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Historical collation of waterbody information in the Lake Eyre Basin catchments for Qld and SA

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ABSTRACT

Historical ecology is the application of information from historical sources to the elucidation of ecological questions. Generally, historical ecologists are concerned with understanding the range of variation inherent in the ecosystems of the past.

This project used an historical perspective to build a picture of dynamism in waterbodies of the Lake Eyre Basin over the one and a half centuries since first European contact with the area. Considerable anecdotal and empirical evidence strongly suggests that deposition of eroded regolith resulting from overgrazing in the late nineteenth century, has resulted in localised reductions in waterbody permanence.

The journals of three nineteenth century explorers and one early twentieth century traveller were examined, and references to waterbodies and other environmental phenomena extracted and geo-referenced. From the resulting database, eight case study locations were selected. Descriptions of these locations from the explorer record were compared with current assessments of waterhole permanence derived from a recent broad-scale study. Explorer observations of a range of mammal species are also presented and their ecological significance discussed.

The explorer record suggested that some reduction in permanence may have occurred in two of the case study locations, while tentative evidence of change existed for a third. Comparison of the explorer observations and current condition did not detect any change for the remaining five locations.

Overall, disparities between the spatial and temporal resolution at which an ecological process of interest operates and the resolution obtainable through a particular historical source is one of the major challenges to the application of the historical record. This can be overcome through the consultation of multiple, corroborating lines of evidence.

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1.0 INTRODUCTION

The aim of this project was to collate historical observations of Lake Eyre Basin (LEB) waterbodies from the journals of nineteenth and early twentieth century explorers. In particular, observations were sought which provided insight into the permanence of identifiable, individual waterbodies at the time of first European contact with the study area. A secondary aim of the project was to use the collated references as a baseline from which to interpret change in the water-holding capacity of waterbodies in the LEB. The project considered waterbodies of all types, but concentrated on waterholes, those deeper sections of river and creek beds which continue to hold water following the cessation of flow.

Initial impetus for the project came from a broad-scale inventory of permanent and semi-permanent natural waterbodies in the LEB (Silcock 2009), which revealed considerable evidence of waterhole silting extending back in time to approximately 1880. The phenomenon was apparently characterised by marked spatial variability in its extent, severity and causation (Silcock 2009). This variation was reflected in long term residents' perceptions of the issue (Silcock 2009). Residents along some watercourses (i.e. Cooper Creek) did not believe that silting had occurred, or saw it as a natural phenomenon which would be reversed by the next flood. Elsewhere (i.e. the Thomson River), long-term residents provided examples of severe siltation, to which they assigned anthropogenic causes, usually heavy grazing pressure and subsequent removal of ground cover during the late nineteenth century (Silcock 2009).

These perceptions are supported by empirical evidence from far western New South Wales, where erosion and subsequent transport of regolith has resulted in infilling of creeklines and the blanketing of valley floors beneath a layer of red sandy sediment (Fanning 1999; Pickard 1994). Radiocarbon dating of charcoal from Aboriginal hearths buried by this sandy layer unequivocally demonstrated its late nineteenth century origin, thus supporting the inference that loss of ground cover through overgrazing has resulted in the widespread deposition of eroded material in watercourses (Fanning 1999).

While not relating directly to semi-arid rangelands, studies of lake bed sediments in the New England Tableland area of north-eastern New South Wales also identify a positive correlation between the commencement of European land management

practices and increased sediment deposition in waterbodies (Gale *et al.* 2004; Gale & Haworth 2004). In the light of this combination of anecdotal and empirical evidence, it seemed likely that an historical perspective on waterhole permanence at the time of first European contact would provide a useful baseline against which subsequent changes could be assessed, particularly given the assay of current permanence afforded by Silcock (2009).

1.1 Structure of the report

Understanding environmental changes which are complex, multi-causal and variable in space and time requires a clear conception of the natural range of variation inherent in the system. In essence, we need to be able to distinguish the 'signal' of causation from the 'noise' of inherent variation (see for example Lotze & Worm 2009; Pearson & Betancourt 2002; Jackson *et al*. 2001; Swetnam *et al*. 1999). It is this recognition which has given rise to the ecological sub-discipline known as 'historical ecology'.

The report begins with a review of the aims and methods of historical ecology, including a discussion of the challenges associated with the application and interpretation of the historical record to ecological questions. Foremost among these challenges are the frequently fragmentary nature of the historical record and disjunctions between the spatial and/or temporal resolution of the historical sources and the scales at which the ecological process of interest operates. The review identifies a strong consensus on the value of an approach involving multiple lines of historical evidence as a means of overcoming these difficulties. Following the literature review, the methodological approach used in the study is described. This section also provides full details of the historical sources consulted.

The project's major output is the spreadsheet containing geo-referenced quotes from the journals, which appears as Appendix 1 in the CD accompanying this report. In the 'results and discussion' section, findings from a preliminary analysis of information contained within Appendix 1 are presented as a series of case studies illustrating the conclusions which may be drawn from the historical sources and the challenges involved in their interpretation. These case studies focus on eight locations; Talleranie Creek in north-eastern south Australia, sandy creeklines in north-western New South Wales, Strzelecki Creek, Cooper Creek between Innamincka and the Wilson River, Ooga-boogina Waterhole near Cooper Creek in

north-eastern South Australia, the Mulligan River, Lake Lady Blanche and Quartier Creek on Durham Downs Station in Queensland. This analysis suggests that changes may have occurred in some of these waterbodies, while for others the assessment of permanence derived from the explorer record closely approximates that obtained by Silcock (2009).

While the major focus of the report was on waterholes, other information of ecological interest was also geo-referenced and is included in Appendix 1. A small selection of this information is presented in part two of the discussion. This section examines information from the historical sources regarding mammal decline and extinction, and kangaroo abundance. Both of these topics have long been of interest to Australian ecologists.

The report concludes with an appraisal of the historical record's potential to contribute to a greater understanding of waterhole dynamics in the LEB. The methodological approach taken in this study is also critiqued. The section finishes with the development of a framework for future application of the historical record to understanding change in waterholes.

Before continuing further, however, the lives and expeditions of the explorers whose journals were studied for this project will be discussed.

1.2 The explorers: four brief sketches

Please note that the nature of the information conveyed in these biographical accounts is such that to follow standard in-text referencing protocol under the Harvard system would result in excessive and distracting in-text references. The sources consulted in the preparation of the four accounts are therefore cited at the end of each, except where direct in-text referencing is unavoidable.

1.2.1 Landsborough

William Landsborough was born on the 21st of February 1825 in Ayrshire, Scotland. His father, Dr David Landsborough, was a clergyman by profession, but a keen amateur entomologist and artist.

William migrated to Australia in 1841 to work with his elder brothers, who were already in the colony and held pastoral leases in the New England tablelands of

northern New South Wales. He soon leased his own run, and by 1850 was already an expert bushman.

Landsborough's long association with Queensland began in 1854, when he moved north to help his brothers on their property 'Monduran' on the Kolan River near Bundaberg. The next few years were filled with exploration and pastoral ventures in central Queensland, including the formation of the Landsborough River Co. with Edward Cornish and Nat Buchanan. The main aim of this company was stocking the land which would become known as 'Bowen Downs', in the present day shire of Longreach.

In 1861, the Queensland and Victorian Governments chose Landsborough to lead one of four parties searching for Burke and Wills. The party was to begin in the Gulf of Carpentaria and travel south from there.

The expedition had an eventful start. They sailed from Brisbane in 1861 in the brig *Firefly*, accompanied by H.M.S *Victoria* under Commander W.H. Norman. Before reaching their destination, however, the *Firefly* ran aground on a reef near Cape York. Eventually, Landsborough and his party were able to get their horses ashore and form a depot on the Albert River in the Gulf of Carpentaria. From this depot they commenced their search by travelling south-west, reaching a point close to the present-day town of Camooweal. Finding water was difficult here, and yet the country appeared prone to flooding in the event of rain. Faced with these twin difficulties, Landsborough and party retraced their steps to the Albert River Depot. This first, short leg of Landsborough's expedition only barely intruded into the LEB, and so has not been examined for this project.

On the 10th of February 1862, Landsborough, accompanied by his second-in-command, George Bourne, a Native Police Trooper named Jemmy, two other Aboriginal men named only as Jacky and Fisherman, and W. Gleeson, the expedition's cook and groom, set out to the south-east.

They arrived at the Leichhardt River on the 13th of February 1862 and followed it for a short distance before crossing over to the Flinders River. Landsborough then followed the generally south-easterly arc of the Flinders all the way to a point just east of the present-day site of Hughenden, before crossing over the watershed known as the 'jump up' near the town of Prairie.

The party then travelled south along Skeleton and Tower Hill Creeks and got onto the Thomson River, which they followed to the south-west. Just to the north-east of the present-day site of Stonehenge, Landsborough turned and crossed to the Barcoo River, then onto the Warrego. Once on the Warrego, the party was in settled areas, and Landsborough stopped keeping his journal for the remainder of the trip back to Melbourne, which the party reached in October 1862.

Landsborough's previous experience as a pastoralist and his ongoing interest in this area are evident throughout his journal, with detailed descriptions of vegetation structure and composition appearing on an almost daily basis. This interest resulted in accusations that he had been more interested in finding good grazing land than in searching for the missing Burke and Wills. He vehemently denied this. These conflicts appear to have been relatively minor, however, and there was great contemporary interest in Landsborough's journey. He afterwards travelled to Britain and was presented with a gold watch by the Royal Geographical Society in recognition of his explorations.

Following this expedition, Landsborough led a varied life, with continuing pastoral interests, a stint as Police Magistrate and Commissioner of Crowns Lands for the Gulf of Carpentaria and a successful tin mining venture in Stanthorpe, Queensland. He died on the 16th of March 1886.

Sources: Trundle (1975, 1965); Landsborough (1862)

1.2.2 McKinlay

The South Australian Burke Relief Expedition led by John McKinlay from South Australia to the Gulf of Carpentaria was part of the same effort to rescue Burke and Wills as Landsborough's expedition. Like Landsborough, McKinlay was already an expert bushman by the time of his selection as leader of this expedition.

McKinlay was born on the 26th of August 1819 at Sandbank on Holy Loch, Argyllshire, Scotland. Together with his brother Alexander, McKinlay migrated to Australia in 1836. The two initially worked with their uncle, Duncan McKellar, who held land near Goulburn. This arrangement ceased when financial difficulties obliged McKellar to give up his land. John then turned his attentions inland. He profited through the purchase and subsequent sale of squatting leases along the Darling River, and also learnt a great deal of bushcraft from Aboriginal people.

By 1861, McKinlay had 25 years' experience of working in the Australian bush, and was consequently a natural choice to lead the South Australian Burke Relief Expedition, or SABRE. Accompanying him on this venture were John George Kirby, William Alexander Bell, Robert Poole, Paul Wylde, John Davis, Edward 'Overland Ned' Palmer (bullock driver) and Thomas Middleton. The expedition's second-in-command was William Oswald Hodgkinson, who was later to attain some eminence in his own right as an explorer and politician. For reasons unknown, Hodgkinson and McKinlay were to clash during the expedition, leading to Hodgkinson resigning and wishing to return to Adelaide. McKinlay accepted his resignation, but refused his return, so Hodgkinson completed the journey as "just another horseman" (Lockwood 1995, p. 69).

Like most exploratory expeditions at the time, McKinlay also employed Aboriginal people. The relationship between the Aboriginal and European members of this party in particular and exploring expeditions in general is summarised well by Lockwood (1995, p. 11):

> *Two Aborigines, Frank (sometimes called Peter) and Jack, were employed at 10S a week to act as shepherds. The prevailing attitude of white superiority is immediately apparent, one black man being given a different name from time to time, and the two being paid 10S a week to be responsible, on foot, for the whites' main food supply while the whites rode on ahead on £2 a week.*

At various stages during the expedition, the party also obtained the services of Aboriginal guides, who proved invaluable in assisting the expedition through areas such as the Coongie Lakes in northern South Australia. Remarks in McKinlay's journal regarding these guides also reflect nineteenth century attitudes to Aboriginal people:

> *During the night a native dog came up to the sheepfold and was shot by Frank (a native). The natives, encamped a short distance from here, hearing the report of the gun, immediately took to flight and with them the native Bullingani who was of so much use to me; however another is easily got.* (19th of December 1861)

Yet in other parts of his journal McKinlay writes sympathetically of his Aboriginal companions. For example, his journal entry of the 28th of September 1861 evinces considerable concern for Peter, who had recently been injured by one of the bullocks.

McKinlay's expedition was also notable for the large number of animals accompanying it. In addition to a flock of sheep intended as a "mobile larder", the party was accompanied by bullocks, camels and horses, all laden with supplies.

The party left Adelaide in August 1861, and made their way north through the settled districts to Blanchewater Station. On the 24th of September 1861, the party left Blanchewater, and the expedition had begun in earnest. They stayed in the Coongie Lakes area for over two months, establishing a camp on Lake Coogie-coogina which served as a base from which McKinlay investigated rumours that survivors from the Burke and Wills expedition were living on one of the lakes. In the course of these investigations, McKinlay discovered upon the shores of Lake Kadhibaerri a grave containing the skeletal remains of a European. Spent rifle cartridges and other debris suggestive of a struggle were also found near the grave, leading McKinlay to conclude that the entire Burke and Wills party had been killed by Aboriginal people. He consequently bestowed upon the lake the rather grim appellation 'Lake Massacre'.

Hodgkinson was sent back to Blanchewater to report this find, and eventually returned on the 29th of November 1861 with the news that their inferences regarding the fate of Burke and Wills had been incorrect, with Howitt discovering their remains on Cooper Creek. In accordance with instructions from the South Australian government, the expedition's main aim now became exploration in search of pastoral land, precious metals and gemstones.

They travelled along the south-westerly arm of Cooper Creek, then turned north, and struck Eyre Creek. From here they turned east and struck the Diamantina River just north of the present-day Queensland / South Australia border. The party then followed the Diamantina north-north-east to Middleton and Caddell Creeks west of Winton before crossing the McKinlay, Fullarton and Williams Rivers. They then followed the Cloncurry River north to the Gulf of Carpentaria.

The expedition seems to have travelled after abundant rain, and McKinlay's descriptions of brimming lakes, flowing streams, teeming fish and bird life, and the large groups of Aboriginal people who had gathered to reap this abundance contrast starkly with the privations experienced by Sturt in the same area some twenty years previously. Indeed, while travelling along the Diamantina River, McKinlay's party had to make a hasty retreat to a high sandhill in order to avoid rising floodwaters.

On arriving at the Gulf, McKinlay found that the steamship *Victoria* had left. The party was thus obliged to make a wearisome trek east all the way to Bowen in Queensland, suffering severe food shortages along the way.

On his return to Adelaide, McKinlay was greeted as a hero and along with Landsborough, feted at public gatherings. He was, however, a particularly shy man, with the courage and resourcefulness he displayed as an explorer apparently not extending to public speaking.

Following the Burke Relief Expedition, McKinlay remained active as both an explorer and a pastoralist, including extensive exploration under conditions of great hardship in the coastal swamps and rivers of the Northern Territory. McKinlay died on the 31st of December 1872, and is buried in Adelaide.

Sources: Lockwood (1995); Anon. (1975); McKinlay (1862)

1.2.3 Sturt

McKinlay and Landsborough can to some extent be characterised as men of a kind – pragmatic, hardworking Scottish immigrants and experienced bushmen. Their journals are, with the exception of a few uncharacteristically lyrical passages, fairly brief and tend to record matters of practical concern such as the likely potential of the land for pastoralism.

Sturt differed from both Landsborough and McKinlay in nationality, social class, and above all, motivation for undertaking his expedition. Raised in genteel poverty, Australian exploration for him represented a last opportunity at recognition and economic prosperity after an army career hampered by relatively peaceful overseas postings which had afforded little opportunity for promotion.

Sturt was born on the 28th of April 1795 in Bengal, India, where his father Thomas Lenox Napier Sturt served as a puisne (that is, minor) judge for the East India Company. On the 9th of September 1813, Sturt was gazetted ensign in 39th (Dorsetshire) Regiment of Foot. His military service took him to France in the aftermath of the Napoleonic Wars, and to Quebec during the American War of Independence. The latter posting involved the endurance of a hard Canadian winter, but entailed few opportunities for advancement. The regiment's subsequent posting for garrison duty in Ireland proved similarly monotonous.

After more than twelve years of service, Sturt was finally promoted to Captain around 1825, an event which coincided with a new assignment for the 39th – escorting convicts to Australia. Sturt arrived in Sydney Cove with his regiment aboard the *Mariner* on the 23rd of May 1827. Before the year was out, he had been appointed Governor Darling's military secretary.

Letters written by Sturt to relatives in England clearly show that by late 1827 he had already begun to seriously consider Australian exploration as a field of endeavour offering opportunities which had not eventuated during his military career. It would, however, be incorrect to assume that Sturt's interest in exploration was solely based on hopes of professional success. He was a keen amateur naturalist and geographer, and there is no doubt that, like many others in the colony, he was extremely curious as to the nature of Australia's interior.

His opportunity to investigate the mysteries of this region was, however, not to come for another twelve months. In November 1828 Governor Darling approved a proposal by Sturt to trace the Macquarie River. The approval of this proposal also earned Sturt an enemy in the form of Major Thomas Livingstone Mitchell, who felt he had been passed over for the expedition. The resulting enmity between the two was to be long-lasting, and accounts for some of the disparaging comments concerning Mitchell which appear in Sturt's journal.

A detailed description of Sturt's explorations of the Murray-Darling system is beyond the scope of this project. It is nonetheless important to note that over 1828 and 1829 Sturt made two extensive and successful exploratory expeditions in this area. These journeys were notable for their use of small boats to facilitate the exploration of inland waterways and for the generally good relations Sturt was able to establish with Aboriginal people.

The years between these explorations of the Murray-Darling and the departure of the Central Australian Expedition in 1844 were marked by a fall in Sturt's economic fortunes as a result of some incautious business ventures and by the enmity which caused Governor George Grey to decline Sturt's applications for government positions. It was partly in hope of bolstering these failing fortunes that Sturt first proposed the expedition, yet to characterise Sturt's motivations as entirely financial would be a gross simplification of the complexity of Sturt's motivations Davis (2002).

Without becoming too enmeshed in these complexities, Sturt's Central Australian Expedition was defined by two broad features. First, it was a venture entirely of Sturt's own making. Unlike the Burke and Wills search expeditions undertaken by Landsborough and McKinlay, the idea for the expedition was Sturt's own, and he had to petition a somewhat unenthusiastic government for financial backing. Second, and most important for a full understanding of Sturt's journal, was Sturt's deep belief in the existence of an inland sea and his determination to find it.

While belief in such a feature may seem ridiculous in the light of current geographic knowledge of inland Australia, nineteenth century geographers had good reason to suppose it existed. Davis (2002, p. xxxviii) describes their reasoning:

> *Scientists and pastoralists alike knew nothing of what lay beyond the tentative geographical probes that had been made around the perimeter of the continent, but they understood a few things about the features of the perimeter and they knew what similar features in other parts of the world meant about the neighbouring topography…. Known as theoretical geography, the practice had been part of cartographical thinking for centuries*.

Sturt's faith in the existence of this sea bordered on the obsessive. His journal is full of references to locations which resemble sea shores, desert dunes are likened on numerous occasions to ocean swells, and the metaphor of a ship at sea is frequently used to describe both the progress and isolation of the party. Sturt's passionate belief in the inland sea is perhaps best illustrated by the whale boat which the expedition carried for use upon that elusive waterbody.

The Central Australian Expedition left Adelaide on the 10th of August 1844. The party comprised seventeen men, including Sturt. The expedition's officers were James Poole (second in command), John Harris Browne (expedition physician) and John McDouall Stuart (draughtsman). During the course of the expedition, Poole was to die of scurvy at Depot Glen in north-western New South Wales. On Poole's death, Browne took over as second in command, displaying leadership, courage and intelligence. Stuart also proved a dependable and trustworthy member of the expedition, and went on to have his own notable career as an explorer of inland Australia.

The remainder of the party comprised Louis Piesse (storekeeper), Daniel Brock (armourer and curator of zoological specimens), Robert Flood (stockman), David Morgan and James Lewis (ex-sailors, to man the whale boat), George Davenport, Joseph Cowley, John Kirby and five bullock drivers: John Mack, John Jones, John Sullivan, Hugh Foulkes and Adam Turpin.

While Sturt's expedition did not have any permanent Aboriginal members, he did rely on the services of a number of Aboriginal guides and messengers. Sturt's approach to the employment of Aboriginal guides differed from that of both Landsborough and McKinlay in that he sought the services of people from within the region he was traversing. When the party crossed a cultural divide and entered the lands of another

group, the erstwhile guides would leave and be replaced by others. Foremost among these guides were Camboli, Nadbuck and Tampawang.

The route taken by the party is complex to follow in detail, since it was based on the establishment of base camps from which numerous exploratory forays were made into the surrounding country. In simple terms, however, the route is easily described. From Adelaide, the party travelled east to Moorundie on the Murray River. They then travelled up the Murray to its junction with the Darling, then up the Darling to the Menindee Lakes. From Lake Cawndilla they travelled north-west into the Barrier Ranges of western New South Wales, establishing base camps on Stephens Creek, Morphetts Creek and Floods Creek.

By the end of January 1845, water was becoming difficult to find, and Sturt moved the party north to the now famous Depot Glen camp on Preservation Creek near Milparinka, New South Wales. Thus began almost six months of virtual imprisonment, while the party waited for rain which would enable them to move on to the north-west. The waterhole at Depot Glen had at first appeared permanent, but the combined demands of men and animals saw it shrink it to a pool of foul, muddy slush. During this period the entire party endured great hardships through sickness, heat and lack of food and water. It was here that James Poole died of scurvy.

During this period of confinement, Sturt made numerous scouting expeditions in all directions, but chiefly to the north-west. During one of these he discovered Lake Pinaroo, at the western end of Fromes Creek in the far north-western corner of New South Wales. This area had good feed for the expedition's animals, leading Sturt to term it 'The Park'. He later called it Fort Grey.

When rain finally released the party from Depot Glen in July 1865, Sturt moved the party north-west to Fort Grey, and established a base camp, which included a palisade fence and vegetable garden. From Fort Grey he undertook two remarkable exploratory expeditions.

The first of these took him to the north-west, across Strzelecki Creek, Cooper Creek, the Diamantina River at Goyder Lagoon and the Sturt Stony Desert. He then travelled north along Eyre Creek and the Mulligan River before being turned back by the sandhills of the Simpson Desert. From there he retraced his steps to Fort Grey. This exhausting effort covered a distance of almost 900 miles.

After resting for only ten days at Fort Grey, Sturt headed north-west once again. This time, he struck Strzelecki Creek, then headed directly north to Cooper Creek, which he crossed before continuing in a northerly direction. Once again, he found his path blocked by sandhills and the gibber plains of Sturt's Stony Desert. He then turned around and trudged back to Cooper Creek, exploring east along that watercourse to the Wilson River before returning to Fort Grey.

Although Sturt wished to make yet another attempt to travel to the north-west, Browne realised that this would be fatal, and managed to dissuade him. The party then began retracing their route back to Adelaide. Sturt's health on the homeward route was extremely poor, with severe scurvy causing him to lose the use of his limbs. Browne appears to have contributed substantially to his cure by collecting native fruit for him, and Sturt was able to ride unassisted into Adelaide on the 19th of January 1846.

The Central Australian Expedition was Sturt's last exploring trip. After the expedition, he took leave and travelled to England, where he published an account of his explorations. On his return to Adelaide he took up the role of Colonial Secretary, but his sight, damaged in the course of his exploring duties, began to fail and he retired on a pension of £600 in late 1851.

Despite his intention to remain in Australia for the remainder of his life, financial and family obligations saw Sturt return to England with his wife Charlotte and their children in 1853. He died on the 16th of June 1869, just before the formalities for the granting of a knighthood were complete.

Sturt's journal of his Central Australian Expedition is notable for its detailed descriptions of plants, animals, Aboriginal people and landscapes. While Landsborough and McKinlay avoided contact with Aborigines wherever possible, Sturt actively sought it, and the friendly relations he established with them are almost unique in the annals of Australian exploration.

Sources: Davis (2002); Gibbney (1967)

1.2.4 Basedow and Grenfell Thomas: The Medical Relief Expedition of 1919

To some extent, Herbert Basedow and Richard Grenfell Thomas must be considered the 'odd men out' in this study, both in terms of the historical period during which their

expedition took place, and its purpose. In the fifty-seven years which had elapsed since McKinlay and Landsborough returned from their expeditions, the LEB had undergone some remarkable changes. A network of bores was being established, tracks had been pushed through, and numerous homesteads had sprung up. Indeed, the European population of the area at this time was higher than in the present day, although the abandonment of pastoral holdings in the face of drifting sand and rabbit plagues had begun (Tolcher 1986).

The Medical Relief Expedition aimed to assess the health of Aboriginal people living in far north-eastern South Australia and south-western Queensland and to provide treatment where possible. It was the culmination of concerns regarding Aboriginal health voiced by members of two prior expeditions to the area, one in 1914 and another in 1916 (Tolcher 1986). A public meeting was held in Adelaide, resulting in the donation of £500 by pastoralists and the contribution of another £500 by the Commissioner of Public Works, who also called for Basedow to lead the expedition.

By the time of the expedition, Basedow was already established as both a physician and an anthropologist. Born in Adelaide on the 27th of October 1881 to parents of German descent, Basedow went to high school in both Adelaide and Hanover, Germany. Between 1898 and 1902 he attended Adelaide University and the South Australian School of Mines and Industry, obtaining a Bachelor of Science. His subsequent work as a geologist took him to remote areas of Australia, providing him many opportunities to follow his passionate interest in anthropology.

In 1907 he returned to Germany where he studied medicine and anthropology at Breslau, Heidelberg and Gottingen. Notably, he worked with the German anthropologist Hermann Klaatsch studying the collection of Aboriginal skeletal remains in the Hunterian Museum of the Royal College of Surgeons in London.

