive agriculture into the interior valley, directly associated with the conquest and subsequent occupation of Oahu Island by Kamehameha I. The relations between demographic variables and intensive production are reviewed next, followed by further considerations of the role of intensive production in the development of the early Hawaiian state.

THE ANAHULU PRODUCTION SYSTEM

The Waialua region of Oahu, lying between the windward Ko'olau and leeward Wai'anae mountain ranges (Fig. 1), offered an abundance of marine and terrestrial resource zones with excellent opportunities for the development of intensive production. One of the first foreigners to write of Waialua, Gilbert Mathison was taken with the productivity of the local landscape:

In the cool of the evening I took a walk along the banks of the river, and was delighted with the beauty and fertility of the whole district. Plantations of tarrow, maize, tobacco, sweet potatoes, yams, melons, and water-melons, everywhere met the eye, all neatly arranged, and enclosed, some by stone walls, others by fences. Of trees, the cocoa-nut, bread-fruit, banana, cotton, castor, coey, and tee species [Cordyline], were most plentiful .... The river, in most places about one hundred feet wide and not very deep, winds its still limpid way through this cheerful scene of cultivation, where the huts, rising at intervals from among small groves of bananas and bread-fruit trees, vary in a picturesque and lively manner the soft harmonious touches of nature [Mathison 1825:394-95].

The main geographical features of Waialua are illustrated in Figure 3. Four major stream valleys penetrate the central Oahu Plateau and western slopes of the Ko'olau Mountains, carrying large quantities of fresh water to the broad alluvial plains inland of Kaaika and Waialua Bays. The longest of these valleys is the Anahulu, with irrigable alluvial terraces extending some 11 km inland. The confluence of broad alluvial flats and abundant water at Waialua are reflected in the large taro (Colocasia esculenta) irrigation complexes shown in Figure 3. Many of these fields were independent of stream water for irrigation, since a substantial aquifer in the Waialua area yields numerous springs at the inland edge of the coastal plain. These springs are estimated to discharge between '2-4 million gallons per day' (Rosenau et al. 1971:D28), more than enough to supply the needs of the taro irrigation complexes.
Figure 3  The Waialua region, showing major streams, fish ponds, and the large coastal taro irrigation systems. (Smaller irrigation systems along the streams not shown). The area delineated by the elongated rectangle was the subject of detailed archaeological study in 1982.
A rather steep rainfall gradient parallels the course of the Anahulu Stream. On the coast, annual precipitation averages about 750 mm, sufficient for such indigenous crops as sweet potato (*Ipomoea batatas*) and yams (*Dioscorea alata*), and for early historic introductions such as melons and maize. Inland, the archaeological study area receives from 1125-1750 mm, while the Anahulu headwaters are deluged with as much as 7500 mm annually. This rainfall gradient corresponds to a series of vegetation zones: lowland shrubs in the coastal region (today largely exotics), open forest with mixed xerophytic and mesic species in the mid-valley regions, and a more closed canopy, mixed *Acacia-Metrosideros* rainforest in the interior mountainous areas. As will be demonstrated below, this zonation of terrestrial resource zones corresponded to a horizontal differentiation of production.

Waialua district was divided radially into the three major *ahupua'a* of Kawaiola, Pa'alaa', and Kamakanui (Fig.3). We shall focus on Kawaiola *ahupua'a*, of which the Anahulu Valley is the central geographic feature. Kawaiola *ahupua'a* was itself subdivided into three sectors: Kawaiola-Kai, the coastal sector with fish ponds and large taro irrigation complexes; Kawaiola-Waena, a lower valley sector with alluvial flat irrigation (and whose occupants had access rights to the coastal ponds); and Kawaiola-Uka, the interior valley region. Kawaiola-Uka corresponds roughly with the archaeological study area shown in Figure 3. Also part of Kawaiola *ahupua'a* was the coastal plain stretching to the north of the valley mouth, occupied by outlying settlements of fishermen and sweet potato cultivators; this peripheral area is not further considered in the present analysis.

Kawaiola-Kai together with Kawaiola-Waena supported a diversified food production complex that included irrigated agricultural fields, fish ponds, and opportunities for marine exploitation. The main productive zones in this complex were: (a) the lower valley alluvial flats, terraced for pondfield irrigation of taro; (b) the low-lying land south of the river mouth (part of which lies in the *ahupua'a* of Pa'alaa') with its extensive spring-fed pondfield complex, the largest single irrigation system in the Waialua district; (c) the large natural pond called Ukoa, a source of freshwater fish; (d) the modified pond named Loko'ea, for breeding mullet, milkfish and other species; (e) the gentle slopes immediately inland of the ponds, used for non-irrigated crops, and including a large communal garden enclosure (the *pa hui*); and (f) the marine resources of littoral strand and bay, to which certain social groups claimed use rights.

Kawaiola-Uka, the interior portion of the Anahulu Valley and setting for our detailed archaeological investigations, differs from the coastal sectors primarily in the absence of marine and pond environments. The interior valley is fairly narrow, but the meandering stream has created an alternating series of graded alluvial flats, most of which were terraced for taro irrigation (Fig.4). The steeper colluvial slopes (*kula*) and talus (*pali*) above the alluvium were utilised for non-irrigated cultivation of sweet potatoes, paper mulberry (*Broussonetia papyrifera*) and other crops. Also included within the inland production complex were rights to exploit the stream for 'o'opu fish (a native gobioid). In addition, many of the upland claimants worked large numbers of *okipu,* a form of non-irrigated garden or swidden in the upland gulches and tablelands. The claims of upland *'okipu* and of stream-fishing rights are summarised in Table 1. Significantly, none of the Kawaiola-Kai or Kawaiola-Waena claimants referred to such upland plantings, suggestive of the economic specialisation between coastal and inland populations.

The irrigated pondfield complexes were the most intensive form of agricultural production, and provided the greatest contribution toward the food supply. The missionary Emerson observed that:

1Although Kawaiola-Kai and Kawaiola-Waena are distinct named sectors of the *ahupua'a*, there are good ecological as well as social reasons for considering them as a single unit. A number of extended family units claimed land in both sectors, and occupants of the Waena sector often had rights to fish in the ponds or bay. In contrast, the occupants of interior Kawaiola-Uka generally did not claim coastal lands or fishing rights.

2Ukoa Pond is a natural lagoon formed by an elongate barrier of unconsolidated marine sands and of Pleistocene elevated reef limestone. A narrow channel drains the pond (referred to in early historic documents as the 'lake') and runs past the seaward gates to Loko'ea Pond. The geomorphological history of the Ukoa Lagoon, and the sequence of artificial modification of Loko'ea and the Ukoa drainage channel are problems that await archaeological and geomorphologic study.

3The term *okipu,* appearing frequently in the native land claims for Kawaiola-Uka, is not entered in any Hawaiian dictionary. Crops probably cultivated in these gardens include *olona* (*Touchardia latifolia*) and bananas. The interpretation of these gardens as swiddens or shifting cultivations is still provisional.
Figure 4  Detailed map of the archaeological study area (Kawaiola-Uka) showing the distribution of major settlement pattern components
As noted, the large coastal irrigation systems were spring-fed, with low earthen embankments separating individual fields. Interior valley systems were irrigated with streamflow, diverted through stone-lined canals into stone-faced, terraced pondfields. A plan of such an interior valley system, situated in the land section (ʻili) of Kapuahilua, is shown in Figure 5.

Aside from the general division of Kawailoa ahupua‘a into three sectors, the Anahulu Valley was territorially divided into named ʻili (or ʻili ʻaina) segments, and these again into smaller mo‘o ʻaina sections. In the interior Kawailoa-Uka region, such ʻili usually correspond with one or more adjacent alluvial flats, and the mo‘o ʻaina to a single integrated set of taro fields. In the lower portion of the valley and on the coastal flats, ʻili are sometimes dispersed, encompassing sections of the lower valley flats and of coastal lands near the ponds. The distribution of ʻili in the upper valley is shown in Figure 4.

These ʻili were a continuation of the late prehistoric territorial and political system of land-tenure. Such ʻili did not comprise corporate kin groups as in many other Polynesian societies, but were strictly territorial units in which one or more households held rights of cultivation and residence under the charge of a headman (luna or konohiki), in exchange for regular labour in specific fields held under the latter’s charge (koʻele fields), and for other tribute (hoʻokupu) such as that due at the annual makahiki harvest festival (see Kamakau 1961, 1964; Malo 1951).

The means of production and their territorial organisation having been outlined above, we may turn to the social relations of production that prevailed in Anahulu in the early historic period. These will be briefly analysed, first, in terms of the dominant vertical relations between various social categories including chiefs, headmen, and grades of commoner cultivator (makaʻaina), and second, in terms of certain horizontal relations that correspond to the ecological and economic differentiation between coastal and inland populations.

Indigenous Hawaiian society was fundamentally hierarchical, although not following the corporate conical clan structure typical of other Polynesian groups. The upper layers of the Hawaiian social hierarchy composed various strata of chiefs and prominent officials, ranging from the paramount (traditionally, the ali‘i-ʻai-moku, “kingdom-eating-chief”) down through various lesser ranks of chiefs holding district and ahupua‘a lands, and including the konohiki land managers or stewards. These people can be classed as mea koʻikoʻi, ‘prominent persons’ (Fig.6), who were as well the ‘masters’ or ‘lords’ of the lands (haku‘aina).

Clearly, any particular land section was under the control of several layers of haku‘aina, all of whom made demands upon the productive resources of the land. For Anahulu, in the period from 1830-48, the haku‘aina of the entire ahupua‘a (and of Waialua district as a whole) were the high chiefesses Kina‘u and her daughter Victoria Kamamalu, along with Kina‘u’s husband, the high chief Kekuanaoa. These prominent chiefs usually resided in Honolulu (a day’s sail from Anahulu) but this did not lessen their demands upon the local Waialua production system. In direct charge of Anahulu and resident in the district was La‘anui, a chief of somewhat lower rank who had married Pii‘ia, younger sister of Ka‘ahumanu (Fig.2). La‘anui served as the konohiki or land overseer to Kina‘u and Kekuanaoa, and later to Kamamalu. La‘anui, however, also appointed a lesser kinsman, Kuokoa, as konohiki under him (from 1824 on). Thus we see the justification in the missionary Emerson’s complaint that:

<table>
<thead>
<tr>
<th>Sector</th>
<th>'Okipu gardens</th>
<th>Ocean fishing rights</th>
<th>Ukoa Pond fishing rights</th>
<th>Stream fishing rights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kawaiola-Kai/Waena</td>
<td>1</td>
<td>7</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>Kawaiola-Uka</td>
<td>6</td>
<td>-</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Total claims</td>
<td>7</td>
<td>7</td>
<td>16</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 1 Claims of upland gardens and fishing rights by Ahupua‘a sector

... twenty persons, I think can be fed on an acre of good kalo [Colocasia] land. The land can generally be cultivated perpetually, if it has two or three months between each crop, in which to decompose the weeds which might grow during the time the kalo was ripening .... It requires one year for kalo to come to maturity [Emerson 1846:81-82].
A medium-sized taro irrigation system at 'Ili Kapuahilua, in Kawaiola-Uka. The rectangular pondfields are stone-faced and were watered through a stone-lined irrigation ditch with intake from the Anahulu Stream (after Kirch 1979)
Oppression from the chiefs is not wholly removed off of the common people. It is felt in the multiplication of haku aina, sometimes to the number of five, six or seven, or more, over one land, each of which considers himself at liberty to live upon the people when convenient, and ask presents of them besides the regular tax, and in this way cut the people out [Emerson 1846:67].

In opposition to the category of mea ko‘iko‘i was that of maka‘ainana4, or commoners, the cultivators and fishermen who constituted the productive labour force (Fig.6). These maka‘ainana were structurally organised into extended family groups (ma), generally centred around important males after whom the group was named (e.g., Kainiki ma). Extensive bilateral kinship networks linked these groups horizontally, and certainly constituted an important economic mechanism for the exchange and distribution of resources over an ecologically differentiated land unit such as the Anahulu Valley.

The hierarchy in Hawaiian society was not confined to the chiefly stratum, however, and several categories of maka‘ainana are clearly evident (Fig.6), with the major distinguishing factors being length of tenure on the land, and consequently, relationship to the haku‘aina (a corollary of this was access to certain means of production). On the one hand were kama‘aina, literally ‘sons of the land,’ including the category kupa o ka ‘aina, cultivators who had received their lands from parents or grandparents (in the Anahulu case either before or at the time of Kamehameha I’s occupation of the island of Oahu in 1804), and the marked category kama‘aina, landholders who received their grants under previous konohiki (e.g., in the time of Ka‘ahumanu). Opposed to these older and more secure landholders were the ‘ohua and hoa‘aina. The hoa‘aina included persons holding land directly under konohiki, while ‘ohua held land from affinal relatives. The hoa‘aina are of particular interest, since these persons were literally ‘placed’ (ho‘onoho) on the land by the konohiki with the usual obligations to perform labour and deliver regular tribute. These cultivators were regarded as holding their lands ‘under’ (malalo) the konohiki or haku‘aina, and could be readily dispossessed for failure to meet the obligations of corvee or tax. In the Whaling-trade period from 1830-50, when the Hawaiian chiefs for various economic reasons stressed agricultural production for commercial purposes, the placing of hoa‘aina on vacant or abandoned lands was a strategy for maintaining a high level of production, and is clearly evidenced in the ethnohistoric record for Anahulu.

4The term maka‘ainana is cognate with other Polynesian reflexes for the Proto-Polynesian lexeme *kainanga, ‘corporate landholding descent group’, and is one clue to the evolution of the Hawaiian system from a more typical Polynesian conical clan model (see Kirch 1984:65-66).
A few of the older kupa cultivators effectively functioned as local 'big men' and exercised some control over portions of the valley. As such they probably acted in carrying out the orders promulgated down the hierarchy of haku'ai'ina. One such kupa was Nauahi, who resided near Loko'ea Pond, but also had extensive holdings throughout Kawaiola-Kai and Kawaiola-Waena. Nauahi himself married into the chiefly family of Pa'ala'a, and had one or two hoa'ai'ina of his own 'under' him. Another 'big man' was Kamakea, resident at 'ili Kapuahilua, who appears to have been in charge of the Kawaiola-Uka sector of the valley, and who had important ties with other kupa residents such as Kainiki and Kalua.

The significance of the vertical social relations outlined above is especially clear when the various categories are examined for their access to productive resources, particularly irrigable lands and rights of access to ponds or stream fish (Table 2). In terms of arable lands awarded during the Mahele, the distinction is notable between the older kupa landholders, and the more recent hoa'ai'ina. In the upper valley, claimants of 'okipu swiddens were nearly always kupa, not the more recent hoa'ai'ina. Distinctive horizontal social relations corresponded to the ecological differentiation between coastal and inland zones of production, and to some extent between fishermen/sweet potato cultivators on the one hand and cultivators of irrigated taro on the other. The holders of lands in Kawaiola-Uka made virtually no claims on lands in the lower valley or coast, and vice versa. The valley was effectively divided then between an interior population which, aside from cultivating both irrigated taro and dryland kula crops, worked extensive upland plantings in which could be raised such crops as 'awa (Piper methysticum) and olona (Touchardia latifolia), not suited for cultivation in the drier coastal sectors. Kawaiola-Uka was also a major zone of paper mulberry (wauke) production. The lower valley and coastal population, on the other hand, produced wet taro, large tracts of sweet potatoes, and exploited fishing resources, both in the ponds and open ocean. There seems to have been further economic specialisation (not totally complete or exclusive) between those with extensive pond rights and those with larger irrigated taro holdings. In 1843, the high chief Kekuanaoa wrote to Puapua, the luna 'auhau or government agent as follows:

The Ukoa pond people are to be separate from those of the taro lands. The pond must be independent of the taro lands .... Those who wish to work at the pond must confine themselves to the pond and in no way shall they have anything to do with the taro lands .... Because you all consented to this, I gave them certain fish for their own use, being o'opu, shrimps, and limu and such other fish ... [Kekuanaoa to Puapua, 11 March 1843, in Archives of the Hawaiian Government].

Thus we see that within the Anahulu production system there was a fair degree of economic specialisation which corresponded to the major zones of production, and was doubtless an effective strategy for intensive production.

<table>
<thead>
<tr>
<th>Category of claimant</th>
<th>N²</th>
<th>Acreage awarded range</th>
<th>Mean</th>
<th>Mean no. of irrigated fields¹</th>
<th>Pond or stream fishing rights¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mea Ko'iko'i⁴</td>
<td>4</td>
<td>5.9-16.7</td>
<td>10.25</td>
<td>ID⁵</td>
<td>ID⁵</td>
</tr>
<tr>
<td>Kupa o ka 'Aina</td>
<td>28</td>
<td>0.8-18.2</td>
<td>6.47</td>
<td>26.3</td>
<td>46</td>
</tr>
<tr>
<td>Kama'ai'ina</td>
<td>16</td>
<td>0.2-6.3</td>
<td>2.34</td>
<td>6.9</td>
<td>33</td>
</tr>
<tr>
<td>'Ohua</td>
<td>8</td>
<td>1.0-3.6</td>
<td>2.18</td>
<td>15</td>
<td>40</td>
</tr>
<tr>
<td>Hoa'ai'ina</td>
<td>8</td>
<td>0.6-3.2</td>
<td>1.41</td>
<td>10.6</td>
<td>12</td>
</tr>
</tbody>
</table>

1 From Native Register
2 Refers to the largest number of that category that can be determined for any type of award or claim
3 From Native Register or Testimonies
4 Excludes the owning chief, Victoria Kamama lu, who received thousands of acres
5 Insufficient data

Table 2 Property claims in Kawaiola (1848)
Figure 7  Distribution of land claims in Kawailoa-Uka, differentiated between ancestral claims of *kupa*, and later claims of *'ohua* and *hoa'aina*.
Thus far, I have described the Anahulu production system in synchronic, structural terms without consideration of historical process. I now turn to this latter problem, in which archaeology takes the forefront in providing the critical time depth necessary to determine the temporal development of intensive production. The majority of this discussion focuses upon the interior portion of the valley, Kawailoa-Uka, where our archaeological investigations have concentrated, though certain implications pertain as well to the coastal sectors.

The ethnohistoric materials provide certain clues regarding the historical development of intensive agriculture. In particular, the 1848 land claims (mapped) for the upper valley region (Fig.7) hint at the possibilities of an occupation sequence. As can be seen in the map, most of the scattered holdings were claimed in 1848 by kupa cultivators, all of whom consistently stated that their tenure on these lands had devolved to them via parents or grandparents (mau makua, kupuna), who in turn received them following the occupation of Oahu in 1804. (The other landholders received their parcels later, generally after 1830, as ‘ohana and hoa‘aina). The absence of any landholders with claims extending back prior to the 1804 occupation thus suggests a major period of inland expansion of occupation and development of interior irrigation systems. The ethnohistorical records themselves, however, do not permit us to discriminate between the former hypothesis, and an alternative interpretation, namely that the statements of the kupa cultivators might simply represent a mode of legitimising occupation by reference to the conquering paramount (Kamehameha I), a practice known to be repeated on a lower level by a double justification of title as at once ‘inherited’ from parents or grandparents and also ‘given’ by a local konohiki, or land manager of the chief. If the latter scenario were true, then the intensive utilisation of the valley interior might extend back into prehistory with no referent in the ethnohistoric corpus. Clearly, only archaeology can provide the critical test.

Excavations were carried out at a variety of inland sites during a four-month period in 1982 (including stratified rockshelters, open residential sites, and irrigation systems). As we had anticipated, the four stratified rockshelters in the lower and middle portions of the study area provided the oldest and longest records of occupation and use of the interior valley. Based on nine C14 age determinations, the large Ke‘eke‘e Nui rockshelter was first used as early as the mid-13th century AD, while the others were certainly in use by the end of the 15th century. All of the shelters continued to be occupied into the early decades of the historic era, as evidenced by the presence of trade beads, gun flints, and iron objects in the uppermost levels.

The depositional sequences of the rockshelters were all similar in suggesting relatively short-term, repeated-use occupation, rather than permanent residence. Limited quantities of faunal remains, numerous shallow, amorphous fire-basins (and absence of slab-lined hearths), and the restricted range of material culture items in each of these sites all indicate a pattern of temporary but repeated use. Our interpretation of these rockshelters is that they served as temporary bases - occupied for a few days up to a few weeks at a time - for local groups practicing shifting cultivation, collecting forest materials such as firewood and fibre plants, catching forest birds, or collecting freshwater shrimp and shellfish from the stream. Thus, from as early as the 13th century and continuing throughout the prehistoric period, the interior sector of Anahulu Valley served as a resource zone for certain inland products, regularly exploited by the resident coastal population.

Excavations were also carried out at a sample of eight open residential sites or habitation terraces distributed throughout the length of the study area. Several of these were known residential complexes of 1848 Mahele land claimants (e.g., Kainiki, Kamakea, Mailou and Kalua). For these sites, our aims were to determine whether or not there were stratified components that might pre-date the 1804 occupation referred to in the land claims. Certain other sites were recorded in the 1848 Mahele records, and excavations there were necessary to determine whether such sites might represent an earlier population displaced by an event such as the 1795 conquest and 1804 occupation. In fact, all eight open sites proved to date no earlier than the late 18th/early 19th century, based on introduced material goods and radiocarbon age determinations. Thus, the pattern of open-site residence on the colluvial slopes can be securely dated as a post-contact phenomenon. The sites not claimed in 1848 appear to have been the residences of households that had either left the valley or died out in the period prior to 1848.
The evidence from both of the rockshelters from open habitation sites strongly supports the view that the very late 18th/early 19th centuries witnessed a radical transformation of residential patterns, a significant stratigraphic disjuncture throughout the upper Anahulu Valley. The prehistoric pattern of short-term, repeated-use occupation of rockshelters was quickly supplanted by permanent residence on the colluvial slopes, the pattern reflected in the early contact era ethnohistoric record.

The question posed by this radical shift in residential settlement pattern is whether the upper valley irrigated pondfields and associated kula lands were also subject to a similarly rapid phase of development. Excavations in two irrigation systems, carried out in 1974 (Kirch 1979), has suggested that the irrigation facilities were indeed late developments. Further work in 1982 confirmed that proposition. The medium-sized irrigation system in 'ili Mikiai, associated with the kupa claimant Mailou, post-dates a radiocarbon age determination of 160 ± 70 BP (from charcoal in underlying alluvial fill). Thus Mailou’s claim that his system dates from the time of his parents who received it during the reign of Kamehameha I is corroborated. Similarly, excavations in a large irrigation complex in 'ili Kaloaloa produced a series of radiocarbon dates again supporting a late 18th/early 19th century construction date.

In sum, the archaeological evidence from rockshelters, open residential sites, and irrigation systems all converges to support the ethnohistoric interpretation of the 1848 land claims, that permanent occupation of the upper valley and the development of intensive irrigation systems there followed Kamehameha’s 1804 occupation of Oahu.

The evidence outlined above documents a case of the expansion of intensive agriculture which can be directly traced to the actions of a ruling polity, specifically to the strategy promulgated by Kamehameha I after his successful consolidation of the Hawaiian Kingdom. Kamehameha is noted for his efforts at agricultural development, as in Manoa and Nu’uanu Valleys (‘I 1959:68; Kamakau 1961:192), and it was most likely under his auspices (direct or indirect) that the productive base of the Anahulu Valley was expanded during the early years of the 19th century. Particularly after Kamehameha’s return to Oahu in 1804, with more than 7000 warriors poised for the invasion of Kaua’i Island, the demands on the productive capacity of local agricultural systems must have been substantial.

The correlation of a phase of agricultural expansion and intensification with major political events of the early contact era is not unique to Anahulu. In work carried out on part of the extensive dryland agricultural field system at Lalamilo and Waikoloa on Hawaii Island, Reeve (1983) convincingly argues that a brief phase of agricultural expansion (including construction of a major irrigation ditch) can be correlated with the period from 1790-94 when Kamehameha resided at Kawaihae with his large entourage of warriors and retainers, preparing for the conquest of the westerly islands.

The evidence from the upper Anahulu Valley documents the transformation of what had been a peripheral part of the Waialua system, a forest hinterland exploited on a relatively low-intensity scale, into an integral part of the agricultural production system. What, however, of the coastal sectors, where intensive production and permanent residence clearly must extend well back into prehistory? Did the conquest and occupation of the area by Kamehameha also lead to agricultural intensification in this core area? Lacking direct archaeological evidence, no firm answer can be given; however, the 1848 Mahele records offer a clue. The largest irrigation complex at Waialua is that to the south of the Anahulu Stream (Fig.3), and divided between the ahupua'a of Kawailoa and Pa’ala’a. Examination of the 1848 land claims reveals that the Pa’ala’a section includes many claimants who had ‘inherited’ from parents or grandparents, suggesting some time depth. In contrast, the Kawailoa section lands were largely received from the konohiki of the high chief Ke‘eaumoku II (‘Cox’, son of the warrior chief Ke‘eaumoku who received the ahupua’a upon Kamehameha’s conquest and redistribution of lands in 1795). This hints at a later and continuing development of the irrigation complex, an hypothesis that makes a good deal of hydrologic and geomorphic sense, since this area of the field complex is lower, subject to greater inundation, and would logically be a later development. It is possible that in the late prehistoric period the Kawailoa section of the complex was a fish pond (it would naturally have been a pond or shallow lagoon behind the coastal sand barrier) that was converted to agricultural use under chiefly aegis. This hypothesis awaits confirmation from archaeological excavations.

The historical process of agricultural development can also be brought forward in time...
to the period from 1830-48, during which a wealth of historical records demonstrate the active stimulation of agricultural intensification by the various chiefs exercising control over the Waialua region. These chiefs, most of whom had incurred large debts during the early Sandalwood period, were forced to fall back upon a strategy of ships' provisioning following the collapse of the sandalwood trade in 1829. The agricultural produce, *wauke* (used for batten), cordage and so on that furnished the commercial enterprises of the chiefs during the Whaling-trade period were of course supplied by the *maka'ainana* cultivators. Thus the placing of numerous *hoa'aina* on vacant lands from 1830-48 directly reflects this renewed emphasis on agricultural intensification.

**THE DEMOGRAPHIC CORRELATES OF INTENSIFICATION**

The relationship between population growth and 'pressure,' and the processes of agricultural intensification have for some time been an issue of theoretical interest, especially following the influential work of Boserup (1965; see also Spooner 1972; Brookfield 1972). The debate has worked its way into considerations of late Hawaiian prehistory, with positions ranging from Cordy's acceptance of population growth as a fully 'independent' variable driving the engine of cultural change (1974a, 1974b), to Earle's rejection of population pressure as a significant 'prime mover' (1978; see also Hommon 1976; Kirch 1980, 1984). Certainly, if we are to accept recent reconstructions of late prehistoric demographic trends in the Hawaiian Islands (Hommon 1976; Cordy 1981; Kirch 1984) as being anywhere close to the mark, significant population increases after about AD 1200 must have had some role to play in the general trend toward development of intensive production. But should we conclude on the basis of such general trends that intensive Hawaiian agriculture was solely a 'density-dependent adaptation' (Athens 1983)? The data from Anahulu have, we believe, some relevance in this debate.

