NEW ZEALAND JOURNAL OF ARCHAEOLOGY

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Air Photo Interpretation of Fortified Sites: Ring-ditch Fortifications in Southern Viti Levu, Fiji

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ABSTRACT

Air photo interpretation and low level reconnaissance flights over the deltas of southeastern Viti Levu have provided the data for two archaeological map sheets (1:50,000 scale) showing the location of more than 700 pre-European ring-ditch settlements and the associated cultivation areas (taro gardens). Settlement sites were stratified according to various physical factors—soil type, landform, etc., demonstrating the deliberate selection of optimum sites above normal flood limits, yet allowing access to backswamp areas for the cultivation of aquatic aroids. Sites were also stratified according to time depth, demonstrating the relative constancy of total numbers (although specific sites shifted) over a period of more than 250 years. Cross-referencing of details provided in ethnohistorical sources with site details interpreted from air photos allowed the positive identification of more than a dozen ring-ditch settlements, thus contributing to an understanding of the socio-political conditions and the spheres of influence of the powerful *vanua* in the nineteenth century. Measurements of various morphological parameters (settlement size, shape, number of ditches, causeways, etc.) were made in order to document the different types of ring-ditch fortification constructed by Fijians and to attempt some estimate of former population numbers in the delta areas.
Keywords: AERIAL ARCHAEOLOGY, SETTLEMENT PATTERN ANALYSIS, RING-DITCH FORTIFICATION, FIJI.

INTRODUCTION

The contribution made by aerial photography since the 1920s has revolutionised our understanding of many problems in settlement pattern archaeology at the regional and local level, as witnessed by the work of Antoine Poidebard in the eastern Mediterranean, John Bradford in Apulia, Etruria and Crete, Paul Kosok in Peru, O. G. S. Crawford, G. W. G. Allen and J. K. St. Joseph in southern England, Roger Agache and Irwin Scollar in northern France and the Rhineland. Aerial photography is a particularly appropriate tool in settlement pattern archaeology because the traces of human activity are frequently seen as distinct anomalies when viewed from the air and the functional interrelationships of the various elements can often be deduced after careful examination of the photo detail. By their very nature, fortifications are more resistant to the ravages of time and man than other artefacts, and so their traces are generally more distinct and more persistent. Defensive works have a special significance for the archaeologist. They provide an insight into the nature of contemporary warfare, since the form of defence is clearly a response to the mode of attack. In addition, fortified sites can provide valuable information in the analysis of demographic and socio-political conditions. Important centres in the settlement hierarchy by reason of population size or administrative significance are generally characterised by more elaborate fortifications encompassing a larger habitation area, which makes them readily identifiable on the air photo.

Aerial photography is a far more powerful and versatile tool in site analysis than is generally realised. When combined with ethnohistorical details and information on physical site conditions, the air photo can illustrate a broad spectrum of topics, seven of which will be explored in this article. Although the details and illustrations presented in this study are derived exclusively from field areas in Fiji, there seems

little doubt that the same topics could be investigated with equally fruitful results in other areas of the South Pacific.

RING-DITCH FORTIFICATIONS

This study is concerned with ring-ditch fortifications—the most common type of earthwork in Fiji. At the contact period in the first decades of the nineteenth century, the early visitors to the islands were impressed by the massive investment of time and effort in the construction of earthwork defences around towns and villages, a situation without parallel in other Pacific islands with the exception of New Zealand. Good descriptions of ring-ditch fortifications (*Korowaiwai*) are available in the ethnohistorical literature, and there are also contemporary sketches and paintings. The basic elements in the morphology were firstly, a more or less circular water-filled ditch, and secondly, a palisade or fighting fence erected on top of the inner bank of the ditch. The ditch encircled the habitation area and access was provided by causeways in the form of narrow earthen banks leading to gateways in the fence, as indicated in Fig. 1. In some cases, the ditch was unbroken, and the crossing was effected on logs of coconut which served as a crude drawbridge, readily removed when the settlement was under attack.

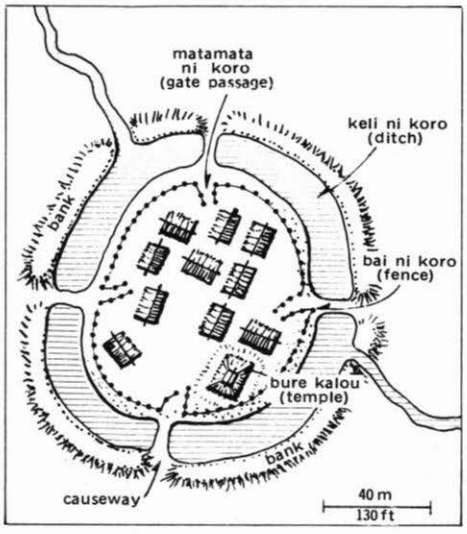

Figure 1: Schematic plan of a typical ring-ditch fortification (*korowaiwai*) indicating the basic elements in the defence system.

In the lowland areas, defensive warfare was pivoted on the ring-ditch fortification, each community generally occupying its own fortified place in the midst of its food gardens. Fortifications gave the besieged a considerable tactical advantage over the besiegers. Warfare was generally small-scale and local, and the immediate requirement of fortifications was that they should provide protection for the community against surprise attack and sieges of short duration (Clunie 1977). A true siege was seldom contemplated and even less frequently carried through to its conclusion. There was no system of organised food distribution for an attacking force, and so if the first assault was repulsed, the attackers would generally retire to secure fresh food supplies. Even in the musket period the ring-ditch gave ample protection against an initial assault, and the fence served as a defensive screen to conceal and shelter the besieged warriors,

while at the same time providing ample opportunity for inflicting casualties on the besieging forces. Such a situation is shown in Fig. 2, Glen Wilson's painting of the attack on Vewara, 1856, a canvas filled with authentic detail on weapons, battle-dress and fortifications.

Figure 2: The ring-ditch fortification at Vewara, Nadi Bay, Vanua Levu from the painting by J. Glen Wilson (H.M.S. *Herald*), 1856.

Many of the ring-ditches are surprisingly large, and doubts have been expressed about the ability of a relatively small community with only primitive tools to create such features. Fortunately, we have an eye witness account in the ethnohistorical literature showing that ring-ditches could be excavated relatively quickly if sufficient manpower was available. During his sojourn in Vanua Levu, 1808-1809, William Lockerby observed the construction of the fortification at Bua and noted that it was completed by 400 men in less than a month (Im Thurn and Wharton 1925:18). The Bua fortification is large—circumference 1,100 m, width 14.6 m, depth 2 m, volume of material circa 30,580 m^3; however, calculations demonstrate that by moving between 3 and 4 cubic metres of material per man day (approximately 20 baskets per hour for a 3-man work team in an 8 hour day) the work could be accomplished in 8,400 man days, which is approximately three weeks for a 400-man work force (Parry 1977:31). Obviously, the typical small ring-ditch could be constructed in a much shorter period of time.

AIR PHOTO ANALYSIS

Air photo analysis of Fijian earthworks has been undertaken in three areas (Fig. 3). The results of the studies in the Rewa and Navua deltas have been published by the Fiji Museum (Parry 1977, 1982), and the results from the Sigatoka valley are to be published shortly. Standard panchromatic, multi-scale, multi-date aerial photography provided the main data base, supported by low-level, hand-held, oblique, colour photography of selected sites. More than 600 air photos were examined in the analysis of the Navua delta, and nearly 1,000 each for the Rewa delta and the Sigatoka valley.

The availability of both multi-date and multi-scale air photography was found to be advantageous. There is no single, optimum scale for archaeological investigations, but a good medium-scale coverage at between 1:10,000 and 1:16,000 is essential for examining the physical background and the settlement pattern. For individual sites, large-scale air photos at between 1:2,000 and 1:5,000 are invaluable. Colour photography has definite advantages in ease of interpretation but is not available unless the researcher can arrange to obtain his own.

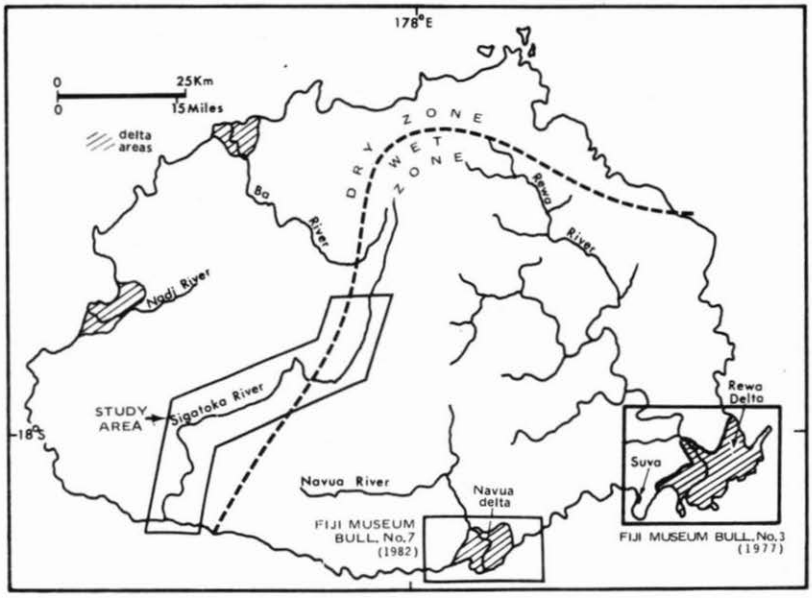

Figure 3: Location of study areas in Viti Levu.