He returned to Adelaide and his geological work in 1910, but in May 1911 accepted a position as Chief Protector and Medical Inspector of Aboriginals in Darwin. He approached the role with enthusiasm, but found himself unable to agree with government policy, and resigned after only 45 days. He returned to Adelaide and resumed private geological and medical practice, while continuing to publish scholarly articles in anthropological journals. He seems to have been occupied in this mode of life at the time of his selection to lead the Medical Relief Expedition.

Basedow was accompanied on the expedition by his wife Olive Nell Noyes, his brother Erwin and Richard Grenfell Thomas, the son of one of the pastoralists who had helped to finance the expedition (Kaus 2008). The expedition basically described a large loop, following the Strzelecki Track up to Innamincka, then travelling along Cooper Creek across the South Australia / Queensland border to Nappa Merrie Station and Durham Downs, then retracing their steps back to South Australia, travelling west to the Birdsville track and thence back home.

Both Basedow and Grenfell Thomas kept journals during the expedition. Basedow's is generally quite brief, with a business-like quality which accords well with descriptions of his personality. Grenfell Thomas is much more descriptive. Indeed, his enthusiastic curiosity on topics ranging from ornithology to geology is very clear in his prose. This is perhaps best illustrated by the remark with which he closes his journal at the journey's end:

> *Thus ended the expedition of which I was priveleged to be a member and I am fully aware of the wonderful experience thereby gained, and the unique opportunities afforded of studying Nature at the Fountain Head.*

Following the expedition, Basedow remained interested and active in the welfare and rights of Aboriginal people and continued both his geological work and his anthropological studies. He died at only 52 years of age on the 4th of June 1933.

Sources: Kaus (2008); Harmstorf (1979)

1.3 A note on place names and spelling

For the purposes of consistency and historical accuracy, I have preserved the explorers' renditions of place names when quoting directly from their journals. For example, McKinlay spelt Coogie-cooginna as 'Cudye-cudyena' and Ooga-boogina as 'Agaboogana', and I have used his variants in direct quotations, with appropriate explanation where necessary.

Readers will also notice differences in the spelling of some English words in direct quotes from the journals. For example, Sturt frequently spells 'depth' as 'debth', while 'though' is often shortened to 'tho'. Furthermore, improper nouns are frequently capitalised, for example: "Flood, when out this morning for the horses, was attracted to the Creek by a sound as of a heavy wind…" (Sturt, 13th of July 1845). I have maintained all of the above usages in direct quotations.

When referring to place names independently of any quotation, I have followed the spelling used on modern topographic maps. This extends to naming conventions such as the omission of the possessive apostrophe in names such as “Coopers Creek”. One exception to this rule was O’Halloran’s Creek in northern South Australia. This watercourse was named by Sturt, but does not appear on modern topographic maps. I have therefore preserved the nineteenth century spelling, with its possessive apostrophe, when referring to this creek.

Finally, the addition of square brackets around punctuation marks and the insertion of the term [BLANK] to denote missing words will be noted in some quotes from the journals of Sturt, Basedow and Grenfell Thomas. These annotations are the work of the journals’ original editors; Davis (2002) in the case of Sturt’s journal, and David Kaus of the National Museum of Australia who has prepared an unpublished transcript of the journals of Basedow and Grenfell Thomas. Since these annotations are intended to preserve the meaning of the quotes as intended by the original authors, I have maintained them throughout.

2.0 LITERATURE REVIEW: THE AIMS AND METHODS OF HISTORICAL ECOLOGY

The aim of this study is to collate historical information which may provide insights into the dynamics of waterbodies in the Lake Eyre Basin over a time-scale of approximately one and a half centuries by analysing the journals and diaries of nineteenth and early twentieth century explorers and travellers who traversed the Basin. A secondary aim of the project is to spatially locate and map observations of environmental and ethnographic interest within these sources. The aims and methodological approach therefore place the study firmly within the discipline of historical ecology, which can be defined as "an attempt to reconstruct historic ecosystems and account for the changes they have undergone" (Gaynor & McLean 2008). More specifically, this project falls within the ambit of applied historical ecology, which in a major review of the discipline's status was defined as "the use of historical knowledge in the management of ecosystems" (Swetnam *et al*. 1999). It is the primacy of this concern with the biophysical environment which distinguishes this particular branch of historical ecology from environmental history, a broader discipline which seeks to understand the interplay between past cultures and environments (Bowman 2001).

Historical ecology in the sense of an attempt to reconstruct past environments has its origins in the recognition that both scientific research and natural resource management can benefit from an understanding of variation in ecosystems over temporal scales exceeding those normally enabled by experiments or monitoring programs (Swetnam *et al.* 1999). Within this context, the timescales of interest to historical ecologists generally range from decades (thus overlapping with some long-running experiments or monitoring programs), to the thousands of years typical of palaeoecological techniques (Swetnam *et al*. 1999).

Embedded within this awareness of the importance of understanding environmental and ecological variation over long timescales is the concept of the 'shifting baseline' (Lotze & Worm 2009; Jackson *et al*. 2001; Pauly 1995). This idea also takes as its starting point an acknowledgement of the insights which can be gained through an increased appreciation of the historical context. It then extends this to incorporate an explicit recognition of the 'collective amnesia' by which each successive generation of resource managers and users views the environmental conditions prevailing at the

commencement of their working life as 'normal' (Pauly 1995). The result is a gradual acclimation to environmental change. The originator of the concept, a fisheries scientist, links this tendency to the inability of resource management disciplines embedded within a scientific positivist tradition to incorporate non-empirical or qualitative information:

> *...fisheries science does not have formal approaches for dealing with early accounts of 'large catches' of presently extirpated resources, which are viewed as anecdotes. Yet the grandfather of my colleague Villy Christensen did report being annoyed by the bluefin tuna that entangled themselves in the mackerel nets he was setting in the waters of the Kattegat in the 1920s, and for which no market then existed. This observation is as factual as a temperature record, and one that should be of relevance to those dealing with bluefin tuna, whose range now excludes much, if not all, all of the North Sea"* (Pauly 1995, p. 430).

To date, the shifting baseline concept appears to have been applied most actively by fisheries scientists and marine ecologists (see for example Lotze & Worm 2009; Jackson *et al*. 2001; Pauly 1995), but there is no reason why it should not be used to understand changes in other ecosystems. The major value of the idea is in its explicit recognition of the manner in which each successive generation is gradually acclimated to view an increasingly depauperate natural world as 'normal'. This has important implications for the manner in which historical ecologists approach two aspects of their work. The first of these is the selection of reference sites, and the second relates to making decisions about how far back in time one needs to look in order to capture the full extent of historical abundances or variation in a given ecosystem.

Ecologists have applied historical information across a very wide range of ecosystems, species and processes, including the reconstruction of nineteenth century fire regimes in Californian chaparral communities (Goforth & Minnich 2007), changes in the abundance of a variety of animal, bird and fish species in marine (Lotze & Worm 2009; Jackson *et al*. 2001), terrestrial (Gammage 2009; Abbott 2002; Lunney 2001; Kerle *et al*. 1992) and palustrine ecosystems (Dow 2009) and vegetation change in locations ranging from the Tasmanian Midlands (Fensham 1989), and the Swan River (Gaynor & McLean 2008) to Tanzania (Borjeson 2009), the Scottish Highlands (Davies & Watson 2007), and arid zones worldwide, including inland Australia (Webeck & Pearson 2005; Pearson & Betancourt 2002; Allen *et al*. 2000).

This diversity of study sites and species is matched by the range of historical sources employed. In a review of progress in historical ecology, Swetnam *et al*. (1999)

grouped these sources into two main classes, which they termed the 'natural archives' and the 'documentary archives'. The natural sources are those which are recorded or captured by biological, physical or chemical processes taking place in the natural world (Swetnam *et al*. 1999). These processes include the deposition of sediment, and the particles (such as pollen and charcoal) entrained within it, deposits of material constructed by animals, such as the nests constructed by stick-nest rats (*Leporillus* spp.), the distinguishing marks of plant and animal annual growth cycles (such as tree growth rings and the otoliths of fish) and a range of other layered records such as ice cores (Davies & Watson 2007; Pearson & Betancourt 2002; Swetnam *et al*. 1999).

The 'documentary archives', as the name suggests, encompass the myriad of records which have been written, tabulated, mapped or photographed by human beings (Swetnam *et al*. 1999). These can include, but are not limited to, diaries, journals, letters, photographs, newspaper articles, maps, plot measurements, weather observations, land survey records and illustrations (paintings and drawings) (Gaynor & McLean 2008; Swetnam *et al*. 1999).

It is important to note that a species, population, community, structure or process of interest could conceivably be recorded in more than one source, sometimes covering both the natural and documentary archives. Indeed, a major point of consensus in the literature is that the comparison of multiple lines of evidence relating to a particular topic improves the rigour of conclusions drawn from historical information (Dow 2008; Davies & Watson 2007; Goforth & Minnich 2007; Jackson *et al*. 2001; Lunney 2001; Swetnam *et al*. 1999; Fensham 1989).

Swetnam *et al*. (1999) recommend extending this comparative approach to include the testing of historical reconstructions against field experiments or model simulations. While this would undoubtedly result in a valuable increase in scientific rigour, the phenomena of primary interest to historical ecologists often operate at spatial and temporal scales which mitigate against empirical investigation. Indeed, this is often the primary motivation for utilising an historical approach in the first place. For this reason, the empirical testing of historical reconstructions appears to have been restricted to processes such as forest succession which tend to lie just within the maximum spatial and temporal scales amenable to investigation through long-term experiments or monitoring (Swetnam *et al*. 1999).

Even when direct testing of the historical reconstruction against experimental results is not feasible, a comparative approach involving the development of 'converging lines of evidence' from a range of independent historical sources remains capable of yielding useful insights. For example, Goforth and Minnich (2007) used a variety of historical documentary records including voter registration rolls, property tax rolls, insurance claims and historical weather data to critically evaluate late nineteenth century newspaper descriptions of the size and intensity of wildfires in Californian chaparral communities. The cross-verification process enabled by the use of multiple, independent sources demonstrated the prevalence of widespread exaggeration of fire size and intensity in the newspaper accounts (Goforth & Minnich 2007). Identification of this distortion had important implications for the management of fire in chaparral communities, since the historical newspaper accounts of large wildfires had been used to argue that large, high-intensity wildfires occurred prior to commencement of a regime of fire suppression in the early 20th century (Goforth & Minnich 2007).

Multiple lines of evidence were also used by Davies and Watson (2007) to study grazing-woodland interactions in the western highlands of Scotland. This study combined pollen core data, which provided information extending back approximately 1100 years, with documentary evidence of stocking rates and other land use information beginning in the 17th century. In this case, the documentary and palaeoecological information complemented one another, with written records showing that changes in the pollen record were caused by tree-clearing related to the commencement of quarrying activity (Davies & Watson 2007). In the absence of documentary evidence, the changes would have been attributed to alterations in grazing regimes, or left unexplained. Conversely, the documentary evidence unsupported by the pollen data would have been too fragmentary and ambiguous to enable quantitative analysis (Davies & Watson 2007).

While the integration of pollen data and documentary evidence provided new insights in this case, Davies and Watson (2007) acknowledge that the integration of these different types of information presented challenges. In particular, they identified differences in spatial specificity and scale, and in temporal continuity, as the major impediments to multidisciplinary research of this nature (Davies & Watson 2007). This consideration of the scale or resolution of the historical sources has both a spatial and a temporal dimension, and is of particular relevance to the application of the explorer journals in the present study. Davies & Watson (2007) noted that the

documentary sources which they consulted were fragmentary in terms of the time periods which they covered, and varied in their spatial resolution from the scale of individual farms to general, estate level information.

Swetnam *et al*. (1999) recognised these disjunctions in scale (either spatial or temporal) between the historical sources and the phenomenon of interest as one of the major limitations to the use of historical sources to answer ecological questions. While significant, these issues do not preclude the use of historical sources. Rather, they require that researchers explicitly identify the spatial and temporal limitations of their sources, and exercise caution if extrapolating beyond these (Swetnam *et al*. 1999).

In an Australian context, multiple lines of evidence, including survey plans, landscape art, remaining paddock trees and accounts written by nineteenth century surveyors and travellers were used by Fensham (1989) to reconstruct the historical vegetation of the Tasmanian Midlands at the time of first European contact with the region in the early to mid nineteenth century. This study differs from those discussed thus far by including remnant vegetation as reference sites to approximate the condition of the historical vegetation.

This use of reference sites as a proxy for an historical ecosystem or natural process of interest is a relatively common approach within historical ecology, and there are several ways in which the concept can be implemented (Swetnam *et al*. 1999; White & Walker 1997). The most usual of these is to substitute space for time, by locating proxy sites which are ecologically similar to the environment of interest, and which are thought to approximate the historical condition (White & Walker 1997). The major difficulty with this approach is finding reference sites with an appropriate degree of similarity to the historical condition, and proving that this is the case (Swetnam *et al*. 1999; White & Walker 1997). This difficulty reflects the fact that all ecosystems are unique at some scale of analysis (White & Walker 1997).

In the case of the Tasmanian Midlands, a methodology was developed which enabled the selection of remnant patches with a high level of confidence that they closely approximated the historic vegetation. Patch selection was based on the degree to which invasion by exotic plant species had taken place, and on the nature of the surrounding matrix habitat or land use type (Fensham 1989). The results of the survey of remnant patches were then combined with information from a range of

historical sources to enable a more faithful interpretation of the vegetation communities extant in the study area at the time of European settlement than would have been possible were either approach employed in isolation.

2.1 Conclusion

Historical ecologists have utilised a range of sources from both the natural and documentary archives to study past environments at time scales ranging from millennia to decades. The use of multiple kinds of historical evidence in these studies is recommended, since it enables the detection of biases and distortions in the sources. This can, however, lead to problems of comparison when attempting to integrate sources with different spatial or temporal resolutions. Issues of scale also become apparent when the historical sources are fragmentary or of insufficient resolution (in either space or time) to illuminate the ecological process of interest. Again, the use of multiple, independent sources can overcome this challenge. Providing the limitations of the data are explicitly stated, historical sources can provide ecological insights which are unattainable through other approaches.

3.0 METHODS

3.1 The sources

Electronic copies of the journals of John McKinlay and William Landsborough were obtained online from the Project Gutenberg Australia website. Project Gutenberg is a not-for-profit organisation which seeks to make printed works of all kinds available online. The journals of many other Australian explorers are also available on Project Gutenberg Australia's 'Journals of Australian Land and Sea Explorers and Discoverers' website.

Selecting an account of Sturt's expedition was more problematic, since there are multiple extant reports of this expedition. Three of these are by Sturt himself. The first is Sturt's original journal, written by him over the course of the expedition. This journal became readily available to the public following the Hakluyt Society's publication of an annotated edition prepared by Richard C. Davis in 2002.

The second is a variant of the original journal, termed the 'fair copy' by Davis (2002). It was almost certainly prepared by Sturt on his return, probably with the intention of using it as his official report to the government (Davis 2002).

Third, there is the account called *Narrative of an Expedition into Central Australia* (hereafter referred to as the *Narrative*, for the sake of brevity), also prepared by Sturt on his return from the expedition. It is a popular account, intended to inform and entertain the public and to earn profits through its sale (Davis 2002).

Of these three variants, only the *Narrative* and the copy edited by Davis (2002) are publicly available. The latter was chosen for the analysis, since it uses Sturt's original notes made during the expedition (Davis 2002; Beale 1979; Cumpston 1951). It is entitled *The Central Australian Expedition 1844-1846, the Journals of Charles Sturt*.

In addition to Sturt's accounts, the journals of two other members of the expedition are also available. One is a fragmentary journal kept by Dr John Harris Browne, the expedition's doctor and second in command. The second is entitled *To the Desert with Sturt: a Diary of the 1844 Expedition*. It was written by Daniel George Brock, who was originally hired as the expedition's armourer, but who also appears to have

been involved in the skinning and preservation of zoological specimens (Davis 2002). Browne only kept his journal very sporadically (Davis 2002), rendering it unsuitable for this project, but Brock's represents a full account of the journey. Time limitations precluded its consultation for this project, but sections of it may prove a useful counterpoint to Sturt's own journal.

Transcripts of the journals of Richard Grenfell Thomas and Herbert Basedow were obtained with the assistance of the National Museum of Australia. Copyright permission for the use of these transcripts was granted by the Mitchell Library.

3.2 Defining permanence

This study seeks to gain insights into waterbody dynamism within the LEB by comparing historical observations which provide information on waterbody permanence with present-day assessments of permanence for the same waterbodies. Assessments of current permanence are drawn from Silcock (2009), who conducted an intensive inventory and classification of permanent and semi-permanent waterbodies across the LEB.

To facilitate comparison between historical and present condition, the definition of 'permanent' and 'semi-permanent' used in this study therefore also follows the classification system developed by Silcock (2009). In this system, 'permanent' waterholes are defined as those which are not known to have dried since European settlement, which is around 1870 – 1880 for most of the LEB (Silcock 2009). 'Semi-permanent' waterholes are split into four categories, these being (i) 'almost permanent', (ii) 'infrequently dry', (iii) 'regularly dry' and (iv) 'annually dry'. These categories are explained fully in Table 1, which is copied directly from Silcock (2009, p. 13)

Table 1: Waterhole and lake permanence categories

Category	Explanation	Amount of time with water (%)	Typical frequency of drying
Permanent (P)	Has not gone dry as far as could be ascertained through oral and written record; typically knowledge dates back to white settlement around 1870-1880 for most large permanent waterholes	100%	0/130-140
Almost permanent (AP)	Only dries out in the most severe droughts, in the order of once or twice in 50 years or less	97-99%	1-2/50 to 1/130
Infrequently dry (ID)	Goes dry during moderate droughts, once a decade or less	91-97%	1/10 to 3/50
Regularly dry (RD)	Dries out at least twice a decade on average	80-90%	2/10 to 3-4/10
Annually dry (AD)	Goes dry every year or nearly every year; will do dry by end of the year in average seasons but last during good seasons	70-80%	1/1, 1/2 or 2/3

3.3 Methodological approach

The primary consideration influencing selection of a methodological approach was the need to identify as accurately as possible the geographic locations of waterholes and other observations of interest recorded in the explorers' journals. After experimenting with several different approaches, the most useful and practical technique for deriving these spatial locations was deemed to consist of a complete reconstruction of each explorer's route through the study area. Observations of waterholes and other phenomena of interest were then recorded as points along the reconstructed routes.

Remarks pertaining to five major 'themes' were recorded and geo-referenced in Appendix 1. These themes were: water, vegetation, fauna, fire and people. The 'people' theme constitutes a record of the explorers' interactions with Aboriginal people. 'Fire' refers to observations made by the explorers of wildfire, regardless of the cause of ignition. The 'vegetation' theme recorded observations of plants, whether in the form of a description of an individual species or descriptions of overall vegetation structure (i.e. 'open forest', 'scrub'). 'Water' obviously refers to waterbodies, and 'fauna' is equally self-explanatory.

A sixth category or theme, that of 'location', will also be noticed by users of Appendix 1. Explorer quotes in this category contain information which may assist in the

identification of locations mentioned by the explorers. These quotes may prove useful to other researchers, especially those conducting fieldwork.

Reconstruction of the explorers' paths utilised a range of sources in order to ensure that the plotted paths were as accurate as possible. The explorers' own descriptions of their route as recorded in their journals provided the basis for plotting their paths for each day's travelling. Typically, each day's journal entry included some form of summary of the day's journey, comprising distance and direction travelled for the day, landscape features encountered such as hills and the bends of rivers, and at times, place names. Some examples are given below:

> *About ten miles before I reached camp I made the meridian altitude of the sun 63.18, on a good land horizon; latitude 22 degrees 27 minutes 39 seconds. We came here on the following courses: 10.20 south-east and by east two and three-quarter miles; 11.40 south-south-east four miles; 12.45 south-south-east two miles to ---- Creek; 3.20 south seven and a quarter miles. Distance today sixteen miles.* (Landsborough, 31st of March, 1862).
>
> *Started back for camp; passed large numbers of natives; marked small gum sapling MK roughly; made for heavy creek that joins another at Strzelecki's Creek, and camped at a water called Tacdurrie, a small water about two miles from Gooneborrow in the main creek. Distance travelled today about twenty-seven and a half miles.* (McKinlay, 8th of December, 1861)
>
> *This day twelve months I left Adelaide. The day has been bitter cold with a strong breeze from the West, but no rain. We have passed thro a Country similar in general character to that traversed yesterday. Spinifex generally covered the summits and sides of the ridges, but grass the Vallies for the first six or seven miles. The sand hills looked like Ocean swells rising before one, and some of them were of considerable height. With the usual trees there was a large Species of Hakea, with a singularly rough bark. At six miles we came to some water and stopped to breakfast. On leaving it, we sank a small well. At 3 miles from this we left a good pond on our right, and have stopped on a flat in which there is an abundance of water, but the face of the Country is very dry, and it admits of a doubt how far we shall be able to get on if rain does not soon fall. Latterly the Country became more open, and the Soil of the flats Clay. At this place we have dug a large water hole.*
>
> *Observed Latitude by Vega 28.21.39*. (Sturt, 15th of August, 1845)

These descriptions were then compared with modern 1:250 000 topographic maps, Google Earth imagery and contemporary (that is, nineteenth century) maps, prepared by cartographers on the explorers' return from their expeditions. The contemporary maps and Google Earth imagery were particularly valuable. Without them, the derivation of latitudes and longitudes for many of the explorers' observations would have been simply impossible. The application of these two resources is explained more fully in the 'results and discussion' section. Other resources consulted on a

regular basis were biographical studies of the explorers, which often included interpretations of sections of their routes, and local histories of particular geographical areas. The latter often included quite detailed remarks regarding the paths taken by explorers, albeit for areas of limited geographic extent.

Information from all of these sources was compared and assessed to enable the determination of a latitude and longitude for each observation of interest. The weighting ascribed to the different sources of evidence (the explorers' own descriptions, nineteenth century maps, Google Earth, modern topographic maps) when assigning a latitude and longitude to an observation varied both within and between the different journals analysed. For example, as Landsborough approached the end of his journey, near the south-eastern boundary of the study area, his measurements of latitude and estimates of distance and direction travelled seemed to be extremely accurate. Derivation of latitudes and longitudes for Landsborough's observations in this area were consequently based almost entirely on Landsborough's own directions, with very little cross checking required through other sources.

In contrast, Sturt's descriptions of his track through the Goyder Lagoon area and along Cooper Creek were extremely ambiguous. Interpretation of his journal entries for this stage of the journey therefore required constant consultation of contemporary maps, Google Earth imagery, and several biographical works. Examples of complex and simple determinations of latitude and longitude extracted directly from the 'Justification' column of my working spreadsheet (Appendix 1) are given in Box 1.

Box 1 Simple and complex examples of the rationale used in the determination of latitudes and longitudes.

Box 1: Simple and complex examples of the rationale used in determination of lat/longs.

Complex: Charles Sturt, Cooper Creek, North West Branch, 13OCT1845:

A combined reading of Sturt's journal entry for the 13th of October and the Arrowsmith map reveals that Sturt has struck one of two tributaries of Cooper Creek. Once again, however, a more precise plotting of Sturt's path proves elusive.

The difficulty in determining exactly which tributary Sturt struck begins back on Strzelecki Creek, and illustrates the manner in which errors or uncertainties in the interpretation of the explorer's routes can have a "ripple effect", with one unclear leg of the journey casting doubt on subsequent stages until a clearly recognisable landmark is reached.

I assigned the lat/long for the point at which Sturt struck Strzelecki Creek based on a north-westerly path plotted from Fort Grey. While the resulting contact point with Strzelecki Creek is probably approximately correct, it is not precise enough to form a reliable 'anchor point' from which to reconstruct Sturt's course north to Cooper Creek at a scale sufficiently fine to enable a confident decision to be made regarding the two tributaries, these being only about four miles apart. Sturt's stated distance travelled for the 12th of October (the day before he struck the creek) is 34 miles, but this is of little help in determining which of the two tributaries is correct, since we don't know Sturt's precise departure point from Strzelecki Creek. Nor is his campsite of the 12th of October 1845 (the night before he struck the tributary) identifiable with the accuracy required for the 34 miles remark to be of assistance.

Sturt's description of events subsequent to his discovery of the tributary make the matter no clearer, although his comment that the tributary contained "...a sheet of water the termination of which we could not see [?] [extending?] to the NNW..." seems to suggest that this may be a snaking section of the tributary I have selected, rather than the alternative tributary to the east, which has no reaches which could conceivably be described as coming from the NNW, and which from the Google Earth imagery also appears to contain fewer and smaller waterholes than the tributary I have selected.

However, Sturt's stated distance travelled of four miles from the tributary to the main branch of Cooper Creek ("...altho we had only come four miles from where we had breakfasted I determined to halt for the day") does not fit very well with the tributary I have assigned, since it is only 2.31 miles from the tributary at the approximate point at which Sturt may have struck it (based on his description of the reach from NNW) and the main channel. Furthermore, this distance allows for a substantial diversion to climb a sandhill, as stated in his entry for the day. The straight-line distance is much shorter. Yet this appears to be the path illustrated on the Arrowsmith map. The distance between the alternative tributary (see 27 48'53"S, 140 30'59"E) and the main channel is a better match at 3 miles, but as discussed earlier most other features of this creek (relatively small size, fewer waterholes, lack of fit with the Arrowsmith map) suggest it is not the correct choice.

Finally, the 'large branch creek from the NE' encountered by Sturt on the 14th of October presents further difficulties of identification. At 27 44'27"S, 140 27'28"E the North West Branch of Cooper Creek takes a bend to the south just prior to joining the main channel, and in this short reach could conceivably be taken as a creek from NE (or rather, the NNE). The North West Branch is, however, a substantial, tree-lined waterway, so surely Sturt would have been able to see its overall course as he crossed the plains? Furthermore, the distance between Sturt's crossing place and the North West Branch in much less than 2 1/2 miles. Encountering the NW Branch would also have required Sturt to take a course further to the west than he seems to have done. In short, it seems that this is another part of Sturt's journey for which Beale (1979) was correct in concluding that only a general plotting is possible (at least for now).