The population of the Hawaiian Archipelago at European contact (AD 1778) is reasonably estimated at between 200,000-300,000 (Schmitt 1968, 1971). Over the ensuing seven decades with which we are concerned, the total population underwent a sickening decline, to approximately 150,000 in 1805 (just after Kamehameha's occupation of Oahu), then to 125,000 in 1830, and to only 87,063 in 1849. Between 1823-50, annual rates of natural decrease ranged from as low as seven per 1000 up to highs of 48 per 1000 (Schmitt 1968:Table 5).

Against this general decline, the populations of Oahu Island and of Waialua district in particular did not suffer nearly so heavily. Estimated to have had about 40,000 persons in 1779, Oahu still supported about 30,000 individuals in the early 1820s. Waialua district had 2640 persons in 1832 (the date of the first reliable missionary census), which had dropped to only 2404 by 1839, and to 1532 in 1849. This lesser rate of population decline was accounted for not by a lower rate of natural decrease, which remained shockingly high in Waialua as elsewhere (Table 3), but through a considerable population mobility, in which the higher per cent of in-migration often resulted in annual net gains in population (Table 4).

The maintenance of a higher level of population on Oahu in the period following 1804 can certainly be attributed to the occupation of the island by Kamehameha I and his forces, estimated to have numbered in excess of 7000 warriors and their dependants (Lisiansky 1814:133; Shaler 1808:163). More importantly, these occupying forces were purposefully settled on the Oahu lands, which had been redistributed to Kamehameha's local chiefs following the 1804 occupation. The noted Hawaiian sage Kamakau (himself born in Waialua) remarked upon the land irregularities that arose following Kamehameha's conquest and occupation (1961:231), with older landholders dispossessed as the occupying forces were given lands to settle and cultivate.

As we have documented, the archaeological and ethnohistoric records for Anahulu demonstrate a rapid phase of agricultural development in the valley interior (Kawaiola-Uka) immediately following the 1804 occupation. The people who settled the interior and constructed the irrigation systems were most likely a segment of the occupying forces under the control of Ke'eaumoku, high chief to whom Kamehameha allotted the Waialua lands. Thus, the agricultural intensification of the Anahulu interior is directly correlated with population increase of a particular kind: a local influx of population precipitated by the political events sweeping the archipelago, and resulting in a local concentration of population contrasting with the archipelago-wide decline. The phase of agricultural expansion can be seen as resulting from a purposeful strategy of placing the occupying forces on the Oahu lands to ensure the productive base for their continued support.
The historical records further elaborate on Kamehameha's reasons for pursuing this strategy of agricultural expansion and intensification: during the initial conquest and brief occupation of Oahu in 1795-96, with as many as 10,000-15,000 warriors, the lack of local agricultural support became an overwhelming obstacle. Broughton, who visited Kamehameha on Oahu in February 1796, could not procure provisions and noted that 'the situation of the natives was miserable, as they were nearly starving; and, as an additional grievance, universally infected with the itch' (1804:40). The situation had worsened by July of the same year (1804:71), and Kamehameha was soon forced to fall back to Hawaii Island, both to provision his army, and to quell a local rebellion that had broken out in the patrimonial chiefdom. Thus, with this experience of 1795-96 behind him, Kamehameha appears to have treated the 1804 reoccupation of Oahu with a different strategy, in which development and intensification of the local agricultural base was a fundamental part. We believe it is the reflection of this strategy that is archaeologically attested in the upper Anahulu Valley, as indeed in other parts of the island (I'i 1959).

Something of the same strategy continued to influence demographic trends in Waialua throughout the later periods under consideration, up until the completion of the Mahele in 1854; particularly during the Whaling-trade period (1830-54), the population of Waialua was maintained at a higher level than the general average by continued in-migration. Immigration was encouraged by the granting of arable lands to maka'ainana cultivators in

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*Figures from local church records as proportions of persons transferring to and from outside churches in relation to existing Waialua membership. Note that the overall mobility was high, apparently reflecting movements of younger people, as has been the consistent Hawaiian custom

Table 4  Population mobility, Waialua district*

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the status of *hoa'aina* relationships under the local *konohiki* and higher chiefs. Serious population decline in the district began only after the completion of the Mahele land division and the dissolution of the ancient system of land rights and associated corvee/tribute.

In short, the historical development of production in Waialua and Anahulu corresponds to a demographic trend that ran counter to the archipelago-wide population decline. The maintenance of large local populations was a politically-motivated and directed phenomenon, and not the result of any steady Malthusian increase. Thus, both the local demographic trend and the associated expansion of intensive agriculture must be understood as the conscious results of a greater political strategy. In Kamehameha’s time, the main impetus to agricultural expansion was the permanent support of a large military force critical to Kamehameha’s plans for archipelago-wide hegemony. Later, under the thumb of Ka‘ahumanu and her successor Kina‘u, the Waialua lands were kept productive and populated to ensure the commercial success of the chiefs’ trade with foreign ship captains and merchants.

The implications of the Waialua case extend back to the late prehistoric era as well. Although one might plead that the post-contact circumstances of general population decline make the historical analysis of Anahulu irrelevant to the pre-contact situation, I am more inclined to believe that the strategies pursued by Kamehameha I and his followers carried on trends already developed in late prehistory. I refer specifically to the conscious mobilisation of local populations in order to carry out planned projects of agricultural and aquacultural expansion and intensification. Certainly the Hawaiian oral traditions would support such a view (see, for example, the cases cited in Sahlins 1972:141-42). The kind of sudden agricultural occupation and development of the north Kohala valleys described by Tuggle and Tomonari-Tuggle (1980) would also hint at such processes. This is not, of course, to deny the significance of the general trend toward population increase without which such politically-induced strategies of intensification would have been impossible (see Kirch 1984). My point is simply that in seeking to explain agricultural intensification in complex chiefdom societies such as Hawaii, the impetus to development of the economic armature must be understood as much in terms of the political motivations of the ruling polity as in long-term demographic trends, and indeed, the considerable ability of ruling chiefs to influence and manipulate demographic trends themselves cannot be overlooked.

One final point about human numbers and intensive agriculture should be noted, which further underscores the significance of agricultural production to the economic and political aspirations of the ruling chiefs. This is the tremendous capacity of irrigated taro to yield at levels well above the immediate caloric needs of the *maka'aina* producers, and thus to finance the greater public (or should we say, chiefly) economy. The point can be illustrated with data from two of the inland Anahulu irrigation systems, at ‘ili Kapuahilua and ‘ili Keae (see Kirch 1979 for details of these systems). As shown in Table 5, these irrigation systems have areas of 1.076 and 0.829 ha respectively, as determined through plane table mapping of the extant stone-faced terraces. Using the estimated yields for irrigated taro given by Massal and Barrau (1956), of 13,432 kg/ha, the two systems could support approximately 29 and 22 persons respectively (Kirch 1979:13-14). There are reasons to believe, however, that

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Kapuahilua</th>
<th>Keae-Nui</th>
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</thead>
<tbody>
<tr>
<td>Total irrigated area (ha)</td>
<td>1.08</td>
<td>0.83</td>
</tr>
<tr>
<td>Number of fields</td>
<td>75+</td>
<td>48+</td>
</tr>
<tr>
<td>Estimated carrying capacity A $^1$ (after Massal and Barrau)</td>
<td>29</td>
<td>22</td>
</tr>
<tr>
<td>Estimated carrying capacity B $^2$ (after Emerson)</td>
<td>53</td>
<td>41</td>
</tr>
<tr>
<td>Number of residents in local producer household</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Per cent of potential surplus (B)</td>
<td>77</td>
<td>76</td>
</tr>
</tbody>
</table>

$^1$ after Massal and Barrau (1956)
$^2$ after Emerson (1846)

Table 5  Production estimates for taro irrigation systems in Kawailoa-Uka
these estimates may be overly conservative. The local missionary Emerson, an astute observer of agricultural matters, estimated that 1 acre (0.405 ha) of good taro land was sufficient to support 20 persons. Applying Emerson’s formula to the two inland systems, we get estimated ‘carrying capacities’ of 53 and 41 persons. We know from government census and tax records of the Mahele period that these two irrigation systems were worked by producer households with total populations of 12 and 10 persons respectively. As shown in Table 5, the differentials between potential production or carrying capacity of these systems, and the small numbers of cultivators (and their dependants) actually deriving their subsistence needs from these field complexes are significant indeed. If Emerson’s figures are anywhere near accurate, the Anahulu irrigation complexes could produce a potential surplus of about 75% of total production. Even taking the more conservative Massal and Barrau (1956) basis for estimating yield, the potential surplus is as high as 55-60%.

These figures leave little doubt as to the efficacy of taro irrigation as the primary productive base of the traditional Hawaiian agricultural system, and clearly underscore the significance of this form of intensification for the Hawaiian economy. Little wonder that the chiefs placed such emphasis on the development and maintenance of the taro lands. In the numbers game of population and production in early historic Waialua, the problem was continually one of maintaining a sufficiently large number of producers to ensure that output remained high. Intensive production never seems to have been a case of too many mouths to feed.

CONCLUDING DISCUSSION

Sahlins has argued that ‘a confrontation of cultures’ such as occurred in the early contact history of Hawaii ‘affords a privileged occasion for seeing very common types of historical change en clair’ (1981:1). The results of the Anahulu Valley project offer some significant comments on the development and intensification of Polynesian production systems.

In both the ethnohistoric and archaeological records, we have documented a major phase of settlement pattern transformation and agricultural expansion directly linked to a series of major political events: the conquest and occupation of Oahu in the late 18th and early 19th centuries. Agricultural development in this instance was a politically-motivated and consciously-directed strategy. Nor is the Anahulu case the only example of this in early historic Hawaii, with the evidence from Waikoloa on Hawaii Island offering a parallel instance (Reeve 1983). These results must cause us to reconsider the prevailing model of agricultural development in pre-contact Hawaii as largely a response to demographic increase and pressure. Furthermore, the results from Anahulu show that (in some geographic areas, at least) no limit had been reached on the possibilities for agricultural development; there was no exhaustion of land nor resources, as has sometimes been suggested or implied.

The Anahulu case further indicates that demographic factors, while significant in the total equation of production, are themselves responsive to the political economy. In Anahulu, we have seen that sizeable populations were mobilised and redistributed in consort with the major political events discussed above. The Anahulu lands were later kept at a relatively high level of production through the stimulus of immigration and grants of arable land, even while the general demographic trend was toward severe population decline. There are suggestions that similar mobilisation of local and regional populations may have occurred (perhaps frequently) in late Hawaiian prehistory. The archaeological sequences from the north Kohala valleys (Tuggle and Tomonari-Tuggle 1980) and from Kawela on southern Molokai (Weisler and Kirch 1985) both reveal rather sudden occupation and agricultural or aquacultural development that may well have been achieved by just such politically-directed population shifts. Certainly, these are significant problems for continued archaeological investigation. Also with regard to population, we have seen that in early historic Anahulu, intensive production was maintained at a level well above the needs of the local domestic economy, and that local demands for food were not a significant impetus to intensification.

That Emerson was not overestimating yield is suggested by Spriggs’ experimentally-derived irrigated taro yields of ca. 39,340 kg/ha from traditionally cultivated systems in Vanuatu (Spriggs 1981:Appendix 5).

I use the term ‘carrying capacity’ loosely here, since we are not considering the role of non-irrigated crops, nor of animal resources, in these calculations.
Finally, the Anahulu case exemplifies the role of an intensive, integrated production complex in the historical transformation of a complex Polynesian chiefdom into the Sandwich Islands Kingdom. In their articulation with the expanding world economic system of the early 19th century, the Hawaiian chiefs further intensified their indigenous production base (including its integral social relations of production) to further their new commercial ventures. Thus the integration of the larger Hawaiian population into the market system was mediated by the chiefly polity according to strongly traditional lines, in ways that directly benefited the chiefly establishments.

Certainly the Anahulu results demonstrate that the value of coordinate ethnohistoric-archaeological investigation of Oceanic cultures lies in more than just 'collaboration'. In lending temporal depth to ethnography, and in providing archaeology with cultural depth, the approach offers the potential of a real cultural history. The possibilities for such studies abound, not only in Hawaii, but throughout many other Pacific Islands where the rich resources of ethnohistory and ethnography have hardly begun to be informed by the time depth of archaeology, and vice versa.

ACKNOWLEDGEMENTS

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REFERENCES


Broughton, W.R. 1804 A Voyage of Discovery to the Pacific Ocean ... Performed in His Majesty's Sloop Providence ... in the Years 1795 ... 1798. T. Cadell: London


Cordy, R. 1974b Complex rank cultural systems in the Hawaiian Islands: suggested explanations for their origin. Archaeology and Physical Anthropology in Oceania 9:89-109


Emerson, J.S. 1846 Responses in 'Answers to Questions'. Hawaiian Mission Children’s Society Library: Honolulu (unpublished manuscript)


Green, R.C. 1980 Makaha Before 1880 AD. Department of Anthropology, Bishop Museum: Honolulu, Pacific Anthropological Records 31


Kirch, P.V. 1984 Evolution of the Polynesian Chiefdoms. Cambridge University press: Cambridge


Kirch, P.V. and M. Sahlins n.d. Anahulu: the archaeology of history in the early Sandwich Islands Kingdom. (Monograph in preparation)

Lisiansky, U. 1814 A Voyage Round the World in the Years 1803-6, Performed by Order of his Imperial Majesty Alexander the First, Emperor of Russia .... John Booth: London


Mathison, G.F. 1825 Narrative of a Visit to Brazil, Chile, Peru, and the Sandwich Islands, 1821-1822. Knight: London


Sahlins, M.D. 1968 Tribesmen. Prentice-Hall: New Jersey

Sahlins, M.D. 1971 An interdisciplinary investigation of Hawaiian social morphology and economy in the late prehistoric and early historic periods. Research proposal submitted to the National Science Foundation, B.P. Bishop Museum, Honolulu

Sahlins, M.D. 1972 Stone Age Economics. Aldine-Atherton: Chicago

Sahlins, M.D. 1974 Historical anthropology of the Hawaiian Kingdom. Research proposal submitted to the National Science Foundation, B.P. Bishop Museum, Honolulu

Sahlins, M.D. 1981 Historical Metaphors and Mythical Realities: structure in the early history of the Sandwich Islands Kingdom. Association for Social Anthropology in Oceania, University of Michigan Press: Ann Arbor, Special Publication No.1

Sahlins, M.D. 1983 Other times, other customs: the anthropology of history. American Anthropologist 85:517-44


Shaler, W. 1808 Journal of a Voyage Between China and the Northwestern Coast of America, Made in 1804 .... The American Register, Part I for 1808, Vol.III


Recent archaeological research conducted within Micronesia, largely in the US Trust Territory under the auspices of the US Historic Preservation Program (Micronesian Archaeological Survey), has produced considerable new information about prehistoric cultural sequences within this area of the western Pacific (Fig.1). Results include improved knowledge regarding the antiquity of various artefact forms and site distribution patterns. Despite the advances made in this area, data on prehistoric food production or subsistence systems remain limited. This is due in part to the intractable, ephemeral nature of archaeological evidence related to prehistoric food production, but also in part to the limited number of research projects designed specifically to address this topic. Our study conducted on Ponape has considered the nature and development of agricultural systems as an integral component of the archaeological research design and provides new information about this basic component of cultural adaptation to island habitats while illustrating the potential of further research on this subject.

Here we review the existing ethnographic and archaeological data on food production systems in Micronesia as a whole and then examine the archaeological and palaeoenvironmental evidence for the development of the Ponapean food production system. Island food production systems must be understood in terms of: (a) derivation and development of the domesticate inventory; (b) introduced and elaborated agrotechnology; (c) local island soil and water resource base; and (d) demographic and sociopolitical dimensions of food production and distribution (cf. Kirch 1982:75-78). A comparison of the traditional Micronesian production systems provides a useful introduction to the archaeological study because many features of agricultural systems are not now known for prehistoric periods.

The basic food crops within Micronesia are those root and tree crops found throughout much of Oceania. These are derived and adapted from an early southeast Asian complex supplemented by some New Guinean and eastern Melanesian cultigens and even possibly one eastern Micronesian domesticate, a species of pandanus (Yen 1985). Aroids, yams, coconut, bananas, breadfruit, pandanus, and arrowroot are dominant in the area but important regional variations do occur (Alkire 1960). Hunting and gathering of foods - especially intensive fishing and shellfishing - supplement the root-tree crop complex. Agrotechnology recorded within Micronesia varies from simple swidden gardens to elaborate wet or dry field terrace and pit cultivation. Minimal agricultural tool elaboration appears beyond the simple digging stick and flat shovel, but storage methods and facilities were highly elaborate.

Micronesia is characterised by island habitats of both high and low types. Well-developed soils on high islands include: (a) widespread lateritic soils; (b) clay-loam soils found in colluvial and alluvial deposits on low elevation slopes and in valleys; (c) hydromorphic soils located in low elevation swamps and bottomlands; and (d) very restricted areas of calcimorphic soils found along shorelines (Barrau 1961:9). Higher rainfall on high islands contributes, along with the richer and more varied soils, to more diverse and zonated vegetation when compared to low islands. Low island or atoll soil development is minimal and only weakly formed calcimorphic soils appear, with the exception of artificial hydromorphic soils in ‘wet gardens’. Vegetation here is considerably restricted because of soil and rainfall limitations.

Demographic factors, particularly those related to population density, and sociopolitically defined distribution methods are significant for understanding food production because these determine to a great extent the nature and degree of agricultural intensification, including innovations in agrotechnology and methods and in the development of new domesticate varieties.
MICRONESIAN FOOD PRODUCTION SYSTEMS

A review of traditional production systems, as ethnographically documented, provides a set of models which aid in archaeologically defining prehistoric food production systems.

Marianas

The long Mariana chain of continental islands, ranging from Guam in the south to the small volcanic islands in the north, is geologically complex. With a total area of 560 km², it forms the largest island chain in Micronesia. Soils are lateritic and overlie limestone or volcanic substrates, perennial streams are rare. The six large islands in the south comprise an older and geologically more complex group within the chain; it is here that the earliest dated evidence of Micronesian occupation is found. Despite this antiquity, very little archaeological data about food production exists and the aboriginal agricultural systems were not well recorded prior to their early alteration due to intense Spanish contact.

Of considerable interest in the Marianas case is whether rice (Oryza sp.) was an indigenous (pre-AD 1521) cultigen. It has long been considered to have been pre-European (see, for example, Barrau 1963), but Craib and Farrell (1981) have recently argued that the existence of pre-contact rice has not been convincingly demonstrated, even from the early historical references to Guam.

The geographical location, known time depth of occupation, and available records suggest that yams, breadfruit, taro, coconut, bananas, and sugarcane were all present in the Marianas pre-Spanish Chamorro food complex (Bowers 1950; Alkire 1977:20), but the relative importance of one compared to the others is less clear. A diversified group of staples is likely and probably taro (Colocasia, Cyrtosperma?) was an important early staple. There are no known yam mounds, which supports the idea that the aroids were more significant. The dog and pig were absent from known prehistoric Marianas fauna.

Palau

Palau consists of a 490 km² complex of continental islands composed of basalt and andesite with a number of uplifted coraline limestone islands ('rock islands') and several atolls. Bryan calculates the lagoon area as 1240 km² (1971). Well-developed perennial streams are found only on the continental islands. These islands also have well-developed lateritic soils in contrast to the poorly developed calcimorphic soils on the other islands. Hydromorphic soils are primarily confined to the volcanic sediments on bottomland alluvium.

Primary aboriginal plant staples are thought to have been the aroids (Cyrtosperma, 11 varieties known ethnographically; Colocasia, over 100 varieties; Alocasia, seven varieties) supplemented by breadfruit, bananas, coconuts and arrowroot (Barnett 1949; Alkire 1978; McKnight and Obak 1960). Cultivation of the important root crop, Colocasia, is perhaps the most intensive of any island group in Micronesia. Its cultivation in permanent dry and wet field systems utilises extensive terracing, irrigation works, mulching, rotational practices, and intercropping with Cyrtosperma. Breadfruit trees are often cultivated on areas surrounding the taro swamp plots. Although today only 5-10% of Palau's swamps are devoted to taro cultivation, it is estimated that prior to contact, 50-60% of this land area was in production (McKnight and Obak 1960). There has been a continued effort to develop dryland varieties of Colocasia and such cultivation is the presumed function of many of the terraces. Dryland varieties of Cyrtosperma and Alocasia are also present (McKnight and Obak 1960). Although the rotational practices for Colocasia production provide a nearly year-round availability of this crop, Cyrtosperma and breadfruit preservation provide a means of storing surplus and evening out staple availability.

One archaeological study conducted by Lucking (1984) in Palau recently addressed the question of agricultural use of the extensive terrace systems that have become known as a major feature of the Palauan archaeological landscape (Osborne 1966, 1979; Gumerman et al. 1981). Soil sample coring and testing of terrace retaining-wall structures have provided details about the terrace use.

Archaeological survey recently undertaken on Babeldaob provides information about terrace systems and residential complexes, but no new evidence about the agricultural system has yet appeared. 'Terraces' - presumably agricultural - and 'agricultural rock piles' have been identified as standard site features in this survey (Gumerman et al. 1981:38, 52).

The intensification of food production in Palau seems to be largely reflected in terrace
field expansion and systematization of crop patterning within terraces and swamps. The extensive terrace systems are confined to the continental islands and are often associated with a secondary vegetation type consisting of grasses and scattered Pandanus. This vegetation occurs in areas where soil is rather shallow and is presumed to have resulted from earlier forest clearing and burning associated with agriculture.

Animal domesticates in Palau include at least two. Osborne (1979:347) notes that 'jungle fowl' were probably present in pre-contact Palau, and the pig is known from prehistoric contexts (Masse pers. comm. 1983). No specific information is available about the antiquity of the dog.

Yap

Yap is a rather unusual Micronesian high island complex (consisting of four main islands, 100 km², and a lagoon of only 26 km²) in that much of its interior has been reduced to parkland covered with savanna grasses, ferns and pandanus. This seems to be a western Micronesian pattern seen also on Guam and Palau. The interior vegetation is thought to be the result of forest clearing and burning. Here accelerated erosion and seasonal rainfall have prevented the regeneration of forests over large areas.

Yap aboriginal subsistence was based on the cultivation of two primary root crop staples, taro (primarily Cyrtosperma, but also Colocasia) and yams, supplemented by bananas, coconuts, and the Tahitian chestnut (Inocarpus edulis) and, rarely, breadfruit (Alkire 1977:34). At least four and probably six yam species have been cultivated on Yap. The most extensively raised are Dioscorea alata (19 varieties), D. esculenta (over 10 varieties), and D. nummularia (at least four varieties, Defngin 1959). Cultivation of yams on Yap in recent times is only rivalled by Ponape in its importance and intensity; however, some of this is known to be the result of historic introductions. Regular rotational practices, complex use of long mounds, mulching, and construction of trellises are associated with yam cultivation. The seasonal availability of yams is mitigated by dry storage of the tubers and by cultivation of varieties with different maturation rates (Defngin 1959).

Cyrtosperma cultivation is also very important as it is consumed daily, in part because of its year-round availability and in part due to dietary preferences (Kim and Defngin 1960). Cultivation is in reclaimed brackish water swamps along the coast and in other inland marshy areas. At least six varieties are recognised and considerable effort is put into field preparation and maintenance. Colocasia may also be intercropped with Cyrtosperma, but it is not widely used for food.

Ogata’s (1960) discussion of coconut cultivation notes the widespread recognition within Micronesia of the heavy bearing coconut palms and the superior seed nuts on Yap. Informants relate the earlier importance of this cultigen and that cultivation methods were closely guarded secrets.

Considerable archaeological work has been done recently on Yap, but no new detail about agricultural systems has appeared. Systematic survey and mapping of mounds and other agricultural features should be undertaken.

Central Caroline Atolls

Compared to the high islands to the west, interisland exchange is more important among the central Caroline atolls to even out resources that vary in distribution from island to island. Exchange is helpful not so much because of climatic differences (e.g. in rainfall) but because of differing sizes and production potentials of atolls. Total land area of the inhabited atolls and raised coral reef islands in this area (excluding Yap) is only 18 km² and the total lagoon area is about 1000 km².

The primary staple plant foods are the aroids: Cyrtosperma (20 recognised varieties), Colocasia (over 17 varieties), and Alocasia; breadfruit, bananas (six varieties), and coconuts. Pandanus (three varieties) and arrowroot were also used (Burrows and Spiro 1953). The relative importance of the primary staples, breadfruit and Cyrtosperma, depends on the amount of interior land suitable for swamp taro cultivation (Alkire 1978). Pit preservation of breadfruit and the year-round harvestability of Cyrtosperma provide insurance against seasonal crop fluctuations, droughts and typhoons (Lessa 1950). Systems of regular rotation within plots and intercropping help sustain these permanent field systems.

Craib’s Ulithi archaeological survey report (1980) notes the ‘careful construction of taro swamps’, but no description or mapping was undertaken. The two largest islets, Falalop and Asor, have taro areas marked. On Lamotrek Atoll, Fujimura and Alkire have shown...
from archaeological evidence that dog was present in pre-contact times; the dating is not clear, but possibly around AD 1300-1500 (1977). They also claim chicken and possibly pig were present in comparable pre-European contact levels, but we find this unconvincing. Archaeological evidence regarding food production systems is lacking for the other atolls.

**Truk**

The 14 main islands of Truk Lagoon comprise approximately 96 km² of land scattered in a lagoon of over 2100 km². These volcanic islands are quite steep and rocky. There is a narrow coastal strip of calcimorphic and hydromorphic soils with fringing areas of mangrove swamp. The pockets of clay-loam soils on the slopes give way to fairly deep lateritic soils on upland ridge tops and plateaus. Secondary and managed forests comprise all but the highest mountain peaks and a narrow strand vegetation strip along the coast.

Primary staples, in order of importance (historic introductions are omitted), are breadfruit (80-100 varieties, Kramer 1932:129), taro (especially *Colocasia* with at least nine recognised varieties), bananas, coconut, pandanus, turmeric, arrowroot and yams (LeBar 1964:55-58). The aroids *Cyrtosperma* and *Alocasia* are cultivated but are less favoured than *Colocasia*.

Breadfruit is more important on Truk than anywhere else in Micronesia (LeBar 1964:55). The proliferation of seasonally variable varieties provides an almost constant supply of fresh breadfruit for at least six months of the year. Pit preservation ensures the availability of this staple during the rest of the year when other foodstuffs are more frequently utilised and during times of shortage due to climatic factors.

Tree crops are cultivated on hillsides, uplands, and coastal areas, except for pandanus which is only grown along the coast. *Cyrtosperma* cultivation is restricted to freshwater swamps often bordered by plantings of *Colocasia*. Field cultivation of *Colocasia*, sugarcane, *Alocasia*, arrowroot, turmeric, and probably in earlier times, yams, occurs on lower elevation slopes and uplands. Field cultivation involves variable fallow periods depending upon moisture requirements (LeBar 1964:60).

Although considerable archaeological work has been undertaken in Truk, this has been largely oriented to artefact recovery and little new information about agricultural systems has been derived. Of interest, however, is that one important animal domesticate, the dog, appears archaeologically as early as 2000 years ago in Truk (Takayama 1982:99). Also, Carucci and King (1982) have recently proposed, in part based on archaeological data, that the importance of breadfruit and its preservation systems are a recent feature of the Trukese food production system and that it appeared as a result of contact with Kosrae to the east.

