1

An Introduction to the Investigations at Kuk Swamp

Jack Golson

The choice of Kuk

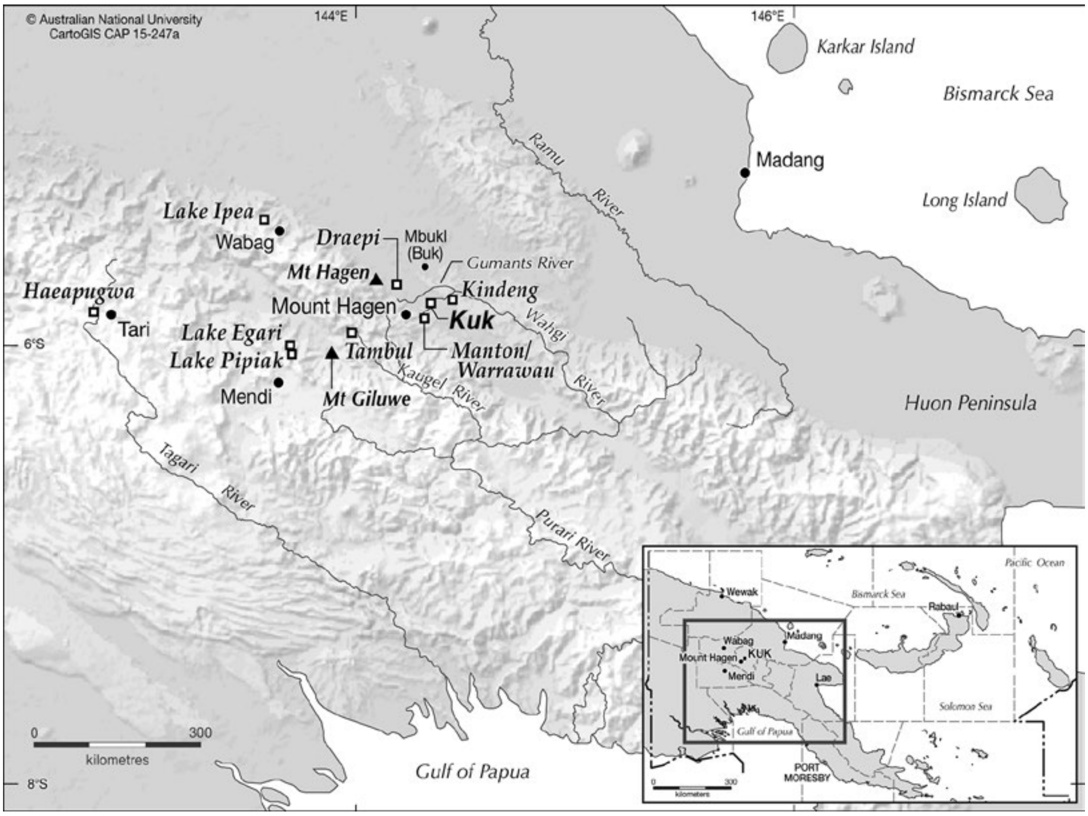

Figure 1.1 This shows the wider region where investigations directly or indirectly related to those at Kuk are discussed in this chapter.

For the relationship of the Wahgi and Gumants Rivers see Figure 1.2. The inset shows the region of the main figure in relation to PNG as a whole and has lines in the background indicating provincial boundaries at the time of the investigations.

Source: Jennifer Sheehan, CartoGIS Services, College of Asia and the Pacific, ANU.

Kuk Swamp is situated at an altitude of about 1550 m some 12–13 km northeast of Mount Hagen town in the upper Wahgi Valley of the central highlands of Papua New Guinea (PNG) (Figs 1.1 and 1.2). Until the 1930s, these were thought by outsiders to be a single continuous and uninhabited mountain chain. Exploration in the 1930s, however, coming from the east, revealed them to consist of a series of massive mountain ranges enclosing basins and valleys between 1400 and 2000 m altitude that were well populated and intensively cultivated, the dominant crop being the tropical American sweet potato (*Ipomoea batatas*) (Brookfield 1964: 20–22). The first European party to reach the Wahgi Basin, in 1933, described the swampy floor of the main valleys as uninhabited and uncultivated, with people and their gardens concentrated on the higher ground of the valley slopes (cf. Leahy 1936: 248, describing an area that is recognisable as including Kuk). Kuk itself, the home territory of the Kawelka people, was at the time uninhabited (see Fig. 22.1, which is a map of the tribal distribution in this area), following the defeat of its owners in conflict with more powerful neighbours possibly around AD 1920. They sought refuge with tribal relatives in the hills of the Sepik-Wahgi Divide to the north, as described in the oral histories discussed in Chapter 22.

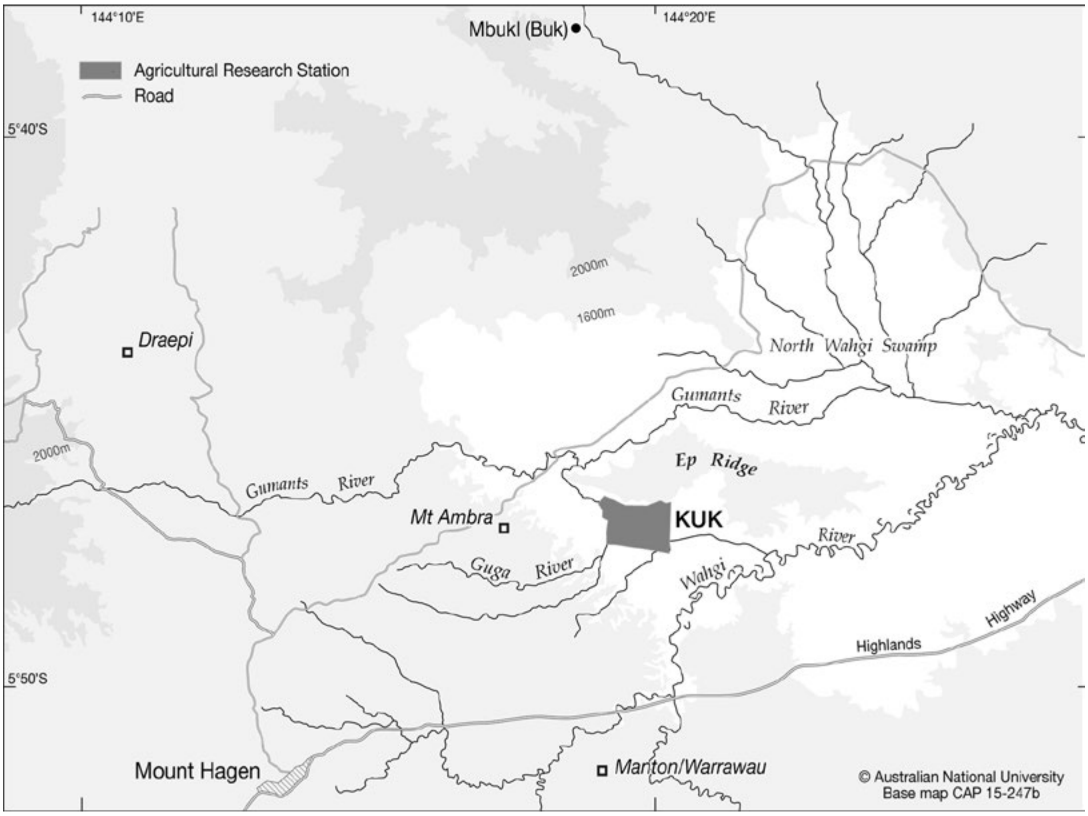

Figure 1.2 This map shows the upper Wahgi area, which was the focus of the investigations centred on Kuk. Figure 22.1 is a map of tribal distribution in this area.

Source: Jennifer Sheehan, CartoGIS Services, College of Asia and the Pacific, ANU.

The recently contacted communities of the highlands became an important part of the Australian administration's expanded responsibilities with the end of World War II and the formal unification of the two hitherto separate entities of Papua and New Guinea. As regards Kuk, the suppression of tribal warfare allowed the gradual return of former inhabitants, beginning around 1960.

Hand-in-hand with these developments went the growth of academic interest and involvement in the highlands, reflected, for example, in the special issue of *American Anthropologist*, edited by James Watson (1964a), with two contributions relevant to our present theme of agricultural history: Harold Brookfield's 'The ecology of highland settlement: some suggestions'; and 'The prehistory of the Australian New Guinea highlands' by Susan and Ralph Bulmer, a pioneering discussion of the evidence for highlands prehistory. Both articles were in part concerned with the implications of the superior capability of sweet potato for growth at altitude compared with that of traditional Pacific cultigens like taro, yam and banana.

For Watson himself (1965a and 1965b), this was the crucial factor in New Guinea history in the context of general agreement that the plant did not make an appearance in the region until after Magellan's circumnavigation of the globe in AD 1519–1522 (Yen 1974: 259–260; cf. Roullier et al. 2013: 2205). This would have only allowed a few hundred years for the increase of population in the newly discovered highlands and the development of the complex economies and societies there that had been the object of study following European contact.

Watson's promulgation of the thesis of an Ipomoean Revolution evoked a swift academic response—the organisation of a three-day seminar at The Australian National University (ANU) in April 1967 by Brookfield and archaeology student Peter White to submit Watson's hypothesis to specialist consideration across the range of essentially synchronic evidence involved, from demography, social organisation and linguistics (Brookfield and White 1968). Before the meeting was held, however, new diachronic evidence became available, which had been unavailable to Watson but which '[demands] a revision of his hypothesis' (Brookfield and White 1968: 44).

From the 1950s on, developments sponsored by the Australian administration in the Wahgi Valley included swamp drainage for the establishment of tea and coffee plantations. In 1965, at one of these sites, Warrawau, an Australian visitor saw a stone mortar that had been unearthed during the digging of drainage ditches, together with stone axes and wooden digging sticks, paddle-shaped spades and fence posts. He wrote a letter about this to, among others, Fred McCarthy, long-time ethnologist at the Australian Museum in Sydney. McCarthy had recently become principal of the newly established Australian Institute of Aboriginal Studies in Canberra, where the letter was forwarded. McCarthy in turn passed it on to Jack Golson, who had been hired in 1961 to establish an archaeological unit in the Department of Anthropology and Sociology in the Research School of Pacific Studies (RSPacS) at ANU.

Golson's first two appointments were Wallace Ambrose, from the University of Auckland, to set up photographic and analytical facilities, and Ronald Lampert, from English Heritage, to undertake field reconnaissance. In 1966, when Fred McCarthy wrote to Golson, Lampert was in PNG and Golson sent word for him to visit the Warrawau plantation. Lampert reported enthusiastically on the prospects for exploratory excavations there and Ambrose and Golson joined him in the field. They invited a fourth person to be a member of the team. This was Jocelyn Wheeler of the Department of Geography, RSPacS. She was already in the highlands doing postgraduate fieldwork using pollen analysis to study human impact on the vegetation of the Mount Hagen region in the past.