Despite these difficulties in a fine-scale mapping of Sturt's path, we can be very confident that he visited Cooper Creek in this area, so many of his observations do retain their value. Finally, and as an afterthought, Sturt's description of the two branches of the creek flowing respectively NNW and SW is however a good fit with the area in which the tributary for which I have given the lat/long joins with the main channel of Cooper Creek.

Simple: William Landsborough, between Langlo and Warrego Rivers, 06MAY1862

The party has now left the Langlo River and is heading south-east towards a point on the Warrego River just to the north-east of Charleville. Landsborough's descriptions of distances and directions travelled match up very well with features on Google Earth.

Once a latitude and longitude had been determined for a particular observation, the explorer quote was copied into a spreadsheet (Appendix 1) along with the following information: explorer name, date of observation, quote, latitude and longitude, reliability and justification. Latitudes and longitudes were recorded in degrees, minutes and seconds directly from the Google Earth screen, then later converted to decimal degrees. Fractions of seconds were rounded to make the nearest whole second – for example, 19 59'43.53"S, 141 01'14.02"E would have been entered into the spreadsheet as 19 59'44"S, 141 01'14"E.

The 'reliability' column is my subjective estimate of the precision of the latitudes and longitudes I have derived. These categories consisted of N/A (lat/long not available), 'Poor', 'Tentative', 'Good' and 'Positive'. The meanings of these categories are described in Table 2.

Table 2 Explanation of reliability ratings accorded to geo-referenced observations from the journals

Reliability rating	Explanation
N/A	Not Available – As a result of insufficient or ambiguous clues as to location, or very confusing terrain (i.e. numerous small channels) determination of a useful latitude/longitude was not possible for the observation.
Poor	The latitude/longitude given is a general guide to location only
Tentative	There is some evidence to suggest that the latitude/longitude given is correct, but this evidence is not conclusive.
Good	There is considerable evidence to suggest that the latitude/longitude given is correct, but this evidence is not definitely conclusive.
Positive	There is no doubt about the location. Used in relation to locations with established place names, or which are otherwise geographically unmistakable.

It is important to note that the uncertainty described by these categories relates to fine-scale precision rather than to overall location. In general, the explorers' descriptions of their direction and distance of travel, combined with the identification of recognisable landmarks (major rivers, lakes, hills), made determination of their general location relatively easy. The difficulty arose in the precise identification of specific locations at spatial scales in the order of tens of metres. Individual waterholes are an example of a class of features requiring identification to this level of precision.

This point is well illustrated by the work of Browne (1993), who searched for some of McKinlay's camps along the Mary River in the Northern Territory. Perusal of topographic maps and McKinlay's journals identified general areas in which McKinlay

must have camped, but the definite identification of camp sites required numerous field trips over a period of several years and extensive use of a metal detector to locate horse-shoe nails and other metallic objects (Browne 1993).

The categories in Table 2 therefore describe uncertainty in the precise identification of particular features, rather than describing an explorer's proximity to that feature. To clarify, most latitudes and longitudes given in Appendix 1 should, regardless of their reliability rating, be within a few kilometres of the explorers' actual locations. However, for a 'Good' reliability rating, there would be reason to believe that the specific location (i.e. waterhole, creek, or campsite) mentioned by an explorer is identifiable, to approximately tens of metres. This situation arose most frequently where identifiable landmarks, such as distinct bends in rivers or creeks, were involved.

In contrast, a location fix to which I assigned a 'Poor' reliability rating may well still be close to an explorers' actual location, but would be much harder to confidently identify. This situation arose frequently in terrain dissected by numerous small creeklines or channels, which appear very similar to one another on topographic maps and Google Earth imagery. Under these conditions, one may still be confident that a particular observation from the journals was made somewhere within (say) a two kilometre 'transect', but not be able to identify the exact creek to which an explorer was referring.

Where the derivation of latitude and longitude for a particular observation was complex or obscure, I also added the rationale I used to arrive at the eventual selection to the 'Justification' column.

4.0 RESULTS AND DISCUSSION

The main aim of this project was the collation of historical observations and the derivation of spatial locations for them. A second aim was the interpretation of change and its possible causative mechanisms from these observations. This section addresses both of these aims, beginning with a critique of the methodological approach used.

Some key observations from the journals are then identified and discussed in terms of the insights they provide and the manner in which they demonstrate the application of historical sources in ecology. The major focus of the discussion is waterhole permanence, with a subsidiary section devoted to observations of mammals of ongoing conservation or management interest.

The ethnographic or anthropological interpretation of Aboriginal culture at the time of first contact with Europeans is beyond both the scope of this report and my own training. While the explorers' experiences in this field are recorded and geo-referenced in Appendix 1, I have not attempted any further analysis of these. It is however hoped that these observations may be of use to a suitably qualified researcher. Similarly, meaningful interpretations of the numerous ornithological and botanical observations contained within Appendix 1 could form the basis of studies in their own right, and are not analysed here.

Before moving on to discuss the content of the journals, the process of reconstructing the explorers' paths and geo-referencing observations from the journals will be briefly discussed.

4.1 Discussion of the methodology

The methodological approach used raises several points for discussion. The first of these is the value of Google Earth and contemporary (nineteenth century) maps for plotting the paths of the nineteenth century explorers in inland Australia. Second, the approach used in this study will be critiqued in order to suggest improvements for future work of this nature.

The value to this project of the imagery presented by Google Earth cannot be overstated. While some of this work could have been conducted with hard-copy

aerial photography, coverage within the study area was limited. In contrast, Google Earth provided complete coverage, often at a surprisingly high resolution given the remoteness of much of the study area.

A second, almost equally valuable feature of Google Earth, was the facility with which lines, paths and polygons could be created and their lengths or perimeters measured. While these latter tasks could be performed with the aid of a topographic map and appropriate instruments, their automation through an accessible, web-based application saved considerable time. Given the time-consuming nature of the task in general, this was an important consideration.

The ability to quickly plot paths was also useful in those cases when an explorers' description of a particular leg of their journey could have been interpreted in several different ways. Multiple paths could be plotted in Google Earth and the 'best fit' obtained by comparing the explorers' descriptions of distance and direction travelled with landscape features on the imagery. The Google Earth imagery can also be tilted to allow the viewer a more horizontal perspective of the scene. This was sometimes useful when interpreting explorers' travel through hilly country, or when attempting to identify hills of very low relief.

The usefulness of Google Earth in this study is best demonstrated by the application of the imagery to the reconstruction of Sturt's route. Several authors who have attempted this task have been frustrated by the numerous inconsistencies between the different accounts of this journey written by Sturt himself, and by the ambiguity or brevity of Sturt's description of his route.

Most notably, Beale (1979) reports on the attempts of an experienced military surveyor, Brigadier Lawrence FitzGerald, to reconstruct Sturt's route. Despite his extensive experience in both surveying and following the paths of nineteenth century land explorers, Brigadier FitzGerald was "obliged to give up Sturt as a bad job because of the dearth of reliable data resulting from most unusual conflicts in the records" (Beale 1979, p. 8). Beale continues on to identify major errors in Sturt's measurement of latitude, concluding caustically that

> *…one wishes joy and plenty of good luck to the future historical geographer who aspires to make sense of Sturt's botch*. (Beale 1979, p. 183)

Before condemning Sturt's navigational abilities too roundly, it must be noted that the primary aim of Beale's book *Sturt, the Chipped Idol*, was the deconstruction of the

image of Sturt as a ‘great man’ established by earlier biographers such as Cumpston (1951) and Langley (1969) (Davis 2002). As a consequence of this aim, Beale (1979) is so relentlessly critical of Sturt as to lead a more recent editor of Sturt’s journal to comment:

> *Beale’s evidence is overwhelming that Sturt was capable of pride, that he often maintained an Olympian detachment from the men he led, that he exaggerated some of his accomplishments, and that he was better rewarded for his efforts than he acknowledged. But in making his case, Beale picks away so incessantly at anything that could possibly reveal Sturt in an unfavourable light that, as I say, the ultimate effect is sinister.* (Davis 2002, p. lxvii)

Indeed, Beale even goes to the extent of enlisting the help of a medical specialist in an attempt to demonstrate that Sturt’s conduct on his expedition was not only incompetent, but actually pathological.

Even when allowance is made for Beale’s possibly excessive zeal in the identification of Sturt’s shortcomings, the navigational aspect of that explorer’s journal does not admit of easy interpretation. Davis (2002) identified numerous inconsistencies relating to distances and directions of travel in the six extant variants of Sturt’s journal he consulted during the preparation of his edition. While these differences can be confusing, Davis (2002) and Beale (1979) both conclude that Sturt’s original journal (that is, the copy written by Sturt during the course of the expedition) is probably the most accurate of the extant accounts.

Swan and Carnegie (1979) also evaluated Sturt’s expeditions, using them as ‘case studies’ in a book intended to instruct school students in the methods of historical research. While praising the geological, botanical and anthropological observations of the *Narrative*, they are similarly critical of Sturt’s approach to detail:

> *I can only conclude from the evidence Sturt has provided that carelessness was a habit, whatever the state of his eyesight.* (Swan & Carnegie 1979, p. 78)

This comment about Sturt’s sight refers to eye damage related to the ophthalmia from which Sturt, like many other inland explorers, suffered during his Central Australian expedition.

The purpose of this somewhat lengthy detour from the topic of Google Earth’s usefulness is not to make further judgements on Sturt’s competence as a navigator, but rather to demonstrate the difficulties encountered by previous authors whose attempts to reconstruct Sturt’s route predate the availability of this imagery. Even with this advantage, reconstruction of Sturt’s path poses many challenges, as the

relatively high proportion of observations to which I have assigned a reliability rating of ‘Poor’ or ‘Tentative’ in Appendix 1 attests.

There were nonetheless portions of Sturt’s route which, by comparing Google Earth imagery with Sturt’s descriptions and directions, I was able to reconstruct with apparent accuracy. Perhaps the best example of this is the portion of Sturt’s journey made in a north-westerly direction from Goyder Lagoon to the Mulligan River. For this portion of the journey, landscape features described by Sturt including extensive flats of cracking clay soil, gibber plains, tree-lined channels and possibly even stands of dead trees are visible in the Google Earth imagery at the approximate locations described by Sturt in his journal. Without this imagery, tracing this section of the expedition’s path would have been highly speculative.

While Google Earth proved invaluable to this study, it did not eliminate uncertainty. Gammage (1984, p. 59) concluded his interpretation of Sturt’s tracks through the Narrandera area of New South Wales during his 1829 exploration of the Murrumbidgee River with the following qualification, which applies equally to the present study:

> *No claim can be made to have proved conclusively the location of any site discussed here. I can only say that I offer the above suggestions fully aware of the valuable but conflicting opinions of my predecessors, and that hitherto no opinion has managed to reconcile all the evidence Sturt provides.*

If Google Earth was of great assistance in the location of landscape features at a relatively fine spatial scale, the contemporary maps prepared from the explorers’ journal upon their return were equally useful in establishing the general routes taken by the various expeditions. While these maps generally only consisted of a line representing the path taken by the expedition, with landscape features (watercourses, lakes, topographic relief) represented in a stylistic way, they enabled a clearer insight into the relative position of features mentioned by the explorers. They also provided confirmation of general direction of travel.

A map made in 1862 by Richard J. Loveday and W.G. Harris of the Surveyor General’s Office showing McKinlay’s route in search of Burke and Wills proved particularly valuable in reconstructing the path of that expedition through the Coongie Lakes area of northern South Australia. While widely recognised as an extremely capable explorer (Lockwood 1995; Browne 1993), McKinlay frequently omitted bearings and distance travelled from his daily journal entries, making reconstruction of his path from the journal entries alone extremely problematic. The map, while

stylistic, does show the shapes of the lakes visited, as well as their positions relative to one another. The value of this map in reconstructing McKinlay's path cannot be overstated; the derivation of point locations for many of his observations would have been simply impossible without it.

A final point of importance for any future workers attempting to either use the spreadsheet in Appendix 1 or attempt their own reconstructions of the explorers' paths relates to the interpretations of the explorers' written words. It can be said without exception of the explorers whose journals were analysed for this project that each attempted to record their observations clearly and faithfully. However, it is inevitable that ambiguities will appear in any attempt to describe through the written word an entity as multi-faceted as a landscape. I refer here not to those subtle distortions which have their origins in differences between nineteenth century perceptions and imaginings of inland Australia and those of our own age (see for example Ballinger 2008; Sanderson 2004), although of course these are present too, but rather to the numerous small technical difficulties.

There is perhaps no better example of this than the issue of describing travel along the banks of a river. When an explorer writes of travelling along the left, or right, bank of a river, what do they actually mean? The 'left' bank facing in their expedition's overall direction of travel? Or the 'proper left bank', derived from the river's direction of flow? While apparently trivial, confusion on this point has major implications for the accuracy of the reconstruction.

Based on the journals analysed for this study, it seems that both practices were followed, but that individual explorers were consistent in their usage of the terms. For example, Landsborough, a pragmatic bushman, seemed to base his usage on his expedition's overall direction of travel to the south-south-east, whereas Sturt, a former military officer and surveyor (even if self taught) employed the more technically correct approach and referred to the left and right banks in relation to the river or creek's direction of flow. In the many cases where the rivers and streams he encountered were dry, he gauged this through the overall fall of the land.

Exactly which usage an explorer is employing was usually unclear when I commenced tracing their paths. This can initially cause some difficulty, but it was my experience that sooner or later a comment will be encountered which allows a confident orientation. This generally occurs when a comment to the left or right bank

of the river occurs in conjunction with readily identifiable landscape features such as hills or major bends in a river.

This issue of the left and right banks is only one example of the many 'technical ambiguities' which will almost inevitably be encountered in any attempt to reconstruct an explorers' route. As a general rule of thumb for inland Australia, these ambiguities will tend to be more numerous, and perhaps more puzzling, in the accounts of explorers and travellers whose journeys were made prior to the 1860s -70s. After this time, pastoral expansion began in earnest, and the consequent rise in the number of stations, bores and generally accepted place names for landscape features provides a much larger network of 'known points' upon which to base the reconstruction.

4.2 Insights from the journals: what can the explorers tell us?

4.2.1 Water

The search for potable water was a constant preoccupation of explorers in inland Australia. Indeed, the search for water was generally the main determinant of their daily path and their selection of campsite. This was particularly true for explorers during the earlier phase of nineteenth century exploration, such as Sturt, who travelled with bullock drays, flocks of sheep and large numbers of horses. In his journal entry for the 4th of November 1844, Sturt estimated that his party required 1200 gallons of water per day.

Given this importance, it is not surprising that frequent mention of the search for water is made in the journals of all explorers whose accounts were analysed by this project. However, while the search for water is a constant theme throughout the journals, not all of these comments are useful for making inferences regarding permanence. It was common for explorers to simply state that they camped 'on water' for the evening, without mentioning whether they were on a waterhole, a reach of a stream, or simply a puddle of rainwater.

Where more detailed comments regarding waterhole size or permanence are made, there are two major barriers to the use of these comments in making inferences about waterhole permanence. The first of these is accurate identification of the waterhole of interest. With the exception of Basedow, whose Medical Relief

Expedition of 1919 travelled through a landscape already altered by an extensive network of bores, the explorers' whose journals are analysed for this project tended to travel along rivers, creeks and other watercourses. Identification of the river or creek along which the explorers were travelling at any given point in their journals very rarely presented a major difficulty in this project, with a combination of place names, descriptions of the river's course and bearing and distance of travel usually enabling a confident identification. However, the journals consistently fell short of the finer-grained spatial resolution required for the confident identification of individual waterholes within these channels. Disparity between the spatial or temporal resolution of the historical resources and that required for an understanding of the ecological processes of interest is an important and ubiquitous challenge in historical ecology and a recurring theme in the literature (Davies & Watson 2007; Swetnam *et al*. 1999).

In those cases where a waterhole mentioned in an explorer's journal can be confidently identified, two interlinked challenges remain to the use of the explorers' accounts in the detection of change in waterbody permanence. The first of these relates to the amount of rainfall received by the study area prior to a particular explorer's visit, and the second to the temporally fragmented nature of the record.

These two problems are linked because the explorers typically did not stay at any given waterhole for long periods of time, with the result that a short visit to a waterhole filled by recent rains provides almost no insight into the permanence of that waterbody. These challenges are, however, more readily overcome than that of confidently identifying the location of individual waterholes in the first place.

The first of these problems (amount of rainfall at the time of the explorer's visit) can be avoided with relative ease by concentrating on the journals of exploratory expeditions undertaken during extended dry periods. As remarked by Silcock (2009), drought provides a 'test' of waterhole permanence; if an explorer writes of finding a reliable source of water in the midst of an extended drought in the LEB, we can be fairly confident that the waterhole is at least semi-permanent. The solution of the second problem, that of the short duration of most explorers' stays on a given waterhole, is slightly more complex, but nonetheless does admit of several possible solutions.

Several authors working in the field of historical ecology have noted that the historical record is often fragmentary in both space and time (Borjeson 2009; Davis & Watson

2007; Gale & Haworth 2002). This applies particularly to documentary records (Davis & Watson 2007; Swetnam *et al.* 1999). In this study, temporal fragmentation of the record is most apparent when a given waterhole was visited for a short period of time by only one of the explorers. This is the case for most of the waterholes visited by both Landsborough and McKinlay (although McKinlay and his party did have an extended stay in the Coongie Lakes). Clearly, it is difficult to draw conclusions about the permanence of a waterbody based on a single visit to a waterhole, unless that visit took place during an extended drought.

Under some circumstances, however, explorers did establish semi-permanent base camps at which they spent extended periods of time. At times these long stays were enforced, as was the case with the wearisome six months spent by Sturt's expedition at the now famous Depot Glen camp on Preservation Creek in western New South Wales. On other occasions, the establishment of a relatively permanent base camp was a strategy employed to facilitate a more through investigation of the surrounding countryside. Sturt's establishment of the Fort Grey camp at Lake Pinaroo in the far north-western corner of New South Wales is an example of the deliberate establishment of a semi-permanent camp. In either case, observations of the permanence of waterholes throughout these extended stays provide a valuable insight into the permanence of waterholes at the time of first European contact with inland Australia. These considerations shape the following discussion, which aims to explore both questions of waterbody permanence and the nature of the historical record.

The discussion uses Sturt's journal as a 'backbone', with observations from Landsborough, McKinlay and Basedow being introduced where they provide additional insights. Sturt's journal was chosen for the departure point of the analysis for three major reasons. First, he travelled during a very dry time, thus providing an effective 'test' of the permanence of the waterholes he visited. Second, his approach of establishing base camps from which he investigated the surrounding country tended to result in repeated visits to locations, as did his overall route, which involved retracing his outwards steps for much of the return journey. Third, Sturt's descriptions of waterholes and other natural phenomena are generally more comprehensive and detailed than those of Landsborough, McKinlay and Basedow (with the possible exception of Landsborough's descriptions of vegetation structure).

Since the majority of the time spent on this project was used in the collation of the information and identification of spatial locations, this section does not constitute a

comprehensive analysis of the record. Rather, the aim of this discussion is to highlight some important observations from the journals.

4.2.2 Insights into waterbody permanence from the explorer accounts

I examined observations from the journals relating to eight waterbodies or groups of watercourses, these being O'Halloran's Creek in northern South Australia, sandy creeklines in the Barrier Ranges of New South Wales, Strzelecki Creek, Ooga-boogina Waterhole (also in northern S.A.), Lake Lady Blanche in the Coongie Lakes, the Mulligan River in far south-western Queensland, the waterholes of Cooper Creek around Innamincka and a rockhole on Quartier Creek, a tributary of Cooper Creek on Durham Downs Station, Queensland.

A preliminary examination of the evidence for these locations did not find conclusive evidence for changes in the permanence of waterbodies within the LEB. However, some aspects of the O'Halloran's Creek, Barrier Ranges and Strzelecki Creek observations suggest that changes may have occurred in these locations. This lack of definitive evidence does not imply that changes have not taken place, but rather that this particular record lacks the spatial and temporal resolution to detect them. In effect, the 'signal' of siltation in waterholes is obscured by the 'noise' of rainy seasons, intermittent visitation by explorers to waterholes, incorrect interpretations of 'permanence' by observers unfamiliar with inland Australia, the natural variability inherent in the system and the difficulty of precisely identifying waterholes described in the accounts.

This lack of apparent change does not, however, mean that the record is bereft of remarks which provide useful insights into the historical dynamism of LEB waterholes. On the contrary, the journals provided numerous insights into the condition of LEB waterbodies at the time of European contact.

4.2.2.1 The O'Halloran's / Talleranie Creek Mystery

4.2.2.1.1 Identifying O'Halloran's Creek: Two Possible Alternatives

With regard to the detection of dynamism in waterholes, the most noteworthy series of observations to emerge from Sturt's journey may well be those relating to O'Halloran's Creek. This creek is shown on a contemporary map of Sturt's route as lying approximately equidistant between Deparanie Waterhole on Cooper Creek and the southernmost margin of Sturt's Stony Desert (Figure 1). The nineteenth century

map of Sturt's route used in this reconstruction was prepared by the London cartographer John Arrowsmith, and is hereafter referred to as the 'Arrowsmith map'.

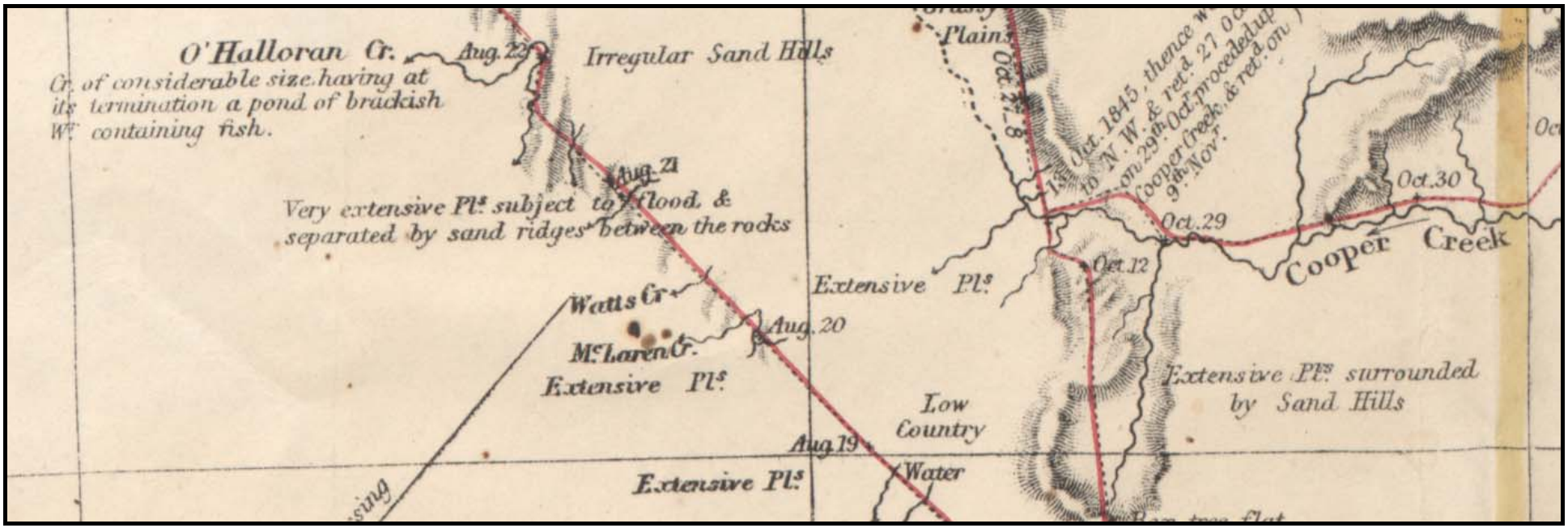

Figure 1 Extract from the Arrowsmith map showing the location of O'Halloran's Creek in relation to other landmarks in the area. The red line represents Sturt's path.

Sturt first encountered O'Halloran's Creek on the 22nd of August 1845 as he travelled north-west from Fort Grey with Browne, Flood, Lewis and Cowley on his way to the Mulligan River. O'Halloran's Creek is listed in the South Australian Gazetteer of place names on the basis of its description in Sturt's journal, but its modern-day locality is officially unknown.

Sturt's directions for the section of his journey which includes O'Halloran's Creek are ambiguous, but admit of two broad interpretations; that proposed by Cumpston (1951), and my own. Figure 2 illustrates both of these possible routes, with Cumpston's suggestion shown in blue and mine in red.

In summary, Cumpston shows Sturt travelling in a straight line to the north-north-west from Fort Grey in north-western New South Wales, crossing Strzelecki Creek between Mudlalee and Della Waterholes (perhaps close to Dullingari Waterhole) then continuing on to cross Cooper Creek close to the location now known as Coontie Hill. Having crossed Cooper Creek, Cumpston shows the expedition maintaining a straight course to the north-north-west across Goyder Lagoon.

My interpretation of Sturt's path differs in that I believe he struck Strzelecki Creek close to Toolache and Mudlalee Waterholes, then travelled on to the long, thin Ooga-boogina Waterhole. From Ooga-boogina I posit that Sturt moved on to the southernmost margin of Cuttapirie Waterhole on Cooper Creek, travelled north along the main channel of Cooper Creek, then encountered its sharp bend to the west in the vicinity of Darbys Waterhole. These locations are displayed in greater detail in Figure 3. I argue that he then travelled west along Moonlight Flat for a short distance before once again resuming a north-westerly course which bought him to O'Halloran's Creek, which I believe to be modern-day Talleranie Creek.

