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To cite this article: Ceri Shipton, Tim Cohen, Matthew Forbes, Fabian Boesl, Zenobia Jacobs, Raymond Dimakarri Dixon, Eleanor Dixon, Susan Kingston, Claudette Albert & Sue O’Connor (2021): Diverse stone artefacts around Lake Woods, Central Northern Territory, Australia, Australian Archaeology, DOI: 10.1080/03122417.2021.1932231

To link to this article: https://doi.org/10.1080/03122417.2021.1932231

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Published online: 29 Jun 2021.

Article views: 315

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Diverse stone artefacts around Lake Woods, Central Northern Territory, Australia

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\textbf{ABSTRACT}

Lake Woods is a large freshwater body on the northern edge of Australia’s arid zone where research since the late 1960s has suggested late Pleistocene, later Holocene, and recent human occupations. We report on surface collections and test excavations undertaken at four sites on the western side of the lake basin in 2019. Each site produced a distinctive lithic assemblage, characterised by different types of shaped and retouched lithics and grindstones. Some material matches the ethnographic descriptions of W. Murgatroyd and R. Paton of local stone tool technology. Our work also confirms the hypothesis of M. Smith that there was later Holocene occupation in the area; and is not inconsistent with the hypothesis of J. Bowler that there was a late Pleistocene occupation around the lake, but definitive evidence of this remains ambiguous. Grindstones occur at all sites, indicating that the harvesting of grass seeds was consistently an important subsistence component for people living by the lake. Distinctive lithic types are found at Lake Woods that are characteristic either of tropical northern Australia or arid southern Australia, suggesting the lake was an inter-regional locus for human activity and a potential zone of interaction between different groups at various times in the past.

\textbf{ARTICLE HISTORY}

Received 26 October 2020
Accepted 17 May 2021

\textbf{KEYWORDS}

Grindstones; horse-hoofs; large scrapers; small notches; points; tulas; Leilira blades

\section*{Introduction}

Lakes Woods has been the subject of archaeological investigation since Jim Bowler found artefacts there in 1967. Some of these lithics were suggested to be of late Pleistocene age based on typology and stratigraphic correlation with luminescence dates (Bowler et al. 1998; Jones and Bowler 1980). This prompted a season of archaeological excavations in 1985 by Mike Smith, who found only later Holocene artefact types (Smith 1986a). Around this time two ethnarchaeological studies on Leilira blade manufacture in the area were carried out by W. Murgatroyd and R. Paton (Murgatroyd 1991; Paton 1994). In this paper we describe renewed archaeological work in the region to document the range of lithic types, describe their potential for occurring in stratified contexts, and, where relevant, to offer preliminary ages for those contexts. We also aim to situate the more distinctive artefact types within the regional geography of Australian stone tools, to determine Lake Woods’ status as an inter-regional node for different groups (Murgatroyd 1991).

Lake Woods is one of northern Australia’s largest fresh-water bodies. Ephemeral in nature, the lake sits on the northern edge of the continent’s arid interior, with the Tanami desert to the southwest and the rocky Davenport Murchison hills to the southeast (Figure 1(a)). North of the lake is the Eucalypt (bloodwood) wooded Sturt Plateau, while the grassy (Mitchell grass) Barkly Tableland lies to the east (Figure 1(a)). Rainfall around Lake Woods averages 500 mm per year with most precipitation falling between November and March (Australian Bureau of Meteorology 27/4/21). The lake is predominantly fed by Newcastle Waters Creek into a basin bounded on its eastern edge by the Ashburton Range of low rocky sandstone hills (maximum height 287 m AHD (Australian Height Datum)). A
productive native grass (*Sorghum plumosum*) grows on and around the lake floor, while sparse Eucalypt (coolabah) woodland dominates across the wider basin. The area is a haven for birdlife, designated an Important Bird and Biodiversity Area by Birdlife International.

Jim Bowler’s paleoenvironmental work at Lake Woods proposed a succession of decreasing lake high stands over the last 200 ka (Bowler et al. 1998). Luminescence dating of the large double dune ridge that forms the western edge of the lake basin extending from site 1. The eastern edge of the basin is formed by the Ashburton Range. Note also the prominent intermediate ridge on the western side of the basin on which site 3 occurs.

Figure 1. (a) Location of ephemeral Lake Woods on the northern edge of Australia’s arid zone. Sentinel-3 scene showing the position of the study site in regards to adjacent biogeographic regions. (b) False-colour Sentinel-2 scene showing the dry lake bed in May 2019. Vegetation in the centre of the lake bed is indicated by red colour. (c) False-colour Landsat-7 scene showing extent of Lake Woods during a high stand in 2001. Sentinel-2 and Sentinel-3 image courtesy of the European Space Agency; Landsat-7 image courtesy of the U.S. Geological Survey. 1 – The Gullies; 2 – Lake Woods 1; 3 – Lake Woods 2; 4 – Lake Woods 3; 5 – Leilira blade quarry. Note the double outer dune ridge that forms the western edge of the lake basin extending from site 1. The eastern edge of the basin is formed by the Ashburton Range. Note also the prominent intermediate ridge on the western side of the basin on which site 3 occurs.
during Marine Isotope Stages (MIS) 7 (\(~180\) ka) and MIS 5 (\(~96\) ka). More recent high stands during MIS 3~53–30 ka and MIS 1 (Holocene) were proposed, but were not ascribed to specific palaeo-shorelines. The presence of stone artefacts suggested human occupation during several of the lake high stands, including a horse-hoof core-scraper that hinted at a Pleistocene occupation (Jones and Bowler 1980). Smith (1986a) then investigated the potential antiquity of human occupation at two localities on the outer dune ridges, near to where they meet the Newcastle Waters Creek floodplain (Figure 1) (Smith 1986a). Stone artefacts were recovered from the upper parts of excavations, but the presence of bifacial points and a tula adze slug implied a later Holocene age.

In 2018–2019 we returned to Lake Woods to explore the archaeological potential of the area further, and, for the first time, to conduct dedicated archaeological, geochronological, and geomorphological investigations at the same locations. Satellite imagery and digital elevation models were used to identify possible palaeo-shorelines and drainage channels (Figure 1). Several archaeological sites were identified in 2018 through vehicle survey with Mudburra and Jingili Custodians for each area. Systematic collection of surface artefacts at four of these sites and test excavations at three (Figure 1(b,c); 1–4) were undertaken in 2019. Here we describe the results of that fieldwork, in terms of the geochronology and sedimentology of the deposits and the typology and technology of the stone artefacts.

**Method**

Ethno-historic literature was reviewed with the aim of determining Aboriginal lifestyle behaviours that could be linked to surface archaeological evidence encountered during the exploratory survey.