The team carried out limited excavations of some 300 m^2 at what they called the Manton site, after the plantation owner. There was a series of ancient ditches cut at different levels in a black, well humified peat, interpreted as an old garden soil (Golson et al. 1967; Lampert 1967). Aerial photographs of the property taken in connection with its development showed the marks of gridded ditching and cultivation plots. The evidence pointed to the implements turned up by drain digging across the 350 ha plantation as a whole having come from the context of wetland cultivation.

A digging stick at the bottom of the oldest of the excavated ditches was dated by the recently established ANU carbon dating laboratory as ANU-43 = 2300±120 radiocarbon years Before Present (BP). Even though there was no way at the time to convert this date into calendar years, it was evidently well before the accepted arrival of the sweet potato in New Guinea a few hundred years ago. Progress over subsequent years in the conversion of radiocarbon dates to calendar years put the calendar equivalent of ANU-43 at two standard deviations between 2710 and 2040 cal. BP (calibrated Before Present = AD 1950 by radiocarbon convention) (see Denham 2005a: Table 5). This is an appropriate place to acknowledge the critical role of the laboratory in the Kuk story and our indebtedness to both Henry Polach, who set it up, and John Head, his right-hand man, over subsequent years.

Visits to other plantations in the region produced a similar story of stone and wooden implements being discovered during drainage, with aerial photographs showing evidence of former drainage of the swampland that they now occupied. The findings overall cast great doubt on Watson's theory of an Ipomoean Revolution, as noted in the discussion of the Brookfield and White seminar of 1967 above, but at the same time indicated the great potential of the Wahgi wetlands for investigating the history of agriculture in the PNG highland zone.

Planning for such a project began as soon as the implications of the Manton work became clear, and ANU was an excellent place to do so. The Department of Anthropology, of which the small archaeological unit was part, was an active centre of research into highlands ethnography. The Department of Geography in RSPacS was also engaged in a wide range of work in the highlands region. Of particular relevance was the palynological research of Donald Walker and his students, looking into highlands vegetation history as revealed in pollen diagrams, including the role of people in vegetation change, something that Wheeler, one of those students, had done for the Manton investigations. Of similar relevance was the work of Harold Brookfield and his students on variations in settlement, landuse and agricultural practice across the highlands and the nature of interrelationships between them. In addition, there were the records of PNG landscapes, soils, climate and vegetation being made by scientific teams from the Division of Land Use Research of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) over the road from ANU, and the programme of geological mapping by the Australian Bureau of Mineral Resources, also Canberra-based.

In this context, a multidisciplinary strategy was developed (Golson 1976: 209; cf. Denham, Golson and Hughes 2004: 263) comprising:

a. archaeological investigation of drainage and cultivation systems in swampland through time;
b. geomorphological study of the origin and history of swamps, with particular attention to interrelationships with human activities in the swamp and on its margins;
c. palynological reconstruction of the regional vegetation within which cultivation systems, both dryland and wetland, operated and with which they interacted; and
d. ethnographic study of traditional agricultural practice in the region.

A suitable site at which to implement this programme was not identified until 1969. A major problem was finding drained land where the investigations would not clash with the activities for which the land had been drained in the first place. A site of possible general interest on the south bank of the Wahgi at Kindeng, 25 km down the valley from Mount Hagen town, was reported by a contact in the Department of Forestry, which had land there. Excavations were carried out in 1968 by ANU archaeologists who had dug the Manton site, together with Peter White, an ANU archaeology PhD student who has previously been mentioned. Though Kindeng was not a useful site for wetland excavation, Wheeler, who had done palynological work at Manton for her PhD fieldwork and was again in the highlands, took a useful pollen core. She analysed this after completing her doctorate and delivered the results to the ANU Department of Prehistory in 1972 (Powell 1982a: 218, 223–224 and Fig. 4).

By this time, Jim Allen, who had recently completed his PhD in archaeology at ANU and was now teaching in the Department of Anthropology and Sociology at the young University of Papua New Guinea (UPNG), identified a potential site during a familiarisation trip to the highlands in 1969. The previous year, the Department of Agriculture, Stock and Fisheries had bought some 770 acres (311.6 ha) of swampland for the establishment of a Tea Research Station at Kuk Swamp,[1] and drainage for the development of its western part had begun in 1969.

Allen (1970: 177) visited the site during its initial drainage and noted similarities to the description (Golson et al. 1967) of the Manton site at Warrawau, located less than 7 km south across the Wahgi River, with the discovery of similar artefacts during drainage and the presence of former ditching in the walls of the modern drains. He returned to Kuk to do some investigation of these towards the end of 1969 and wrote to Golson, identifying the site as worthy of large-scale investigation. A most promising feature was that since the site involved a government agency and not a commercial entity, it should be possible to avoid a clash of interests, which indeed proved to be the case.

Golson was due to attend the 42nd Congress of the Australian and New Zealand Association for the Advancement of Science in Port Moresby in August 1970, so he planned to visit the Kuk Research Station with Lampert after the meeting to confirm the potential of the site and, if this were the case, raise the question of working there. The walls of newly dug drains exposed the swamp stratigraphy and the profiles of numerous ancient ditches for their inspection. While there, they were visited by two young geomorphologists: Colin Pain, a graduate student from ANU, who was on his way to his research area at Tambul in the upper Kaugel Valley further west, and his friend Russell Blong, a senior tutor at Macquarie University, Sydney. Both were New Zealanders and readily identified as volcanic ash a number of lighter-coloured occurrences in the swamp stratigraphy that Golson and Lampert had been unable to understand. As a result, they were asked if they would be interested in giving their geomorphological services to any future project. Both were interested, but only Blong was available.

Kuk management was agreeable to the idea of hosting a project at the site, but would need a detailed plan to consider the implications for the work of the Station before seeking the approval of head office in Port Moresby. Golson promised to return to Kuk in mid-1971, after field commitments elsewhere, to discuss with John Morgan, the Agronomist-in-Charge, the details of the proposed work and a start date in the dry season of 1972. Because of the interest in the proposed work on the part of the Station staff, Golson suggested that Blong return to Kuk with ANU support in the summer university vacation of 1971, to look for volcanic ashes in the part of the Station under development. This led to the identification of a young volcanic ash below surface peat in the southwest corner of Station block A4 on the bank of Tibito Creek (see Fig. 6.14), for which the ash was later named. Blong also found three other ashes in the northeast corner of block C6, all lower in the stratigraphy. He collected samples of ash for analysis and associated organic matter for dating at each location.

While he was engaged in this work, Blong was approached by a group of consultants doing a feasibility study for the Papua New Guinea Department of Agriculture, Stock and Fisheries for the drainage of a large block in the North Wahgi Swamp, over Ep Ridge from Kuk. This led to the drilling of a series of deep boreholes (>30 m) around the margins of that swamp, referred

1 Area varies in Station documents; see Chapter 6, section 'Kuk Swamp and its drainage for the Research Station'.

to by Blong as the Gumants Basin for the river that drains it and into which most of the runoff from Kuk itself flows. The boreholes provided evidence of a long history of volcanic, fluviatile, lacustrine and swamp sedimentation, most of it well beyond the range of radiocarbon dating.[2]

Another early start was made by Jocelyn Powell (née Wheeler), who had worked with ANU archaeologists at the Manton site and was available again because she had moved to Port Moresby with her husband. In mid-1971 she was at Kuk Swamp doing stratigraphic recording of drain walls and choosing a place where she could collect from a long swamp sequence. She recorded a 9 m long column through the deposits, collecting samples for pollen analysis and four samples for radiocarbon dating, two of these (ANU-955 and 956) giving dates in radiocarbon years beyond 20,000 BP (Powell 1984).

At his meeting with Golson in mid-1971, Morgan decided that the proposed work should take place in the eastern part of the Station to avoid interference with Station activities in the western half, and he undertook to provide the labour for the major drainage lines that would make this possible. The research team would be responsible for the minor drainage lines that would be needed to lower the watertable for its work and would have to hire its own workmen to dig them. These minor drains would be located and dug in conformity with the Station drainage plan, except that they could be 1 m wide at the top, instead of 0.61 m (or 2 ft), to make room for our recording of the walls. Approval for our project from Port Moresby was not long in coming.

At this stage, the question of large-scale area excavations, as distinct from localised testing, was put to one side due to the reluctance of the Station management, which planned to monitor soil fertility in various parts of the Kuk block, to consider major disturbance of the ground. However, as was clear from experience at the Manton site and the previous year at Kuk, the walls of the drains that were necessary to lower the watertable and give access to the site were ideal for stratigraphic and archaeological recording and the collection of samples for radiocarbon and other analyses. Drain digging indeed remained a major focus of our operations until mid-1975. By this time, Station management was well aware of the amount of disturbance that the Kuk deposits had undergone through ditch digging and earth moving in previous millennia and withdrew their objection to the area excavations that by then were essential to advance our knowledge of the site. From mid-1975 to 1977, the major focus was the area excavation of early cultivation systems and only a few drains were dug.

The Kuk Project: The main fieldwork, 1972–1977

The team that took to the field at Kuk in 1972 reflected the multidisciplinary character of the programme that had emerged in the later 1960s from the Manton work (Table 1.1). The archaeological component was Golson's responsibility but involved other members of what by this time was an independent Department of Prehistory at ANU, specifically Wal Ambrose and Winifred Mumford for the mapping of the surface evidence of the latest drainage channels and field systems and Ron Lampert for the excavation of surface-visible house sites. For the record of swamp stratigraphy there was Russell Blong, who had offered his services the year before, and for pollen work Jocelyn Powell. The role of swampland in traditional landuse practices in the upper Wahgi Valley was to be investigated by Ian Hughes of the New Guinea Research Unit of ANU based in Port Moresby.

2 Blong's (1972) contribution to the feasibility study forms a section of the first of five technical volumes accompanying the consultancy report: ANU Archives, Russell Blong papers, ANUA593/Box 2, Geomorphological Report, Part 3 of Technical Volume 1, Geomorphology, Site Investigation and Peat Shrinkage, pp. 4–48, September 1972.

Table 1.1 The archaeological, chronological, palaeoecological and stratigraphic work undertaken by Jack Golson with Philip Hughes and by Tim Denham under Golson's supervision.

