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Australian Prehistory: New Aspects of Antiquity

Recent discoveries make the prehistory of Australia's Aborigines longer and emphasize local developments.

J. Peter White and James F. O'Connell

Interpretations of Australian prehistory have generally emphasized the foreign origin of many aspects of Aboriginal culture, as of Aborigines themselves. While excavations from 1790 onward showed that economic and technological changes occurred in Australian prehistory, full appreciation of the import of these changes is recent. Since the 1960's, the development of anthropologically oriented archeology has led to the discovery of a prehistoric record dating back into late Pleistocene times. We review evidence that defines more precisely the antiquity and probable mode of arrival of the first Australians and shows that their impact on the local fauna and the evolution of their economy and technology possess distinctive characteristics.

Earliest Arrivals

The earliest indisputable date for human occupation of Greater Australia (including New Guinea, Tasmania, and other islands on the Sahul Shelf) is 32,750 ± 1,250 years before present (B.P.; sample ANU-331) on man-transported unioid shells at Lake Mungo in western New South Wales (Fig. 1) (*1, 2*). This site, on the shores of a now extinct lake, lies within the Mungo depositional unit, one of a series of layers of wind-blown sand and clay that document fluctuating water levels during the late Pleistocene. Other dates on charred plant remains and unioid shells from the same unit are older (34,000 to 38,000 years B.P.), but less certainly associated with human activity (*3, 4*). Slightly more recent human occupation (24,000 to 30,000 years B.P.) is well documented both from these deposits and their stratigraphic equivalents in nearby lake basins (*1, 5*). Extensive searches have so far failed to produce any evidence for man in the underlying Golgol unit, which has an estimated age of 70,000 to 120,000 years B.P. (*2*).

At Keilor, southern Victoria, long-term investigations of a complex depositional sequence in the Maribrynong Valley have led to the discovery of quartzite artifacts from throughout a unit (the "D Clay") with an age conservatively estimated at 26,000 to 36,000 years, and possibly as great as 45,000 years (*2, 6*). Stone tools are claimed from earlier horizons (*7, 7a*), but their human origin has not been clearly demonstrated (*8; 9*, p. 146).

Other claims for greater antiquity are based on indirect evidence. Singh reports (*10*) evidence from studies of pollen of an increasing proportion of myrtaceous herbs and shrubs in forests around Lake George, eastern New South Wales, beginning at about 50,000 years B.P. He suggests that this could result from an increased frequency of fire, reflecting a drier climate, or the presence of man, or both. There is at present no direct archeological evidence for man in the area before 4000 years B.P. (*11*).

The most controversial claims for occupation prior to 50,000 years B.P. are made on the basis of human skeletal remains from several terminal Pleistocene (about 10,000 years B.P.) sites in northwest Victoria and adjacent parts of New South Wales. These remains are definitely from *Homo sapiens*, but bear a strong resemblance to mid-Pleistocene *Homo erectus* in certain features of cranial morphology, notably overall cranial size, vault bone thickness, and form of face and mandible (*12*). Thorne (*13*) has offered several possible explanations for this resemblance, one being that greater Australia was initially occupied by a morphologically archaic population. This would require a date much older than any mentioned above. The only other indication of similarly early movement toward Australia comes from reported occurrences of Patjitanian or Patjitanian-like stone tools on several islands within

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Wallacea (*14*). Some of the tools are thought to be in association with *Stegodon* and other elements of a now-extinct Early to Mid-Pleistocene Sino-Malayan fauna. However, none of the occurrences have been radiometrically dated, and at least some of the associations with the extinct fauna may be questioned (*15*), as may the dating of the latter (*16*).

Another explanation for the presence of these archaic skeletal morphologies is local development from a demonstrably modern population some time after 30,000 years, possibly as a result of dietary or other selective factors (*17*). Proponents of this view stress the presence of highly gracile *Homo sapiens* forms within the same local region at 25,000 to 30,000 years B.P. and the absence of archaic forms from the record at that time (*18*). No other supporting evidence has been offered; there are summary objections by Hallam (*19*). However, we believe that the local development model provides the simplest explanation for the evidence and is to be preferred at present.

Finally, since the earliest finds now known are more than 2500 airline kilometers or 6500 coastline kilometers from the probable area of entry on the northwest coast, an initial entry date of the order of 50,000 years B.P. seems certain. Occupation at a significantly earlier time remains to be demonstrated.