**Eastern Caroline Atolls**

Atoll dwellers in the eastern Carolines have depended upon the same aroid-breadfruit base as in atolls farther to the west, but in general, *Cyrtosperma* cultivation is more important and *Colocasia* less so in the east. Archaeological evidence is available only from the Polynesian outliers. Davidson's early work on Nukuoro (1968, 1971) provides some specific information about prehistoric animal domesticates. In contrast to Fischer's expectation (Fischer and Fischer 1957:96) that dogs would be limited to high islands in eastern Micronesia, she found that the dog was present prehistorically on the atoll. No chicken or pig were found. Two sizes of rats (*Rattus mansorius?* and *R. exulans?*) were recognised. Although she notes the taro swamp pit cultivations on five of the Nukuoro islets, no figures on size or other characteristics are offered.

Research on the other Polynesian outlier in this area, Kapingamarangi, has recently produced some evidence relating to food production (Leach and Ward 1981). Today, the taro swamps there total about 10 ha and these are used primarily for *Cyrtosperma*; however, this and *Alocasia* reportedly were introduced from Nukuoro during Spanish times (1885-99), and thus, the present taro swamps may reflect a recent historic expansion. They are much larger than those in other atolls with similar populations. Leach and Ward (1981:65) found no dog on Kapingamarangi; a single tooth was tentatively identified as pig. Chicken is reported as possibly prehistoric (1981:64). All rats found were *R. exulans*. Thus, the two Polynesian outlier settlements in Micronesia show a number of differences in available food resources.
Ponape

Ponape as a volcanic island of over 300 km² is the third largest in Micronesia and it exemplifies all of the high island characteristics. Its environment is unique in eastern Micronesia because of the island’s large size, high elevations (up to 750 m) and general environmental diversity.

The traditional agricultural pattern is based on yams (over 200 named varieties) and breadfruit (over 150 varieties, Bascom 1965:98-101; Hiyane and Hadley 1977). A total of 42 wild and cultivated food species are reported by Bascom (1965:4). Only the dog and rat are known to be pre-contact animal domesticates. The diversity of cultivated plants and the soil fertility have caused some to call Ponape the ‘garden isle’.

Seven yam species are recorded for Ponape: Dioscorea alata L., D. bulbifera L., D. esculenta (Loureiro) Burkhill, D. nummularia Lamark, D. pentaphylla L., D. hispida Dennstaedt, D. fiabellifolia Prain and Burkhill (Barrau 1962; Sasuke 1949; Bascom 1965; Ayres and Haun in press:178). The primary cultivated species are D. alata and D. esculenta and over 150 named varieties and subvarieties are recognised (Bascom 1965; Hadley 1977). Some yam varieties are used primarily for subsistence and others for presentation at feasts; the latter is related to the complex redistributional feasting system and ranked sociopolitical status. Because of the prestige aspect, the techniques of yam cultivation are designed to produce the largest tubers, not the greatest production per land unit or amount of effort expended (Mahoney and Lawrence 1959:2-3). Cultivation of yams requires considerable soil preparation, including mulching, and labour intensive maintenance during the growth cycle. In contrast to Yap, and much of Melanesia, prestige yams were not dug up and then stored for later use, but were kept in the ground until needed.

Breadfruit, like yams, is particularly important seasonally on Ponape. The use of pit fermentation and storage is essential to even out the availability of breadfruit; this storage is also important as insurance against disaster-induced famine and for providing large quantities of food for the competitive prestige feasting. Numerous preparation techniques and at least six named feasts associated with breadfruit also signify the value of this staple.

A wide variety of other root and tree crops are cultivated, including bananas (41 varieties), coconuts (14 varieties) and Cyrtosperma (21 varieties), but these serve primarily as substitutes if yams and/or breadfruit are in short supply. Ponapean sakau (kava, Piper methysticum) is also an important domesticate.

Bascom (1965) characterises Ponapean agriculture in the late 1940s as primarily confined to ‘farmsteads’ consisting of ‘land about the house’ that was taken up by a two-tiered cultivation of permanent, perennial tree crops (mostly breadfruit, bananas and coconuts) and root crops (mostly yams and Alocasia) grown on a permanent or bush fallow rotational basis depending upon land availability and fertility (Bascom 1965:88). ‘Mountain gardens’ and freshwater swamps were also cultivated prior to Japanese Period restrictions. Swamps were devoted to Cyrtosperma, and the mountain farms located in remote areas were used for forest fallow swiddening of yams, bananas, taro (Alocasia, Colocasia) and sugarcane.

The situation today follows the ‘farmstead’ pattern. In many areas, for example, Awak, the entire lower elevation valleys and coastal areas are ‘gardens’ with a bush fallow rotation of root crops beneath a canopy of economically important trees and small areas of permanent swamp cultivation. The earlier (1920-30s) use of forest fallow swiddens represents a situation resulting from the low population levels of the 19th and early 20th centuries when much of the interior must have reverted to forest.

Kosrae

Kosrae (Kusaie) is a rugged volcanic high island with a very narrow fringing reef and small lagoon areas; the land area is 109 km². It is similar to Ponape in climate, rainfall and topography. Staple cultigens for Kosrae are breadfruit (18 varieties), pandanus (11), coconut (eight), bananas (over 23), yams (nine), Colocasia (12), Cyrtosperma (eight) and arrowroot. A two-storied mode of cultivation involving tree and root crops is found near dwellings and surrounding fields devoted to root crops (Sarfert 1919:97). It is thus similar to the Ponape system, but with some different cultigen emphases.

Although archaeological survey has been underway since 1979, no information on agricultural systems has been forthcoming, other than Cordy’s statement (1982:131) that agricultural sites consist of ‘retaining walls along streams or gradual ridges, terraces on slopes and drainage channels associated with swamps’. Agricultural sites are described as being adjacent to dwelling sites.
Marshall Islands

The inhabited Marshall Islands consist of two main chains of atolls: the Ratak chain to the east is composed of 10 inhabited and six uninhabited atolls (82 km² land, 3930 km² lagoon); the Ralik chain to the west has 16 inhabited and two uninhabited atolls (90 km² land, 7235 km² lagoon; Bryan 1971). Within these island chains considerable intercontact existed in prehistoric times, which probably helped to even out differences in plant food production capabilities that were due to uneven rainfall distribution. This is particularly true of the staple breadfruit (*me*) which, according to Barrau (1961), requires 60 inches or more of rain per year to provide sufficient fruit. There are at least six recognised varieties. Thus, in the southern islands, breadfruit is the primary staple compared to coconuts, pandanus and arrowroot, which substitute in the northern atolls of the chains. In both areas, elaborate preservation techniques were used to provide insurance against droughts and disasters and to even out the seasonal availability of these staple crops.

One other very important food crop was *Cyrtosperma* (Bikajle 1960), of which at least four varieties were recognised. In all cases, cultivation required the laborious construction of taro beds in the islet interiors. Rotational procedures, intercropping with *Colocasia*, and extensive mulching were used. *Cyrtosperma* was of great importance because of its year-round harvestability and thus it also provided a hedge against natural disasters, especially the seasonal availability of breadfruit and pandanus.

Recent archaeological survey and excavations on Arno (Dye 1987) and Majuro (Riley 1987) in the Marshalls have provided specific details about subsistence, especially marine dietary components and wet garden sizes. As yet, no systematic integration of archaeological evidence for food production and atoll settlement patterns has appeared.

Gilberts (Kiribati)

Sixteen atolls in the Gilberts contain approximately 295.6 km² of land area. In terms of dependence on specific cultigens, the Gilbertese traditional subsistence pattern is the latitudinal reverse of the Marshalls, because here, breadfruit supplemented with *Cyrtosperma*, coconuts and pandanus, is the staple in the north, while pandanus, supplemented with *Cyrtosperma*, coconuts and breadfruit, is the staple in the drier south. Thus, there is a central eastern Micronesian belt of slightly higher rainfall and greater dependence on breadfruit; this includes the southern Marshalls and the northern Gilberts. Nauru, the raised coral island, is like the southern Gilberts in this regard.

Catala (1957) records five named varieties of breadfruit, four of coconuts, and nine for *Cyrtosperma*. As many as 194 varieties of pandanus are listed in earlier descriptions, but Catala's informants were only able to identify 16 on Tarawa and 25 on Nikunau (Catala 1957:50-51).

Drews' (1944) account of Gilbert Island horticulture, while mistakenly considering *Cyrtosperma* to be the only cultivated plant, provides a valuable description of the wet gardens. They are located in the islet interiors and are approximately 1.5 m deep by 9-12 m wide and considerably longer. The lower 0.6-1.2 m of the surrounding embankments are often retained by shaped coral slabs. Individual plants are grown in loosely constructed baskets of pandanus leaves filled with humus and sand and arranged in rectangular patterns within the gardens. Little maintenance is necessary and the plots are used for generations. Although this characterisation of stonework in pits suggests that archaeological excavations might be fruitful, no such information is available about Gilbertese food production. At present, archaeological evidence of past food production practices in the Gilberts and in Micronesian atolls in general remains minimal.

MICRONESIAN REGIONAL COMPARISONS

The relative significance of specific cultigens (Fig.2) and associated cultivation patterns (Fig.3) for the areas discussed above show certain broad patterns. These graphs are based upon ethnographically known societies and they are generalised for each island group or area because variations occur due to differences in local rainfall patterns and other environmental factors. The Marianas are omitted from the comparisons because little is known of the aboriginal situation. Although *Colocasia* can be grown in swamps, for example, interplanted with *Cyrtosperma*, it is also cultivated in dryland gardens, and so it is divided equally in Figure 3 between wet and dry gardening components. Dryland cultivation seems to be widespread in Micronesia because, compared to Polynesia for
Diagram of the relative importance of major Micronesian plant domesticates used at the time of Western contact. The proportions reflect traditional subsistence patterns as reported or reconstructed from various sources (see text).
Diagram of relative importance of major cultivation methods within Micronesia. The proportions reflect contact period subsistence patterns as reported or reconstructed from various sources (see text)
example, high rainfall permits effective cultivation without irrigation. Spriggs (1982) discusses problems of archaeological visibility in both cases.

In general there is a pattern of increasing emphasis on certain cultigens as one moves from west to east across Micronesia. There is a noticeable increase in tree-crop utilisation in particular. The use of *Colocasia* decreases dramatically from west to east, being replaced by *Cyrtosperma*, but breadfruit, pandanus, coconut and probably bananas increase significantly. This change occurs most dramatically in the atolls to the east, but it also appears as a general gradient. The change in emphasis is reflected in: (a) soil management, i.e. partial or full tillage; (b) rotational practices; (c) water control; (d) nutrient control; and (e) maintenance.

The intensive terrace and soil preparation for *Colocasia* in the west, especially Palau, declines to simple and minimal dryland tending in the east or intercropping with the more important *Cyrtosperma*. We suggest that the extensive reliance on aroids, particularly *Cyrtosperma*, in western Micronesian high islands reflects a long process of environmental degradation resulting in reduced yields from other root crops and arboriculture. Yam cultivation ranges from very elaborate techniques on Ponape to partial tillage or harvesting wild yams; the most intensive yam cultivation is on the three high islands of Ponape, Yap and Kosrae.

It is clear that there is greater diversity in Micronesian food production systems than is implied by the division - based largely on linguistics and on an extension of human physical type classification - of western and central-eastern Micronesia, or on the division between high and low islands. Many differences in crop complexes relate directly to environmental variations, understandable when the modern setting and the reconstructed palaeoenvironment is examined, but others, including many of the animal distributions, must be examined in more detail as probable reflections of the settlement process within Micronesia and the western Pacific. Given this, it seems clear that archaeological and palaeoenvironmental evidence will be essential for understanding the regional variations and food production systems development in Micronesia; our research on Ponape has specifically addressed this problem.

**PONAPE FIELD RESEARCH**

Field research we have undertaken on Ponape aims to integrate archaeological and environmental data in order to examine interrelationships among environmental diversity, settlement patterns, developing political complexity and agricultural system evolution. The research objectives are to document environmental factors affecting differential productivity and to determine their relationships to agricultural intensification and population growth. Palaeoenvironmental and botanical studies provide the basis for establishing vegetational history; ethnographic information and archaeologically derived data are used to reconstruct agricultural and demographic relationships and development.

Various lines of evidence have been used to identify prehistoric subsistence means and to relate this data to the questions of food production elaboration and agricultural intensification. Importantly, Ponape provides a setting where existing agricultural systems can be examined for insight into pre-contact operations (Ayres and Haun 1985, in press:213-14). Based on these existing systems, the early historic observations, botanical evidence, and reconnaissance and intensive archaeological survey, there is every indication that prehistoric Ponapean agriculture was spatially extensive and agronomically diverse.

**Botanical and soils evidence**

Botanical and palaeoenvironmental studies comprise an integral part of our subsistence study. These have included qualitative and quantitative botanical surveys and collections made by botanist L. Stemmerman and Haun, as well as sediment and pollen sampling from cores in three inland swamps and one shoreline mangrove location in Awak, a valley on Ponape's northeastern coast (Ayres and Haun in press; Haun 1984).

A series of radiocarbon dates going back to 570 BC (calibrated to 380-970 BC at 2 s.d.) from cores up to 3.3 m deep in Awak's Leh en Luhk Swamp provide sufficient time depth to review the entire vegetation sequence from near the time of initial human occupation of the island up to modern times. This is extended back even farther by a core at Taweiso in the mangrove coastal swamp going back to about 4000 BC (calibrated to 4680-5210 BC at 2 s.d.). As the cultural associations of the earliest dated peat layers in Leh en Luhk have yet to be
verified, the first definite evidence of human activity at this location is in the 2nd century AD in the form of charcoal and wood layers reflecting extensive land clearing. Pohnle Swamp on the opposite side of the valley has been cored to a depth of 1.4 m and has provided a radiocarbon reading of AD 460 (calibrated to AD 256-797 at 2 s.d.) for buried layers containing charcoal. It, like Leh en Luhk, is currently used for *Cyrtosperma* cultivation.

Reconnaissance has been carried out on the ridge tops and the plateau that lie south above the head of Awak Valley in order to do a vegetation survey and to collect sediment and pollen samples from the native upland and montane forests. A small swamp was cored at this high elevation and a *mall* or 'fern desert' dominated by the fern *Dicranopteris* spp. was sampled. There is little soil formation in the *mall*, and it is probable that these areas represent previous vegetation clearing in localities where soil formation was minimal; the resulting erosion and loss of fertility reduce the remaining soil into a medium unsuitable for forest regeneration.

The botanical survey documents differences within the valley, e.g. between the western and eastern sides, reflecting differences in soils and recent cultivation intensity. It also establishes the mixed canopy managed forest as the dominant vegetation type for the entire valley (Ayres and Haun 1985).

Palynological analysis of one sample from 125-130 cm below the surface of the Leh en Luhk deposit identified 16 spore and pollen types. This sample is associated with a date of AD 315 (Isotopes 10, 171; calibrated to AD 179-600 at 2 s.d.). Most types have only been classified to the family level pending a more complete comparative collection; however, the limited number of species within several dicotyledonous families documented by botanical surveys permits several tentative species identifications.

The flora represented by microfossils includes low-growing herbaceous species such as grasses (Gramineae), sedges (Cyperaceae), *Jussiaea* spp. (Onagraceae; usually found in marshy areas), and probably one species of *Convolvulaceae* (*Merremia* spp.). Other ground cover and epiphytic plants present are ferns (*Schizaeaceae* and *Polypodiaceae*) and club mosses (*Lycopodium*). Tree species common in Ponape forests and represented in the sample include *Ficus* spp. or *Artocarpus altilis* (*Moraceae*), *Barringtonia* spp. (*Lecythidaceae*: probably *B. racemosa*), and *Syzygium* spp. (*Myrtaceae*). A member of the *Leguminosae* family is also present and at least one species of *Malvaceae* (either *Hibiscus* spp., *Sida* spp., *Urena lobata*, or *Thespesia populnea*).

The ground cover vegetation indicated by the sample would be present in areas where the flora has been disturbed. The tree species mentioned, because of their economic uses, are today sometimes selectively retained during forest clearance. However, quantified data are necessary to verify if the vegetation represented in the samples reflects anthropogenic modification. The possible occurrence of breadfruit (*Artocarpus altilis*) and species of *Syzygium*, both used as food, could be very significant.

A recent Ponape soil survey completed by the US Department of Agriculture Soil Conservation Service (1983) identifies two soil types that appear to correlate with the cored deposits at Leh en Luhk and Pohnle. The Inkors and Mesei soil distributions are closely associated and are often found in areas used for *Cyrtosperma* cultivation. The presence of buried organic layers at about 100 cm in some Inkors soils is similar to the organic (peat) layers at Leh en Luhk at the same depth and may mark an important anthropogenic soil horizon. The organic layers at Leh en Luhk are situated between charcoal flecked grey clay deposits that are nearly identical to the lower horizon Inkors soils. They very likely represent either natural peat layers buried by rapid erosion resulting from forest clearance or swamp cultivation episodes. The Mesei soil type's colour, composition, and lack of horizon formation is very similar to the upper layer at both coring sites and is probably an anthropogenic soil resulting from mulching and tillage of swamp gardens.

**ARCHAEOLOGICAL EVIDENCE**

The Ponape archaeological survey has identified several agricultural feature types that aid in reconstructing the system's integrated components. Fieldwork conducted since 1977 has produced considerable evidence for specific agricultural activities (Ayres and Haun 1980, in press; Ayres *et al.* 1981). Seven microenvironmental zones with soil and vegetation differences have been identified and used in conjunction with this survey. Sampling in three environmentally distinct portions of the island has also been undertaken in order to
place the archaeological data in a broader context. Evidence of early agricultural practices includes the following: (a) interior forest clearance reflecting slash and burn gardening is dated to at least the 2nd century AD, and possibly as early as 500 BC, in Awak; (b) a large starch paste fermentation pit, Site PoD5-11, located near the southeastern coast in Wene, Kiti district, is dated to the 3rd-4th century AD and documents early communal starch, probably breadfruit preservation technology; (c) radiocarbon ages between AD 300-400 from Awak swamp layers indicate early aroid cultivation in the interior middle elevations of the valley; and (d) good evidence for middle elevation residential settlement in Awak dates to between AD 800-900; there is a strong possibility that water-spreader type, irrigated terraces were in use by that time (Ayres 1985).

Other details about prehistoric Ponapean subsistence are derived from survey and excavations. Most archaeological remains are architectural features, including residential platforms, meeting houses, tombs, and other stone constructions like those contained in chiefly complexes, but a number of these features (terraces, pits, mounds and walled enclosures) specifically relate to food production.

**Survey data on food production**

Extensive use of roughly constructed stone-wall terracing in irregular patterns has been documented in many surveyed areas. Most of these are minimal field systems. Over 250 terraces have been mapped and of these approximately 50% are agricultural terraces of four basic types: (a) very small rough constructions of stone, retaining usually less than 10 m² of soil; (b) talus slope terraces; (c) large terraces on moderate slopes; and (d) wet terraces along stream channels (Ayres and Haun in press:48-51). Of these, the wet terraces are the most substantial constructions, but even these are only long, low walls forming the common water-spreader terraces.

Over 100 pits have been recorded; ones with agricultural function include yam pits, *Cyrtosperma* cultivation pits, breadfruit fermentation storage pits, and pits for cultivating in very rocky areas. Breadfruit storage pits vary considerably in size, and have areas ranging from approximately four up to 100 m² and volumes of 4-150 m³. Small storage facilities have been used in historic times and many of the smaller pits recorded in the survey date to this period.

A variety of walls and enclosures have been located and classified. All of these appear to date to the early historic period (post-AD 1826) and later agricultural activity after pigs and other large animals were introduced into the island. Historic walled yam plantings are probably most common.

Large earth mounds of presumed agricultural function are known from southern and eastern Ponape; several in Wene were systematically surveyed. These mounds represent a very substantial labour investment and reflect an aspect of Ponapean food production not known during the historic period. While the overall mound distribution is imperfectly known, it seems to correlate with areas of relatively poor agricultural soil.

Finally, survey in the upper Awak Valley has identified a quarry for the large flat diestone segments used as anvil surfaces for pounding sakau (*kava*). When dated, the quarry activities will help to determine when ritualised sakau use became prevalent in this area. Sakau is an important cultigen in that it ties the prestige elements of the food production system to the status and sociopolitical hierarchy. The flat slabs and hand-held pounding stones are found in archaeological sites.

**Excavations**

Excavations in several agricultural sites provide additional details about terrace cultivation, use of earth mounds and breadfruit storage. Trenching in a five-terrace wet complex (Site PoB7-29) in Awak shows an irrigated system which effectively flooded about 1000 m² of surface. It appears to date to the same time period as the architecturally adjoining complex of platforms and dry terraces interpreted as part of a high status residential area. The early levels of this complex date to approximately AD 875 (calibrated to AD 770-1154 at 2 s.d.). Testing has also been done in a stratigraphically complex stream-flooded terrace (Site PoB7-122) showing cultivation layers.

Trenching was carried out in one of the large earth mounds in Wene. Some of these mounds, as recorded in the survey, measure 2-3 m high, 4-6 m wide at the base, and up to 500 m long; others are large, low rectangular platform-like mounds of 50 x 200 m. One of
Figure 4  Diagram of changing relationships among food production methods on Ponape; graph width represents estimated relative importance of each named production type
the latter, Site PoD10-1, was trenched to disclose layers of rich, well-drained soil with charcoal stains and organic matter, thus supporting the idea that these functioned as agricultural mounds. They appear to be associated with particular soil types on Ponape, the Umpump Series (US Department of Agriculture 1983:43), that are poorly suited for yam cultivation. The excavations in the Wene example provided historic artefacts from the upper layers of the fill; however, the historic soil cap may have been added when these mounds were used, reportedly, for burial purposes in early historic times.

Also in Wene, excavations were conducted in two large storage pits, presumably used for breadfruit paste (mahr) because banana paste is normally stored in smaller holes. One pit, Site PoD11-9, is 16 m long by 4.5 m wide at the top and 1 m deep; this was trenched through the pit wall, but no datable material was recovered. The second site, PoD5-11, is a pit 17 m long by 6 m wide at the top and 1.2 m deep; testing provided a charcoal sample from the pre-construction surface dating to AD 300 (calibrated to AD 80-640 at 2 s.d.; Ayres and Haun in press:203-5).

Recent work at Nan Madol has confirmed oral history references to an unusual type of cultivation on the artificial islets built up on the coral reef. In one example, Pahn Kadira, this was accomplished by transporting at least 2500 m³ of clay loam soil to cover nearly 0.25 ha of the islet. This soil deposit would have been suitable for cultivating dryland crops such as breadfruit and Alocasia which grow there today. Oral traditions also refer to other intensive food production practices associated with Nan Madol, including raising shellfish (Anadara sp.) and storing or actually raising fish in ponds there. Size and quantity increases in Anadara deposited in Nan Madol middens do suggest purposeful raising of this clam, a popular item in prehistoric Ponapean diet (Ayres et al. in press:194). According to local informants, large-scale cultivation of Cyrtosperma to support Nan Madol’s residents may also have occurred in brackish water swamps along the coast of the main island opposite the ruins.

Archaeological evidence suggests specialisation in inshore marine exploitation; use of reef weirs for daily subsistence fish and inshore reef netting for prestige fish were highly developed. Based on faunal distributions, specialised use of the dog in later prehistoric times as a prestige feasting food is evident.

FOOD PRODUCTION SYSTEM RECONSTRUCTION

A tentative reconstruction for the Ponape food production system development is offered in Figure 4. This is generalised for the entire island; local variations exist due to microenvironmental factors. Ethnographic and historic data define the endpoint of the prehistoric system at about AD 1800. By this time tree cultivation extended over most of the lower elevations, and dryland crops were grown both in permanent gardens and in swiddens with bush fallow rotation. Forest fallow was limited because of the tree crop dominance. A minor component of the system was permanent field cropping of Cyrtosperma in natural and artificial swamps. Animal husbandry (dog) played a minor role in the overall system but was particularly important for prestige feasting.

The ethnographically defined pattern can be extended back to approximately AD 850 when settlement of lowland interior sites is initially documented and is associated with evidence for permanent field cultivation (wet and dry terraces). While tree cultivation, particularly of breadfruit, appears to be important at least as early as AD 300, the lack of inland habitation sites dated to this period indicates that forest fallow of dryland crops would have been more significant prior to AD 850. A slash and burn shifting utilisation of interior valleys is suggested by dated levels in the Leh en Luhk Swamp in Awak at about this time. As noted above, scattered charcoal in the lower levels of this swamp pre-dating 570 BC may represent even earlier slash and burn clearing. This probably occurred prior to the areal expansion of arboriculture from the coastal areas and thus a forest fallow cycle was no doubt even more widespread prior to the AD 200-300 time frame.

The areal expansion of arboriculture and the concomitant increase in permanent dryland gardens are thought to culminate about AD 800-1000 with the residential settlement of most low elevation areas of Ponape. We relate further elaboration of the agricultural systems in the direction of intensified tree-root intercropping in permanent field or ‘managed forest’ systems, and in increasingly intensive yam cultivation, to prestige feasting. This is associated with chiefdom development on the island encompassing geographical areas approximating the size of historic wehi or districts, i.e. ca. 50-75 km².
FOOD PRODUCTION AND MICRONESIAN SETTLEMENT MODELS

Because understanding Micronesian food production requires knowledge of its
derivation, migration and settlement theories are pertinent for the present discussion (Yen
1973). Yams and *kava* provide specific cases related to this question.

Two major settlement migrations into Micronesia appear likely, based on available
evidence:

1. One basically from the west to the east, which quite clearly resulted in the
occupation of the Marianas, Palau and Yap, from somewhere in island Southeast
Asia, and a subsequent, more questionable movement further to the east. The
latter movement was first identified by Buck (1938) who saw these migrants
dropping cultural baggage (e.g. pottery), along the way as the rigours of atoll life
were encountered. More recently, based on perceived similarities in pottery styles
in the east (Truk and Ponape), to Marianas redware, Takayama (1982:104)
proposes that the early settlement of eastern Micronesia stems from the west.

2. A dispersal basically in the opposite direction from east to west or from southeast
to northwest from eastern Melanesia into eastern Micronesia and then continuing
on all the way to Tobi and Sonsoral south of Palau. On linguistic grounds this
movement seems well documented (Bender 1971) and its beginnings are thought
to relate to the spread of early Lapitoid pottery users. A subsequent movement of
people who were culturally Polynesian into eastern Micronesia, specifically
Nukuoro and Kapingamarangi Atolls, is well documented. The derivation of these
Polynesian atoll dwellers from western Polynesia, probably the Ellice Islands
(Tuvalu), marks the same general direction of the proposed earlier movement of
Lapita-related colonisers.

Of these two possible major directions of population influx into Micronesia, evidence
from the cultigen inventory and food production systems largely supports the east to west
movement, although significant west to east settlement, conceivably taking place during
initial colonisation period, cannot be entirely discounted due to lack of archaeological data.