A systematic surface collection in the areas of highest artefact density was conducted at four occupation sites to characterise the artefacts and link them to excavated sequences through the same landforms. The positions of surface artefacts and excavations were measured using two Reach RS+ GPS receivers made by Emlid Ltd. The absolute elevation of each site was determined by correcting the observations using the closest GNSS station in Renner Springs. The surface collection strategy was tailored to the circumstances of each site, so will be detailed individually in the site descriptions. However, all surface collections had the goal of covering the range of formal artefact types observed on the particular landforms during the 2018 exploratory survey, while obtaining a representative sample of other artefacts.

Test excavations were dug to understand depositional and chronological context. Test excavations were \(1.2\) m\(^2\) to allow for potential deepening of trenches by a mechanical excavator with a \(1.2\) m wide bucket after archaeological sterility had been reached. Due to the indurated nature of the sediments, hand excavation was conducted with a small mattock as well as a trowel. Excavations were dug by stratigraphic context, and in \(~4\) cm spits for thicker contexts, with all sediment manually broken up and sieved through a \(1.5\) mm\(^2\) mesh. Mechanical excavations were monitored for any deeper artefact-bearing layers, but none was observed.

All sites, once sampled for archaeology, were deepened to investigate their primary stratigraphy, if present. Exposures were stratigraphically logged with samples collected for grain size, elemental and mineralogical analyses. Excavation profiles were also sampled for optically stimulated luminescence (OSL).

We used single grain OSL dating procedures to obtain burial ages for seven samples at Lake Woods (Aitken 1998; Duller 2004; Huntley et al. 1985; Roberts et al. 2015): four from the archaeological excavation at the Gully Mouth, one from Lake Woods 1, and two from Lake Woods 2. Each sample was collected from cleaned profile walls using stainless steel tubes \(62\) mm in diameter and \(150–200\) mm in length. Additional sediment was collected at the same depths for laboratory-based measurements of radioactivity and moisture content. Sand-sized quartz grains (\(180–212\) microns in diameter) were isolated for OSL dating and purified using standard procedures (e.g. Wintle 1997). Equivalent dose (\(D_e\)) values were estimated from 500 individual grains per sample, using the single aliquot regenerative-dose (SAR) procedure (Murray and Wintle 2000), and experimental apparatus and statistical models described elsewhere (Botter-Jensen et al. 2000; Galbraith et al. 1999; Wintle and Murray 2006). Supplementary Table S1 presents the number of individual quartz grains measured, rejected, and accepted for each sample and the rejection criteria used. Environmental dose rates were calculated as the sum of the beta, gamma, and cosmic-ray dose rates. The \(D_e\) divided by the environmental dose rate gives the burial time of the grains in calendar years. Further details about how \(D_e\) and dose rate values were estimated are presented in Table 1, Supplementary Table S1, and Figure S5.

Stone artefacts were classified according to material and class (ochre, grindstone, core, flake, retouched flake, shaped tool). Grindstones and flaked stone artefacts were assigned a type, their
condition noted, and their length, width, and thickness measured where they were not broken. For complete flakes, platform type, scar pattern, and any platform preparation were recorded, while the number of scars were counted, and the platform angle measured using a goniometer. For retouched flakes and shaped tools, the maximum height of the retouch scars and the length of retouch along the perimeter were measured. Total perimeter length of retouched flakes was estimated as twice the length plus the width of the piece (Dogandžić et al. 2015).

**Ethno-historic background**

Nineteenth century documentary evidence from Lake Woods was recorded in the diaries of the explorer John McDouall Stuart and the drover Arthur C Ashwin, as well as by the lay anthropologists Spencer and Gillen. Ashwin describes large numbers of people living near the Ashburton range when he went through the area in 1871 (Ashwin 1927:62): ‘There must have been quite 200 natives, judging by their tracks a quarter of a mile wide, and all making for the Ashburton Range, about one mile distant’. Ashwin also noted how productive the area was (Ashwin 1927:62): ‘The country all along here was splendid for native country, there being abundance of food and game and thousands of mussels in the lake and in all the pools along Newcastle …’ In particular he noted that a large amount of native grass seed was stored (Ashwin 1927:64):

> There was a large mia-mia [hut], about seven feet high, in the middle and about 16 feet diameter. It was round and arched off to the ground. There were large bundles of spears stored there, and large wooden dishes four and five feet long filled with grass seed as large as rice with the husk or skin still on the seed. I think it was a species of rice which grows in the flooded country 40 or 50 miles in extent and north of Newcastle Waters. There must have been about a ton of seed stored there in 17.5 and 133.4... Newcastleton the seed. I think it was a species of rice which grows in the flooded country 40 or 50 miles in extent and north of Newcastle Waters. There must have been about a ton of seed stored there in 17.5 and 133.4.

Table 1. Environmental dose rate, equivalent dose (D$_e$) and overdispersion values and age estimates for all OSL samples.

| Lab code (CABAH) | Site (km) | Depth (cm) | Field moisture (%) | Environmental dose rate (Gy/ka) | Age estimate (ka) |
|------------------|-----------|------------|--------------------|-------------------------------|------------------|
| S00              | LWSQA     | 20         | 0.8                | 0.20 ± 0.01 0.18 ± 0.02 0.60 ± 0.04 | 162 0.81 ± 0.04 nMAD CAM 85 ± 5 1.4 ± 0.1 |
| S01              | LWSQA     | 44         | 0.8                | 0.20 ± 0.03 0.16 ± 0.02 0.58 ± 0.04 | 114 1.60 ± 0.09 nMAD CAM 81 ± 6 2.7 ± 0.2 |
| S02              | LWSQA     | 66         | 1.2                | 0.22 ± 0.02 0.17 ± 0.02 0.61 ± 0.04 | 126 3.06 ± 0.12 nMAD CAM 56 ± 4 5.1 ± 0.4 |
| S03              | LWSQA     | 67         | 3.3                | 0.28 ± 0.02 0.27 ± 0.02 0.76 ± 0.04 | 110 4.51 ± 0.18 nMAD CAM 60 ± 4 5.9 ± 0.4 |
| S04              | LW1       | 27         | 8.5                | 0.50 ± 0.03 0.66 ± 0.03 1.38 ± 0.06 | 211 57.6 ± 2.9 MAX 73 ± 5 41.7 ± 2.8 |
| S05              | LW2       | 4          | 0.3                | – – – – | 100 0.04 ± 0.02 CAMul 243 ± 96 modern |
| S06              | LW2       | 15         | 3.0                | 0.38 ± 0.03 0.34 ± 0.02 0.94 ± 0.05 | 97* 0.44 ± 0.05 FMM-1 (40%) 204 ± 45 0.47 ± 0.06 |

*Laboratory measured field moisture contents. A moisture content of ± 2.5% was used for correction of beta, gamma and cosmic dose rates for all samples.

