Conservation Science W. Aust. 6 (3) : 1–214 (2008)

Historical perspectives of the ecology of some conspicuous vertebrate species in south-west Western Australia

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ABSTRACT

This paper, an integration of history, ecology and zoogeography, is based on a comprehensive search for firsthand (eyewitness) information from navigators' and explorers' journals (1658-1875), colonists' accounts (1829-1889) and later settlers' records and oldtimers' recollections (1890-2006). Pertinent data for 37 conspicuous vertebrate species (10 bird, 26 mammal and 1 snake species) were collated, analysed, and integrated with more recent scientific information. Much of the information discovered in colonial records and obtained from interviews with oldtimers has been neglected by zoologists and ecologists. The original distributional limits of many of the species studied were thus clarified and redetermined.

Detailed information is also provided on the history of the introduction of 14 mammal species into south-west WA, in order to assess their potential contribution to the extinction of native vertebrate species. The introduction, spread and density in bushland of commensal and livestock species does not correlate with the chronology of declines of native species.

Changes in geographical distribution of species were assessed against an interpretive framework of 29 factors, and based on this analysis, a conceptual model (termed the 'fusion' model) of mammal declines and extinctions in south-west and adjacent parts of WA since European settlement is proposed. The reconstructed sequence of events commenced in the 1880s, with declines being caused by disease (10 species estimated to have become totally extinct in WA and 8 species abruptly reduced in abundance and distribution). Another 12 species subsequently reached near-extinction status, following establishment of the fox in the 1920s. Trapping of some species for their fur and accidental poisoning by rabbit baits contributed to local extinctions but were not finally decisive factors.

The conceptual framework adopted, based on detailed examination of the information discovered, recognizes three tiers of relevant factors. Only one or two main factors operate at one time, with some of the remaining factors acting in a subsidiary way, and sometimes concurrently or sequentially. Dominant factors are not necessarily the same for each species. Factors usually affected species adversely.

South-west WA, despite being settled by Europeans earlier than most other parts of Australia, experienced a stagnant economy, slow population growth and hence minimal clearance of the original vegetation until the 1890s. The anthropogenic factors identified as significant in the decline and depletion of the native fauna, together with an understanding of their correct sequence of operation, provide a historically appropriate conceptual model that may be applicable elsewhere in Australia.

The baseline data and historical accounts provide a resource for specialists working on particular species, and include much new material relating to the pelt industry and pest control activities.

> *'what's past is prologue'* (Shakespeare 1623, *The Tempest,* Act 2 Scene 1)
> *'The past is never dead. It's not even past'* (Faulkner 1953)
> *'The pastness of the present and the presence of the past'* (Taruskin 1988)

INTRODUCTION

In the period from 1658 to 1826 south-west Western Australia (WA) was visited by Dutch, English and French navigators. Although several of these expeditions collected natural history specimens, few of the animal specimens collected were described scientifically and named (Alexander 1914, 1916; Whittell 1954a part 1: 3-85; Vallance *et al.* 2001).

When Western Australia was occupied by Europeans in 1826 (at Albany) and 1829 (at Fremantle and Perth), the long term conservation of its biota was given little attention (Abbott 2004), probably because the immediate challenge in a newly-created society of pioneering settlers was to secure land, grow sufficient food, husband livestock populations so that they increased, and establish trading opportunities. For many years the inroads of Europeans in WA were tentative and there was no cogent reason to be concerned whether native birds and mammals coped with the relatively limited clearing of native vegetation for farms, roads and villages. Indeed, some of the larger native birds and mammals were sufficiently common that early settlers relied on them to supplement their food supplies and often experienced loss of crops and livestock from some native birds and mammals.

In March 1829 Robert Hay, Under-Secretary in the Colonial Office in London, asked the founding governor of WA, James Stirling, to comply with a request for

specimens from the recently established (1826) Zoological Society of London (Statham-Drew 2003: 138). During 1833-7 casual collections of specimens of some conspicuous insect, bird and mammal species from near Perth and York were sent to England (Alexander 1918). They were described as species new to science[1] and published in the *Proceedings of the Zoological Society* and in other scholarly journals published in London. Some collecting opportunities, however, were not advantageously pursued: for example, Charles Darwin on his brief visit to WA in 1836 collected only one mammal species new to science, viz. *Rattus fuscipes* (Waterhouse 1839: 66-7).

Collection activities became more directed a few years later with the arrival of the percipient naturalists Ludwig Preiss (December 1838) and John Gilbert (March 1839), who travelled extensively throughout the then-settled parts of the Colony (Marchant 1990; Fisher 1992; Abbott 2001a). They relied on shooting specimens, purchasing specimens from settlers, and exchanging specimens brought in by Noongars (Aborigines) for flour (Whittell 1941: 128; Whittell 1942: 221). Even though the collecting efforts of Preiss and Gilbert were probably hampered by flies blowing specimens (cf. Clark 1994: 53), their collections were regionally comprehensive.

This golden age was followed by a hiatus of nearly 50 years when formal recording of birds and mammals in south-west WA was sporadic. This is because WA, relative to the other jurisdictions in Australia, retained a stagnant economy and attracted few settlers until the discovery of gold in 1885. Knowledge of the distribution of mammals was limited, however, more by the absence of zoologists than by the lack of animals (Ride 1968). Museums in Australia operated under the 'mistaken assumption that the stocks of Australian animals were inexhaustible' (Stanbury 1987), resulting in the collection of relatively few specimens (Wood Jones 1924: 221). Compounding this, WA did not have the population or revenue base to become self-governing until 1890. Although a natural history museum was organized in Perth in 1892 from existing collections (Woodward 1914) and collecting of birds and mammals accelerated with the appointment of JT Tunney from 1895 to 1906, much of this material was not adequately labelled and some specimens were exchanged with other institutions. The collection included 'all the known living W.A. Marsupials with seven exceptions' by 1907 (Perth Museum 1907) and some 6 000 bird specimens by 1916 (Anon. 1917).

The WA government did not establish at this time the formal biological equivalent of the immediately more economically useful geological survey (in 1896, Maitland 1911), and few resources were provided to support the activities of the WA Museum (Serventy 1957). It is pertinent to note that the first zoological surveys of mainland south-west WA, in the sense of thorough locality-based collecting resulting in published annotated notes on specimens, were performed by the visiting scientists GC Shortridge in 1904-7 and W. Michaelsen and R. Hartmeyer in 1905. It was not until the late 1950s that accessions of mammal specimens into the WA Museum increased above the average for the years 1901-50 (How and Cowan 2006: 114). This may have resulted from the appointment of the mammalogist WDL Ride as Director in 1958. In 1954 CSIRO became involved in research into native mammals on mainland south-west WA (Calaby 1960). University interest in mammal research on mainland south-west WA commenced partially in 1960 (Kelsall 1965) and more completely in 1967 (Sampson 1971). A fauna research unit was established by the Department of Fisheries and Fauna in 1964, and the Forests Department commenced fauna research in 1972.

In south-west WA the opportunity to study the displacement of species and depletion of the fauna following European settlement was taken up by Barney Woodward and Jack Tunney at the WA Museum and Chester Shortridge in the period 1895-1914, based on the firm foundation provided by John Gilbert only 50 years earlier. This was a situation unparalleled elsewhere in Australia (Fletcher 1900: 100-101).

Nevertheless, it is very difficult to reconstruct the original limits in south-west WA of the geographical range of some native species from extant museum collections. Many marsupial species became extinct shortly after European settlement but before pastoral development or the establishment of rabbits and foxes (Main *et al.* 1959: 320). Factors such as the introduction of disease in c. 1880, incursions of pest British animals after 1910, and extensive clearing of native vegetation after 1920 have in sequence contracted the distribution and reduced the abundance of many native species. However, surface fossils collected from caves and coastal sites have successfully contributed to this reconstruction (e.g. Lundelius 1957; Baynes 1979).

This paper offers a different approach, based on the synthesis of a mass of fragmentary information disinterred or gleaned from historical documents (archival and secondary) and from interviews with oldtimers (informants aged at least 70 years, with a reliable long-term memory and knowledgeable about the more charismatic species of birds and mammals). Use of historical documents is of course not novel, although this study has attempted to be thorough in searching for relevant material in comparison to the few sources cited by Glauert (1933, 1950), Kitchener *et al.* (1978), and Storr (1991). Nearly 1600 documents are cited. In addition, anecdotal information acquired from oldtimers has expanded from 46 interviews (Abbott 1999) and 155 interviews (Abbott 2001b) to more than 200 interviews. This paper consolidates this information, re-assesses existing knowledge based on this

[1] In chronological order, the vertebrate species named in the 1830s were *Malurus 'pectoralis', Myrmecobius fasciatus, Gallinula ventralis, Oxyura australis, Calyptorhynchus 'naso', 'Perameles' lagotis, Acanthorhynchus superciliosus, 'Halmaturus' irma, Malurus elegans, Falcunculus 'leucogaster', Eopsaltria 'griseogularis', 'Sittella pileata', ' S. melanocephala'* and *Anthochaera lunulata.*

newly uncovered information, and attempts to preserve this local information, much of which is based on irreplaceable memories.

Various literary sources also yielded useful information, though not generally with precise locality data. Examples include novels (O'Reilly 1879, Lawrence and Skinner 1924, Prichard 1926), children's literature (Rowan nd), short stories (Prichard 1931; Ewers 1946, 1949), verse (Clay nd), and autobiography (Groser 1927; Hasluck 1977; Facey 1981; Ewers 1983; Hewett 1990; Hungerford 2003). Nevertheless, these casual references to fauna reinforce the concept that many conspicuous vertebrate species were widespread and common enough to be readily familiar to observant people living in rural WA up to the 1940s.

There are surprisingly few studies of single species in Australia that make effective use of historical information. Worthy of mention are those by Ryan (1964, on *Canis lupus dingo*), Rolls (1969, on the rabbit and fox), Prince (1984, on *Macropus fuliginosus*), Barker and Caughley (1990, on *Macropus giganteus*), Grant (1992, on *Ornithorhynchus anatinus*), Lunney *et al.* (1997, on *Petrogale penicillata*), and Sassoon (2003, on cormorants and pelicans). The only publications based on retrieval of information from oldtimers are those of Carr and Robinson (1997, on *Caloprymnus campestris*) and Bailey (2001, on *Thylacinus cyanocephalus*).

There are several reasons why it is important to delineate the original geographical range of species, in particular to fix the south-western limits of WA species:

- First, for those species that have contracted so markedly from their original distribution, once the key threatening process has been identified and rectified, it is then feasible to re-introduce species to areas within their original range. It is undesirable to artificially disperse (translocate) species without a sound scientific understanding of their original range, otherwise resources may be wasted in trying to establish populations in areas where species were not present in 1829.
- Second, it is of great interest to the biogeographer (e.g. Milligan 1905) to establish as accurately as possible the geographical range limits before the environmental impacts of Europeans took effect.
- Third, establishing the extent of occurrence is the first step in determining the area of occupancy of a species in its geographic range, thus avoiding false positives (Habib *et al.* 2003).
- Finally, an historical approach is considered appropriate, as it enables the present to be positioned in terms of the past, demonstrates the continuity between past and present, re-unites the present with the past, and provides a sound setting for assessing the future. There is also much that can be learned from the past which can help in understanding issues and problems of the present.