Ponape has the largest number of recorded yam species and named varieties in
Micronesia and this should be considered in examining settlement hypotheses. Migrants
moving from west to east could perhaps have brought these yams, but not by atoll-hopping,
only by bringing them from a high island, of which Yap is the best candidate based upon
the historic crop complex. However, the Yapese yam cultivation and storage systems are
very different from those found on Ponape and the distance involved is over 2000 km with
no large high islands in between. Migrants coming to Ponape from the east-southeast
(eastern Melanesia-western Polynesia) could have brought such a yam complex, but again
not by atoll-hopping through the Gilberts and Marshalls as has been suggested (Shutler and
Marck 1975:Map 3). The distance to the nearest potential high island source is about the
same as to the west but we believe the yam complex is older in eastern Melanesia than in
Yap. Several lines of evidence support the view that the early migrant groups reaching
Ponape came from a high island with a wide range of yams represented, and this seems
most likely to have been in eastern Melanesia or even Fiji-western Polynesia prior to the
reduction of the yam inventory in the Polynesian crop complex.

While it is likely that the wide range of yam species present on Ponape is not the result of
a single early introduction but of additions to the yam inventory over a period of centuries,
the intensive cultivation of these tubers appears to have great antiquity. We do not have
actual dates for when yams became important on Ponape, but the evidence showing the
very limited development of wet terracing and swamp preparation on Ponape suggests that
production of the aroids was never as important as on some other Micronesian islands such
as Palau or Yap. In this case what is left are the familiar tree crops, including breadfruit
which is cultivated today on Ponape in close association with yams; often the breadfruit tree
branches serve as a trellis for yam vines. This yam-breadfruit association is characteristic of
Ponape and it reflects a well-integrated cropping system utilising hundreds of varieties. It
is very different from that of Yap. Thus, an argument can be offered that the Ponape yam
complex is old and that it is not derived from western Micronesia.

Another significant cultigen with regard to settlement questions is *kava* (Ponapean
*sakau*, *Piper methysticum*). The use of this narcotic beverage is known only from Ponape and
Kosrae in Micronesia and it contrasts with the use of betel-nut in the west, particularly Yap
and Palau. The sociopolitical significance of *sakau* and available archaeological evidence
suggests that it is not a recent introduction to Ponape. As a high island rather than an atoll
crop, *kava* was likely introduced into Ponape from the same general area as yams; the
distribution of kava includes eastern Melanesia and Polynesia and thus provides another link between these areas and Ponape.

In sum, we view the impact of early western Micronesian settlement on the central and eastern Carolines, Marshalls and Gilberts as minimal due to a hypothetical 'atoll barrier' resulting from the adaptation of early western Micronesians to high islands, from which they would have been unlikely to successfully colonise atolls to the east. There is no documentation for an emphasis on ocean travel and navigation in this area as there is in the eastern Melanesian areas settled by early Lapita potters. One result of this long-distance Lapita voyaging was settlement of western Polynesia and the suggested colonisation of eastern Micronesian high islands; successful atoll adaptations may very well have come later.

SUMMARY AND CONCLUSIONS

We wish to stress that archaeologists must expand their study of food production systems beyond analysis of faunal remains and dietary components. Within the broader subsistence realm, archaeological evidence of domesticate derivation, adaptation and intensification of use within island ecosystems is essential for a number of reasons:

1. Up to 50% of the archaeological site/feature landscape and inventory is made up of agricultural features (ca. 30% on Ponape).
2. Human modification of the landscape and vegetative environment, e.g., as we describe for Ponape and as Kirch (1982) has recently discussed for Hawaii, is directly related to and interpretable in terms of food production systems.
3. Knowledge of plant and animal distributions as documented ethnographically and prehistorically is essential for testing settlement models.
4. Settlement patterns cannot be understood except in terms of the overall food production system.
5. Ethnographic models reflect recent historic subsistence systems and require testing against archaeological, palaeobotanical and other palaeoenvironmental data. We must be careful not to assume continuity of production systems and project untested reconstructions of 'traditional' subsistence systems back into prehistoric times.
6. Prehistoric atoll cultivation systems are not particularly well documented and archaeological studies of the production parameters should be undertaken, e.g., through determining taro swamp pit excavation or building sequences.
7. Understanding the evolution of production systems in Micronesia and in Pacific islands in general requires examining the importance of social production as it relates to agricultural intensification. This applies to atolls (see e.g. Mason 1968:328) as well as high islands.

REFERENCES


Alkire, W.H. 1977 *An Introduction to the Peoples and Cultures of Micronesia.* Cummings Publishing Co.: Menlo Park


Buck, P. 1938 *Vikings of the Sunrise*. Whitcombe and Tombs: New Zealand


Carucci, J. and T.F. King 1982 Maay oo Maay (Mai oh mai): breadfruit and prehistoric culture change in Truk. (Unpublished manuscript)


Craib, J. 1980 *Archaeological Survey of Uliitti Atoll, Western Caroline Islands*. Pacific Studies Institute: Guam


Davidson, J. 1971 Archaeology on Nukuoro Atoll, a Polynesian outlier in the eastern Caroline Islands. Auckland Institute and Museum: Auckland, Bulletin No.9


Fujimura, K., and W. Alkire 1977 Recent excavations on three atolls in the Caroline Islands: a note. *Journal of the Polynesian Society* 86:413-14


LeBar, F. 1964 *The Material Culture of Truk*. Yale University Press: New Haven, Yale University Publications in Anthropology 68


Shutler, R. Jr and J.C. Marck 1975 On the dispersal of the Austronesian horticulturalists. Archaeology and Physical Anthropology in Oceania 10(2):81-113


SECTION IV

THE ANIMALS, THE PLANTS
Students of domestication seem now to agree that 'the simple terms wild and domesticated are an inadequate description of the status of animals within the complex spectrum of their possible relationships with man' (Bahn 1978:183-84), and that consequently one must view domestication as 'the end-product of a series of gradually intensifying man-animal relationships' (Jarman and Wilkinson 1972:96). Geographer Clarissa Kimber (1978:2), speaking of plants in the context of 'folk domestication', points out that various 'stages' exist between man's relationships with various wild plants, on the one hand, and 'sophisticated plant breeding', on the other. Archaeologist Charles Reed (1977:19) has observed that 'domestication is not a clean-cut concept' and that the taming of wild plants and animals merges gradually into full domestication. Finally, biologist Marston Bates (1968:22) has suggested that the term 'cultigen' be used to refer to fully domesticated animals, as well as to plants, and that the term 'captive' be used to refer to animals and plants 'that man keeps purposively, but that he has not modified through breeding'.

In pre-European times only three domesticated animals - the dog, the pig and the fowl - were kept by the native peoples of the Pacific (Australia, Melanesia, Micronesia and Polynesia). Two initial points need to be stressed concerning these domesticated animals of the Pacific. First, the typical Pacific triad of dog, pig and fowl was not present everywhere within the Pacific region. Second, the degree of control that human groups exercised over each of these three animal species varied from place to place, with pigs, for example, being customarily 'captured' in one place while being carefully and purposely bred (as 'cultigens') in another.

Urban (1961:Map I) has published a useful map illustrating in a general way the geographic distributions of the dog, pig and fowl in the Pacific. Urban, however, focuses specifically on the domestic animals of Polynesia, and his map is constructed at too small a scale to describe adequately the complex patterns of animal domestication in the southwest Pacific, defined here as including Australia (with Tasmania) and Melanesia (New Guinea and the island chains from the Bismarck Archipelago eastward to Fiji).

The goal of this paper is to expand on Urban's work by presenting a series of maps illustrating in detail man's relationships with the various animal 'cultigens' and 'captives' of the aboriginal southwest Pacific. In addition, the maps will be used to develop certain hypotheses concerning the historical geography of animal domestication, not only in the southwest Pacific but in nearby Southeast Asia as well.

EARLY MAN AND AGRICULTURE IN THE SOUTHWEST PACIFIC

Before describing the historical geography of man's animal associates in the southwest Pacific, it will be helpful to review briefly the historical geography of the presence of man himself in the region. Hominid remains date as far back as the middle Pleistocene in central Indonesia (the famous 'Java man' or Homo erectus fossils) (Clark 1977:5), but to the east, across 'Wallace's Line', the earliest archaeological evidence of the presence of man dates only to ca. 33,000 BP in Australia, at Lake Mungo in New South Wales (White and O'Connell 1979:21), and to ca. 27,000 BP in New Guinea, at Kosipe in the Papua New Guinea Highlands (White and Allen 1980:728).

Since the earliest human sites in Australia have been found on the far side of the continent from Indonesia, archaeologists are in general agreement that the date of man's earliest arrival in Australia-New Guinea (then joined because of lowered Pleistocene sea levels) can safely be pushed back to perhaps 50,000 BP (Jones 1979:460; White and

1For discussion and critique of the significance of Wallace's Line to zoogeography see Mayr (1944) and Simpson (1977).
Most probably it was the development of some sort of elementary watercraft that gave man (and no other placental mammals except bats, rats and man’s domesticates) access to the isolated, marsupial-dominated Australia-New Guinea landmass (Jones 1977:358).

At the end of the Pleistocene two events occurred of significance to the historical geography of man and his domesticates in the southwest Pacific. First, rising sea levels flooded the area that was to become Bass Strait, separating the early human inhabitants of Tasmania from the Aborigines of the Australian mainland. This event, dated to about 12,000 BP (Jones 1979:457), resulted in a cultural and genetic isolation of Tasmania that was to last until almost AD 1800. The second significant post-Pleistocene event was the initial settlement of the islands eastward of New Guinea, where the earliest human site so far discovered (Balof shelter on New Ireland) dates to ca. 7000 BP (White and Allen 1980:730). Distant New Caledonia seems to have been reached by ca. 4000 BP (Pawley and Green 1976:54-57); Tonga, apparently the first Polynesian archipelago to be settled, was inhabited by ca. 3000 BP (Bellwood 1976:153).

The earliest human settlers of Australia and New Guinea were certainly at the hunting and gathering level of subsistence (Brown 1978:269; Bulmer 1968:306), a way of life that survived until European contact among the Aborigines of Tasmania and the Australian mainland. Archaeological evidence, however, indicates that agriculture arrived surprisingly early in the southwest Pacific, diffusing eastward out of Southeast Asia. Golson (1977b:612-14), the excavator of a series of sites in the Papua New Guinea Highlands near Mt Hagen, maintains that intensive agricultural practices, including drainage, mounding and tillage, were undertaken by cultivators in the local area by 9000 BP. The crops grown have not been identified but were probably tuberous crops having their origin in the even more ancient agricultural and para-agricultural traditions of Southeast Asia (Barrau 1965; Burkill 1951; Sauer 1952; Solheim 1972).

The earliest archaeological evidence of the dog, pig and fowl in the southwest Pacific includes dog ('dingo') bones found at Mt Burr, in South Australia, and dated to between 9000-7500 BP (Mulvaney 1969:179). Pig remains found at two sites in the Papua New Guinea Highlands have been dated to the surprisingly early level of ca. 10,000 BP (Bulmer 1976:iv), and soil disturbances discussed as possibly 'pig wallows' from the same area date to ca. 9000 BP (Golson 1977a:46). The earliest remains of fowl in the southwest Pacific appear to be those discovered at a series of sites in eastern Melanesia and dated to the 1st millennium BC (Bulmer 1974:24). Since dog, pig and fowl are not native east of Wallace’s Line, these dates demonstrate that man was quite early manipulating those animals by moving them from place to place.

The remains of fowl from eastern Melanesia mentioned above occur in sites of the ‘Lapita Culture’, identified by archaeologists as indicative of a people ancestral to the Polynesians and certainly speaking a language or languages of the great Austronesian (or Malayo-Polynesian) language family (White 1975:151). These ‘Lapita’ people seem to have appeared in island Melanesia by 6000 BP (Pawley and Green 1976:54-57). They were, as we have seen, in Tonga by 3000 BP and by AD 1000 they had reached far-distant Hawaii, New Zealand and Easter Island (Bellwood 1979:361).

Widespread among traditional human groups throughout the world is the penchant for keeping as pets the young of animal species captured in the wild. One may assume that this trait, common today in both Australia and Melanesia, was carried into the Pacific by the earliest human settlers of the region. Animals commonly kept as pets by Australian Aborigines today include baby wallabies and kangaroos, small cuscus (Phalanger spp.), emu chicks, and even various lizards (Baglin and Moore 1970:53; Kimber 1976:143; Kolig 1978:93; Tindale 1974:109). Animals commonly kept as pets by the native peoples of New Guinea include baby wallabies and cuscus, as well as various birds kept primarily for their colourful feathers, which are used for ceremonial decoration (Bulmer 1968:307; Landtmann 1927:441; Sorenson 1976:57). The Gogodala of southern New Guinea even occasionally capture small water snakes (Acrochordus javanicus), which are kept alive for short periods of time largely as an amusement for children. Pet-keeping is likewise reported for the Melanesian islands east of New Guinea; in the Solomons, for example, small cuscus are reportedly kept as pets (Lever 1937:284).
Most pet birds in the southwest Pacific appear to be wild birds captured from their nests as chicks and kept especially for their plumage. The Motu of coastal Papua, for example, keep various species of colourful parrots and cockatoos tied to sticks placed near their homes (Turner 1878:496). Most pet mammals appear to be infant animals captured in the hunt, usually following the slaughter of the mother. Such captives are kept alive primarily for the amusement of children or perhaps to satisfy the mothering longings of human females; usually such pets do not survive in captivity for very long. Among ‘joey’s’ (baby kangaroos) kept by Australian Aborigines, for example, the usual fate is either to be killed and eaten by their hungry human captors or to be killed and devoured by the even more hungry camp dogs (Kolig 1978:93-94). Among certain groups, as among the Papuans of the Schrader Mountains, captive live birds are used as decoys in hunting other members of the species (Bulmer 1968:310). In Australia when wild kangaroos are plentiful, rather than kill them immediately,

... some [Aboriginal] tribes maim them and move them into territory in which there is enough fodder ... to keep them alive. They then kill them at their leisure and as they need them [Terry 1974:135].

Both of these practices, the use of live decoys and the ‘herding’ of wounded game animals, appear to be rare.

Evidence that pet-keeping is an ancient practice in this part of the world can be seen in the geographic pattern of wild animal distribution on both sides of Wallace's Line. Alfred Wallace (1869:160) himself first suggested that the wild deer of the island of Timor (east of ‘his’ line) had been introduced there by man, ‘for Malays often keep tame fawns’. Later research has suggested that the macaque monkey, the civet cat and a species of cuscus were also introduced to Timor by man (Bellwood 1979:217-18), the macaque and civet coming from the west, the cuscus from the east. As well, evidence indicates that early humans, transporting captive pets in boats, were responsible for the successful introduction of deer, civets and cuscus to Celebes, where, having escaped from captivity, they became the founders of the wild populations of those species now ‘native’ to that island (Groves 1976:207-9).

We may describe the instances of pet-keeping mentioned above as ‘random’, that is, the animals involved are usually not sought out especially for captivity, their importance to the groups keeping them is minimal, and they are usually not kept alive for long periods of time. This contrasts markedly with the more limited practice which we might term ‘institutionalised’ pet-keeping. One important case of such ‘institutionalised’ pet-keeping is evident in the relationship of various Australian and New Guinea groups to the wild cassowary.

**CASSOWARY REARING**

The cassowary is one of the largest land animals native to the southwest Pacific. The term ‘cassowary’ refers to a single genus containing three separate species of quite large, flightless birds, members of the ratite group which also includes the ostriches of Africa, the rheas of South America, the kiwis of New Zealand and the emus of Australia. The dwarf cassowary, *Casuarius bennetti* (the smallest of the genus with a body weight up to 23 kg) is the most wide-ranging species, being found widely in New Guinea and New Britain, from sea level up to some 3000 m. *C. unappendiculatus*, which weighs up to 45 kg, is found in the lowland forests and savannas of northern New Guinea, while *C. casuarius*, of the same weight, is found in the lowland forests and savannas of southern New Guinea, the eastern Cape York Peninsula of northern Australia, and also on the islands of Aru and Seram, to the immediate west of New Guinea (Ellen 1978:17; Rand and Gilliard 1967:608-9; Schodde 1972; Thomson 1955; Wallace 1857:477).

All three species of cassowary are widely kept as pets throughout the natural range of the genus (Table 1a, 1b; Fig.1). Among the agricultural Maring of the Papua New Guinea Highlands, for example, men commonly capture cassowary chicks after watching the eggs hatch on the nest of the wild parents. The chicks, as a result of constant handling and feeding by their masters, quickly become tame, a natural consequence of the ‘imprinting’ process. When the chicks are about one year old and begin to become dangerous, they are confined within a specially constructed stockade. No longer permitted to range freely to find much of their food supply, they are now provided with all of their food, consisting largely of sweet potatoes. As adults the birds are killed, always at some sort of ceremonial
Ethnic group | Location | Reference
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Aborigines (Atherton Tableland) | North Queensland, Australia | Campbell 1965:210
Aborigines (Cape Grafton) | North Queensland, Australia | Tindale 1974:109
Aborigines (Cape Sidmouth) | North Queensland, Australia | Campbell 1965:210
Aru islanders | Aru Island, Indonesia | Wallace 1857:477
Baining | New Britain, Papua New Guinea | Laufer 1965:41
New Guineans | New Guinea | Austin 1950:206;
 | | Reid 1978-79:418;
 | | Reay 1959:6;
 | | Sorenson 1976:57
Nuualu | Seram Island, Indonesia | Ellen 1978:17

Table 1a  Groups rearing cassowaries

Ethnic group | Location | Reference
---|---|---
Karam | Madang Province, Papua New Guinea | R.N.H. Bulmer 1967:12
Aborigines south of Cape York Peninsula | Australia | Groups living beyond the natural range of *Casuarius* spp.
Tasmanian Aborigines | Tasmania |
Melanesian islanders east of New Britain | Melanesia |

Table 1b  Groups not keeping cassowaries

occasion, and the meat consumed (Clarke 1971:89; Rappaport 1968:56). There are apparently no reports of cassowaries breeding or being encouraged or allowed to breed in captivity.

Most New Guinea groups keep cassowaries alive primarily for their feathers, which are favoured for use in ceremonial decoration. The birds also find an important place in ceremonial exchanges, such as, for example, the te cycle of the Enga (Meggitt 1974:170). The birds are also used as items of exchange in long-distance trade networks, particularly in the New Guinea Highlands (Nilles 1943-45:3); they also serve as part of ceremonial bride prices (Rappaport 1968:56). There is one report, concerning the Mailu of New Guinea’s southeastern coast, that captive cassowaries are sometimes used as decoys to lure wild birds within easy range of human hunters (Malinowski 1915:604).

As mentioned above, the capture and maintenance of live wild cassowaries is common practice throughout the geographic range of the genus. In New Guinea the practice is known among nearly all ethnic groups, from, for example, the lowland-dwelling Turamarubi (Austen 1950:206), Gogodala and Kamula to the Mendi, Kuma and Fore of the Highlands (Reid 1978-79:418; Reay 1959:6; Sorenson 1976:57). A search of the ethnographic literature has revealed only one New Guinea ethnic group who expressly do not keep captive cassowaries. These people, the Karam of the Papua New Guinea Highlands, believe that if live cassowaries enter their homesteads or gardens, their pigs, taro and bananas would be harmed. Consequently, the Karam taboo the keeping of live cassowaries (Bulmer 1967:12).

Captive cassowaries are kept by peoples living on various islands offshore from New Guinea, for example, among the Nuualu of Seram (Ellen 1978:17), the Aru islanders (Wallace 1857:477), and the Baining of New Britain (Laufer 1965:41). Cassowary feathers were traditionally traded south from New Guinea into the islands of Torres Strait, between New Guinea and Australia (Moore 1979:171); field research, however, has produced oral evidence that in the past, live birds were occasionally exported from New Guinea to various islands in the strait, islands where the birds are not native (Haddon 1932:226).

With reference to the Australian Aborigines, there are at least three reports of the
keeping of captive cassowaries among groups occupying the Cape York Peninsula. These groups occupy the areas around Capes Sidmouth (Campbell 1965:210) and Grafton (Tindale 1974:109) on the east coast of the peninsula, as well as the Atherton Tableland in the interior (Campbell 1965:210). Unlike the cassowary-rearing groups of New Guinea, the Australian Aborigines keep their birds alive only until they become dangerous and aggressive at about one year of age. Then, rather than being penned in stockades as in New Guinea, the birds are slaughtered by the peripatetic Aborigines (Tindale 1974:109), who cannot be tied down to any one particular place to care for their ‘captives’.

This practice of cassowary rearing deserves to be called ‘institutionalised’ pet-keeping. The cassowary is, in Bates’ (1968:22) terms, a ‘captive’: no attempt is made, either in New Guinea or in Australia, to breed such a large and dangerous bird in captivity. The practice is ‘institutionalised’ in the sense that it is such a common and widespread practice that the groups keeping cassowaries have normal and generally accepted modes of behaviour associated with it. In New Guinea and nearby islands the captured chicks wander freely for about one year, and then when they become dangerous are penned up until their eventual slaughter. In Australia, on the other hand, the chicks are kept for one year only, and then are killed and their flesh consumed.

**DOG REARING AND DOG BREEDING**

Unlike the cassowary, the dog (*Canis familiaris*) is not native to the southwest Pacific. Thus the dogs found there today must at some time in the past have been introduced there by man from the nearby Indonesian islands. At European contact dogs were associated in one way or another with most indigenous groups in the southwest Pacific (Table 2, Fig.2), with Australian Aborigines, with the native peoples of New Guinea, and with the peoples of all of the Melanesian archipelagoes with the exception of New Caledonia.

<table>
<thead>
<tr>
<th>Ethnic group</th>
<th>Location</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aborigines (Bass Strait Islands)</td>
<td>Between Australia and Tasmania</td>
<td>Jones 1970:258</td>
</tr>
<tr>
<td>Aborigines (Bentinck Island)</td>
<td>Gulf of Carpentaria</td>
<td>Tindale 1974:120</td>
</tr>
<tr>
<td>Aborigines (Kangaroo Island)</td>
<td>Off coast of South Australia</td>
<td>Jones 1970:258</td>
</tr>
<tr>
<td>Aborigines (Tasmania)</td>
<td>Tasmania</td>
<td>Jones 1970:258</td>
</tr>
<tr>
<td>Bellona islanders</td>
<td>Highlands of Irian Jaya</td>
<td>Lambert 1931:162</td>
</tr>
<tr>
<td>Kapaauku (Ijaaj-Pigome subgroup)</td>
<td>Vanuatu</td>
<td>Pospisil 1963:203</td>
</tr>
<tr>
<td>Malekula</td>
<td>Madang Province, Papua New Guinea</td>
<td>Deacon 1934:16</td>
</tr>
<tr>
<td>Maring (Tsembaga subgroup)</td>
<td>New Caledonia</td>
<td>Rappaport 1968:56</td>
</tr>
<tr>
<td>New Caledonians</td>
<td>Solomons</td>
<td>Sterly 1962:100</td>
</tr>
<tr>
<td>Ontong Java islanders</td>
<td>Santa Cruz Islands</td>
<td>Titcomb and Pukui 1969:57</td>
</tr>
<tr>
<td>Santa Cruz islanders</td>
<td>Vanuatu</td>
<td>Forster 1777:56</td>
</tr>
</tbody>
</table>

Table 2 Groups lacking dogs

There are, however, in scattered locations throughout the southwest Pacific various groups who did not keep dogs at the time of earliest European contact. Dogs were missing from most of the islands off the south coast of Australia, including Kangaroo Island, the Bass Strait Islands, and most notably Tasmania. Since dog remains have never been discovered in archaeological sites in any of these areas, one may conclude with Jones (1970:258) that, when these insular areas were first separated from the Australian mainland by rising sea levels at the end of the Pleistocene, the groups occupying those islands did not know the dog. At earliest European contact there were no dogs on Bentinck Island in the Gulf of Carpentaria off Australia’s north coast. In this case, Tindale (1974:120), using evidence from local mythology, suggests that the dog did indeed exist at one time on that island but at some unknown date became extinct.

Turning to New Guinea, the literature reveals two instances of groups - or rather subgroups - who once possessed dogs but who have subsequently lost them: the Ijaaj-
Figure 2  Dog
Pigome Kapauku of the Highlands of Irian Jaya, whom Pospisil (1963:12) believes no longer keep dogs because of a local absence of game animals for hunting; and the Tsembaga Maring of the Papua New Guinea Highlands who recently lost all their dogs to disease (Rappaport 1968:56). In the islands east of New Guinea, dogs were lacking among the native inhabitants of Ontong Java and Bellona, two Polynesian ‘outlier’ islands in the Solomons (Sterly 1962:100; Lambert 1931:162); among the Santa Cruz islanders (Titcomb and Pukui 1969:57); among the peoples of Malekula and Tanna in Vanuatu (Deacon 1934:16; Forster 1777:56); and among the peoples of New Caledonia (Sterly 1962:99). The lack of dogs on Ontong Java, Bellona, Malekula and Tanna can perhaps best be explained by assuming that at some time in the past the inhabitants of those rather small islands did possess dogs, but that during some sort of local crisis in the past (e.g. famine following a typhoon) the animals were entirely killed off, either to provide a convenient source of food, or to eliminate canine competition for scarce food resources.

In many areas of the southwest Pacific where dogs have existed as close associates of man for millennia, feral populations of dogs have become well established. Wild dogs roam vast areas of Australia (Carter et al. 1945:85), and competition from wild dingoes was most probably a critical factor in the post-Pleistocene extinction of the two largest marsupial carnivores, the thylacine (Thylacinus cynocephalus) and the Tasmanian devil (Sarcophilus harrisii), on the Australian mainland (Barker and Macintosh 1979:42). It is instructive to recall that both the thylacine and the devil survived into modern times on the isolated island of Tasmania, where the dog was absent. In New Guinea feral dogs seem to be rare in lowland areas; field investigation turned up no evidence of feral dogs in the Aramia River area of Papua New Guinea’s Western Province, Baldwin (1980:66). Most reports of ‘wild dogs’ in New Guinea come from sparsely populated mountainous areas, for example, the slopes of Mts Wilhelm and Giliuwe (Wade and McVean 1969:30; Bulmer and Bulmer 1964:48) and isolated areas within the Owen Stanley Range (MacGregor 1897:23). Feral dogs are also reported in the Solomon Islands, particularly in the Shortlands Group (Lever 1937:285) and in the mountainous interior of Malaita (Ivens 1930:246-47).

The ‘native’ dogs of Australia and New Guinea are quite similar in appearance, although zoologists tend to classify them differently as Canis familiaris dingo and C. f. hallstromii. Both varieties are usually dun-coloured (but black and/or white animals are not unknown) and about the size and shape of a European terrier. They both apparently lack the ability to bark, but only moan or howl. Although Gould (1980:240) has recently reported barking dingoes among two widely separated Aboriginal groups (assumed by him to be unaffected by interbreeding with European dogs), the majority of researchers agree that both the true dingo (Barker and Macintosh 1979:45; Hayden 1975:13) and the New Guinea dog (Guisinde 1958:568; Heider 1970:55; Turner 1878:495) do not bark, at least until they intermix with introduced European animals. In any case, the dingo and the New Guinea dog almost certainly share a common ancestry, and in this regard one notes that, compared to the domestic dogs of other regions of the world, the dingo and the New Guinea dog, as well as - significantly - the Indian wild dog, possess noticeably larger upper carnassial teeth than those of other breeds of dog (Barker and Macintosh 1979:42).