For many sections of each study area, several air photo coverages flown at different times of year (multi-date) were available, and, in almost all cases, it was found that new information was derived from an examination of the additional photo coverage. In several instances, ring-ditch sites not previously located were detected as a result of changes in the angle of solar illumination, differences in the crop or vegetation cover, or variations in the soil moisture content (Fig. 4). In other cases, additional details were provided which were not visible on any one set of air photos.

It is clear that no reconnaissance survey using air photos can claim to have achieved complete success in detecting all the sites in an area. However, when multiple photo coverages of the same area have been examined, there is good reason to believe that the great majority of sites have been identified. The question of the detectability of archaeological sites using air photo interpretation methods is obviously a critical one in a study of this type because the extent to which one can obtain a reliable statement of the settlement pattern archaeology is clearly dictated by the detectability level that is achieved in the air photo interpretation. A test was devised to determine the probable level of detection of archaeological sites that could be expected. The test was carried out in two sample areas in the Sigatoka valley where detailed field work had been undertaken by an archaeological team from the Fiji Museum (Palmer 1966). Precise locations are given in the survey notes and details are recorded about the function

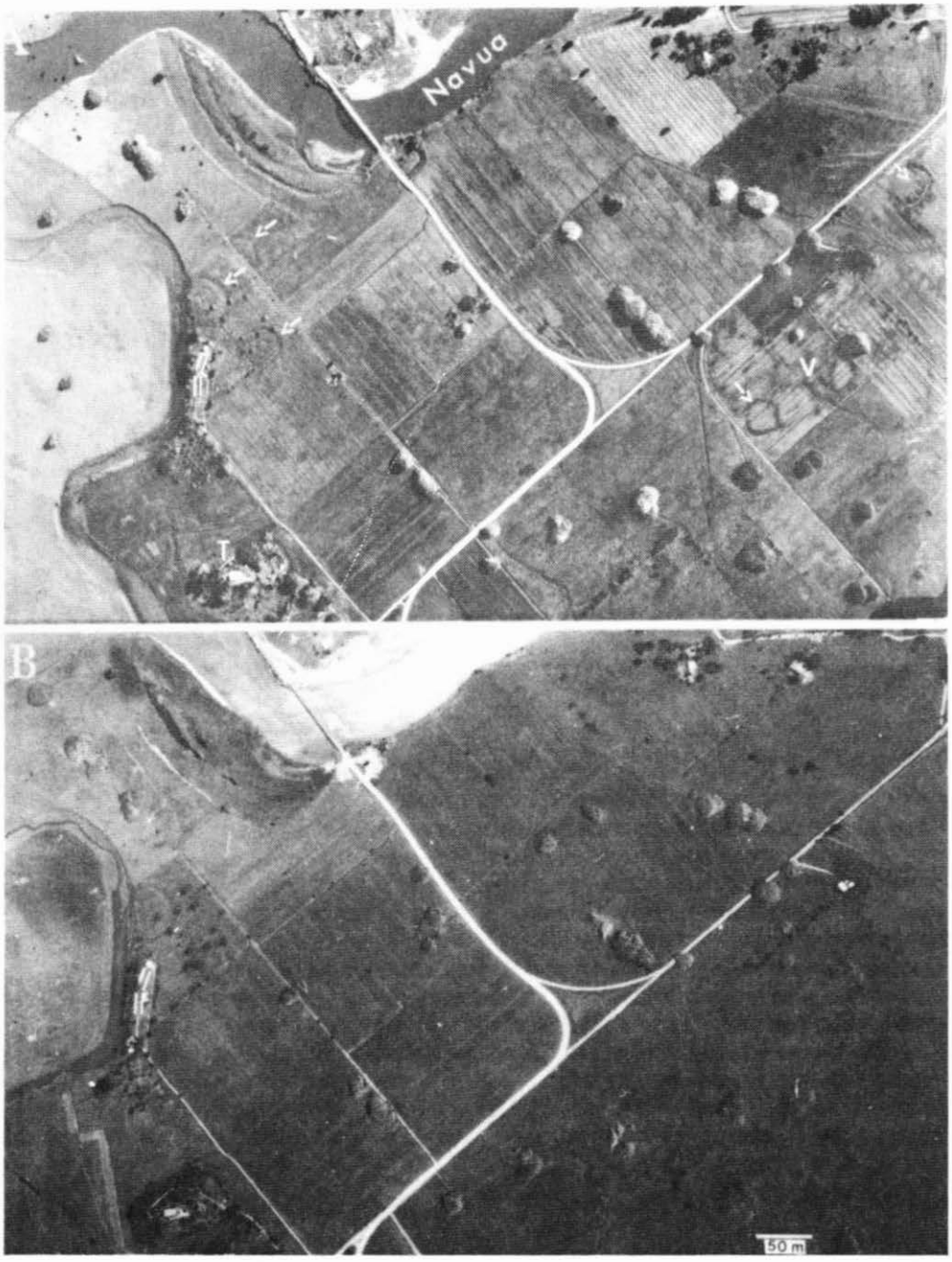

Figure 4: Variation in the amount of archaeological detail revealed in two sets of air photos of identical scale, as the result of differences in illumination (time of day, soil moisture and crop cover), Navua delta. A: Fiji Landsphoto 66/28-38 1:9,500, March 1966, 08.30 hrs. B: Fiji Landsphoto 73/1-73 1:9,500, Jan. 1973, c. 11.00 hrs. \ = Moisture contrast marks. / = Crop contrast marks. T = Tamunua. v = former *vuci*.

of the site and the surface features identified during the field surveys, which range from lithic scatter to substantial earthworks. The field survey data were not consulted until after the completion of the air photo interpretation of the two sample areas. The two sets of data were then compared. The detectability level achieved provides a good indication of what can be expected in comparable conditions elsewhere (Fig. 5). The results of the test show that ring-ditch fortifications were readily detected – only one out of the thirty ring-ditch fortifications in the two sample areas was not identified in the air photo analysis, giving a performance level of 96 percent.

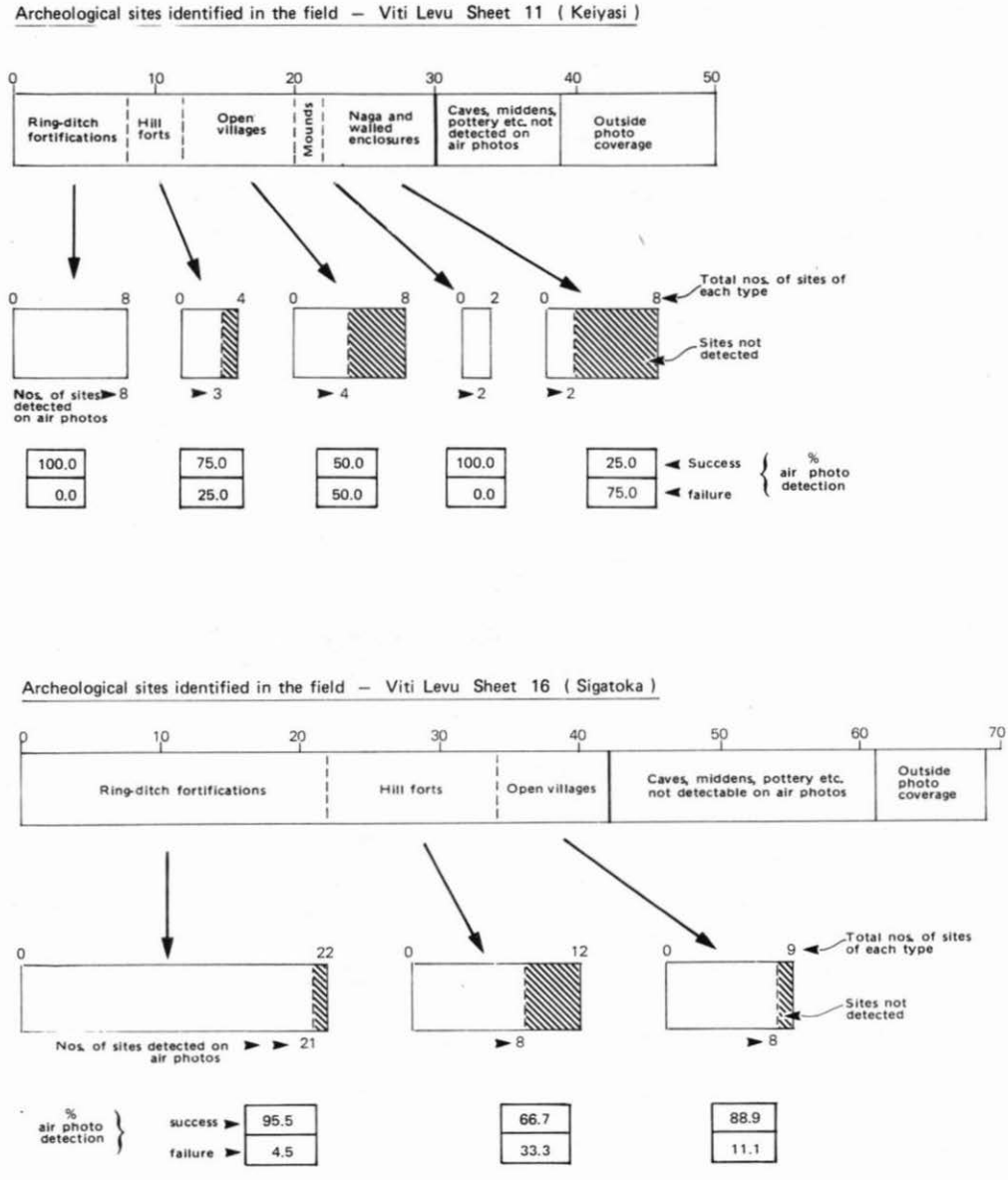

Figure 5: Detectability of archaeological sites in the Sigatoka valley. Comparison of results from field reconnaissance (Palmer 1966) and air photo interpretation.

