Introduction
An Aboriginal hearth near Port Augusta has been dated to ca 40,000 years old, making it the oldest known site in South Australia (SA). It is also one of only two sites in southern Australia and one of only seven locations in Australia to demonstrate such antiquity (cf. David et al. 2011; O’Connor and Veth 2006). Since first observing the hearth in 2010, it has been entirely eroded by natural processes. This paper describes the find and confirms the urgent need for (1) systematic archaeological and palaeoecological research on the Quaternary dunes in this region, and (2) conservation and protection of these fragile open sites.

Background
Port Augusta is a large regional centre in SA and Coopers Dune is one in a series of late Quaternary-aged dunes situated west of the city (Figure 1). Coopers Dune is linear in shape, trends northwest and is highly eroded through its centre where it measures ca 1000 x 100 m. The dune borders the southern side of a source-filled lake known as ‘Dempseys Lake’ fed by a stream channel from the northwest spilling into an arm dipping southwest. Two clay pans are located on the southern side of Coopers Dune and these are filled irregularly by runoff. Dempseys Lake is also filled irregularly by runoff but more so from the channel to the northwest.

Numerous stone tools, most knapped from silcrete quarried from outcrops above the southwest arm of Dempseys Lake, are strewn over Coopers Dune, along with less frequently occurring quartzite cores. In the 1930s Tindale, a former SA Museum officer (SAMO), noted stone tools and megafaunal bone present on the dunes west of Port Augusta (AA338/01/15/2) and this observation was repeated by Campbell (another SAMO) in the 1950s (AA52/01/1/14). However, it was Cooper (1959) (also a former SAMO) who formally proposed that the stone tools might provide evidence of human megafaunal predation.

In the 1970s Wells and Williams commenced a palaeoenvironmental investigation of Dempseys Lake. Williams (1982) identified two clearly different stratigraphic horizons beneath the modern sand drift on Coopers Dune. The upper horizon of reddish brown sand he characterised by the remains of burrowing marsupials and archaeological deposits, whilst the lower horizon he characterised as carbonate cemented light brown sand encrusted with land snails shells, calcareous rhizomorphs and megafaunal bones. The stratigraphy implied that the archaeology was derived from a distinctly different horizon to that of the megafaunal remains, with the latter associated with a lower horizon. Williams was unable to provide strong evidence for the duration of each horizon, but placed the lower horizon and its megafaunal remains in Marine Isotope Stage (MIS) 3 (ca 27,000 to 60,000 years ago). This suggested that the archaeology was less than 27,000 years old.

During research into ‘Kartan’ sites, Lampert (1976) was alerted by Wells and Williams to the archaeology on Coopers Dune. In order to assess the age of the Coopers Dune stone artefacts, Lampert compared them to those described from Lake Mungo. He noted that, although the two assemblages were typologically remarkably similar, that from Coopers Dune displayed a significant quantity of on-site knapped stone lacking any calcarenite coating, whereas the Lake Mungo assemblage displayed no evidence for on-site knapping and the majority of stones were coated with calcarenite (Lampert 1976). Lampert also concluded that the Dempseys Lake area did not contain Kartan material. These observations, plus Williams’ observation about the stratigraphic association of the stone tools at Coopers Dune, led Lampert to suggest a chronology of 17,000 to 15,000 years old for the stone tools – well short of the 30,000 year old date for...
the Lake Mungo assemblages (Bowler et al. 2003) and well short of the probable date for megafaunal remains (Williams 1982).

Thereafter interest diminished, largely due to the lack of articulated remains and demonstrable overlap between the stone tools and megafauna. The harsh deflationary nature of the area results in most specimens being exposed on the surface in an already fragmented state and the number of complete elements is few compared to the amount of highly fragmented and disaggregated bone. However, since the pivotal paper by Roberts et al. (2001) arguing for the continental-wide extinction of Genyornis by ca 46,000 years ago, there has been renewed interest in the dating of megafauna sites. Roberts et al. considered only those sites with articulated remains and their announcement of the ‘extinction window’ at 46,000 BP stimulated other dating efforts and rekindled interest in previously documented sites, including Coopers Dune.