There is much debate in the literature about just why Australian Aboriginal groups bother to keep dogs. Meggitt (1965a:24) and Kolig (1978:90-91) have questioned the assumed importance of dogs in aiding Aboriginal hunters in their quest for game. Hayden (1975:11-12), however, argues strongly that dogs are indeed useful in helping humans to track, spook, and bring down, game. Hamilton (1972), on the other hand, argues that there exists some sort of primal nurturing urge that provides the incentive for Aborigines, particularly Aboriginal females, to care for, fondle, and even breast-feed their dogs. It cannot be denied that dingoes do act as scavengers around Aboriginal encampments, keeping the areas relatively free of garbage, and that on cold nights people will sleep with their dogs for added warmth (Tindale 1974:109). Kolig (1978:109) has argued that the dingo ‘serves as guard against supernatural threats’, that is, that the recognised superior sense perceptions of Canis familiaris somehow enable the animals to warn of the presence of sorcerers, ghosts or evil spirits. Not mentioned by Kolig, but also of importance to a full understanding of why Aborigines keep dogs, is the fact that the animals do indeed warn people of rather less supernatural dangers (e.g. enemies and wild animals, especially

2 Thylacines survived long enough on the Australian mainland, however, to be depicted in Aboriginal rock paintings (Clegg 1978).
snakes). Aboriginal groups generally make little if any effort to provide food for their adult dogs, although small puppies may be breast-fed by the women (Simoons and Baldwin 1982:426). Food for camp dingoes consists of 'any offal or scraps of human food discarded or left incautiously about' (Tindale 1974:109).

In New Guinea as in Australia the most widespread economic use for dogs is as aids in the hunt, for example, among the Dani (Heider 1970:35), Saiyololof (Hatanaka and Bragge 1974:56), Kwoma (Whiting and Reed 1938:183) and Gogodala. Many Gogodala men possess packs of 10-20 hunting dogs which accompany the men into the bush, where together they spook and chase game (wild pigs, cassowaries, or wallabies), and in many cases it is the dogs that do the actual killing. Of course, a man must take care not to fall too far behind his dogs in the chase or by the time he arrives at the scene of the kill little meat will be left to carry back to the village. Hunting with dogs is also reported for the island chains east of New Guinea (e.g. Armstrong 1928:19; Bell 1946-49:233; Bogesi 1948:227; Clay 1977:17).

The eating of dog flesh is only an occasional practice in the southwest Pacific. Simoons (1961:178), in his comprehensive survey of meat taboos, reported only five societies in Melanesia east of New Guinea which commonly consume dog flesh. Dog eating does occur in New Guinea, but its geographic aspects have not been worked out in detail. The Gogodala, for instance, react with abhorrence to the idea of eating dog flesh, although their immediate neighbours in the Bamu River region to the east are said to consume it eagerly. Among the Gogodala, as among other New Guinea groups, little effort is made to feed the village dogs, except that garbage is frequently tossed their way. As in Australia, however, small puppies are occasionally breast-fed by women, particularly if a pup is rejected by its mother.

It seems appropriate to divide geographically the dog-keeping tradition of the southwest Pacific into two subregions: an area limited to Australia where 'dog rearing' is the dominant form of dog husbandry, and an area, embracing all of Melanesia except New Caledonia, where a certain degree of 'dog breeding' is practiced (Fig.2). Among many, if not all Aboriginal groups, the most common way of acquiring dogs is to capture dingo pups in the wild, bring them back to the camp, and then rear them as camp dogs. Such capture of wild pups is widely reported (Basedow 1925:88-89; Kimber 1976:143; Thomson 1972:52; Tindale 1974:109). Among at least one Aboriginal group, the women sometimes break the leg of a recently captured puppy to keep it from straying from the camp (Meggitt 1965:15). Pups brought back to the camp, besides adding to the supply of camp dogs, could also serve as a subtle yet 'visible display of hunting success' (Kimber 1976:143). Dogs will and do breed in the Aboriginal encampments, but there is no evidence that conscious attempts are made by the Aborigines to control the process (Tindale 1974:109). It also seems likely that a camp bitch with newly-born puppies would find it difficult to keep up with the movements of the migratory human-dog symbiotic community, and being left behind, she and her pups would revert to the wild.

In Australia, therefore, there is little differentiation between wild and camp dingoes; they form a single biological population, with continual transfer of genetic material from the wild to the camp and vice versa. Man plays little or no role in the reproduction of dingoes, but he does take an active role in the rearing of captive pups. The fondling of newly-captured wild pups, to say nothing of the pups' taking milk from human females, quite likely causes them to imprint on human beings, a practice which then serves as an effective taming mechanism. All of this constitutes what may be termed the 'dog-rearing' tradition.

In New Guinea and island Melanesia, in contrast to Australia, dogs living in association with man are encouraged to breed. The village site stability of the agricultural peoples of New Guinea and island Melanesia makes it easier for such groups to rear pups in one place from birth to adulthood. Among the Gogodala, for instance, village dogs that are recognised as good hunters are encouraged to mate with other such hunters, in order to 'improve the breed'. And, since wild dogs are only rarely encountered in most parts of Melanesia, there is little interchange of genetic material between the two populations. Consequently what can be considered a fully domesticated dog population, controlled by peoples of the 'dog-breeding' tradition, has developed in the region.

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4Personal experience in New Guinea teaches one that it is very difficult to approach undetected a village in which dogs are kept.

5See Sterly (1962) for a general discussion of the use of dogs in hunting throughout Melanesia.
PIG REARING AND PIG BREEDING

The pig (Sus scrofa) is the most favoured animal in the estimation of the native peoples of Melanesia. To express their feelings, the Enga of the Papua New Guinea Highlands, for example, proudly proclaim that 'Pigs are our hearts' (Meggitt 1974:165). Rare indeed is the Melanesian village whose inhabitants do not keep pigs (Table 3a, 3b; Fig.3). Apparently the only Melanesians to be deprived of the pleasures of pig-keeping are the natives of the Polynesian outliers of Rennell, Bellona (Lambert 1931:162) and Tikopia (Rivers 1914(1):333), as well as the peoples of New Caledonia and nearby islands (Yen 1971:9). Pigs are not kept by any of the Aboriginal groups of Australia, although there is evidence that pigs had been introduced from New Guinea to the Australian continent in pre-European times and existed as a wild population on Queensland's Cape York Peninsula (Baldwin 1983).

Table 3a Pig-rearing groups

<table>
<thead>
<tr>
<th>Ethnic group</th>
<th>Location</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arapesh</td>
<td>East Sepik Province, PNG</td>
<td>Tuzin 1976:268</td>
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<tr>
<td>Aru islanders</td>
<td>Aru Islands, Indonesia</td>
<td>Sperling 1936:134</td>
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<tr>
<td>Asmat</td>
<td>South Irian Jaya</td>
<td>Eyde 1967:61-62</td>
</tr>
<tr>
<td>Ayon</td>
<td>Madang Province, PNG</td>
<td>Gusinde 1958:568-69</td>
</tr>
<tr>
<td>Baktaman</td>
<td>Western Province, PNG</td>
<td>Barth 1975:34</td>
</tr>
<tr>
<td>Buka islanders</td>
<td>Buka Island, PNG</td>
<td>Blackwood 1935:133</td>
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<tr>
<td>Daribi</td>
<td>Chimbu Province, PNG</td>
<td>Wagner 1967:15</td>
</tr>
<tr>
<td>Elema</td>
<td>Gulf Province, PNG</td>
<td>Williams 1940:11-12</td>
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<tr>
<td>Enga (Gadiso subgroup)</td>
<td>Enga Province, PNG</td>
<td>Dornstreich 1973:234</td>
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<td>Etoro</td>
<td>Southern Highlands Province, PNG</td>
<td>Kelly 1977:41</td>
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<td>Gogodala</td>
<td>Western Province, PNG</td>
<td>Baldwin (field notes)</td>
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<td>Goodenough islanders</td>
<td>Milne Bay Province, PNG</td>
<td>Jenness and Ballantyne 1920:20</td>
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<td>Kamoro</td>
<td>South Irian Jaya</td>
<td>Baldwin (field notes)</td>
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<td>Kamula</td>
<td>Western Province, PNG</td>
<td>Eechoud 1962:133</td>
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<td>Kaowerawédj</td>
<td>North Irian Jaya</td>
<td>Williams 1936:224-25</td>
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<td>Keraki</td>
<td>Western Province, PNG</td>
<td>Landtman 1927:44</td>
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<td>Kiwi</td>
<td>Western Province, PNG</td>
<td>Fischer 1968:289</td>
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<td>Kukukuku</td>
<td>Morobe Province, PNG</td>
<td>Whiting and Reed 1938:183</td>
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<td>Kwoma</td>
<td>East Sepik Province, PNG</td>
<td>Crockett 1942:110-11</td>
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<td>Madik</td>
<td>Vogelkop Peninsula, Irian Jaya</td>
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<td>Mailu</td>
<td>Central Province, PNG</td>
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<td>Maring (Tsembaga subgroup)</td>
<td>Madang Province, PNG</td>
<td>Malinowski 1915:606</td>
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<td>Miyammin</td>
<td>West Sepik Province, PNG</td>
<td>Rappaport 1968:70-71</td>
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<td>Namatanai</td>
<td>New Ireland, PNG</td>
<td>Morren 1974:263-64</td>
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<td>Nasiol</td>
<td>Bougainville, PNG</td>
<td>Neuhaus 1962:67</td>
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<td>Ngalum (or Ok Sibil)</td>
<td>Highlands of Irian Jaya</td>
<td>Ogan 1972:27</td>
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<td>Nuauulu</td>
<td>Seram Island, Indonesia</td>
<td>Brongersma and Venema 1962:92-93</td>
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<td>Orokaiva</td>
<td>Northern Province, PNG</td>
<td>Ellen 1978:17</td>
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<td>Purari</td>
<td>Gulf Province, PNG</td>
<td>Williams 1930:60-61</td>
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<td>Sanio</td>
<td>West Sepik Province, PNG</td>
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<td>Townsend 1969:49</td>
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<td>Siassi</td>
<td>Morobe Province, PNG</td>
<td>Salisbury 1962:91</td>
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<td>Sio</td>
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<td>Suki</td>
<td>Western Province, PNG</td>
<td>Harding 1967:158</td>
</tr>
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<td>Tangs</td>
<td>New Ireland, PNG</td>
<td>Harding 1967:86</td>
</tr>
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<td>Tangu</td>
<td>Madang Province, PNG</td>
<td>Baldwin (field notes)</td>
</tr>
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<td>Tor</td>
<td>North Irian Jaya</td>
<td>Bell 1946-49(18):37</td>
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<td>Torres Strait islanders</td>
<td>Between New Guinea and Australia</td>
<td>Burridge 1969:50</td>
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<td>Trobriand islanders</td>
<td>Milne Bay Province, PNG</td>
<td>Oosterwal 1961:70</td>
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<td>Turamarubi</td>
<td>Gulf Province, PNG</td>
<td>Baldwin (field notes)</td>
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<tr>
<td>Umeda</td>
<td>West Sepik Province, PNG</td>
<td>Malinowski 1929:190-91</td>
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PNG = Papua New Guinea

Although widely distributed within Melanesia, pigs are not kept everywhere according to the regimens of the same pig husbandry system. In fact one can identify two distinct pig husbandry systems, as well as two dog husbandry systems, within the southwest Pacific region. In an earlier paper (Baldwin 1978) I classified these two pig husbandry systems as 'pig rearing' and 'pig breeding'. 'Pig rearing' involves the castration of each and every village boar. Thus, in order to maintain the village pig herd, wild piglets are purposely captured alive and reared to maturity in the villages. As well, occasional matings take place between wild boars and village sows, and the resultant progeny are reared as village animals. No intentional breeding of pigs therefore takes place, and the wild and village pigs remain genetically a single interbreeding population. The 'pig-breeding' system, in contrast, involves the intentional breeding of pigs, and the local village and wild pigs consequently form two separate breeding populations.

The Gogodala may be considered as a typical pig-rearing group. When Gogodala men return from hunting expeditions they occasionally carry back with them small piglets, captured after the wild sow has been killed. These piglets are kept tethered in the women's section of the communal longhouse and are given premasticated sago as food. If a piglet refuses the sago a woman will offer it her breast to keep it alive. This practice, and also the women's habits of continually petting, soothing, and carrying their piglets as if they were human infants, serves the critical function of taming the born-wild piglets by imprinting them on a human mother. In effect, the Gogodala have not domesticated the pig; they are continually domesticating it.

All male piglets among the Gogodala are castrated, traditionally with a bamboo knife. Following the operation the severed testicles are placed in a small bag and suspended from the ridge pole of the longhouse. The Gogodala believe that castration keeps the animals gentle and enables them to grow bigger and fatter. The suspension of the severed testicles in the longhouse is said to prevent the pigs from wandering away from the village and reverting to the wild. At maturity Gogodala pigs, male and female, are slaughtered, always as part of some sort of ceremonial or ritual occasion.

In contrast to the Gogodala, the Chimbu of the Papua New Guinea Highlands may be
considered as a representative pig-breeding group. Among the Chimbu,
most [i.e. not all] male pigs are castrated .... [Uncastrated] boars have to be
cared for separately and often become dangerous. Only a few men keep boars,
and charge a fee for their services. This fee might be one of the piglets, or some
valuables ... [Brookfield and Brown 1963:57].

Among the Gogodala the pig-to-man ratio is usually quite low, on the order of 0.1:1.
Among the Chimbu and other such pig-breeding groups, in sharp contrast, the ratio may
rise to 2.5:1 immediately preceding a major feast (Brookfield and Hart 1971:87). Among the
Gogodala the village pigs are allowed to range freely around the village and into the nearby
bush; the animals are encouraged to provide for themselves the great bulk of their food
(garbage, grubs, fruits, etc.). Again in contrast, among the Chimbu and other such groups
the village pigs - and in particular the uncastrated boars - are kept confined or herded under
close human supervision, and must be provided with the bulk of their food (Malynicz 1970;

A survey of the ethnographic literature of the southwest Pacific reveals that of the 62
societies for which a classification can be made, most (i.e. 41, or 66%) belong to the pig-
rearing tradition (Table 3a, 3b). The 21 groups classified as belonging to the pig-breeding
tradition cluster in four general areas: the north coast of New Guinea, the Central Highlands
of Irian Jaya, the Central Highlands of Papua New Guinea, and the Melanesian islands to
the east of New Guinea (Bismarcks, Solomons, New Hebrides and Fiji). One notes that pig
breeding is spatially correlated with: (a) the two Highland New Guinea areas of intensive
agriculture identified by Brookfield and Hart's detailed analysis (1971:111-16) of Melanesian
agriculture; and (b) the areas of Austronesian (Malayo-Polynesian) speech along the north
coast of New Guinea and into the Melanesian islands to the east (Wurm 1975:Maps I, II).

The pig-rearing tradition on the other hand, is most common among Papuan groups
living in southern New Guinea (e.g. among the Gogodala and Kamula), in the Mamberawo-
Sepik Basin of northern New Guinea, and in the Highland areas of central New Guinea
astride the Irian Jaya-Papua New Guinea border6. It also occurs among groups living on
various of the smaller islands to the east of New Guinea. The populations of these islands,
for example, the Siassi of Umboi Island and the Mailu islanders, obtain all their pigs
through trade with nearby peoples who either breed the animals or capture them in the
bush. The islanders themselves, probably because of the limited food resources available on
their islands, elect not to breed their pigs.

This distinction between Melanesian pig rearing and pig breeding has been recognised
by earlier researchers (e.g. Bulmer 1968:304; Watson 1977:61). However, as far as I am
aware the maps presented here and in an earlier form (Baldwin 1978:24) are the first to
depict cartographically the geographic distributions of the two traditions.

THE 'DOMESTIC' FOWL

The fowl (Gallus gallus) has been described as being 'largely coastal in distribution' within pre-European Melanesia (Chowning 1977:26). A search of the ethnographic
literature, the results of which have been depicted cartographically (Table 4a, 4b; Fig.4),
reveals this indeed to be the case.

Chickens are widely kept by the peoples of eastern Indonesia, for example on Timor
(LeBar 1972:98), Seram (Ellen 1978) and the Aru Islands (Wallace 1862:131). They are also
widely kept by peoples living along the north coast of New Guinea: the Biak (Jansen 1959:5),
Waropen (Held 1957:313), Karkar islanders (McSwain 1977:5) and Gawa (Hogbin 1951:55),
for example. In southeastern New Guinea, chickens are present among the coastal Motu
(Allen 1978:428), Elema (Williams 1940:11) and Purari (Williams 1924:27). Fowl are almost
universally kept in the Melanesian islands east of New Guinea, in the Trobriand, Bismarck,
Solomon, Vanuatu and Fiji archipelagoes, as well as in New Caledonia. In the interior of
New Guinea, fowl appear to be commonly kept only in the lower Sepik River Basin of the

6Two Papua New Guinea ethnic groups seem to be divided into pig-rearing and pig-breeding subgroups. The Bomagai-Angoiang Maring, as described by Clarke (1971:84-85), castrate their male piglets and prefer to have their village sows mate with fully virile wild boars, while the nearby 'sembaga Maring, as described by Rappaport (1968:70-71), do breed their pigs. Among the Gadio Enga 'all sows mate with wild boars' (Dornstreich 1973:234), while among the nearby Mae Enga, deliberate pig breeding is practiced (Meggitt 1965b:239). One notes that both of these groups, the
Maring and the Enga, are 'transitional' in culture between the truly intensive horticulturalists of the Wahgi-Chimbu-Asaro Valley systems and the more extensive agricultural and hunting peoples of other (generally lower in altitude) parts of Highland New Guinea (see Brookfield 1961).
### Table 4a

<table>
<thead>
<tr>
<th>Ethnic group</th>
<th>Location</th>
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<tbody>
<tr>
<td>Abelam</td>
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<td>Admiralty islanders</td>
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<td>Alorese</td>
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<td>Du Bois 1961:23</td>
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<td>Amele</td>
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<td>Tuzin 1976:7</td>
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<td>Wallace 1862:131</td>
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<td>Baining</td>
<td>New Britain, PNG</td>
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<td>Banks islanders</td>
<td>Vanuatu</td>
<td>Rivers 1914(1):92</td>
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<td>Blak islanders</td>
<td>Biak Island, Irian Jaya</td>
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<td>Buka islanders</td>
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<td>Blackwood 1935:284</td>
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<td>Elemen</td>
<td>Gulf Province, PNG</td>
<td>Williams 1940:11</td>
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<td>Enga (Raiapu subgroup)</td>
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<td>Waddell 1972:60</td>
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<td>Enga (Yandapu subgroup)</td>
<td>Enga Province, PNG</td>
<td>Sinnett 1977:28</td>
</tr>
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<td>Espiritu Santo islanders</td>
<td>Enga Province, PNG</td>
<td>Guirt 1958:36</td>
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<td>Fijians</td>
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<td>Codrington 1891:18</td>
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<td>Kajo</td>
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<td>Kalil</td>
<td>New Ireland, PNG</td>
<td>Stephan and Graehner 1907:205</td>
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<td>Karkar islanders</td>
<td>Madang Province, PNG</td>
<td>McSwain 1977:5</td>
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<td>Lau islanders</td>
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<td>Thompson 1949:256</td>
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<td>Howe 1977:102</td>
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<td>Pentecost islanders</td>
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<td>Santa Maria islanders</td>
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<td>LeBar 1972:112</td>
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<td>Woodford 1890:226</td>
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### Table 4b

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<td>Brookfield and Brown 1963:57</td>
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<td>Meggitt 1958:298</td>
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<td>Eastern Highlands Province, PNG</td>
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<td>Highlands of Irian Jaya</td>
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<td>Madang Province, PNG</td>
<td>Clarke 1971:88</td>
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<tr>
<td>Tikopia Island, Solomons</td>
<td>Rivers 1914(1):353</td>
<td></td>
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**Groups keeping fowl**

**Groups with fowl described as 'recent'**
Figure 4  Fowl
north-central part of the island. Such representative lower Sepik groups as the Abelam and Arapesh are reported as keeping fowl (Koch 1968:17; Tuzin 1976:7).

The fowl is apparently only of recent introduction to the New Guinea Highlands. Two subgroups of the Enga, the Raiapu and the Yandapu, are reported by their ethnographers (Waddell 1972:60; Sinnett 1977:28) as keeping fowl, but no indication of the time of introduction is given. Since both authorities state that fowls occupy a place in ceremonial life (the te exchange cycle), it is possible that fowls among these Enga subgroups do antedate European contact (and this has been so indicated on Fig.4). Six other Highlands groups besides the Enga are reported to possess fowl, but in these cases the ethnographers indicate that the birds were obtained only recently, either just prior to European contact or soon thereafter. Among the Gadsup of the Papua New Guinea Highlands, for example, chickens were ‘traded in from the Markham Valley’, apparently recently (Du Toit 1975:165); among the Kapauku of the Irian Jaya Highlands, ‘poultry ... spread into the valley after having been introduced by the Dutch Administration in the Pamiari and Tigi lake regions’ (Pospisil 1963:12).

Finally, although fowl are almost universally kept in the Melanesian islands east of New Guinea, at least one island did not possess fowls at the time of European contact. Tikopia, a Polynesian outlier island lying north of the New Hebrides, apparently at one time did have resident fowl, but the Tikopians testify that they ‘destroyed them on account of the harm done to their gardens’. The Tikopians, however, began to raise fowl once again following European contact (Rivers 1914(1):353).

Ball in his monograph on Pacific fowls suggests that — although Captain Cook reported no fowls in his survey of the east coast of Australia in 1770 - fowls could indeed have been present in Australia by that date. Ball points out that fowls might have been introduced to Australia as a result of the activities of Indonesian traders who had developed contacts with the continental centuries before Europeans arrived in the area (Ball 1933:11). This writer, however, is unaware of any concrete evidence to confirm the presence of chickens in Australia in pre-European times.

In those areas of the southwest Pacific where chickens are kept, the husbandry of the animals is as a rule rather loose. Chickens are described as ‘free-roaming scavengers’ (Clay 1977:17), commonly laying their eggs in the bush (Oliver 1967:34) and probably interbreeding with feral populations which exist in many areas (Bellwood 1979:149). Since little attempt is made to house the birds, the chicks especially fall easy prey to dogs, rats and snakes, and in some areas ‘hawks and other carnivorous birds carry off many of the grown chickens’ (Rappaport 1968:56).

Fowl in the southwest Pacific are only rarely killed for their meat, and reports of eggs being eaten are even more rare. The primary use for the birds is to produce feathers for decoration. Among the Orokaiva of Papua New Guinea, for example, ‘the domestic cock is valued for [its plumage], being mercilessly plucked and bereft of his sweeping tail feathers in order to serve the vanity of his owner’ (Williams 1930:18-19). Among the Tangu, also of Papua New Guinea, ‘ockerels are kept for their feathers, and may ultimately go into the pot .... Eggs are not wanted’ (Burridge 1969:50). And, among the Buka islanders of the northern Solomons, ‘domestic fowls are rarely eaten, and seem to be kept only for the sake of the cock’s tail feathers, which are valued as hair ornaments on ceremonial occasions. The eggs of the domestic fowl are left alone’ (Blackwood 1935:284).

Cock fighting is a common and popular use of fowl in Indonesia (e.g. Featherman 1887:404; Fox 1977:88), and also in various parts of Polynesia, for example in Hawaii, Tahiti and the Tuamotus (Ball 1933:7; Bellwood 1979:149). Surprisingly, however, cock fighting as an organised sporting/gambling activity seems to be unknown in Melanesia.

Since the fowl exists in such a loose relationship to the southwest Pacific groups among which it is found, it is probably prudent to classify the relationship as something less than a fully ‘domestic’ one. On the model of the previous discussions of cassowary, dog and pig ‘rearing’, we might perhaps best classify the husbandry of fowl in the southwest Pacific as ‘fowl rearing’. True ‘fowl breeding’ cannot be said to exist in the region.

**RECENT INTRODUCTIONS**

In the two centuries since European penetration of the southwest Pacific began in earnest, the dog, pig and fowl have been widely adopted by groups which originally did not know them. For example, the Gogodala of Papua New Guinea, once breeding only
dogs and keeping pigs according to the 'pig-rearing' tradition, now purposely breed their pigs (occasionally with introduced European pigs) and keep chickens, first introduced to their villages during the present century. The originally dog-less Tasmanian Aborigines, before their virtual extermination in the last century, quickly adopted European dogs which were well utilised in hunting (Jones 1970). There is also a report that Australian Aborigines living on the fringes of white communities have adopted the (presumably European) pig as a domesticate (Trezise 1969:56).

In addition, certain new animals have been added to the pre-European southwest Pacific triad of dog, pig and fowl. Most significant among these are cats, goats and cattle. The house cat (*Felis catus*) is today a common pet throughout the southwest Pacific (Baldwin 1980), even serving as an occasional source of human food, at least in parts of Australia (Gould 1979:31) and New Guinea (Wallace *et al.* 1974:11). The Tasmanian Aborigines reportedly - and surprisingly - trained European cats to assist in the hunt (Robinson 1966:170). Feral cat populations are now well-established in many parts of both Australia (Rolls 1969:117) and New Guinea (Wallace *et al.* 1974:11). Since many of the cats of New Guinea have noticeably kinked tails (Robinson 1959:329), and since the Aborigines of far-northwestern Australia claim that they knew the cat before the first Europeans arrived in that corner of Australia (Rolls 1969:117), cats may have first spread into at least certain parts of the southwest Pacific in pre-European times from nearby Indonesian islands, the nearest of which are only 300 miles off the coast of Australia and where most of the native cats possess the kinked tail phenotype (Baldwin 1980:62-63).

Another late introduction to the southwest Pacific with possible Indonesian origins is the goat (*Capra hircus*). Goats are now kept by many New Guinea village populations, for example, by the Gogodala, who testify that they received their earliest goats from Europeans sometime in the last two decades. Goats are also now kept as 'camp goats' by certain groups of acculturating Australian Aborigines (Kolig 1978:100). Surprisingly, goat remains have been excavated from two archaeological sites along the New Guinea coast near Port Moresby and have been dated to the 17th century AD. This of course is much earlier than the earliest permanent European presence in the area (which in fact began only in the late 19th century). The earliest European visit to southern New Guinea was that of the Torres expedition of 1606, but there is no evidence that any goats were left behind by Torres on the Papuan coast. Rather, Susan Bulmer (1979:18), the excavator of the sites in which the goat remains have been found, has suggested that the animals 'could have been introduced [to New Guinea] by Indonesian voyagers or traders'. When Europeans did arrive permanently on the Papuan coast in the late 19th century, local groups such as the Motu were definitely not keeping goats. Perhaps the best interpretation of the evidence is that occasional goats were adopted by coastal Papuans, obtaining them either from passing European vessels or more probably from Indonesians, but that these occasional acquisitions were never numerous enough to form a breeding, self-generating population.

Cattle (*Bos taurus*) were apparently first introduced to New Guinea by German colonists in the late 19th century (Connell 1979:587), and relatively small breeding populations of cattle, raised primarily for their meat, have been maintained since then. Some New Guinea groups have even transferred to cattle some of the prestige and status once reserved for their pigs. One commentator has specifically noted that 'there is a widespread desire among Melanesians to own cattle both for prestige of ownership and as a source of meat and wealth' (Anderson 1962:133).

Besides the cat, goat and cattle, other domestic animals have been introduced to various areas of the southwest Pacific over the last two centuries, particularly to Australia where many species have escaped to form feral populations, often with major implications for the stability of local ecosystems. Recent research (e.g. McKnight 1976; Rolls 1969) has focused on the role of these animals, including such exotic species as the water buffalo and the dromedary camel, in modifying the biogeographic pattern of Australia.