Summary. Human occupation of greater Australia occurred by 50,000 years ago, probably through deliberate voyaging by a small group of people. Later migrations, if any, are unlikely to have significantly changed the original genetic and cultural makeup. While early Aborigines may have hunted extinct megafauna, the data do not support a rapid "Pleistocene overkill" hypothesis. Finally, aspects of Australian Aboriginal economy, especially plant utilization, and technology—the small tool tradition, ground stone hatchets and boomerangs—are of considerable antiquity and probably originated locally.

Continental Occupation

The earliest settlers may have arrived 50,000 years ago, but continent-wide occupation is clearly demonstrated only within the 30,000- to 20,000-year age range. Sites occur then less than 100 km from Pleistocene glaciers in Tasmania [Cave Bay Cave (*20*)] and at an altitude of 1900 meters in the southeastern highlands of New Guinea [Kosipe (*21, 22*)], as well as in southwestern Australia, Arnhem Land, and the eastern coast and highlands (*8; 9*, p. 53; *23*). The one exception is the central desert, but it is not clear whether this is a real absence or the result of inadequate archeological survey. Bowdler (*20*) has argued strongly that the absence of sites in this region, which includes about two-thirds of the continent, is a real one, and derives from the fact that the economy of the earliest settlers must have been coastally oriented, and that the initial spread of settlement would therefore have been around the Australian coasts. Her argument has not been universally accepted (*24*).

However, even if the central desert was not populated, we infer, from the ready discovery of terminal Pleistocene archeological remains throughout greater Australia, that population numbers must have been of an order of magnitude similar to those known in the ethnographic present. The accepted figure (*9*) for Australia is around 300,000 people. Another 50,000 to 100,000 could be added for Pleistocene New Guinea, whose estimated population at the time of European contact is 1.5 to 2.5 million (*25*), but which presumably experienced massive population growth with the increasing intensification of environmental exploitation during the Holocene. Even if we accept a total figure of only one-half this size (about 200,000 people), late Pleistocene Australia contained a population sufficiently large to maintain its general characteristics in the face of all but overwhelmingly great foreign genetic, cultural, or linguistic impacts (such as occurred in the 19th century). Consequently, we think it is now time to discard the model of trihybrid origins of the Australian population (*26*), at least insofar as it postulates large-scale migrations of new groups to the continent within the last 20,000 years.

Pleistocene Voyaging

Greater Australia has been separated from Southeast Asia by the Wallacean water barrier for at least 50 million years. Despite claims (*27*) of considerable tectonic uplift and downwarping within Wallacea during the Pleistocene, there is still no support for the idea of a land bridge between the two continents (*28*), although the breadth of the barrier has varied with the fluctuations in sea level. This implies sea voyaging was necessary to bring people to greater Australia.

On the basis of sea-level oscillations reconstructed by Chappell (*28*) and Chappell and Thom (*29*), Birdsell (*24*) calculated that, at periods of lowest sea level some 53,000 and 20,000 years ago, the shortest route through the Wallacean water barrier involved eight voyages. The longest sea trips on this route were 19, 29, and 87 km (Fig. 2). Birdsell also noted that all other possible routes required three or more crossings of greater than 30 km and all routes required longer sea voyages as sea levels rose.

The other factor to consider is the viability of newly arrived populations in Australia. Sea crossings are irrelevant if adventurers die without continuing issue. Computer simulations by McArthur and others (*30*) show that even given fairly liberal expectations concerning individual fertility and mortality, and a mating system unrestricted except by a rule of monogamy, a group of three couples with all members at the beginning of their reproductive lives have less than a one-in-two chance of founding a successful population. Reducing the number of women in the founding group, increasing the ages of group members at time of arrival, or imposing a rule of incest all reduce the chances for success quite markedly. However, in a recent series of simulations McArthur (*31*) shows that eliminating the rule of monogamy gives groups consisting of a man and two women at the start of their reproductive careers a three-in-four chance of surviving. Imposing an infertile year on a woman following the birth of a child reduces the long-term chances of population survival to one-in-two.