Much information available about original distributions is considered unsatisfactory, being terse description lacking adequate referencing (Serventy and Whittell 1976; Storr 1991), coarsely mapped without displaying the underlying point source data (Shortridge 1910; Marchant and Higgins 1993; Strahan 1995, Johnstone and Storr 1998; Higgins 1999), mapped as presence/absence using large grid cells (Busby and Davies 1977; Baynes 1979), or the point source data mapped are not based on a comprehensive search of historical documents (Blakers *et al.* 1984; WA Museum 2005). Nonetheless, I acknowledge that the maps prepared for this paper are imperfect and will be subject to addition, revision and correction.

Having removed ambiguities concerning the original distributional extent of several species, I then took a comprehensive, evidence-based approach to assess all of the factors potentially involved in the decline and extinction of these species. A 'bottom-up' approach was considered more likely to provide a reliable perspective than a 'top-down' approach based on a particular theory (as, for example, in Johnson 2006). Punctilious attention to detail is valued as important because it enriches the process of developing a sound theory while at the same time providing an independent check of the seductive attraction of particular concepts. This led to the development of a more unified conceptual model to explain the timing of the decline and extinction of the mammal fauna of south-west WA, and why this component of the fauna was impacted on earlier and more severely than other vertebrate groups.

The objectives of this paper therefore are to:

- Establish as accurately and fully as possible the geographic range of conspicuous animal species in south-west WA at the time of European settlement, and thereby contribute to the empirical foundations of biogeography in WA
- Document both beneficial and detrimental responses by these species to the relevant natural and anthropogenic factors
- Assess the relative importance of factors in south-west WA influencing the ecology of the species studied, distinguishing those with pervasive and enduring influence from those that left transient imprints
- Determine how these factors operated in space and time
- Bring to the general attention of modern ecologists hitherto neglected historical and parochial information about these species
- Evaluate current theories about the causes of declines of species in the light of the historical information discovered
- Link fragmentary information with dispersed and previously isolated data, whether historical or scientific, to yield revealing details, and use the fresh insights gained to develop a robust and valid explanatory framework.

This paper is the last of a series with a theme of historical ecology in south-west WA (Abbott 1979, 1980, 1997, 1999, 2001a, 2001b, 2002, 2004). In this paper,

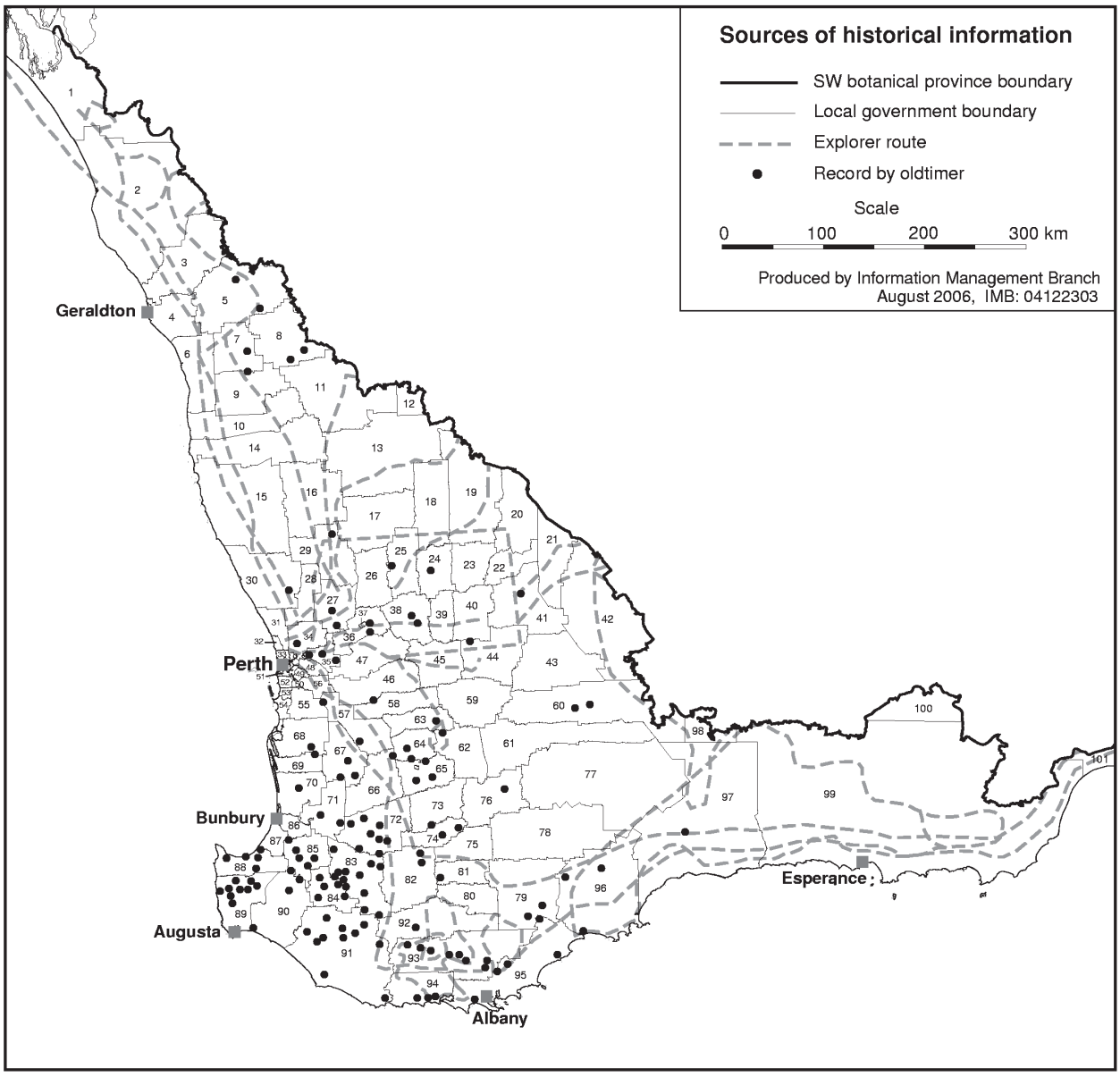

Fig. 1. South-west WA, showing routes of explorers and location of records contributed by oldtimers. Current local government areas are as follows: 1 Shark Bay (part); 2 Northampton (part); 3 Chapman Valley; 4 Greenough; 5 Mullewa (part); 6 Irwin; 7 Mingenew; 8 Morawa; 9 Three Springs; 10 Carnamah; 11 Perenjori (part); 12 Yalgoo (part); 13 Dalwallinu; 14 Coorow; 15 Dandaragan; 16 Moora; 17 Wongan-Ballidu; 18 Koorda; 19 Mt Marshall (part); 20 Mukinbudin (part); 21 Westonia (part); 22 Nungarin; 23 Trayning; 24 Wyalkatchem; 25 Dowerin; 26 Goomalling; 27 Toodyay; 28 Chittering; 29 Victoria Plains; 30 Gingin; 31 Wanneroo; 32 Joondalup; 33 Stirling; 34 Swan; 35 Mundaring; 36 Northam; 37 Cunderdin; 38 Tammin; 39 Kellerberrin; 40 Merredin; 41 Yilgarn (part); 42 Narembeen; 43 Bruce Rock; 44 Quairading; 45 Beverley; 46 York; 47 Kalamunda; 48 Gosnells; 49 Canning; 50 Melville; 51 Cockburn; 52 Kwinana; 53 Rockingham; 54 Serpentine-Jarrahdale; 55 Armadale-Kelmscott; 56 Wandering; 57 Brookton; 58 Pingelly; 59 Corrigin; 60 Kondinin; 61 Kulin; 62 Wickepin; 63 Narrogin; 64 Cuballing; 65 Williams; 66 Boddington; 67 Murray; 68 Waroona; 69 Harvey; 70 Collie; 71 West Arthur; 72 Wagin; 73 Woodanilling; 74 Katanning; 75 Dumbleyung; 76 Lake Grace; 77 Kent; 78 Gnowangerup; 79 Tambellup; 80 Broomehill; 81 Kojonup; 82 Boyup Brook; 83 Bridgetown-Greenbushes; 84 Donnybrook-Balingup; 85 Dardanup; 86 Capel; 87 Busselton; 88 Augusta-Margaret River; 89 Nannup; 90 Manjimup; 91 Cranbrook; 92 Plantagenet; 93 Denmark; 94 Albany; 95 Jerramungup; 96 Ravensthorpe; 97 Esperance; 98 Dundas (part). In addition; the following are in the Perth metropolitan region (bounded by numbers 33, 47, 48, 49 and 50) and could not be depicted at this scale: Cambridge; Vincent; Victoria Park; Nedlands; Subiaco; Claremont; Peppermint Grove; Cottesloe; Mosman Park; Fremantle; East Fremantle; South Perth; Bassendean; Bayswater, and Belmont.

south-west WA is defined as the area depicted in Fig. 1. This region comprises 30.7 M ha.

METHODS

I considered that oldtimers would be unlikely to discriminate reliably between most species of small marsupials (e.g. *Parantechinus, Antechinus, Sminthopsis*), rodents (*Notomys, Pseudomys, Rattus*), and bats. Other small mammals (*Cercatetus, Tarsipes*) have well characterized geographical ranges and these have not changed remarkably. Information was also not sought for some conspicuous bird species (e.g. emu *Dromaius novaehollandiae*, wedge-tailed eagle *Aquila audax*, common bronzewing *Phaps chalcoptera*) because knowledge of their distribution and past interaction with humans is satisfactory (Gabbedy 1972: 253-257; Serventy and Whittell 1976; Storr 1991; Saunders and Ingram 1995; Maddock 1998: 481-485; Abbott 1999).