Gamma dose rates for CABAH-500–502 were based on in situ field gamma spectrometry measurements. A combination of thick source alpha counting and beta counting was used for the rest of the sample. All gamma dose rates were adjusted for the calculated moisture content given in this table using the equations of Nathan and Mauz (2008).

Beta dose rates were measured using a GM-25-S beta counter, the data analysed, and beta dose rates and their uncertainties calculated following procedures described and tested in Jacobs and Roberts (2015). Beta dose rates were adjusted for moisture content (Nathan and Mauz 2008) and grain size (Brennan 2003).

Total dose rates include an assumed internal dose rate of 0.03 ± 0.01 Gy/ka and a cosmic-ray dose rate. The latter was calculated from the equations presented in Prescott and Hutton (1994) using a latitude and longitude of –17.5 and 133.4°, a altitude of 210 m, and sediment depths for each sample with sediment density of 1.60 g/cm³. A 15% systematic uncertainty (at 1σ) was assigned to each cosmic-ray dose rate.

Number of grains accepted after application of rejection criteria and used for D$_e$ determination (see Supplementary Table S1).

Modelled D$_e$ ± (1σ) uncertainty.

The statistical models used in the calculation of the sample D$_e$ values. CAM – central age model of Galbraith et al. (1999); CAMul – an ulogged version of the CAM allowing inclusion of negative D$_e$ values; nMAD is the normalised median absolute deviation (Powell et al. 2002; Rousseeuw et al. 1984) used to identify and reject statistical outliers. Grains were rejected if nMAD was >1.5, using 1.4826 as the correction factor for a normal distribution; MAM – minimum age model of Galbraith et al. (1999); MAX – maximum age model of Olley et al. (1999). An overdispersion (OD) value of 20% was assumed for the MAM and MAX models. FMM – finite mixture model of Roberts et al. (2000); the percentage in brackets indicates the proportion of grains with D$_e$ values consistent with that component.

OD value (%), where OD refers to the amount of spread within the sample once all known sources of measurement uncertainty have been taken into account. This is prior to outlier rejection using nMAD.

OSL age ± (1σ) total random and systematic uncertainty. Total uncertainty calculated as the quadratic sum of all random and systematic uncertainties associated with D$_e$ and dose rate measurements.

After removal of 30 grains consistent with D$_e$ values of 0 Gy (at 2σ).
The seeds were ground into flour to make damper loaves. A spring on the banks of Powell Creek, the main southern tributary of Lake Woods, was described by Gillen (1968:165) as being of ‘almost tropical luxuriance’ in the late dry season, at which time grass seed was still abundant there.

The focus of both Murgatroyd’s (1991) and Paton’s (1994) ethnographic studies was the manufacture, exchange, and use of Leilira stone blades by Mudburra and Jingili men (note that they used some of the same informants). Murgatroyd recorded seven silcrete Leilira blade quarries on the Ashburton Range, one of which we also came across (Figure 1). Rights to work the stone at such quarries were restricted to the maternal uncle of the quarry owner and those who did not seek the correct permissions before accessing the resource would be punished. The stone at these quarries was held to be potent because of its bright shiny quality (Figure 3) and the quarries were associated with a body of Dreaming stories called the *puwarraja*.

Blades from different quarries had the power to cure different illnesses, so care was taken to keep them separate because they were often not visually distinguishable (Paton 1994). Other functions of the hafted blades included the creation of cicatrices during transitions in social status, ‘sorry cuts’ during mourning, and to use in fights to settle personal disputes (Murgatroyd 1991).

The blades were used as gifts for married men to present to their in-laws and they were traded locally between individuals and groups (Murgatroyd 1991). More formal inter-regional exchange (*winan*) of Leilira blades took place at four sites after the end

*Figure 2. Scarred Eucalypt trees from The Gullies site.*
of the wet season, at locations that had permanent water sources, but also high ground to escape flooding (Murgatroyd 1991). During the wet season itself 'much of the region is either flooded or so waterlogged that the movement of people is severely restricted' (Murgatroyd 1991:39). The large ceremonial exchanges involved many groups including other Mudburra from the northwest, other Jingili and Alawa from the north, Wambaya and Ngandji from the east, and Warlmanpa and Warumungu from the south (Murgatroyd 1991). During such exchanges, long-distance social ties would be formed and maintained with exchange of information about resource ownership and Dreaming stories. Blades were exchanged for a range of items including other Leilira blades, hair belts, boomerangs, digging sticks, small flake spear points, ground stone axes, and bamboo spears; the latter three items were not produced locally (Murgatroyd 1991; Paton 1994). Blades were carefully curated and were not observed by Paton to have been discarded whole at occupation sites, though deliberately broken and reworked fragments were found. We also observed a patinated broken and retouched Leilira blade fragment at The Gullies site.

**Lake Woods 3 (Longshore Spit)**

The most proximal site to the modern lake is Lake Woods 3, a coastal spit rising ~1.5 m above the lake floor and running for several kilometres along the south-western edge of the lake (Figure 1 location 4, and Supplementary Figures S1 and S2). At a point where the dune curved from a north-south to an east-west spit we undertook a surface collection of artefacts through walking a 10 m wide transect up and down over a 400 m length of the dune (Figure 4). Due to the loose nature of the surface sand, smaller artefacts are more easily covered and were less visible to our collection. Artefact locations were
recorded using a differential GPS and plotted on a georeferenced aerial photograph of the site. A beautiful retouched Leilira blade on yellow silcrete was among the artefacts recovered during the surface collection (Figure 5), providing a connection to the ethnographically documented technology of the area. The yellow silcrete, while distinct from the white material in the quarry we visited (Figure 3), was observed elsewhere at the base of the Ashburton Range ($S17^\circ38.984', E133^\circ33.528'$). Two other artefacts found on the dune were made of this material, a partially patinated bifacial point, and a fully patinated Pirri point (Figure 5). This range of patinations suggests the incorporation of older artefacts in this landform. Of the 11 other silcrete artefacts, one is a discoidal core with a double patina suggesting reuse of older artefacts, while the remainder are unpatinated suggesting the bulk of the assemblage is from the most recent occupation, contemporary with the Leilira blade.