Research Field	Period	Methods
Archaeology	Original	Excavation trenches (n=187) Archaeological and stratigraphic recording in plantation drain walls (n=>15 km)
	Renewed	Excavation trenches (n=19)
Dating[1]	Original	Conventional radiocarbon dating (n=78; ANU)
	Renewed	Conventional and AMS radiocarbon dating (n=36; ANU and ANSTO)
Palaeoecology	Original	Macrobotany: seeds and wood (n>500; J. Powell/L. Lucking) Phytoliths (n=30; S. Wilson) Pollen and microcharcoal (n=31; J. Powell)
	Renewed	Diatoms[2] (n=50; B. Winsborough) Insects (n=10; N. Porch) Phytoliths[2] (n=40; C. Lentfer) Pollen and microcharcoal[2] (n=60; S. Haberle) Tool residues (n=12; R. Fullagar, J. Field, C. Lentfer, M. Therin)
	Subsequent	Diatoms[3] (n=55; B. Winsborough, K. Saunders) Pollen and microcharcoal[3] (n=76; K. Sniderman)
Stratigraphy	Original	Deposition rates (P. Hughes) Organic matter and bulk density (P. Hughes) Chemical and physical composition (M. Latham) Ferrimagnetism (R. Thompson and F. Oldfield) Physical composition (J. Powell) X-radiography (R. Blong)
	Renewed	Thin section description (T. Denham) X-radiography (A. Pierret with T. Denham) X-ray diffraction (L. Moore with T. Denham)
	Subsequent	Geochemical characterisation of tephra (S. Coulter)

Note that the Renewed Period of investigation for Denham's PhD (2003a) and that of the Subsequent Period (Denham, Sniderman et al. 2009) focused on early and mid Holocene remains (Phases 1, 2 and 3; but see Haberle et al. 2012), as well as upon the geochemical characterisation of tephras at Kuk and Ambra Crater (Coulter et al. 2009).

Source: Updated version of Denham, Haberle and Pierret (2009: Table 2).

Notes:

[1] Conventional and AMS radiocarbon dating undertaken by ANU and AMS dating by the Australian Nuclear Science and Technology Organisation (ANSTO).

[2] During the renewed period of investigations, diatom, phytolith, pollen and microcharcoal analyses were undertaken by specialists on 40 'paired', or comparable, samples, with additional samples for some techniques. Several of these paired samples were also subject to AMS dating.

[3] During the subsequent period of investigations, diatom, pollen and microcharcoal analyses were undertaken on paired and contiguous samples through Phase 1, 2 and 3 contexts.

Over the six years of intensive fieldwork between 1972 and 1977, personnel changed as people moved on and new requirements emerged. Ian Hughes carried out his enquiries of older inhabitants about the agricultural use of swampland in the upper Wahgi during the first two years of the project, but stayed on with the New Guinea Research Unit in other roles.

It was in this planning stage that RSPacS awarded a PhD scholarship in its newly established Department of Prehistory to a Canadian applicant, Ole Christensen, who was well qualified to play a role in its Kuk project: MA research at the University of Calgary on prehistoric subsistence in Banff National Park and experience in tropical agricultural systems in Sudan and South America. He chose to undertake a study of resource utilisation in one of the side valleys of the Wahgi in the vicinity of Kuk to provide information about what was going on in dryland contexts while swamp agriculture was being practised. He did so in the Wurup area to which he was introduced by members of the Manton family whom ANU archaeologists had got to know during their 1966 excavations at the Warrawau Tea Plantation nearby. He was well advanced with his PhD research and had just submitted a summary of his work for publication (Christensen 1975) when he was killed in a road accident in December 1974. Besides the records on which the 1975 article was based, he left two important collections that have received subsequent attention. One is a large archaeobotanical collection from the wet sieving of four excavated rockshelter deposits in the Manim Valley (Donoghue 1988; and Chapters 10 and 14 here). The other is a stone axe collection from the Wurup area (White et al. 1977), which Chapter 21 notes as one of those that made it possible to study the nature and extent of the highlands stone axe trade and, because of axe fragments found in Christensen's rockshelter excavations, suggest a date for its beginning.

In order to provide a wider context for the understanding of the deposits that he was studying at Kuk, Russell Blong undertook cooperative work with Colin Pain, whose doctoral research on the Quaternary history of the Kaugel Basin, 40 km west of Kuk, was coming to an end (Pain 1973). They began with the unravelling of the stratigraphy of the thick older tephras deposited across much of the Western and Southern Highlands Provinces by eruptions mainly of Mt Hagen and Mt Giluwe more than 50,000 years ago (Pain and Blong 1976), as well as the nature of highland valley footslopes and fills (Blong and Pain 1976; Pain et al. 1987). Blong later persuaded a group of consulting engineers to drill a series of boreholes into the massive and widespread (>105 km^2) debris avalanche from Mt Hagen responsible for the presence of ash-mantled low hills beneath the swamp sequence at Kuk. The age of this avalanche is unknown, but it is at least 80,000 years old (Blong 1986a: 292).

Pain and Blong (1979: 229 and Fig. 2) note that while highlands volcanoes virtually ceased activity more than 50,000 years ago, numerous younger thin (<100 mm) tephra falls had been recorded, particularly at Kuk, where the most intensive work had been done. The youngest of these tephras was Tibito, first identified by Blong in 1971. A few years later, Blong (1975: 215) could report its age as about 250 years BP on the evidence of half a dozen radiocarbon dates and its distribution as covering an area of at least 5500 km^2, on the basis of trace element analysis of samples. Blong's 1975 article effectively discredited the 1883 eruption of Karakatau (the former Krakatoa) as the source of not only the ash but also the stories of a Time of Darkness when 'sand' fell from the sky and crops failed. These were widespread on mainland PNG, but Blong had to admit that the source of the responsible tephra remained unknown (1975: 215). The possibility that it was Krakatau had occurred to the American anthropologist James Watson (1963: 154) when he was told a Time of Darkness story in the Kainantu region of Eastern Highlands District in 1954 (Watson 1963: 152).

Beginning in the late 1960s, interest was independently shown by workers over a range of disciplines in the geological, biological and human history of Long Island, off the north coast of PNG about 140 km east of Madang and a member of the Bismarck Volcanic Arc. By mid-1976 the various projects had become 'so intertwined that a joint publication was decided upon' (Specht et al. 1982: 414–416).

Ian Hughes went to Long Island in 1972 as part of a Department of Agriculture, Stock and Fisheries team evaluating proposals for conserving the natural environment. He was impressed by the high cliffs of tephra on the north coast, saw buried soils at various places under the tephra and collected three samples of carbonised wood for radiocarbon dating. Among the first material to appear below the surface, they came from underneath several metres of sterile volcanic deposit later called the Matapun beds (Pain, Blong and McKee 1981: 104–105 and Fig. 3, where ANU-1127-1129 are the three samples collected by Hughes). Back at Kuk, Hughes described what he had seen and sampled and, knowing of the tephra in the Kuk stratigraphy, suggested investigations of the Long Island sites.

In 1973, Hughes went to Long Island with Jim Specht from the Australian Museum, Sydney, and Brian Egloff of the Papua New Guinea Public Museum and Art Gallery, as it was then. Specht and Egloff were archaeologists who had been PhD scholars in prehistory at RSPacS, ANU, around the time that Hughes was a PhD scholar in geography there, all three working on PNG topics. In their new positions, Egloff and Specht had separately taken up field research in adjacent areas of the PNG north coast, Madang (Egloff) and Huon Peninsula (Specht), with Long Island overlapping the boundary between the two and likely to have links with both (Egloff and Specht 1982: 427). On their combined visit to the island they collected potsherds, obsidian and molluscan remains from a number of archaeological sites and two radiocarbon samples to back up those collected by Hughes the year before (Pain, Blong and McKee 1981: Fig. 3, ANU-1307 and 1308; Egloff and Specht 1982: 427–431). Though, as Specht et al. say (1982: 415), the dates of the samples collected by Hughes in 1972 'bridged' those associated with Tibito Tephra at highlands sites, it is unclear how widely this was known in the mid-1970s because Blong did not allude to the Hughes dates in his 1975 article.

Blong and Pain made a first visit to Long Island in 1976, accompanying an officer of the Rabaul Volcanological Observatory, C. O. McKee, in the course of his geological and geophysical work (Specht et al. 1982: 415). They collected samples for further radiocarbon dating (Pain, Blong and McKee 1981: Fig. 3, SUA-623 and 624) and volcanic ash samples from the Matapun beds, which showed that the Tibito Tephra of the PNG highlands, the source of which Blong (1975) had had to admit was unknown, had in fact been erupted from Long Island (Pain, Blong and McKee 1981: 105). The earliest published notice of this is a *Nature* article of January 1978 in which Frank Oldfield reported an (undated) personal communication from Blong to say that his geochemical analyses showed that the latest tephra in the highlands sequence, i.e. Tibito, came from Long Island (Oldfield, Appleby and Battarbee 1978: 341).

It was now clear that the widespread stories of a Time of Darkness in most cases referred to Tibito Tephra, which originated from Long Island. Such stories had been collected over the years by anthropologists, missionaries, government officials and the like. With their renewed assistance and the use of a questionnaire that he circulated in 1976–78, Blong now began to collect further examples (Blong 1979a),[3] testing the accuracy of the detail that the answers provided against accounts from across the world of the observed consequences of thin falls of volcanic ash (Blong 1982; see Chapter 8 here). This is the background to his career move into the field of natural hazards and his well-regarded work on volcanic hazards (e.g. Blong 1984).

In 1974, Philip Hughes moved from the University of New South Wales (UNSW) to the Department of Prehistory, RSPacS at ANU, and assumed responsibility for the geomorphological work at Kuk in 1974 (Fig. 1.3). From 1974 to 1977, he extended the record of swamp stratigraphy begun by Blong and undertook a detailed study of the large water-disposal channels by which the swamp had been drained in the past (see Figs 14.2, 14.4, 15.2 and 15.4). In this he was helped from time to time by Marjorie Sullivan, a fluvial geomorphologist, also formerly of UNSW.

3 Blong has deposited his 1979 *Oral History* summary of all the legendary accounts with the Pacific Manuscripts Bureau, together with the correspondence that he received in response to his questionnaire: PMB MS 1329, Blong, Russell, Time of darkness legends from Papua New Guinea: questionnaire returns, correspondence and reports 1977–1982.

Figure 1.3 Jack Golson (second from left) and Philip Hughes (second from right) with workmen from Kuk village.

Source: Photograph by Barbara Greaves, 1974.

At the time of the first Kuk investigations, techniques were not capable of extracting pollen grains without damage from clayey formations like those making up the bulk of the Kuk stratigraphy. As a result, some of Powell's palynological work for the project took place outside Kuk itself. The picture of advanced forest clearance by the mid Holocene, provided by the Manton and Draepi sites in her ANU PhD thesis (Powell 1970a), was confirmed by investigations at a pond at 1620 m altitude 3 km west of Kuk just below the small volcanic cone of Mt Ambra. The name of this was borrowed to identify the palynological site as Lake Ambra (Powell 1982a: 218–224).