The equipment used in this study was relatively simple, consisting of an ODSS II scanning stereoscope with 1.5x, 3x, 4.5x, and 9x magnification, a Bausch and Lomb Zoom macroscope with a magnification of up to 30x for detailed examination of particular sites, a Finescale magnifying comparator with various reticles for making specific measurements, such as ditch width, habitation area, garden area etc.

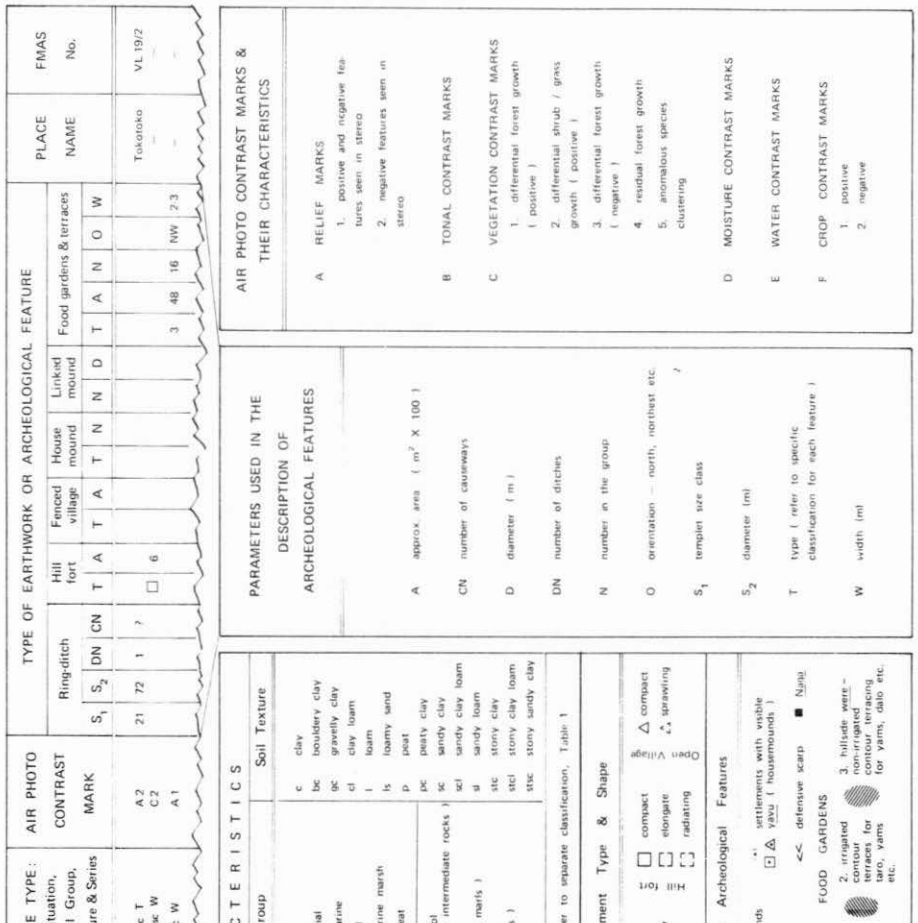

Figure 6: Layout of the air photo interpretation sheets and key to the characteristics used in the inventory and analysis of ring-ditch fortifications and other site types.

For convenience in carrying out the air photo interpretation a comprehensive data collection sheet was designed as shown in Fig. 6. The classification schemes utilised for characterising a particular site are partly symbolic (for mapping purposes) and alphanumeric (for purposes of statistical analysis). The symbols were devised to provide information on the type of feature, its shape, size, site type, etc., at a mapping scale of 1:50,000. The site type is identified in terms of landform and soil series, and the data collection sheet provides space for recording information on the soil texture. Size measurements were made with a transparent overlay templet consisting of a graded series of circles with diameter increments of 0.5 mm. In making a size measurement, the best visual fit was obtained between the image of the ring-ditch and one of the circles in the templet. The diameter and area of the site were then calculated using the scale number of the air photo. Details of smaller features such as house mounds, cultivation terraces, and *vuci* (or wet taro gardens) were obtained with the zoom macroscope and magnifying comparator. In addition, the air photo image type was recorded using a classification of air photo contrast marks elaborated specifically for South Pacific conditions (Fig. 7). Some of these are well known in the literature of aerial archaeology (Crawford 1929, Bradford 1957, Solecki 1960, Deuel 1969), whereas others are unique to the Pacific. The various indicators of former occupance can be grouped in different categories depending on diagnostic features such as surface relief visible in the stereo-image, shadows and tonal anomalies produced by differential illumination of the various facets of microrelief, vegetation and crop contrast marks generated by differential growth or species clustering, and soil contrast marks resulting from disturbance of the soil profile and the moisture regime.

APPLICATIONS OF DATA DERIVED FROM AIR PHOTO INTERPRETATION

1. RECONSTRUCTING THE PHYSICAL LANDSCAPE

At the start of this study it was not realised how important a role aerial photography was to play in the interpretation of the changes that have occurred in the physical landscape. By combining oral traditions of devastating floods, ethnohistorical details provided by the early visitors, and geomorphological evidence derived from air photo interpretation, it was possible to reconstruct the major changes in the pattern of distributary channels that have occurred in the last two hundred years.

In the Navua delta, the earliest discharge is marked by a series of braided channels in the western part of the delta. The gap in the reef barrier in this section suggests a progressive shift in the silt-laden flow as the delta extended south and east of its initial position. In the case of the Deuba channel, there has been a gradual migration of the diffluence point from west to east. Thus, the Kabecake was the oldest of the Deuba series and the Qarailulu is the antecedent of the present Deuba. Oral tradition indicates that the Waidradra meander loop was active until about fifty years ago.

In the Rewa delta, there is geomorphological and pedological evidence of sudden shifts in the position of the major distributary channels as a result of overtopping and breaching of the levees by major flood crests. In the eighteenth century an important channel, the Wai ni Ki, drained across the northern delta. The shift from this channel in favour of the present Wai levu probably occurred circa 1793, when there was a major flood in the delta. In the early part of the nineteenth century, the Kuku channel was opened and for a short period it was the dominant channel; however, by 1850 it was blocked and is now occupied by a small misfit stream (Fig. 8).

The recognition of earlier channels and levees proved to be very significant because the settlement pattern was found to have developed in response to these changing

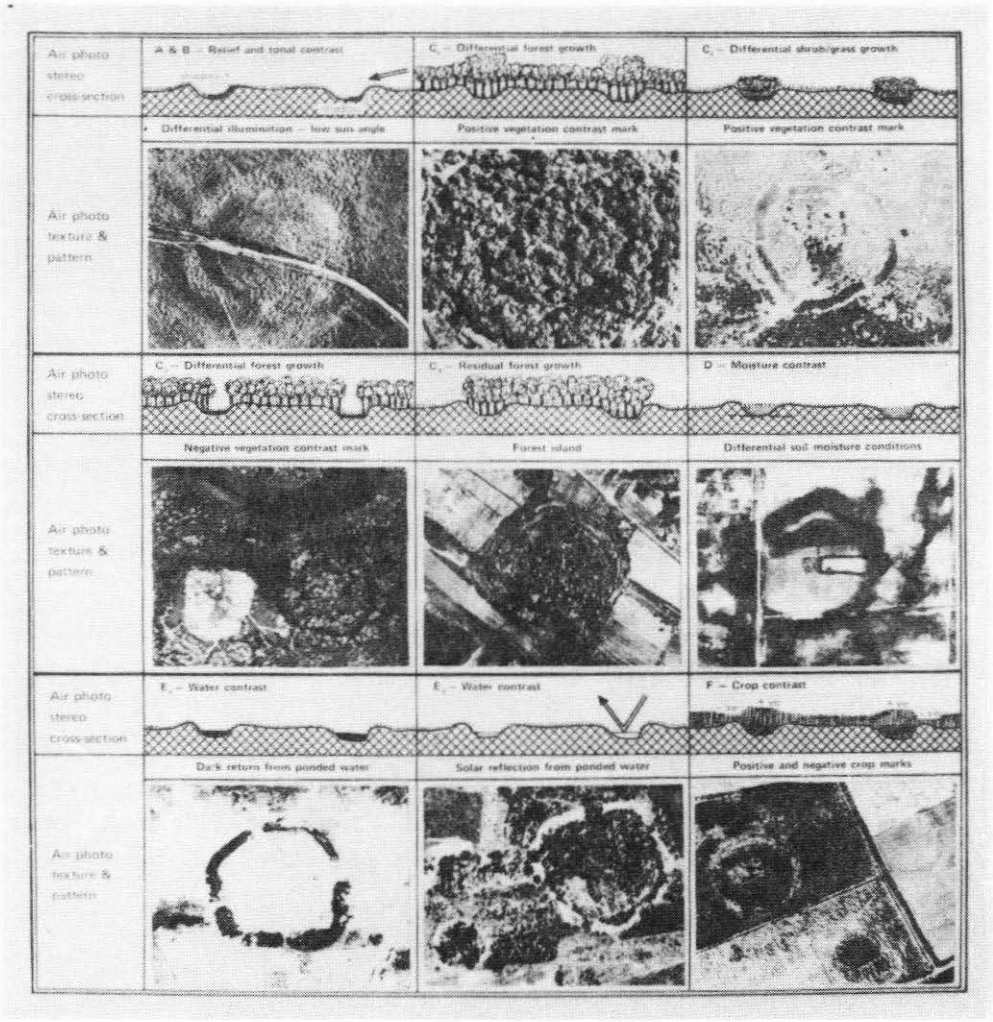

Figure 7: Air photo image types, ring-ditch fortifications: illustrative key and schematic sections.

conditions. Channels that are now completely infilled were once the highways for canoes filled with people and produce from the settlements along their banks.