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7 Both cats and goats, however, successfully spread from Indonesia to the Philippines in pre-European times. The Magellan expedition reported both species, besides the expected Pacific triad of dog, pig and fowl, on one of the Philippine islands in 1521 (Harris 1814:17).
DISCUSSION

Bellwood (1979:135) has recently noted that there exists within the southwest Pacific:

... an observable gradation in economies ... from non-cultivation right through to intensive cultivation, and, if we perhaps exclude wet-rice, at no point is there any marked break in this gradation.

Indeed, it is possible, with respect to the geographic distribution of the domestic animals in the southwest Pacific, to speak of a ‘domestication continuum’ in the region. The maps constructed for this paper (Figs 1-4) serve to illustrate this continuum. In fact, by drawing a line northward from Tasmania across Australia to the north coast of New Guinea, and then by sampling societies along that line, we see a gradually increasing complexity to man’s relationship with and control over the animal world. The isolated Tasmanian Aborigines possessed no domestic animals, not even the dog, and practiced only a rather random sort of pet-keeping. The Aborigines of southern and central Australia, however, enjoy a rather loose relationship with a variety of dog, the dingo; this rather elementary relationship can be termed ‘dog rearing’ since little attempt is made to breed the animals, and indeed the Aborigines seem to prefer to capture small live pups in the wild rather than have their dogs whelp in camp. On Australia’s Cape York Peninsula, meanwhile, other Aboriginal groups have entered into a similarly rather loose relationship with the cassowary, which like the dingo is captured live in the wild and then reared in captivity.

Across Torres Strait from Australia, the Gogodala of southern New Guinea also rear cassowaries. The Gogodala, however, do give some attention to the breeding of their dogs. Unlike the Aborigines of Australia they keep village pigs, but under a rather loose system of ‘pig rearing’, piglets always being captured live in the wild. All male piglets are castrated, and the piglets, both male and female, are raised to maturity, eventually to be slaughtered at some ceremonial or ritual occasion. In the central Highlands of New Guinea, meanwhile, groups such as the Chimbu keep cassowaries and breed not only their dogs but also their pigs, usually by keeping a few stud boars expressly for that purpose. Finally, along the north coast of New Guinea, among the Waropen of Irian Jaya, for example, cassowaries are kept, both dogs and pigs are purposely bred, and a new addition, the fowl, is added to the domestication repertory. Little attempt is made, however, to control the fowl, which is kept primarily for its plumage. Since no attempt is made purposely to breed the fowl, I suggest using the term ‘fowl rearing’ to describe the relationship.

In the islands of Indonesia and on the nearby Southeast Asian mainland, more intensive systems of animal husbandry can be found than those found in New Guinea. These occur in association with the more intensive, wet-rice *sawah* agriculture characteristic of the region (Geertz 1963), and include, in addition to the breeding of dogs, pigs and fowl, the breeding of a number of other fully domesticated animals (e.g. cats, goats and ducks). Especially important is the breeding of cattle and water buffalo for use in ploughing, an agricultural practice totally unknown east of Indonesia.

Nevertheless, the distinction between the ‘rearing’ and the ‘breeding’ of animals is as evident among at least some of the diverse peoples of insular and mainland Southeast Asia as it is among the peoples of the southwest Pacific. The general Southeast Asian pattern is that the culturally dominant peoples who practice wet-rice farming seem universally to breed all of their animals, and thus the relationships can be said to attain a state of full domestication. In contrast, the more isolated and culturally ‘backward’ peoples of the region, particularly those who still practice hunting and gathering or who cultivate root crops as staples (Burkill 1951), practice various forms of animal rearing. For example, pig rearing (i.e. the capture of live wild piglets for rearing in captivity) is reported for the Agta of the Highlands of Mindanao, the Nicobar islanders, and the Semai and Naga of the southeast Asian mainland (Peterson 1978:2; Heine-Geldern 1963:129; Dentan 1968:34; Hutton 1921:71, 223).

The geographic evidence so far presented may be used to reconstruct certain details of the origin and diffusion of man’s animal domesticates in both Indonesia-Southeast Asia and in the southwest Pacific. Since it is now generally agreed that domestication must be considered, not as a single historical event, but rather as a long evolutionary process involving very gradual shifts in the relationships between man and the organism or organisms he is attempting to manipulate (Johannessen 1966; Lynch 1973), one might assume that some traces of man’s early attempts at domestication would be evident in the ethnography of human groups still relatively isolated from the major technological
developments of the last five or six millennia. It seems more than likely that the institutionalised rearing of captive wild animals to maturity is, as it were, the 'missing link' between the hunting of wild animals, on the one hand, and the breeding of fully domesticated and genetically modified animals on the other.

Many authorities have argued that the Pacific triad of dog, pig and fowl first entered into a close association with Homo sapiens somewhere within the general region of Southeast Asia. The geographer Carl Sauer (1952:28-32), for example, argued strongly that the domestication of these 'household animals' developed as a consequence of a long tradition of pet keeping by indigenous peoples in the area. From Southeast Asia then, the dog, pig and fowl diffused into the Pacific along with those root crops (taro and the yams especially) also originally domesticated in Southeast Asia (Sauer 1952:32-33).

Since the archaeology of Southeast Asia is still little known, only tentative dates can be given for the beginnings of the process of animal domestication in that area. Dogs date to the 5th millennium BC in China, and to the 4th millennium BC in Thailand, at the site of Non Nok Tha (Bellwood 1976:162). This is much later than their earliest archaeological presence in Southwest Asia (14,000 BP at Palegawra Cave in Iraq) and in the New World (13,000 BP, at Jaguar Cave in Idaho) (Harlan 1976:94-95). But since Southeast Asia lies in an intermediate position between Iraq and Idaho, it is not unreasonable to assume that dogs were associated with man there, at least as early as they were in Iraq and Idaho. Direct archaeological evidence of this, however, has not yet been unearthed.

Among the earliest pieces of evidence relating to man's manipulation of pigs comes in fact from New Guinea where archaeological evidence, cited earlier, indicates the presence of pigs by roughly 10,000 BP. Since pigs are not native to New Guinea, the presence of pigs in archaeological sites this early indicates that man had at some even earlier date transported them eastward across Wallace's Line. The earliest evidence of domestic pigs in Southwest Asia is slightly later than the New Guinea evidence, dating to about 9000 BP at Cayönü in Turkey (Harlan 1976:94-95). In the Southeast Asia-Indonesia area, meanwhile, some sort of pig husbandry must date back before 10,000 BP in order for the region to have been the source for the pigs present in New Guinea at that date. Pig teeth, evidently used as charms or pendants, have been found in association with a human burial at Niah Cave on the island of Borneo; these date to ca. 22,000 BP (Medway 1958:638). There is, of course, at this early date no suggestion of domestication, but the burial does indicate a ritual interest in pigs at a quite early date. The earliest possibly domestic pigs in Southeast Asia are some animals, the bones of which have been excavated at Spirit Cave in Thailand, from a stratigraphic level dating between 12,000-8500 BP (White 1975:136).

The earliest domesticated fowl are documented for the Indus Valley civilisation of southern Asia and date to the period 5000-4000 BP. Geographer George Carter (1971:185) argues, however, that the initial domestication process must have taken place well to the east of the Indus Valley region, since wild jungle fowl (the ancestral species) are not native to the Indus Valley, and that this must have occurred somewhere in Southeast Asia ('Burma and eastward') at least a millennium earlier than the Indus Valley dates, that is, as early as 6000 BP.

Summarising the Southeast Asian evidence, one may assume that man was initiating experiments in animal domestication in this region at quite early dates: with the dog by about 14,000 BP, with the pig by about 12,000 BP, and with the jungle fowl by about 6000 BP. The evidence for the dog is admittedly the most tentative.

Our next step is to match the known archaeological evidence with the cultural geographic evidence presented earlier, in order to suggest a rough reconstruction of the historical geography of animal domestication in the southwest Pacific. As Sauer and most other researchers have recognised, the domestic animals of the southwest Pacific (the dog, pig and fowl) were initially introduced into the region from the west, that is, from Southeast Asia and Indonesia. The evidence of geographic distribution indeed suggests that these three domesticates did not diffuse into the Pacific as components of a single cultural complex. The dog most probably was the first animal to be introduced into the Pacific by man; this must have taken place well before 9000 BP, the approximate time of the earliest

Geographer John Winslow (pers. comm.) has gathered evidence he believes suggests that pigs could indeed, by swimming, have reached New Guinea on their own, without the aid of man. Most other researchers, however, agree with Golson (1977a:46): 'It is difficult to see how independently of man [the pig] could have crossed the considerable water barrier separating the eastern Indonesian islands from New Guinea in sufficient numbers to establish viable populations.'
dog remains in Australia. This is also roughly the date for the post-Pleistocene flooding of Bass Strait, which physically separated Tasmania from the Australian mainland. Thus, although dogs were introduced successfully into Australia, they never managed to reach the now-isolated landmass of Tasmania. It can be assumed that the degree of husbandry in this early Australian dog-keeping tradition was rather loose, surviving as it has as the Australian dog-rearing tradition. Man apparently brought the dog to Australia in some sort of primitive watercraft; the animal went feral (successfully preying on the numerous species of unwary marsupials) and the Aborigines developed a symbiotic relationship with the wild dingo, rearing dingo pups in their camps and utilising the adult animals as companions, guardians and hunting aids. At some later date the practice of dog breeding was introduced to the southwest Pacific from the Southeast Asia-Indonesia area, but this more intensive practice did not diffuse across Torres Strait to Australia.

The next animal to be carried from Indonesia to the southwest Pacific was the pig. The earliest New Guinea pigs, like the dogs of Australia, were most probably cared for rather loosely. The animals went feral and the New Guineans immediately and naturally entered into a close relationship with an otherwise wild animal. Wild animals were captured for rearing by man (or rather, by woman), and the New Guinea pig-rearing tradition, simply an eastward extension of an ancient Southeast Asian-Indonesian practice, took shape. One cannot know for certain, but perhaps the practices of dog breeding and pig rearing entered New Guinea at the same time. Man would probably have needed much greater control over the behaviour and genetics of his captive dogs if he were going to indulge in pig hunting as a major pursuit.

The actual controlled breeding of pigs, from the geographical evidence, appears to be a late development in the southwest Pacific. In the ethnographic present the breeding of pigs is largely confined to the Austronesian-speaking peoples of the north coast of New Guinea and of the island chains to the east. The only major exception is that the non-Austronesian intensive agriculturalists of the New Guinea Highlands practice the breeding of their pigs. The geographical evidence is thus quite supportive of the thesis that the Austronesian-speakers introduced pig breeding to New Guinea and to the islands eastward. The New Guinea Highlanders either adopted the practice as a consequence of contacts with Austronesians along the north coast, or as an independent adaptation to a local intensification of food crop agriculture, which brought about a food surplus and a destruction of nearby forests in which wild pigs could easily be procured for the purpose of maintaining a ‘captive’ village pig population (Baldwin 1978:25).

The coastal and insular distribution of fowl in the southwest Pacific, as well as the fowl’s close association with peoples of Austronesian speech, strongly suggest that it was Austronesian speakers who first introduced fowl keeping to the region. The earliest archaeological evidence of fowls in the southwest Pacific dates to the 1st millennium BC. Bones tentatively identified as fowl date to ca. 800 BP at two sites in the eastern Highlands of Papua New Guinea (White 1972:60). If these indeed are the remains of fowl, they perhaps are the remains of isolated individuals sporadically traded into the Highlands from the coastal areas. The native peoples of the local areas, where the supposed fowl bones were found, did not possess ‘domestic’ fowls when first contacted by 20th century Europeans.

The linguistic evidence indicates that peoples of Austronesian speech, relatively late emigrants from Indonesia, have been in Melanesia for at least 6000 years. It was these people, then, coasting along the north shore of New Guinea and eastward through the Melanesian island chains, who most probably introduced the fowl and also the practice of pig breeding to the southwest Pacific. It was also these people, the first Oceanic people to possess the full complement of Oceanic domestic animals, who had carried their way of life into the island chains of Polynesia by the 1st millennium BC. Bones of pig and fowl are commonly found in archaeological sites belonging to the ‘Lapita Culture’, the ancestral culture of the far-flung Polynesians (Bellwood 1979:247; White 1975:151).

Finally, the role of the cassowary in the historical geography of animal domestication in the southwest Pacific remains to be considered. Although ‘random’ pet-keeping, as discussed earlier, is rather common among indigenous peoples of the southwest Pacific, only the cassowary has been brought into an ‘institutionalised’ rearing relationship with man. The captive bird is kept alive not only for amusement or to satisfy human feelings of tenderness towards small and helpless wild creatures; rather a serious attempt is made to rear the animal to maturity, at which time it is slaughtered, always in some sort of ritual
context. This institutionalised rearing of cassowaries is clearly identical in structure to the
dog-rearing and pig-rearing traditions also common in the southwest Pacific. It is an
interesting problem why only the cassowary, of all the indigenous wild creatures kept as
pets in the southwest Pacific, is kept in such a formalised manner. Might it not be that, since
cassowary chicks are striped in a way very reminiscent of small wild piglets, that the idea
took root of capturing these small birds and, in imitation of the way small captive pigs were
handled, rearing them to maturity? Such a practice would necessarily have originated
somewhere in New Guinea or perhaps in nearby Seram or Aru, and could then have spread
across Torres Strait to the areas of northeastern Australia where wild cassowaries occur. It
is pertinent to note here that the planting of wild yams was also practiced on the Cape York
Peninsula of northeastern Australia (Campbell 1965:208), and that a species of taro now
growing wild on the Cape York Peninsula (tentatively identified as Alocasia macrorrhiza) is
believed to have been introduced by man from nearby New Guinea (Harris 1977:433). The
apparently ancient Torres Strait trading system was effective in introducing a number of
cultural traits into Australia (Baldwin 1976:16). Why not the practice of rearing captive
cassowary chicks as well?

CONCLUSIONS

By way of summarising the historical geography of animal domestication in the
southwest Pacific, I would like to present for consideration the following temporal outline:

1. Man first settles the area, by watercraft from nearby Southeast Asia, about 50,000
BP. Random pet keeping (of cuscus, wallabies, kangaroos, emus, cassowaries, etc.)
is practiced. This way of life survives into the 19th century AD on the physically
and culturally isolated island of Tasmania.

2. The dog is introduced into the southwest Pacific area, again from Southeast Asia,
probably as early as 12,000 BP. The husbandry of the animal is only rather loosely
controlled by man. This system, here termed 'dog rearing', survives today in the
traditionally loose relationship of Australian Aborigines to their associated, and
symbiotic, dingoes.

3. The pig is introduced to New Guinea from Indonesia, sometime before 10,000 BP.
Again, the husbandry of the animal is only loosely controlled by man, and a 'pig-
rearing' tradition is maintained. Man elects to rear captured wild piglets rather
than to breed the animals in captivity. It is probable, however, that the full and
complete breeding of dogs is introduced at this time.

4. Austronesian-speaking migrants enter the southwest Pacific around 6000 BP,
bringing with them from Indonesia the fowl and the practice of controlled pig
breeding. These migrants, coasting along the north shore of New Guinea and
through the Melanesian island chains, settle western Polynesian by the 1st
millennium BC. The Pacific triad of dog, pig and fowl is thus successfully
introduced from Melanesia to Polynesia. The practice of pig breeding begins in the
Central Highlands of New Guinea, either as a result of contact with Austronesian
pig breeders or because of an independent development in response to agricultural
intensification in the area.

5. Europeans arrive in the southwest Pacific in the years after ca. AD 1800,
introducing such new animals as the cat, goat and cattle to the peoples of the
region. There is a possibility, though, that at least the cat and goat had been
initially, if hesitatingly, introduced to the region from nearby Indonesia, but at
dates certainly not much earlier than ca. AD 1600.

One last conclusion seems pertinent to the study of early domestication, not in the
southwest Pacific, but in Southeast Asia. Since the geographical evidence presented here
strongly indicates that the dog, pig and fowl did not diffuse into the Pacific as components
of a single cultural complex, then consequently it is most unlikely that their domestications
took place simultaneously in Southeast Asia.

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paper dealing with pig keeping has been adapted from an earlier paper published in the

9A Gogodala informant once jokingly referred to small cassowaries as 'two-legged piglets'.
REFERENCES


Bahn, P.C. 1978 The 'unacceptable face' of the west European upper Paleolithic. Antiquity 52:183-92


Barker, B.C.W. and A. Macintosh 1979 The dingo: a review. Archaeology and Physical Anthropology in Oceania 14:27-53


Barth, F. 1975 Ritual and Knowledge among the Baktaman of New Guinea. Universitetsforlaget: Oslo

Basedow, H. 1925 The Australian Aboriginal. F.W. Preece and Sons: Adelaide

Bates, M. 1968 Captives and cultigens. Natural History 77(1):22-26

Bell, F.L.S. 1946-49 The place of food in the social life of the Tanga. Oceania 17:139-72, 310-26; 18:36-59, 233-47, 19:51-74


Bogesi, G. 1948 Santa Isabel, Solomon Islands. Oceania 18:208-32, 327-57


Bulmer, S. 1976 The Prehistory of the New Guinea Highlands. Department of Anthropology, University of Auckland: Auckland, Oceanic Prehistory Records No.1

Bulmer, S. 1979 Prehistoric ecology and economy in the Port Moresby region. New Zealand Journal of Archaeology 1:5-27

Burridge, I.H. 1951 The rise and decline of the greater yam in the service of man. *Advancement of Science* 7:443-48


Clegg, J. 1978 Pictures of striped animals: which ones are thylacines? *Archaeology and Physical Anthropology in Oceania* 13:19-29


Crockett, C. 1942 *The House in the Rain Forest.* Houghton-Mifflin Co.: Boston


Featherman, A. 1887 *Social History of the Races of Man: second division, Papuo and Malayo Melanesians.*Ticknor and Co.: Boston


Fischer, H. 1968 *Negua: eine Papua-Gruppe im Wandel.* Klaus Renner Verlag: Munich


Fox, J.J. 1977 *Harvest of the Palm: ecological change in eastern Indonesia.* Harvard University Press: Cambridge

Geertz, C. 1963 *Agricultural Involution: the process of ecological change in Indonesia.* University of California Press: Berkeley


Hamilton, A. 1972 Aboriginal man’s best friend? Mankind 8:287-95


Hayden, B. 1975 Dingoes: pets or producers? Mankind 10:11-15


Ivens, W.G. 1930 The Island Builders of the Pacific. J.B. Lippincott: Philadelphia


Jones, R. 1970 Tasmanian Aborigines and dogs. Mankind 7:256-71


Kimber, C. 1978 A folk context for plant domestication: or, the dooryard garden revisited. Anthropological Journal of Canada 16(4):2-11


Lambert, S.M. 1931 Health survey of Rennell and Bellona Islands. Oceania 2:136-73


Woodford, C.M. 1890. *A Naturalist among the Head-Hunters: being an account of three visits to the Solomon Islands in the years 1886, 1887 and 1888.* George Philips and Son: London.


The term colonisation has been applied often by Pacific archaeologists to the dispersal of humans in adaptive processes of discovery and early settlement. As such, this is consistent with biological terminology, e.g. 'the successful foundation of a new population where none recently existed' (Brown and Marshall 1981:351) - and especially if the concept of secondary colonisation, 'the localised process of range expansion' of ecologists, is less sharply distinguished, as in the case of evolutionary biologists such as Brown and Burdon (1987:115). Indeed this is the case whether Mulvaney (1975) addresses the Pleistocene colonisation of Australia, or Kirch (1984) the eastward expansion of the Polynesians from the Fiji-Western Polynesian region within the two millennia encompassing the Christian era.

There is however, a further form of prehistoric colonisation, for which 'secondary' seems an apt descriptor yet a source of obvious confusion with its ecological meaning. In the sense of the historians' colonies, 'the foundation of a new population where earlier populations are already in occupation', may be an adequate definition for the cultural succession or coexistence that is implied, and perhaps of more importance to culture history. This is not to suggest that local endogenously generated expansion is unimportant, but as Kirch (1985) illustrates for Hawaii, distinctions of extensification and intensification are subsumed in the consideration of overall process of adaptation and social change. The historicist sense in which secondary will be used in this paper can have problems of archaeological recognition; the single or multiple settlements of outer Polynesia, the internal or external source of the Australian small tool tradition, or even of the appearance of the two-piece fish-hook in Polynesia, if material manifestations of change in other cultural correlates remain unclear for definite discriminations. It may well be that this is a function of island size, in which the domain expansion character of primary colonisation (the 'ecological' secondary) is insignificant, as exemplified in the Tikopia sequence (Kirch and Yen 1982). Here the culture of the first Lapita colonisers gave way abruptly to secondary colonisation, while the evidence for a further intrusion suggested a more gradual process of change. Whether this represented a sequence of conquest or repression, then a later colonisation of temporary co-existence is conjectural, but it is certain that while cultural traits associated with the changing social environment could be correlated, the indicators for the secular subsistence and environmental changes offered only an approximately parallel phasing.

The subsistence strategies of colonisation are obviously influenced by the nature of subsistence systems of the immigrants' homelands, and by the environments to which they enter. What we have called the segregation of subsistence systems, with particular reference to agriculture (Yen 1973a), is a reassortment of nature-nurture equations with man as equator. The ethnobiological knowledge that cultivators brought with them was therefore as significant as the transferred biota, and with hunter-gatherers as well as agriculturists, familiarity with elements of wild biota and their environmental associations expedited the process of colonisation and adaptation in volitive directions. In cases of secondary colonisation, however, there is a 'social' environmental factor, the subsistence system whose developmental course is already set, in which case, again using the Tikopia example, there is a sort of exchange of elements, the supplementation of some species, the elimination of others for cultural reasons such as dietary or other restrictions.

Considerations of the complexities of colonisation strategies in Pacific prehistory now transcend the relative simplicity of a quarter of a century ago, when the tenet of agricultural diffusion through the transfer of agricultural species out of Southeast Asia was the rule, while the significance of the developing Australian archaeology was virtually ignored. Curiously perhaps, it was the accent on Australia in a set of papers edited by Mulvaney and Golson (1971) that spelled out the importance of the New Guinea connections in physical
geographic, biological and cultural terms that had their immediate beginnings in the Pleistocene when the two landmasses were joined as the continental Sahul. White (1971) particularly addressed 'the Neolithic problem' of the divergence of the development of subsistence systems - agriculture in New Guinea, the sustenance of hunting-gathering in Australia - and was the forerunner of increasing evidence for independent agricultural development in the northern part of Sahul that was to be one of the themes in his integration (White and O'Connell 1982) of the prehistory of the region.

This paper then, has as its objective an attempt to reconstruct the formation and development of Oceanic agriculture whose final expression was its diffusion into eastern Polynesia. Recent archaeological investigation in the Pacific forms the background for reconsidering the role of subsistence in the colonisation of the island world.

THE SAHUL COLONISATIONS AND AGRICULTURE

The primary, pre-agricultural colonisation of Sahul is now well established with near 40,000 year BP dates in the southeast and southwest of Australia (with 23 others from many parts of the continent in a range of 16-32,000 years) as summarised by Jones (1987), and an 'at least' 40,000 year old site on the northern coastal Huon Peninsula site of New Guinea reported by Groube et al. (1986), exceeding in age the previously discovered Pleistocene Highland site of Kosipe (White et al. 1970). That internal (but hardly local) expansions were accompanied by an outward correspondence appears to be borne out in the recent discovery of a 33,000 year old site on New Ireland (Allen et al. 1988) predating the earliest known in the Bismarck Archipelago previously on New Britain at the terminal Pleistocene. Furthermore, 28,000 years of occupation on Buka Island of the northern Solomons chain (New Guinea) recorded by Wickler and Spriggs (1988) offers a view, perhaps minimal, into the extent of maritime colonisation by the early hunter-gatherers of the Pacific, even allowing for the lower sea levels and consequent shorter distances between islands.

The very magnitude of the Sahul continent might indicate that its colonisation was the product of multiple hunter-gatherer entries through space and time, and the consensus among physical anthropologists, in the absence of archaeological evidence, suggests that the Australian skeletal variabilities could not be the product of a single population. In their review of the situation, White and O'Connell (1982:74) remain open in terms of the New Guinean relationship, but Alan Thorne (pers. comm.) has suggested that more recent studies of the Highlands skeletal material may provide firmer indications in favour of the multiple origin hypothesis. However, Howells' findings (1976) pointing to affinities of the Tasmanians with the Austronesian-speaking Tolai of New Britain may find some archaeological resonance from the recent Pleistocene finds of the Bismarck Archipelago, the linguistic situation notwithstanding.

Whatever the nature of primary colonisation, the essential of time for endogenous agricultural development was conferred by the 40,000 year sequence that is being built up for the Sahul continent and its immediately neighbouring islands. Within that sequence is the divergence, from a common hunter-gatherer base of primary colonisation that was to be maintained in Australia, to agricultural economies through independent development in New Guinea. Domestication, as the key to such development, was enacted largely on the extension of the Indo-Malayan or Malesian flora, and its results were the principal reason for the attribution of completely Southeast Asian origins in the past. For the Sahulian flora shared with island and the coastal mainland Southeast Asia many plant families, genera and even species that resulted in the parallels of much of the economic use of flora between the Australian hunter-gatherers and New Guinea cultivators (Golson 1971). Thus the genetic bases for agricultural development in New Guinea and Oceania were intimately associated with the geological events of Gondwanaland history, for the region is central to the study of plate tectonics and, as Whitmore (1981) and his contributors have emphasised, associated movements of vegetation.

'The Gondwanaland legacy'

Between the middle Miocene and Pliocene, at 15 to three million years ago, the drifting Australian-New Guinea fragment of Gondwanaland that included the present-day Moluccan island group, collided with the Laurasian plate at its margin of the eastern Celebes (Audley-Charles et al. 1981). Thus were brought into contact two floras and faunas that gave rise to the present-day distributions of plants and animals. Such exchange could
thus have provided the evolving substrata for colonising man to exploit similar species over a wide range of natural environments; further, it provided a situation in which domestication through human selection of biota in the more favourable climates of the late Pleistocene and early Holocene could result in coincident yet separate agricultural developments with considerable early resemblances.

On taxonomic relationships, Dransfield (1981) with Palmae and Whitmore (1981:70) considering a wider range of plant families have separated Laurasian (originally Malesian) and Papuasian (of Gondwanaland origin) groups. An example of major importance for utilisation by the primary New Guinea colonists and subsequent domestication is the genus *Metroxylon* or sago palms, whose Gondwanic origins are indicated by its distribution 'in nature, confined east of Wallace's Line' (Dransfield op. cit.:52). *M. sago*, the true sago, is cultivated in the southern Philippines and in central Indonesia, but Brown (1951) and Ochse with Bakhuizen van der Brink (1977) indicate that the species is not found wild in either archipelago. Dransfield (op. cit.), in interpreting the diversity and distribution of six *Metroxylon* species, suggests an 'austral' or Gondwanic origin for the genus, and thus a westerly transfer by either natural exchange or later carriage by man. One of the dominant sago-producing palms of Asia, *Caryota* spp., of wide distribution throughout the rainforest environments of India, Sri Lanka and all of Malesia (Ruddle et al. 1978), is likely to have been an Asiatic contribution to the New Guinea flora. That this was a natural phenomenon finds support in its absence as a food resource or domesticate on the New Guinea mainland. The palm genus *Areca*, occurs as endemic species on both sides of the Wallace Line, with recognisably differing diversities that suggest a convergence of related genotypes after earlier separation. *A. catechu*, the betel nut, however, as a cultigen whose use is again evidenced traditionally through tropical India and Southeast Asia, is almost certainly a cultural transfer.