Historical information on conspicuous (generally large) species of birds, mammals and snakes of interest was accessed from seven kinds of sources:

- Local histories published for south-west WA, usually on the basis of a particular Local Government Area (Fig. 1). Since 1970 numerous histories have become available (Bolton 1981: 688). I found that indexes of these books could not be depended upon to locate this information, and therefore I read these books in their entirety, though this effort was not always well rewarded.
- Published journals of navigators and explorers, the six volumes of typewritten exploration diaries held in Battye Library, Perth (Exploration Diaries 1827-1871), and the WA Explorers' Diaries Project (Shoobert 2005).
- Books, published reports, reports in newspapers[2] (1831-), printed records of parliamentary debates (1870-1950), Government Gazette (1836-1949), Acts of the Executive Council, Legislative Council and Parliament of WA (1831-1952), articles in the historical journal *Early Days* (1927-), and other documents written by visitors, collectors, naturalists, colonists and government officials.
- Papers by naturalists and scientists published in *The Magazine of Natural History* (1829-40), *Journal of Zoology* (1830-), *Journal of Natural History* (1838-), *Papers and Proceedings of the Royal Society of Tasmania* (1842-), *Proceedings of the Royal Society of Victoria* (1855-), *Ibis* (1859-), *Journal of the Royal Society of New South Wales* (1867-), *Proceedings of the Linnean Society of New South Wales* (1875-), *Transactions of the Royal Society of South Australia* (1878-), *Victorian Naturalist* (1884-), *Proceedings of the Royal Society of Queensland* (1884-), *Proceedings of the Australasian Association for the Advancement of Science* (1888-), *Agricultural Gazette of New South Wales* (1890-1910), *Records of the Australian Museum* (1890-), *Memoirs of the Queensland Museum* (1891-), *Journal of Agriculture Western Australia* (1894-), *Journal of the Department of Agriculture of South Australia* (1897-1910), *Queensland Agricultural Journal* (1897-1910), *Journal of the Royal Society of Western Australia* (1899-), *Emu* (1901-), *Journal of the Department of Agriculture of Victoria* (1902-1910), *Australian Naturalist* (1906-), *Memoirs of the Museum of Victoria* (1906-), Tasmanian *Naturalist* (1907-), *Queensland Naturalist* (1908-), *Records of the Western Australian Museum* (1910-), *South Australian Ornithologist* (1914-), *Australian Zoologist* (1914-), *Australian Forestry Journal* (1918-), *Records of the South Australian Museum* (1918-), *South Australian Naturalist* (1919-), *Nature Australia* (1921-), and *Tasmanian Journal of Agriculture* (1929-). These journals (and their predecessors) were searched at least up to 1930, unless otherwise stated. Some early issues are not held in any library in WA and therefore were not assessed.
- Columns published weekly in *The West Australian* by the naturalist J. Pollard (under the pseudonym *Mo-poke*, Denizens of the Bush, 7.7.1923-14.2.1931[3]) and monthly in *The Farmer* newspaper by the ornithologist DL Serventy (under the pseudonym *Miletus*, While the Billy Boils 5.3.1923-5.4.1924, Bush Notes 5.5.1924-5.9.1927), columns published weekly in *The Western Mail* newspaper by the naturalists FL Whitlock (Wild Life in W.A. 1.4.1926-29.12.1927) and L. Glauert (The Naturalist 5.1.1928-31.7.1930), and columns usually published monthly in *The Westralian Farmers' Gazette* by L. Glauert (20.1.1927-27.11.1930) and FL Whitlock (13.9.1928-29.1.1931).
- Interviews conducted between 1997 and 2006 with 207 oldtimers born in the period 1901-35 (Appendix 2, Fig. 2). Most had spent a substantial portion of their early life on a farm in south-west WA. A few people born later than 1930 were also able to provide some information told to them by their parents. I presumed it unreliable to seek information on small marsupials or rodents because these species are rarely seen and are difficult for the layperson to identify accurately. I was also mindful of not imposing an unreasonable demand on the mental faculties of oldtimers. (Note that the colloquial term 'oldtimer' is used in this paper in a respectful sense and none of my interviewees expressed objection to the term).
- Noongar (south-west WA Aboriginal) names (Curr 1886; Abbott 2001a; Bates unpubl. and other compilers).

[2] Details of newspapers searched systematically are provided in Appendix 1.

[3] According to Whittell (1954a Part 2: 590), this column was published until 1937; I only read as far as the date indicated.

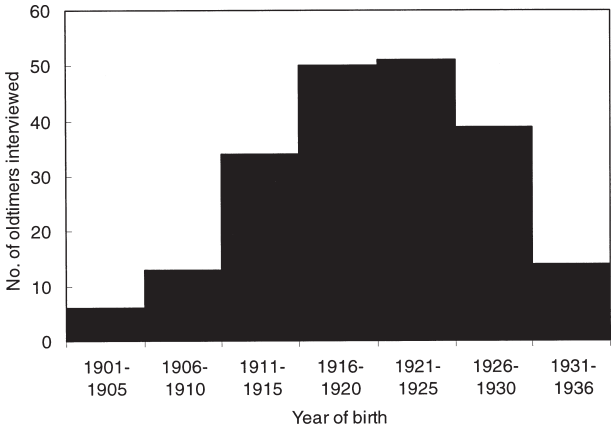

Fig. 2 Year of birth of all oldtimers interviewed.

My interview technique began with me introducing myself, stating how I had obtained their name and contact details (often from another interviewee) and requesting their permission to proceed with the interview. Each species was mentioned by its common name and subsequent questions were directed but as open-ended as possible: *Do you remember seeing the -? Can you recall where it lived? What was its tail like?* Such questions were intended to act as crosschecks. If the common name did not elicit a response, I mentioned alternative common names that I knew had been in use. If this did not result in species recognition, I then described the key identification features of the species in turn. Sometimes the interviewee knew the species but could state definitely that it had not occurred at the locality under discussion. Where species no longer occurred I sought an estimate of when it was last seen, based on the age of the interviewee e.g. *were you still at school?* Views as to why a species had disappeared were also sought.

Although seeking information from the public about animals is not new (e.g. Finlayson 1958; Burbidge *et al.* 1988), it is believed that focusing on the retrieval of zoological information from oldtimer rural residents is novel.

All records obtained were appraised for errors, mistakes and misinterpretations, and no record was accepted without discrimination. To avoid circumlocutions, records of fauna mentioned in the text, and which were obtained by explorers and pioneer settlers, have been localized anachronistically (i.e. European toponyms have been used before they were actually applied). Monetary values are quoted in pounds (£), shillings (s, 20s = £1) or pence (d, 240d = £1), weight is given in pounds, ounces or hundredweights (1 lb = 16 ounces = 0.45 kg; 1 cwt = 112 lb), distance in feet and inches, yards or miles (1 foot = 12 inches = 30.5 mm; 1 yard = 3 feet = 0.91 m; 1 mile = 1.61 km), area in acres (1 acre = 0.41 ha), and volume in bushels (1 bushel = 36.4 litres).

The material obtained from the seven sources outlined above was organized by extracting and collating information for each of the species of interest. This information, which in some cases proved to be encyclopaedic in quantity, was then analysed further and subsequently consolidated and synthesized into a narrative and map for each species.

The narrative provided for each species is set out in a structured format. First I summarize information resulting from my interviews with oldtimers. This information was kept separate from other records as oral testimony may be less reliable than other sources through distortion of recollections caused by faulty memory. As noted by Semon (1899: 142), the recorder of oral history has to strike a balance between credulity and scepticism. The facts related by oldtimers are often of value but the the conclusions drawn may be false. Observations are most believable if related by the original observer, as was generally the case in my study. Observations made and related independently of each other by different people (as was the case in my study) are most deserving of belief.

Then I note relevant records from colonial times. Anecdotal information from accounts in early books and newspapers and parliamentary debates is referenced so that others can check my interpretation. Key phrases are frequently quoted rather than paraphrased. Discrepancies are carefully assessed if considered important. Modern information is mentioned as appropriate, and the views of scientists from other parts of Australia are cited. The large quantity of information found for the most visible and conspicuous species is further organized thematically. For those species that have contracted in distribution, I have shown on the distribution map the decade in which oldtimers last observed the species.

The species distribution maps do not purport to include every known record, although all of the records discovered are included. Other records (e.g. *Western Australian Bird Notes* 1943-; Kitchener and Vicker 1981) have only been included if their omission would have given an incorrect impression of the extent of geographical distribution. Other distribution maps of the species considered are available in Johnstone and Storr (1998), Strahan (1995), WA Museum (2005), and Department of Environment and Conservation (2006).

Binomials for bird and mammal species adhere to those of Johnstone (2001) and How *et al.* (2001) respectively. Aboriginal names for some species are in widespread use in Western Australia, but not elsewhere. It has also been proposed that more of these names should be adopted (Abbott 2001a). Therefore, Noongar names are provided, together with vernaculars used by Strahan (1995), How *et al.* (2001), and Johnstone (2001), for the convenience of readers unfamiliar with Noongar names. Noongar names do not commence with a capital letter.

Accepted common names for plant species are used throughout, with the Latin binomial being provided only on the first occasion that the common name is used.

RESULTS

Native species

Leipoa ocellata ngawoo/gnow/malleefowl

Oldtimer information The local occurrence of the malleefowl was unknown to most of the oldtimers

interviewed (Fig. 3). Those who knew this species noted that it had been plentiful. R. Herbert recalled that his father had fed them wheat, with the malleefowl mixing freely with poultry. A. Hunter remembered that birds were not timid, as they did not react to his use of a chainsaw near an active nest. Oldtimers implicated clearing of vegetation, predation by foxes, and the shooting of birds for food in the decline of this species in south-west WA.

First observations by settlers The malleefowl first came to the attention of settlers in April 1835, when G. Moore met near Lennard Brook an Aboriginal on whose arm was 'an ornament composed of feathers, resembling those of our domesticated turkey. He said there are abundance of them in the Northern districts, that they are well known to the natives, & are called by them "Gnow"' (Shoobert 2005: 424).

Nests robbed of their eggs were first seen by Europeans on an expedition (that included G. Moore) eastwards of York on 13 October 1836 near Emu Hill, though these were described at the time as 'circular excavations in the ground, the sandy soil being raised very regularly in a circle of diameter about 12 ft and was first thought to be a grave'. Europeans first observed birds on 19 October 1836, north of Welcome Hill. The two birds seen were described as 'about size of a barn door cock or a large drake…Wings small, and not adapted to long flights' (Roe 1836: 29). On 20 October, 'in a close thicket, came to another of the circular holes which have so often attracted our notice in this region, and as it appeared to have been freshly scratched about by a bird', Roe then provided a lengthy description of its composition and structure (Roe 1836: 31), although it was not yet realized that these were gnow nests. More nests were met with on 23 October, but the link with gnows had yet to be made (Roe 1836: 39).

The next day (24 October), near Mt Moore, the party came across 'a circular nest on the ground, heaped up differently from the others – which had all been hollowed in the middle.' The party found 6 eggs 'about the size of the Black Swan's' (later eaten) and then it was surmised that it was the nest of the gnow. Hatching had commenced in some nests near Eaglestone Hill and was well advanced in other nests (Roe 1836: 42). The next nest was found near Mandiga on 30 October, with eggs (Roe 1836: 55). The next day, east of Cadoux, the explorers at last made the link between convex-topped nests containing gnow eggs and concave-topped nests (seen earlier on the expedition and thought to be termitaria – Roe 1836: 18) robbed of their eggs by Aborigines. The last nests seen were near Cadoux on 1 November.

The first specimen was collected by J. Drummond in January 1837 (*Swan River Guardian* 12.1.1837: 60). Its crop was full of *Acacia* seeds and its flesh was stated to be 'superior in flavour to the domestic Turkey'.

Later explorers who set out eastwards from the Avon Valley also did not meet nests until well to the east (H. Lefroy 1863 in Exploration Diaries **5**: 245; B. Clarkson *et al.* 1864 in Exploration Diaries **5**: 336). Was this an artefact because explorers avoided travel through thickets?