Taken together, these data have interesting implications for the type of watercraft necessary to negotiate the passages across Wallacea. Elaborating on the work of Birdsell (*24*), we suggest that these must have had sufficient size and buoyancy to carry at least three people and some drinking water for 2 days or more. We suspect that some ability to make headway across or even against currents may have been required. Among ethnographically known Australian watercraft not even the sewn-bark canoe of Arnhem Land really meets these requirements (*32, 33*). These canoes were up to 5.5 m long and 0.6 m wide and could carry six to eight people (*33, 34*), though over what distance is not recorded. In other parts of Australia, bark-bundle canoes, tied-bark canoes, and rafts carried fewer people, failed to remain buoyant for more than a few hours, or were more difficult to navigate (35). As a result, trips of greater than 10 km were very rare in Australian seas and disasters could easily occur (36). The sewn-bark canoe seems to us to be at or below the minimum level of technology required to transport humans through Wallacea (37).

We suspect that marine technology of this kind is more elaborate than most prehistorians imagine might have been in use 50,000 years ago. For instance, while sea crossings of the Strait of Gibraltar (maximum distance 20 km) have been posited (38) in what are implied to be some numbers as early as Middle Pleistocene times, this idea is not generally accepted (39). Discussions con-

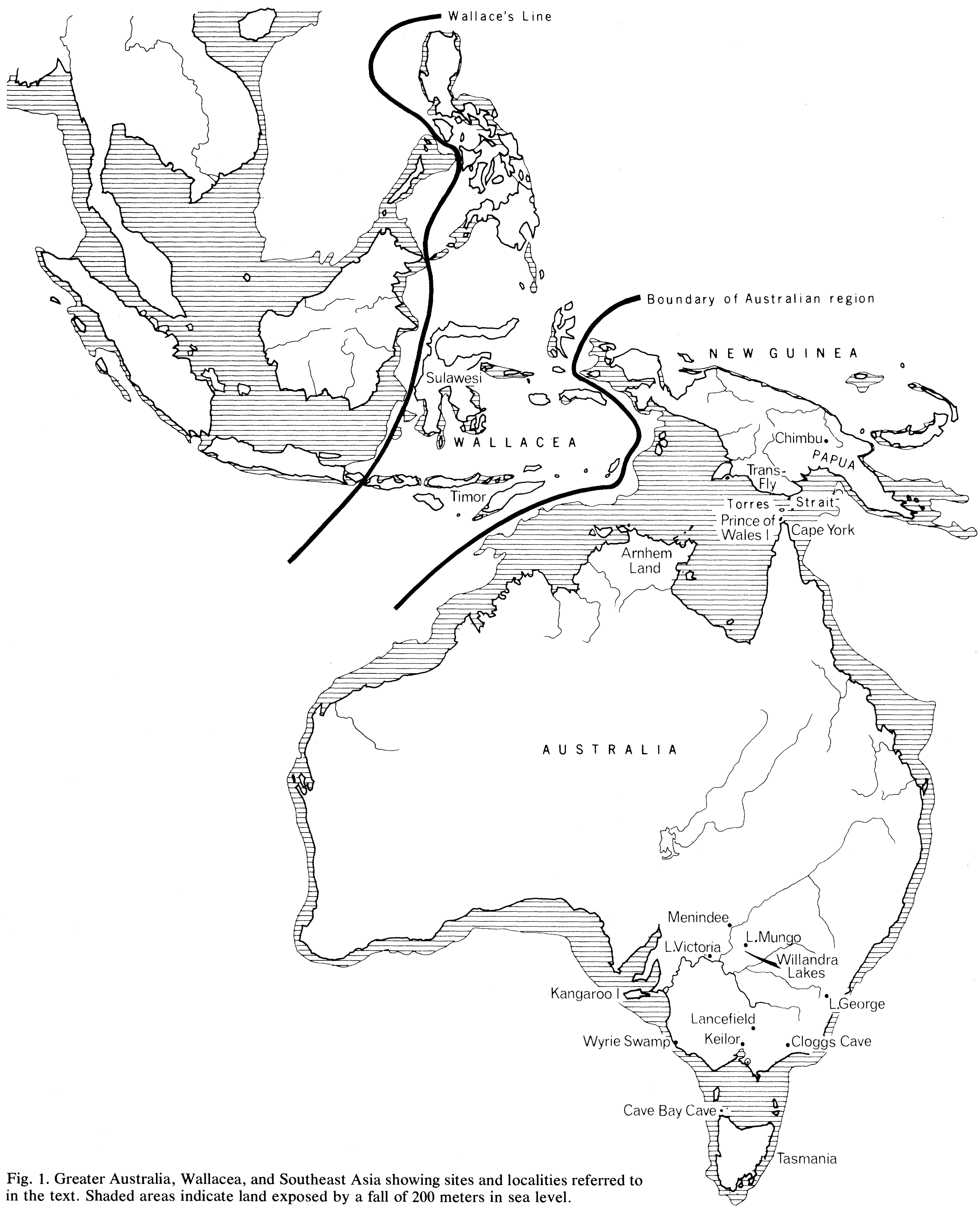

Fig. 1. Greater Australia, Wallacea, and Southeast Asia showing sites and localities referred to in the text. Shaded areas indicate land exposed by a fall of 200 meters in sea level.