Grün et al. (2008) dated samples of megafauna teeth from various sites in SA, including Coopers Dune, regardless of the degree of articulation of the remains. This work is now equally critical for spelling out the problematic nature of dating organic remains (such as at Black Swamp, Kangaroo Island), as it is for offering dating outcomes. Using CSUS-ESR Grün et al. (2008) provided age estimates of between ca 45,000 and 60,000 years old for six tooth samples from Coopers Dune, thereby placing the megafauna within and older than Robert et al.’s (2001) extinction window. It also confirmed Williams’ (1982) earlier correlation of the deposit with early MIS3.

Williams (1982) had also identified on Coopers Dune numerous fragments of eggshell from both emu and the extinct Genyornis newtonii. Miller et al. (1999) later used amino acid racemisation to date a large sample of emu and G. newtonii shell fragments from the Lake Eyre and Lake Frome regions. Their results put the disappearance of G. newtonii from these regions at ca 50,000 years ago (Miller et al. 1999; Robin et al. 2009), fitting well with the results presented by Grün et al. (2008) for Coopers Dune. Research into the palaeohydrological record for Lake Eyre by Magee and co-workers identified a dry phase between ca 60,000 and 50,000 years ago, after which time a ‘low-level, probably perennial, lake phase’ commenced (Hesse et al. 2004). This is interesting in regard to the apparent disappearance of Genyornis ca 50,000 years ago and the commencement of human occupation ca 40,000 years ago.

Dating archaeological sites in the Port Augusta region has been limited and problematic, with the nearest dated sites located some 90 km to the northeast in the lower Flinders Ranges. The only Pleistocene date in this same area is for a ‘fireplace in a pit’ on the margin of Hawker Lagoon: 14,770±270 (SUA2253) (Lampert and Hughes 1987, 1988; Walshe 2005). Hawker Lagoon provides comparatively stable surfaces where exposed features such as hearths remain durable for some time and excavation can occur. In contrast, the potential for finding datable samples on the Quaternary dunes around Port Augusta is compromised by the extreme deflationary activity of modern winds – it has been estimated that 10 cm of sand is deflated from the top of Coopers Dune annually (Williams 1982).

Many of the late Quaternary dunes in this area have also been destroyed or severely impacted by sand mining, 4WD and dirt bike adventuring, rubbish dumping and the encroachment of urban infrastructure (Walshe et al. 2001). One such dune was destroyed 12 years ago during an extension to the Port Augusta Aerodrome runway (Walshe 1997). Prior to destruction, Nukunu People’s Council Inc. (NPC) salvaged artefacts from the dune and took samples for OSL dating. OSL results provided an age range of 100,000 years old at the base and 35,000 to 30,000 years old at the top of the dune (Walshe et al. 2001). Extensive stone artefact scatters were exposed in the deflation bowls of this dune. A series of mechanically dug excavation pits was placed over the margins of the dune prior to its destruction, but these failed to find any artefacts between the surface and the base of the dune and it was concluded that occupation post-dated 30,000 BP (Walshe et al. 2001). As Lampert (1976) had described for Dempseys Lake, these artefacts also lacked any calcarenite coating and appeared to have been derived from strata overlying the calcareous horizon.