While Powell was conducting this palynological work in the upper Wahgi, complementary work was taking place to the west in Enga and Southern Highlands districts (soon to become provinces). This built on the pioneering reconnaissances of Donald Walker in the 1960s, of which the first results were Walker on the Lake Ipea region (1966, 1972) and John Flenley's doctoral thesis (1967), followed by Walker and Flenley (1979) and Walker and Hope (1982). Other work is associated with Frank Oldfield, who had been a graduate student for a year in the famous Subdepartment of Quaternary Research in the Botany School at Cambridge University, learning the techniques of pollen analysis and vegetation history. Here Walker was one of his teachers, who shortly afterwards moved to ANU, and after his pioneer trips in the PNG highlands persuaded Oldfield of the attractions of work there. Oldfield spent the northern hemisphere sabbatical year 1972–73 in the country, returning several times over the following decade for conferences, workshops and more fieldwork.

Oldfield inherited three sites from Walker's fieldwork, Lakes Egari and Pipiak in Southern Highlands and Lake Ipea in Enga, and these were the subject of renewed sampling in the 1970s (Oldfield 1977: 59–60, 1988: 529): in 1973 by Oldfield and his team and in 1978 by Walker. The aim was to supplement the evidence of pollen analysis on landuse history by looking at the chemical and magnetic properties of recent lake sediments and using lead isotope 210 (^{210}Pb) to date them, all this benefiting from the work of Oldfield and colleagues in the British Isles and elsewhere. The conceptual framework and results from the PNG field were described in a paper (Oldfield, Worsley and Baron 1985) given at a conference in Canberra in August 1981 that had been organised to complement the proceedings of the XIII International Botanical Congress in Sydney the following week.

Establishing the age of Tibito Tephra played an important role in the development of ^{210}Pb dating, as Oldfield has recently explained (pers. comm., March 2015). First indications, from measurements carried out at the Atomic Energy Research Establishment, near Harwell in Oxfordshire, suggested an age of around AD 1880, close to that of the Krakatau eruption and also compatible with indications from oral history. Subsequently, Blong's ascription of Tibito ash, on geochemical grounds and radiocarbon dating, to a caldera eruption on Long Island that must have predated AD 1827, when the French navigator Dumont D'Urville noted the outline of the island, prompted the development of an alternative basis for interpreting the results (Oldfield, Appleby and Battarbee 1978: 341). Using this new model, the estimated age was revised to around AD 1800. That age also was shown to be too young, as a profile of the island sketched in 1700 by the English sea captain William Dampier almost certainly of the coast of Long Island in the early 1700s clearly postdated the caldera created during ejection of the ash (see, for example, Blong, Kemp and Chen 2016). Detailed measurements on each sample in the newly established Radiometric Dating Laboratory at the University of Liverpool confirmed that the age of the ash lay beyond the reach of ^{210}Pb dating. These new results, together with measurements of palaeomagnetic secular variations recorded in lake sediments (Thompson and Oldfield 1978), placed the age of the ash in the mid-17th century (Oldfield, Appleby and Thompson 1980). The development of the new ^{210}Pb dating model and the establishment of the Liverpool laboratory were thus triggered by the challenge of dating the New Guinea tephra.

In 1979 only Lake Ipea was resampled (Oldfield, Worsley and Baron 1985: 390), by Ann Worsley (née O'Garra), a graduate student whom Oldfield brought with him into the field that year for her PhD fieldwork. However, cores were taken for magnetic measurements at two of Jocelyn Powell's Wahgi pollen sites, Lake Ambra near Kuk and Draepi in the hills of the Sepik-Wahgi Divide 13 km north-northwest of Mount Hagen town (Oldfield 1988: 542–548), while Worsley made collections for her own doctoral research (Worsley 1983).

This upper Wahgi activity was linked with a week of Oldfield's time that Golson had booked at Kuk at the beginning of July 1979 for him to make an assessment of site stratigraphy in the light of his wide experience of sites and methods and in which he was joined by Worsley. The same week Golson had independently booked a visit for a similar purpose for the French soil scientist Marc Latham of the Office de la Recherche Scientifique et Technique Outre-Mer in Noumea, with whom he had visited Matthew Spriggs on his doctoral work on the southern Vanuatu island of Aneityum. Both Latham and Oldfield produced reports that could not be immediately followed up since the main Kuk fieldwork was finished and Powell and Blong were engaged elsewhere. They were made available to Tim Denham, then in the Department of Archaeology and Anthropology in the faculties at ANU, when he started doctoral research at Kuk in the late 1990s and they feature in the appendices that form part of his dissertation (Denham 2003a, vol. 2, Appendices E6 and E7).

Attention now turns to the other work that Powell had done before she left PNG in mid-1975 to take up a position with the National Herbarium of New South Wales. She was interested not only in the plants, tools and techniques of traditional cultivation, but also plants and their uses in the non-agricultural and agricultural domain. She worked with UPNG students from the Mount Hagen area during their 1971–73 summer vacations to gather material for *Agricultural Traditions of the Mount Hagen Area* (Powell et al. 1975); and with Simon Harrison, a future ANU PhD, to do similar work in Southern Highlands Province, *Haiyapugwa: Aspects of Huli subsistence and swamp cultivation* (Powell with Harrison 1982). While with the ANU New Guinea Research Unit, Powell (1976a) contributed Part III, on ethnobotany, to a book on *New Guinea Vegetation*, edited by Kees Paijmans (1976).

Pollen was considered unlikely to provide direct evidence of the staples under cultivation in the prehistoric past of New Guinea agriculture, which were expected to be the yams, taros and bananas of contemporary Pacific agriculture, none of them regular pollen or seed producers under cultivation. However, as she had done earlier at the Manton site and the archaeological site of Kindeng, Powell began a programme of sampling for fossil seeds from stratigraphic columns and ditch infills across Kuk Swamp for the light they might throw on the swamp environment at different stages of its history and for the presence of native highlands species that had food or other uses for the current inhabitants (Powell 1982b). She instructed Laurie Lucking, a graduate student of the University of Minnesota introduced to the Kuk project in 1973, in seed extraction and identification, on which Lucking worked over the years 1974–76, as well as on wood identification (see Chapter 18). In the earlier 1980s, other samples from Kuk were used by Sam Wilson for his BA (Hons) research project at ANU exploring the potential of phytoliths in the investigation of agricultural history at the site (Wilson 1985). This was shortly before the ANU Department of Prehistory appointed Tom Loy, from the Royal British Columbia Museum, and Barry Fankhauser (formerly University of Otago) from the Chaminade University of Honolulu, to set up a laboratory for the analysis of organic residues in archaeological contexts. Loy subsequently made a selection of some 58 items from the Kuk stone artefact collection that showed promising evidence of usewear and residues (see Chapter 20).

There were two problems with doing most of our data gathering from the walls of the minor Station drains. At Kuk these ran parallel to each other, north–south, within the large grid of major road and boundary drains planned for the Station as a whole. One problem was that linear features like drainage channels serving gardening systems in the past were much more easily studied when they ran eastwards and could be crossed by the minor drains dug 22.5 m apart rather than when they ran northwards and would only be cut by the bordering drains of east–west roads some 250 m apart (cf. Fig. 15.4 and Fig. 16.12). There were, of course, channels running just west or east of north that were cut obliquely by north–south minor drains. In these cases, excavation was needed to supplement the drain record. Such targeted excavations were carried out in 1974 in connection with the complex courses of the Phase 4 disposal channels in the northern part of block A11 and the southern part of block B10. This work was done by Jim Rhoads, the second graduate student from University of Minnesota to join the project in 1972 and whose 1974 report is part of the Kuk Archive. At other times during 1973 and 1974, Rhoads worked on test excavations and drain recording with Golson and Hughes. He took every opportunity to explore the region around Kuk, recording oral histories, and between his two Kuk seasons worked under Egloff at the PNG Museum and with Specht in New Britain. He went on to become an ANU PhD scholar researching the past and present of Papuan Gulf sago exploitation (Rhoads 1980).

The second problem was that the Station management's requirement that drains once started be finished led to great differences in the completeness and comprehensiveness of archaeological and stratigraphic recording between drains. Some drains were dug for archaeological rather than stratigraphic purposes and others the reverse. In others the interest, whether archaeological or stratigraphic, was in a specific section of the profile. As a consequence, archaeological recording ranged from cursory notes to the comprehensive record of every archaeological feature and stratigraphic recording, from no record to systematic documentation at 10–15 m intervals.

Nevertheless, the study of the archaeological and stratigraphic evidence in drain walls had led to the conclusion that six phases of drainage and cultivation were represented in the swamp, all of them followed by a period of abandonment. Each phase was characterised by a morphologically distinctive set of features; associated with one or more specific water-disposal channels; and in a consistent relationship with the different units of the stratigraphy of the swamp and the volcanic ashes. The aim of area excavation, when this became possible, was to isolate the individual systems and to establish how they were organised and how they operated. The knowledge accumulated over preceding years about the distribution of archaeological structures through the swamp and the different contexts of their occurrence served as a guide for the location of excavations. It was possible to nominate areas of the site where individual phases would be best investigated because they were most abundant, showed the clearest expression or had the least interference from disturbance by activities in later phases.

The plan was to begin with the excavation of the earlier phases of the sequence, Phases 1–3, and finish with that of the later ones, Phase 4–6 (Tables 1.1 and 1.2). In the event, only the earlier phases were investigated, though none of them fully and Phase 3 very incompletely. In the case of the excavation of Phases 2 and 3, the procedure was to dig down to the surface of grey clay, a widespread component of the Kuk stratigraphy, where the darker fill of archaeological features identified them more clearly against the lighter background of the clay so that they were more easily recorded and, if necessary, cleaned out. Phase 1 features were beneath grey clay and typically revealed as disturbances filled with grey clay on a darker surface. Their investigation obviously involved the record of features on the surface of grey clay before this was removed to expose the earlier surface.

The grey clay was from the outset interpreted as the influx of eroded material from the catchments of the swamp due to forest clearance on the slopes in the course of shifting cultivation. Some years after the suggestion was made in public and in print (Golson 1977a: 612–613; cf. Golson and Hughes 1980: 296–298), Sam Wilson (1985: 96, Fig. 3) produced phytolith evidence from samples of the grey clay to support it. His analysis showed two differences in phytolith frequency over the early Holocene period of grey clay deposition: a drop in total phytolith density due to a faster rate of sediment deposition and a dramatic drop in the percentage of grass phytoliths seen as due to the inwash of material coming off swidden clearings in the forest.