2. ANALYSING SITE PREFERENCE

The air photo is a very effective tool in analysing settlement patterns and making an inventory of discrete archaeological features such as ring-ditch fortifications. The aerial perspective provides precise evidence as to location and site conditions, and it allows the researcher to integrate all of the site factors in understanding the function of a particular settlement and also in the interpretation of the pattern as a whole. As each ring-ditch site was detected in the course of the air photo analysis, its position was plotted on a base map at a scale of 1:50,000 using the set of symbols described above.

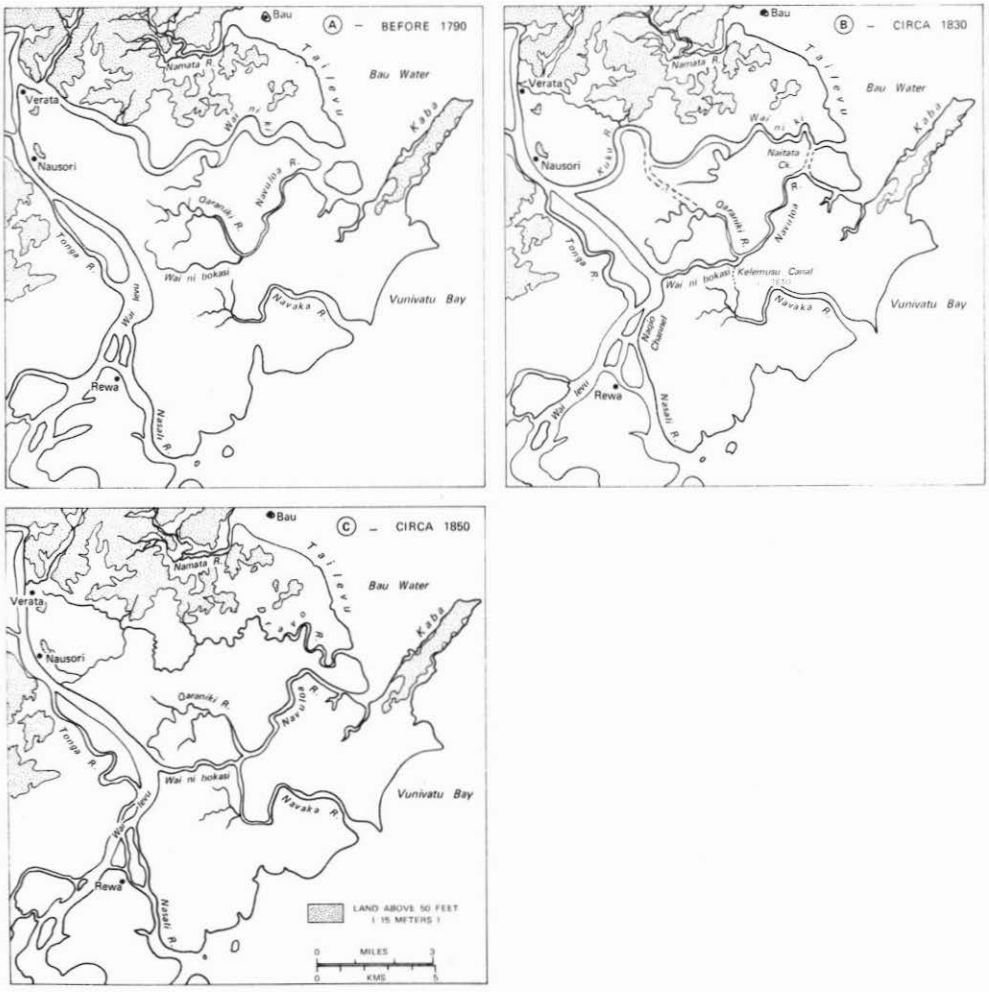

Figure 8: Major changes in the distributary pattern of the Rewa delta in the eighteenth and nineteenth centuries based on air photo interpretation.

More than 700 ring-ditch fortifications were identified in the two deltas (96 in the Navua delta and 606 in the Rewa delta), and a close correspondence between site conditions and settlement frequency was established. The preferred sites included the higher beach ridges of the strand zone, the edge of the marine terrace on the inner margin of the deltas, "swamp island" sites on outliers of volcanic rocks, the delta-bar fingers, and the present and former levees. When the data sets for the two deltas are compared (Fig. 9), some interesting differences appear: the preference for the levee crests in the Rewa delta compared with the levee backslopes in the Navua delta, and the significance of the estuarine bars in the Rewa delta and their relative insignificance in the Navua delta. Careful selection of settlement sites is a characteristic feature of difficult environments such as deltas, and the degree of site selection exhibited in the deltas of south eastern Viti Levu is indicative of a relatively lengthy occupation of the area and a good understanding of the delta ecosystem.

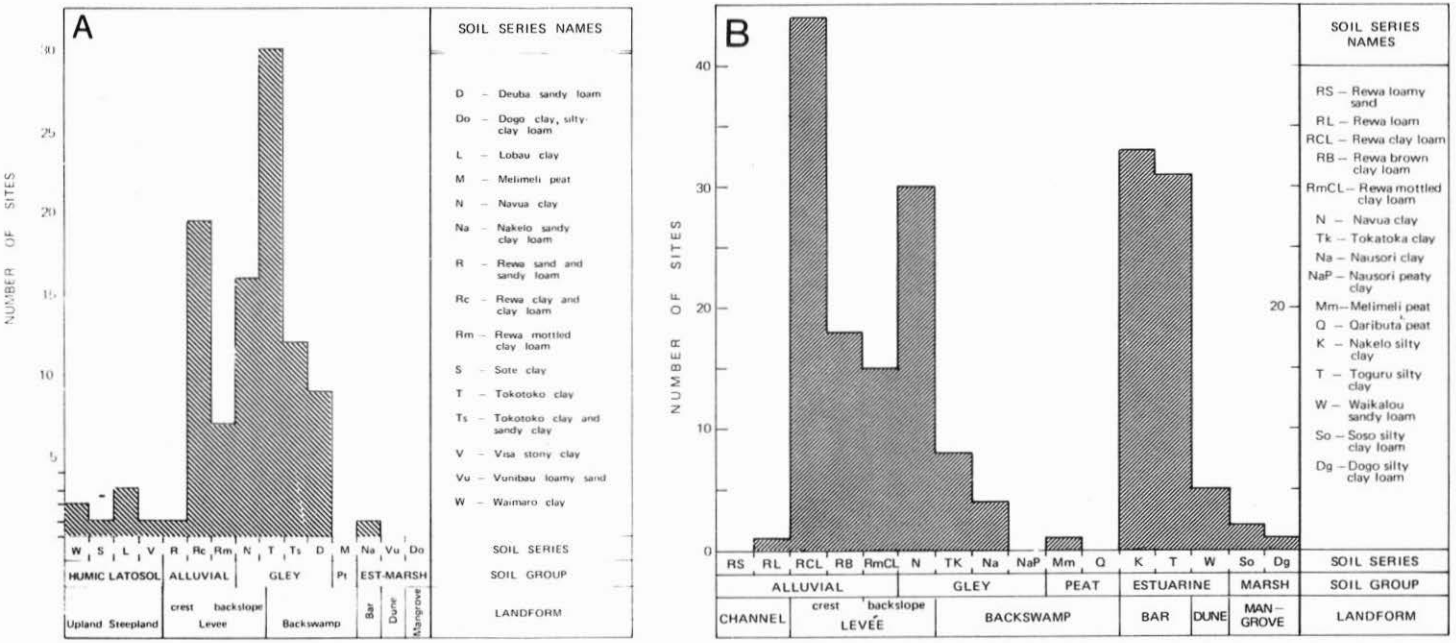

Figure 9: Frequency of occurrence of ring-ditch sites according to landform and soil type. A: Navua delta. B: Rewa delta.

3. CLASSIFYING FORTIFICATION TYPE

The availability of medium to large scale aerial photography allows accurate assessment of a number of parameters. In the case of ring-ditch fortifications where there is a general conformity in the morphology, it is possible to obtain comparative data on the shape, the number of ditches, the number and type of causeways, and the settlement size.

The basic shape of the ring-ditch fortifications in the delta areas is annular (Fig. 10). The form is seldom a true circle, demonstrating that there was no concern for exact geometry, and distortions of the annular form were found to occur in about four percent of the total, representing adjustments to specific site conditions. Polygonal fortifications (Fig. 11A) with a series of rectilinear banks and ditches and offset maze type causeways accounted for less than two percent of the total, occurring mainly in the Rewa delta. No satisfactory explanation for their presence has yet been found.

The great majority of settlements in the deltas have a single ditch and the causeways exhibit a simple quadriform pattern. However, larger and more important settlements were often protected by multiple ditches. These are more common in the Rewa delta (9 percent of the total) reflecting the greater influence and political power of the Rewa *vanua* (Fig. 11B).

The mean size of ring-ditch sites was found to be comparable in the two delta areas. The modal diameter at 77 m with a corresponding habitation area of 0.3 hectares is well-defined in both sets of data and obviously reflects the socio-economic structure of Fijian society in the eighteenth and nineteenth centuries with small kin groups, *tokatoka* and *mataqali* occupying fortified sites in a dispersed pattern (Fig. 12).