Colonial name In colonial times this species was known by its Noongar name, variously spelled as *Ngowoo* (F. Armstrong in *The Perth Gazette* 16.7.1836: 728), *gnow* (Roe 1836: 29; Austin 1855: 16; H. Lefroy in Exploration Diaries **5**: 245; B. Clarkson *et al.* in Exploration Diaries **5**: 336; Monger nd), *Nau* (Drummond 1839), *Ngow-o* (Grey 1840: 108), *Now* (Landor 1847: 250), *Nowa* (Buchanan 2003: 70), *n-gou* (R. Salvado 1840s in Stormon 1977: 200), *gnow-ow* (Austin 1855: 9), *ngou* (Clay nd), *gnou* (Game Act, 1874), *Ngow* (G. Grey 1842 in Gould 1848 vol. 1: lxxv; Carter 1888: 191), *ngow* (Curr 1886 vol. 1: 361), *Ngou'o* (*The Inquirer* 9.6.1841), *gnowoo* (*Kalgoorlie Miner* 30.12.1902), or *Nower* (Greaves 1903: 18). According to G. Grey, 1842 (Gould op. cit.), the Aboriginal name is from the tuft on its head, as *Ngoweer* is their name for a tuft of feathers. Thus it should not be presumed that localities with the Aboriginal names Nower-gup Lake [near Yanchep, Grey 1841], Gnowing Spring [c. 14 km north-west of Wandering, Schorer 1974: 11], Gnowanallup [south-east of Nyabing, Beecham nd: 141], Gnowangerup, and Gnowergerup and Gnowergerup Brook (near Mayanup), and Mangowine necessarily indicate the past occurrence of malleefowl.

The terms 'Colonial pheasant', 'native pheasant', and 'Scrub Pheasant' were also in use (Moore 1842: 67, 103; Austin 1855: 9; Armstrong nd; Oldfield 1865: 294). The name 'malleefowl' is of eastern states provenance, as is the word 'mallee', and does not appear to have been used in WA until the 20th century.

Distribution and abundance Although recorded throughout south-west WA (Fig. 3), the malleefowl seems to have been most numerous north and east of a line joining Kalbarri, Wongan Hills, Goomalling, Cunderdin, Yealering, Broomehill, western edge of the Stirling Range, and Beaufort Inlet:

- Nests encountered 'every few yards' in dense mallee south of Flint Cliff, Hamelin Pool (Carter 1888: 191-2); 'innumerable' nests between lower Murchison River and Hamelin Pool (undated, *The West Australian* 27.9.1924: 13)
- 'great numbers of nests' in mallee belt between Wooramel and Murchison River (Carter 1904: 173-4)
- hundreds of old mounds met with at Wongan Hills (Milligan 1904: 217; *The Western Mail* 12.2.1920: 4)
- breeding in kwongan vegetation 25 miles north-east of Toodyay, i.e. between Bejoording and Goomalling (Drummond 1839)
- Not found closer to York than two days' walk to the east (Information provided by Aborigines to F. Armstrong, *The Perth Gazette* 16.7.1836: 728)
- 'I never saw any nests…nearer than about fifty miles from York, near Coraling [?Caroling], beyond Dangin. Nests seem to be pretty frequent further out at Woggerling [?Wogolin, near Harrismith] and also at Gulurkey, seventy to a hundred miles south-east of York' (J. Cowan in Leake 1961: 72)
- occurs in 'the far interior & where there is great

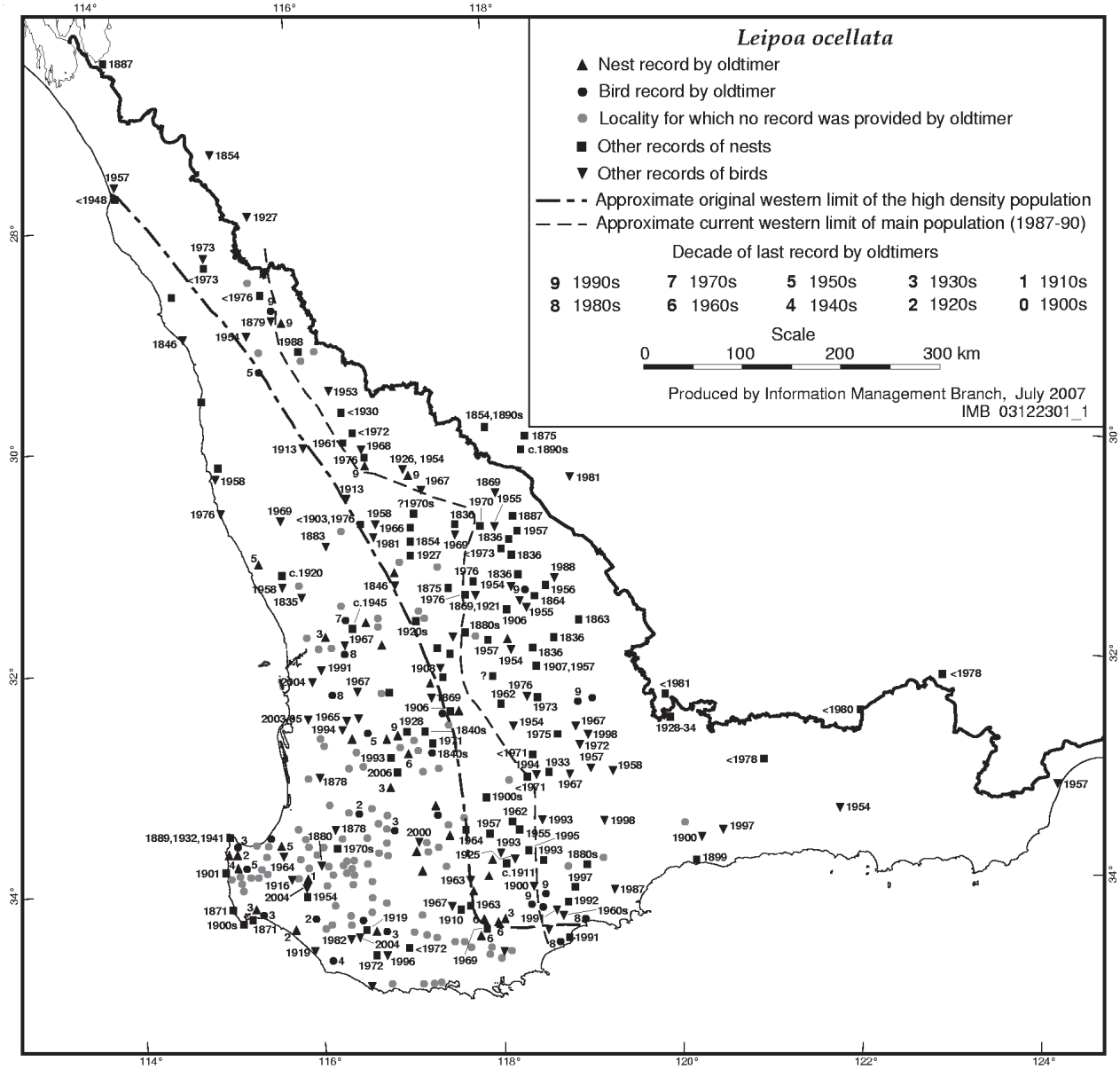

Fig. 3 Distribution of Leipoa ocellata. *Additional records not already cited in text: Anon. 1989; Archer 1979; Ashby 1930; Bush 1879; Clemens 2000; Curr 1886; Dell 1977, 1978b, 1979c, 1981; Dell and How 1985; Dell and Johnstone 1976, 1977; Dell and McGauran 1981; Ewers 1959;* Fauna Bulletin*; Harold and Dennings 1998; Hasluck 1963; How* et al. *1988; Landor 1847; McKenzie* et al. *1973; McKenzie* et al. *1993; Orton and Sandland 1913; Sedgwick 1953; Sedgwick and Morrison 1949; Southern Scribes 1999; Stokes 1984; Stranger nd: 45; Tunney letter 22.5.1897;* The West Australian *21.1.1928: 6;* The Western Mail *14.5.1925: 1; Whitlock 1911; Whittem 2000. The line depicting the main western limit of distribution in 1987-90 is based on Saunders and Ingram (1995: 76).*

scarcity of water', i.e. well to the east of Beverley (Monger nd)

- old nest mounds are to be found 'almost everywhere', at Woyaline (Ogilvie-Grant 1910: 190-1)
- breeding east of the Great Southern Railway, south and south-east of Broomehill (T. Carter in North 1913 vol. 4: 164; Carter 1923: 127)
- recently used nests, south-west of Mondurup Peak, Stirling Range, November 1969 (Department of Conservation and Land Management file 01468573807 vol. 1)
- active mounds, Beaufort estuary, November 1991 (Department of Conservation and Land Management file 044185F1999).

I thus differ from Storr (1991), who recognized the main original western limit as from East Yuna, Wilroy, Caron, Buntine, Nugadong, 30 miles east of Moora, Wongan Hills, Clackline, Woyaline, Dryandra, Dumbleyung, Broomehill, northern foot of the Stirling Range to Beaufort Inlet.

Corroborating evidence comes from numerous records inland that provide information on local abundance (listed from north to south):

- thousands of old nests scattered about on poorer land about Latham (*The Western Mail* 16.1.1930: 36)
- east of Pigeon Rocks, eggs form a principal item in the diet of Aborigines, 1875 (Giles 1889 vol. 2: 232)
- east of Mt Churchman, numerous nests, 1875 (Giles 1889 vol. 2: 236)
- 'I saw more mallee hens [sic] nests through here [near Mt Churchman] than I have seen anywhere else in WA', c. 1890s (Ashwin 2002: 140)
- numerous in 1880s along edge of (usually dry) salt lakes near Mt Caroline. Eggs eaten by settlers (Leake 1961: 73)
- many nests 20 miles east of Kellerberrin, near salt lakes, 1902-23 (Leake 1961: 73)
- great numbers, Merredin district, 1864 (B. Clarkson *et al*. in Exploration Diaries **5**: 336)
- the outer edge of wheat-growing areas in c. 1861 was 'the home of very considerable numbers of the mallee hen' (C. Harper in *The Western Mail* 22.4.1920: 9)
- six shot, Danginning, 1869 (Forrest 1875: 27)
- many nests north of Emu Hill, 1836 (Roe 1836: 18)
- leisure time spent hunting for eggs, Forrestiana 1928-34 (Shorter 1987: 120)
- many old mounds, Cumminin (Crossman 1909: 84-5)
- fairly numerous near Welbungin, 1956 (*Fisheries Department Bulletin* 3/4); Narembeen 1957 and Nyabing (*Fisheries Department Bulletin* 4/1-4)
- mounds very plentiful north, south and east of Lake Grace (Carnaby 1933: 103)
- Aborigines looking for eggs in nests along lake edge, Badjaling district (Eaton 1979: 140)
- eggs eaten, Wishbone, nd (Anon. 1999: 106)
- eggs eaten, north-east of Gnowangerup, nd (Marshall 1993: 120)
- nests 'very plentiful not far from here', Jerramungup, 1880s (Hassell 1975: 130).