Lake Woods 3 was the only location where a groundstone axe was identified (Figure 6), with no axe rejuvenation flakes from any site. The axe was made on quartzitic sandstone, flakes of which material were not seen at any other site, which accords with the ethnographic evidence that axes were not produced locally but acquired from the north in exchange for Leilira blades (Paton 1994). Earlier in the day on which we found the axe, local Custodian Claudette Albert had been describing how her grandfather had a stone axe with it hafted between two crossed sticks, attesting to their recent use. Other noteworthy artefacts from Lake Woods 3 were a tula slug and a large proximally retouched convex scraper, both made on chalcedony (Figure 6).

Of the 32 surface artefacts found at Lake Woods 3, 10 were grindstones. This assemblage was distinctive in the bevelling on seven of the pieces, including both the bottom stones and mullers (Figure 7). Functions of the grindstones are indicated by one of the pieces which had ochre staining on part of one surface and a grass seed adhering to it.

The gullies
The original work of both Bowler and Smith took place in the north of the area, where the outer arcuate lunette dunes meet the Newcastle Waters Creek floodplain (location 1 in Figure 1). At this point, two erosional gullies cut through the valley between the dunes and run down to Newcastle Waters Creek (Figure 8). Two localities, LW1 and LW2, excavated by Smith (1986a), are shown on Figure 8. LW2 produced only three artefacts, but LW1, closer to the Newcastle Waters Creek floodplain, yielded an assemblage of 163 artefacts from a 9 m$^2$ trench; including grindstones, bifacial points, and a tula slug. The artefacts all occurred in the upper metre of deposit and were assessed to be in situ, but within an unstratified sedimentary unit.
Our study focused on the mouth of the larger of the gullies where a high density of artefacts was visible on the surface (Figure 8). Here the surface unit was a buff-coloured silty sand that appeared to be actively eroding, with some very small artefacts on it. We conducted a systematic collection of artefacts on this surface, within seven 1.5 m squares (Supplementary Figure S3). The squares were placed to capture fresh artefacts recently eroded out of the buff sediment proximal to trees and to gain a representative sample of diagnostic artefact types like points. Two sets of conjoins attest to the recent

Figure 5. Three yellow silcrete artefacts from Lake Woods 3. (A) is a Leilira blade with retouch around the entire perimeter save the platform. (B) is a bifacial point with a broken tip. Notably the patination is more developed on the ventral surface (right) suggesting it had been lying with this face up for a long time. (C) is a fully patinated Pirri point with minor damage to the tip showing the original yellow colour of the material. Scale bars are 1 cm long.

Figure 6. Unique artefacts from Lake Woods 3. (A) is a bifacial groundstone axe made on quartzitic sandstone. (B) is a large proximally retouched convex chalcedony scraper (the downward end is the proximal part of the flake on which it was made, while the opposing distal hinge termination is unretouched). (C) is a chalcedony tula slug. Scale bars are 1 cm long.
exposure of these artefacts (Supplementary Figure S4). Artefacts continued to occur in high density patches along the eroding edge of the buff-coloured unit several hundred metres north to LW1.

The test excavation was located on the tabular gully fill deposit to the west of the eroding surface (Supplementary Figure S3). This unit, as described by Bowler et al. (1998), most probably onlaps older sediments within the gully complex. The excavation was terminated at a depth of \( \sim 90 \) cm due to reduced artefact numbers and the extremely indurated nature of the sediment. A sondage in one corner increased the depth to 110 cm, with no artefacts recovered. Three principal stratigraphic units were delineated in the excavation (Figure 9): A well-sorted brown very fine sand in the top 13 cm; underlain by a yellow buff very fine sand down to \( \sim 78 \) cm; underlain by a homogenous mix of very fine sand and silt down to the base of the excavation.

No artefacts were identified in the upper 8 cm of deposit, but there were several at the contact of the brown and yellow buff sands (Figure 9). This suggests this may have been a stable surface on which artefacts accumulated. Artefacts continued throughout the yellow buff sand with a particularly high density between 50 and 70 cm (Figure 9). Some artefacts occurred in the upper part of the lower siltier sands (Figure 9). Three grindstones from Lake Woods 3. (A) is a small bevelled piece. (B) is a bevelled muller with pecking on the right end. (C) is a bevelled bottom stone with pecking to rejuvenate the surface (left), ochre staining and a grass seed (cf. S. Plumosum) adhering (right). Scale bars are 1 cm long.
unit, but as these tended to be heavier artefacts like cores, grindstones, and haematite, we interpret them as having moved down from the deposit above, post-depositionally.

The excavated sediments are equivalent to what Bowler et al. (1998) described as the lowermost gully infill. The archaeological excavation, along with outcrops occurring within the gully, all lack bedding and show signs of both pedogenesis and bioturbation. Four OSL samples were collected from depths of 20, 44, 66, and 87 cm, with 22 – 29% of measured grains accepted and their broader than expected distribution of single-grain $D_e$ values suggesting post-depositional disturbance (Table 1 and Supplementary Table S1). About 14% of accepted grains from the uppermost sample (CABAH 500) at 22 cm depth had $D_e$ values consistent with zero at 2σ (i.e. ‘modern’ grains). Samples at greater depths contain little to no modern grains, but the spread (overdispersion, OD) of $D_e$ values within each sample are still larger than what would be expected of samples that have not been disturbed (85–60% OD, Table 1, Supplementary Figure S5). Using the nMAD central age model (CAM) we estimate the uppermost sample, which shows the most mixing, was deposited ~1,400 years ago. Weighted mean ages using the nMAD CAM of the other three samples are $2.8 \pm 0.2$ (44 cm), $5.1 \pm 0.4$ (66 cm), and

Figure 8. The Gullies. Top – the localities where Mike Smith excavated, LW1, and LW2, and the Gully Mouth excavation site for this study. The Newcastle Waters Creek and (submerged) floodplain are located to the right. Satellite image courtesy of Esri: Digitalglobe Esri Community Maps Contributors, Esri, HERE, Garmin, METI/NASA, USGS, created using ArcGIS® software by Esri. ArcGIS® is the intellectual property of Esri and is used here under licence. Copyright © Esri. Note image taken during flood event in January 2015 with the water coming right up to the Gully Mouth. Note the low-density woodland covering much of the landscape. Bottom – the Gully Mouth during 2019 showing the yellow buff surface from which artefacts were eroding in the foreground, the redder sands of the gully bed washing material off the dune at back right and the excavation on the edge of the gully at back left.
6.0 ± 0.4 (87 cm) ka, and increase in age with depth (Table 1). The compromised stratigraphic integrity of the sediment profile prevents precise age estimates for the associated archaeology, but the OSL results do suggest that artefacts were deposited sometime during the latter half of the Holocene.