4. MAPPING INDIVIDUAL SITES AND EXPLORING THE SPIRIT OF A PLACE

Air photos have a dual role in archaeological research—to demonstrate the known and discover the unknown. Often these two roles are linked because the air photo can present the site situation in such a way that it captures "the spirit of the place". By careful analysis of a large scale air photo it is often possible to obtain an integrated view of the settlement morphology, its site and its surroundings, thus each assemblage becomes more than a sum of its parts and the researcher is a long way towards his goal of understanding the raison d'être of the settlement and relating its economy and setting. Two examples must suffice to illustrate this point. At Kurimalawai in the Sigatoka valley (Fig. 13), a site with a cover of tall grasses, reconnaissance surveys identified two house mounds, failed to locate any causeways, and were uncertain about the water source for the ring-ditch. The air photo clearly reveals nine house mounds, one entrance causeway, and a defensive site which formerly had a secure and permanent water supply. At Nabudrau in the Rewa delta (Fig. 14), the air photo provides dramatic evidence confirming oral traditions which record the reclamation of an estuarine bar and the establishment of settlements, food gardens, and fish ponds connected by a network of causeways. The creation of this settlement pattern between 1750 and 1770 takes on a new dimension when it is examined in conjuncton with the air photo. The alignment of the estuarine bank can be identified trending northeast-southwest, and the significance of the chiefly villages Nabudrau, Nacuru, and Nakorowai is apparent from their greater size. Nabudrau, with its double ring-ditch, dominates the area and the causeways radiate from it to the *cakovaki* or tenant villages in the mangrove swamps like the spokes of a wheel (Thomson 1908:380-381).

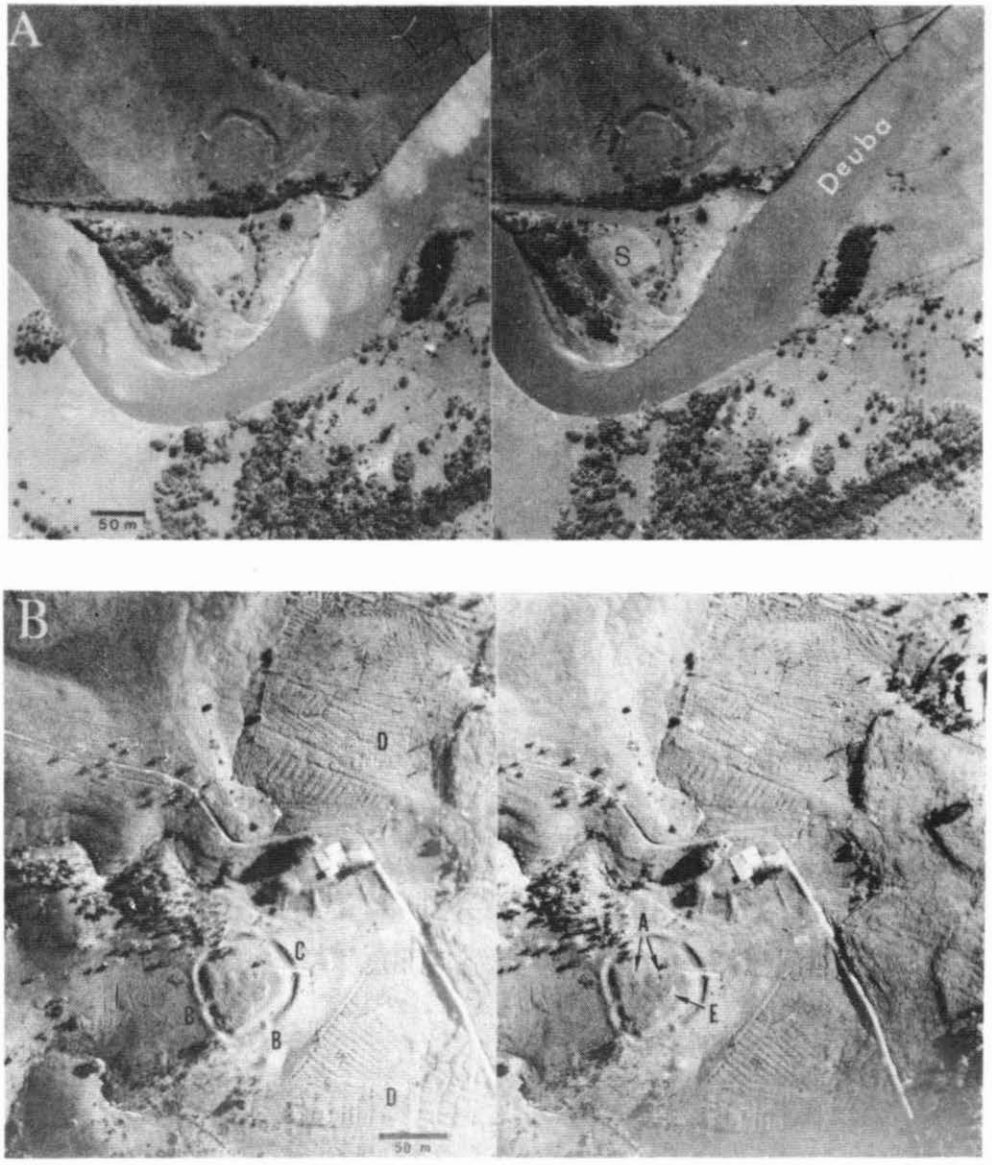

Figure 10: Typical ring-ditch fortifications.

Fig. A: Stereogram of Batinikia, a ring-ditch fortification on the Deuba channel, Navua delta. Fiji Landsphotos 74/4 9 and 10, 1:6,000, May 1974. c = causeway. S = probable earlier site.

B: Stereogram of Nasinu, a ring-ditch fortification on a knoll site, Suva peninsula. Late afternoon sun provides shadow enhancement. Fiji Landsphotos 67/51 16 and 17, 1:4,700, July 1967. A = housemounds. B = causeways. C = erosion scar, cattle track. D = former *vuci*. E = excavation quadrat.

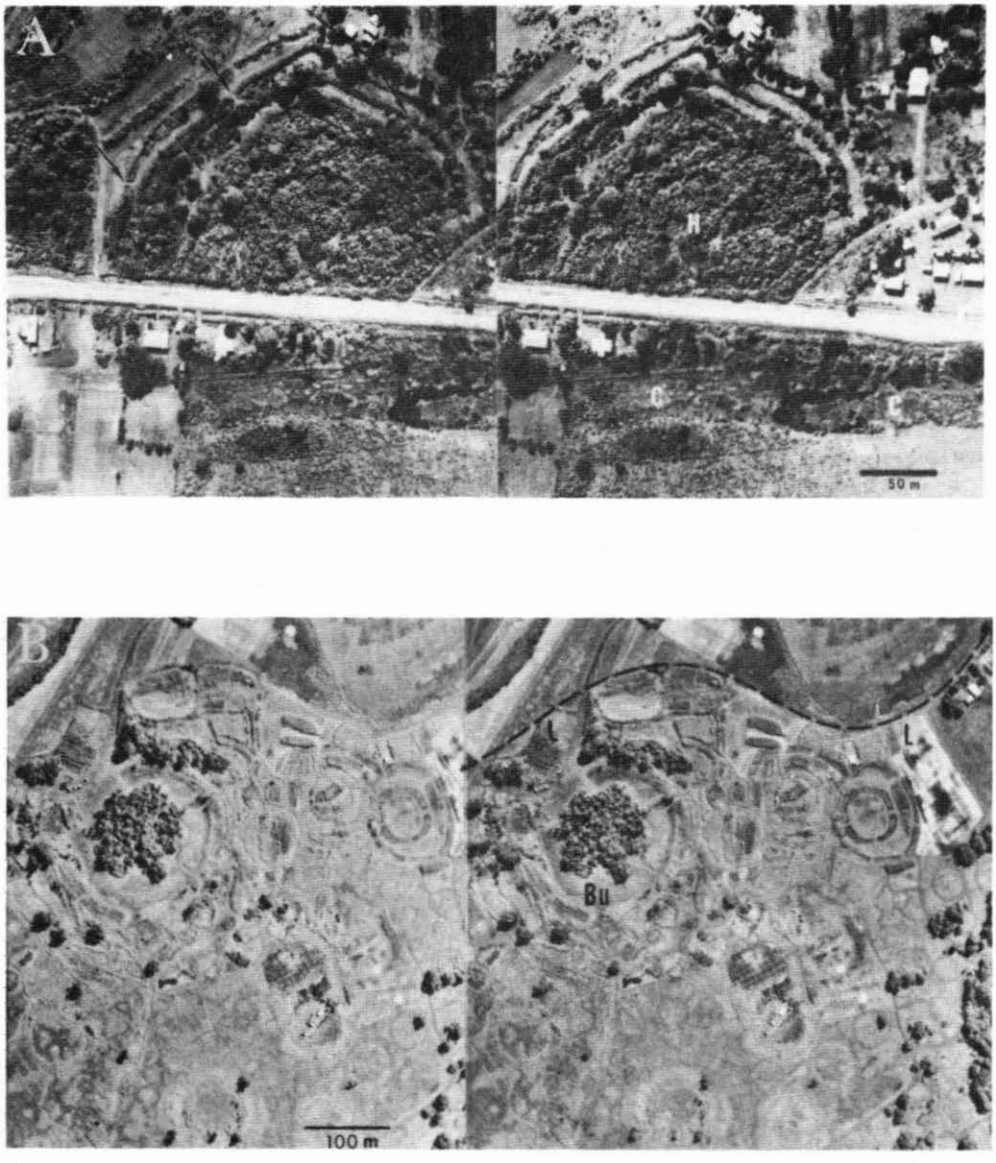

Figure 11: Examples of polygonal and complex fortifications.