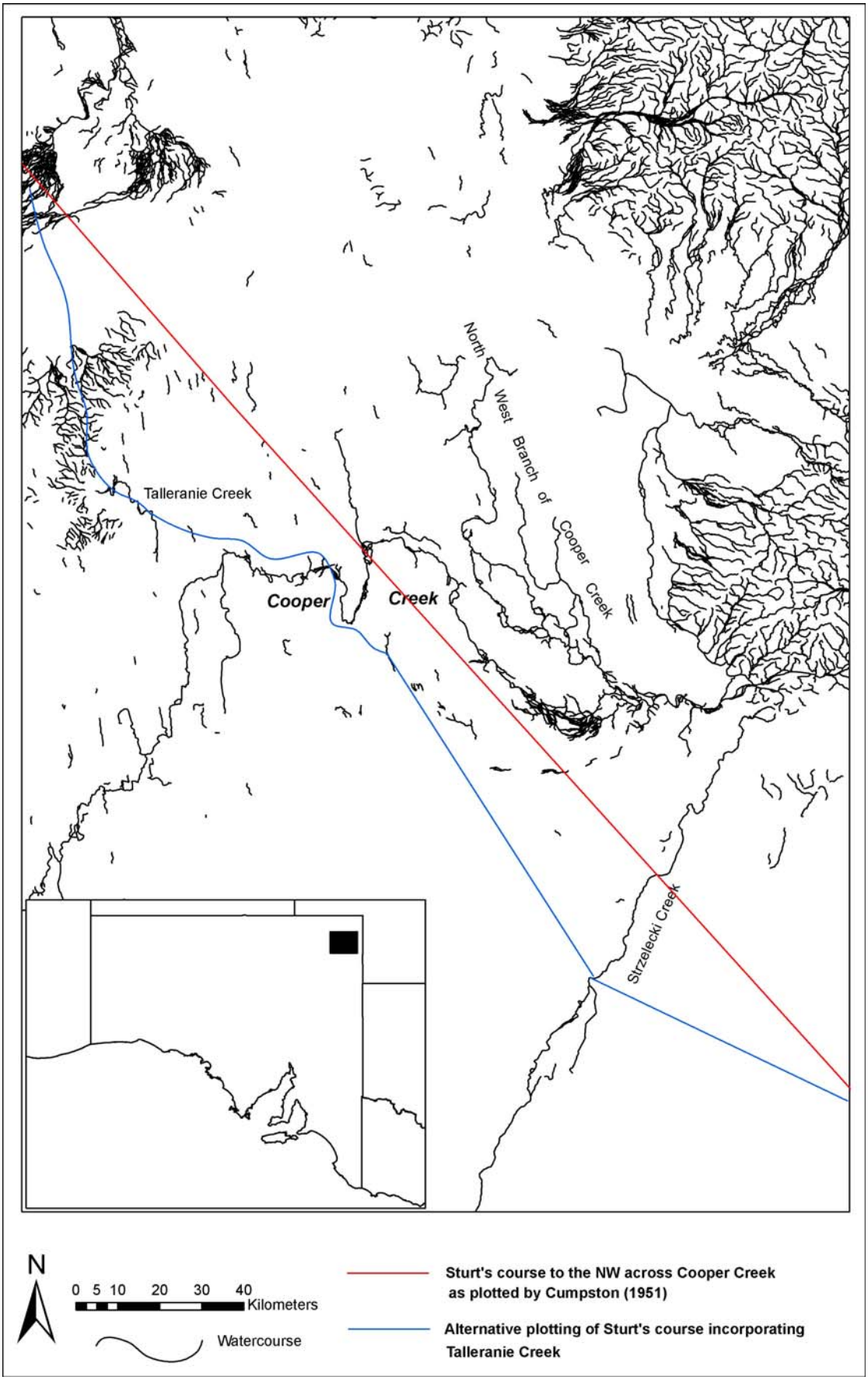

Figure 2 Two interpretations of Sturt's route through the Cooper Creek area in August 1845

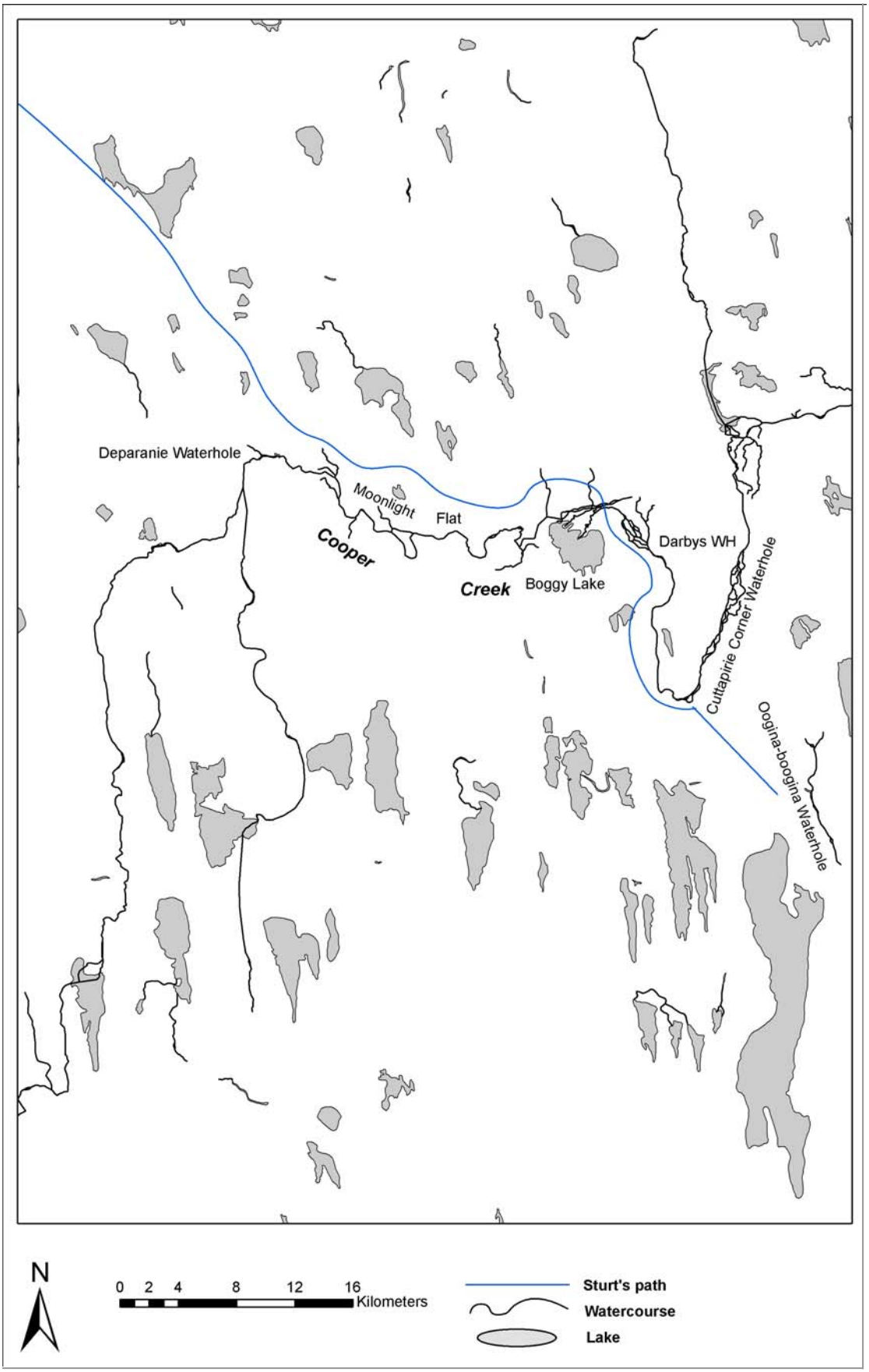

Figure 3 My interpretation of Sturt's path to the north-west in August 1845, incorporating Cooper Ck.

Correct identification of O'Halloran's Creek has implications for understanding waterbody dynamism, since Sturt describes a waterhole in O'Halloran's Creek which may have been permanent or semi-permanent, and which may have subsequently undergone significant reduction in water holding capacity. In this discussion, therefore, I outline the evidence for both interpretations.

It should be noted at the outset that Cumpston's primary purpose was not the reconstruction of the expedition's route. Rather, his book is primarily biographical, and aims at an overall understanding of Sturt's personality and career. The reconstructions of various sections of the party's route presented by Cumpston therefore seem intended mainly as general guides for the reader.

Nonetheless, Cumpston's description of Sturt's path through this area has some attractive features. First, it accounts parsimoniously for the significant distance and the high sandhills which Sturt's journal and the Arrowsmith map describe as lying between O'Halloran's Creek and the south-easterly margin of Sturt's Stony Desert.

In his journal entry for the 25th of August 1845, Sturt comments that "…we had left all water known to us about 35 miles behind". This comment was made as the party drew close to the southern margins of the area of gibber plains which would become known as Sturt's Stony Desert. The journal and Arrowsmith map also show that it took the party almost three full days (the 23rd, 24th and 25th of August) to traverse the distance between O'Halloran's Creek and the Stony Desert. Furthermore Sturt (25th of August 1845) describes the sandhills "from eighty to 100 feet high, and very abrupt, with bare and uneven summits full of hollows and clumps of Spinifex…" which lay across their path.

Cumpston's reconstruction accounts for both this distance and difficult terrain very well. On the course suggested by Cumpston, there are almost exactly 35.5 miles between Sturt's putative crossing point of Cooper Creek Hill to the southern edge of the Stony Desert. Furthermore, Google Earth imagery shows that much of this area consists of dune fields.

Second, the Arrowsmith map's depiction of the course of Cooper Creek contains errors which suggest the possibility that O'Halloran's Creek was not a separate creek at all, but rather a subsidiary channel of Cooper Creek. The presence of these errors tends to support Cumpston's reconstruction, which does not attempt to identify O'Halloran's Creek. Since Cumpston worked from the Arrowsmith map, which plainly

shows O'Halloran's Creek as a separate watercourse, this omission presumably means that that he believed O'Halloran's Creek to have simply been a branch or channel of Cooper Creek.

Specifically, the Arrowsmith map is erroneous in that it shows the main channel of the Cooper terminating at a point approximated by Deparanie Waterhole, with Sturt then crossing small, unrelated creeks labelled as 'Watts Creek' and 'McLaren Creek' to the west of this point. As Figure 1 shows, the Arrowsmith map thus implies that Sturt did not encounter Cooper Creek at all during this leg of his journey. This is clearly incorrect, with his journal during this period containing numerous descriptions of large waterholes which can only have been on Cooper Creek.

The Arrowsmith map's termination of the Cooper around Deparanie Waterhole, and its consequent naming of Watts and McLaren Creeks as creeks in their own right are clearly artefacts of Sturt's incomplete knowledge of the area, since the Cooper actually bends and begins to meander to the south and southwest immediately below Deparanie. Watts and McLaren Creeks would therefore almost certainly have been channels of Cooper Creek. Given this evidence of Sturt's incomplete understanding of the course of Cooper Creek, it seems both feasible and conservative to assume that O'Halloran's Creek was likewise simply a channel of Cooper Creek.

I argue, however, that is possible to account more explicitly and satisfactorily for O'Halloran's Creek. The route I propose has Sturt travelling northwest from Toolache or Mudlalee Waterhole on Strzelecki Creek to Ooga-boogina Waterhole, which lies just to the south-east of Cuttapirie Corner Waterhole. From Ooga-boogina, Sturt seems to have continued on a north-westerly track, before diverging "two points to the north" to reach Cooper Creek on the 20th of August 1845. This accords very well with the path one would have to take to travel from the central reaches of Ooga-boogina Waterhole to the south-eastern corner of Cuttapirie Corner Waterhole (Figure 3).

Sturt and his party then briefly investigated Cuttapirie Corner, finding abundant water and considerable evidence of Aboriginal occupation. As shown by Figure 3, Cooper Creek below Cuttapirie Corner Waterhole has a long channel which runs almost directly north-south. At the north-western termination of this channel, Cooper Creek turns sharply to the west near Darbys Waterhole and enters the area marked on topographic maps as 'Moonlight Flat'. It is upon this sharp turn to the west that my argument hinges; Sturt's journal entry for the 21st of August 1845 describes it so

distinctively that it can hardly be other than the western bend of Cuttapirie Corner Waterhole:

> *I had hoped that its course was to the NW, but we crossed it at about a mile and a half as it branched off almost due West. There were some well trodden Native paths from angle to angle of it*.

Sturt then writes of crossing plains for five miles before striking a "branch Creek with a large pool of Water in it which we crossed...". This fits well with a westerly direction of travel along the stretch of anastomosing channels and flats known as Moonlight Flat. On this course, Sturt would have passed to the north of Boggy Lake, and the branch creek with the large pool of water would have been located approximately equidistant between the western end of Moonlight Flat and Deparanie Waterhole. In this case, the branch creek and pool of water would mark the resumption of the main channel of Cooper Creek itself, as Google Earth imagery shows the creek once again forming a distinct channel at approximately this location.

After leaving Cooper Creek, Sturt then writes of crossing sandhills (on the 22nd of August 1845) before finally arriving on the creek which he later named O'Halloran's Creek. The wording of Sturt's journal at this point clearly conveys an impression of having encountered two creeklines – Cooper Creek, then O'Halloran's Creek - rather than simply crossing different channels of Cooper Creek as Cumpston's reconstruction implies. The crossing of sandhills supports this, since Google Earth imagery shows that it is not possible to cross sandhills in this area while travelling in a north-westerly direction and still remain upon the channel of Cooper Creek.

Sturt's description of O'Halloran's Creek as being "two Chains or 132 feet wide with banks of from 15 to 18 feet high" at the point at which the party struck it also supports my argument. Measurements of the width of Talleranie Creek (made with the measurement function in Google Earth) show that the creek is at least this wide for the great majority of its course; despite being quite isolated, Talleranie Creek is actually a fairly substantial watercourse.

The most serious challenge to my reconstruction is Sturt's remark on the "twenty miles of sandhills" his party crossed between O'Halloran's Creek and the Stony Desert. Travelling from Talleranie Creek in a north-westerly direction, one would begin to encounter the gibber-covered plains of the Stony Desert after only about three and a half miles; it is difficult to envisage the circumstances under which this short distance could be interpreted as twenty miles. However, there is a possible

solution to this conundrum, namely that the party actually started their day's travel from a location other than O'Halloran's Creek.

Sturt's journal entry for the night of the 22nd of August 1845, when the party were camped on O'Halloran's Creek, narrates the following incident:

> *Last night we drove the horses down the Creek past our Camp to some good feed. About 8 however something alarmed some of them and six came rushing past us upwards, and this morning were more than five miles off. The Consequence was that we did not get off until 1/2 past 8.*

It is therefore possible, though speculative, that the party did not actually begin the day's travel of the 23rd from O'Halloran's Creek, but from the location at which they eventually caught the six straying horses. This change of starting point could possibly have put them on a more northerly heading for the day, resulting in the long tramp over the sandhills.

Finally, the shape of O'Halloran's Creek on the Arrowsmith map (Figure 1) corresponds well with the shape of Talleranie Creek, as seen in Figure 2. In his journal entry for the 22nd of August 1845, Sturt also gives a verbal description of the course of O'Halloran's Creek, stating that "…it falls to the north, its general direction being SSE and NNW". This description matches Tallerannie Creek very well indeed. In contrast, if Sturt could discern a "fall of waters" in Cooper Creek, it should have been to the west or south west (i.e. towards Lake Eyre).

4.2.2.1.2 Implications for Understanding Waterbody Dynamism

If my identification of O'Halloran's Creek as Talleranie Creek is correct, what are the implications for understanding waterhole dynamism? It may be that Talleranie Creek once had permanent, or semi-permanent, waterholes which now exist only as ephemeral pools. Sturt described O'Halloran's Creek as follows in his journal entry for the 22nd of August 1845:

> *Where we struck the Creek it was two Chains or 132 feet wide with banks from 15 to 18 feet high, shewing traces of floods to their top. There was an abundance of muddy water in long Clay holes almost too thick for us to use, but the pool at which we have halted is clear, and sweet to the taste, being slightly saline, a thin crust of salt being round its margin, and Gypsum in the Soil as at Lake Torrens from which we are more than 100 miles distant to the North.*

In a more general reflection on the creeks he has recently encountered, Sturt then comments that:

> *The waters of all the Creeks are exceedingly muddy and are almost unfit for use but the truth is we have not had good water since we left the little pond under the Cliff in the Boonbaralba range in November last.* (22nd of August 1845)

This comment illustrates the difficulties encountered by the party in locating water over an extended period of time, and provides some context for Sturt's subsequent characterization of the waterhole in O'Halloran's Creek as permanent:

> *The pool near us is very deep and the water clear. There are fish in it of about ½ a pound weight but we have not taken one. The water I should imagine is permanent.* (22nd of August 1845)

In the very next paragraph, Sturt once again emphasises the scarcity of water at the landscape scale:

> *It is now nearly six weeks since we had any rain, nor is there any indication of a change in the weather. All the Surface water is dried up and we should be unable to proceed but for this fortunate feature of the Country, its creeks emanating from the last places from which one would expect such water courses to take their rise, Plains.* (22nd of August 1845)

The next day, the 23rd of August 1845, afforded Sturt the opportunity for a closer examination of the waterhole's finned inhabitants:

> *Before we started Mr Browne went to amuse himself at the water hole with a hook Lewis had made out of a pin and succeeded in catching 13 nice little fish. The Silver Perch, the largest weighed about a quarter of a pound or hardly so much. How these fish came in that clear and isolated hole it is difficult to say. They could not have come from above. Whence then came they? They are most likely the produce of Spawn left after the subsidence of the Floods. I had hopes that this riddle would have been solved by us today, but it is a singular country this[,] as anomalous as its productions, undergoing the most rapid and unaccountable changes.*

In honour of these fish, Sturt named the waterhole the 'Fish Pond'. A definite identification of these fish are not possible, but based on their size and apparent abundance in a saline, isolated waterhole, they were probably spangled perch *Leiopotherapon unicolor*, which can attain about 600 grams but are more commonly seen at 200 grams or less (Grant 2004). This identification accords well with the perch-like shape of the fish as described by Sturt, their size of 'a quarter of a pound or hardly so much', and the habitat in which they were caught.

Spangled perch are commonly found even in very ephemeral bodies of water (Unmack 2001), so the presence of these fish does not necessarily constitute evidence that the 'Fish Pond' was permanent, or even semi-permanent. Sturt's surprise at encountering the fish does however tend to support my speculation that

O'Halloran's Creek was in fact modern-day Talleranie Creek rather than just a channel of Cooper Creek. Had Sturt still been close to the deep, permanent waterholes he had recently visited along that watercourse, he would hardly have been so surprised at the presence of fish.

If O'Halloran's Creek and Talleranie Creek are indeed one and the same, the next question we need to answer relates to the permanence of the Fish Pond. As demonstrated above, Sturt judged the water to be permanent. How accurately is Sturt likely to have estimated permanency? On one hand, it could be argued that Sturt's judgement on this matter should carry considerable weight. He had at this juncture been away from Adelaide for just over a year, much of which had been spent in extremely dry conditions. He had already endured six months of virtual imprisonment at Depot Glen waiting for rain, and had observed how this water, which he had initially thought to be permanent, had dwindled with frightening rapidity. His journal is littered with remarks on the speed with which surface water disappeared in inland Australia. Sturt's detractors have been harsh in their criticisms, but even they could not accuse him of naïveté in this regard.

On the other hand, there is evidence of overly optimistic estimates of waterbody permanency even by experienced explorers of inland Australia. William Oswald Hodgkinson accompanied McKinlay on his expedition in search of Burke and Wills before undertaking several expeditions of his own. Yet in 1877 he still described as permanent, waterholes along the Mulligan River which are unlikely to have ever been so (J. Silcock pers. comm. August 2009).

Despite this, I argue that Sturt's judgement should be trusted on this matter. After all, we are specifically discussing the value of Sturt's opinion here, not Hodgkinson's, and as we have already seen, Sturt had immediate and painful experience of the scarcity of even semi-permanent water in this environment. While Sturt's detractors have frequently cast doubts upon the veracity of his observations, this criticism has most often been made in the context of exaggerations by Sturt to enable the construction of a more 'heroic' image of himself. Such criticism can surely not apply in this case, since the discovery of an unexpected source of potable water would presumably alleviate the privations experienced by an inland explorer, thereby depriving him (if only briefly) of opportunities for the heroic endurance of hardship.

There is one final piece of evidence which suggests that the Fish Pond may have been permanent or semi-permanent; there was still water in the waterhole when Sturt

and his party returned to it on their way back to Fort Grey from the Mulligan River almost exactly one month later on the afternoon of the 24th of September 1845. While illustrating the alacrity with which Mr Browne seems to have returned to his old pastime of fishing, Sturt is however frustratingly brief with regard to the condition of the waterhole:

> *Mr Browne was very successful yesterday afternoon in catching six dozen perch. They were however very small. How these fish got into that pond it is difficult to say. The water is slightly brackish, that above it is fresh and muddy. Below it there is none.* (25th of September 1845).

The party then left the Fish Pond forever. What are we to make of this? Rainfall in inland Australia is characterised by high spatial variability (Stafford Smith & Morton 1990), so it is also possible that small, localised falls could have refreshed the Fish Pond while Sturt was away to the north-west. Alternatively, the slightly saltiness of the Fish Pond also suggests that it may have been subject to recharge from groundwater (Silcock 2009).

For how long was the Fish Pond capable of retaining water? None of the other explorers whose journals were analysed for this report appear to have visited O'Halloran's Creek, although McKinlay may have passed close. Silcock (2009) did not locate any permanent or semi-permanent water on Talleranie Creek during an extensive mapping of natural waterbodies in the area.

The possibility that the Fish Pond has silted since Sturt's visit therefore cannot be ignored. Sturt's description of O'Halloran's Creek as having banks "from 15 to 18 feet high" might be a useful clue here. Significant infilling of creeks is a well-documented consequence of the deposition of eroded regolith or soil in creeklines elsewhere in Australia's semi-arid rangelands (Fanning 1999; Pickard 1994), and it would be interesting to compare the current height of Talleranie's banks with Sturt's description.

The Google Earth imagery provides a final piece of evidence in this puzzle. At its far north-western extremities, the course of Talleranie Creek becomes tortuous, and some of its reaches appear to contain either water or mud. The image does not however, allow a more definite determination. Is it possible that one of these pools may have been the Fish Pond?

To conclude, the evidence gathered during this project allows only the following conclusions;

(i) Some evidence (the resemblance of both shape and general location between O'Halloran's Creek and Talleranie Creek) suggests that O'Halloran's Creek and Talleranie Creek are synonymous.

(ii) Sturt found water on O'Halloran's Creek which he believed to be permanent, and that the same waterhole still contained water when the party returned to it a month after their initial visit during a drought of such severity that Sturt comments on not having seen any appreciable rain for 11 months.

(iii) No permanent waterholes are known on Talleranie Creek today (Silcock 2009).

Sturt's mystification at finding fish in such an isolated body of water also suggests that O'Halloran's Creek was some distance from the deep waterholes of Cooper Creek.

To claim on the basis of this evidence that permanent water once existed on Talleranie Creek but does so no longer would be extremely imprudent. However, the evidence does warrant further investigation, either through telephone calls to the relevant landholders, or (preferably) ground-truthing. As a final aside on this matter, the Fish Pond on O'Halloran's Creek clearly made something of an impression on Sturt. On the 1st of November 1845, Sturt was exploring along Cooper Creek east of the present-day site of Innamincka. A waterhole he encountered there reminded him of the Fish Pond, and his description of it therefore provides us with a final, oblique glimpse of that elusive waterbody:

> *Here the water was beautifully clear and on tasting it I found it to be slightly brackish, just in the same proportion as the little fish pond in the 4th Creek to the NW. In this also there were hundreds of thousands of little fry swimming about with some larger fish of the same size as the Silver perch we caught there.*

4.2.2.2 Sandy creeks in the Barrier Ranges, north-western New South Wales

While travelling through the Barrier Ranges of western New South Wales (Figure 4), Sturt made several observations of a particular type of waterbody – small pools contained within the sandy or gravelly beds of the numerous dry watercourses which dissect this area. Sturt's first encounter with these features came on the 6th of November 1844, one day after an eighty-eight gallon tank he had planned to use for storing water had been ruptured after jolting over rocky terrain in the cart. The

discovery of these small, but high quality, sources of water was clearly a welcome surprise:

> *From the gravelly and thirsty nature of its bed I had no hope of finding water, until we came to where the hills closed in upon the Creek, and large rocks overhung its bed. The accident to our tank would have obliged us to break in upon our supply of water in the Casks & would in the event of our not finding any water have shortened our journey some thirty or thirty five miles, but as we rode from one side of the creek to the other we found a clear small pool under a rock, which I had no doubt would afford us an abundant supply by enlarging it. We therefore let three of the horses drink at it, and to our delight found that they could make but little impression on it, the stream flowing in almost as fast as they drank it. When Morgan came up he soon altered its appearance, and made a beautiful little pond, the water of which was as clear as crystal filtered as it was through a gravelly soil…*

There are three main points of interest in this description. First, the substrate of the pool is clearly sand or gravel, rather than rock. The pools are therefore not 'rockholes' (rocky hollows or depressions which collect local runoff) (Silcock 2009). Second, the pools seem to have been subject to reasonably significant recharge from a subterranean source. The third main point of interest relates to the location of this pool. I believe this pool was found on Purnamoota or Cusin Creek (Figure 4) possibly close to close to 31 31'41"S, 141 24'52"E. The location fits Sturt's description of the hills closing in upon the creek. While the Google Earth imagery for this area is of very high quality, the pool was obviously small in size. Its detection on the imagery is therefore unlikely, even if still present. The predominantly sandy or gravelly nature of the creekbeds throughout this area is however clearly visible, punctuated with occasional outcrops of rock. Nor was this pool the only one of its type encountered by the expedition in this area:

> *We left our Camp about eight oclock, and kept on the gravelly bottom of the creek for some little distance, when in attempting to cut across an angle we found it so rocky that we could not travel any where but where the gravel prevailed. We passed several pools of water, one of them being of considerable size and debth* [sic]*, but the bed of the Creek was so rocky in places that we could hardly get the Cart on.* (Sturt, 7th of November 1844)

The Google Earth imagery shows that many creekbeds in the area today still have this predominantly sandy character, punctuated in some places by rocky outcrops.