Our evidence for homologous crop plants of New Guinea and foraged species of the Australians is not strong for Gondwanaland origins but for the taro-yam Oceanic complex, the possibility for Laurasian origin and New Guinea domestication exists as an alternative to Quaternary human transport. Earlier study on the cytology of Pacific taro, *Colocasia esculenta* suggested that diploid forms were brought out of Asia by humans and later were followed by triploid forms (Yen and Wheeler 1968). On reanalysis, using karyotyping of chromosomes in addition to enumeration, and with emphasis on wild forms, especially those used by the Aborigines of northern Australia, Coates et al. (1988) hypothesised a two-line evolution of triploidy, Asiatic and western Pacific, but with the exclusively diploid forms of New Guinea and Australia forming the most likely immediate source of the diploid Polynesian taro. The results of molecular study now being completed on the same material by Matthews (1989, pers. comm.) appears to provide some support for this hypothesis. The dominantly cultivated *Dioscorea* yams of Oceania including New Guinea, *D. alata* and *D. esculenta*, are almost certainly of Southeast Asian origin, and a diffusion from there, but little is known about the New Guinea wild yams (Coursey 1972) that are foraged and sometimes cultivated. *D. bulbifera* is recorded virtually pantropically in the Pacific as a wild plant, with only some notice of cultivated forms from New Guinea and the eastern Solomon Islands; it has formed an important element in the diet of the northern Australian foragers (Jones and Meehan 1989), as it does in northeast Thailand among rice farmers (Joyce White 1989). But despite the fact that endemic species of food yams have evolved in Australia (taxonomy recently published by Telford 1986), *D. transversa* in the north and *D. hastifolia* in the southwest (Hallam 1989) at a latitude as high as the genus is found in the world, there is no firm indication for an earlier than Laurasian exchange to account for this distribution.

The most likely of all the tuberous resources of the Aborigine related to Oceanic crop plants that may have Gondwanaland origins are the *Ipomoea*, and specifically those with a desert distribution. All are basic diploids for the genus, 2n = 30 (Yen et al. ms.), cf. the hexaploid American sweet potato. A notable feature of two of the species, the localised *I. yardiensis* of the west coast and *I. costata* found from that coast, in the valleys of the Kimberley and Pilbara ranges of Western Australia and the central deserts at between latitudes of 15-20°S to the Queensland border, is their woody growth. The plants develop as shrubs, with vining as well as underground rhizomes, surface stolons and prolific seeding habit on sandy soil, and on the coast can become trunked trees of some 5 m in height. There are only three such *Ipomoea* species recorded (A. Jones 1968:100), two diploids from Mexico and Kenya and a tetraploid from Florida. No such forms have been recorded.
in the floras of Southeast Asia. As evidence of an ancient Gondwanaland connection, this is hardly conclusive, but future phylogenetic attention to the genus may produce a firmer hypothesis of ultimate origin. The same may be said for another group of plants of Sahul that did undergo domestication in New Guinea to which further reference will be made, *Canarium* of the family Burseraceae, with distribution in Africa and the Americas, as well as in Southeast Asia. The shift in the centre of speciation of *Canarium* from eastern Malaysia to New Guinea proposed by Leenhouts (1959:328) may be only the end of a long and complex set of changes that Gondwanic history implies.

The vegetational legacy of Gondwanaland and plate tectonics for Sahul thus would seem to be dominated by its later history, the expansion of the Malesian flora through the Laurasian collision. But perhaps there is enough evidence indicating that the primary human colonisation in the Pleistocene was enacted on a flora of mixed derivation, some species of which were the result of evolution in long isolation after the division of the continent that existed over 140 million years ago. Sahul, after the Laurasian collision, was to undergo its own division, with the postglacial rise in sea level of 10,000-8000 years ago, separating New Guinea from Australia. By then, plant domestication had already begun, with evidence for agricultural technology in the Highlands of New Guinea after some 30,000 years of hunter-gathering settlement of the north coast and contiguous islands. That *cultural* isolation of the Australians from the New Guineans was considerably earlier than the geographic seems patent in the total lack of evidence for influence of the northern Sahulian agricultural development that, in terms of world prehistory, could be called revolutionary. Indeed, the Australians had pioneered even the central desert region at over 10,000 years earlier as foragers when "... it was the most difficult of any Australian environment encountered by Pleistocene immigrants ..." (Smith 1987). The Aboriginal forebears were thus already committed to a developmental pathway of subsistence which, despite extremities of regional variability of species exploitation, did not vary from its original hunter-gatherer framework. This adherence was maintained despite the record of possible secondary colonisations in the continent's relatively recent prehistory. These include the arguable external source of the small stone tool tradition, and its rapid spread ca. 5000 years ago, recently reviewed by White and O’Connell (1982:105 et seq.), whose discussion (p.121) appears to favour internal development; the appearance of the dingo, again over a wide range of Australian contexts, at ca. 3500 years BP, which Gollan (1985) cannot attribute morphological resemblance to either island Southeast Asian or New Guinean dogs; contact of the Macassan trepang fishermen from the beginning of the 18th century having considerable cultural impact on the central coastal Arnhem Land Aborigines (Macknight 1972). The naturalisation of the tree *Tamarindus indicus* brought by the Macassans, like the *Dioscorea* yam example previously referred to with regard to New Guinea contacts and the dingo as the only domesticate to maintain a 'partial' status as such in Aboriginal subsistence, may illustrate the absorptive character in the essentially conservative, long-founded production system.

### New Guinea agriculture I: the domesticates

The hypothesis for the independent origins of New Guinea agriculture is founded on two constructions, firstly the ethnobotanical considerations for plant domestication (Barrau 1965; Yen 1971) based originally on the cytogenetic research on *Musa* (Simmonds 1962) and *Saccharum* (Brandes 1958) indicating that the Australimusa banana and sugarcane of pan-Pacific cultivation as well as a range of other domesticates of more limited distribution were of New Guinea origin. Powell (1976) significantly extended this enumeration, and in a recent review of the distribution of New Guinea domesticates (Yen ms.a), the following characteristics may be discerned:

1. Domestications arose in all altitudinal areas. While the Highlands species were to play little role in Oceanic agricultural history, the remainder were to have varying dispersals - to the Melanesian margins east and west or to the very outward extensions of Polynesia.
2. In the domestication process, there seems to have been an accent on vegetative reproduction, facultative in cultivated forms. In some cases of herbaceous vegetables, e.g. the Highland *Setaria palmifolia*, *Saccharum edule*, there was deliberate selection for sterile forms. The kava bush, *Piper methysticum* is also sterile (Lebot et al. 1986).
3. Apart from the disputable taro and yam and the probably important Highland and coastal dryland root crop *Pueraria* (Watson 1968; French 1986) in the past, there
was a concentration on tree and tree-like plants that could provide potential staples, e.g. the Highland nut *Pandanus*, the Australimusa banana of the Highland fringes, the low montane rainforest *Artocarpus* as important for its seeds as for its breadfruit, the lowland *Metroxylon* sago. Archaeological finds of Highland *Pandanus* remain at some 10,000 years ago have been found in rockshelter sites in the Wahgi and Porgera Valleys (Christiansen 1975; Mangi pers. comm.). Their determinations as the domesticated *P. juliannettii* or other species often foraged as food are forthcoming. The selection trend towards clonal reproduction is patent in most of these plants, but this potential of *Artocarpus* remains unexploited in mainland New Guinea.

4. There are a number of fruit trees however, species of *Pometia* and *Burkea* among them, which did not have genotypes allowing for vegetative reproduction. One of the most important was the *Canarium* nut, the domesticate of which, *C. indicum* and *C. salomonense* spread from a wide New Guinea distribution to much of Melanesia, while *C. decumanum* and *C. lamii* were more localised to the north coasts of West Irian and Papua New Guinea respectively. *C. indicum* and *C. decumanum* have spread to eastern Indonesia, and the latter species has been reported in eastern Borneo. The solid nutshells of *Canarium* offer the promise of preservation in archaeological sites that has been realised in the products of recent excavations. The earliest come from the Sepik-Ramu Basin: an unpublished site of Paul Gorecki with an associated date of 14,000 years BP for *C. indicum*, including larger fruited forms (Yen ms.a), and another with the same species at over 5000 years BP recently identified from Swadling’s Dongan site (Swadling et al. 1988:16).

Some of these New Guinea plants resulted in a dimension of production and arboriculture, influential enough to be transported Pacific-wide, successful enough to pass through the screens of distance and marginal environmental adaptation through selection by the itinerant coloniser-cultivators, to be incorporated as a component in all production systems. Additionally, most of the rainforest trees became adapted to coastal village and small island horticulture. In this respect, arboriculture had similar prehistoric effect that the transfer of water control had on the cultivation component of systems. Without the label of intensification (perhaps appropriately, extensification), the culture of trees produced a ‘permanent’ component of systems in its influence on the landscape - the establishment of orchards (Firth’s expression 1936) that produced the typical village environs of Polynesia and Micronesia, the conservational effects of tree stands among dryland field systems to reduce dependence on the sometimes deleterious effects of purely slash-and-burn technology.

Discussion on New Guinea domestication cannot conclude without addressing the pig. Not endemic to New Guinea, a phylogenetic analysis by Groves (1981) of the New Guinea *Sus* indicates that its hybrid ancestry may be traced to the Molucca Islands. Furthermore, Groves (1985:437) quotes a personal communication of Helmut Hemmer to the effect that Hawaiian pigs have skull characteristics in common with a putative parent in the original eastern Indonesian cross. That the Ambon-Ceram part of the Moluccan region, from whence the materials for comparison with the New Guineans were originally made, is within the eastern extremity of the Australia-New Guinea plate, may have endowed it with the role of recipient area of southeast Asian biota in the post-Laurasian collision era - and the site of the beginnings of the evolution and domestication of the Oceanic pig. This area of Indonesia, with its marked biogeographic affinities with New Guinea, may need to be considered more in the general story of agricultural origins in the region.

**New Guinea agriculture 2: agricultural technology**

The second line of agricultural evidence was archaeological, providing the temporal aspect for putative New Guinea origin that no plant modelling could achieve. The major breakthrough was Golson’s Highland excavations at Kuk in the Wahgi Valley swamps (1977a, 1982, 1989, this volume) that revealed a developing sequence of increasingly complex agricultural drainage. Covering a period divided into five phases beginning at 9000 years ago and ending at 100 years BP, this swamp site portrayed a sequence of environmental manipulation that is the only in situ example in Pacific archaeology of a sequence of production intensification that might be labelled as evolutionary (Yen 1982). The significance of the complementary slash-and-burn agriculture of the surrounding landscape in relation to the sequence of land use and soil deposition at Kuk has had strong support from the palynological research of Powell and others (reviewed by Powell 1982). Significant changes from climax to secondary vegetation occurred in three of eight sites in the Wahgi at prior to 5000 years ago, and such evidence for forest clearance for all sites by
4000 years BP. As Powell (p.218) points out, this approximates the beginning of the third phase of the swamp sequence, the first highly articulated drainage channel system that lasted some 1500 years probably reflected at least one social imperative, that of population increase, for expansion and intensification of the production system in terms of both swamp and dryland components. The earlier phases were of much shorter duration, and as Walker and Flenley (1979) stated in their interpretation of similar palynological results in the Enga Province of the Highlands, human influences on vegetation prior to 4500 years BP were insufficient to alter the natural regenerative pattern, or perhaps were of too small a scale for perception in pollen diagrams.

The development of the Kuk drainage system has been seen generally as founded on taro, *Colocasia esculenta*, from its beginnings, until the fifth phase beginning at ca. 400 years ago, at about which time the sweet potato most likely entered New Guinea economies. A more contentious possibility first expressed by Golson (1977b) was sweet potato introduction at ca. 1200 years ago, on the grounds of the relatively extreme sedimentation of the drainage system through natural transport of erosional products from the clearing of steep mountain slopes best suited to *Ipomoea* cultivation. The earliest phases however, have an experimental appearance, the first, gross drainage characterised by large channels in which planting surfaces remain uncontrolled, with probably large areas drained sufficiently to plant taro in still-wet edaphic conditions, with intermittent dry higher sections in which banana (*Australimusa*), sugarcane, and perhaps Highland endemic vegetable plants might be tried. Phase 2, with its large channels and interstitial network of curved, intersecting and shallow drains and amorphous-shaped elevated raised platforms, mimic the earlier natural surfaces with artificial high-low planting areas. Indeed this site in its earliest phases may be as close as we may ever come to an archaeological record of environmental manipulation that is a part of the domestication process, with the adaptation of plants (taro) already domesticated in other environments as the stimulus.

Golson (1977a) found other archaeological support in the earlier, but only partially reported two Highland excavations of Susan Bulmer (1966) wherein were found remains of pig, generally associated with agriculture in New Guinea, and not a part of the endemic fauna. The further analysis of this material (Bulmer 1975, 1982) produced evidence for pig at around 10,000 years ago, so that whether this was the product of early and small suid populations which penetrated the higher altitudes as feral or accompanied the early cultivators there remains an unanswerable question. Whatever the case, the combination of animal with agricultural technology in the Highlands at these early dates imply earlier agricultural introduction at lower altitudes - as yet undiscovered (Golson 1989) in the still expanding effort in New Guinea archaeology. The *Pandanus* situation described earlier is another avenue to add to the structural picture of the Highlands agricultural system in its earliest phases.

The reciprocal technology of water control to drainage is of course, irrigation. Without the benefit of much archaeology, Spriggs (1982, this volume) has reviewed Melanesian irrigation techniques and their distribution; he separates four forms of fieldwater supplementation, simple flooding, raised island beds with interstitial channelling, pondfields and the furrow irrigation exclusively found on Aneityum, Vanuatu. Indeed the New Guinea sector looks like a contemporaneous spatial model of development, although the technical apogee of pondfield construction however, is exemplified by questionable identification in some cases. A recent report of sightings on New Hanover by Gorecki (1985) and P. Kirch of extensive valley floor systems of bounded fields that may have been irrigated (if Kirch's reaction was that these were like a 'copy of Futuna taro fields', this is an inescapable conclusion). That it is 'related to the Lapita phenomenon' (Gorecki 1985:22) without pottery finds, if true, would take this development outside of the realm of New Guinea development. Spriggs (1982:317) allows of possible independent invention of some irrigation techniques, but suggests a common origin of Oceanic and island Southeast Asian through the evidence of 'common pondfield morphology and techniques'. This is a rather bold claim that may yet be true, but it carries the burden of proof from future studies of prehistoric and contemporary Southeast Asian rice-growing systems. The exception is a comprehensive description of the Ifugao technology of Luzon by Conklin (1980) in which the homologies of Oceanic valley irrigation methods may be recognised, but whose extensions encompass the resculturing of ridge and mountain terrain. A further differentiating morphological feature of Ifugao and Bontoc (Yen fieldwork 1962) pondfield irrigation is the provision of major drainage canals for individual systems, illustrated by
Conklin (1980:28). Such major features may be seen in the systems of Bali and Java but cannot be duplicated in even the most intensive of Pacific island systems to the east.

In developmental terms of water control in agriculture, the discrimination between irrigation and drainage may have been overstressed. The achievement of one as objective confers the ability, and perhaps necessity of the other. We have the Luzon examples of this. In 1958 during fieldwork in West Irian the author saw Dani cultivators blocking some water outlets of the Wamena drainage system into the Baliem River. Its significance was lost on him at the time, but a review of the photographs taken then of sweet potato and taro cultivation, within the one system and a few day’s span (Yen 1974a:Figs 34-35), illustrate the complexities of water control to include simultaneous drying out for tillage, drainage and water supplementation of standing crops in individual fields. While these observations hardly constitute a case for Oceanic invention of water control technology as a whole, they, with the archaeological example of development of similar systems at Kuk, could provide the alternative view of endogenous development to diffusion out of Southeast Asia. With the more simple forms of irrigation as ethnographic entities in New Guinea, the valley pondfield systems of Melanesia may be seen as not an impossible developmental direction. It is the expansion of archaeological effort in New Guinea and the Southeast Asian islands that will provide clearer answers.

Austronesian agricultural transfers into New Guinea

The advent of the Austronesians into the New Guinea region was undoubtedly the most significant of all secondary colonisations of Sahul in its far-reaching effect. Identified as horticulturalists largely on linguistic criteria (Pawley and Green 1973; Shutler and Marek 1975), their arrival in the western area that included the Molucca Islands at ca. 3500 BC (Tryon 1985) represented an eventual meeting of two agricultural peoples. As we have seen, the influence of this congress on the by-then isolated Australian hunter’s subsistence economy was minimal, but for the New Guinea non-Austronesian speakers it produced the exchange effect in which southeast Asian species could be implanted into systems advantaged by prior establishment. At ‘somewhat earlier than 1600 BC’, Pawley and Green (1985) construe that the archaeological evidence of Lapita beginnings in the Bismarcks was associated with the earlier breaking up of the reconstructed Proto-Oceanic language of the Austronesian colonisers. Kirch et al. (1989), on the basis of human skeletal remains, suggest affinities with Javanese of Lapita populations occupying the Mussau Islands of the Bismarcks at 1600 BC. While this perhaps poses problems of equating the physical evidence with the linguistic in terms of language ancestral to Proto-Oceanic, cf. Pawley and Green (1985:170), it allows for nearly 2000 years of colonisational process and man-carried biotic transfer in the northwest Sahul region until the Bismarcks were reached. In one of the few significant archaeological studies in the eastern Indonesian part of the region, Glover (1986) outlines a cultural sequence for Timor of 13,500 years with the appearance of agriculture, from the evidence of domestic animals, especially pig, at 5000-4000 years ago. May this then be a remoter part of the secondary colonisation that we are addressing? The earlier records for pig in New Guinea archaeology may perhaps illustrate the phenomenon of trans-domestication (Harlan 1975:243), in which wild hybrid individuals were transported to areas outside of natural distribution where domestication occurred. A further example is the Eumusa banana, probably of Indian and Malaysian origin in its variable forms. Simmonds (1959:126) however, leaves open the status of New Guinea with its greatest known diversity of Eumusa with ‘is it merely a centre of diversity of imported edible diploids? or a primary centre of origin by hybridisation with wild bananas? or a secondary centre of origin diversified by intercrossing between, or somatic mutation in, AA types?’. The responses to any or all of these questions would indicate some degree of the transformational qualities of trans-domestication at the end of a long chain (in distance and time) of transmission and indeed, intermediate evolutionary or selective change.

There are nevertheless, plants of mainland southeast Asian origin and domestication that appear to have been transferred to New Guinea without significant change and recognisably within the range of phenotypic variability displayed in their homeland. The two major Dioscorea yams, common in Indonesia (Ochse with Bakhuisen van der Brink 1977) are such examples; and we have discussed the equivocal position of Colocasia taro, with the possibility of the confluence of two parallel domestications in New Guinea. The betel nut palm of the genus Areca has a disputed origin as a domesticated narcotic from India to Malaysia, Corner (1966) preferring the Celebes on taxonomic grounds. There has
been no evidence of the plant's antiquity in New Guinea prehistory until recently when an analysis of the flora remains of the Dongan site (Swadling et al. 1988) provided one example of well preserved fibrous seed husk typical of the discards from preparation for chewing that can be picked up from the ground of almost any contemporary lowland New Guinea village. The associated date of this find is ca. 5800 years ago, within the putative period of early Austronesian incursion into the region, earlier than present evidence for the Lapita pottery-bearing people. The example of A. catechu focuses on another ethnobotanical indication - of the westward movement of plants. Not that the palm itself was moved backwards from New Guinea, but that its distribution is indicative of prehistoric passages from the Celebes to mainland Southeast Asia and to India, defined by Vavilov (1949/50) as a possible secondary centre of origin for the species. From other lines of evidence however, including historical that preceded the observations of Wallace (1869), summarised by Elmberg (1968), the chain of communication through trade in the Moluccas included western New Guinea.

It is interesting that Ellen (1979:51) observes, with reference to the islands of Ceram, Halmahera, Buru and the Aru Islands and the unimportance of cultivated plants there, that since AD 1400 'the extent of plant domestication in the Moluccas and the form that this has taken has changed radically. For one thing, sago itself has been increasingly domesticated'. This does not suggest that agriculture or horticulture arrived late in these areas. But the islands were apparently so rich in natural Metroxylon sago stands and so adaptable in stand renewal under foraging that palm exploitation was able to underpin the development of the spice trade along indirect routes to Europe and China beginning more than 2000 years ago (Ellen 1979:53). Thus the potential of the latent horticulture was only expressed during the expansion of the trade concomitant with the growing economic and political influence from South Asia, then the Portuguese and Dutch. By the late 16th century, Rumphius (Merrill 1917) was able to describe a whole range of economic plants, the subsistence food cultigens of which could form an enumeration of New Guinea equivalents today. There is, however, a question on the origin of the Moluccan M. sagu. Corner (1966:316), while accepting this species and M. rumphii as native to the swamps of New Guinea and New Britain, leaves open the question of early introduction into the Moluccas. While the hypothesis for naturally shared palm flora in northwestern Sahul might be valid enough, the possibility of sago as an introduction by humans indicates support not only for plant origins in New Guinea, but also perhaps its domestication that we have previously discussed. There are other New Guinea domesticates that Rumphius (van Slooten 1959:307) described for the Moluccas, Canarium indicum and Pandanus conoideus, with preparation methods for consumption that may be seen ethnographically among the peoples of the northern islands and low montane forest areas of New Guinea. Further, there are spices from endemic tree species of New Guinea, mace (Myristica argentea) and massoi (Cinnamomum sp.) that entered the Indonesian trade. There is enough indication of a westward track for plant movement as far back as the beginnings of the Christian era for traded products; but it may well be that subsistence species of New Guinea have a longer history of a shorter distance exchange, donor as well as recipient. It is the Austronesian horticulturalists as canoe navigators of great ability who likely effected such exchanges.

THE AUSTRONESIAN EXPANSION

The recent emphasis on Lapita studies in western Oceania has had, as stated by Kirch et al. (1989:63), a major implication 'that the modern Austronesian-speaking cultures of both eastern Melanesia and Polynesia have common origins in the Lapita Complex'. As important for ethnobotany is the much discussed view (Bellwood 1979; cf. Allen 1984) of the speed of colonisation of Oceania through Melanesia from island Southeast Asia that adds identity and rapidity to the old diffusion theory. In a summary of the radiometric evidence that covers C14 datings from the colonisation of the Mussau Islands from the second millennium BC, Kirch and Hunt (1988) hypothesise that these Lapita populations from the New Guinea region dispersed through the Melanesian islands to the Fiji-western Polynesia area 'over a period of not more than ca. 300 years'. Thus it is unlikely in the extreme that the Lapita-bearers had any real part in the domestication of the species, particularly arboreal, in New Guinea, but, as secondary colonisers, adopted rather rapidly these elements of a foreign subsistence system for emigrant transmission and for the local development by those who remained.
The various pathways through the Melanesian islands - the Solomon Islands chain, New Caledonia, Vanuatu to western Polynesian periphery composed the 'Melanesian-Polynesian border region' on ethnobotanical grounds. Defined firstly on agricultural and plant use technologies (Yen 1971), this was expanded with the plant evidence (Yen 1973a) of the first phase of the Southeast Solomons project (Green and Cresswell 1976) that filled the Lapita void in the region. Systematic variability is perhaps the keynote in the characterisation of the subsistence systems of the region. The ethnographic endpoints suggest independence of development that cannot be entirely attributed to species loss during transfer analogous to a genetic founder effect on an interspecific scale, nor to environmental influences. Further, the variability of endpoint systems reflect different states of equilibrium between and within components, achieved through alternative and flexible paths of development. The summary that follows is arranged along the lines of a componential analysis of Oceanic subsistence systems:

**Hunting-gathering**

As the Austronesians moved east, they left the richness of small mammalian fauna behind, and as the archaeological record shows, the 'hunting' aspects of economies became dependent largely on avian and marine resources. The initial colonisations of all landfalls needed to accent this aspect of production, and the 'gathering' of terrestrial resources of these mariner-cultivators was as important for its maintenance as its extractive functions. We may exemplify the Tikopia study (Kirch and Yen 1982) for early negative environmental effects such as extinction of native bird species, as much the result of habitat destruction as overexploitation. While the inshore products of the sea, and particularly shellfish, suffered the common predatory effect of size reduction, the maintenance of the capabilities and indeed further development of pelagic fishing was an essential function of terrestrial production in the provision of raw materials for canoe building and fishing gear. The domestication of *Calophyllum* as evidenced on Tikopia and Nupani (Davenport 1972:24), the differentiation of *Pandanus* into food and fibre forms indicates the accent on the industrial uses of plants whose supplies could not meet demand through their natural occurrence. This small but significant trend was to be continued throughout the settlement of marginal Polynesia (Yen 1985).

In relative terms, the hunting-gathering mode of production may be seen to have given way to the dominant agriculture, but it was never to lose its importance, even on the larger islands such as Santa Cruz, where inland agriculturalists conducted exchanges with coastal dwellers for fish (Yen 1976a). This initial phase of colonisation involving the introduction of transported agricultural elements depended firstly on successful transport (with the greater number of canoes, the greater the chances), and secondly on subsequent adaptive success. This 'experimental' stage based on earlier ethnoscience knowledge may have lasted less than a century to build up stocks of planting material of crop plants, and especially of trees. But it would account for the directions of development of subsistence systems, and varying success with the adaptive experiments producing the variations so evident in the systems of the Melanesian-Polynesian border region that survived the homogenising effects of any subsequent secondary colonisations.

**Crop cultivation**

The species range of the taro-yam complex was successfully transferred to the border region in its entirety, as were the perennial sugarcane, bananas, tapioca and kava and *Cordyline* to eventually become the elements of Polynesian and Micronesian agriculture (Barrau 1958, 1961). Among other New Guinea domesticates, the vegetable *Saccharum edule* had a more inconstant distribution, not appearing in the eastern Solomon Islands, New Caledonia, Tikopia or Anuta, yet recorded for the central Solomons, Vanuatu and Fiji. Recent research by Lebot (1989) on kava, *Piper methysticum*, indicates not only the ritual importance of the plant in Vanuatu, but raises the question of origin there in terms of the plant's variability in active alkaloid chemotypes. Indeed it may be necessary to revise the usually acceptable New Guinea origin based largely on the criterion of the richness of specific forms of wild *Piper*, and to posit once again a westward or 'backward' track, as well as eastward, of a number of plants in the western Pacific.