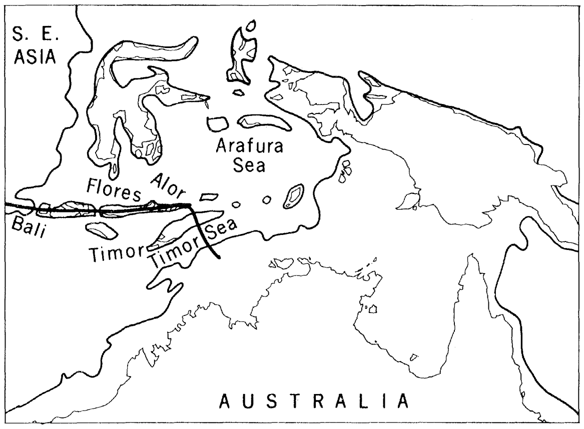

Fig. 2. The shortest sea route, indicated by the black line, between Southeast Asia and Australia when sea level was 200 meters lower than at present.

cerning initial entry to the American continent are oriented almost totally to land travel (*40*), although this has recently been criticized (*19*). In the case of Australia, where sea crossings cannot be avoided, "accidental" crossings, such as by drifting while clinging to uprooted trees (*41*) or by rafts being impelled by *tsunamis* (*42*), must be rejected because of the unlikelihood of a series of accidents occurring to an adequate number of sexually appropriate people. Further, if reasonably sophisticated watercraft did exist, we can only wonder about the associated littoral and marine economies, the evidence for which is now presumably beneath the Timor and Arafura seas.

We are therefore not convinced that the Wallacean barrier was ultimately breached by chance voyagers in the context of an infinite period of time (*43*). The often promulgated idea that the offspring of a single pregnant woman clinging to a log could ultimately populate a continent (*41*) can be relegated to the realm of theoretical biology.

Pleistocene Extinctions

It has been recognized for a century that certain larger elements of the Australian fauna either became extinct or underwent a substantial reduction in size in the Late Pleistocene (*44*). Taxa affected include several genera of large macropods (*Sthenurus*, *Procoptodon*, *Protemnodon*, *Macropus*), the diprotodons (*Diprotodon*, *Palorchestes*, *Zygomaturus*), a ratite bird (*Genyornis*), and a predator (*Thylacoleo*). Dates for the disappearance of these forms are a matter of some dispute. In 1968, independent reviews of the evidence (*45*) concluded that only two occurrences of some extinct forms were possibly younger than 30,000 to 35,000 years. These were at Menindee (*46*) and Keilor (*47*).

In the past decade, discoveries in the southeastern quarter of Australia show that extinct forms persisted into the period 30,000 to 20,000 years B.P., and later in some areas. The strongest single piece of evidence comes from a swamp deposit at Lancefield, near Keilor, which has produced a massive accumulation of *Macropus titan* with some specimens of other similar sized genera such as *Diprotodon*, *Protemnodon*, *Sthenurus*, and, perhaps, *Genyornis* (*48*). The total number of individual animals is estimated to be 10,000 to 12,000 (*48*, *49*). All bones were clearly deposited within a short time span, possibly a few hundred years. Charred wood from a small channel underlying the bone bed is dated to 26,000 years, while dates on the bones themselves indicate a minimum age of 20,000 years. The site's excavators have not yet agreed among themselves on the exact cause of this accumulation, but there is no disagreement concerning the dating, which conclusively demonstrates that quantities of now extinct forms coexisted with humans in southern Australia for many thousands of years. Confirmatory evidence of coexistence comes from the Willandra Lakes (*5*, *50*), Lake Victoria (*51*), Kangaroo Island (*52*), and Clogg's Cave, Victoria (*53*).