Fig. A: Stereogram of the offset maze type causeways and multi-ditch polygonal fortifications at Nadali, Rewa delta. Fiji Landsphoto 70/4 19 and 20, 1:4,400, July 1970. / = causeways. C = former river channel now occupied by water hyacinth. H = habitation area.

B: Stereogram of the multi-ditch complex at Burebasaga. The smaller ring-ditch sites around Burebasaga provided tribute labour and warriors. The interconnecting ditches provided a defensive screen in the event of attack. Fiji Landsphotos 68/194 25 and 26, 1:9,500, June 1968. Bu = Burebasaga. L = levee bluff. ---- former channel of the Rewa.

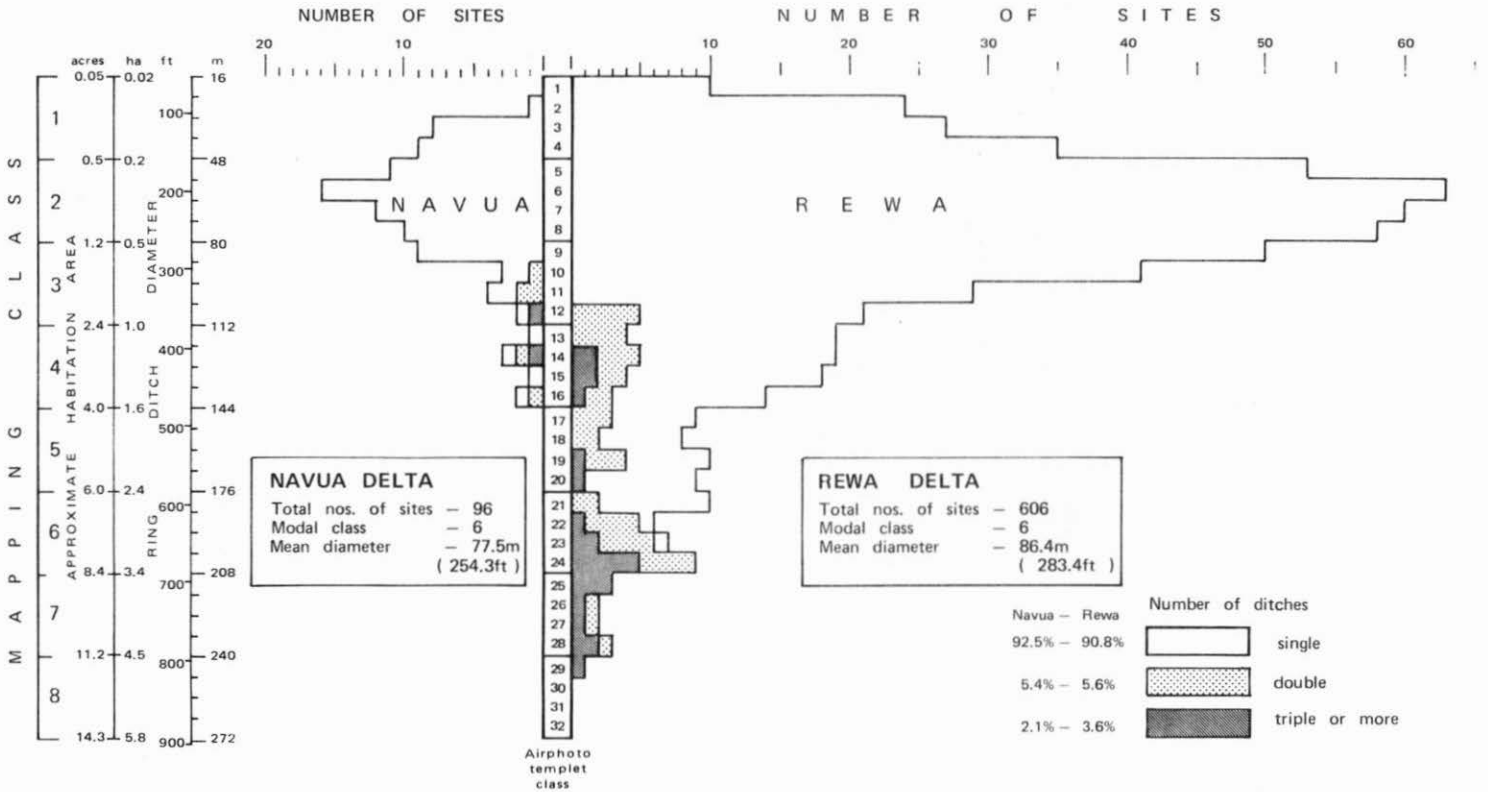

Figure 12: Frequency distribution histogram – settlement size and number of ditches.

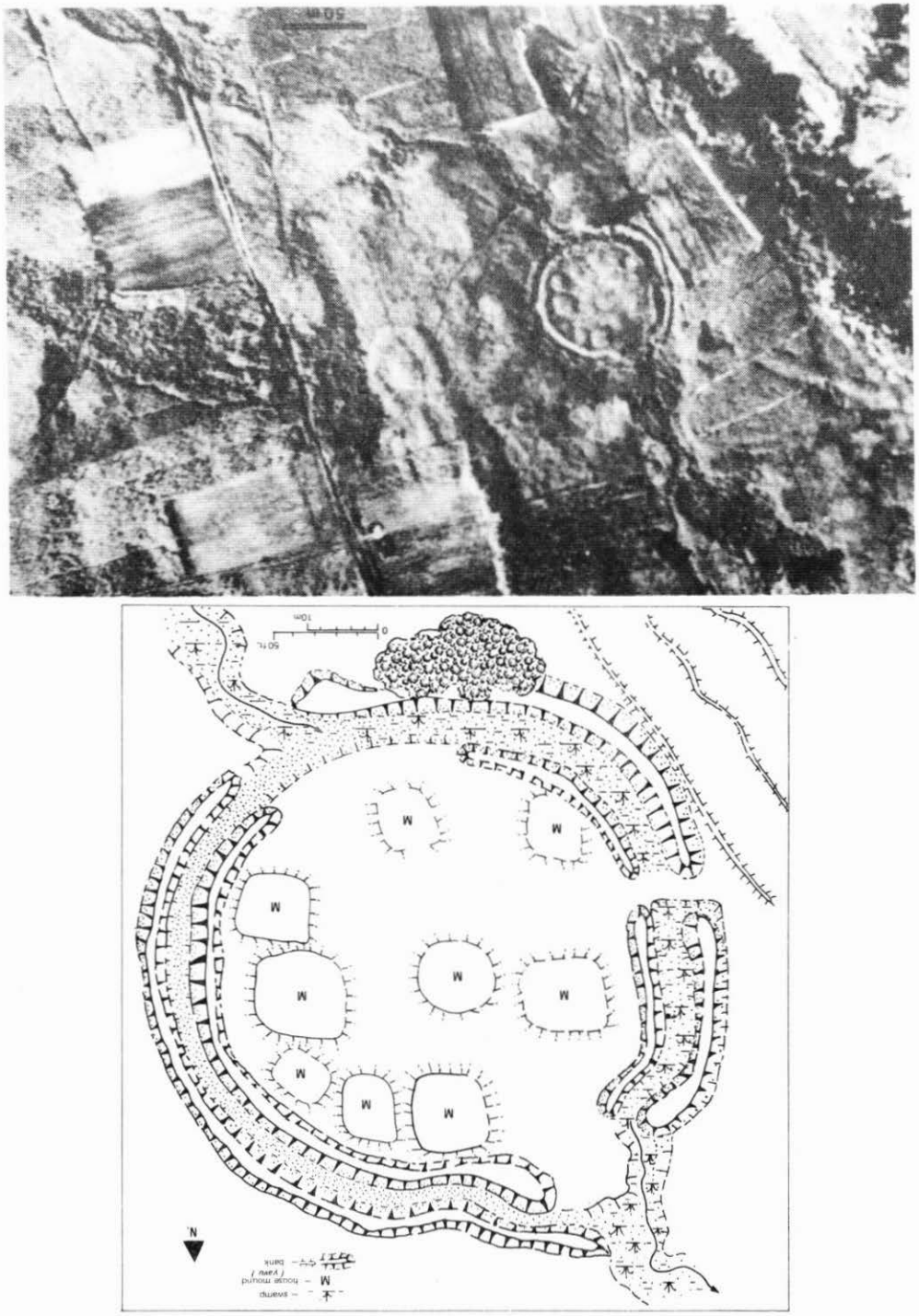

Figure 13: Air photo and site plan prepared by air photo interpretation—Kurimalawai in the upper Sigatoka valley. Fiji Landsphoto 64/74 7, 1:4,250 (2x enlargement of original scale), July 1964. Site plan—approx. scale 1:1,000.