To the west of Wongan Hills, Goomalling, Cunderdin, Yealering and Broomehill, null records are numerous, and any records of occurrence are transitory:

- on an expedition from York to Albany and return via a slightly different route, no birds or mounds were recorded (J. Roe 1835 in Shoobert 2005: 456-497, 509-534)
- comes into the valley of the Avon river with the bronzewing pigeon to feed upon *Acacia* seeds (Drummond 1839)
- no mention of birds or nest mounds on a journey from Kalbarri to Perth close to the coast (Grey 1841 vol. 2: 1-98)
- not recorded on a journey from Toodyay, Bolgart, Yenart, Badji Badji Spring, New Norcia to Moora, 1842 (Whittell 1942: 228-32; Wagstaffe and Rutherford 1954: 491)
- birds move to Avon Valley in March of dry years (C. Hunt 1865 in Maddock 1998: 10, 50)
- 'the gnow came into the York district in considerable numbers about the year 1865' (J. Cowan in Leake 1961: 72)
- not nesting at Northam but will drink at pools along the Avon River in very dry summers (Leake 1961: 72)
- not recorded along Moore River between New Norcia and Regans Ford, 1903 (Lawson 1905)
- apparently absent from Gracefield district, as it was necessary to travel eastwards in order to collect specimens (J. Tunney, letters 20.6.1900, 25.6.1900).

Nevertheless, west of Wongan Hills, Goomalling, Cunderdin, Yealering and Broomehill, the species did breed at low density and populations were very local. This is contrary to the claim that the malleefowl is absent from the south-west forests (Serventy and Whittell 1948: 66). Nor were the populations at Meanarra Hill, Freshwater Point, Cockleshell Gully, Beermullah, Busselton to Cape Mentelle, Blackwood River to Point d'Entrecasteaux, and Lake Muir area outliers as implied by Storr (1991: 45):

- Gnows Nest Hill, c. 20 km north-east of Geraldton (geographical name)
- old mounds, Cockleshell Gully, near Padbury farm (Dell and Johnstone 1977: 45)
- 'fairly numerous' in Dandaragan district many years ago (*The Western Mail* 21.6.1928: 6)
- bred 3 years ago 20 miles south-east of Moora, but used to be common 50 years ago [i.e. in 1889] according to old settlers (Orton 1939)
- remains of nests c. 1913-23, Beermullah (Roe and Roe 1992)
- one nest c. 1945 near Clackline (Masters and Milhinch 1974: 233)
- still nesting in 1927 5 miles south-west of Brookton (*The West Australian* 7.1.1928: 8)
- nest in Dale district (Broun 1995: 98)
- one or two birds seen on 3 days out of 62 days, 1967-8, Dryandra (Job 1969: 92), Eight active mounds in 1978-9, decreasing to two in 1990-3 (Department of Conservation and Land Management file 044185F1999 vol. 3)
- one disused nest found in the 1970s at Windmill Gully between Grimwade and Noggerup (Abbott 1999: 15)
- two mounds near Geographe Bay, 1889 (Campbell 1900: 706); 'very plentiful' within a mile or so of the coast near Dunsborough, c. 1880s (Department of Conservation and Land Management file 01468573807 vol. 1, R. Darbyshire 1940-1)
- active mound (photographed) near Cape Naturaliste 'within a couple of miles of the ocean', 1932 (Whittell 1933: 315-6)

- active nest, Ngoocardup, near Ellenbrook between Cowaramup Brook and Cape Mentelle, 1901 (Milligan 1902: 76)
- one nest, Cape Mentelle, 1902 (Carter 1903: 39; Carter 1923: 128)
- birds and nest recorded in jarrah forest, 12 km south-east of Nannup (Department of Conservation and Land Management file 01468573807 vol. 1 and LJ McClennan pers. comm.[4])
- 'conical mounds' near Cape Hamelin and on the coast a few miles eastward of Augusta, 1871 (Lovat 1914: 203)
- tracks seen near mouth of the Warren River, 1919 (Carter 1920: 687)
- a few pairs nesting near Lake Muir, 1919 (Carter 1923: 128)
- 'still doing well on the coast', on a practically cleared farm near Margaret River (Le Soeuf 1920)
- 'still plentiful' around Lake Gingilup in 1948 (Storr 1954)
- nests and young birds seen in karri *Eucalyptus diversicolor* forest near Frankland River, 1971-77 (Christensen *et al.* 1985: 38; Abbott 1999: 14-16).

Claims by FF Armstrong, that he saw a mound of this species on Mt Eliza, Perth in 1829 and that Aborigines had robbed nests of their eggs from a thicket between the coastal sandhills adjacent to the beach, were not substantiated by J. Gilbert in 1842 (Wagstaffe and Rutherford 1954: 502).

Many records of birds west of the high density population (Fig. 3) are mainly after November (when chicks hatch) or from the end of summer (when birds wander from their mounds to feed on wattle seeds, T. Carter in North 1913 vol. 4: 164; Carter 1920: 688):

- December 1846: Bookara, lower Greenough River flats (*The Inquirer* 20.1.1847)
- Summer 1857: 'extraordinary numbers' appeared 'on the back sheep runs during summer, so much so that it is said in a day's ride hundreds might be seen where usually it is a rare thing for one to be found' (*The Perth Gazette* 10.4.1857: 2)
- May 1957: two birds, Kalbarri townsite (*Fisheries Department Bulletin* 4/1-4)
- June 1958: in thickets down river [?Hill River] from Jurien Bay (*Fisheries Department Bulletin* 5/1, 1959)
- June 1958: several seen 10 miles west of Gingin (*Fisheries Department Bulletin* 5/1 1959)
- September 1961: one roadkill between 33 and 34 mile pegs east of the Lakes on road to York (Abbott 1999: 16)
- August 1964: one bird, Willcock pine plantation via Tutunup (Department of Conservation and Land Management file 01468573807 vol. 1)
- Late summer 1965: one bird, North East Road, Windsor/Boonering forest blocks (Abbott 1999: 16)
- April 1967: one bird, Brookton Highway 40 miles from Perth [?near Yarra Road] (Department of Conservation and Land Management file 01468573807 vol. 1)
- April 1967: one bird, 7 miles west of Cranbrook on Boyup Brook Road (Department of Conservation and Land Management file 01468573807 vol. 1)
- ?December 1969: 14 birds on farm near Dandaragan (Department of Conservation and Land Management file 01468573807 vol. 1)
- May 1973: one bird, Chitty Road south-west of Toodyay (Department of Conservation and Land Management file 01468573807 vol. 1)
- March 1976: one bird, Nambung National Park (Department of Conservation and Land Management file 01468573807 vol. 1)
- December 1982: one bird, Middleton Road, Westcliffe forest block (Langfield 1982: 15; Abbott 1999: 15)
- July 1991: one bird, Roleystone garden (Smith 1991; possibly an aviary escape – L. Hassan pers. comm.)
- March 1994: one bird, Nettleton Road near Admiral Road, Jarrahdale district (H. Burne pers. comm.)
- August 1994: one bird, crossed North East Road into Windsor forest block (Department of Conservation and Land Management file 036043F3807)
- January 2000: one bird, Boscabel (Department of Conservation and Land Management file 044185F1999 vol. 3)
- October 2004: one bird, Murtin forest block in karri regrowth (I. Wilson pers. comm.)
- December 2004: one bird, Beaton forest block (I. Wilson pers. comm.)
- October 2005: one bird, Poorginup forest block (I. Wheeler, pers. comm.).

For other records of vagrant birds, without precise month of record, see Abbott (1999: 15-16).

Habitat and interaction with humans The malleefowl occurred as a breeding species in a variety of vegetation types: 'close scrubby thickets' and 'close thicket' (Roe 1836: 56-7); barely impenetrable kwongan [sandplain heath] (Drummond 1839); nearly impenetrable thickets (Monger nd); nesting in 'the most impervious thickets' (Oldfield 1865: 274); 'mallee scrub' (*The Western Mail* 12.2.1920: 4); 'seem to have preferred ridges or high land with gravel for their nesting sites' (*The Western Mail* 16.1.1930: 36); dense scrub, with most nests within a mile of granite rocks (Leake 1961: 71, 81; see also Greaves 1903: 18); mallee and low woodland (Newbey and Chapman 1995: 50); and on islands of slightly raised sandplains with mallee and shrubs (Repton 1999: 310).

Although considered 'very shy & upon the least sound disappear' (Monger nd), 'very shy…and not easy to flush' (Ogilvie-Grant 1910: 191) and rarely venturing out of

[4] Details of personal communications are collected in Appendix 2.

dense scrub into the open (Leake 1961: 71), there are numerous instances of malleefowl mixing with domestic fowls (Carter 1923: 128; *Fisheries Department Bulletin* 2/2, 1955), feeding on fallen grain from harvesting (C. Hamilton in *Gould League Notes* 1948-9), feeding on roads on wheat spilt from trucks (*Fisheries Department Bulletin* 3/2, 1956), feeding in pasture (Department of Conservation and Land Management file 01468573807 vol. 1), wheat crops (Department of Conservation and Land Management file 044185F1999 vol. 3; de Rebeira and de Rebeira 1977: 81) and stubble paddocks (Dell 1979: 95-115), remaining on wheatbelt roadsides undisturbed by passing traffic (Department of Conservation and Land Management file 01468573807 vol. 1), and walking into a camp and eating potatoes and crumbs of cake and bread (F. Whitlock in *The Western Mail* 28.10.1926: 40, 11.11.1926: 40). One nineteenth century source stated that young birds are easily tamed (Monger nd). In New South Wales the malleefowl was also regarded as easily domesticated (Bennett 1884: 196).

Moore (1842: 67) thought that this species would be 'very valuable if domesticated', no doubt because of its edible eggs. One egg is equivalent in volume to three fowl eggs (Leake 1962: 44). Hassell (1975: 131) admitted to having eaten many eggs during the 1880s.

Malleefowl are able to run very fast and almost keep a horse in a gallop, eventually flying into a 'thick topped tree' or putting its head in a hole (Monger nd; *Kalgoorlie Miner* 30.12.1902).

Change in distribution and abundance The malleefowl has experienced mixed fortunes, with an extensive decline in distribution and abundance and some local increases in abundance. A number of factors appear to have operated to cause this:

• Aboriginal predation of eggs

Given that the malleefowl occurred as a breeding species at both the southern and northern ends of the Swan Coastal Plain, it is surprising that it was absent from most of this Plain when European settlers arrived in 1829. This district is known to have supported relatively high density populations of Noongars (Hallam 1975, 1989). This absence may have resulted from unsustainable predation of eggs, as there is evidence that Aborigines ate these eggs, available from August to November (Roe 1836; Monger nd; Oldfield 1865: 274-5; Giles 1889 vol. 2; *The West Australian* 27.9.1924: 13; Bird 1986: 285). Aborigines also speared birds roosting at night on branches in thickets (Oldfield 1865: 275). The local occurrence of nesting malleefowl populations west of the high density line marked on Fig. 3 also corresponds to areas where Aborigines probably occurred at high densities (Hallam 1989). Humans have caused extinction of megapodes on islands in the western Pacific Ocean in past millennia (Steadman 1999). Aboriginal predation where densities are high, as on the Swan Coastal Plain and along the Avon River, may explain the absence of malleefowl from these areas in historical times.