Our interpretations of the Gully Mouth locality are in agreement with those of Smith (1986a). Artefact discard was contemporaneous with the deposition of the yellow buff unit, with artefacts on the surface having recently eroded out of this same deposit. Diagnostic later Holocene point types (Figure 10), in particular bifacial Northern Territory Triangular points (Akerman and Bindon 1995), as well as tulas, occurred on the surface. While we did not find any such classic types in the excavation, we did recover 12 flakes with bending initiations – indicative of fine bifacial retouch; and two tula-like artefacts (Figure 11). A single example of a unifacial foliate point was observed at the site (outside of the surface collection) (Figure 12). Notably it was made on a dark brown banded chert of which we recovered no other artefacts, suggesting it was an exotic import. Of the seven grindstone fragments from the site (including one from the excavation), most could be described as amorphous with none being bevelled, but there was a dished piece (Supplementary Figure S6).

**Lake Woods 1**

Lake Woods 1 is located on a promontory of a low semi-continuous ridge of sand, running north-south across the basin to the west of the modern lake (Figures 1(b,c) and 13). Artefacts were observed eroding out of this ridge at a point where the slope rises gently. The test excavation was situated immediately above this point. The excavation reached a maximum depth of ~30 cm where it was stopped as deposits became culturally sterile and the sediment was extremely indurated. Two 2 m-wide and 20 m long transect collections were conducted next to the excavation, to capture artefacts along the same level of the slope as the excavation and running up and down the slope beside the excavation (Figure 14). Artefacts continued beyond the western limits of the transects, but at much lower density.

The surface collection showed artefacts, including larger cores and grindstones than found in the excavation, were concentrated at the level of the excavation and below, but scarce above it (Figure 14). No artefacts were observed higher up the slope than that depicted on the left of Figure 14, while artefact density decreased further downslope. These observations confirm that the artefacts are generally derived from around the level of the excavation.

The test excavation revealed three principal layers: a yellowish brown medium sand in the top 10 cm; a finer yellowish silt to 25 cm; and a coarser sand deposit below that (Figure 15). Artefacts seemed to be concentrated at the transition between the two uppermost units. Three artefacts were recovered from a ~5 cm diameter burrow into the clay (Figure 15). The majority of artefacts were in fresh (unrounded) condition, but six of the excavated artefacts appeared to have been water rounded, suggesting a lake margin as a possible depositional setting.

The excavation at LW1 was extended to a depth of 1 m, but lacked further stratigraphy, showing ped development and root penetration to ~0.5 m. An OSL sample collected from 27 cm depth (CABAH 504, Table 1), well below the lowest artefacts, had 42% of measured grains accepted but these had a large spread in \( D_e \) values (OD = 75%) indicative of extensive bioturbation. About 60% of the accepted grains are consistent with a Pleistocene age (>20 ka), and we have therefore calculated a
maximum age (MAX model, Table 1) of 42 ± 3 ka for this yellow silt unit (Table 1 and Supplementary Figure S5). Given that the bulk of the artefacts occur within the brown medium sand in the top 10 cm, or in a burrow to 15 cm depth, we assume that this cultural layer is of Holocene age and rests on a late Pleistocene deposit whose depositional origin has been obscured by pedogenesis.

No diagnostic artefact types were observed, but the site was distinctive from the Gully Mouth in having a high proportion of notches from both the surface collection and excavation: 17% of the 64 lithics (Figure 16). In addition, there was a distinctive grindstone fragment from the site, which has been bifacially flaked and then pecked to give it a regular circular edge (Figure 16).

**Lake Woods 2**

Lake Woods 2 sits on a north-south oriented sand ridge to the west of the lake (Figure 1(a,b)). This ridge is more distal to the lake than that on which Lake Woods 1 sits and is more continuous across the basin, occurring on the boundary that separates the buff sand to the east from the red sands to the west (Figures 1 and 13). The site consists of a chert gravel surface behind which the red sand ridge rises. The excavation was placed on the edge of the ridge just before it drops to the gravel surface. For the surface collection we used two 2 m-wide transects, one running 95 m along the gravel at the base of the ridge immediately in front of the excavation, and one running 65 m perpendicular to the ridge across the gravel surface (Figure 17). Artefacts continued beyond the eastern, northern, and southern limits of the transects, but at much lower densities.

The excavation reached a depth of 30 cm where culturally sterile and extremely indurated sediments occurred, but the trench was deepened with a mechanical excavator to a total depth of 55 cm (Figure 18). Four principal layers were identified. The uppermost ∼5 cm was a fine sand with a ∼1 cm
Figure 11. A classic tula slug from the surface collection at Lake Woods Gully Mouth (A), and two tula-like artefacts from the excavation (B and C). (B) is from spit 17 (~63 cm) and (C) is from spit 16 (~60 cm). While (B and C) do not have the classic tula convex edge shape or overhang removal, they both have cortical platforms and continuous steep retouch along the broad distal end. (B) has the characteristic prominent bulb of a tula, but C does not. Scale bars are 1 cm long.

Figure 12. Two points from the Gully Mouth (not part of the surface collection). (A) is a Northern Triangular Point on Chalcedony. (B) is a unifacial foliate point made on a dark brown chert which we did not find used in any other artefacts. Scale is in cm.
Figure 13. The locations of Lake Woods 1 and 2 in relation to the north-south running ridges of sand. The modern shoreline of the lake can be seen in white in the bottom right while the sand ridges may represent palaeo-shorelines. Note that Lake Woods 1 is more proximal to the lake. Image courtesy of Planet Labs, Inc.

Figure 14. Lake Woods 1 surface collection. The photograph at the top shows the across slope transect with the camera looking downslope and the excavation on the bottom right. The plan at the bottom shows where the artefacts occurred along the two transects and their relationship to the excavation. Note the low density of Eucalypt trees in the background.
thick crust of sandy silt on the surface. This was underlain by a fine sand with gravel containing artefacts down to a depth of ~17 cm. Below this was a layer of fine sand and coarse silts with a few artefacts to ~26 cm, and below that were culturally sterile fine sand and coarse silts extending to the base of the excavation. As with Lake Woods 1, two of the excavated artefacts from Lake Woods 2 were sub-rounded, possibly suggesting a lake margin depositional setting. The OSL sample collected at 4 cm depth (CABAH 505) had 44% of measured grains accepted but yielded a modern age (Table 1). The sample from 15 cm depth (CABAH 506, 22% of grains measured were accepted – Supplementary Table S1) also had a large proportion (25%) of modern grains probably intrusive from above. After excluding the modern grains, the De distribution could be fitted to the remaining 97 grains with four almost discrete De components (Table 1, Supplementary Figure S5); 78% of the grains made up the two lowermost De components that gave weighted mean ages of 0.47 ± 0.06 ka and 2.1 ± 0.3 ka (Table 1). The component centred on 0.47 ka (FMM-1) forms a continuum with the zero dose grains, so ~55% of the total number of accepted grains gave ages consistent within the range 0–590 years at 2σ. About 30% of grains have ages consistent with ~2 ka (FMM-2) and the rest of the grains (~15%) with ages >9 ka. Our interpretation is that the artefact-bearing fine sand unit to 17 cm depth was deposited sometime ~2 ka ago during the late Holocene and subsequently bioturbated, resulting in the incorporation of both older grains from the underlying units and modern or very recent aged grains from the overlying unit. As there were also low numbers of artefacts in the unit below this,
it is possible there was an earlier phase of occupation at the site. Over half (57%, \(N=103\)) of the artefacts from Lake Woods 2 were chert. However, these were generally larger (mean length = 26.1 mm) than the small rounded pieces of chert gravel (>20 mm) with which they were associated, both in the excavation and on the surface. This suggests chert was not procured for flaking on site, but was introduced along with the silcrete and other materials. The chert gravel indicates this material occurs naturally in the Lake Woods basin and indeed we found a quarried source of chert in the northwest (S17°32.329′, E133°17.921′).