The situation in other parts of the continent is less well known, since finds are fewer and less well dated and paleoclimatic sequences are less well understood. In New Guinea, for instance, probably Late Pleistocene faunas, including extinct giant species, are known but are not radiometrically dated (*54*), and do not occur in archeological sites reported in the literature. However, Hope (*55*) reports the tentative identification of a few specimens of two now extinct forms from a site in Chimbu Province excavated by M. J. Mountain. Probable dates are 10,000 to 15,000 years B.P. Thus, while any discussion of extinction and dwarfing of the Pleistocene fauna must recognize that the process occurred throughout the many different environments of the continent, we cannot yet take account of these local circumstances. The following discussion is primarily applicable to the southeastern quarter of Australia.

The disappearance of large Pleistocene animals has sometimes been attributed to climatic change, particularly to a supposed mid-Holocene arid period 7000 to 5000 years ago (*56*). Reviews in 1968 (*45*) pointed out there was no evidence for this period and that extinctions occurred much earlier. However, a recent review of paleoclimatic data by Bowler and others (*57*) concludes that conditions of extreme aridity and high seasonal temperature variation did prevail throughout south and central Australia 16,000 to 17,500 years B.P. Still, there is no reason to believe that regional climate was more severe then than at periods within earlier arid intervals (for example, 45,000 to 120,000 years B.P.), and since the species involved evidently inhabited a wide range of environments, they should have survived this period. The available evidence indicates that they did not.

The other most frequently advocated mechanism of Pleistocene megafaunal extinctions is human activity, either through direct predation, by changing local environments through the use of fire, or both (*58*). In spite of the fact that megafauna and artifacts are associated in some of the late Pleistocene sites discussed above, no clear "kill-sites" or other large-scale associations proving human predation have yet been located. Nonetheless, we believe that Pleistocene Aborigines did kill and eat these animals [see (*20*) for a contrary view]. In support, we note that throughout Australia modern Aborgines hunted European-introduced animals of comparable or larger size than those of the Pleistocene (*59*) and did so with weapons no more complex than those probably in use during the Pleistocene.

At the same time, we find it hard to believe that direct predation was the sole cause of extinction. All archeological evidence as well as recent studies of Aboriginal hunting (*60*) indicate that Australian hunters were and are "generalists" with a highly opportunistic prey selection strategy. Even if large animals were particularly attractive targets, continued predation would simply reduce their numbers to the point that hunters were more likely to encounter and pursue other prey, thereby easing the pressure on larger fauna. Although heavy initial kills of unsophisticated prey may have occurred, this probably did no more than limit their distribution in some areas.

Fire-induced changes in local vegetation are even less likely to have played a critical role in faunal extinction. Evidence from the period of first European contact shows very clearly that fire was used throughout Aboriginal Australia in hunting, land clearance, and communication, as well as for domestic purposes, and that it almost invariably contributed to increases in the numbers and diversity of local faunal communities (*61*). The frequent small-scale fires favored by Aborigines recycle nutrients back into the soil, create a much more patchy array of habitats, and reduce the chances that lightning strikes will lead to catastrophic "blanket burns" which devastate large areas. Thus the probable increase in fire frequency following the Aborigines' arrival is at least as likely to have enhanced as reduced the chances of survival of some, if not all, species (*62*).

We conclude that the Late Pleistocene disappearance of large fauna in Australia was not a catastrophic event directly and immediately connected with arrival of man on the continent. Whatever the value of overkill models proposed for North America and elsewhere (*63*), they are inapplicable to the Australian situation.

In general, we believe that Late Pleistocene extinctions are likely to have been the result of climatically induced environmental change, with the assistance of human predation in some areas. The mechanism we envisage for inland southeastern Australia involves the assumption that free surface waters were essential to the survival of large animals (*64*). If these waters were restricted to an extreme degree 16,000 to 17,500 years ago, then the animals may have been predictably concentrated in a relatively limited number of localities, especially during the summer months. Human populations, probably clustered in the same areas, might have wiped out these ecologically tethered species fairly quickly. The process may have been assisted by reduced breeding rates for the animals concerned (*65*). Horton (*62*) suggests a similar mechanism, but without the human input. Extinction in this way would not involve any change in Aboriginal hunting strategies, nor would we expect any sudden, large-scale change in the nature of the archeological record.

Resistance to Agriculture?