With the decline of Aborigines after the 1860s, this species should have increased in abundance (cf. Leake 1961: 83).

• Drought

Leake (1961: 72, 73) implicated drought from 1877 to the 1890s in the change of status of this species from 'fairly plentiful' to 'scarce' to 'almost non-existent' by 1902. From 1920 there was a run of wet years and the capture of one bird in a dingo trap in 1922 was the first sighted by Leake near Kellerberrin since 1892. By 1926 he had heard of 12 records (bird or nest) within 40 miles of Kellerberrin (Leake 1961: 74). Drought in c. 1895 was also suggested as a possible explanation of the local extinction at Wongan Hills (Milligan 1904: 219-220).

• Clearing of vegetation

Leake (1961: 83) thought that the malleefowl would persist until large areas of native vegetation were cleared. But declines commenced well before there was extensive removal of vegetation (Carter 1888; Milligan 1904; Crossman 1909). It seems unlikely that birds recorded occasionally to the west of their usual range represent displacement by clearing operations, as was suggested by Garstone (nd). Stranger (nd: 48-9) described how nests on land being cleared in 1961 were destroyed by the first ploughing.

• Inappropriate fire regime

The disappearance of malleefowl from Wongan Hills before 1903 was attributed by Milligan (1904) to burning in summer by pastoralists to produce green pick after the first autumn rains. Carter (1921, 1923) hypothesized that 'constant burning off' of coastal scrub would eventually cause decline.

• Shooting of birds by settlers for food

Birds provided 'very delicate meat, exceedingly tender…like a Pheasant' (recorded by J. Gilbert 1843 in Whittell 1942: 300), were considered 'excellent eating', with the flesh being 'very white & delicate' (Monger nd) and 'the most gamey of all Australian birds; its flesh is very succulent and well-flavoured' (Oldfield 1865: 275). Although no actual records of shooting were found, the malleefowl was first given the protection of a closed season by the Game Act of 1874, from September to November inclusive (the breeding season). Aborigines were not bound by this Act, however, provided that birds were taken only for their own subsistence. The Game Act Amendment Act of 1876 (and *Government Gazette* 26.9.1876: 201) extended the closed season by one month (August to November). Following a subsequent amendment in 1879, a closed season from August to October inclusive was declared within a radius of 5 miles of 16 towns between Northampton and Albany (*Government Gazette* 21.10.1879: 263). In 1885 the closed season was extended to July and to a larger portion of south-west WA (south and west of the mouth of Murchison River, Bompas Hill,

Wongan Hills, Mt Stirling, mouth of Fitzgerald River, and Eucla, *Government Gazette* 15.10.1885: 491). There was a further extension of the closed season to the period July-November inclusive throughout the south-west and along the south coast as far east as Eucla (*Government Gazette* 31.10.1889: 639). It was not until 1930 that the malleefowl was protected at all times throughout the State (*Government Gazette* 28.2.1930: 721).

• Disease

Early declines, evidenced by the presence of inactive mounds, north of the Murchison River, Wongan Hills, Cumminin, east of Pingelly and near Kellerberrin (Carter 1888: 191-2; Milligan 1904, Crossman 1909: 84-5; Ogilvie-Grant 1910; Leake 1961) may have resulted from a disease outbreak. Consistent with this hypothesis is the subsequent return of nesting birds (e.g. *The Western Mail* 12.2.1920: 4; 16.1.1930: 36). The malleefowl during the 1890s was 'almost exterminated' within a radius of c. 75 km of Kellerberrin (Leake 1961: 71), with only one record of an active nest (in 1906) in the period 1902-20. This is well before the fox colonized the area in 1924. Many old nests were present. Birds re-appeared in the 1920s. In Coorow district the malleefowl was plentiful in the 1890s but was last reported in 1913 (*The West Australian* 14.11.1925: 15). The malleefowl was 'many years ago' [?1890s] 'fairly numerous' in Dandaragan district but became locally extinct apparently by c. 1903 (Green 1928).

• Vulpine predation

Prima facie, predation by foxes should be an important factor because of the poor flight of the malleefowl, which relies more on its running powers. When pursued, it will fly to a tree, partially exhausted (Leake 1961: 71). Empirical support comes from Peron Peninsula, Shark Bay, where poisoning over an area of 100 000 ha has allowed translocated malleefowl to establish and persist (Morris 2000). McColl (1929: 98) and Ford and Stone (1957: 11) linked decline of the malleefowl to the arrival of the fox. The regular sighting of single birds around Huntly bauxite mine from December 2003 to July 2005 (H. Burne pers. comm.) may have represented an unsuccessful attempt to re-establish within the original low density sector of its geographical range.

In contrast,

- During 1954-6 (c. 30 years following the establishment of the fox), malleefowl were increasingly reported from a number of districts, including Kalannie, Merredin and Bruce Rock (*Fisheries Department Bulletin* 2/2 and 2/3 1955). Malleefowl were sighted for the first time in 30 years near Merredin (*Fisheries Department Bulletin* 2/4, 1955). At Welbungin they appeared not to suffer any impact from foxes (*Fisheries Department Bulletin* 3/1, 1956) and in 1956 more were seen than at any time since 1911 (*Fisheries Department Bulletin* 3/4, 1956).
- Malleefowl were nesting again at Wongan Hills (after an earlier decline) by 1920 (*The Western Mail* 12.2.1920: 4) and were still present in 1973 (de Rebeira and de Rebeira 1977: 81).
- Malleefowl at Dryandra Woodland have not responded to nearly 20 years of 1080 baiting (Pridham 2002). Only one active mound is known to occur in this reserve in 2006 (B. MacMahon pers. comm.).

• Feline predation

Cats, which are 'of large size', had been advanced 'by some' as the factor accounting for the decline of the malleefowl (Carter 1888: 191-2; see also C. Harper in *The Western Mail* 22.4.1920: 9). Evidence against a significant role for cats in this decline comes from Peron Peninsula, where malleefowl translocated in 1997-8 have persisted, constructed mounds by 2000, and successfully hatched young birds in the presence of feral cats (Morris *et al.* 2004).

There is little doubt, however, that overall the malleefowl has declined in distribution and abundance. The western limit of the main population had by 1987-90 retreated to the east of its original limit (Fig. 3). In a survey of wheatbelt birds conducted in the period 1987-90, malleefowl were recorded by only 13-21% of observers and the proportion of the recording period during which malleefowl were observed was very low, at 2.3-3.0% of recording weeks (Saunders and Ingram 1995: 76).

The suggestion by EA Le Soeuf that malleefowl be translocated to an island to improve the conservation of the species (*The West Australian* 17.12.1927: 6) was not followed up.

Ardeotis australis bebilya/Australian bustard

Oldtimer information Most oldtimers knew the bustard (usually as bush turkey, native turkey or wild turkey) as an occasional visitor or had not seen any. All of the records of this species as occurring regularly in the same district come from the interior portion of south-west WA (Fig. 4). The oldtimers who recalled its past occurrence cited habitat loss (through vegetation clearing) and shooting (for bush meat), and not the arrival of the fox, for its demise.

Distribution and abundance Although widely distributed, the bustard originally occurred regularly only in the north and interior of south-west WA, south to Busselton on the Swan Coastal Plain (F. Ludlow 1834 in Shoobert 2005: 348) and east of a line joining Mogumber (Loaring 1952: 109; Milligan 1904: 11), New Norcia (Hasluck 1963: 70; Stormon 1977: 199, 256), Goomalling (F. Boase in Saunders and Ingram 1995: 89), Cunderdin (Stokes 1984: 31), Aldersyde (Knox-Thomson 1975: 26), Kunjin (Jenkyn 1999: 75), Yealering (Gardner 2000: 48), east of Broomehill (Carter 1923: 134), and Esperance (McCarthy nd). Storr (1991: 51) thought that its western limit on the south coast was near Cheyne Beach but I have been unable to confirm that.