Serious area excavations began in October 1975, and from then until the close of the 1977 season involved the investigation of Phases 1–3 concurrently. They were all located in the southeast corner of the Station, in blocks A11 and A12. Klim Gollan, who went on to do a PhD thesis on prehistoric dingo in the Department of Prehistory, RSPacS, ANU (Gollan 1982), took part in the 1975 excavations, assuming responsibility for mapping and photography. He had previously taught mathematics at the Teachers College in Port Moresby, to which he added the study of prehistory at UPNG, where his lecturer, Mary-Jane Mountain, encouraged him to do MA studies at the University of London Institute of Archaeology. Alistair Marshall of the School of Biological Sciences at the Flinders University of South Australia, brought archaeological experience on prehistoric sites in UK to help with the mainly Phase 2 excavations of 1976 and their mapping and photography. Arthur Rohn, an archaeologist in the Department of Anthropology at Wayne State University, Kansas, who was on sabbatical leave at the University of Sydney, directed Phase 2 excavations in 1977 and with his wife Cherie mapped these and some of Golson's Phase 1 excavations. Help with Phase 1 photography was given by Art Rohn and Ed Harris, a doctoral student from University College London working on stratigraphy in archaeology, who was excavating Phases 5 and 6 houses at the site as part of his study. In the same year, Paul Gorecki of the then Department of Anthropology at the University of Sydney arrived to begin fieldwork for his PhD thesis on archaeological site formation processes in the context of the activities of the contemporary Kuk community.

Though there were no substantial excavations targeted at the field systems of Phases 4–6, they were still investigated and recorded in detail. Aerial photographs of Kuk Station in 1970 at an early stage of its development showed a grid pattern identical to that of contemporary sweet potato gardens to be typical of the last stage of Phase 6 cultivation before gardening ceased. The evidence as to date was provided by the stratigraphy of the walls of the minor drains that our workmen had dug through them. Grid patterns were also typical of Phases 4 and 5, although they could not be readily seen, if at all, on aerial photographs because they were buried. However, since a grid pattern is formed by straight lines crossing or joining at right angles, the old drainage networks could be reconstructed by mapping and interpolating the direction of ditches of the same phase from the two exposures of every relevant ditch in the opposite walls of the same Station drain. The procedure was an intricate one, complicated by some ditches having been dug along the line of older ones. However, the reconstructions provided by Tim Bayliss-Smith for Phases 4, 5 and 6 allowed comparisons to be made of garden size and ditch shape through time that had interesting implications (cf. Bayliss-Smith 2007).

Golson had met Bayliss-Smith, a geographer from Cambridge University, when he briefly visited the Kuk excavations in 1976 on his way back from fieldwork in Fiji. They renewed their acquaintance when Golson was in Cambridge in 1978–79. They talked about taro as a possible highlands staple before the arrival of the sweet potato, particularly in the context of the garden grids that had made an appearance with Phase 4 of wetland drainage at Kuk. As a result, Bayliss-Smith spent the period from June to October 1980 in the highlands, establishing experimental taro plots at Kuk, making field observations at the drained taro plantings at Baisu Corrective Institution 4 km down the valley and, for comparison, setting up high-altitude taro plots in the upper Kaugel Valley near Tambul, some 40 km to the southwest. In August 1981, he went back to Kuk and Tambul to harvest the experimental taro plots, with the assistance of Jean Kennedy from the UPNG Anthropology Department. During this period, as far as he was able, he got information on drainage densities and planting densities, yields and labour inputs. With this background, he then worked with Golson on the records of Phase 4 ditch cross-sections and networks in the Kuk fieldbooks, initially for block A9, then for blocks A10 and A11 (Bayliss-Smith and Golson 1992a, 1999). This cooperative work then extended to other Phase 4 blocks as well as to Phases 5 and 6, resulting in a Phase 6 publication (Bayliss-Smith et al. 2005) and Chapters 14–16 here, dealing with Phases 4–6 respectively.

Other ethnographic data relevant to the recent agricultural systems had been investigated in 1975 by Axel Steensberg, specifically the traditional tools and techniques that had been used for land clearance and gardening. He did this with older men of the community, who made the tools and demonstrated their use. He discussed this work in a book (1980) and in 1983 brought his experience to the cataloguing of the wooden artefacts found at Kuk and elsewhere, which is the basis of Chapter 19 here.

Steenberg had been Professor of Material Folk Culture in the Institute of European Folk Culture at the University of Copenhagen from 1959 to 1970. This followed many years of service in the Danish National Museum's Third Department, which dealt with upper-class, urban and especially peasant life from 1660 to the 19th century and of which he was head from 1946 to 1959. Golson had worked under him in the early 1950s on excavations of Danish village sites and they had kept in touch. In 1968, he took advantage of a visit that Steensberg and a colleague, Grith Lerche, were making to a conference in Tokyo to invite them to visit the archaeological work beginning in the upper Wahgi Valley in the aftermath of the Manton excavations of 1966. Steensberg paid another two visits to New Guinea, the second in 1975, when he spent three weeks at Kuk working on agricultural tools and techniques associated with land clearance and gardening, as mentioned above. This had been preceded by a couple of weeks among the Duna people further west, where he had looked into traditional tools and techniques in tree felling, house building, fencing and cooking.

Closer to hand, staff members of the National Museum and UPNG provided on-site services as they were able. Mary-Jane Mountain of the Department of Anthropology at the university brought groups of students on different occasions for a period of excavation experience under her supervision. There were also regular visits by student parties from Mount Hagen High School, Mount Hagen Technical College and the Highlands Agricultural Training Institute.

Reading the history of highlands agriculture: The first period at Kuk

Before the end of the 1970s fieldwork, the first published reports about it were describing a sequence of six episodes of swamp drainage and cultivation running parallel with a continuous sequence of dryland cultivation, both beginning around a date of some 9000 radiocarbon years ago. Because this was before the days of calibration of radiocarbon dates to calendar years, 9000 radiocarbon years was referred to as 9000 BP (Golson 1977a: 612) or, more loosely, 9000 years ago (Golson 1977b: 46) (for the individual dates leading to this conclusion see Golson 2000: 236). After the appearance of the first accepted calibration curve (Stuiver and Kra 1986) and subsequent modifications, dates of around 9000 radiocarbon years for Kuk Phase 1 reported by Denham (et al. 2003: 189, 190, Table 1 and Table S1, note 4) from his 1998–99 fieldwork at Kuk gave calendrical dates of around 10,000 cal. BP (see Table 1.2 here).

Table 1.2 Archaeological phases at Kuk Swamp, Wahgi Valley.

Phase	Age	Description	Stone artefacts	Wooden artefacts[2]	House sites[3]	Ditches	Cultivation features[4]	Artificial channels[5]
6	AD 1700–1900	grid-like field systems	X	X	X	X		X
5	AD 1250–AD 1660s	grid-like field systems	X	X	X	X		X
4	2000–1230/970 cal BP	grid-like field systems	X	X	?	X		X
3	2700–2400 cal. BP	late subphase: rectilinear/dendritic ditch networks	X			X	?	X
	4350–3980 cal. BP	early sub-phase: rectilinear ditch networks	X			X		X
2[1]	6950–6440 cal. BP	mounded palaeosurface	X				X	?
1	c. 10,000 cal. BP	amorphous palaeosurface	X				X	?

Source: Update by Denham of Denham (2007a: Table 2).

Notes:

[1] Another possible Phase 2 subphase predates Kim (R) ash, which fell in the period between 3980 and 3630 cal. BP, although it is not well characterised and is not included in the table.

[2] No wooden artefacts were collected from Phase 1–3 contexts (cf. Powell 1982a: Table 2).

[3] Ed Harris in 1977 noted unexcavated house remains at a multi-occupation site that could predate Phase 5.

[4] Occasional features interpreted to represent 'within plot' cultivation features have been recorded for late Phase 3.

[5] Palaeochannels have been differentiated from ditches at Kuk on the basis of scale, although the mode of formation of some palaeochannels is debated (see discussion in Denham, Golson and Hughes 2004). Golson and Hughes have argued for the artificiality of all palaeochannels, whereas Denham has argued that the Phase 1 and 2 palaeochannels may not be artificial.

These dates suggested an antiquity for cultivation comparable to that of the extensively and intensively studied Fertile Crescent of the Middle East, at a time when the conventional wisdom was that New Guinea had received its agriculture from colonists moving out of Southeast Asia into the Pacific within the last few millennia (Yen 1971: 6; Golson 1985: 307, 308; Yen 1995: 831; Denham et al. 2003: 192; Bellwood 2005a: 141).

The period now claimed for New Guinea agricultural origins is when modern temperature levels arrived in the highlands at the beginning of the Holocene after a period of late glacial warming that followed the Late Glacial Maximum. The pollen evidence from the Wahgi Valley shows that the temperature regime after some 10,000 years ago was suitable for the major staples of Pacific agriculture (taro, yam and banana), generally considered as of tropical Indo-Malesian ancestry, to be grown in the New Guinea highlands. Indeed, there was a serious argument 40 years ago for their presence there around 10,000 years ago. This involved the introduction of hand-fed Southeast Asian pigs into New Guinea accompanied by the cultivated plants that kept them tied to people (Golson 2007: 113). It was an argument based on Susan Bulmer's report (1975: 18–19, 36) of a pig incisor in the basal layer of a Simbu rockshelter dating to the terminal Pleistocene, supported by comparisons of basins in Phase 1 and Phase 2 contexts at Kuk Swamp to modern pig wallows (Golson and Hughes 1980: 299).

The pig hypothesis remained weak because only one other claim for Late Pleistocene/early Holocene finds was made (for Yuku rockshelter, S. Bulmer 1982: 188) before direct dating of pig bone appeared on the scene to challenge it (O'Connor et al. 2011: 5). There were also explanations other than pig for the Kuk basins, including plant husbandry, as suggested by Doug Yen (1980: 143–144; cf. Golson 2007: 113). For Pacific ethnobotanists, however, the appearance of New Guinea plants like sago palm, *fehi* bananas and sugarcane in the register of Pacific cultigens was reason for the consideration of the region as an important division or extension of Vavilov's Indo-Malesian centre, following Barrau (1963: 6), or a site of agricultural origins parental to Oceanic subsistence systems, following (Yen 1995: 831; cf. Yen 1971: 4).

Golson came to know Yen in Auckland in the 1950s, when he was an archaeologist on the staff of the Department of Anthropology at the then Auckland University College and Yen was in charge of the Vegetable Breeding Station of the Crop Research Division of the New Zealand Department of Scientific and Industrial Research. In his work, Yen had a strong ethnobotanical interest in traditional Maori food plants, as a result of which he became associated with scholars worldwide through the Pacific Science Association. Yen came to concentrate on the history of the sweet potato, which he travelled widely to collect. This led in 1966 to his appointment as ethnobotanist at the Bernice P. Bishop Museum, Honolulu, where his monograph on the sweet potato was published in 1974.