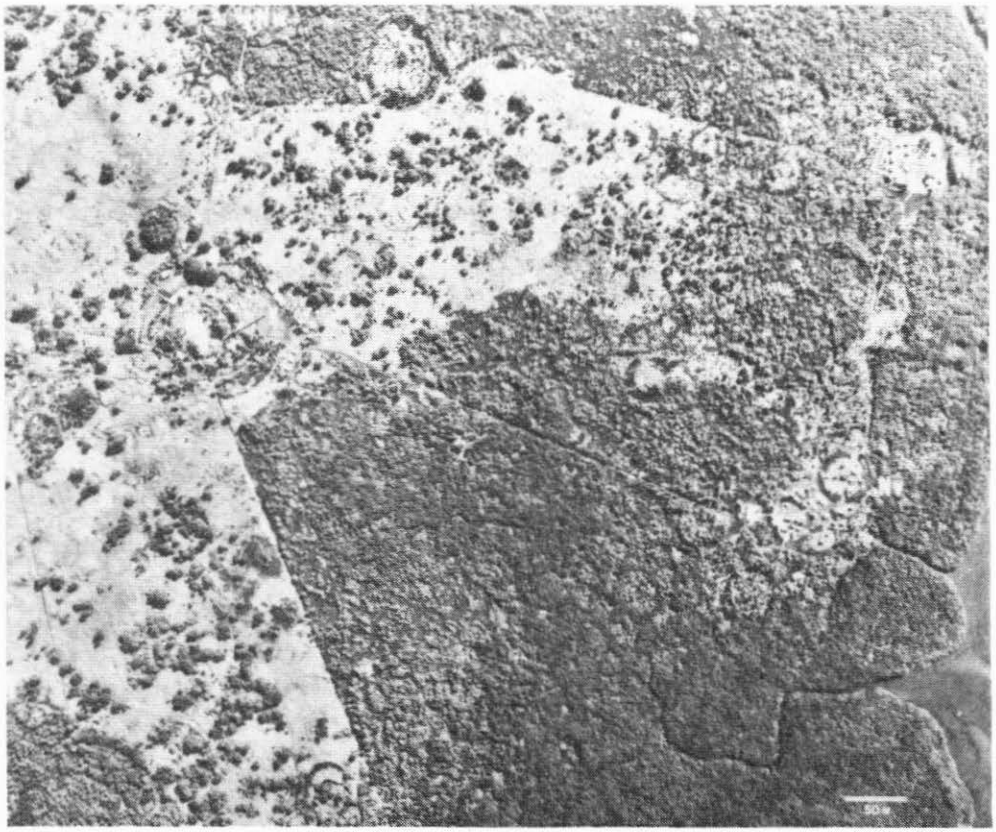

Figure 14: Nabudrau and the causeway villages of the mangrove swamp, Rewa delta. Fiji Landsphoto 68/91 98, 1:9,500, June 1968. N = Nabudrau. Nk = Nakorowai. Nv = Naivilaca. T = Taci. Nc = Nacuru. Nr = Narocake. Nw = Nakauwaru. y = *yavu*.

5. TIME-DEPTH STRATIFICATION

Careful stratification of the different types of image contrast mark can provide a framework for the examination of time depth in the settlement pattern. Some forms, by their very nature, must represent sites occupied then abandoned in the distant past, whereas other forms indicate relatively recent abandonment. The various types of contrast marks that were encountered in the air photo analysis were grouped in three categories and relative age relationships were established, assuming that a feature would become progressively subdued and overgrown after its abandonment (Fig. 15). Absolute age relationships are more difficult to establish. However, ethnohistorical sources and oral tradition provide dates of abandonment for particular settlements and these can be used as date lines for other ring-ditch fortifications in the same category. When the number of occurrences of a particular image contrast mark is stratified in time depth, then we find that approximately a third are well-preserved, indicating recent abandonment, probably at the time of the measles epidemic in 1875, when ethnohistoric sources indicate that approximately a quarter of the population was wiped out in the space of four months. The second tier, representing somewhat older diachronic sites, were probably abandoned at various dates during the early nineteenth century. This group includes slightly more than a third of the total. The final group, consisting of

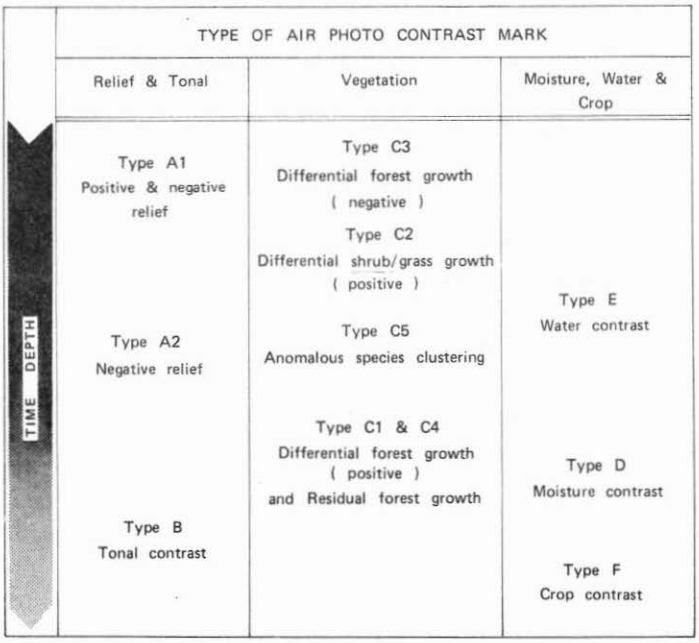

Figure 15: Time depth—the probable age relationships of the various types of air photo contrast marks.

the subdued types of contrast mark, contributes somewhat less than a third of the total and these settlements were abandoned in the eighteenth century.

Two conclusions can be drawn from this examination of the time-depth relationships: first, that the development of the settlement pattern was a lengthy process spanning at least two hundred years, and second, that the total number of diachronic settlements at any given time was more or less constant and represented approximately a third of the total. It is difficult to establish a date for the earliest settlements. However, the very subdued air photo contrast marks (image types B, D, and F) probably represent traces of settlements that flourished in the seventeenth century.

6. POPULATION ESTIMATION

One of the most interesting problems that can be addressed by the archaeologist in the South Pacific is that of estimating the population of an area in the prehistoric period. Air photo interpretation can make a significant contribution to palaeo population studies because it provides a reasonably accurate indication of the number and size of settlements that existed at any given time. It was established in the course of this study that there was a relationship between the size of certain ring-ditch fortifications and their population as given in ethnohistorical sources. This relationship can be used to estimate approximate population totals for larger areas, using the data on numbers of ring-ditch settlements in different size classes derived from the air photo analysis. After an extensive search of the literature, five delta settlements were found that met all the necessary conditions for establishing the settlement size:population relationship—a literature reference that was specific as to the settlement's location and population, and an archaeological trace in the form of a ring-ditch, clearly visible on the air photo, which by reason of its situation could be positively identified as

the settlement mentioned in the literature. The regression line between population and habitation area (Fig. 16) gives a reasonably good fit with a correlation coefficient r = 0.975. Using this relationship, it is possible to make an estimate of the population for any given size of ring-ditch habitation area. The total numbers of settlements in the various size classes are available from the air photo analysis; however, as noted above, only about a third of these are diachronous. Thus, the total population of the area can be calculated according to a relatively simple summation:

$$T_{TD} = \tfrac{1}{3} \Sigma\, N_1.P_1 + N_2.P_2 + N_3.P_3 \ldots N_n.P_n$$

N_1N_2 etc.—numbers of ring-ditch sites in size classes 1, 2 etc. (derived from air photo analysis)

P_1P_2 etc.—population of ring-ditch settlements in size classes 1, 2 etc. (derived from the regression equation)

T_{TD}—total population of the area at any time depth stage

The estimated population figures for the two deltas in the early nineteenth century are 8,500 for the Navua delta and between 35,000 and 40,000 for the Rewa delta, Suva Peninsula, and Tai Levu coast. There is a certain degree of consistency in the results because the Rewa delta is substantially larger than the Navua (250 compared with 47 km²). More than 600 ring-ditch sites were mapped in the Rewa compared with approximately 100 at Navua, and so simply in terms of proportionality (five times the area and six times the number of settlements) one would expect the Rewa delta to support a larger population.

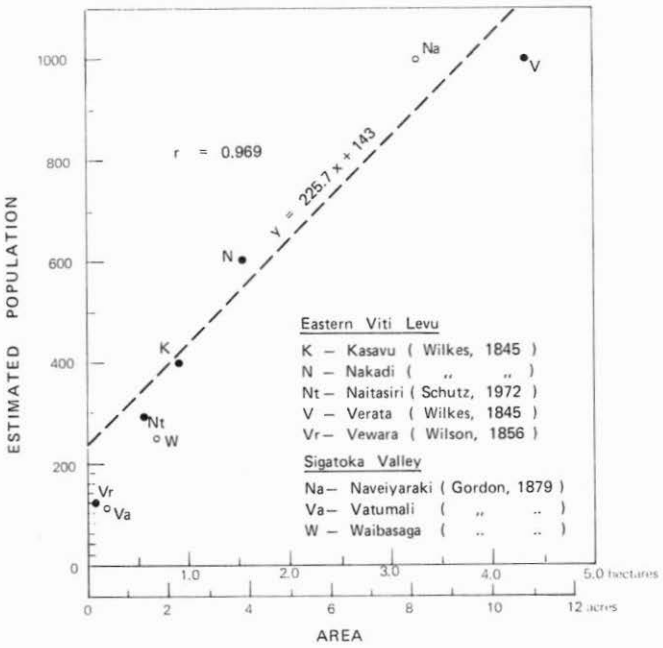

Figure 16: Regression line for the relationship between population and habitation area for ring-ditch settlements.

Perhaps more important than the total number of ring-ditch sites identified is the fact that there were many more large and elaborately defended sites in the Rewa delta

(Fig. 12). This would suggest that in the Rewa delta a more elaborate socio-political infrastructure had developed, supported by a more productive agricultural base. The relationships between population, the agricultural ecosystem, and the socio-political system in Fiji in prehistoric times can be expressed in terms of schematic linkage (Fig. 17). It is tempting to interpret the relationships as symbiotic. A *mataqali* that was successful in war could command the tribute and service of the conquered people as warriors or *vanua kaisi*. Military victory ensured the availability of a food surplus which in turn meant the ability to support large numbers of warriors. These factors in turn promised further military success and increased territory and tribute. A militarily successful group had the possibility for agricultural improvements denied an unsuccessful group. It could achieve the quantum jump leading to an intensification of agricultural practice by directing tribute labour to the construction and maintenance of food gardens in the delta swamps. Increased food production could consolidate its position and provide the base for renewed political and military expansion. It was this linkage which sustained the socio-political infrastructure of the more elaborate *vanua* and *matanitu* of the Rewa delta, such as Verata, Rewa, and Bau. In the Navua delta, no single group achieved military and political dominance, and so the status quo was maintained with a relatively small total population, few large settlements, and comparatively small areas of food gardens.