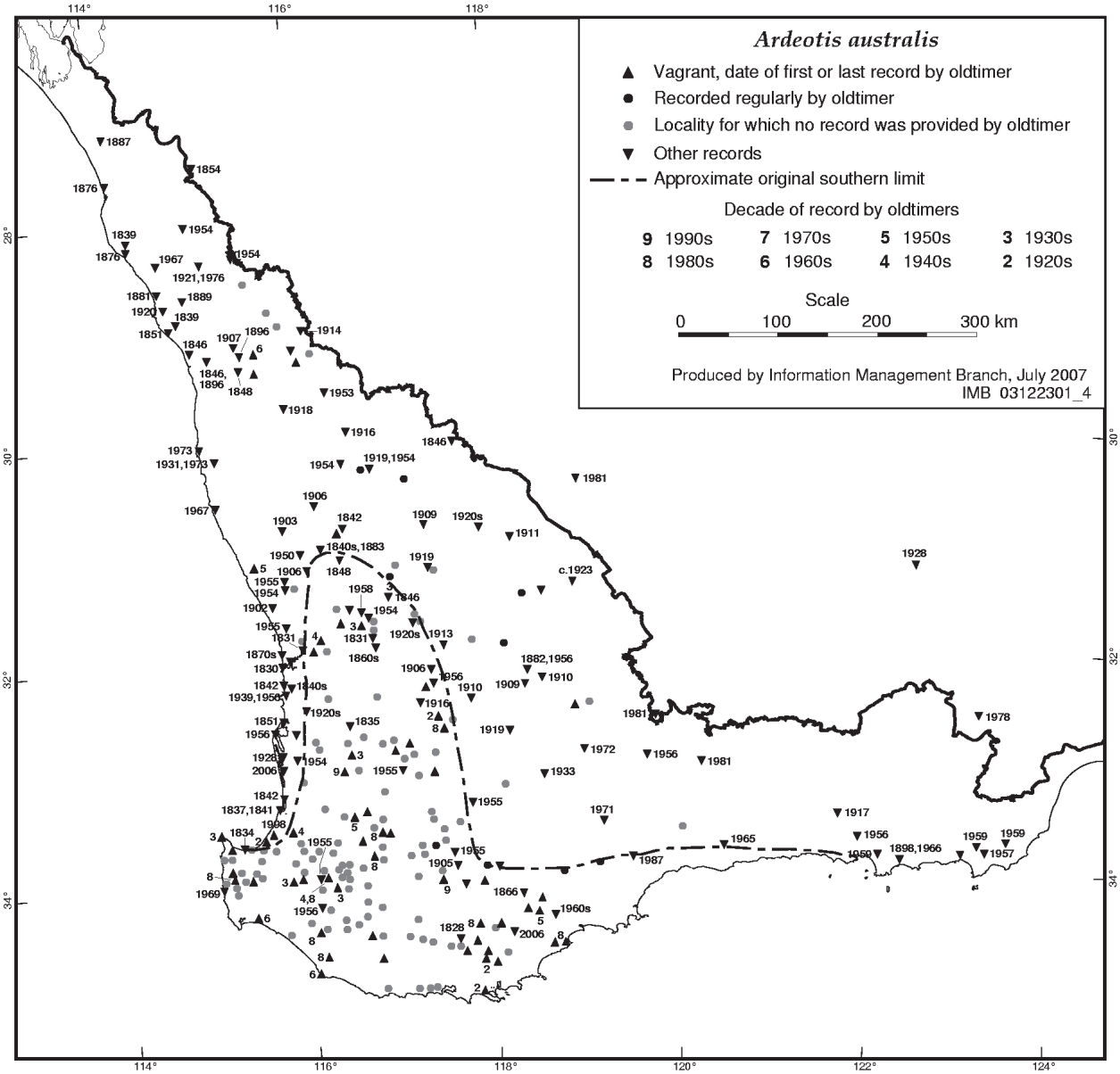

Fig. 4 Distribution of Ardeotis australis. *Additional records not already cited in text: Anon. 1989; Briggs 1917; Buchanan 2003: 70, 130, 138; Cameron 1989; Carnaby 1933; Carter 1888; Clark 1994; Crossman 1909; Dell 1976; Dell and How 1985; Dell and Johnstone 1977;* Esperance Chronicle and Dundas and Norseman Advertiser *12.2.1898; F. Helpman 1846 in Exploration Diaries vol. 4; Fisher 1992; Grey 1841; J. Harris 1835 in Shoobert 2005: 402; Hillman 1990; Heydon 1988; How* et al. *1988; Kitchener* et al. *1975; Krefft 1867; Landor 1847; Lawson 1905; Mann 2006; Masters and Milbinch 1974; McKenzie* et al. *1973, 1993; Metcalfe 2006; Milligan 1903a; G. Moore 1831 in Shoobert 2005: 259; O'Connor 2001; Ogilvie-Grant 1910; Royal Commission 1917b; Sedgwick 1940, 1953; Serventy 1929a, 1930a; Shann 1926; Southern Scribes 1999;* The Western Mail *25.10.1928: 6; Tunney letters 18.1.1896, 27.1.1896; Wakefield 1828; Wellard 1983.*

Bustards occurred on open sandplains (Taunton 1903: 47; Gardner 2000: 48), coastal dunes and alluvial country (E. Brown 1851 in Cowan 1977: 152; Serventy 1948: 29) and other open country (Le Soeuf 1900: 199; Le Soeuf 1921: 140), including paddocks (Stokes 1984: 31). This species did not 'like to feed in timber or thick country' (T. Carter in Mathews 1913-4: 369).

Dated records of bustards on the Swan Coastal Plain indicate that this species occurred in all months, as is the case elsewhere in its normal range. Correlates of regular occurrence are remarks such as c. 20 birds seen (F. Ludlow in Shoobert 2005: 348), 'a large number' (Gregory and Gregory 1884: 5), 'many' (Bolton *et al.* 1991: 184), 'plentiful' or 'numerous' (Taunton 1903: 47), 'abound' (*The Western Mail* 11.1.1908: 19), 'numerous' (Le Soeuf 1921: 140), 'many' or 'flock' (Melia and Bosworth 1997: 178), 'very plentiful', with flocks of a dozen often seen (Rice 1993: 100), 'plentiful' (Coy 1984: 139), in flocks (Eaton 1979: 169), 'flourished' in district (Goldsmith 1961: 59), 20-30 at dams (Braid and Forbes 1997: 59),

20 birds (Cowan 1977: 152), mobs of 20-30 (*Fisheries Department Bulletin* 1/3, 1954), 'common' (Carter 1923: 134), 14 in flock (*Fisheries Department Bulletin* 2/4, 1955), abounded on farm (Stokes 1984: 31), and 'hundreds' (Dell and McGauran 1981: 67-93).

Outside of the range limits defined above, the species is either not listed or mentioned only as a vagrant or seasonal visitor, supported by comments such as:

- 'We lost the only wild turkey that we ever saw' – York, 1860s (Millett 1872: 224)
- Bustards used to migrate in summer to wheatfields and kwongan east of Pingelly (Gardner 2000: 48)
- Third record in Northam district since 1930 and 1944 (*Fisheries Department Bulletin* 2/2, 1955)
- Two records in Katanning district since 1935 (*Fisheries Department Bulletin* 2/3, 1955)
- Only three birds seen in 15 years on a farm at Coolup (A. Robinson in Sedgwick 1954: 181)
- Single birds in 1949 and 1956 near Bolgart (Erickson 1956)
- 'One seen [north of Westonia] in 30,000 miles travelled in the wheat belt' (H. Wilson in Sedgwick 1954: 182)
- One bird in paddock between Williams and Narrogin, January 1955 (Sedgwick 1962: 89)
- Rarely seen on farm c. 10 km west of Broomehill (T. Carter in North 1913 vol. 4: 245)
- Not resident in the district bounded by Narrogin, Toolibin, Dumbleyung, Badjebup, Broomehill, Kojonup and Arthur River (Garstone nd: 12)
- One or two birds (vagrants) separately reported in Albany district in the period 1998-2007 (*Western Australian Bird Notes* No. 88: 3, 105: 5, 114: 10-11, 118: 7, 122: 3).

Human impact Although Meagher (1974) recorded no instances of Aboriginal predation on the bustard, there is no reason to suppose that they were not captured and eaten. Indeed, bustards were eaten at New Norcia (Stormon 1977: 160). Furthermore, bustards were obviously well known to Aborigines because various Noongar names for this species have been recorded (Gilbert nd1, Moore 1842, Curr 1886). In contrast, there are numerous records of consumption by settlers or explorers (Moore 1842: 8; *The Perth Gazette* 5.3.1852: 4; Austin 1855: 56; Cameron 2006: 461-2; Campbell 1890: 936; Hall 1902b: 177; T. Carter in North 1913 vol. 4: 244-5; Anon. 1931: 9-10; Ewers 1959: 97; Goldsmith 1961: 59; Johnston 1962: 164; *Fauna Bulletin* 1/3, 1967; Knox-Thomson 1975: 26; Greble 1979: 64; Parnell 1982: 64; Bristow 1984a; Coy 1984: 139; Stokes 1984: 31; Maddock 1987: 78, 143; Jenkins 1988: 5; Marshall 1993: 9; Melia and Bosworth 1997: 184; Braid and Forbes 1997: 122; Statham and Erickson 1998: 306; Jenkyn 1999: 75; Berryman 2002: 154).

The Game Act 1874 conferred protection in the breeding season (September to November, inclusive), except from Aborigines. This period was extended to August by the Game Act Amendment Act 1876 (see also *Government Gazette* 26.9.1876: 201), and a subsequent amendment in 1878 permitted proclamation of a closed season for any portion of WA. Action followed the next year with a closed season declared from August to October inclusive within 5 miles of Northampton, Geraldton, Greenough, Dongara, Toodyay, Northam, York, Beverley, Guildford, Perth, Fremantle, Rockingham, Pinjarra, Bunbury, Busselton and Albany (*Government Gazette* 21.10.1879: 263). The closed season was later extended to include July and the area was broadened to include land bounded by Murchison River, Bompas Hill, Wongan Hills, Mt Stirling, mouth of Fitzgerald River and Eucla (*Government Gazette* 15.10.1885: 491). A closed season was subsequently proclaimed for the period July to November inclusive, for the South-west Division and south coast east to Eucla (*Government Gazette* 31.10.1889: 639). These early responses evidently reflect official concerns that the bustard was declining in distribution and abundance.

The bustard was considered to require full protection because it ate grasshoppers, which were a threat to wheat farming in the 1920s (F. Whitlock in *The Westralian Farmers' Gazette* 15.11.1928: 17; L. Glauert in *The Western Mail* 12.9.1929: 40; Mingenew 1988: 82-3; Jenkins 1988: 5).

The major natural factor that influenced the local distribution of the bustard was probably drought (Le Soeuf 1915; Carter 1920: 700). Rain inland resulted in populations near Geraldton moving east (RM Brown in J. Tunney letter 5.3.1896), and conversely rain in agricultural districts attracted bustards (Leake 1962: 76).

In south-west WA the bustard has contracted in distribution and abundance through a combination of two factors:

- Unsustainable predation by settlers. This is linked to the conspicuous size and low reproductive rate of this species (Berney 1907: 109). Bustards, 'the best game bird that flies in the bush' (Boldrewood 1888: 381), were scarce in 1876 between Lynton and Geraldton relative to the sparsely settled Lynton-Murchison River district (Taunton 1903: 47, 95). Campbell (1890: 936) did not see any and was informed by his guide that his bag for 3 months of last season was 44 birds. F. Hare of York (*The West Australian* 1.1.1896: 3) noted that turkeys 'will shortly be things of the past [as they] are ruthlessly destroyed at times'. Hall (1902b: 177) mentions 84 being shot near one locality (not disclosed) in December 1899. This species was being slowly but surely exterminated in settled districts (F. Whitlock in *The Westralian Farmers' Gazette* 15.11.1928: 17). The closed season (July to November inclusive) was extended in 1929 to everywhere south of 26° (*Government Gazette* 28.3.1929: 867), apparently after lobbying by pastoralists and the Royal Society of WA (*Journal of the Royal Society of WA* **16**: xiii). In 1935, the bustard became 'at all times strictly preserved generally throughout the State' (*Government Gazette* 1.11.1935: 2067).

- Unsustainable predation by foxes. Craig (1925: 98) correctly predicted that the bustard 'will suffer severely' if the fox were to become numerous, probably based on the fact that this species normally lays only one egg, which is deposited on the ground. A few years later foxes were said to be 'annihilating' the bustard (J. Holmes WAPD **84**: 1209, 22.10.1930).

In Moora district bustards had been 'fairly plentiful' up to 1920, but shooters (in cars) and predation by foxes had caused declines by 1939 (Orton 1939). The bustard was considered to be 'very scarce and seen but rarely in the agricultural districts' in 1941 (Jenkins 1942: 212). Both factors operating in the 1960s led Passfield (1988: 156) to 'see no cause for optimism' concerning the persistence of this species.

The outcome of both shooting and fox predation was that none of the 22 nature reserves in the wheatbelt that were investigated in the 1970s had bustards present on or near them (Kitchener *et al.* 1982: 152). Even in the heartland of its original range, as at Wongan Hills, Kwolyin, and Dumbleyung, the bustard was either no longer recorded or occurred only as a vagrant (de Rebeira and de Rebeira 1977; Ford and Stone 1957; Serventy 1958). Although an Australian-wide aerial survey of kangaroos detected no bustards in south-west WA, they remained abundant in northern Australia (Grice *et al.* 1986). In a survey of wheatbelt birds during 1987-90, bustards were recorded by only 13-28% of observers and in only 2.9-4.1% of the total number of weeks when observations were made (Saunders and Ingram 1995: 89). Furthermore, records tended to be concentrated east of a line joining Mullewa, Three Springs, Dalwallinu, Kellerberrin, Lake King and Esperance.