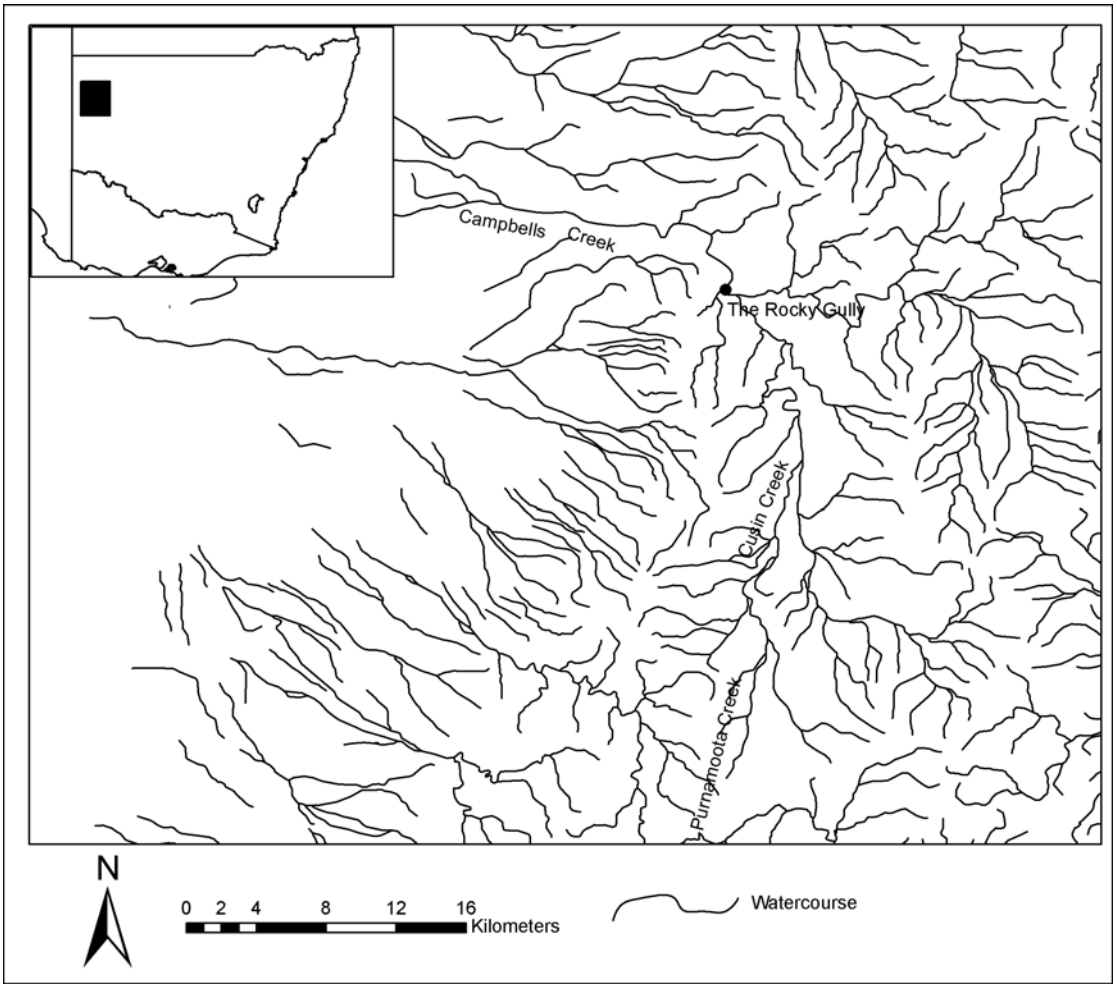

Figure 4 Small creeks explored by Sturt in the Barrier Ranges of north-western New South Wales.

On the 8th of November 1844, Browne returned from a scouting expedition to the north (probably to Campbells Creek), and reported a continuation of this creekbed morphology:

> *Mr Browne informed me that he found pools of considerable size and debth in the creek, but that from the sandy and gravely nature of its bed he feared we should not find any below the place where he had been.*

Following this excursion, Sturt and his men retreated to a base camp at Parnari Waterhole on Stephens Creek, but returned to the Campbells Creek area later in November, after some rain had fallen. His journal entry for the 27th of November seems to indicate that he believed the source of the underground water recharging the pools was runoff from the surrounding hills:

> *I find the water has diminished in the water holes notwithstanding the late rains. In fact it has not found its way down yet, and I consider the underdrainage as more favourable to us than any surface water for the evaporation and absorption is terrific in this hot position and on this thirsty soil.*

If these pools were indeed fed by runoff, they would not be expected to be permanent, with the intensity of recharge gradually diminishing with increasing time since rain, before eventually ceasing altogether. Unfortunately, Sturt's journal provides only very limited information on the longevity of these waterbodies. When the party was finally making its way back to Adelaide during the last days of 1845, they passed through the Barrier Ranges once again. Conditions for the expedition were now dire. Both men and animals were in desperate need of water, and Sturt himself was suffering from severe scurvy (Davis 2002). He does, however, mention that Browne found 'plenty of water' at the 'Rocky Gully', a term which may refer to the point at which the southern and north-western branches of Campbells Creek join (Cumpston 1951). It is possible that this was the location at which Mr Browne had found the "pools of considerable size and debth", which he reported to Sturt on the 8th of November 1844.

It is noticeable that the Google Earth imagery for the Campbells Creek location mentioned above now shows a flat, sandy bed, which looks to have an extremely limited capacity to hold water. The deposition of eroded regolith and consequent infilling of creeklines in this area since European contact is well documented in the geomorphological literature (Fanning 1999; Pickard 1994). These changes seem to have occurred very quickly following the establishment of pastoralism in the area, probably reflecting vegetation loss associated with extremely high initial stocking rates (Fanning 1999; Pickard 1994). It thus seems likely that Sturt's observations of the creeks and pools of this area constitute a rare and important glimpse at the area's immediate pre-European condition.

Cumpston (1951) provides an additional clue that silting may have occurred slightly to the north, at the Depot Glen waterhole on Preservation Creek. He visited this site during the preparation of his book, and compared its appearance with a sketch made by Sturt. Among other changes, Cumpston noted that the waterhole has 'silted up', but provides no further information.

In addition to his remarks on the area's creeks, Sturt made another observation worthy of comment during his exploration of the Barrier Ranges. While on an exploratory foray to the west-north-west of a base camp on Morphetts Creek, Sturt encountered an unusual waterbody which he described as follows:

> *Having taken bearings Mr Stuart and I descended to go to another hill, and in doing so I followed the Creek up, and at last came to a clear hole of water near which there was a Native hut. Bushes were growing round this water hole and*

> *the grass in the bed of the Creek was raised as if by the force of a Spring, as I am led to believe this was, altho I could not distinctly make out that it was so. The water however was clear and Cold, whereas that in the ponds was muddy. They all had a narrow sward of grass growing round them, but the plains on either side were barren in the extreme.* 29th of November 1844

It seems clear that this is a description of a spring, surrounded by *Phragmites* reeds. This uncertain location seems to have been Willowurrawa Creek, around lat/long 31 14'43"S, 141 10'55"E.

4.2.2.3 Strzelecki Creek

Sturt was the first European to visit Strzelecki Creek, coming upon its salty waterholes on the 3rd of August 1845, and revisiting it several times during his travels to the north and north-west. This pattern of revisitation over time provides a picture of Strzelecki Creek at the time of first European contact as a chain of waterholes, which while holding water for a considerable period of time, would ultimately go dry. Sturt first visited Strzelecki Creek on the 3rd of August 1845, striking it just south of the site upon which Carraweena Homestead (now ruined) would be established (Cumpston 1951) (Figure 5).

> *At 3 1/2 miles from where we stopped last night we reached some Gum trees (Box) that we had seen from a distance , and found that they were growing near a Salt water Creek of some size, in which there were several large deep pools of clear water, as salt as Brine. This creek came from the North and Falls to the South towards the Ranges we saw yesterday...* (3rd of August 1845)

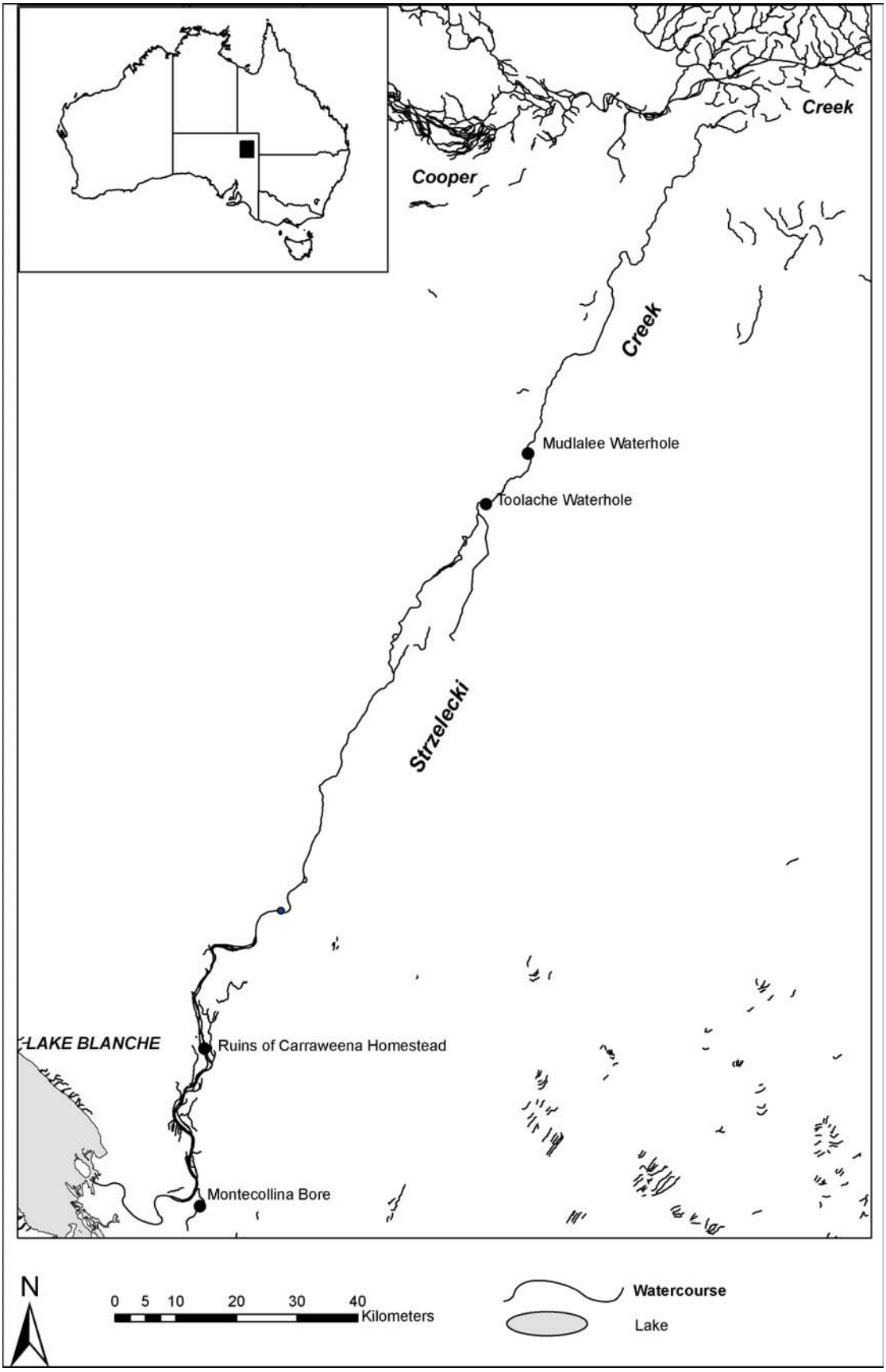

Figure 5 Strzelecki Creek, showing landmarks which assist in the identification of points visited by Sturt.

Sturt's subsequent visits to Strzelecki Creek were approximately 65 miles to the north-north-east of this point, possibly around Toolache and Mudlalee Waterholes. Indeed, the language of Sturt's journal entry for the 18th of August 1845 suggests that he did not realise (at least initially) that these northerly waterholes of Strzelecki Creek were part of the same creek he had visited earlier in the month:

> *At 2 miles Mr Browne and I struck a broad creek in the bed of which the trees were growing, for which we were in some measure prepared as it was evident to us as we rode over it that many parts of the plain were subject to over flow. We were not however prepared to find so large a creek as that which presented itself to our view. Its waters rise to a considerable height, and over flow a great extent on either side of it, but its channel in places is of considerable width, tho not deep. There is a large sheet of water close to us (for I have stopped here for the day) of about 150 yards long and fifty broad.* 18th of August 1845

The latitude and longitude I have given for the point at which Sturt struck Strzelecki Creek on the 18th of August is approximate, so a positive identification of the 'large sheet of water' he mentions is not possible. He must however, have been close to both Toolache and Mudlalee Waterholes, and could have been referring to either of these. These waterholes were visited by Basedow and Richard Grenfell Thomas during the 1919 Medical Relief Expedition led by the latter. Their descriptions of the waterholes are much briefer, with Grenfell Thomas' journal entry for the 3rd of September 1919 simply describing Toolache as a "big waterhole" inhabited by "many coots teal & black duck", while Basedow only mentions it in passing without description. Only slightly more information is provided for Mudlalee Waterhole, with Basedow describing it as "a large hole with muddy banks" (Basedow, 3rd of September 1919).

Sturt's first visit to the section of Strzelecki Creek around Toolache and Mudlalee Waterholes on the 18th of August was made as he travelled north-west from Fort Grey towards the Mulligan River. He revisited this stretch of Strzelecki Creek on the 28th of September, as he returned from the Mulligan towards Fort Grey:

> *There is an abundance of water still remaining in this fine Creek and plenty of Grass, but no natives.*

Shortly afterwards, on the 11th of October 1845, Sturt returned once again to this same reach of Strzelecki Creek, this time on his way to explore Cooper Creek:

> *I was glad to find the water holes still containing a considerable body of water, and we were fortunate enough to shoot two ducks.*

Almost exactly a month later, on the 10th of November, Sturt returned to this area, but by now the waterholes provided very little relief to his exhausted and thirsty horses:

> *When we reached the water holes we found nothing but mud in the one and the water in the other very little better than mud.*

This series of observations accords well with the current rating of the Strzelecki Creek waterholes as at best, semi-permanent (Silcock 2009). Sturt's visits and Basedow's brief comments also serve to highlight some important points about the value of the explorers' journals for studying changes in waterholes.

First, the accurate identification of individual waterholes is likely to be difficult in most cases where this record is applied. In the case of Sturt's visits to Strzelecki Creek, I was able to identify the general area in which Sturt would have struck the creek, but conclusive identification of specific waterholes proved elusive. This was not necessarily a major problem for this particular example, since Sturt's repeated visits clearly show a general trend of waterholes persisting for some time, but eventually going dry.

Second, Sturt's repeated visits to the same reaches of Strzelecki Creek over a period of approximately four months illustrate the value of a relatively rare event in the explorer record – a time series of observations on a single waterbody by the same observer over a period of time going into drought. In particular, the final visit on the 10th of November was the crucial one in terms of identifying the impermanent nature of the Strzelecki Creek waterholes. If Sturt had not made this final visit, during which he recorded the dwindling of the waterholes he had described only a month previously as 'still containing a considerable body of water', I may have reached a different conclusion regarding the permanence of the Strzelecki Creek waterholes at the time of Sturt's visit.

Finally, it is important to keep the spatial and temporal specificity of this information in mind; Sturt's observations relate to a specific area over a specific time, and the results should not be generalised to other areas, even those which are quite close. The hazards of extrapolating in this manner are illustrated by a comment made by Basedow when he visited the abandoned Carraweena Station, also situated on Strzelecki Creek, but approximately 100 kilometres to the south south-east:

> *Once a prosperous sheep station drift sand has ruined many of once good waterholes. One man in 6 weeks made [£]140 dog scalping.* (25th of August 1919)

His journal entry for the 23rd of August, two days prior to this, includes a similar comment in relation to a swamp which once existed somewhere near the Montecollina bore:

> *The swamp originally of good capacity and a favourite camp for drovers now largely filled with sand.*

Basedow did not enlarge upon this remark, and certainly did not ascribe an anthropogenic cause (i.e. overgrazing) to this smothering of waterholes by drift sand. Nonetheless, this description of a station abandoned after the obliteration of water sources by drifting sand, and now inhabited by wild dogs, does create a context within which it is easy for the reader to form an impression of human-induced damage to the land, whether or not this was Basedow's intention.

Significantly, these observations were made very close to the 'Cobbler' dune field, the formation of which has been attributed to erosion resulting from rabbit-induced vegetation loss beginning in the 1890s (Leader-Elliot & Iwanicki 2003). However, the LEB's dunefields are inherently mobile, and significant shifts in location within the span of human lifetimes, including infilling of watercourses, may simply represent natural dynamism (Twidale & Wopfner 1990; Wopfner & Twidale 1988). Nonetheless, the formation of mobile dunes is known to be symptomatic of land degradation in drylands throughout the world (Dregne 2002), and further investigations of the origins of the Cobbler dunefield are warranted. Identification of an anthropogenic cause for the formation of the Cobbler would suggest that infilling of nearby waterholes by sand had a similar cause.

4.2.2.4 Ooga-boogina Waterhole – visits by Sturt and McKinlay

Ooga-boogina Waterhole is a long, thin waterhole found in northern South Australia (Figure 6). It runs approximately north-south, and is a channel connecting two unnamed dry lakes. The latitude and longitude 27 39'45"S, 139 58'10"E marks its approximate centre. It was not identified as permanent by a major survey of waterbodies in the LEB (Silcock 2009), and the historical record provides no evidence to suggest that it was permanent at the time of European contact with inland Australia.

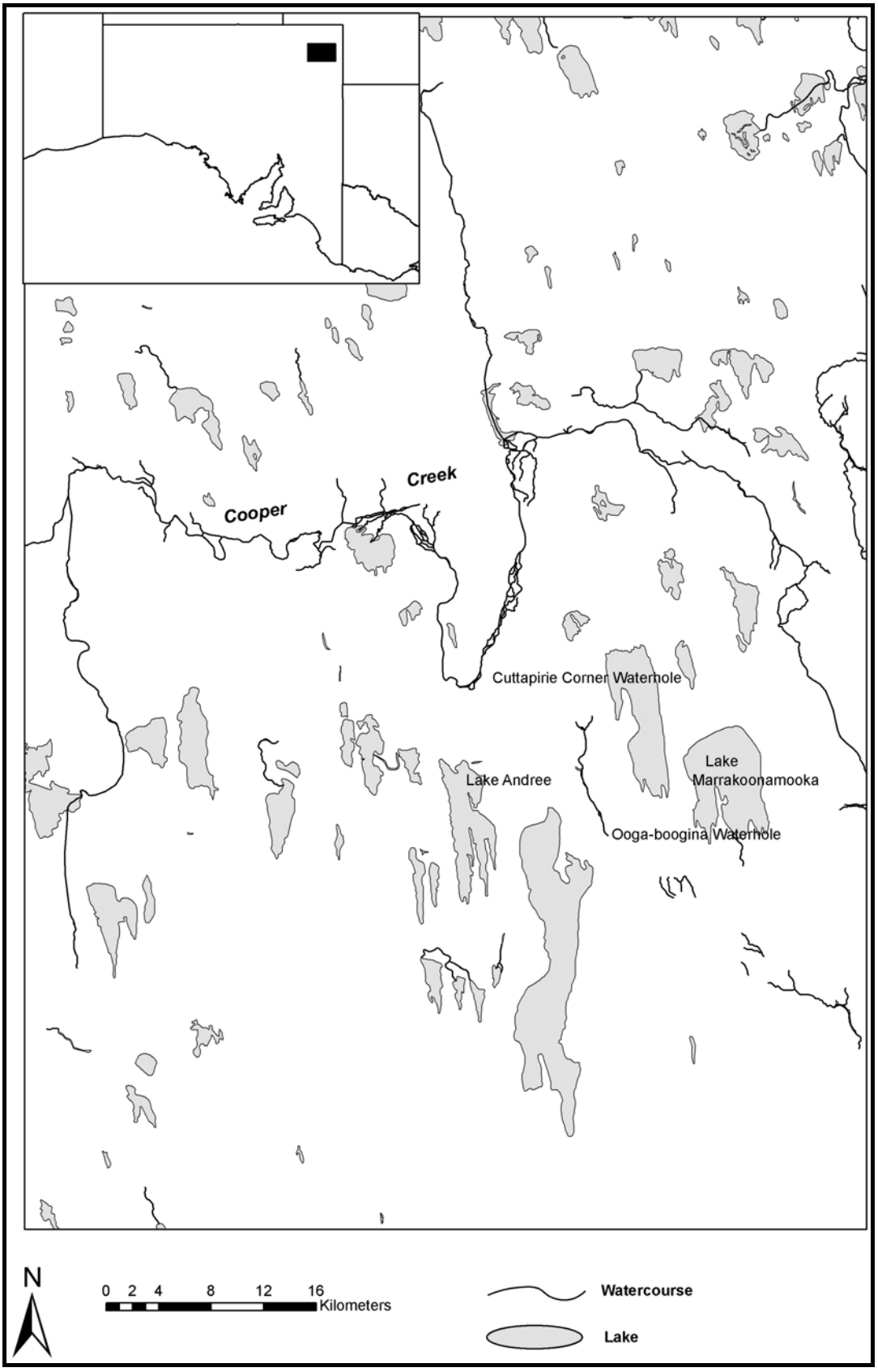

Figure 6 Position and geographic orientation of Oogina-boogina Waterhole relative to Cooper Creek and surrounding lakes.

However, Ooga-boogina Waterhole warrants some discussion in this report because it seems to have been visited by two of the explorers whose journals were analysed for this project, thereby allowing a comparison of the two sets of observations. The first visitor was Sturt, who may have visited Ooga-boogina waterhole on the 20th of August 1845. Sixteen years later, on the 3rd of December 1861, McKinlay almost certainly visited the same waterhole.

The visits of these two explorers illustrate two important points regarding the application of explorer journals to the study of waterhole dynamics. The first of these points is the importance, and difficulty, of confidently identifying waterholes visited by explorers with the degree of precision required for the drawing of robust conclusions about changes in permanence. The second relates to the value of accounts written by explorers who travelled during drought. I will begin by discussing the first of these issues.

On the 20th of August 1845, Sturt, accompanied by Browne, Flood, Lewis and Cowley (Cumpston 1951) was travelling in a north-westerly direction, on the early stages of a journey which would see him travel all the way to the Mulligan River and Simpson Desert. He had left Fort Grey six days earlier, on the 14th, and his horses were already tired. He describes his first contact with what I believe to have been Ooga-boogina waterhole as follows:

> *At 10 miles we crossed a line of Box trees and a Creek of considerable size coming from the NE, but it did not contain any water in its bed, although there were numerous Pidgeons and Parrots in its neighbourhood. A little below where we struck it it appeared to spread over extensive bare and rotten plains having deep fissures and holes in them.*

This entry then continues to describe the remainder of the day's events, which concluded with the party finding a campsite on the banks of Cooper Creek itself. Sturt appears to have written his entry for the day that same evening (he did not always do this), and in so doing mentions Ooga-boogina Waterhole once again:

> *The Natives do not it appears frequent the upper part of this creek* [that is, Cooper Creek] *excepting during the Seed Season for the Grass and Box tree Seed. We observed at the last creek at which we stopped all the Branches of the Box trees broken down for Seed*.

My reasons for identifying this "Creek of considerable size", with its dry bed, abundance of bird life and evidence of Aboriginal seed harvesting, as Ooga-boogina are as follows:

First, Ooga-boogina Waterhole is long (approximately 6.5 kilometres from end-to-end, if one follows its meanders) and narrow. It could consequently have appeared to be a 'creek' to someone striking it for the first time, especially if this first contact was with the middle reaches. Second, based on my plotting of Sturt's course to the north-west (see Figures 2 and 3, pp. 43 – 44), Ooga-boogina WH would have lain directly across Sturt's direction of travel. Third, Ooga-boogina WH does spread out onto plains (actually dry lakes) at both its northern and southern ends.

Fourth, Sturt remarked that the branches of box trees along this creek has been broken down by Aboriginal people collecting seed. This observation suggests that this watercourse was of some importance to Aboriginal people. Ooga-boogina waterhole shows on Google Earth as a large and well-defined feature, with tree-lined banks. While Ooga-boogina is not permanent (Silcock 2009), it does have water in its bed in the Google Earth imagery, and is of sufficient size to hold water for some time following rain. This combination of features suggests that it probably would have had at least some importance to Aboriginal people in the area.

Finally, and perhaps most importantly, Sturt writes that he diverged "two points from our course to the North" to get to a large creek 'across the plain distant from five to six miles' which was probably Cooper Creek itself. The position of Ooga-boogina waterhole is such that a slight northerly diversion from a generally north-north-west path would bring one to Cooper Creek after five to six miles of travel across plains (depending of course upon the exact point at which one struck Ooga-boogina Waterhole).

The only realistic alternative identification for this waterbody is the long reach of Cooper Creek running in an almost north-south direction immediately to the north of Cuttapirie Corner Waterhole. If Sturt had followed a route through this area similar to that described by Cumpston (1951) (see Figure 2, p. 43), he could conceivably have encountered this reach of the Cooper. The relative merits of my plotting of Sturt's course and that advanced by Cumpston are discussed in detail in the section on O'Halloran's Creek, and will not be repeated here. Suffice to say that my plotting of Sturt's route accounts more satisfactorily for the number of creek crossings made by Sturt and his party and the sharp bends of the creek described by Sturt.

I am considerably more confident about McKinlay's visit to Ooga-boogina than I am for Sturt. This is a result of McKinlay's use of Aboriginal guides during his sojourn in northern South Australia, and his consequent record of the Aboriginal names for

many of the lakes and other geographic features in the area. McKinlay spelt these Aboriginal words phonetically, and sometimes even employs multiple spellings for the same word. Nonetheless, with the aid of the contemporary map of McKinlay's journey and a modern topographic map, it is generally quite easy to identify the places to which McKinlay refers in his journal. McKinlay's first visit to Ooga-boogina was on the 3rd of December 1861, and in his only mention of the waterhole he describes it as follows:

> *...passed over sandhills and flooded flat to a creek very broad, deep, and well defined by timber, and trending northward; not much water at present, good here but unfit for use above and below, like that of last night; creek called Agaboogana.*

What conclusions can we draw from these observations? Once again, the major issue appears to be the spatial resolution of the record. Despite considerable evidence suggesting that the waterhole described by Sturt was indeed Ooga-boogina, we cannot be completely sure. McKinlay's visit is much more concrete, with his 'Agaboogana Creek' almost certainly being Ooga-boogina Waterhole.