Before Yen left New Zealand he had become mentor to Jocelyn Wheeler, a young cytologist at Crop Research, and steered her to undertake research at ANU into PNG palynology. He took a great interest in the Kuk project of the 1970s that grew out of the Manton investigations of the mid-1960s in which Wheeler had taken such an important part. In 1980, Yen moved from the Bishop Museum to a post in the Department of Prehistory at ANU, where he spent 10 productive years. He was intrigued by the implications of the sharing of genera of food plants by Australian Aborigines using them wild and gardeners in New Guinea (and more widely in Oceania) using them cultivated—in particular *Dioscorea* yams and *Colocasia*, *Alocasia* and *Amorphophallus* taros (Golson 2007: 116). He saw this geographical sharing of genera, and a few species, as a result of the collision some millions of years ago between the Australian/New Guinea fragment of the ancient continent of Gondwanaland with the Laurasian Plate at its margin in eastern Sulawesi (Yen 1990: 259, on the basis of Whitmore 1981). This raised the possibility that the Oceanic taro-yam complex was of Laurasian origin, with New Guinea domestication as an alternative to its human transport from Southeast Asia (Yen 1990: 260). It was shortly after this that Loy, Spriggs and Wickler (1992: 910) reported *Colocasia* starch grains some 28,000 years old on stone tools from a site in the northern Solomons and Simon Haberle (1995: 207) *Colocasia* pollen from Lake Wanum in the Markham Valley behind Lae in PNG dated about 9000 years ago.

Very few of the basic data relating to the claims about Kuk were published (cf. Denham, Golson and Hughes 2004: 261). The sequence of drainage episodes in the swamp and the characteristics of the cultivation systems established on the drained surfaces were summarised in an early article (Golson 1977a) that had been modified subsequently but not superceded. The evidence for the early beginnings of wetland and dryland agriculture was discussed by Golson and Hughes (1980) and the dryland evidence amplified in a later article (Hughes, Sullivan and Yok 1991). Overall, however, publication had less to do with the data from the site than the implications of the interpretations made of them for broad issues in New Guinea prehistory (see Golson 1990: 140, for a list of publications about Kuk to that date). As a result, when attempts were made to evaluate the Kuk claims in the light of the greater understanding of regional prehistory that had been achieved by the early 1990s, there was a limited data base to refer to (Bayliss-Smith 1996: 500, 507–510; see also Spriggs 1996: 528–529).

Renewed investigations, 1998–1999

The lack of publication of the primary evidence was only one of the difficulties facing Denham, when, as an ANU doctoral student in the later 1990s, he planned to address the claims for early and independent agricultural origins at Kuk, concentrating on Phases 1–3 of the sequence. As he worked through the files and collections from the previous work, he found weaknesses with the characterisation of the three phases related to the limited archaeobotanical evidence of cultivated plants, limited palaeoecological evidence for associated environments and environmental change, and the uncertain significance of archaeological structures and finds on the wetland margin (Denham 2003a: iii). As a result, with Golson's supervision, he planned new excavations of Phases 1–3 at Kuk.

The renewed excavations at Kuk were undertaken with permission and support from the Papua New Guinea National Museum. Members of the museum staff came to Kuk both years in order to engage with the local community, participate in the excavations and undertake field training. Staff members included Herman Mandui and Nick Araho. Additionally, John Dop and Daniel Gono, students at UPNG, came into the field for training. Fieldwork in both years was greatly assisted by John Muke, a lecturer in prehistory in the UPNG Department of Anthropology and Sociology, whose close engagement with the Kuk community is discussed below. Thomas Wagner, a lecturer in geology at UPNG, who over the years had worked with Russell Blong on Kuk tephras, joined both field seasons and undertook characterisation and sampling of volcanic tephras (see Chapter 7). In 1999, Tim Bayliss-Smith and Inga-Maria Mulk from Europe and Robin Torrence and Peter White from Sydney assisted with the fieldwork.

The 1998 and 1999 excavations undertaken by Denham were primarily designed to characterise the function of features associated with Phases 1–3 and to undertake sampling (Denham, Golson and Hughes 2004: 261). The sampling was to facilitate multidisciplinary analyses—chronological, archaeobotanical, palaeoecological and stratigraphic—to address the shortcomings of the existing evidence. These expanded on those that had been employed in the original fieldwork in decisive ways (see Table 1.1).

Denham's own efforts went into: assessments of the archaeology and stratigraphy recorded in previous investigations, with emphasis on the function of features, whether associated with cultivation or other activities; multiscale and mixed-method analyses of sediments, soils and fills of archaeological features; site formation processes over the long term; and the integrity of samples for radiocarbon dating and palaeoecological analyses (Denham 2003a: iii). The availability of AMS as well as conventional radiocarbon dates allowed better chronological resolution than the conventional dates of the previous investigations.

Denham directed a range of other analyses on archaeological features and stratigraphy associated with Phases 1–3. These were undertaken by people who were new to the project (Denham 2003a: iv; Table 1.1 here). Simon Haberle undertook pollen and microcharcoal analyses on samples from archaeological and stratigraphic contexts dating from the terminal Pleistocene to the mid Holocene (Haberle et al. 2012). Previous studies had been limited by processing techniques available to extract pollen from dense clays at the site. These methodological problems had been overcome by the late 1990s, thereby enabling a history of vegetation change and burning to be established for the key periods of early agriculture and subsequent changes at Kuk.

Since the investigations of the 1970s, there had been advances in the application of microfossil techniques to archaeological questions, especially in the fields of phytolith, starch grain, diatom and insect research. All these techniques enabled the environments associated with the earliest phases to be better characterised. Additionally, phytolith and starch grain analyses were employed to identify the presence, use and cultivation of key food plants in the highlands, most of which do not ordinarily preserve as microbotanical remains and do not produce abundant pollen in cultivated contexts.

Denham was fortunate to work with a number of key researchers within each field. Carol Lentfer (then at Southern Cross University, Lismore, NSW) had already established a reference collection for phytoliths in Island Melanesia, including for many cultivars of Pacific agriculture (Lentfer 2003a). Barbara Winsborough, an independent consultant from Texas, was a diatom specialist who had worked on wetland archaeological sites in the Pacific (e.g. Denham et al. 1999). Most of the pollen, microcharcoal and diatom analyses were conducted on 'paired' samples, i.e. the samples were from the same location in the fill of an archaeological feature or in the stratigraphy (Denham, Haberle and Pierret 2009; Denham, Sniderman et al. 2009). These analyses provide complementary records of environmental change through time: pollen and phytoliths on vegetation history; microcharcoal on burning; and diatoms on soil and open-water conditions. The analysis of insect remains by Nick Porch (then at Monash University, Melbourne) served to enhance the palaeoenvironmental record.

Richard Fullagar (then at the University of Sydney) undertook usewear analysis of stone tools from Kuk. Most of these were subsampled from those previously selected by Tom Loy, while some came from the new excavations of 1998 and 1999. Organic residues, especially those in the form of phytoliths and starch, were subsequently extracted for identification by Lentfer (phytoliths) and Judith Field (at Sydney University, starch) (see Fullagar et al. 2006).

Taken together with the results of previous research, the composite findings represented major advances in our understanding of the archaeobotany and palaeoecology of the early phases at Kuk (Denham et al. 2003; Denham, Haberle and Lentfer 2004; see Denham, Sniderman et al. 2009 for the subsequent extension of this work):

a. There emerged a sounder basis for the case for human disturbance of the primary forest in the early Holocene than that given by earlier work and a picture of its subsequent degradation to grassland by the start of Phase 2, roughly between 7000 and 6500 years ago. Golson (1977a: 621–622; cf. Golson 2007: 119–121) had argued that a prominent break in the Kuk stratigraphy at around 2500 years ago between the end of Phase 3 and the beginning of Phase 4 marked the beginning of soil tillage after the establishment of grassland. This is a disputed claim that is taken up again in Chapter 6, section 'Garden soils', and Chapter 14, section 'Soil tillage as an innovation';

b. There also emerged a list of edible plants present in Phase 1, the most significant being taro and a yam, with the presence and possible planting of Eumusa bananas from the end of Phase 1 and in Phase 2.

The conclusion that Denham (2003a: iv) drew from his work was that 'the multi-disciplinary lines of evidence presented in [his] thesis are consistent with previous claims for the early and independent origins of agriculture in New Guinea'. At the same time there were differences of interpretation between Denham on the one hand and Golson and Hughes on the other. These could involve both the interpretation of specific features of the field record, like the artificiality or not of some of the disposal channels in the early phases, and the assessment of the overall evidence on a question, for example as to whether Phase 1 sees the beginning of agriculture at Kuk (Denham, Golson and Hughes 2004: 294; Golson 2007: 117–119), or whether it is Phase 2 (Denham et al. 2003: 192). Such differences are presented here in the form of a dialogue where each side states its case (cf. Denham, Golson and Hughes 2004: 261–262).

Kuk Phase 8: Between the original and renewed excavations

With the end of the 1977 field season, the focus of attention had shifted to the records of six years of fieldwork and the collections of artefacts and samples that they had produced. Field visits did not completely stop, but were reduced to short periods by a few people doing necessary updates, like a resurvey of the site. It was also felt necessary to keep in touch with the Station personnel and the Kuk community to show continuing interest in the site in the light of the possibility that further fieldwork might be desirable there, as became the case with Denham's PhD research.

Golson was on such a visit to Kuk in August 1990 when Martin Gunther, the Officer-in-Charge for the previous 10 years, told him of the imminent closure of one of the two highlands research stations of the Department of Agriculture and Livestock. Shortly afterwards the axe fell on Kuk, which closed down at the end of the year. In Chapter 24, Golson and Muke discuss the uncertain years that followed, with government effectively abandoning the Station it had set up along with the land it had bought and still owned.

Golson did not visit Kuk again until 1993 and when he did so it was with John Muke, who had recently returned to the staff of the UPNG Department of Anthropology and Sociology from Cambridge University with a PhD in archaeology. He began an archaeological research and training programme in his home district near Minj in the middle Wahgi Valley, in which he invited Golson to take part. There was a plan to negotiate a visit to Kuk to assess the situation on the ground and this took place towards the end of 1993 and was highly encouraging. Muke and Golson paid a follow-up visit in 1994 (see Chapter 24, section 'Prelude 1991–1995').

Beginning in late 1995, the traditional owners started moving across the Station boundaries in a well-planned and efficiently executed operation that was followed by house building and garden preparation to confirm the act of repossession. This was the beginning of what Golson and Muke have called Kuk Phase 8 and raised concerns about the site's future. Muke and Golson paid a visit in early May 1997 to assess the prospects for renewed fieldwork in the changed circumstances of landuse and landholding. When he got back to Australia, Golson wrote a short report on the situation at Kuk, of which he sent one copy to Muke and one to Pamela Swadling, Chief Curator of Prehistory at the National Museum (cf. Muke 1998: 75). She received it at a time when the Director, Soroi Eoe, was preparing for a UNESCO meeting at the Fiji Museum in Suva, where he was to propose two PNG sites for World Heritage listing, one of them Kuk, on the grounds of its cultural values. It was in this context that the museum sent a small team to Kuk for a week (23–30 May) to report on two matters: the likely implications of the resettlement of the site for its archaeological features; and the views about its heritage aspects held by the people who had just repossessed it. Director Eoe submitted the museum report and Golson's earlier one at the Suva meeting, together with a World Heritage nomination proposal for Kuk by Golson and Swadling.