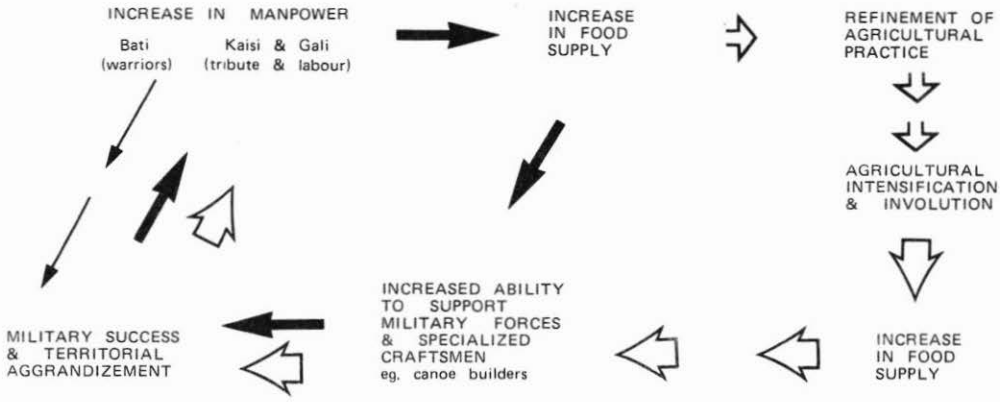

Figure 17: Schematic diagram showing the linkages between military success, tribute, labour, increased food supply and agricultural intensification.

7. ANALYSING THE RESOURCE BASE

The swamps of the deltas presented one of the most difficult agricultural environments of the South Pacific because of the high water table and frequency of flooding. On the limited well-drained sites, it was possible to grow yams, plantains and several tree crops; however, over the greater part of the area conditions were such that only hygrophilous plants could survive and so the wet-land taros came to be of great importance as food crops.

The pre-European food gardens of the delta areas are now largely abandoned and overgrown. They are difficult to identify on the ground because of vegetation growth, but they are readily discernible from the air. The clue to their identification is provided by reticulated patterns of darker tones which are found to result from the denser growth of shrubs and grasses along the lines of infilled ditches.

In the air photo analysis two types of ditch patterns and garden systems were recognised – the reticulated maze which is clearly a type of pond field and the grid-iron which is the relic trace of an island-bed garden type (Fig. 18). The former is the characteristic type throughout the two deltas and traditional *vuci* cultivation is still followed in certain parts of the Rewa delta today. The gardens are prepared by creating a semi-permanent arrangement of interconnected pond fields, separated, and wholly or partly surrounded by banks. The plots are variously crescentic, semi-circular, oval or kidney-shaped and the whole complex presents a maze-like or reticulated appearance in plan view. In the more elaborate systems, it is apparent that the natural drainage has been articulated with the ditches so as to utilise the gentle hydraulic gradient of the levee backslopes, combining drainage with water supply. A slow circulation of water is essential for swamp taro because the plants do not thrive in stagnant ponds.

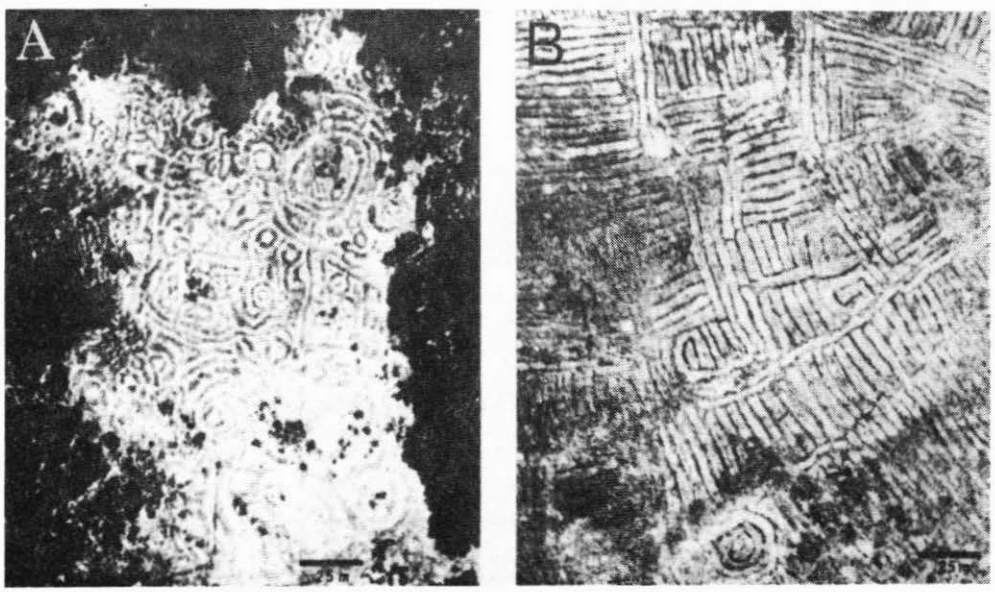

Figure 18: Examples of former garden systems.
Fig. A: Reticulated *vuci* belonging to Nabouciwa village on Sawai island, Rewa. Fiji Landsphoto 66/8 03, enlarged to 1:2,750, June 1966.
B: Grid-iron *vuci* in the Mokani backswamp west of Cautata, Rewa. Fiji Landsphoto 65/42 18, enlarged to 1:2,750, March 1965.

The grid-iron *vuci* with their regular geometric pattern of raised beds have a very limited distribution in the Rewa delta and were not found at Navua. They appear to be restricted to backswamp areas and are clearly a response to high water table conditions. Measurements on the air photos indicate that the rectangular garden plots are between 3.5 and 5 m in width and 20 to 40 m in length. Ditch widths are very uniform at approximately 0.5 m.

The distribution of *vuci* was carefully mapped from the air photos. There is a close correspondence between the distribution pattern and site conditions in the deltas. Almost all the better sites have been utilised and the gardens formerly extended down the levee backslopes and into the backswamp areas. In the Rewa delta, the total area of *vuci* is estimated at 5200 hectares, with 92.5 percent classified as reticulated and

7.5 percent as gridiron. Gardens covered approximately 21 percent of the total area of the delta and a significantly larger percentage of the habitable area. In the Navua delta, the total area of gardens is estimated at 550 hectares which is approximately 12 percent of the total area of the delta.

Ethnohistorical evidence and the form of the *vuci* indicate that the most significant crops were the aquatic aroids. *Via kana (Cyrtosperma chamissonis* (Schott) Merrill) was preferred by the Fijians because its flavour was superior to that of *via mila (Alocasia indica,* Schott) and less effort was required in its preparation as a food (Seemann 1862:303). The significance of *via* as the staple food crop of the Rewa delta in the pre-European period can be judged from the occurrence of the word as a component in several of the place names of the area such as Koronivia, Tumavia, and Natavia and also from the practice of referring to the people of the delta as the *bata via*. With the help of aerial photography it has been possible to determine how extensive the *via* gardens were, and also to demonstrate their significance as a highly specialised and labour intensive agricultural ecosystem.

CONCLUSION

In this study, a particular set of problems in tropical archaeology has been explored and it has been possible to illustrate some of the results that can be obtained using evidence interpreted directly from air photographs or derived from photo measurement. Air photo interpretation allows the researcher to "explore" large areas efficiently and economically. The full range of physical site conditions can be assessed using photo interpretation techniques and specific archaeological details can be obtained using evidence interpreted directly from the air photo or derived using surrogate detail. In the South Pacific, where the traces of material culture are relatively infrequent and the ethnohistorical literature is tantalisingly selective in the topics that are treated, the air photo provides one of the few opportunities for examining relic traces in the landscape at local and regional levels. If we accept the view presented by John Bradford in his *Ancient Landscapes* (1957) that the ultimate aim of archaeology is the overall picture of a human community, its economy and its setting, then clearly the aerial perspective is one of the most effective ways of achieving such a synopsis.

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GLOSSARY

bati – literally borderers but more specifically *bati* settlements were those with obligations to provide warriors in time of war.

cakovaki – a type of tenure in which a servile group colonised and occupied land under the protection of a powerful chief and paid for their occupation with a certain portion of the produce of the land.

kaisi – the most complete condition of servitude with obligations to provide labour for housebuilding, tillage, ditching, and the removal of refuse.

korowaiwai – a ring-ditch fortified settlement.

i tokatoka – a group of closely related families acknowledging the same relative as their head.

matanitu – a powerful political confederation.

mataqali – a group of people claiming descent through the male line from a common ancestor.

vanua – a group of people (settlements) linked by treaty obligations.

via – giant swamp taro (*via kana, via mila*).

vuci – wetland taro gardens with careful control of water circulation through integrated pond fields.

yavu – house mounds.

Pronunciation: The orthography devised by the Wesleyan missionaries in the mid-nineteenth century provides an exact and totally phonetic system for the rendering of Fijian words. Each vowel is pronounced individually. In general, vowels follow the Italian tradition, although they may vary in length and stress. Consonants are the same as in English, with the exception of five letters for which the sounds are unlike those assigned to them in English.
b – 'mb' as in number; c – 'th' as in this; d – 'nd' as in fund; g – 'ng' as in ring; q – 'ngg' as in linger.

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