Retouched flakes were abundant at Lake Woods 2 (19% of 98 flaked artefacts), and typically large (mean length = 37.42 mm) (Figure 19). A distinctive artefact from the site was a horse-hoof core-tool with battering wear all around the main platform edge and a rounded sheen on two of the flat surfaces (Figure 20). A small complete grindstone was recovered from the site, its main surface measuring 103 × 91 mm, alongside a larger broken grindstone conjoined from six pieces and measuring 187 × 168 mm (Supplementary Figure S7).

Artefact comparison

In this section we statistically compare lithics from the different localities to assess their distinctiveness. We use non-parametric tests where sample sizes are small or non-normally distributed, and parametric tests where not. Excavated and surface assemblages are grouped together for each site to increase sample size (Table 2). Table 2 shows the proportion of different lithic materials and classes at the four sites. Lake Woods 1 and 2 are dominated by chert with a chi-square test showing no significant difference in the proportion of different materials (\(\chi^2 = 0.03, p = 0.862\)). Chalcedony was combined with chert for this test, and sandstone, quartzite, and haematite were not included as they relate to grindstones and pigment. Likewise, both Lake Woods 1 and 2 have a similarly high proportion of retouched flakes (\(\chi^2 = 0.18, p = 0.671\)), consistent with high mobility (e.g. Centi and Zaidner 2020; Clark and Barton 2017).

Notches were common at both Lake Woods 1 and 2, comprising 17% (\(N=64\)) and 12% (\(N=98\)) of non-grindstone artefacts respectively (Figures 16 and 19), whereas only a single notch was recovered at the Gully Mouth. There was no significant difference in notch widths (Mann-Whitney \(U=102, N=34, p=0.167\)) between Lake Woods 1 (median = 6.69 mm) and Lake Woods 2 (median = 9.3 mm), suggesting similarity in functions.
Retouched flakes were significantly longer (Mann-Whitney $U = 36, N = 30, p = 0.002$) at Lake Woods 2 (median = 33.85 mm) than at Lake Woods 1 (median = 24.3 mm). However, a $t$-test showed no significant difference ($t = 0.36, N = 99, p = 0.971$) in unretouched flake length between the sites (mean = 21.15) (mean = 21.23). To explore the possibility that this pattern is being driven by greater reduction intensity at Lake Woods 1, we calculated the Geometric Index of Unifacial Reduction (Kuhn 1990) by dividing retouch height by flake thickness for unifacially retouched pieces. There was no significant difference in this variable (Mann-Whitney $U = 66, N = 26, p = 0.597$), nor in the proportion of the perimeter that was retouched (Mann-Whitney $U = 78, N = 28, p = 0.735$) between the two sites, indicating there are no systematic differences in reduction intensity. These results suggest the preferential creation of large retouched flakes at Lake Woods 2. In conjunction with the horse-hoof core-tool from the site, this indicates the use of lithics in heavy duty work.

Unlike Lake Woods 1 and 2, the Gully Mouth is dominated by silcrete ($\chi = 7.55, p = 0.006$, Lake Woods 1 versus Gully Mouth), and the site shares this emphasis on silcrete with Lake Woods 3 ($\chi = 0.492, p = 0.483$, chert and chalcedony were combined, and sandstone was not included in this test). The differences in materials between Lake Woods 1 and 2 versus the Gully Mouth and Lake Woods 3 may be due to their proximity to particular outcrops, or it may reflect preference for particular materials, with bright coloured silcrete known as a potent and valuable material in recent times (Murgatroyd 1991).

Six points occurred on the surface at the Gully Mouth (Figure 10), five of which were bifacial, linked to the excavated material by frequent bending initiations on the flakes. Bifacial working results in low platform angles on lithics, so we used a one-way ANOVA to compare platform angle between the Gully Mouth and Lake Woods 1 and 2 lithics. The results indicate significant heterogeneity ($F = 5.228, N = 196, p = 0.006$), with post-hoc LSD tests indicating the Gully Mouth had significantly lower platform angles (mean = 61°) than the other two sites (mean = 68°, $p = 0.005$; and mean = 69°, $p = 0.009$; for Lake Woods 1 and 2 respectively), which were not significantly different from each other ($p = 0.638$). The fine working on the Gully Mouth points requires careful platform preparation and a chi-squared test showed there was significantly more platform preparation on flakes with intact platforms from the Gully Mouth (34%, $N = 119$) than at Lake Woods 1 (20%, $N = 46$) and Lake Woods 2 (16%, $N = 73$) ($\chi = 12.471, N = 259, p = 0.002$). Small flakes are produced by the fine retouch of small shaped tools like points and tulas, with five of the latter recovered from the Gully Mouth. There was significant variation in

Figure 19. A selection of large retouched artefacts from Lake Woods 2. Dots denote parts of the ventral perimeter where flakes have been removed on the dorsal. Arrows denote notch widths. (A) is a silcrete double side scraper. (B) is a chert notch and scraper. (C) is a chert scraper. (D) is a silcrete scraper. Scale bars are 1 cm long.
unretouched flake length between the Gully Mouth and Lake Woods 1 and 2 (one-way ANOVA $F = 3.617, N = 148, p = 0.029$). Post-hoc LSD tests indicated significantly shorter flakes for the Gully Mouth (mean $= 12.57$ mm) than the other two sites ($p = 0.048$ and $p = 0.014$, for Lake Woods 1 and 2 respectively), which were not significantly different from each other ($p = 0.853$).