If Sturt's observations could be more confidently associated with Ooga-boogina waterhole, the comments of the two explorers would provide an initial case for no change in the permanence of Ooga-boogina since European settlement; Ooga-boogina is not currently known to be permanent, it was dry at the time of Sturt's visit, and it contained some water (although apparently not a great deal) at the time of McKinlay's visit.

The example of Ooga-boogina Waterhole also highlights the value of accounts written by explorers who travelled during dry years. McKinlay's descriptions of flowing creeks and full lakes in the Coongie Lakes area only 30 miles to the north of Ooga-boogina strongly suggest that the area had received abundant rainfall prior to his journey. It is therefore not surprising that he should have found some water in Ooga-boogina. He also only visited Ooga-boogina once, and so does not provide us with any evidence as to how long the water in Ooga-boogina Waterhole may have persisted. Therefore, while his observation can be tied to Ooga-boogina with much greater certainty than Sturt's, its utility in isolation is much less.

4.2.2.5 A clear location – Lake Lady Blanche

Many of the examples discussed to this point have stressed the difficulty of positively identifying locations visited by the explorers as the major impediment to drawing defensible conclusions regarding changes in waterhole permanence from this

component of the historical record. Clearly, this difficulty is a function of the broader challenge inherent in accurately plotting the paths of the explorers, an exercise which the imprecision of many of the location estimates obtained in this study suggests does not always return results commensurate with the effort expended in its accomplishment. One logical response to this difficulty which may assist in planning future work is to avoid complete reconstructions of the explorers' paths, and instead focus on only those locations which, through place names or others means, can be positively identified.

One example of such a location is Lake Lady Blanche, one of the Coongie Lakes in northern South Australia (Figure 7). Lake Lady Blanche is connected via a small channel to Lake Sir Richard, which lies immediately to the east. These lakes were visited by both Sturt and McKinlay. In fact, it was the latter explorer who named them (in honour of the then Governor of South Australia and is wife). McKinlay also named the small channel connecting Lake Lady Blanche and Lake Sir Richard 'New Year's Straits' after spending the 31st of December 1861 and the first of January 1862 camped there. He then explored around the lakes, commenting on the abundance of water, the fish and bird life, and the numerous groups of Aboriginal people gathered around the Lakes.

> *…arrived on top of a very prominent sandhill which I have named Mount MacDonnell, from which hill opens out to our view two beautiful lakes which, in honour of her Ladyship and His Excellency the present Governor of South Australia, I have named respectively Lake Blanche and Lake Sir Richard, separated by a small sandy rise through which passes a small channel that connects them, and which I have named New Year's Straits.* (31st of December 1861)

and;

> *The first-named of these lakes is, where it was tried, between five and six feet deep, and seven and three-quarter miles in circumference, nearly circular, bare of timber….* (1st of January 1862)
>
> *...tens of thousands of pelicans on it, one solitary swan, with innumerable other birds, gulls and ducks of various kinds (one new and one dark brown large-winged), cormorants, avocats, white spoonbills, crows, kites, pigeons and magpies of various kinds, and plenty of fish.* (1st of January 1862)
>
> *Between forty and fifty men (natives) came to meet us as we were passing round the lakes at the creek, which they had all to swim and, from the appearance of the camp some short distance off, there could not have been less than about 150, all apparently friendly.* (1st of January 1862)

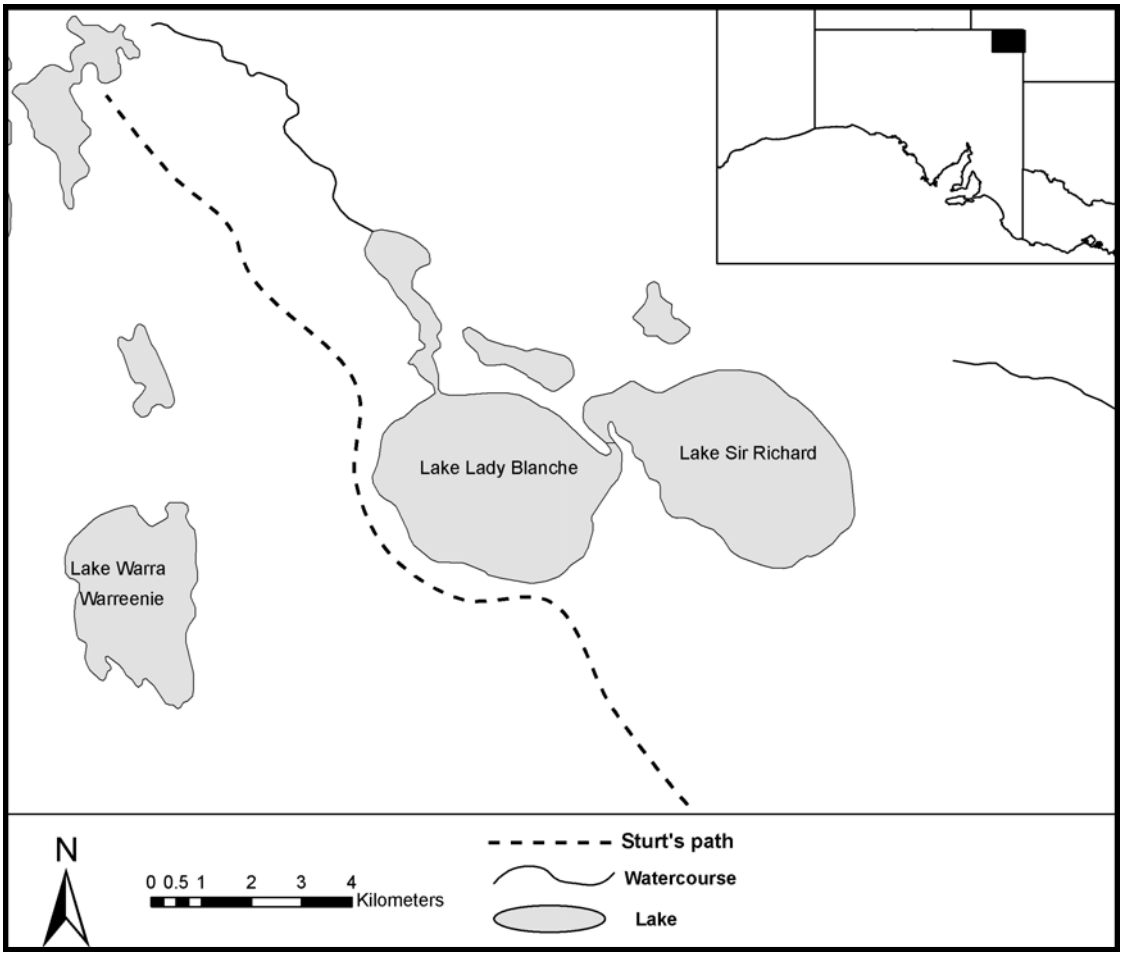

Figure 7 Lake Lady Blanche and Lake Sir Richard, showing Sturt's path around the former.

Sturt visited Lake Lady Blanche on the 16th of October 1845 as he travelled north during his second attempt to find a path through the sandhills of the Simpson Desert. Sturt struck Lake Lady Blanche on its southerly margins, and skirted around its southern end, then up its western shoreline. He did not visit Lake Sir Richard, but did see it in the distance from a high sand hill. This distant glimpse perhaps explains why he referred to the two lakes as one, which he called Lake Lipson (Figure 8).

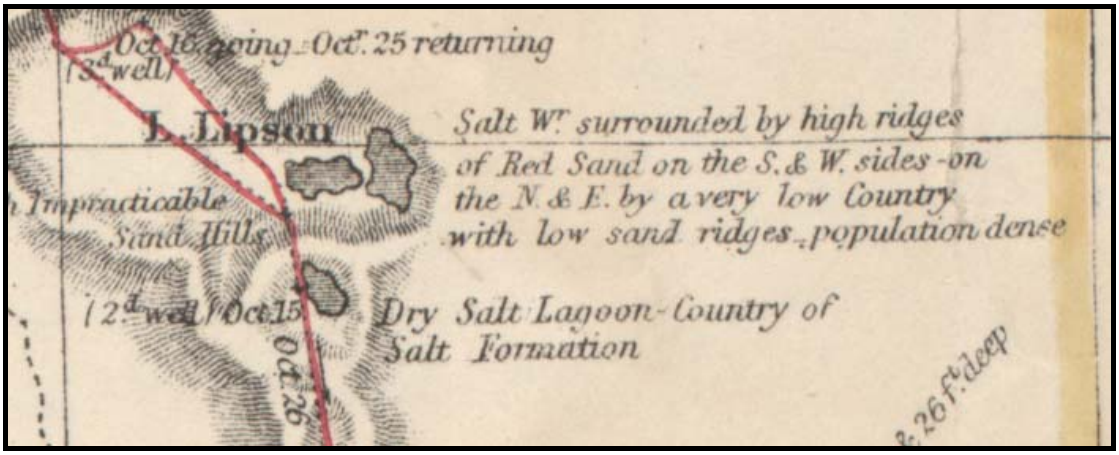

Figure 8 Extract from the Arrowsmith map showing Sturt's Lake Lipson (Lake Lady Blake and Lake Sir Richard).

While Sturt obviously did not refer to the Lakes by their current names, the terrain traversed, and, most importantly, the representation of the two lakes on the Arrowsmith map all combine to enable a very positive location fix for this area. In particular, Sturt notes in his journal that prior to arriving at the lake he and his men traversed seven miles of "heavy sand hills which had no regularity in their disposition but lay in a confused mass" (16th of October 1845). This is a very good description of the sandhills lying just to the south of Lake Lady Blanche. The conditions he encountered contrast sharply with those experienced by McKinlay:

> *I was uncertain as I descended to the lake whether it was fresh or salt. There were no salt water plants growing near it but it appeared to be too clear for fresh water*. (Sturt, 16th of October 1845)

Then later in the same entry:

> *Immediately at the base of the Sand ridge from which we had been overlooking it we struck a Native Path of great size that led down to a well built hut about 100 yards from the Water, which on tasting I found to be brackish and putrid having a most abominable smell. Nevertheless it was covered with wild Fowl of various kinds, but it was extremely shallow, and the Natives had a long line of Sticks erected almost across it to hang their nets on for capturing Ducks.* (16th of October 1845)
>
> *Hoping that I might get fresh water by digging I sank a hole near the lake but the water was as salt as brine.* (16th of October 1845)

While there is no suggestion that there has been a change in the permanence of Lake Lady Blanche since Sturt and McKinlay visited the area, these accounts do highlight the inherent variability of the Coongie Lakes systems. Recognition of this variability should inform studies of the historical ecology of inland Australia. In

particular, the selection of multiple sources through time (where these are available) will assist in understanding the full range of seasonal variation for a given location. An understanding of the natural variability inherent in the system should increase the likelihood of detecting anthropogenic change in these ecosystems.

4.2.2.6 The Mulligan River: Sturt's descriptions

Sturt struck the main channel of the Mulligan River (at this point shown as Eyre Creek on topographic maps) on the 4th of September 1845, after continuing his north-western journey from Strzelecki Creek to the Cooper's North-West Branch, then on to O'Halloran's Creek and across the Stony Desert and the deeply cracked clay flats of Goyder Lagoon (Figure 9). Sturt followed the Mulligan River up to a point slightly north of the junction with Eyre Creek, visiting Taranga and Kalidewarry Waterholes. He then broke away from the stream and once more attempted to travel to the north-west, despite having noted the formidable appearance of the country lying before him:

> *From a high sandhill near us, the view is over as terrible a region as Man ever Saw. Never at any time during this doubtful excursion has the Country looked more difficult & more forbidding.* (6th of September 1845)

Finding it impossible to make headway through the fearsome, waterless dunefields of the Simpson Desert, he turned back to the Mulligan River, where he camped at a 'Salt Lagoon', which may have been Taranga Waterhole. From here he briefly explored Eyre Creek to the NE, before finally deciding to turn back to Fort Grey on the 13th or 14th of September 1845 (Davis 2002). He then retraced his steps back south along the Mulligan River, still finding water in some of its holes. Table 2 gives more details of his observations along the Mulligan River.

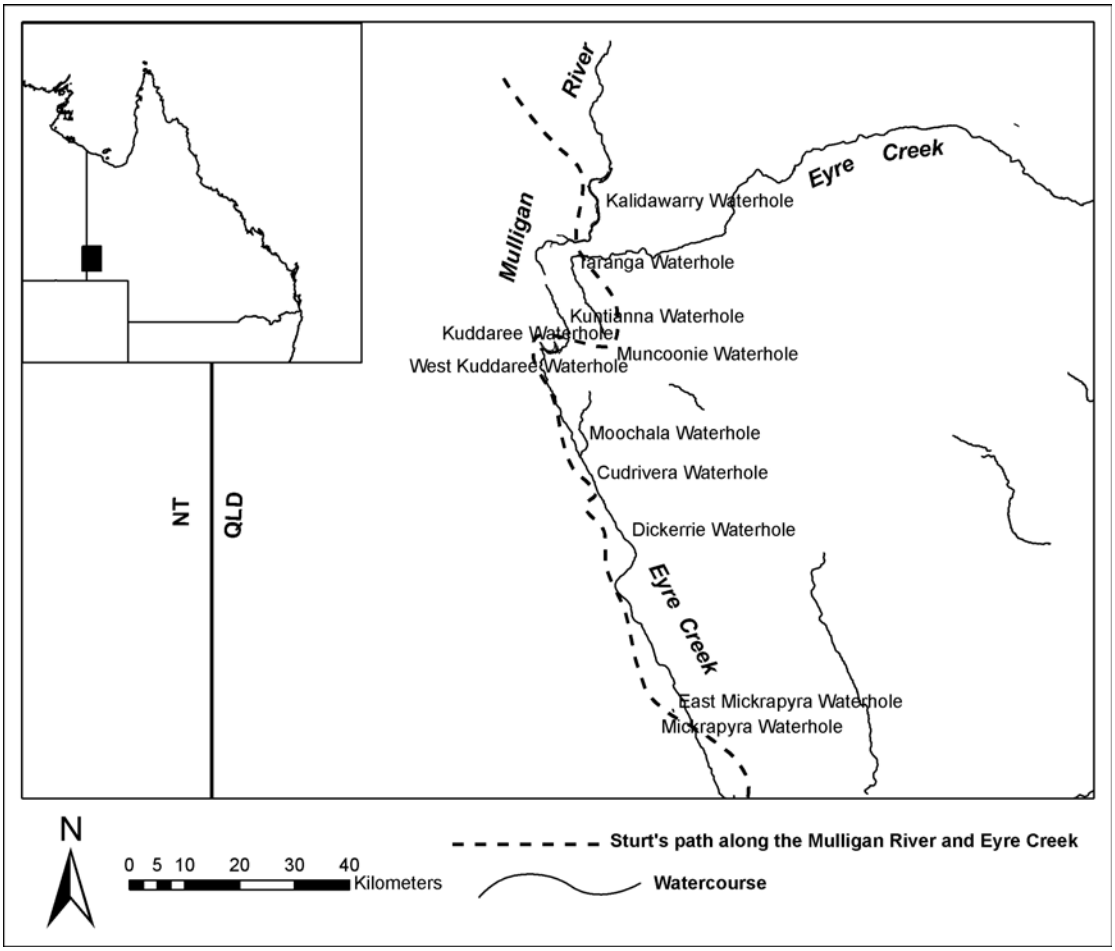

Figure 8 Eyre Creek and the Mulligan River. Note that topographic maps show the Mulligan River flowing into Eyre Creek to the south.

Overall, the picture of the lower Mulligan which emerges from Sturt's remarks is similar to the area's current condition as described by Silcock (2009); a series of broad, shallow waterholes, tending to a slight saltiness as they dry up. Interestingly, Sturt's journal contains a description of one extremely salty waterhole (see observations for 07SEP1845 in Table 2) which seems to have been Kalidewarry Waterhole, identified by Silcock (2009) as the only one of the Mulligan River waterholes which becomes very salty.

Once again, Sturt's observations are valuable because they provide a glimpse of the system during a dry time. Furthermore, Sturt's descriptions of the waterholes and other landscape features he encountered along the Mulligan coincide well with his estimates of distance and direction, enabling a relatively confident reconstruction of his path for this stage of the journey. This facilitates comparison with current condition.

Table 2 Sturt's observations of waterholes along the Mulligan River

Date	Quote	Location (approx lat/long)
04SEP1845	At 10 [miles] struck a very large creek with exceeding high bank and a breadth of 5 or 6 Chains. This creek where we came upon it had two large but shallow pools of water & an abundance of grass in its bed and was there joined by two considerable tributaries coming from the SSE[,] its own course being N by W & S by E, the fall being to the latter point.	This marks Sturt's first real contact with the Mulligan River (or Eyre Ck). He must have been on, or close to, Mickrapyra WH (25 45'46"S, 138 43'56"E)
04SEP1845	…followed it upwards on a Course of 340 for 11 miles, when we stopped in its bed with an abundance both of water & grass. We passed numerous pools but they were generally shallow; some however were more than 2 feet deep, so that my anxiety as to a retreat is for the present at an end...	Mulligan River (Eyre Ck) north of Mickrapyra WH (25 32'47"S, 138 40'22"E)
05SEP1845	Passed a small vein of Limestone tertiary protruding on the left bank and some compact quartz on the plain a little away from the Creek near a fine pond of water.	Possibly West Kuddaree WH (25 10'28"S, 138 32'25"E)
05SEP1845	At [BLANK] passed a very large sheet of water with numerous wild fowl on it.	Kuddaree WH (25 08'55"S, 138 33'16"E)
05SEP1845	The creek diminished as we proceeded upwards. Its bed was no longer grassy but traversed at intervals by Sandstone.	Based on Google Earth imagery, this is a good description of the Mulligan River between Kuddaree and Kuntianna waterholes (25 08'42"S, 138 34'19"E)
05SEP1845	Encamped near a long narrow sheet of water at 20 to 3. Distance 20 miles. The Sand hills continue to bound in the flat on both sides. That to our left being quite close to the Creek running very straight north by west influences the course of the Creek.	This description of a sandhill influencing the course of the creek fits well with Muncoonie WH (25 10'38"S, 138 39'53"E)
06SEP1845	Altho the Creek as not so large where we stopped upon it, it was still a fine one, and I had hoped that it would have drawn us into a better Country.	Refers to the campsite on Muncoonie WH (25 10'38"S, 138 39'53"E)

Table 2 Continued - Sturt's observations of waterholes along the Mulligan River

Date	Quote	Location (approx lat/long)
06SEP1845	At a mile and a half we came on the creek again with an abundance of water and grass, but it here suddenly turned to the NE and in keeping wide of it to avoid the inequalities made by the waters in cutting channels to it, we suddenly came on a large sheet of water[,] an apparent junction of a creek from the ESE as indicated by its first reaches".	Junction of Eyre Creek and Mulligan River. The 'large sheet of water' could be either one of the long, bifurcating arms at the southern end of Kalidewarry WH (24 58'38"S, 138 33'26"E), or Taranga WH (24 59'21"S, 138 35'36"E)
06SEP1845	On this water there were hundreds of Ducks but they were very wild	Could be either one of the long, bifurcating arms at the southern end of Kalidewarry WH (24 58'38"S, 138 33'26"E), or Taranga WH (24 59'21"S, 138 35'36"E)
06SEP1845	The waters we found on tasting to be too salt for use as we had suspected from their colour and transparency	Could be either one of the long, bifurcating arms at the southern end of Kalidewarry WH (24 58'38"S, 138 33'26"E), or Taranga WH (24 59'21"S, 138 35'36"E)
06SEP1845	…altho we found several puddles at which the Birds still water, they were too thick for the horses to drink, and we have halted without any.	Refers to cracked clay flats to the ENE of Taranga WH (24 58'28"S, 138 37'42"E)
07SEP1845	Before we set off, I sent Mr Browne to the Westward to examine the Country in that direction who returned before I had proceeded a mile and informed me that he had struck a salt water creek of considerable size, with great quantities of Salt crystalized round it, coming from the North. As I could expect no favourable change so long as I continued on a course nearly parallel to this Creek I determined on crossing it at once.	The 'salt water creek of considerable size' was almost certainly the main channel of Kalidewarry WH (24 54'40"S, 138 37'56"E)

Table 2 Continued - Sturt's observations of waterholes along the Mulligan River

Date	Quote	Location (approx lat/long)
07SEP1845	We therefore altered our course a little to the westward and struck the Creek at two miles. Its direction appeared as Mr Browne stated to be nearly North and South. Its channel was as white as the driven Snow and it was flanked by sand banks on which the Marks of flood were 12 feet high. There was no water in the bed where we struck it, but the bed was too soft for us to cross with the horses, so that we turned up it or northerly, passing a long sheet of water on which the salt was coated like Ice.	Kalidewarry WH (24 54'40"S, 138 37'56"E)
08SEP1845	This afternoon Lewis and Joseph saw near twenty Natives[,] men[,] but they would not approach them nor did they come near the Camp this afternoon. They evidently live around the lagoon at our end of which there is a well that I should imagine contains permanent water. The food of the Natives seems principally to be muscles[,] seeds[,] roots.	Sturt has been out to the NW and now come back to the Mulligan River. The exact location is unclear, but is probably Taranga WH (24 59'21"S, 138 35'36"E)
08SEP1845	The neighbourhood of the Salt Lagoon is exceedingly pretty and there is a considerable space of park like land near it with an abundance of Grass	Probably Taranga WH (24 59'21"S, 138 35'36"E)
11SEP1845	We were fortunate in finding a small pool of water at 14 miles at which [we] stopped there being a little feed in the Creek but none in the Plain	Sturt is now heading back south down the Mulligan River (24 46'43"S, 138 37'40"E)
14SEP1845	The creek consists of a number of little Channels overgrown with polygonum but containing an abundance of water, the Soil being a white Clay tinges all the waters and give them the colour and in most places the Consistency of pipeclay water	Sturt is now heading back south down the Mulligan River (25 04'40"S, 138 37'24"E)

4.2.2.7 Cooper Creek Waterholes

Sturt arrived back at Fort Grey from his Mulligan River expedition on the first or second of October, 1845, having covered approximately 900 miles of some of the harshest terrain in Australia (Cumpston 1951). He rested at Fort Grey for only nine days before starting out once again on the ninth of October 1845, this time in the company of John McDouall Stuart, Morgan and Mack. On this excursion he travelled north from Fort Grey, again crossing Strzelecki then Cooper Creek. He passed by Lake Lady Blanche, and once again crossed Sturt's Stony Desert:

> *It was really painful to ride the horses over such terrible ground, unshod as they were. Their hoofs were worn almost to a level with the quick and they limped at every step.* (21st of October, 1845)

Here, at the Stony Desert's northern edge, Sturt began to once again encounter the sand ridges of the Simpson Desert. He climbed one of these and surveyed the scene before him:

> *Immediately in front of us there were a succession of ranges similar to that on which we stood [extending] as far as the eye could reach[,] certainly to a distance unattainable by us over such ground, yet I sat for more than an hour on that burning hill before I could make up my mind to turn back, and I am free to observe that I believe it was some unknown influence, not my own inclination that ultimately determined me to do so.* (21st of October 1845)

Having turned back, Sturt retraced his steps to Cooper Creek, striking it on the night of the 27th of October, about 10 miles to the west of the modern-day site of Innamincka.

After giving his horses a day's rest on the abundant feed, Sturt began to explore east along Cooper Creek. He followed the creek along to the point where the Wilson River and Cooper Creek meet in a huge knot of braided channels. At this point, the Cooper makes a sharp bend to the north, towards Durham Downs. Cumpston (1951) believes Sturt travelled along the Wilson for between twenty and thirty miles. The party then retraced their steps back along the Cooper before returning to Fort Grey and finally beginning their long journey back to Adelaide. Figure 9 shows details of this journey.

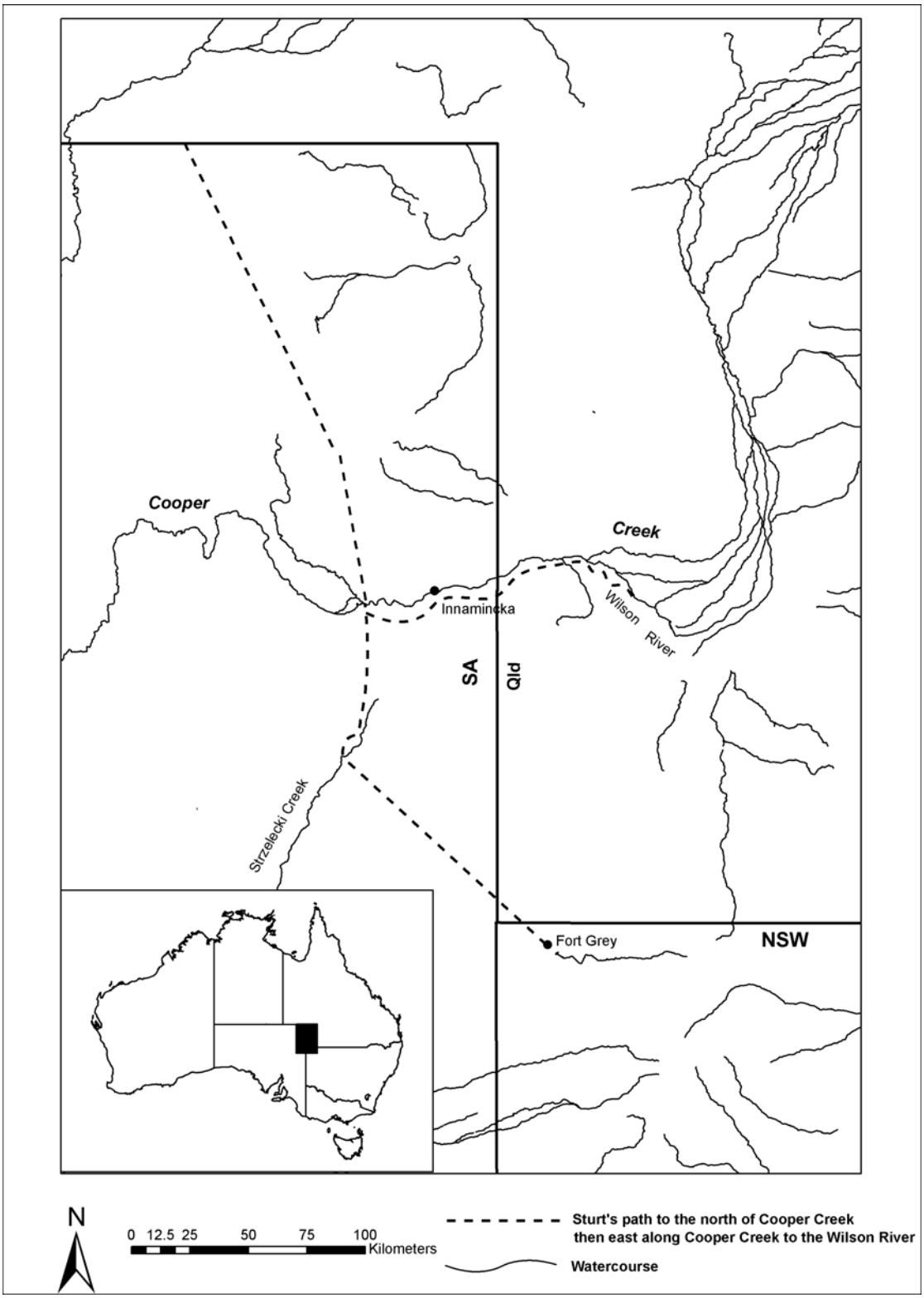

Figure 9 Map showing Sturt's explorations on and north of Cooper Creek in October 1845.