In the Flinders Ranges area, lida are earth ovens used to cook large game that do not utilise heat retaining rocks (Tunbridge 1985). They are made by digging a hole in which wood is burned to form coals to which the food is added and the whole sealed with hot ash and more coals. Tunbridge (1985) noted that sometimes vegetation is also put into the hole and water poured over the coals to create a steaming effect before sealing. Rocks were occasionally added, but these had been described ethnohistorically as dangerous due to their ‘propensity to explode and embed ... in someone’s flesh’ (Tunbridge 1985:19). This same method of cooking was also observed much earlier and elsewhere in Australia by Grey (1841), Dawson (1881) and Beveridge (1884) and clearly is not tied to any particular region or cultural group. For example, Gould (1967) provided a similar ethnographic observation for cooking large game in the Western Desert, where oven construction follows the same pattern of digging a shallow trench, creating coals, adding the carcass and then closing it over. Smith et al. (1991) described a series of hearths located in the Strzelecki Desert dunefield. These hearths were dated between 10,000 and 15,000 years old and consisted of earth ovens, some with charcoal and/or baked clay as heat retainers. Smith et al. (1991) suggested that perhaps ovens lacking harder material were only used to heat the rocks or baked clay which was then transferred to another oven, along with the food.

Recent Archaeological Investigations on Coopers Dune, Dempseys Lake

As reported elsewhere, agreement over the destruction of the dune to allow an extension to the Port Augusta Aerodrome runway was reached following difficult and divisive discussion (Walshe 1997; Walshe et al. 2001). Since then NPC members – in particular James (Jimmy) Bramfield (since deceased), Margaret Smith and Darcy Evans – have maintained a strong interest in the archaeology of the local dunes, particularly Coopers Dune, to which the author has made a number of visits with NPC members, slowly accumulating data and gaining an understanding of site processes by direct observation. Over the last decade, numerous small and large artefacts, fragments of emu and Genyornis egg shell, and bone from small animals, including bettongs and bandicoots, as well as megafauna have been noted. The dune dips down from the southeast before rising up to the more elevated northwestern end, and deflation activity at this latter end is noticeably stronger, resulting in the hardpan
The PACD H1 hearth was a discrete, slightly mounded feature at a seismic record of approximately 380 x 400 mm on an X-Y axis, with a diameter of ca 470 mm. The height of the mound was approximately 40 mm above the hardpan surface. Cross-sectional shape and depth is unknown, as no excavation was undertaken. The hearth was composed of burnt sandy sediment, some of which had formed into clumps (n=6) due to the presence of an unidentified highly organic residue (Figure 2). The clumps were not solid and readily fell apart after transferal to a container. Whilst in situ the clumps measured between 100 and 180 mm across and were loosely arranged in three clusters atop two linear patches of dark organic sediment. No heat retaining rocks or organic material (e.g. bone, shell etc.) were noted to be directly associated with the hearth. The nearest associated elements were 400 mm from the northwest edge of the hearth and included Genyornis egg shell fragments, two silcrete flakes and one reddish-coloured small stone, all situated directly on the hardpan surface.

The hearth reported here is considered to be the remains of an earth oven lacking heat retainers (i.e. an ilda). Further, in view of the absence of bone, eggshell and shell fragments, it is possible that butchering and consumption occurred elsewhere. On request from NPC representatives and in recognition of the rarity of finding such a fragile feature on Coopers Dune, ca 100 g of sediment was removed for dating purposes.

**Chronology**

A sample of the collected sediment from PACD H1 was sent to Rafter GNS Science for radiometric dating. The sample returned an age of 40,500±950 BP (GNS NZA 34976). This date was of unexpected antiquity and demanded to be confirmed through repeat radiometric dating, as well as alternative dating techniques.

Three months after initially recording the hearth, a second visit was made to the site with a Heritage Officer from the SA State Government Aboriginal Affairs and Reconciliation Division (AARD). At the time of this subsequent visit the hearth was found to have been dramatically diminished by environmental processes and, under direction from NPC representatives and AARD, the remaining burnt sediment was salvaged.