In the 1970s, there was considerable supplementation of the knowledge of water control in taro growing in the Melanesian islands to supplement the accounts for New Caledonia (Barrau 1956), for Éspiritu Santo in Vanuatu (Gulart 1958) and for New Georgia in the
western Solomons (Chikamori 1967). Spriggs (1981) has shown that varying forms of irrigation extend to seven other major islands of Vanuatu, and that, at their most complex and especially in the provision of primary water source, they approach the New Caledonian forms in their technical complexity. In the Solomons, pondfield systems abound on Kolombangara (Yen 1976b) and are reported on another island close to New Georgia, Rendova. Roe (pers. comm.) has finally confirmed the 1568 Spanish record for irrigation on Guadalcanal in an archaeological study of an extensive valley terracing system. So far, the datings of such systems, such as those of the Solomon Islands, have proven to be late in cultural sequences, and thus indicate late development or recent (17th or 18th century) introduction, as has Spriggs' careful interpretation (1981:119) of prehistoric Aneityum, Vanuatu systems and the priority in time of dryland cultivation over valley floor irrigation.

Irrigation, identifying taro cultivation, confers the most specific of archaeological visibilities for agriculture in Oceania. In its relatively late materialisation in temporal sequences an inference for colonisation suggests itself; that the technology was not transferred, but rather reinvented over generations, sometimes millennia after first settlement, on the basis of ethnoscientific principles of hydrology that are always retained and indeed enacted in other contexts of water delivery. A comparison with agricultural archaeology in Hawaii may be of interest. Although until recently, the dates for first use of pondfields have been ca. AD 14th century, these are generally earlier than those recorded for Melanesia; but since they are also relatively earlier on the criterion of the respective cultural sequences, it may be reasonable to expect to find earlier evidence still in Hawaii, in the first expansionary move after primary colonisation. Although such examples have been reported by Schilt (1980) from Kaua‘i and Jane Allen (1987) from Oahu, the acceptance for first millennium AD dates is moot after further investigation of the Kaua‘i site by Athens (1982), and Allen’s own report (p.174) on the inconsistency (AD 4th, cf. 15th century) of C14 dating of the same sample from two laboratories. Perhaps the archaeological signals for experimentation and early expansive colonisation must be sought as Clark (1980) has, in estuarine environments with feeding streams, where the architectural remains of agriculture are less formalised in an environment that gave rein to the reestablishment of a subsistence system structured on terrestrial and marine components. Geomorphological changes in such environments over a longer time span of experimentation in Melanesia however, may complicate such a quest.

In the eastern Solomons, it has been noted that irrigation is absent, except for pit cultivation of *Cyrtosperma* on some coral atolls of the outer Reef Islands. This exploitation of the Ghyben-Herzberg freshwater lens, known from the northern islands of New Guinea, East Sepik Province (illustrated by Swadling 1981:42) and the major agronomic technique on the coral atolls of Micronesia and eastern Polynesia, may have its origin on the coralline plains of small volcanic islands. The digging through sand for water is a common practice, and on Anuta, such large and rather amorphous shaped ponded tracts are still used for swamp taro growing (Yen 1973b), with a complex pattern of traditional occupancy by households. This is not to suggest that Anuta is the seat of origin for this technique, but rather that the technology reflects a further hydrologic choice depending on environmental circumstance in Oceanic agriculture.

The impression that no water control technology existed in the Santa Cruz group (Yen 1976a) was dispelled by fieldwork by the writer on the southern islands in 1978. On Vanikoro *Colocasia* taro is now found as an element in mixed swidden gardens dominated by sweet potato or occasionally as small plantings beside streams. However one extensive drainage system behind a mangrove-covered floodplain and close to an occupation site, VK-6, excavated by Kirch (1983) on Teanu Island. Replete with recovery of wooden digging sticks buried in a drainage canal, this reticulated system, resembling the larger tracts of the Rewa Delta in Fiji (Parry 1977), carbon-dated as ‘modern’. The technique was recalled by older informants as typical of drainage for *Colocasia* and *Cyrtosperma* growing on the main island of Banie, and details of alternative use of the systems as irrigation during dry spells were accompanied by native terminology. The estimate that the cessation of this form of agricultural water control was about three generations ago is not at odds with the account of Rivers (1922) of the depopulation of the Santa Cruz region at the beginning of this century. Two smaller systems of this type were extant, one being drained, the other irrigated, on neighbouring Utupua Island in August 1978, and again informants stated that in ‘the old days’ the wet plains, whose soil *ivuvu* was a mix of coralline and eroded volcanic mountain components were modified in this way.
Arboriculture

The hypothetical transfer of tree crops from the New Guinea region to the Melanesian-Polynesian border region by Austronesian peoples (Yen 1976a) finds strong support from Kirch (1989) in the parallels of the archaeological remains of species at early levels in Mussau, with most of those represented in their ethnohistoric record and present day occurrence in Santa Cruz and Vanuatu extending to the Samoa-Tonga-Fiji region. Lapita may not be the only association with tree species transfer through the Melanesian island corridor however. The exception is New Caledonia, where most of the species do not exist as cultigens with the exception of coconut and breadfruit. Since breadfruit remains have not been found archaeologically as yet, its antiquity here is unknown. If indeed the revision of the New Caledonian archaeological sequence by Green and Mitchell (1983) is valid, its allowance of pre-Lapita colonisation by ‘an aceramic, Neolithic, non-Austronesian population ... perhaps as much as 6000 years ago’ and perhaps two other peoples indicated by the complex of pottery traditions predicate earlier possible dispersals (on an assumptive provenience) of New Guinea tree species. That such trees as Canarium, Pometia and Burckella are absent after primary colonisation presumably from the New Guinea region may perhaps suggest that the domesticated species of these genera had not yet been fully domesticated in that contact region at 6000 years ago; their absence after secondary colonisations including Lapita may be ascribed to a ‘gross’ founder effect at specific level; their continued absence to historic times may mean that there was little post-Lapita contact between New Caledonia and the other Melanesian islands of the region. To complete this speculative reasoning there is one alternative; that there was nearly 3000 years for primary colonisation and the establishment of a yam-taro economy with complex technology of such productive efficiency that newly introduced species had difficulty in gaining adaptive places in the system.

The attribution of the first Austronesians as Lapita bearers of a full range of New Guinea domesticated trees is further questioned on our recent identifications of excavated materials from archaeological sites in the Melanesian islands. Wickler and Spriggs (1988) report endocarp of C. indicum from charcoal at levels ranging from ca. 9400-6600 years ago from the northern Solomons, while on Guadalcanal in the main Solomon Islands, Roe (pers. comm.) has the same species from some 6000 years ago. This represents the modern range of the species that extends from New Guinea over all the Solomons to San Cristobal, and to Vanuatu, and could be indicative of pre-Lapita Austronesian or even non-Austronesian distribution. In the Santa Cruz area of the eastern Solomons, where the precedence and indeed even identity of non-Austronesian elements of the languages have been debated (Wurm 1978; Lincoln 1978), the Canarium species is exclusively C. harveyi, whose modern distribution includes the Banks Islands, Tonga, Fiji and the Samoa. It is unfortunate that in Green’s excavations (1976) on the Reef Islands no Canarium remains associated with Lapita sites were recovered; on Santa Cruz (McCoy and Cleghorn 1988), remains of recent deposition were clearly C. harveyi, but material associated with one Lapita level, while certainly of the genus, could not be reduced to species because of its highly fragmented nature. In the eastern Solomons then, the possibility still remains that the earliest cultivated Canarium was C. indicum, and in this extension of the range of the species, the work of the Lapita carriers. From an excavation of Kirch (1983:96) on Vanikoro however, levels dated from some 17-14 centuries ago yielded remains of both C. indicum and C. harveyi, while a similar situation obtains in the sites of Ward (1979) on the Banks Islands in sites that date back over 2000 years. While the time association of the two tree species in the cultural sequence has yet to be determined for the latter case, there is perhaps enough evidence to hypothesise that the archaeological presence of both in the Banks and Vanikoro indicates that this is the region of contact between the Santa Cruz and Vanuatu Archipelagoes in prehistory. It has been implied (Yen 1974b) that the Santa Cruz cultivated Canarium is a local domesticate, in which the Vanikoro populations appeared as the most highly variable (Yen 1978 fieldwork). Archaeology has tempered this view: in the plant material identified for Green and Anson (1987) from their Watom site on New Britain, one putamen fragment that matched with whole seed cases of C. harveyi recovered from an earlier excavation of the same site (Specht 1968) was dated to ca. 1300 years BP; Spriggs’ excavations on Nissan Island, northern Solomons (Gosden et al. 1989) produced fragments whose ages exceed 4000 years. These incidences may fit into a general hypothesis of the transdomestication of a hybrid between C. indicum and C. salomonense (another New Guinea wild and cultivated nut
species with minor archaeological occurrence in many of the Melanesian sites so far studied) resulting in the taxonomically distinguishable *C. harveyi* in the Santa Cruz area of the eastern Solomons, with its restricted external distribution. However, the excavated seed material, most often fragmented, limits its use in phylogenetic analyses that require a wider range of variable plant characters.

The *Metroxylon* sago palm perhaps demonstrates best the development of domesticated taxa of the wide Melanesian-Polynesian border region that discriminates the New Guinea region of origin and the Polynesian region of agricultural diffusion. While in New Guinea the concentration in domestication was on *M. sagu*, tillering to produce clonal planting material and with starch production taking precedence over leaf for house building, the concentration in the border region was on single stemmed forms, with the priority for utilisation reversed. *M. salomonense* of New Guinea, and occurring on the Bismarcks and the Solomon Islands to Santa Cruz, may be the progenitor species for the localised species *M. bougainvillense* (northern Solomons), *M. warburgii* (Vanuatu), *M. vitiense* (Fiji), *M. upolense* (Samoa). As Barrau (1959:155) states in his review of this distribution, 'It is possible that in some distant epoch species of the *Metroxylon* group, whose center of origin spreads from Indonesia to New Guinea, were transported by men right to the borders of what is at present known as Polynesia', Indonesia meaning the Moluccas.

Sago palm and the *Canarium* nut represent the array of New Guinea trees that reached the Samoa-Tonga-Fiji border, but were not to have any impact on Polynesian agriculture - unlike breadfruit, the *Inocarpus* Polynesian chestnut and the fruit *Syzygium*. Perhaps the omissions were, as Kirch (1989) has opined, an indication of choice or simply accident. Choice may hinge on the success of the agronomic experiments with crops, as well as the important innovation of *ma/masi* ensiling of breadfruit that reduced the importance of the other tree crops. However, unless plant remains are found in early contexts in western Polynesian archaeology, it could also be suggested that the border area was the subject of secondary colonisations from the west, whose arboricultural traces were too late to join the crop rosters of the eastward emigrants. Notable also is the absence of the nut and fruit species in Micronesia where tree culture matches the Polynesian short list. That this is not simply a case of maladaptation is the fact that *Canarium, Burckella* and *Pometia* in the eastern Solomon Islands are cultivated not only on the inland volcanic soils but also on the sandy coralline soils of village gardens on high islands, as well as on the atolls of the outer Reef Islands.

The complexity of colonisation patterns in this region has ethnobotanical support of a long recognised 'backflow' cultural movement to the Polynesian 'outliers'. The archaeological evidence for pit preservation of breadfruit on Tikopia (Kirch and Yen 1982) and Anuta (Kirch and Rosendahl 1973) appears after the first millennium AD, compared with the finds of similar structures in Samoa by Green (1969) dated to the beginning of the Christian era. This storage process had a strong influence on the selective pressures exerted by the cultivators, for the presence of seeds in the fruit of *Artocarpus altilis*, highly valued for food in New Guinea and western Melanesia, in the border region was to be selected against (Yen ms.b), a process that resulted in virtually a varietal population of parthenocarpic, seedless fruit trees in eastern Polynesia.

Animal husbandry

Of all the biotic transfers associated with the colonisation of the Pacific Islands, the most vulnerable was probably the short roster of animal domesticates - pig, dog and chicken. As accompaniments of canoe voyagers, they were prone to loss overboard and perhaps to emergency consumption, and their husbandry under those conditions did not have any of the advantages of the suspended growth requirements of transported seed or clonal plant stocks. After landfall, the founder effect would be operative, dependent on the population number and the sampling of genotype represented. The smaller the breeding population (down to a single pregnant animal), the greater the likelihood of deleterious inbreeding that could take the species to early extinction. Thus where animal remains are numerous in early parts of archaeological sequences, either the numbers of animals and colonising humans were relatively large or there were secondary colonisations whose genotypes could supplement the narrow variability of populations.

In the colonisation of the larger high islands, the introduction of animals seems to have followed at least something of the pattern of New Guinea, where feralisation is often as much a part of the system of 'husbandry' as domestication (Yen ms.a). From the
Melanesian to the far tropical Polynesian islands, wild pigs are attributed taste qualities not accorded the domesticated and probably contributed seminally to the breeding of village sows. It does appear that island size governs the presence or absence of this form of animal raising and Tikopia (Kirch and Yen 1982) provides an example of the early introduction of pig, dog and chicken with Lapitoid peoples, with subsequent extinction of the first two species. That the pig was deliberately eliminated because of its destructive effects on the agricultural environment is a part of the traditional record. Chicken has sometimes been described as ‘semi-domesticated’ in Oceania because much of its survival depends on foraging. On Santa Cruz Island however, there is a truly feral Gallus, much prized by the subsistence farmers for its feathers and meat; apparently feralised chicken was also recorded by 19th century explorers for Truk and Kosrae in Micronesia (Intoh 1986).

The association of animals, particularly the culturally important pig, with Lapita colonisation in the northern New Guinea islands (Gosden et al. 1989) is not consistent further to the east. In New Caledonia the pig does not appear in the archaeological sequence until some 785 years ago as ‘a very late prehistoric introduction by the Polynesians’ (Green and Mitchell 1983:58). Apparently it did not persist, for Clerke on Cook’s second voyage (Beaglehole 1961:764) unequivocally stated that the New Caledonians in AD 1774 ‘were total strangers to Quadrupeds’, pigs and dogs being among the gifts to them by the British. Barrau (1956:112) agrees that traditional animal husbandry was limited to chicken. It may be argued that the savannah environment, almost unique for the Melanesian islands, was unsuited for the introduction of feral aspects of pig husbandry, but more likely may have been the complexity of terraced field systems, dry and irrigated, whose long-distance water supply systems (Spriggs 1982) would be extremely vulnerable to depredation by free ranging pigs.

Archaeology in the Santa Cruz group of the Solomons - Vanikoro (Kirch 1983), the Reef Islands and the southern offshore islands of Santa Cruz (Green 1976) - has produced pig remains at earliest time levels of settlement with the added presence of chicken but no dog on Vanikoro. On the atolls of the outer Reef Islands there has been no excavation, but ethnographically, Davenport (1972) described the tenuity of pigs husbandry within the subsistence system of 1959 that he judged to be marginal with the collapse of the Santa Cruz trading system in which the prestige items of red feather money, sharks, women, pigs was underscored with food exchanges (Davenport 1962). With the settlement of the island of Tinakula some 20 sea miles to the south by the Nupani people after the cessation of volcanic activity in 1957/58, a system of pig husbandry was instituted whereby the small high island became the breeding ground, the atoll for fattening with coconut. In 1971 fieldwork on Ndeni, Santa Cruz, this writer witnessed a flotilla of Nupani canoes whose principal load was 22 pigs, a pale reflection perhaps of the traditional trade cycle of the past, but contrasting with Davenport’s 1960 visit (1972) when the atoll’s pig population amounted to four.

This example may illustrate, in reverse, the fragility of atoll and small island environments for the animal husbandry component of subsistence systems in terms of size, edaphic and water statuses, as well as the ever-present threat of cyclones that could render this establishment (or revival?) a temporary episode. Intoh (1986) reviews the incidence of pig in Micronesia, indicating that it was absent at European contact. Archaeologically in western Micronesia however, its presence on the larger islands of Yap, Guam and Palau seem certain in later prehistoric periods. The uneven distribution in time of not only pig but also dog and chicken on Lamotrek (Fujimura and Alkire 1984) may be testament to secondary colonisations, or to the perpetuation of the fragile animal husbandry component of atoll subsistence systems by intensified voyagers. Intoh speculates that subsequent disappearance on atolls, as on Tikopia (Kirch and Yen 1982), may be due to elimination by the islanders, reflecting the inadequacy of the environment to maintain pig husbandry in the face of the destructive effect on crop agriculture; but in the case of the high islands of greater potential, particularly Palau, she seeks an explanation of contemporaneous elimination of intensive agronomy. While these prehistorical situations may also include the genetic factor with which this discussion began, perhaps two atoll examples of the archaeological appearance of the dog at early phases of human colonisation may more clearly represent the latter. On Nukuoro (Davidson 1971) and Pukapuka of the Cook Islands (Chikamori 1987), the canine is not to occur again until modern times, and is absent from traditions of the past. Such absences have implications for little secondary colonisation from high islands with relatively intact animal husbandry in the past. The
uneven ethnohistoric records of dog (there are none for pig before the 19th century) in the 17th and 18th century in the Tuamotu Islands - present on Anaa, Pukapuka and Takaroa (Emory 1975), absent, as was chicken and pig, on Reao even in the 19th century, until 'very recent' introduction from other islands in the group (Hatanaka 1982:35) - offers variable situations for animal husbandry within a single cultural area that should be interpretable after more archaeological excavation, e.g., the unidentified mammalian remains reported from Reao by Chazine (1982:291).

The expansion of agriculture from the New Guinea region into the Melanesian islands, in the various manifestations of subsistence systems, may best be viewed as the product of primary and secondary colonisations. The influx of the Lapita peoples was probably the most important because of its wide ranging influence, but on some islands there is evidence for primary colonisations of non-Austronesian or Austronesian without Lapita ceramics. The variation of resultant systems lies in the elements of the successfully introduced cultigens and in the development of associated agronomic techniques; the overall structural components of the systems - hunting-gathering-fishing, crop cultivation, arboriculture, animal husbandry - remain intact. It is the animal component that is the most dynamic through time, with areal limitation as a relatively constant determinant in the ebb-and-flow pattern emerging from small island archaeology. The general adoption of animal husbandry on atolls at European contact may be a reflection of past opportunism, always prone to limited success - or failure.

Returning to the Melanesia-Polynesia border region, with its unquestioned primacy of the Lapita colonisers, the full complement of the Oceanic animal domesticates was conveyed there, as represented by the early remains of pig, chicken and dog in the archaeological sequence of Niuatoputapu of the Tongan archipelago (Kirch 1988). The endpoints of indigenous cultivation systems saw the development of water control of the highest order for taro growing as irrigation on Futuna and drainage on Uvea (Kirch 1976) and Fiji, both of which were evident in eastern Polynesia. By contrast, *Dioscorea* yam growing, while important in Polynesia, especially on Easter Island and Niihau, Hawaii, was never to regain the equal quantitative and cultural status with taro that was traditional in Melanesia, nor the level of formal cultivation technology that was evident on Uvea. The riches of the Melanesian domesticated flora were nearly all assembled in the eastern extremity of the border region, indicating perhaps a succession of Austronesian contacts rather than a single linear plant introduction. It is in the transferred arboricultural elements that the segregational effect can be seen; for with something like 1500 years of colonisation and settlement to produce the subsistence system that could be recognised structurally as 'Polynesian', the migrations to the east without such trees as sago, *Canarium*, *Pometia*, *Burckella*, reflected the result of the formative processes in the Fiji-Tonga-Samoa area, where these genera were presences that had lost most of their impact in the subsistence systems. This, however, was balanced by the ascendency of breadfruit *Artocarpus altilis*, Tahitian chestnut *Inocarpus edulis*, and the southeast Asian *Eugenia malaccensis* or Malay apple which, unlike the betel palm, survived the Melanesian screen to reach Polynesia. Indeed the elaboration of food technology to produce a pit-stored product of preference, *ma/masi*, having archaeological visibility in Samoa (Green 1969), endows this border area with a technological innovation that not only assured a major role for arboriculture in tropical Polynesia, but dictated the course of selection in the species.

THE NATURE OF AGRICULTURAL COLONISATION

The successful introduction of agriculture on primary colonisation has a strong element of chance - the gross founder effects of the loss of species during canoe transit; excessively narrow genetic variability in transferred stock; landfall environments unfavourable to some species that may act as immediately eliminative screens. With secondary colonisations, such strictures still obtain, but since pre-Ipomoean Oceanic agricultural systems all derive from the same region, the greater the number of such events, the more the first two chance elements can be obviated. Even initial maladaptations may sometimes be overcome with the environmental modifications that are wrought by colonisers on the remembered templates of earlier economic landscapes of their homelands. It is indeed this transference of such information with plants and animals, the cultural aspect of agricultural transmission, that reproduces the structure of Oceanic subsistence systems.

Primary colonisation implies the direct carriage by small populations of cultural
information from one island to another without generational transmission. In this paper we have observed the initial componential emphasis on hunting-gathering-fishing that underwrote the early period of agricultural introduction and experimentation. Inescapable, even on population considerations alone, is the implication of disintensification of agricultural technology as the components of the broad structure of subsistence systems were being reassembled. The best exemplification of this phenomenon lies in the archaeologically visible pondfield irrigation which, on present evidence on Kolombangara (Yen 1973b), Guadalcanal (Roe pers. comm.) and Futuna (Kirch 1976) appear relatively late in their respective cultural sequences. The Hawaiian prehistoric irrigation systems, the best investigated in the Pacific, are undisputably in evidence (Allen 1987) by the 13th century AD (the earliest direct dates for Oceanic pondfields so far) and in his review Kirch (1984) suggests that such water control systems began to expand with population at that time. Earlier, Kirch (1980) used the biogeographical configurations of r- and K-selection as a sequence of colonisation for Hawaii, emphasising the correlated successions of rapid to slow population growths, broad-based subsistence to economic specialisation and weak to highly developed sociopolitical control. In this case, and perhaps for Polynesia, the analogy seems entirely appropriate, but whether the governance of different social systems reveals the same characteristics in the prehistory of other irrigation societies such as those in Melanesia is for future determination.

Hiatus between primary colonisation and the resumption of high level technology may be attendant on secondary colonisation due to the earlier gross species founder effect, but this is unlikely in the case of *Colocasia* taro in Polynesia. The experimental period that followed the introductory stock-building interval would hardly require the advantages of intensive cultivation such as Spriggs (this volume) describes. Thus in the Hawaiian example some 30 generations elapsed before irrigation was to become evident in the archaeological record; the acceptance of the equivocal early date corresponding to the beginning of Hawaiian settlement may even confer greater realism to a sequence of degeneration of agricultural technology, then recovery with the rise in population. A further example is breadfruit, the knowledge of whose preservation technology must have been transferred with the plant from the Society Islands or the Marquesas. Neither in Hawaiian archaeology nor tradition was it to materialise again, although the tree itself was to become a specific arboricultural element in zonal differentiation of the production landscape on the island of Hawaii at European discovery (Kelly 1983). Such ebb-and-flow patterns in subsistence technology (many instances could be cited) have considerable significance in the interpretation of generational or vertical cultural transmission that followed the initial colonisation and direct non-generational cultural transfer accompanying the successful or unsuccessful moving of biological or species elements of earlier homeland subsistence systems. This discussion is obviously predisposed by readings of the works of evolutionists addressing non-biological, cultural transmission such as Cavalli-Sforza and Feldman (1981), Lumsden and Wilson (1981), Boyd and Richerson (1985). For direct reference to the dynamic nature-nurture adaptation of Pacific subsistence system however, I turn to Findlay et al. (1989) whose conclusion that 'cultural transmission is often Lamarckian' strikes an immediate chord with our rendition of the vertical transmission of agricultural behaviour subsequent to primary colonisation transfers; and as they (p.571) have generalised, the transmissions are of strategy sets rather than the individual strategies themselves. In our terms, 'sets' correspond to the overall componential structure of Oceanic subsistence that reflect the natural (hunting and gathering) environment, whose terrestrial aspects become artifically modified with the development of crop cultivation, arboriculture and animal husbandry, while nevertheless retaining its own identity in systems. The individual strategies as the translations of ethnoscientific tenets are the dynamic elements related to the species that may disappear through unsuccessful biological transfer, through absolute ecological non-adaptability, or eventually through social choice on criteria of alternative cost that may be environmental. The 'successful' transmitted strategies must be rebuilt on a background of the demand of increasing human population, and such development may result in the mimicry of intensive ancestral technology, different directions to achieve the same purpose, or combinations which, particularly in crop agronomy, can enlarge the range of environments of cultivation as well as the number of species. Vertical transmission of the cultural (technological) aspects of subsistence then, with the initial hiatus that we have discussed, must go beyond the elements of systems, to adaptive fundamentals of knowledge of edaphic conditions of rich and poor, surface and
subterranean water and its control, wild and domesticated biotic forms - albeit with the mnemonic of colonisers' early adaptive steps in the building up of genetic stocks.

The study of Findlay et al. (1989) is the comparison of a biocultural game model with vertical cultural transmission and the standard biological model of heredity. Their major conclusions indicate that the application of cultural information formulating subsistence strategy in colonisation seems to fit with the biocultural model:

(i) the conditions for evolutionary stability in biocultural systems are different from those in the purely biological game, so that points in the strategy space satisfying standard ESS (evolutionarily stable state) conditions need not be bioculturally stable, and BCSSs (bioculturally stable states) need not satisfy the standard ESS conditions; (ii) biocultural games can evolve to different equilibrium states depending on the initial conditions, with the number of possible states generally exceeding those in biological games; (iii) equilibrium strategy diversity is greater on the average than that in the biological case [Findlay et al. 1989:572].

A further observation is of considerable relevance to agricultural colonisation, that 'the tendency of natural selection to increase high-fitness strategies may be counteracted by the effects of cultural selection influencing strategy adoption. Alternatively, strategies conferring low biological fitness may be culturally selected' (ibid.). Certainly the application of more intensive techniques to crop cultivation tend to select against sexual reproduction in root crops, narrow the genetic diversity of species; directive selection towards parthenocarpy and vegetative reproduction has the same restrictive effect. The adaptation of rainforest tree species to coastal soils physiologically restricts their reproductive capacity; the flexible nature of the biocultural game of agriculture in its vertical transmission however, can be illustrated by the same tree genera which, adapted into former rainforest settings, may feralise on abandonment to recover at least some of their variability. More volitive is the husbandry of domesticated animals, where the feralisation factor can become an integral part of the agriculturalist's breeding method.

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REFERENCES


Golson, J. (this volume) Kuk and the development of agriculture in New Guinea: retrospection and introspection


Intoh, M. 1986 Pigs in Micronesia: introduction or re-introduction by the Europeans? Man and Culture in Oceania 2:1-26


Kirch, P.V. 1983 An archaeological exploration of Vanikoro, Santa Cruz Islands, Eastern Melanesia. New Zealand Journal of Archaeology 5:69-113


Lebot, V. 1989 *Kava (Piper methysticum Forst. f.): the Polynesian distribution of an Oceanian plant. Paper presented to the symposium 'Plants and Man in Polynesia*, Brigham Young University, Laie, Hawaii


Merrill, E. 1917 *An Interpretation of Rumphius’s Herbarium Amboinense*. Bureau of Printing: Manila


Spriggs, M. (this volume) Why irrigation matters in Pacific prehistory


Vavilov, N.I. 1949/50 The Origin, Variation, Immunity and Breeding of Cultivated Plants. *Chronica Botanica*: Waltham


Yen, D.E. ms.a Domestication: the lessons from New Guinea. Department of Prehistory, Research School of Pacific Studies, Australian National University: Canberra


Yen, D.E., P.M. Gaffey and D.J. Coates ms. Chromosome numbers of the Australian *Ipomoea*. Department of Prehistory, Research School of Pacific Studies, Australian National University: Canberra