Sturt's journal for this exploration along Cooper Creek contains numerous observations of the large permanent waterholes which characterise this area. Unfortunately, it is extremely difficult to identify individual locations visited during this period. Indeed, amongst the braided channels at the junction of Cooper Creek and the Wilson River, I found it so difficult to follow the party's progress that after several days' effort I was forced to abandon the attempt of deriving latitudes and longitudes for these observations.

In this particular case, however, this inability to identify specific locations seems not to be of great concern. We know that Sturt certainly traversed that part of the Cooper which contains large permanent waterholes including Cullymurra, Mulkonbar, Nappaoonie, Nappa Merrie, Nappapethera and Maapoo. Sturt encountered abundant water and large groups of Aboriginal people along this reach of the Cooper, and his observations, while not spatially explicit, support an inference that the large waterholes of this stretch of the Cooper have not undergone appreciable reductions in permanence since his visit. Sturt's observations of these waterholes are reproduced in Table 3. Latitudes and longitudes given in this table must be viewed as speculative.

The most noteworthy points from Table 3 are probably Sturt's observations of the manner in which even the large waterholes of Cooper Creek were dwindling (see observation for 28OCT1845 & 09NOV1845 in Table 3), and the abrupt changes between salty and fresh waterholes (see observations for 02NOV1845 in Table 3). The 'brine springs' mentioned in the observations for 02NOV1845 are also intriguing.

Table 3 Sturt's observations of waterholes along Cooper Creek, between a point approximately 10 miles west of the current site of Innamincka and the Wilson River junction

Date	Quote	Location (approx lat/long)
13OCT1845	At half a mile from this dry lagoon we entered an open Box tree flat, and at 1/4 of a mile Struck a creek of very unusual dimensions and appearance. There were large Red Gum trees growing on its banks, a sheet of water the termination of which we could not see [?] [extending?] to the NNW, and its bed was filled with a luxuriant crop of Couch Grass.	Channel of Cooper Creek just east of Wilpinnie Creek – crossed by Sturt on journey north to the Stony Desert (27 46'26"S, 140 28'14"E)
13OCT1845	There were well trodden paths along the side of the Creek, and it was of much larger dimension than any I had seen.	Location as above. The comment refers to paths made by Aboriginal people
13OCT1845	…the Creek now enlarged to what might be termed a river…	Cooper Creek somewhere close 27 44'57"S, 140 27'51"E
13OCT1845	…the green burnt feed was so luxuriant round the margin of the long broad sheet of water that occupied the centre that altho we had only come four miles from where we breakfasted I determined to halt for the day.	Cooper Creek somewhere close to 27 44'57"S, 140 27'51"E
13OCT1845	On measuring the Creek across at the head of the water I found it to be 241 yards broad. Its banks at 10 feet were 13 feet high and from the lowest part of its bed to the levels of its banks it was 23 feet. It was very evident that this was a main channel and that the one on which we had breakfasted was only a branch of it.	As above
13OCT1845	I observe that its banks are covered with Muscle Shells, and we have found the Vertebrae of a small fish at the Native fire place similar to those of the fish Mr Browne caught in the westernmost of the Creeks on our last Journey. I do not however see the remains of any larger fish, or of any Cray fish here.	As above
28OCT1845	The water here has fearfully diminished since we left it.	Cooper Creek (27 46'04"S, 140 31'47"E)
29OCT1845	We have halted near a fine water hole[,] the termination of which downwards we cannot see[,] but we are at the head of it.	Cullymurra WH (27 43'46"S, 140 45'27"E)
29OCT1845	There are many ducks upon it but they are very wild, and either fly at our approach or keep quite out of Shot in the Center of the reaches.	Mulkonbar WH (27 43'43"S, 140 44'49"E)
30OCT1845	Notwithstanding the magnificent Sheets of water we have passed I have doubts about this Creek[,] it has changed its character so often, but I observe that the Native paths are much broader and better beaten upon it so that it would appear we are approaching more populous parts.	As above

Table 3 (Continued) Sturt's observations of waterholes along Cooper Creek, between a point approximately 10 miles west of the current site of Innamincka and the Wilson River junction

Date	Quote	Location (approx lat/long)
31OCT1845	Seeing[,] I suppose[,] that we intended them no injury the Natives in the Morning went on with their ordinary occupations as if we had not been present and dived for muscles. They do not go head foremost as we do, but sink feet foremost and without any noise or splash. How they manage this I cannot say but they do this when spearing fish under water, an operation they perform with wonderful and unerring dexterity. The women also sink feet foremost when they hunt for Cray fish or Muscles.	Mulkonbar WH (27 43'43"S, 140 44'49"E)
31OCT1845	…we again struck the Main Creek where it was very broad & had an upper & lower channell thus which had water in the lower one. [NOTE: Davis (2002) notes that in the 'fair copy', Sturt left space for an illustration following the word 'thus', but has not reproduced it].	Close to south-western end of Nappa Merrie WH (27 37'39"S, 141 04'17"E)
31OCT1845	Up here it lost its Gum trees (a bad sign) and had fallen off in appearance but we are encamped at a fine sheet of water notwithstanding.	Marranumbla WH (27 36'26"S, 141 21'51"E)
01NOV1845	At 1 1/2 miles ascended a Sand hill under which there was a magnificent Sheet of water	This remark may refer to the conjoined Womakie and Unka Waterholes (27 36'27"S, 141 23'20"E)
01NOV1845	…the Melaleuca here grown from 15 to 20 feet high and being nearly a foot in diameter (a sign of Salt).	27 35'22"S, 141 09'50"E
01NOV1845	Here the water was beautifully clear and on tasting it I found it to be slightly brackish, just in the same proportions as the little fish pond in the 4th Creek to the NW.	27 36'01"S, 141 10'25"E
01NOV1845	In this also there were hundreds of thousands of little fry swimming about with some larger fish of the same size as the Silver perch we caught there.	27 36'01"S, 141 10'25"E
01NOV1845	Here the water is so salt that we are obliged to get what we want for our own use lower down.	27 36'01"S, 141 11'42"E
01NOV1845	The Channel of the Creek is now exactly like an arm of the Sea & is fringed round with beautiful Melaleuca	27 36'01"S, 141 11'42"E
02NOV1845	A little above the place where we slept, we struck an angle of the Creek where there was a beautiful sheet of water but it was as salt as the sea, and there were many brine springs in its banks.	27 35'53"S, 141 12'33"E

Table 3 (Continued) Sturt's observations of waterholes along Cooper Creek, between a point approximately 10 miles west of the current site of Innamincka and the Wilson River junction

Date	Quote	Location (approx lat/long)
02NOV1845	At 4 miles when we again struck the Creek after crossing the plain, on again making a large sheet of water[,] we found it perfectly sweet. The first was clear as crystal and of an indigo blue, the last opaque and muddy.	N/A
02NOV1845	Neither had any fish in them nor do I think they could exist in the strong solution of the Salt water hole, where I say neither we saw none, but at the same time there were Seagulls & Cormorants perched on the rocks in the water. The Existence of these fish in such Isolate[d] holes is very remarkable.	N/A
02NOV1845	…still finding that I had receded from all traces of the Creek or of Natives[,] I turned to the SE, and at 5 miles struck the former[,] much diminished in size…	N/A
02NOV1845	I had previously crossed many small channels, and was therefore prepared to see some alteration for the worse. Here however there was no water.	N/A
02NOV1845	have stopped at a small waterhole around which there is beautiful green feed for the Horses	N/A
02NOV1845	In the early part of the day however we crossed a fine Creek coming from the North that I purpose running up on my return…	N/A, but this 'fine Creek' may have been Cooper Creek itself, as it makes a sharp bend at its junction with the Wilson River.
03NOV1845	At a mile and a half farther we struck the Creek again, with a large sheet of water in it	N/A, but the party would have been on the Wilson River by this stage.
03NOV1845	Thus at intervals of from a mile & a half to two miles we passed four tribes whose collective numbers amounted to 71. They were all encamped on detached channels and near water holes of the most filthy water, such indeed as we could not have drank and they all told me that there was no water higher up than the water hole to the SW that we had crossed.	N/A, but almost certainly among the braided channels at the junction of Cooper Creek and the Wilson River.
03NOV1845	On examining their water hole I found it so small that I did not think it fair to let my horses drink at it. They would in truth nearly have emptied it...".	N/A, but almost certainly among the braided channels at the junction of Cooper Creek and the Wilson River.
09NOV1845	The water even in these deep reservoirs has evaporated so rapidly that I doubt if we shall find water in the 1st Creek in which case our return to the Camp will be cut off.	Marpoo WH, or close to it (27'45"28"S, 140 34'05"E)

4.2.2.8 An observation from Basedow: A possible rockhole on Quartier Creek, Durham Downs, Queensland

A final observation with relevance to detecting change in waterbodies is provided by Basedow and Grenfell Thomas, who briefly describe a 'rockhole' on Quartier Creek, a tributary of Cooper Creek near Durham Downs Station:

> *Small rock-hole immediately beyond upon wh. we camp at night fall…Water Hole known as [blank.] Millimurra Creek has same name*. (Basedow, 18th of September 1919)

> *At 26 miles a little rock waterhole is reached, in a creek bed, & we decide to camp here. The hole is very small – about 10 yards by 2. – and we were obliged to fill every available utensil with the precious fluid before watering the horses who were very thirsty.* (Grenfell Thomas, 18th of September 1919)

It should be noted that these descriptions do not clarify the exact morphology of the 'rockhole'. A 'true' rockhole (c.f. Silcock 2009) is a rocky hollow which harvests local run-off from rain. They typically occur in rocky ranges, often in incised creeklines (Silcock 2009), and Quartier Creek certainly fits this description. However, it is also possible that this is simply an 'ordinary' waterhole – a scoured area of creekbed which holds water once flow has stopped – but with rocky banks.

The creek in which Basedow and his party found this rockhole was easily identified. Basedow's initial description of the location creates some confusion as the name of the waterhole is left blank, followed by the somewhat cryptic remark that 'Millimurra Creek has same name'. Later in the entry however Basedow does give the name of the creek in which the rockhole was found as "Kwartia Creek", which clearly corresponds to Quartier Creek, the name which appears on modern topographic maps. It seems that the name 'Millimurra' probably corresponds to Murramurrah Creek, which runs roughly parallel to Quartier Creek and just to the north of it (Figure 10).

While we can be very confident that the rockhole was on Quartier Creek, its exact location along that watercourse is much less clear. A recent survey of waterbodies in the LEB did not locate a rockhole on Quartier Creek (J. Silcock pers. comm. August 2009), and the resolution of the Google Earth imagery for this area is not sufficient to enable positive identification.

Furthermore, neither Basedow nor Grenfell Thomas provide directions which enable a determination of the distance of this rockhole from the point at which Quartier

Creek joins the Cooper. Fortunately, however, Quartier Creek is a relatively short creek, and ground-truthing would quickly reveal the true nature of this possible rockhole.

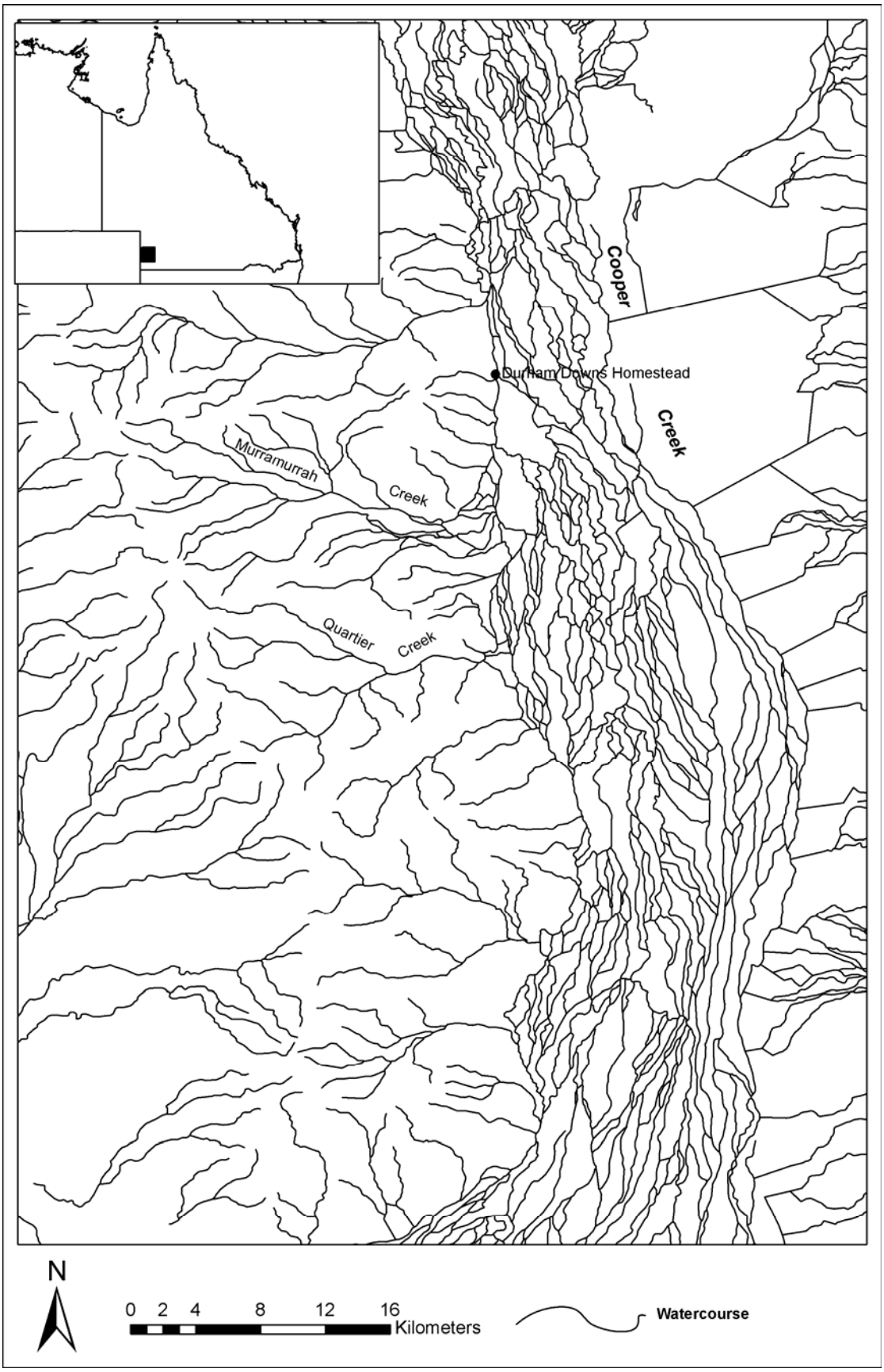

Figure 10 Map showing Quartier Creek in far south-western Qld, location of a possible rockhole mentioned in the journals of Herbert Basedow and Richard Grenfell Thomas.

4.3 Fauna

The major focus of this report was on the collation of information relating to waterholes. However, while reading the journals I also encountered numerous references to other phenomena of ecological interest. In particular, the observations of mammals recorded by both Landsborough and Sturt are of some interest, given the wave of mammalian extinctions and declines which subsequently swept across inland Australia (Johnson 2006). Again, this report does not attempt a comprehensive analysis, but rather highlights some relevant observations and provides a brief interpretation of their significance.

4.3.1 Possums

The brush-tailed possum, *Trichosurus vulpecula*, was once common and widespread in inland Australia, but declined markedly in this part of its range after European colonisation of inland Australia (Lunney 2001; Kerle *et al*. 1992). The reasons for this decline are unclear, but appear to have involved a combination of the destruction of high quality habitat patches, competition for food with rabbits and other introduced herbivores, predation by cats and foxes, and hunting for fur (Kerle *et al*. 1992). Both Landsborough and Sturt either saw possums directly, or found evidence of their presence. Sturt first became aware of the presence of this marsupial during his expedition's stay at Floods Creek, in far north-western New South Wales:

> *It is marvellous to me that this country is not inhabited. Tho it be a very desert to civilized man it must be a paradise to the savage, for the profusion of Game is inconceivable. The birds build in the most exposed places and there are thousands of nests of all Kinds. Emus in Scores and the trees are absolutely rugged with the marks of Opossums yet there is not a Native to be seen. Have they a better country to inhabit more to the North, or what prevents their inhabiting this?* (11th of December 1844)

Sturt's only other reference to possums within the LEB was made at Depot Glen, as the waterholes and the life which depended upon them dwindled around the party:

> *We have enough to supply our wants but that is all this desolate and barren region is capable of giving. The total absence of Animal life upon it is the best evidence of its poverty. There is not even an opossum.* (31st of January 1845)

Sturt's journal entries during this period emphasise the lack of animal activity observed by the party. Given this context, it is entirely possible that Sturt's intention in this quote is not to convey a literal decline in observed activity of possums. Rather, it seems that this may be a narrative device in which Sturt uses the absence

of even so common an animal as an 'opossum' to illustrate what he perceived as a wholesale exodus of the local fauna.

This speculation could be extended further to suggest that Sturt may even have conflated Australian possums with the Virginia opossum, *Didelphus virginia*, with which he may have become acquainted during his military service in Canada. This hardy, widespread and adaptable omnivore inhabits an extremely wide range of habitats in north America and Canada (Feldhamer *et al*. 2003), so Sturt could be forgiven for envisaging as truly forsaken any habitat shunned by it or its ecological analogues.

Indeed, there are numerous remarks throughout Sturt's journal in which the local-scale movements of animals and Aboriginal people are interpreted by Sturt as forming part of a much larger migration (Davis 2002). For example:

> *It would appear that the feathered race anticipating the total failure of water in these dreary Regions, are preparing to quit it. They are congregating in vast numbers, and are no longer widely distributed over the face of the Country, and as far as I can judge they are winging their flight to the West.* (9th of February 1845)

It must be remembered here that Sturt was the first European to visit these areas; such misinterpretations are inevitable during the initial stages of contact with such unfamiliar ecological cycles. Understandable though these errors of interpretation are, they do illustrate the need to interpret the ecological observations of the explorers in the light of the cultural context within which they were written.

William Landsborough also commented (though very briefly) on possums, this time along the banks of the Flinders River, just south of Mount Fort Bowen in Queensland:

> *This being Sunday we rested ourselves and horses. In this neighbourhood Jackey and Fisherman caught five possums* (23rd of February 1862)

The location of these possum captures along the banks of a watercourse (the Flinders River) is similar to that reported in other historical accounts (Kerle *et al*. 1992), which suggest that possums favoured habitat along riverbanks and creek lines. Kerle *et al*. (1992) also postulate that rainy periods would have seen an increase in *T. vulpecula* populations, with associated dispersal and establishment of metapopulations. This may have been the case during Landsbourough's journey.

Under these circumstances, it does seem unusual that the journals analysed for this project do not contain more possum observations. McKinlay does not mention

possums at all within the LEB, while Landsborough's only other comment on possums is extremely nebulous, and may not refer to a possum at all. It was made as the party travelled along the Warrego River:

> *We observed blacks on the opposite banks of the river to us. One of them was up a hollow tree cutting out a honeycomb or a possum.* (16th of May 1862)

This relative paucity of observations of an animal which a range of other sources suggest should have been relatively common and widespread during the study area at the time of first European contact raises an interesting question about the use of written historical accounts to study faunal abundance. Namely, do infrequent mentions of a given species in the historical record imply that it was rare or absent, or does it signify the exact opposite; that the species was so common as to be hardly worth recording? In the case of *T. vulpecula*, historical accounts and skeletal or sub-fossil remains are sufficiently numerous and widely distributed to provide convincing evidence that the species was abundant when the first Europeans visited the LEB (Lunney 2001; Kerle *et al*. 1992).

Perhaps the final word on possums in the arid zone should go to Basedow, who with characteristic brevity recorded the following remark at Nappaoonie Waterhole on Cooper Creek:

> *Nappa Oonee means Nappa wurnie wurnie being thread made from opossum which used to be very plentiful.* (28th of September 1919)

4.3.2 Kangaroos

The historical abundance of kangaroos in inland Australia has long been a matter for debate and speculation among ecologists (see for example Newsome *et al.* 2001; Barker & Caughley 1993). The use of historical records to study historic kangaroo population density can be quite complex (Barker & Caughley 1993), and is beyond the scope of the study. My intention here is rather to alert readers interested in this topic to the fact that all of the explorers whose journals were analysed for this project did mention kangaroos, often in ways which enable some (admittedly speculative) inferences to be drawn regarding the abundance of these animals. The kangaroo references made by the explorers have been geo-referenced in Appendix 1. This resource may be of interest to more qualitative attempts to answer this question. Some examples of these comments follow:

> *This afternoon one of the Kangaroo dogs caught a Kangaroo in the ranges, but we could not find it. They[,] the dogs[,] have got into the habit of hunting by*

> *themselves, and I am sorry to say they destroy a good deal of Game that is lost both to us and to the Natives*. (Sturt, 19th of June 1845)

Sturt made the above comment during his expedition's enforced stay at the Depot Glen camp. While the comment refers specifically to only one kangaroo, the reference to the dogs' "habit of hunting by themselves" and consequently destroying "a good deal of Game" suggests that this occurrence was not necessarily rare, although it is of course likely that prey animals other than kangaroos were also involved.

Additional evidence suggesting a relatively dense kangaroo population in north-western New South Wales comes from an observation Sturt made while en route from Depot Glen to Fort Grey (Lake Pinaroo):

> *After the Party halted Mr Browne and I rode to a small elevation to the south in hopes that we might see some change of country but we were disappointed. It proved to be a stony range connected with the hills to the Eastward but it was so low that we could see nothing from it. There were however a number of Kangaroos in its neighbourhood, some of them of large size.* 23rd of July 1845

Sturt also found evidence of kangaroos around Fort Grey itself:

> *Saw several Emus, and numerous tracks of Kangaroos, a proof of a better Country*. 16th of August 1845.

Sturt's association of kangaroos and emus with "better country" is interesting, since it implies considerable spatial variability in the distribution of these animals.

McKinlay and Landsborough also recorded observations of kangaroos on a reasonably regular basis. Their descriptions tended to be brief, and are summarised in Table 4. Note that Table 4 also includes a single observation of a Wallaroo or Euro, *Macropus robustus*. Again, the most notable feature of Table 4 is the spatial variation in kangaroo numbers which it suggests. After not mentioning kangaroos at all, Landsborough reports "more kangaroo and wallaby than on any previous location" as he approaches the present-day site of Charleville. Similarly, McKinlay's reports of large numbers of kangaroos (and one wallaroo) all come from an 11 day period as he travelled close to McBride Creek on the upper Diamantina River in Queensland.

When interpreting these observations, it should be kept in mind that by the time they undertook their respective expeditions in search of Burke and Wills, both McKinlay and Landsborough were very experienced bushmen, each having more than 20 years experience of living and working in rural or remote Australia. It therefore

seems reasonable to assume that kangaroos would have been quite commonplace to them, and that they consequently would not have reported them unless they encountered unusually high population densities.