**Discussion**

The Lake Woods 1, 2, and 3 sites are each associated with different lake margin landforms (Figures 1 and 14). Given the differences in lithics between the three sites, a parsimonious explanation is that they represent three different periods of occupation (Table 3). Lake Woods 3 is the only one of the three sites where Leilira blades and ground axes were represented, and the only one with bevelled grindstones. Lake Woods 1 was distinguished by numerous small notched pieces and a distinctive carefully shaped circular-edged grindstone. And

**Table 2.** The breakdown of lithics according to collection method, material, and class, by site. Other includes flaked pieces, heat pops, and manuports.

| Collection | Lake Woods 3 | Gully Mouth | Lake Woods 1 | Lake Woods 2 |
|------------|--------------|-------------|--------------|--------------|
| Surface    | 33 (100%)    | 81 (41%)    | 46 (67%)    | 87 (84%)    |
|-excavation | 0            | 116 (59%)  | 23 (33%) | 16 (16%)    |
| Material   |              |             |              |              |
| Silcrete   | 14 (43%)     | 114 (58%)   | 28 (41%)    | 40 (39%)    |
| Chert      | 4 (12%)      | 66 (34%)    | 35 (51%)    | 59 (57%)    |
| Chalcedony | 2 (6%)       | 2 (1%)      | 3 (4%)      | 1 (1%)      |
| Sandstone  | 10 (30%)     | 1 (<1%)     | 0           | 0           |
| Quartzite  | 3 (9%)       | 6 (3%)      | 2 (3%)      | 3 (3%)      |
| Haematite  | 0            | 8 (4%)      | 1 (1%)      | 0           |
| Class      |              |             |              |              |
| Core       | 3 (9%)       | 4 (2%)      | 4 (6%)      | 2 (2%)      |
| Flake      | 9 (27%)      | 154 (78%)   | 47 (68%)    | 74 (72%)    |
| Retouched  | 10 (30%)     | 17 (9%)     | 11 (16%)    | 19 (18%)    |
| Grindstones| 11 (34%)     | 7 (3%)      | 3 (4%)      | 4 (4%)      |
| Other      | 0            | 15 (8%)     | 4 (6%)      | 4 (4%)      |
| Total      | 33 (100%)    | 197 (100%)  | 69 (100%)   | 103 (100%)  |

**Figure 20.** Horse-hoof core-tool from Lake Woods 2. Above left is a side of the tool that was previously utilised developing a sheen on its main surface that has since been truncated by scars struck from the later main surface shown in the above centre image. Above centre is the main polished surface of the tool with a battered edge around the entire perimeter, and incipient ring cracks where failed flake removals could not rejuvenate the edge, probably leading to the tool’s abandonment. Above right is the opposite side of the tool from above left, note that it does not display the same sheen as the other two surfaces. Scale bar for the above images is 1 cm long. Below right is a close-up of the rounded polished surface of the above centre. Below left is a close-up of the unused surface of above left.
Lake Woods 2 was characterised by large retouched flakes and a horse-hoof core-tool.

Lake Woods 3, the site closest to the modern lake, must represent the most recent occupation as the Leilira blade and axe found there are artefact types that were made and used in the area in living memory. At Puritjarra rockshelter some 600 km south-southwest of Lake Woods in the central desert, the distinctive bevelled grindstones are also found in the most recent phase of occupation dating to the last 800 years (Smith 2004).

The Gully Mouth site is not associated with a lake margin landform, instead occurring on the edge of the Newcastle Waters Creek floodplain. Our OSL age estimates indicate occupation at the site spans ~5–1 ka. Tulas are frequent at the Gully Mouth, as would be expected for a later Holocene site in arid Australia (Hiscock 2007; McNiven 1993).

At Puritjarra, for example such artefacts occur from ~3500 years ago (Hiscock and Veth 1991; Smith 2006). The non-classic tulas from the Gully Mouth excavation occur at the same level as the OSL sample at 66 cm depth (5.1 ± 0.4 ka), which is older than the appearance of classic tulas across Australia from ~3700 years ago (Veth et al. 2011). However, the single-grain OSL data from the Gully Mouth show evidence for post-depositional mixing, so the age estimates are not necessarily reflecting the age of the artefacts which may also date from within the last 3700 years.

The Gully Mouth yielded several points including some particularly finely made Northern Territory Triangular pieces, with plano-convex profiles (i.e. one flat and one domed surface) (Figure 10). These point types were not in use in historical times (Akerman and Bindon 1995). Neither Lake Woods 1 nor 2 produced the bending initiations associated with fine bifacial point working in their flake assemblages, but a single large Northern Territory Triangular point was found some 80 m to the west of Lake Woods 2 (Supplementary Figure S8). The depositional age of 2.1 ± 0.3 ka for Lake Woods 2 suggests contemporaneous sediment deposition with the upper Gully Mouth occupation between 44–22 cm depth, but the artefacts are strikingly different. Occasional double patinas on Lake Woods 2 artefacts (Figure 21) suggest the site was reused after the main occupation, perhaps because the large artefacts that characterise the site were themselves a source of material. The re-flaking on two double patina chert artefacts shows that the patination extends ~2 mm into the body of the flake (Figure 21), a thickness that would be considered extreme even for terminal Pleistocene chert artefacts (Frederick et al. 1994). We think the site was probably reused ~2 ka, resulting in the double patination artefacts and the single example of a Northern Territory Triangular point nearby, and that this secondary occupation is what the OSL sample from 15 cm is dating, rather than the main occupation and formation of the ridge itself.

There are two possible scenarios for the occupation of Lake Woods 1 and 2. Mid-late Holocene assemblages that occur within the modern maximum filling range is the first scenario. Occupation would have taken place in the wet season, or in the early part of the dry season, when the lake had flood water in it. These assemblages would then most likely match the mid-late Holocene hydrological maxima. In the second scenario, the sites (Lake Woods 2 at least) may actually be on Pleistocene landforms and represent Pleistocene occupations during wetter periods when a lake shore would still have been present at these locations in the peak of the dry season. The Pleistocene record would then have been disturbed through pedogenesis and/or reoccupation of the site. In the case of Lake Woods 2, the double patina on some artefacts indicates both scenarios could be true.