This second sample of burnt sediment was sent to NSF-Arizona Laboratory for radiometric dating, and returned an age of 38,300±1000 BP (AA94759). This provided confidence that the hearth was indeed of considerable antiquity. However, in view of Gillespie’s (1998) research into ancient hearths at Willandra Lakes, it was decided that luminescence dating was also necessary to confirm the radiometric determinations. Ancient hearths on dunes at Willandra Lakes have either baked earth heat retainers, charcoal and little humic acid, or no visible charcoal but abundant humic acids (Gillespie 1998). PACD H1 is comparable to the latter type, i.e. with no visible charcoal but abundant humic acids. Gillespie identified a critical problem in dating this type of hearth for, although no visible charcoal is present, fine particulate organic charcoal may be. In investigated Willandra Lake hearth samples it was found that the organic charcoal was significantly younger than the dominant humic acids fraction (Gillespie 1998:173).

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<th>Table 1 Comparison of average dimensions of tools at the southeast and northwest ends of Coopers Dune.</th>
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<td><strong>Southeast grids</strong></td>
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Samples of sediment for OSL dating were obtained from a small hummocky formation adjacent to the PACD H1 hearth location. Two samples each were taken from layers equivalent to above and below the hearth, with the two lower samples being from inside the hardpan surface (Williams 2011). At the same time, environmental radiation was measured by in situ field gamma spectroscopy and samples taken (Williams 2011). The OSL samples were analysed at Environmental Luminescence, School of Chemistry and Physics, University of Adelaide, and the background samples by Genalysis Laboratories.

The two samples from above the hearth returned dates of 32,100±2,400 years and 36,600±2,600 years BP, respectively. The two samples taken from below the hearth returned dates of 44,500±3,700 and 48,100±3,300 years BP, respectively. This places the layer on which the hearth was located at ca 40,000 BP, thus supporting the radiometric dates (Williams 2011).

Future Research

Ten years ago it was reported that late Quaternary dunes at Port Augusta were dated to approximately 100,000 years at the base and 35,000 to 30,000 years at the apex (Walshe et al. 2001). It was conjectured at that time that occupation could well have commenced during the 35,000 to 30,000 year phase of dune building. There is now very convincing scientific evidence for human occupation at Dempseys Lake, Port Augusta, at ca 40,000 years ago based on the now destroyed PACD H1 hearth site.

The PACD H1 site is now the oldest known site in SA and the region in which it occurred holds enormous significance for further archaeological research. The age of occupation raises many intriguing questions regarding the relationships between archaeology, palaeoenvironment and megafauna. As noted earlier in this paper, the stone tools are not calcarenite coated, suggesting that either the implements associated with the 40,000 year level are yet to be revealed or that different soil chemistry is involved. As noted, the most recent and robust date for megafauna at Dempseys Lake is ca 46,000 BP (Grün et al. 2008). Perhaps megafauna disappeared before humans arrived some 6000 years later, or perhaps they did spend a brief time together around the margins of Dempseys Lake. Recent research by Cohen et al. (2011) suggested that peak water levels in lakes further north occurred at intervals during MIS4 and early MIS3, one such interval being about 48,000 to 45,000 years ago. As commented by Cohen et al. (2011), this coincides with lake full eras for other Australian inland lakes between 50 and 42 ka, such as Mungo (Bowler et al. 2003) and Gregory (Veth et al. 2009), and supports work by Magee and others (Hesse et al. 2004). Perhaps Dempseys Lake underwent a similar high water regime at 45,000 to 42,000 years ago, at a time that megafauna were disappearing and humans moving in.

At this point it is not possible to offer an interpretation of occupation at 40,000 years ago near Dempseys Lake. Any attempt to do so would be deeply fraught considering the lack of specific archaeological and palaeoecological information available. However, this investigation highlights the potential for significant interdisciplinary research to take place on this dune system. Given that hearths were also recorded in the 1970s by Williams (1982) it is highly likely that others could be located by regular monitoring and conducting controlled excavation. The investigation has highlighted the ability for very fragile features to persist, but emphasises the need to capture them before they are exposed and demonstrates the urgency for, effective long-term site management. The site is currently under management by SA Water and is subject to Native Title determination between Nukunu and Barngarla claimants. It is hoped that research can continue in the near future.

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