Observers have long remarked on the fact that while Australia remained a land of hunters and gatherers until the arrival of European colonists in the late 18th century, its largest continental island, New Guinea, was occupied by agriculturalists. The development of systems of plant cultivation based on exotic and indigenous domesticates, and involving relatively permanent settlements, elaborate water management practices, and extensive forest clearance is now well documented in the Highlands by 5000 to 6000 B.P. (*66*), and aspects of them occur by 9000 B.P. (*67*), perhaps 1000 to 2500 years before New Guinea was separated from Australia by the rising post-Pleistocene sea (*68*).

Although agriculture in New Guinea developed early, and became highly intensive in some areas, many economies include a substantial component of hunting and gathering (*69*). This is true of the Trans-Fly region where some local groups derive up to 70 percent of their total dietary intake from wild stands of sago (*Metroxylon* spp.), an indigenous plant which is also cultivated (*70*). Other plant foods are raised in small gardens or collected from uncultivated bush. We note particularly that many of these species, or very closely related forms (notably *Dioscorea*, *Colocasia*, and *Tacca*), are gathered in the wild in Cape York and Arnhem Land (*71*). Yams are, in fact, a staple in both areas.

The Australian situation is also complex. Although Aborigines never practiced labor-intensive plant cultivation, they took steps to increase the abundance and productivity of economically important plants. Throughout Australia, their most effective step was frequent and systematic burning of selected patches of country. This favored not only the native fauna but most plant foods as well (*61*). For example, Harris (*70*) suggests that regular burning in tropical woodlands of Cape York and Arnhem Land increased the distribution and productivity of the seasonal staple *Cycas media*. He notes that burning makes seed harvesting easier and stimulates asexual reproduction. Beaton (*72*) shows that where stands of another, equally important cycad (*Macrozamia* spp.) are fired, seed production is apparently synchronized and may be multiplied by a factor of 7 or 8.

Aborigines also frequently replanted the tops of yams and other tubers after harvest (*73*) and tended many other plants throughout Australia (*74*).

Given these data, we should not question why horticulture failed to spread from New Guinea to Australia, but rather why New Guinean practices of localization of cultivation, particularly those applied to taxa which were collected wild in Australia, were not adopted by Aborigines, especially in the Cape York region. Previous explanations which have been offered are not convincing (*75*). Lack of contact with agricultural groups can be ruled out. Intergroup visiting was frequent between Cape York and some Torres Strait islands, and Cape York Aborigines were undoubtedly familiar with the cultivation of yams, taro, sugarcane, bananas, and other species as undertaken on Prince of Wales (Muralug) and other nearby islands (*76*). Cultural conservatism on the part of Aborigines has also been suggested (*77*), but it too seems inadequate to serve as a total explanation given that Cape York people adopted other elements of New Guinea culture, including items of technology, folklore, ritual, and language (*78*).

Harris' recent treatment (*70*) of the problem notes differences in the intensity of plant cultivation on several Torres Strait islands, and suggests that they are a result of environmental diversity and stability and local group sedentism. On small islands, intensive cultivation practices may have been necessary to ensure an adequate food supply. The more diverse environments on larger islands may have encouraged more frequent movement, thereby reducing population pressure and eliminating the incentive for cultivation. Following Harris, we suggest that under traditional conditions, the comparative productivity of the Cape York and Trans-Fly regions was such that Aborigines in the former area were able to maintain higher populations, while at the same time minimizing labor input through hunting, gathering, and low-intensity cultivation using fire. Thus Cape York, like Aboriginal California (*79*), may be an area in which domesticated plants and intensive cultivation techniques were known but rejected on the grounds that the investment of labor required to integrate them into local subsistence economies was not worth the return.

In support of this, we note that reefs and other marine resources such as dugong and turtle are more diverse and richer closer to Cape York. We can therefore anticipate that both hunted and gathered marine resources were more reliably available in quantity than was the case closer to New Guinea, and that the poor seasons which caused some Torres Strait islanders to make gardens from time to time (*76*) may have been of less effect.

Even if some aboriginally used species were originally introduced from New Guinea (*71*), they were managed and harvested in a similar way to other plants already in use. Thus the spread of preindustrial agriculture in this area was determined not by the environmental limits of the plants, but by an assessment on the part of particular local groups about the potential benefits of cultivation relative to continued dependence on hunting and dispersed plant management.

In the wider Australian context, once this decision was taken by a very few Cape York Aboriginal groups, intensive cultivation techniques would be prevented from spreading further into the continent, for it is clear that Torres Strait islanders were not in direct contact with many Aboriginal groups (*80*).