In addition to these documents, there were relevant early discussion papers that Swadling also thought deserved attention and she made a request for help in this respect from Andrew Strathern and Pamela J. Stewart, who were in PNG on anthropological work. Strathern had an association going back to 1964 with the Kawelka, the traditional owners of Kuk, which they had been forced to abandon around AD 1920 due to defeat in war. They moved to kinsfolk at Mbukl on the Sepik-Wahgi Divide, where it was that Strathern had first got to know them. He also knew the Kawelka who from about 1960 had moved back to live at Kuk and he had given Golson advice and support from the very beginning of the Kuk project. At the University of Pittsburgh he was starting a new programme of work in PNG with Pamela J. Stewart, his wife and University of Pittsburgh colleague.

At a meeting in Port Moresby, Stewart offered, on behalf of Strathern and herself, to take over the documents that Swadling had discussed with them and museum authorities gave their consent. In 1998, they presented them in an edited book, *Kuk Heritage: Issues and debates in Papua New Guinea*, the purpose of which was to show 'the complexities that surround matters to do with cultural heritage generally in cases where a delicate balance has to be sought between international, national, provincial and local interests' (Strathern and Stewart 1998a: Preface and Acknowledgments). A good number of copies went to PNG and copies were sent to libraries and scholars elsewhere.

The Suva meeting, for which the foregoing discussion provides a PNG context, was an important one for the Pacific region. It was a Global Strategy meeting organised by UNESCO's World Heritage Centre to identify World Heritage sites in the Pacific, of which at the time there was only one nominated for a Pacific island nation—the East Rennell natural area in the Solomon Islands. This situation was partly due to the requirement for a country to have signed the World Heritage Convention to be eligible to make a nomination for the World Heritage List. PNG became only the third Pacific island nation, after Fiji and the Solomon Islands, to do so when it signed in July 1997.

When Strathern and Stewart took over responsibility for a publication on Kuk linked to the Suva meeting with its emphasis on the heritage aspects of the story, Golson and Swadling began to develop sections of the chapter they had contributed to it (Golson and Swadling 1998: 7–9) for a volume reporting on the Kuk Project as a whole. The present book is the ultimate result.

Planning for it began in earnest when Swadling retired from the National Museum in 1999 and moved south to Canberra. John Muke, who was already involved, became PNG-resident editor. After the completion of Denham's doctoral work and the presentation of his results there was an obvious need to rethink the whole operation and he came onto the editorial committee. With his participation, the scope of the volume expanded and, as the work progressed, Philip Hughes was added to the editorial team. There was a conscious effort not to lose touch with a PNG readership that had been one of the targets of the planned publication. That is why we retain the original structure in the present volume.

The structure of the volume

Part 1 has four chapters that set the Kuk work in a number of different contexts:

Chapter 2 the world of agricultural origins, which New Guinea has now entered;

Chapter 3 the world of agriculture based predominantly on the vegetative exploitation of plants. This is true not only of root crops like yams and taros but also of a range of other plant types like bananas and several cane grasses, while many trees and palms are exploited by the transplanting of seedlings rather than the planting of seed;

Chapter 4 the world of New Guinea and the environmental factors that have been important in determining its agricultural present and past; and

Chapter 5 the world of living New Guinea wetland agricultural systems for the light these can throw on the abandoned wetland systems of the upper Wahgi Valley in terms of technologies and social contexts.

Part 2 has five chapters dealing with specific kinds of evidence provided by the project's field operations and crucial for their interpretation.

Chapter 6 discusses Kuk Swamp, its place in its local setting and its drainage for the establishment of the Kuk Tea Research Station. The drain walls revealed a stratigraphic record combining the biophysical processes of swamp formation with the evidence of its drainage for gardening and the inwash of eroded material from vegetation clearance for dryland gardening in its catchments. This stratigraphic record is the framework within which the discoveries are presented, dated and interpreted.

Chapter 7 is concerned with thin (<100 mm) occurrences of airfall volcanic ash that are preserved from place to place across the site and at different levels in its stratigraphy. There are at least 10 such occurrences between 18,500–15,000 years ago and the AD 1660s, seven of them in the last 4000 years. Each represents an instant of time and could be used, with other stratigraphic evidence, to define time horizons across the site. There is potential for this also to be done from site to site and over large areas. This requires geochemical characterisation of the different tephras in combination with careful dating, as demonstrated in the chapter.

Chapter 8 discusses the relationship between the fall of Tibito Tephra in the AD 1660s, the latest tephra in the sequence at Kuk, and the many versions of a Time of Darkness story collected within the 85,000 km^2 area that it covered, the first collection being made nearly 300 years after the eruption. The reports of the negative effects of the ashfall in the collected versions seem to be accurate in the main when judged against contemporary accounts of similar ashfalls elsewhere in recent times, with the effects repeated during every ashfall in the past. There are some localised versions of the legend that report the Tibito ashfall as agriculturally beneficial and a positive effect of soil replenishment by ashfall is cited by some modern authorities. The chapter views this hypothesis with caution.

Chapter 9 looks at the history of human and environment interactions at the Kuk wetland and its immediate catchments using a range of complementary techniques to reconstruct past environments, particularly pollen and charcoal. This is done in the context of pollen evidence from Kuk wetland and other sites in the upper Wahgi Valley and the result is an account of the vegetation history of the region told in three broad periods:

1. the Late Pleistocene (here referring to the period before 25,000 years ago), when the first human occupation of the region took place;
2. the Last Glacial Maximum to the early Holocene (25,000–7000 years ago), comprising:

a. the coldest period in the pollen records, the Last Glacial Maximum (25,000–18,000 years ago);
b. a period of late glacial warming (18,000–10,000 years ago) ushering in the early Holocene (10,000–7000 years ago) after the modern temperature regime was reached; and
c. the mid to late Holocene (7000 years ago to present).

The subject of **Chapter 10** is archaeobotany, the study of plants in archaeology, here with particular reference to food plants since Kuk is a site with a long history of cultivation. The methods used in the 1970s were traditional ones largely restricted to the identification and analysis of macroscopic remains like seeds, wood and nutshell and the microscopic evidence of pollen and spores. Because Kuk is a wetland site, where organic preservation is better than at most dryland ones, even in circumstances of periodic drainage, a wealth of information was produced about the past occurrence of plants important to contemporary communities for a variety of purposes, including food. Beyond the reach of the methods of the time were plants that did not seed or produce pollen under domestication, like the tubers and fruits of the likely cultivated plants of past Kuk communities, taro, yam and banana. These awaited the development of a battery of microscopic techniques to deal with plant tissues, as well as phytolith, starch and raphide analyses. The first stage of the Kuk investigations caught only the beginning of this process.

Part 3 has six chapters that describe the evidence for each of the six phases of swamp gardening recognised at Kuk in the light of the considerations discussed in the five chapters of Part 2. A seventh chapter deals with houses, which are significant in the Kuk story in Phase 6. The first three chapters deal with Phases 1, 2 and 3, which were the subject of extensive excavations during the mid-1970s and reinvestigation by Tim Denham at the end of the 1990s.

Chapter 11 discusses Phase 1, a short-lived period of activity around 10,000 years ago. The authors differ as to whether the disposal channel carrying water away from the area, Kundil's Baret, channel 101, is natural or artificial. They agree that the pits, runnels, stakeholes and postholes excavated on its banks indicate the cultivation of edible plants and that the grey clay that fills them and constitutes the upper fill of the disposal channel is the product of erosion from the catchments, due to forest clearance for dryland cultivation. They disagree, however, as to whether the activities of the phase constitute agriculture. Whatever is the case, the evidence recovered for edible plants in the vicinity at the time includes genera that were the basis of agriculture later: *Colocasia esculenta* taro, *Dioscorea* sp. yam and Musa section banana.

Chapter 12 discusses Phase 2, which is characterised by mounded cultivation in two subphases, the earlier falling within a period starting 6950 and ending 6440 years ago, the later within one starting 3980 and ending 3630 years ago. The former is considered by Denham to represent the earliest unequivocal evidence of agriculture in the New Guinea highlands.

1. The early subphase, which was investigated in the southeast corner of the Station, has three disposal channels, the nearest one over 300 m west of the excavated palaeosurface, which would have allowed use of the southern part of the swamp margin by limiting its flooding by incident water. Golson and Hughes think that all three channels are artificial, but Denham is unconvinced.
2. In the later subphase there are two palaeochannels, both accepted as artificial by all authors, one of which continued in operation into early Phase 3. As in the earlier subphase, their connection with the garden features of the later palaeosurface was indirect.

At the end, the authors make the point that these two straight disposal channels of late Phase 2 date, as well as two straight and one curvilinear alignment of human construction of the same age, are of potential significance in understanding the appearance of rectilinear ditch networks in Phase 3.

Chapter 13 discusses Phase 3, which has at least three palaeochannels that follow straight courses that are visible on aerial photographs and can be independently reconstructed from the points where they are crossed by modern drains. They are associated with the first networks of linear ditching to appear at the site and are restricted to the southern margin of the swamp. They are described as a technical innovation compared with previous practice, representing a deliberate attempt to drain the wetland margin for cultivation by way of large palaeochannels diverting incident water from the southern catchment and receiving discharge from artificial ditch networks dug to lower the watertable. The ditches have been grouped into three subphases by the stratigraphy of their fills, early (around 4400–4000 years ago), mid to late (undated) and late (closely predating 2700–2400 years ago).

The big question posed towards the end of the chapter relates to the appearance of rectilinear ditching in highland New Guinea. As discussed in relation to Phase 2, there is possible continuity with the linear and curvilinear features of that phase, in addition to which there is the late Phase 2 palaeochannel (Joseph's Baret, channel 107) that continued in use in early Phase 3. These considerations point to swift on-the-spot change. The authors argue that it happened before Austronesians arrived in the Bismarck Archipelago and there is no evidence of anything earlier in Southeast Asia.

Chapter 14 accepts the argument of Chapter 6 that a distinct break in the Kuk Swamp stratigraphy between wetland Phases 3 and 4, with a change in the composition of the deposits from black clay to soil, marks the introduction of soil tillage into dryland agriculture. This is seen as a response to problems following the progressive replacement of forest by grassland. The stratigraphic break is roundly dated at 2500 years ago. The beginning of Phase 4 at Kuk is not very precisely dated, but estimated as around 2000 years ago. The phase ends with the fall of Olgaboli Tephra, an event dated between AD 720 and 980 or around 1100 years ago.

Phase 4 is described as a new and distinctive system of swamp management. It consists of a hierarchy of major disposal channels taking water mainly northwest then west from the southern catchment to the Guga River, a distance of more than 2.5 km, and joined by at least two minor disposal channels that collected water from eastern areas of the swamp. The field ditches articulate with the disposal channels. They are linear gutter-like features, deeper than they are wide and crossing each other at right angles to form grid-like networks defining planting beds that are remarkably uniform in shape and size. It is suggested that the swamp was for taro cultivation, with yams and bananas in dryland gardens. The large disposal channels show evidence of at least two subphases of use.