Table 4 Observations of kangaroos and other large macropods recorded by Landsborough and McKinlay

Explorer	Date	Quote	Location (place name - approx lat/long)
Landsborough	06MAY1862	In this day's journey we saw more kangaroo and wallaby than on any previous occasion, but we were so eager to get water that we did not try to shoot them.	Along Warrego River just north of present-day site of Charleville, Qld – 26 08’ 22”S, 145 53’ 13”E.
McKinlay	06APR1862	Just as I was getting up this hill a fine Euro hopped off down side some distance off...I call the hill Euro Hill".	Probably along Gum Creek, a tributary of McBride Creek, which in turn flows into the Diamantina River, Qld – 23 08’ 05”S, 141 52’ 01”E
McKinlay	09APR1862	Camp 32…Started, bearing of 285 degrees for one and a quarter miles, at three-eighths of a mile crossed the Robinson, at three-eights of a mile further crossed a nice creek with large reaches, the Mansergh;…creek on left about two miles off…plenty of feed and numerous traces of kangaroo...	Close to Fletcher Creek, Qld – 22 37’ 00”S, 141 59’ 00”E.
McKinlay	14APR1862	Lots of kangaroo and emu here but shy…	Middleton Creek, Qld – 22 10’ 31”S, 141 19’ 37”E
McKinlay	17APR1862	Emu and kangaroo in abundance	Blackeye Creek, Answer Downs Station, Qld – 21 39’ 52”S, 140 59’ 53”E

The parallel accounts written by Basedow and his fellow traveller Grenfell Thomas also feature numerous observations of kangaroos. Their expedition was conducted in 1919, and it is consequently tempting to look for the imprints upon the ecosystem of events such as the provision of artificial watering points in the form of bores. This latter has been identified as a major causative agent in kangaroo population increases (Barker & Caughley 1993). And indeed, the comments of Basedow and Grenfell Thomas do in some instances tend to emphasise the number of kangaroos which they saw:

> *Leave Murnpeowie Station. Country undulating stony gibbers and tablelands. Kangaroo plentiful.* (Basedow, 28th of August 1919)
>
> *Kangaroos are very plentiful and we have seen some very large ones which must measure easily 8 ft. high*. (Grenfell Thomas, 20th of August 1919)
>
> *Two native companions & dozens of large kangaroos were seen just inside the fence; we have tried several shots at kangaroos but have not been successful so far.* (Grenfell Thomas, 12th of September 1919)
>
> *Very numerous red and 'blue" kangaroo. Shoot large buck at 6 miles*. (Basedow, 15th of September 1919)
>
> *Kangaroo large red very numerous, one over 6 ft very tame and sluggish, keeping but chain or two ahead of us*. (Basedow, 18th of September 1919)
>
> *...make N over well grassed downs, more kangaroo*. (Basedow, 19th of September 1919)..
>
> *Kangaroos & cocatoo [sic] parrots are extremely plentiful but we have not come across any water so it is difficult to see where they get a drink.* (Grenfell Thomas, 24th of September 1919)

Despite this, Grenfell Thomas and Basedow also record an equal number of observations of small groups of kangaroos. Note that most of these occurred around the same time as the quotes listed above describing larger, (but unquantified) numbers of kangaroos. In particular, Grenfell Thomas' journal entry for the20th of August contains references to kangaroos being both "very plentiful" and a specific reference to a group of six. Some of the more quantitative kangaroo quotes appear below:

> *At 7½ miles we sighted two large red kangaroos feeding.* (Grenfell Thomas, 17th of August 1919)
>
> *At about 5½ miles we sighted 6 huge kangaroos far off against the sky-line*. (Grenfell Thomas, 18th of August 1919)

> *At 11½ miles we surprised 6 large kangaroos which were feeding in a small creek near the roadside.* (Grenfell Thomas, 20th of August 1919)
>
> *On coming suddenly round a bend I came right upon a pair of kangaroos, they were only about 20 yards away & one had a young one in its pouch, it was unfortunate that I was not carrying my camera*. (Grenfell Thomas, 21st of October 1919)

Such is the nature of working with historical sources at times. The ambiguities of language, the non-quantitative nature of the sources, possible bias resulting from non-recording of 'routine' sightings and innumerable confounding factors associated with spatial and temporal variation in resource availability clearly preclude any meaningful comparison between the numbers of kangaroos seen by the nineteenth century explorers and the 1919 observations.

4.3.3 Other mammals

In addition to kangaroos, this project located references to a range of other mammal species, some of which later became completely extinct or suffered local extinctions and drastic range reductions during the mass extinction of mammals which followed European pastoral occupation of inland Australia (Johnson 2006). The observations have been reproduced in Table 5. The preponderance of observations from Sturt's journal is noticeable in Table 5. This probably reflects a range of factors, particularly Sturt's own interest in natural history and the greater contact which Sturt and his party had with Aboriginal people, whose hunting activity they were able to observe.

Interestingly, Sturt's *Narrative* also contains some mammal observations which do not appear in his original journal. Most noticeably, the *Narrative* mentions Sturt and Tampawang attempting to capture stick-nest rats (*Leporillus* sp.) by firing their nests. The *Narrative* places this incident on the 30th of December 1844, while the party was camped at a 'muddy lagoon' about half-way between Floods Creek and Depot Glen. The corresponding entry in the original journal (used in this project) does not mention stick-nest rats at all. The appendix to the *Narrative* also provides an additional comment on possums:

> *There was only one Opossum killed, or indeed seen to the westward of the Barrier Range, nor do they appear to inhabit the interior in any numbers. Since there were no signs of the trees having been ascended by the natives in search of them.*

Two observations of the water rat, *Hydromys chysogaster*, recorded by Grenfell Thomas at two different waterholes in Cooper Creek have also been included in Table 5. Although this animal is very widely distributed across Australia and still

reasonably common in parts of its range (Olsen 2004), Silcock (2009) found anecdotal evidence that its distribution within the LEB may be quite patchy. Ouimmanroo Waterhole on Cooper Creek south of Windorah is thought to support a relatively large population of *H. chrysogaster*, but other details of its ecology are poorly known (Silcock 2009). In the light of this information, Grenfell Thomas' observations are therefore of some interest.

Landsborough also referred briefly to 'rats' on two occasions, but while these observations were geo-referenced and included in Appendix 1, they have not been included in Table 5, since they provide insufficient information to enable even a tentative guess at the species involved. McKinlay was even briefer (at least for that proportion of his journey within the LEB), referring only to 'reptiles' and 'other animals'.

The identification of animals listed in Table 5 was based on the species descriptions contained in the Appendix to Sturt's *Narrative of an Expedition into Central Australia*, and the species descriptions and distribution maps from *The Mammals of Australia* (Strahan 2004). Identification of animals observed by Sturt in New South Wales also relied upon the species list compiled by Dickman *et al*. (1993) in their paper *Mammals of particular conservation concern in the Western Division of New South Wales*. Wood Jones (1923) provided information which assisted in confirming the identity of the 'dipus' as *Chaeropus ecaudatus*, the pig-footed bandicoot.

The explorers also made numerous references to birds, and some to reptiles. These observations were all geo-referenced and are included in the spreadsheet (Appendix 1). A comprehensive analysis of these is beyond the scope of this project; indeed, identifying all of the birds mentioned in the journals and placing these observations into a meaningful ecological context would constitute a project in its own right.

Table 5 Mammals of conservation interest observed by Sturt and Grenfell Thomas

Explorer	Date	Quote	Species	Location
Sturt	12OCT1844	We have observed among the Natives here a number of the skins of the rock Wallaby, of which there are many no doubt in the hills, and Mr Browne learnt that the Dipus is numerous near Lake Caundilla..."	Rock wallaby = *Petrogale* spp or possibly Onychogalea spp. Dipus = Pig-footed bandicoot, *Chaeropus ecaudatus*	Menindee Lakes, N.S.W
Sturt	19OCT1844	This morning he brought me a present of a Net headdress made of Swans Down and the fur of the Dipus in securing specimens of which we have been so unfortunate...".	Dipus = Pig-footed bandicoot, *Chaeropus ecaudatus*	Menindee Lakes, N.S.W
Sturt	25OCT1844	As we rode along Topar with the quick eye of a Savage saw some Natives… This proved to be an old man and his family seeking for food. Mr Brown surprised the old fellow digging out a Talpero…"	Talpero = probably greater bilby, *Macrotis lagotis*	31 43'17"S, 141 50'40"E
Sturt	04NOV1844	Mr Poole[,] who was out on the hills on Friday[,] saw a new Kangaroo which from his description must be a beautiful animal. He says that it was dappled all over and had broad black bars on the tail alternately with light grey. There were three of these animals, an old one and two young.	Possibly yellow-footed rock wallaby, *Petrogale xanthopus*	Near Parnari Waterhole, Stephens Creek, N.S.W. 31 54' 45"S, 141 40'23"E
Sturt	24APR1845	These Sandy Ridges have an abundance of game in them, Animals that must live without water as the Wallaby[,] the Talpero[,] and insectivorous animal, the striped Bandicot [sic] and others.*	Wallaby = ? Talpero = Greater bilby, *Macrotis lagotis* Striped bandicot [sic] = Probably Western Barred Bandicoot, *Perameles bougainville*	Sandhills NW of Depot Glen 29 26' 12"S, 141 36' 08"E
Sturt	25APR1845	We started two [Colpiznos?] so called by the natives in the centre of a large plain. These Animals are numerous in the country north from Adelaide, and are called hares for their sitting in forms like the hare, out in open plains. They have the form of a Kangaroo, or Wallaby, but are much smaller, and are very delicate.	Hare-wallabies, probably the Eastern Hare-wallaby *Lagorchestes leporides*	Sandhills NW of Depot Glen 29 26' 12"S, 141 36' 08"E
Sturt	13MAY1845	Mr Browne very nearly succeeded in taking a Jerboa which jumped out of a bush from under my horses feet but he escaped. We have seen several of these pretty little animals.	Jerboas = prob hopping mice of the genus *Notomys*. He probably encountered several *Notomys* species during the expedition.	Observation made at or very close to Depot Glen, NSW 29 39' 57"S, 141 47' 03"E

*Davis (2002, p. 182) notes that Sturt's punctuation here is such that "it is impossible to say with any certainty whether the phrase 'an insectivorous animal' is meant to describe 'the Talpero' or 'the striped Bandicot', or to add a totally distinct animal to the list".

Table 5 (Continued) Mammals of conservation interest observed by Sturt and Grenfell Thomas

Explorer	Date	Quote	Species	Location
Sturt	16JUN1845	This morning one of the Kangaroo Dogs caught a Jerboa which Mr Piesse my Storekeeper took from her and brought to me. We have seen several, but this is the first we have procured.	Hopping mouse *Notomys* spp.	Depot Glen, N.S.W
Sturt	26JUL1845	There are an immense number of the smaller animals on these Sand hills, on which the Natives must subsist during the winter months. They are already dispersed over the country, and we have passed several Burrows of the Talpero that have been visited by them.	Talpero = Greater bilby, *Macrotis lagotis*	Between Depot Glen and Fort Grey (Lake Pinaroo), N.S.W. Approx lat/long 29 16' 43"S, 141 22'41"E
Sturt	01AUG1845	They had their nets full of the little Kangaroo Mice (Jerboa) "Wonka" and several Bandicoots, the former in great numbers, not less than 200. They roasted these in hot sand, and two of the natives eat them entire, entrails[,] skin[,] hair and all, one of them more particular took out the Entrails, before he devoured them.	Jerboa or Wonka = *Notomys* spp., Bandicoots are possibly Western barred bandicoot, *Perameles bougainville*	Between Fort Grey, N.S.W and Lake Blanche, S.A. Approx lat/long 29 09' 35"S, 140 35' 49"E
Sturt	08SEP1845	All the feathered race are extremely wild, but smaller animals are scarce of which the Dipus appears to be the most numerous	Dipus = Pig-footed bandicoot, *Chaeropus ecaudatus*	Close to Taranga Waterhole on the Mulligan River, Qld, 25 00' 00"S, 138 35' 29"E
Sturt	14SEP1845	The Dipus is still alive and appears to be an omnivorous animal. It has devoured several birds, and appears to have the habits of a pig"	Dipus = Pig-footed bandicoot, *Chaeropus ecaudatus*	Although this entry clearly refers to a captive Dipus, the animal's capture is not mentioned in the journal. It clearly too place somewhere along the lower Mulligan River, approx lat/long 25 04' 40"S, 138 37' 24"E
Grenfell Thomas	14SEP1919	Irwin & I went down early before breakfast to pull up the fish trap & found in it two very large fish & a big water rat, which was not a bad catch	Water rat = *Hydromys chrysogaster*	Nappa Merrie Waterhole, Cooper Creek
Grenfell Thomas	20SEP1919	Early this afternoon I took a walk along the waterhole bank, the ground is thickly strewn with unio shells & bits of crayfish on which the water rats have been feasting.	Water rat = *Hydromys chrysogaster*	Tabbareah Waterhole at Durham Downs Station, Cooper Creek, Qld.

5.0 CONCLUSION

The major purpose of this project was the collation of historical information which may provide insights into the dynamics of LEB waterbodies. The particular aspect of waterbody dynamism upon which the project focussed was the question of whether a trend towards reduced waterhole permanence as a result of silting is discernable in the historical record at a timescale of approximately 150 years. There are several different kinds of historical documentary record which could contribute to answering this question. Examples include surveyors' maps and reports, early photographs, newspaper articles and the records of pastoral stations.

However, this project focussed on the journals of the nineteenth and early twentieth century explorers. This component of the historical record was chosen as many journals are readily available, and have been shown by previous studies to contain valuable information on a range of environmental phenomena (see for example Gammage 2009; Fensham 2008; Abbott 2002; Lunney 2001).

In most cases, the explorers' journals also represent the very first European observations of a given geographical area, and are thus more likely than settler or pastoralist accounts to reflect pre-European conditions. Furthermore, the location of potable water was a crucial factor determining the success of exploratory expeditions in inland Australia, so it seemed likely that explorers would have afforded some prominence to waterbodies in their journals. In this conclusion, I evaluate the extent to which the project met its aims, and also establish some guidelines for planned ongoing work in this area.

While collation and geo-referencing of waterbody observations was the major aim of this project, a preliminary analysis of the collected information was undertaken to assess the likelihood of detecting change. While not detecting any concrete evidence of change, the results overall suggest that some waterbodies may have undergone change (O'Halloran's / Talleranie Creek, the sandy creeks in the Barrier Ranges, the waterholes towards the southern end of Strzelecki Creek), while the water holding capacity of others remains largely unchanged.

This exercise also provided insights into the pre-European condition of LEB waterbodies, particularly the Mulligan River and Cooper Creek. A comparison of the observations of Lake Lady Blanche recorded by McKinlay and Sturt also illustrated

the extremely variable nature of the Coongie Lakes ecosystem. Perhaps the most valuable outcome of this preliminary analysis, however, was the manner in which it clarified both the utilities and shortcomings of the approach used in this collation exercise, thereby enabling the production of some general guidelines for future work in this area.

5.1 Guidelines for the selection of explorer journals

There are four major requirements of any journal which is to be used in the detection of change in waterholes. The first of these is that waterbodies mentioned by the explorers need to be identifiable to the scale of an individual waterhole. Second, the explorer record needs to provide at least some information on the amount of water contained within the hole. The third requirement is linked to this, and states that to be most useful the explorer's observation should have been made during drought, since this provides a 'test' of waterhole permanence (Silcock 2009). Finally, a reliable assessment of the present-day permanence of the waterholes under scrutiny is necessary.

In addition to these requirements, the usefulness of a journal for this task is greatly increased if it includes a record of repeated visitations to a singe waterhole by the same explorer through several dry months. Sturt's observations of the northern Strzelecki Creek waterholes fit into this category, and provided an excellent opportunity to gauge the permanence of those waterholes. However, this pattern of visitation is likely to be very scarce in the record, and to stipulate it as a requirement would be unrealistic.

This is a reasonably specific set of requirements. Fortunately, the last of them (need for an assessment of current condition) is now met for the entire LEB, with the systematic mapping of natural permanent water for the LEB conducted by Silcock (2009) constituting a reliable assessment of waterhole permanence back to (approximately) the early twentieth century.

The requirement to obtain historical observations recorded during drought is also extremely important. This is demonstrated in the current study by the dominant role which Sturt's journal came to play in the analysis. This was not intended at the commencement of the project, but as work proceeded it became apparent that Sturt's journal was the only one which would provide real insights into permanence. The

journals of both McKinlay and Landsborough contain many useful observations of subjects ranging from vegetation structure to resource use by Aboriginal people, but because these explorers travelled after relatively abundant rainfall, their observations are not particularly useful for assessing waterhole permanence.

Determining whether a given explorer travelled during a wet or dry time is generally best determined by an initial reading of the journal before work commences in earnest. The earliest rainfall records for inland Australia seem to date back only to the 1890s, which will inevitably be later than many of the expeditions of interest. Furthermore, the spatial distribution of rainfall in inland Australia is notoriously patchy (Stafford Smith & Morton 1990), so records of rainfall from a monitoring station may not reflect the experiences of an explorer whose route passed tens of kilometres from this.

A relatively rapid initial perusal of the journal should, however, clarify the situation with relative ease. For example, McKinlay writes frequently of rainfall, flowing creeks, having to get his animals through boggy ground, and even having to shift camp to avoid floods. In contrast, Sturt makes repeated references to long periods without rain and the dwindling of waterholes. When taken over the duration of an expedition, remarks such as these enable the formation of a clear picture of local conditions.

This initial reading of a journal also serves another important purpose; that of acquainting the researcher with the author's descriptive style. Some explorers made only brief notes describing their distance and direction travelled for the day, while others are far more descriptive. Almost all had their own personal interests, which generally become apparent a short distance into their journey.

In this project for example, Landsborough's pastoral background is evident in his daily descriptions of the country traversed. In keeping with surviving depictions of his character, he also presented clear and methodical records of the bearings and distances constituting the days' travel at the conclusion of each journal entry.

Sturt, in contrast, could be vague and ambiguous when giving directions, but provides a great deal of detail upon many different aspects of the countryside through which he travelled. In particular, his enthusiasm as an amateur naturalist and his interest in Aboriginal people are obvious in his detailed notes and frequent speculations on these topics. Clearly, the journals of explorers who tended towards

the descriptive will generally prove more useful. Some background reading of historical works on the chosen explorers should quickly provide an idea of the range of opinion regarding the veracity of the observations.

The final point which needs to be considered when assessing the value of an explorers' journal for this purpose is the extent to which identification of individual waterholes is possible. Accurately and confidently identifying waterholes mentioned in the journals was the single most difficult component of this project, and the one which mitigated to the greatest extent against the formulation of rigorous conclusions. It was an unfortunate fact that Sturt, whose journal contained such a wealth of information, should also prove so obtuse in this area. While this difficulty is probably inseparable to some extent from the interpretation of historical documents, this study did reveal some points which serve to minimise its impact.

First, the journals of explorers whose expeditions took place relatively late in the period of Australian inland exploration (after approximately 1865) will generally prove less troublesome than their predecessors. This is because place names, whether for geographical features or early stations, became increasingly well-established with the passing of time, providing 'known points' between which the legs of the journey can be reconstructed. In the current project, the most extreme example of this was Basedow. His Medical Relief Expedition took place in 1919, and by this time most watercourses and waterholes had been named, while numerous stations (more indeed than persist today) and bores provided additional reference points. Collating the information from his journal and that of Grenfell Thomas was therefore a simple matter of 'joining the dots'.

Less obviously, a difference is also visible between the journals of McKinlay and Landsborough on the one hand and Sturt on the other. The former two explorers undertook their expeditions in search for Burke and Wills in 1861-1862, while Sturt's Central Australian Expedition took place between 1844 -1846. Even in this relatively early period of the LEB's history, the greater prevalence of place names in the journals of McKinlay and Landsborough is very noticeable.

It is nonetheless inevitable that almost any expedition which took place before about 1890 will feature large spatial extents for which no place names are given. It is here that the true value of contemporary maps becomes apparent. Maps of the routes taken by most expeditions were made upon their return. Their value has been discussed elsewhere in this report (see Methods section), but will be reiterated here.

While these maps are generally fairly rudimentary in nature, their usefulness in establishing overall directions of travel and the relative position of landmarks mentioned by the explorers cannot be overstated. Researchers wishing to reconstruct the routes of exploring parties will make their task much easier by consulting these maps wherever they are available.

Finally, while this project has concentrated solely on explorers journals, these are not the only records with potential to yield insights into change in waterbodies. Old photographs can allow valuable visual comparison (B. Kitson, pers. comm. April 2009). However, if photographs are to be used for determining changes in waterholes, it would be important to establish their provenance and date, so this could be related to historical rainfall patterns. Similarly, local histories and the records of pastoral stations should be considered as potentially useful sources of information. Ideally, these sources should be combined to provide 'multiple lines of evidence'. A framework for this approach will be discussed below, but first some brief recommendations on the actual process of reconstructing the explorers' routes are warranted.

5.2 Following their steps: recommendations for plotting the explorers' routes

An approximate reconstruction of the routes of explorers is generally reasonably straightforward, as attested by the proliferation of popular maps professing to show the routes of Burke and Wills and other explorers. However, where the aims of the study require identification of relatively small-scale features such as waterholes, a much more accurate reconstruction is required. As has been previously discussed in the methods section, I can see no way around the requirement to reconstruct the journey as a whole in order to identify waterholes. After discussions with other researchers who have attempted similar tasks (M. Denny pers. comm. August 2009, A. Yeates pers. comm. April and July 2009, O. Powell pers. comm. July 2009), the basic methodological approach used in this project, as outlined in the Methods section, also seems reasonable. There are however some small refinements which may improve both its accuracy and efficiency.

First, there is little doubt that the process of identifying specific locations visited by the explorers is, when done carefully, an inescapably time-consuming path. The complexity of the derivation presented in Box 1 (p. 28) attest to this. However, I

believe some improvements to the efficiency of the exercise could be made by implementing the following two recommendations.

First, assign a time-limit for the derivation of a latitude and longitude for each observation. While plotting the routes of McKinlay and Sturt, I sometimes found myself spending up to a week determining the explorers' routes through a relatively restricted area. While this painstaking approach can yield results, in the interests of efficiency it is perhaps better to acknowledge that some aspects of the explorers' journeys are likely to remain unclear through a lack of information, ambiguity in their description, or subsequent changes to the landscape (Gammage 1984). If a particular point cannot be identified in, say, half an hour, it may be better to list it as ambiguous and move on. Of course, there will be exceptions to this; if the observation is one for which the confident derivation of a latitude and longitude is particularly important to the achievement of the study's aims, extra time is justified.

Second, begin the attempt by indentifying as many 'known points' as possible. An initial reading of the journal and perusal of the contemporary maps can provide useful here. The number of known points which can be identified will vary from journal to journal, but will typically include mountains or hills, major bends of rivers and distinctively-shaped lakes (such as some of the Coongie Lakes). Working between these known points should improve both the efficiency and accuracy of the reconstructive effort, but will not always do so; it is almost inevitable that some long stretches will remain between known points, or that the route will cross confusing terrain. I found this to be particularly so in either very uniform (i.e. dune fields) or extremely heterogenous terrain (the maze of channels and sandhills at the confluence of Cooper Creek and the Wilson River). In these circumstances, it can be difficult to accurately plot the path of an expedition even between two relatively close known points. This was the case for Sturt's travel east along Cooper Creek between Cullymurra Waterhole and the Wilson River, and for part of Basedow's route through approximately the same area.

When viewed in combination, the recommendations I have discussed thus far point to a rather cumbersome methodology. First one must identify those accounts which conform to a fairly specific set of criteria, then a great deal of time is spent in an attempt to geo-reference observations, usually with highly variable success within a given account. In light of these considerations, I propose a revised framework for future work in this field. It incorporates the rigour of the 'multiple lines of evidence' approach with an improved version of the methodology used in this study.

5.3 A framework for future studies of historical changes in waterbodies

In summary, the approach which I suggest for future research on the historical ecology of waterhole silting involves identifying a geographic area within which there is anecdotal evidence of silting, and focussing the effort of source collation and analysis on this area. The incorporation of the widest possible array of sources is a key component of this approach.

Identification of areas in which silting is likely to have occurred could come from a variety of sources, but most probably through conversation with long-term residents of a particular area. Much of this work has already been done, with Silcock (2009) outlining numerous areas within the LEB for which there is some evidence of waterhole silting.

Having identified a study area (probably a particular stretch of a river or creek), the next step is to attempt to establish a 'baseline' condition for the watercourse at the time of European contact. It is at this point that the explorer journals are likely to be useful. Explorers who travelled through the study area should be identified, and copies of their journals read to determine if they passed close to the area of interest. Preference should be given to the journals of explorers who travelled during drought. If suitable explorer journals exist for the study area, this is the time to geo-reference their observations of the waterhole(s) of interest. It is important that the waterholes are identified with confidence, since these observations constitute the baseline against which future change is to be measured.

If there are no explorer journals for the study area, then the search must begin for other sources. These may include the diaries or journals of the earliest settlers in the study area, or possibly early survey plans (although these do not always provide a great deal of information on waterholes (B. Kitson pers. comm.. Apr 2009).

From this point, the process would simply be a matter of accumulating the widest range of source material possible, and comparing this with current condition of the waterbody. Current condition can be assayed from the assessments in Silcock (2009).

This approach should detect changes in waterhole permanence, but will of course, not always be applicable. For some areas, there will simply not be sufficient source material to allow an assessment. In other cases, the source material may be so

widely scattered in museums, libraries and private possession that its collation (or even awareness of its existence) is beyond the scope of the project.

In these cases, an attempt could be made to implement a technique commonly used in historical ecology – the substitution of space for time (Swetnam *et al*. 1999; White & Walker 1997). It may be possible, after careful consideration of the geomorphology and local hydrology of waterholes in the study area, to compare them with similar locations from which the suspected causative mechanism of silting (such as overgrazing) is absent. Given the variability of inland Australian environments, locating suitable analogue sites is likely to be extremely difficult. This approach also entails numerous other complexities, particularly when larger-scale hydrologic effects are considered in systems such as Cooper Creek. In these particular ecosystems, the substitution of space for time should only be attempted as an absolute last resort.

5.4 A final remark: let the sources do the talking

In addition to their use to study change in waterbodies, the journals of the nineteenth century explorers contain a great deal of information about the environmental conditions prevailing in Australia at the time of European contact. Although this project only studied four journals, the preliminary analysis of these presented in this report has covered only a fraction of the information they contain.

Indeed, it could be argued that the journals are at their most useful when the phenomena of interest does not require such fine-grained spatial resolution as the identification of individual waterholes. For example, Sturt made innumerable observations of birds, most of which can be clearly identified to species level (Davis 2002). He also recorded many ethnographic observations. Some of these are inaccurate (for example, those which interpret localised movements of small groups of people as part of a larger ‘mass migration’), yet others have provided valuable understanding of the culture and resource management practices of Aboriginal people.

Similarly, McKinlay’s extensive travel through the Coongie Lakes area after rainfall provides fascinating insights into the human ecology of this frequently harsh ecosystem. Landsborough’s daily journal entries almost invariably include clear, concise descriptions of the structure of the vegetation through which the party travelled. These could inform an analysis of historical vegetation communities (c.f. Fensham 2008).

Perhaps, then, the way to approach the journals of the nineteenth century explorers is to simply listen to what they have to say; read them critically, with an awareness of their historical context, and be alert for the themes which will undoubtedly emerge.

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