Technological Evolution

The general history of flaked stone technology has been clear for at least a decade (*81*). An Australia-wide Pleistocene and early Recent industry consisted of high-domed chunky cores, generalized "scrapers," and flakes. To this was added, in early to mid-Recent times, several new tool types including microlithic backed blades, unifacial and bifacial points, and flaked stone adzes (*tula*). They are collectively called the Australian small tool tradition (*82*), and are restricted to the Australian mainland (*83*).

Debate has focused on questions of their origins and economic significance. For many years, majority opinion (*84*) has seen this tradition as a unitary phenomenon, introduced to Australia from an external source between 5000 to 7000 years B.P. However, the search for precursors in nearby areas such as Sulawesi (*85*) and Timor (*86*) has been unsuccessful. We reject the majority viewpoint on two other grounds:

1) Various elements within the "tradition" have radically different geographical distributions. Microliths are restricted to the eastern and southern half of the Australian continent, while points occur in a north-south band in the central third. No area containing classic examples of all elements has been located to date.

2) Elements of the tradition appear at different times in different areas. Adzes are known from two terminal Pleistocene sites in western Australia (*87*), points from only around 5000 years B.P. Most important, Pearce (*88*) shows not only that the oldest dates for the backed blade technology come from southeastern Australia—the reverse of what the external origin theory would predict—but also that terminal dates are earliest there and that earliest and latest dates tend to move forward in time as distance from southeastern Australia increases. Although Pearce's time ranges have been altered by Stockton's (*89*) dismissal of the four earliest dates on grounds of inadequate stratigraphic control, his proposal for a southeastern Australian origin for this tool class seems to us simpler, and thus more satisfactory than an external origin model.

The significance of these technological changes is also in dispute. Mulvaney (*90*), who originally called their introduction the "Inventive Phase," still maintains (*91*) that the new technology implies wider changes in Aboriginal society, although his more strictly technological suggestion that it represented the introduction of hafting into Australian tool kits has been formally discarded. Jones (*92*) suggests that the small tools mark a significant increase in extractive efficiency, which allowed ritual to be elaborated and social networks to be expanded to equal those of the ethnographic present, but he has not documented how old subsistence resources are exploited more efficiently (*93*) or that new ones come into use. Flood (*94*) and Beaton (*72*) have shown in two areas of the eastern highlands that exploitation of a new resource occurs contemporaneously with the new stone tool forms, but no functional relationship is shown. Peterson (*95*) and White (*93*) have indirectly suggested that the new forms of tools may no more than formalize already existing functional tool groups, but this has not to date been tested by functional analyses of industries from various periods.

For backed blades in particular, Lampert notes that in several areas their appearance is related to increased exploitation of "exotic" stone sources (*96*). This may signal expansion or intensification of exchange networks and regional social relationships, but the occurrence of a similar-timed change in stone source exploitation in Tasmania (*92*), where no backed blades occurred, suggests that the new technology is not a critical factor. We therefore suggest that the distribution of backed blades is best understood as a transcontinental stylistic phenomenon, the closest parallels to which may be the spread of projectile point styles in North America (*97*).

The evidence is not available to posit a similar model for the point industries, though we note here that both large unretouched blades and delicate, bifacially flaked points were traded as nonutilitarian items in north Australia in the recent past (*98*). For *tula* adzes we suggest, on the basis of ethnographic data and use-wear studies (*99*), that their role in woodworking is clear and they were probably invented in terminal Pleistocene Australia.

Other aspects of technology are also of interest. In 1965 C. White (*100*) recovered 15 ground stone axe [properly, hatchet; see (*101*)] heads from three shelters in Arnhem Land, two with associated dates of 18,000 to 25,000 years B.P. Confirmatory evidence (*102*) has been obtained from other tropical northern Australian sites, but the earliest equivalent tools in the center and south are found only in conjunction with backed blades and points. The origin of the ground stone technology remains obscure. Ground stone axe or hatchet heads occur at similarly dated sites in Japan (*103*) and may occur in Southeast Asia (*104*). Ground stone axes are thus far dated only to about 10,000 years in New Guinea (*105*). Given that the Australian tools are hatchets, whereas tools in adjacent regions are axes, a local origin is likely.