Chapter 15 argues that Phase 5 began around AD 1250, which may have seen a transition to a cooler and more unstable climate, and ends in the AD 1660s with the fall of Tibito Tephra, the last of the ashes in the Kuk sequence. The Phase 5 drainage system is structured like that of Phase 4, with a hierarchy of major and minor disposal channels and a grid of field ditches defining the planting areas. The major difference is in the field ditches, with a change from the narrow slots of Phase 4 to a wide trapezoid shape with flat bottoms and steep sides, quite like the larger ditches of Phase 3.

The substantial field ditches provided a plentiful supply of soil for making raised gardens in the swamp. Similar ditches have also been found outside wetlands, in grid patterns antedating Tibito Tephra at Mugumamp Ridge in the North Wahgi Swamp and at Kuk. The practice suggests that taro was no longer the dominant crop that it is thought to have been in Phase 4, with its place taken by yams. By late Phase 5, pigs had moved into the highlands from the lowlands, where Austronesian-speaking colonists had been settled for some time. Houses were making an appearance in dryland and swampland situations, their size and shape suggesting that they were housing pigs as well as people. Given the limited opportunities for forage in the grasslands, they would have been partly fed on garden food, so that their ownership would have been a sign of wealth and prestige. The evidence from Phase 5 is that although cultivation may have become less intensive, it was not in crisis when Tibito Tephra fell in the decade of the AD 1660s.

Chapter 16 confirms this by showing that a new phase of swamp cultivation, Phase 6, was beginning by around AD 1700, ending a couple of hundred years later. The major and minor disposal channels of Phase 5 were redug, so must have been visible at the swamp surface. However, the system that the redug Phase 5 channels were employed to operate was one of quite a different kind. The line of the two main drainage channels, which was northwest from the southern catchments, then west to the outfall, separated gridded areas of raised gardens overlying those of Phase 5 on the shallower swamp to the west from the deeper swamp to the east, which had been under cultivation in Phase 5. In Phase 6, however, to judge from the fence lines that took the place of ditches, this area became pasturage for pigs. In between were clusters of house sites following the line of the major disposal channel, women's houses in the main, with room for pig stalls judging by house shape and size and conveniently situated for the two sources of their food, the gardens and the pastures.

The suggestion is that the centre of attention and production has become the raised gardens of the dryland sphere, where a new crop, sweet potato, had taken over as staple. The field evidence from Kuk and the lack of an oral tradition of large-scale drainage among the older inhabitants of the upper Wahgi questioned by Ian Hughes in 1972–73 would suggest that the widespread patterns of former swamp gardening on aerial photographs belong to Phase 5. The pattern of population distribution in the sweet potato epoch is the hill slopes of the upper Wahgi Valley and the volcanic apron of Mt Hagen at its head, the swampy valley flats largely unused perhaps with the arrival of malaria in the course of trade with people at lower elevation.

Chapter 17 deals with houses, or rather house sites, in and out of the swamp. The earliest of them appear in Phase 5, but in such small numbers that it is difficult to say very much about them, either in the swamp or on dryland. Most houses belong to Phase 6 and occur in the swamp and the majority of them can be interpreted in the light of ethnographic evidence as women's houses with room for the stalling of pigs. They have therefore been important in the interpretation of Phase 6. The chapter is based on the fieldwork reports of Ron Lampert for 1972 and 1973 and Paul Gorecki and Ed Harris for 1977.

Part 4 deals with the portable artefacts found either in the course of the archaeological excavations of 1972–77 or turned up by the drain digging and garden preparation that preceded and overlapped with them in the course of the establishment of the Kuk Research Station. The aim is to show what they contribute to an understanding of the activities that have been the subject of previous chapters.

Chapter 18, the first of four chapters, is introductory in the strict sense: it describes how inadequate storage facilities plus changes of storage initially resulted in poor curation of the collections. It goes on to describe how, after adequate storage had been secured off campus, a good proportion of those collections was destroyed, damaged or rendered unusable by the Canberra bushfires of early 2003.

Chapter 19 deals with the wooden artefacts, which were not as badly affected in these circumstances as the stone collections. This was because after they had all undergone freeze-drying in Wal Ambrose's conservation laboratory, some items were separately stored on campus. Before this separation they had all been drawn and catalogued by Axel Steensberg during an academic visit to ANU in 1983.

Chapter 20 is the first of two dealing with the stone items, which had been catalogued by the early 1980s. Material that had been withdrawn for study, including the selection made by Tom Loy of items that looked likely candidates for evidence of usewear and organic residues, avoided the 2003 bushfires. Such material formed the bulk of a small collection that was available to Richard Fullagar for the study of stone artefact technology and function, but it provided data of great importance.

Chapter 21 reports on the raw materials from which the stone artefacts reviewed in the previous chapter had been made. It reveals a striking difference between two groups. The flaked tools and grinding/pounding implements found throughout the six phases of the Kuk sequence were all made from rocks at home in or near the catchments of Kuk Swamp. The other group, consisting of fragments and flakes broken off ground and polished axes during use (and often recycled as other tools), appeared in small numbers in Phase 5 and more frequently in Phase 6. These came, for the most part, by way of trade and exchange from specialised quarries in the middle Wahgi and the Jimi Valleys.

The same is true of the axes of the upper Wahgi as a whole by the evidence of two large undated axe collections, one made at Kuk during the opening up of the Research Station and added to by Paul Gorecki and John Burton in later years, the other made by Ole Christensen in the Wurup area across the Wahgi from Kuk in the early 1970s. The axe trade has been mentioned in connection with the possible implications of the intensified agricultural systems at Kuk during Phases 4, 5 and 6. The chapter ends with Burton's reworking of archaeological evidence gathered by Christensen, which supports an antiquity for the axe trade in the Wahgi back to Phase 4 of the Kuk sequence.

Part 5 looks at the history of the Kawelka, the traditional owners of Kuk before and after their defeat in war and their resettlement with kinsfolk in the Mbukl (Buk) region of the Sepik-Wahgi Divide perhaps around 1920. The 1960s and 1970s saw their return in increasing numbers to Kuk following the establishment of Australian administrative control over the highlands in the aftermath of World War II. This included their successful adjustment to the sale of some of their Kuk swampland in 1968 for the establishment of the Kuk Tea Research Station. The closure of the Station in 1990 led to a period of uncertainty since there was no official presence at Kuk, though the government still owned the land. The traditional owners moved over its boundaries to repossess it late in 1995 and over the following period their reoccupation was consolidated by house building and gardening. It was in this context that the National Museum proposed the Kuk site for World Heritage listing by UNESCO at a meeting in Suva in 1997 and the landholders agreed to further archaeological fieldwork, which took place in 1998 and 1999. After this, a start was made on the complex task of preparing a formal nomination document for UNESCO to which the various interested parties could agree. Four chapters cover this ground.

Chapter 22 starts with an analysis of population figures for tribal groups in the Hagen area in the early 1960s that reveals large differences in size, with the Kawelka being just below the average. Their historical place was set by them being a small group that moved into Kuk from elsewhere and lived cheek by jowl with two very powerful groups. Their displacement from Kuk to Mbukl (Buk) was one result of this. Reasons for their return to Kuk can be illuminated by the oral histories. Different subgroups tend to maintain overlapping versions of the history of resettlement, each claiming some precedence respecting specific tracts of land at the former

Research Station. The chapter ends with a selection of such divergent narratives, commenting that the juxtaposition of cooperation and conflict that they reflect has relevance for the reoccupation of land at the former Kuk Station, including the section designated for World Heritage status.

Chapter 23, Phase 7, deals with the move back to Kuk by Kawelka from Buk and elsewhere, starting around 1960, in a different context: the suppression of tribal warfare by the Australian administration, which allowed freer movement of people, and the opening up of the upper Wahgi Valley to development, including the purchase of unused swampland for coffee and tea plantations. In 1978 came the sale by the Kawelka of perhaps a quarter of their land at Kuk for the establishment of a Tea (later Agricultural) Research Station. The unsold three-quarters occupied two blocks of unequal sizes, one north of the Station on and below Ep Ridge, the other, half the size, on the volcanic debris avalanche forming the southern catchment of Kuk Swamp and here called South Kuk. The inhabitants of South Kuk were able to connect with the drainage infrastructure of the Station and so make effective use of the swampland on their block, freeing up its dryland for cash cropping, particularly coffee. By the end of 1978, the population of Kuk overall—South Kuk and Ep Ridge—had overtaken that at Buk.

Some of **Chapter 24** is discussed above under 'Kuk Phase 8', since the official closure of the Kuk Research Station at the end of 1990, its effective abandonment by the authorities over the next five years and its occupation by its traditional owners from late 1995 into 1996 were important for both them and the site. In the absence of government authority, the Kawelka had regained both their land and the ability to say what happened on the land that the site occupied. This became important when the Director of the PNG National Museum proposed the nomination of Kuk for World Heritage listing on cultural grounds at a UNESCO meeting in Suva in 1997.

Chapter 24 pursues the matter of the local context within which grassroots agreement was sought for decisions made at the higher levels discussed above. It does so by reference to chapters in the Strathern and Stewart 1998 volume on Kuk heritage, and by considering the close on 30 years continuous association that Kuk Project members had had with the Kuk community.

Chapter 25 describes the new developments that occurred at the national, provincial and local levels regarding the formal nomination of Kuk for World Heritage listing. From 1997 onwards, various institutions and organisations in PNG contributed to the nomination process, which, however, by mid-2004 had stalled for various reasons. It was rescued by the Department of Environment and Conservation (DEC) and reinvigorated at a National World Heritage Action Planning Workshop in Port Moresby hosted by DEC in 2006. Here Denham and Muke volunteered to lead efforts to complete the nomination document.

A complete nomination document for the Kuk Early Agricultural Site was submitted by DEC to UNESCO in January 2007 (Muke, Denham and Genorupa 2007). It is described as an organically evolved cultural landscape comprising components past and present. The proposed management plan for Kuk as a World Heritage site is community-based. It formalises existing arrangements in that the Kawelka recognise the government's legal title to the land, while the government recognises the Kawelka as the traditional owners and grants them use rights over it.

Postscript

The Kuk Early Agricultural Site was formally accepted onto the World Heritage List at the 32nd Session of the World Heritage Committee in Quebec in July 2008. The management plan for the site is still to be completed, even though effective management occurs based on the preliminary plan detailed in the nomination document, as well as through the mutual support of local Kawelka, the Western Highlands Provincial Government and DEC.

This text is taken from *Ten Thousand Years of Cultivation at Kuk Swamp in the Highlands of Papua New Guinea*, edited by Jack Golson, Tim Denham, Philip Hughes, Pamela Swadling and John Muke, published 2017 by ANU Press, The Australian National University, Canberra, Australia.