High artefact densities at Lake Woods 1 and 2, 1.725 and 0.32 artefacts per m² in the surface collections respectively, suggest long-term occupations. For comparison, these densities are in the range of the Willandra Lakes sites in south-eastern Australia: 0.03–3.4 artefacts per m², where there is a combined mean of 0.34 (Allen 1998). Geomorphological evidence from the Willandra Lakes indicates the lake margin lunettes were most heavily occupied when lake levels fluctuated, rather than when they were consistently high or low (Fitzsimmons et al. 2014; Stern et al. 2013), suggesting lake margins were seasonally attractive when the surrounding landscape was dry. A similar model may apply to Lake Woods as during flooding the land next to the lake becomes

| Table 3. Elevation (metres above Australian Height Datum), age, and distinctive artefact types of the four sites around Lake Woods. |
|---------------------------------------------------------------|
| Gully Mouth | Lake Woods 3 | Lake Woods 1 | Lake Woods 2 |
| Elevation (m) | 205.4 ± 0.3 | 199.6 ± 0.2 | 201.3 ± 0.65 | 202.3 ± 0.1 |
| Occupation age (ka) | 5.1 ± 0.4–1.4 ± 0.1 | Recent | 4.1 ± 0.2 | 2.1 ± 0.3 and >9 ka? |
| Grindstones | Dished | Bevelled | Bifacial | Amphorous |
| Tulas | Yes | Yes | – | – |
| Other shaped tools | Bifacial points | Ground axe & large proximal scraper | – | Horse-hoof core-tool |
| Retouched flakes | Rate | Leilira blade | Small notches | Large scrapers |

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swampy and inhospitable, but in the dry season the lake and feeding creeks retain water and subsistence resource abundance.

While there are no late Holocene analogues to the main Lake Woods 2 assemblage, there are older assemblages with similarities. The terminal Pleistocene and initial Holocene at Puritjarra is characterised by a large retouched flake assemblage (Smith 2006), as well as a moist environment (Smith 2009). At Willandra Lakes a similar industry of large scrapers and horse-hoof core-tools dates to MIS 3 (Bowler et al. 1970, 2003). MIS3 human occupation around a large palaeolake has been proposed for Lake Gregory in the Great Sandy Desert (Veth et al. 2009), ~700 km west-southwest of Lake Woods. A smaller increase in monsoonal strength and lake formation has also been suggested for the terminal Pleistocene around 14 ka at Lake Gregory (Fitzsimmons et al. 2012; Wyrwoll and Miller 2001).

Lake Woods currently sits at the transition between the arid interior and the wet north of Australia (Hesse et al. 2004), with northern and southern shifts in the Australian summer monsoon over at least the last 30,000 years probably having made the region both wetter and drier than it is at present (Reeves et al. 2013). In keeping with this liminal position, there appear to be both northern and southern cultural connections during the human occupation of Lake Woods. Large scrapers and the horse-hoof core-tool represented at Lake Woods 2 are known from Pleistocene sites to the south (Bowler et al. 1970; Smith 2006). The Northern Territory Triangular points from the Gully Mouth are characteristic of the later Holocene of sites in the tropical north (Akerman and Bindon 1995; Smith and Cundy 1985), while the site also contains many tulas which characterise arid Australia (Veth et al. 2011). A single unifacial leaf-shaped point from the Gully Mouth (Figure 12), as well as a single patinated Pirri point from Lake Woods 3 (Figure 5(C)), suggest sporadic links to southern Australia (Campbell 1960; Hiscock 1994;
Mulvaney and Kamminga 1999) in the later Holocene. Tulas were found at the site of Parnkupiti on the edge of Lake Gregory (Veth et al. 2009), but none of the other distinctive types seen at the Gully Mouth was observed, suggesting the unique position of Lake Woods as a magnet for diverse human groups. The most recent phase of occupation includes Leilira blades, which are common in the north and the arid interior of Australia (Hook 2009; Tibbett 2006); a ground stone axe, an artefact type that seems to have spread from the north of Australia in the last two thousand years (Morwood and Hobbs 1995); and bevelled grindstones which are characteristic of arid interior occupation in the last one thousand years (Smith 2004).

Lake Woods may be characterised as an amplifier lake: a lake occupying a shallow basin that fluctuates dramatically in area depending on precipitation, although it does not have a tectonically formed graben morphology like the amplifier lakes in east Africa as originally defined (Street 1980). The diversity of tool types found around Lake Woods is consistent with the amplifier lakes in east Africa, which have been suggested to promote diversity in mobile groups as they are most attractive to habitation during prolonged high-stands when they also form effective barriers (Trauth et al. 2010). The Mudburra and Jingulu languages spoken around Lake Woods are interesting in this regard, because though structurally very different (Mudburra is Pama-Nyungan while Jingulu is not), they have a large proportion of shared lexicon in the region, such that there are dialects referred to as Kuwarrangu in both languages (Black 2007).

Of the 402 stone artefacts recovered from Lake Woods, 6.2% (25) were grindstones. This proportion is comparable to the site of Wanmara in the Central Desert where seed processing grindstones were exceptionally common, and is an order of magnitude more than most other Australian sites where grindstones occur (Gorecki et al. 1997). Grindstones were represented at each of the four sites, with the S. plumosum grass that grows around the lake probably having been an important aspect of local subsistence. This is in line with evidence from Madjedebebe that seed grinding was practised throughout Australian prehistory (Clarkson et al. 2017). Most of the Lake Woods grindstones were broken, but a complete one from Lake Woods 2 was only 10 cm long, with experimental grinding indicating such small pieces can be used for processing seeds (Mildwaters and Clarkson 2018). The frequent and more formal bevelled grindstones from Lake Woods 3 are consistent with the widespread intensification of seed grinding in the interior of Australia in the recent past (Smith 1986b, 2014) and the ethnohistoric evidence for the large-scale harvesting and storage of these seeds (Ashwin 1927).

Renewed investigation at Lake Woods did not obtain Pleistocene ages for human occupation at any of the sites, however we agree with Jones and Bowler (1980) that given the distinctive stone artefact technology and the presence of Pleistocene landforms bounding the lake (Bowler et al. 1998), we cannot rule out Pleistocene human occupation. To test this hypothesis robustly requires further geomorphological and sedimentological research to clarify the nature of the lake and its environs in the Pleistocene and finding stratified lake margin deposits with associated archaeology. Our investigations have corroborated the earlier ethnographic and archaeological work of Paton (1994), Murgatroyd (1991), and Smith (1986a) in documenting distinct recent and later Holocene phases of occupation respectively. The formal artefacts from these phases are a mixture of northern and central/southern Australian types, with Lake Woods sitting on the transition between both cultural and ecological zones. Ethnographic evidence suggests the Lake could support dense populations and was frequented by many groups for the purposes of exchange. The lake may have promoted cultural diversity by being attractive to groups from the distinctive surrounding regions in times of abundance.

Acknowledgments

Newcastle Waters Consolidated Pastoral Company generously provided accommodation and access to the area. We thank Aara Welz, Alexander F. Wall, and Will Reynolds for their work in the field.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This research was funded by the Australian Research Council Centre of Excellence for Australian Biodiversity and Heritage [CE170100015].

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