Although returning boomerangs are known popularly as the Aboriginal weapon par excellence, ethnographic records suggest that they were usually playthings, and their recorded use in hunting is rare (*106*). Their origin has often been sought externally (*107*), though their distribution within the continent argues against it (*106*). Luebbers now reports (*108*) fragments of preserved wood with characteristic boomerang features of curvature and lateral twist from swamp deposits at Wyrie, South Australia, dated to 10,200 ± 150 years (sample ANU-1292). Reproductions to allow testing of flight patterns are still in progress, but the existence of boomerangs at this early date strengthens the argument for local derivation from curved throwing sticks.

We thus conclude by stressing that the local development of many aspects of Aboriginal technology is increasingly supported by the data.

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NEWS AND COMMENT

Toxic Substances: EPA and OSHA Are Reluctant Regulators

Despite a panoply of laws intended to protect society from hazardous chemicals, the regulatory road from discovery of a hazard to its control remains rough. Bureaucratic inertia and delay are permanent features of the process; pressure from affected industries is constantly applied; and statutes are often unworkable from the start. As a result, prompt regulatory action is virtually nonexistent, and when action does occur, it is usually at the prodding of outside citizen groups.

Officials of the Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA), the main actors, are often reluctant to take the first step in restricting exposure to a toxic substance because they know what happens next: outside pressure is applied, both directly and through Congress, followed inevitably by a lawsuit, which may expose deficiencies in the original law. Familiarity with this chain of events suggests that a safe approach is to do nothing at all. The result is that, at a time when the use of potentially hazardous chemicals in our society is dramatically increasing, evidence is abundant that the Washington regulatory establishment has not been able to keep up.

As Thomas Jorling, EPA's assistant administrator for water, recently told a congressional committee, "One of the most acute frustrations I have come to experience is the immense difficulty associated with taking statutory mandates into implementation. Complexity, procedures, and shortages of resources all contribute; but there are also larger, more pervasive reasons related to institutional fears of changing or altering the system."

These fears are often revealed in the statements of EPA and OSHA regulators that what they do is so complex they hardly know where to begin. As an example, EPA has been considering for some time whether to regulate cadmium, a highly toxic heavy metal discharged into sewage systems by the electroplating industry and by the deterioration of rubber auto tires. Exposures to high amounts of cadmium have been linked to birth defects, cancer, and damage to kidneys and livers. EPA has three laws at its disposal to control cadmium exposures, and environmentalists firmly believe that the regulations are long overdue. But nothing major is likely to happen soon. Swep Davis, the deputy assistant administrator for EPA's water-treatment program, says, "I wouldn't understate the cadmium problem, but it is simplistic to think that it can be solved easily. Because of the complexity of this, there are legitimate reasons for not moving more quickly."

The consequences of such an attitude are twofold. First, regulatory agencies typically do not act until pressure is exerted by outside citizen groups. According to Sidney Wolfe, who has initiated several petitions for regulatory action on toxic substances as director of Ralph Nader's Health Research Group, unions or public interest groups have been the initiators of OSHA, EPA, or Food and Drug Administration action in 22 of the 26 instances through 1976 when the agencies regulated carcinogens. This record suggests that EPA and OSHA have been taking a passive role, acting as judges and not prosecutors in environmental protection.

Chronic Indecisiveness

Second, when either OSHA or EPA actually begins to regulate a toxic substance, the length of time spent deciding exactly what to do is immense. According to Jorling, the average time for rulemaking by EPA "is now approaching 4 years." A case in point is the regulation of polychlorinated biphenyls (PCB's), which have been linked to neurological and reproductive disorders as well as to cancer. PCB's remained unregulated for at least 3 years after these hazards were widely known; Congress, acting in large part because of EPA's waffling, included a provision in the Toxic Substances Control Act of 1976 to prohibit the manufacture of PCB's.

Such delay is frequent. As a result, the gap between awareness of potential hazards and the efforts to control them continually widens. The EPA estimates, for example, that one-third of the 1500 active ingredients of registered pesticides are toxic and that one-fourth are carcinogenic. Although the agency has established limits on the amounts of pesticide residues permitted in food, it has restricted the use of only five (heptachlor/chlordane, aldrin/dieldrin, DDT, Mirex, and DBCP, three of which had been targeted in Rachel Carson's 1962 book, *Silent Spring*). Twenty percent of the 70,000 chemicals in commercial use examined by the EPA thus far are suspected carcinogens, says EPA administrator Douglas Costle. (Presumably, the percentage will decline as the agency moves on to chemicals of lesser priority.) Still, the agency has set permanent standards for exposure and effluent limits for only