Bustards were attracted to cleared areas by the availability of water in farm dams and the provision of a new food source, agricultural crops (Alexander 1921: 159; Augustin 1916: 73-79; Braid and Forbes 1999: 122; Carter 1923: 134; Gardner 2000: 48; Greble 1979: 64; Stokes 1984: 31), but were not an economic pest like the emu (F. Whitlock in *The Westralian Farmers' Gazette* 15.11.1928: 17). Ironically, they could be shot more easily in cleared areas than in uncleared vegetation. Their attraction to recently burned country (Dell and McGauran 1981; *Western Australian Bird Notes* No. 42: 9; Passfield 1988: 154; Newbey and Chapman 1995) should also have facilitated shooting of birds. Birds could also be more easily approached on horseback than on foot (Stormon 1977: 199).

There was a period after c. 1861 when the bustard increased its distribution and abundance (C. Harper in *The Western Mail* 22.4.1920: 9). Before then, this species was very rare in the wheatbelt south of Moora. This increase was tentatively attributed to the destruction by farmers of wedge-tailed eagles and dingoes.

I found no evidence to confirm the claim made by Woodward (1907: 18) that feral cats had caused local extinction of bustards in Geraldton district.

With a late 20th century shift of societal values from shooting to protecting biodiversity, the bustard should recolonize parts of its original range. Perhaps the numerous sightings of birds (usually singletons) since 1986 on the Swan Coastal Plain (*Western Australian Bird Notes* No. 39: 6, 58: 2, 83: 3, 85: 3, 87: 2, 105: 5, 114: 10; *Western Wildlife* **10(2)**: 9) are the fore-runner of this re-establishment.

Burhinus grallarius werloo/bush stone-curlew

Oldtimer information Most oldtimers were familiar with the call ('weelo') of the bush stone-curlew, heard mostly at night. This species became very rare or locally extinct following the arrival of the fox, but has not completely disappeared from south-west WA (Fig. 5).

I was told of several instances of this species nesting close to farm houses, perhaps benefiting from protection against foxes by farm dogs and sympathetic farmers. Bush stone-curlews also relied on camouflage, making it possible to walk up and touch individual birds (B. Young pers. comm.).

Distribution and abundance The original geographical range of the bush stone-curlew in south-west WA appears to have excluded the jarrah and karri forests (Abbott 1999) and the sector east of Hyden and Jerramungup (Fig. 5).

For a species with an 'extraordinary whistling noise in the night…often heard by the settlers' (Drummond 1843), an 'unearthly noise' (Monger nd), a 'doleful noise' (Armstrong nd), a 'sad note' (Nicolay 1896: 129), a 'wailing, blood curdling, shuddering clamour' (*The West Australian* 11.1.1930: 4), a 'weird whistle' (*The West Australian* 23.8.1930: 4), a 'weird and frightening call' (Gardner 2000: 64), 'melancholy whistling' (Harris 2002: 182), 'awful wail' (Gervas 1999: 107), or 'eerie wail' (Shiner 2003: 36), there are surprisingly few records of this species in historical documents, despite explicit statements of its abundance or wide distribution:

- 'in hundreds' around Brookton in the 1870s (*The West Australian* 6.9.1930: 4)
- very plentiful in wandoo *Eucalyptus wandoo* country; came very close to camp at night; and flushed on many occasions from thickets during the day (Milligan 1903a: 19)
- heard every night (Hill 1903: 107)
- plentiful in jam *Acacia acuminata* country, 1904 (Anon. 1999: 347)
- very plentiful (Crossman 1909: 85)
- 'distributed everywhere, but nowhere can be called really abundant' (T. Carter in North 1913 vol. 4: 249)
- 'fairly plentiful throughout the central and south-western divisions' (Ogilvie-Grant 1910: 178)
- 'fairly numerous' about Broomehill (T. Carter in Mathews 1913-4: 356)
- 'fairly common' (Alexander 1921: 159)
- far from a rare bird, though more often heard than

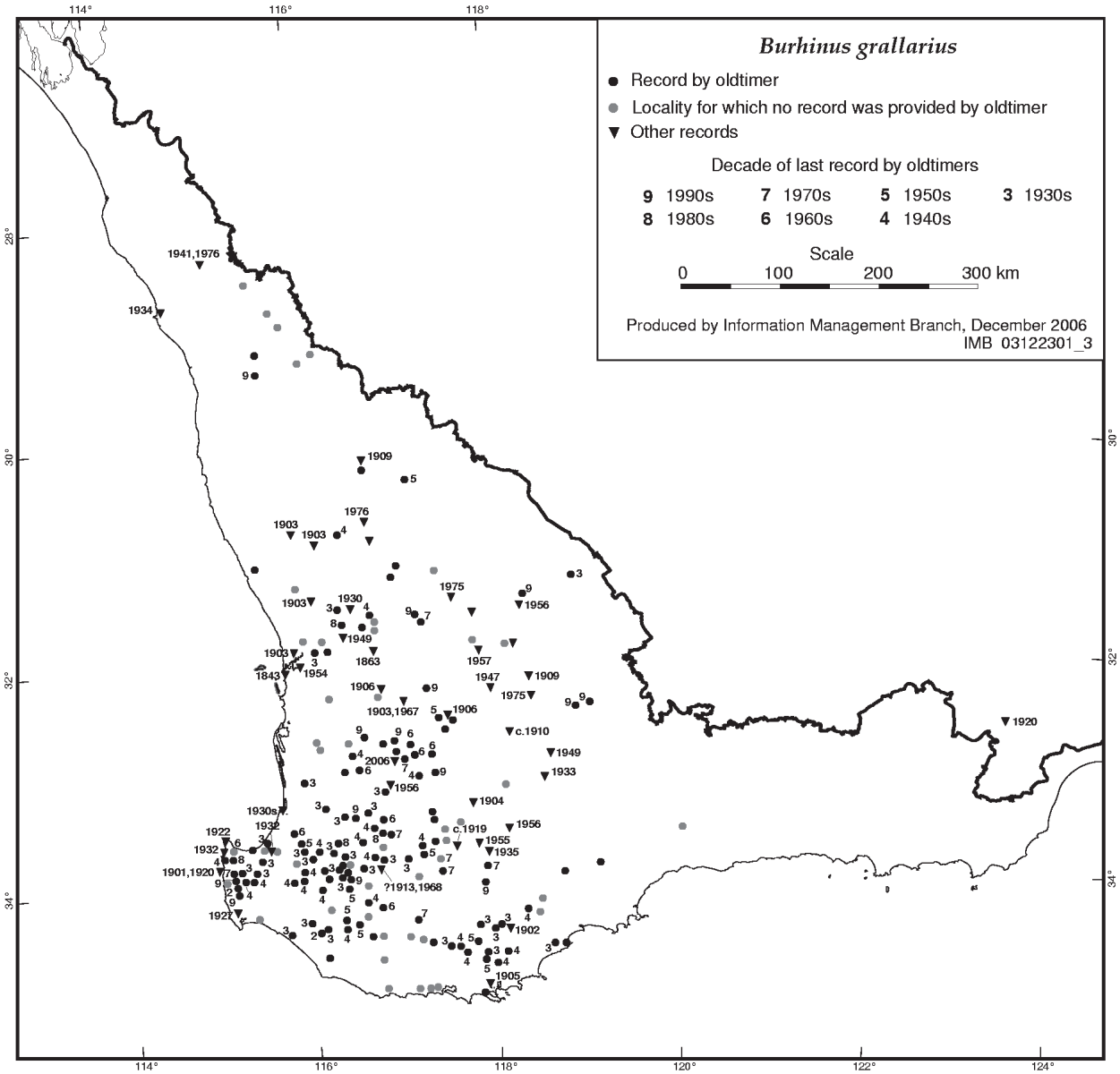

Fig. 5 Distribution of Burhinus grallarius. *Additional records not already cited in text: Abbott 2006 pers. obs.; Crake 1985; Dell 1977, 1980a; Dell and McGauran 1981; Fisheries Department files 103/49, 83/50; Harris 2002; Hill 1904; Lawson 1905; Lowrie nd; Milligan 1904; Nannup 1992; M. Oates in* Our Rural Magazine *7: 85 (1932); Payne 1987; Sedgwick 1947; Serventy 1958.*

seen (F. Whitlock in *The Westralian Farmers' Gazette* 13.9.1928: 8)

- 'fairly plentiful' (Serventy 1948: 29)
- 'Still plentiful in the agricultural areas' (R. Aitken in *Gould League Notes* 1953-4).

Carnaby (1933: 104) noted that it was more often heard than seen. Aborigines called stone-curlews 'Jingy birds' from an association with evil spirits (Millett 1872: 58), doubtless based on the call. Hill (1903: 107) noted that when possums were being hunted, birds called after a gunshot.

Habitats recorded include: jam tree country (Anon. 1999: 347); patches of York gum *Eucalyptus loxophleba*, where it rests during the day (Leake 1962: 89); the banks of lakes and rivers (Nicolay 1896: 129) and margins of shallow pools (F. Whitlock in *The Westralian Farmers' Gazette* 13.9.1928: 8); shade patches and thickets close to dams (R. Aitken ibid.); paddocks and clearings (Milligan 1902: 75; Hall 1902b: 178; White 1921: 125; Whittell 1933: 185; *Fauna Bulletin* 1/3, 1967); golf links (Sedgwick 1944: 232); 'open coastal scrubs' (Carter 1923: 133-4); sandhills, where it hides during the day, and tidelines where it feeds during the night (Whitlock 1939: 51); wandoo woodland (Milligan 1903a: 19); brown mallet hills (Garstone nd: 14); regenerating mallee (de Rebeira and de Rebeira 1977: 82); and generally confined to patches of timbered country (Ford and Stone 1957: 13).

Nesting or occurrence close to houses was recorded by Leake (1962: 89), Stewart (1962), Garstone (nd: 14), and Wellard (1983: 153). Young birds were occasionally tamed (Monger nd; *The West Australian* 4.10.1930: 4).

Human impacts Whitlock was of the view that agriculture did not affect this species (*The Westralian Farmers' Gazette* 13.9.1928: 8). Clearing of native vegetation, so long as patches of vegetation remained, has been favourable to the bush stone-curlew, particularly where forest has been partially cleared (Abbott 1999: 46). This species increased in Kellerberrin district after 1910 because there was more open water available following the establishment of farms (The *West Australian* 4.10.1930: 4).

This species has disappeared from some localities (Ackland 1965: 103; Bignell 1997: 70; Giblett 2006: 60) or has declined in numbers at others (Lange 1981: 378; Masters and Milhinch 1974: 234; Orton and Sandland 1913: 76). An apparent revival was noted in 1955 in Upper Blackwood (*Fisheries Department Bulletin* 2/4) and in 1969 near Busselton (*Fauna Bulletin* 3/1), but near Northam the species decreased 'alarmingly' in c. 1960 (Masters and Milhinch 1974: 234). A survey by staff of the Western Australian Museum of 22 reserves in the wheatbelt in the 1970s recorded this species on only three reserves, either as single birds or as 'scarce' (Kitchener *et al.* 1980). In a survey of wheatbelt birds conducted in 1987-90, only 18-24% of observers recorded this species, and then only on 5-7% of recording weeks (Saunders and Ingram 1995: 90).

In the 1980s and early 1990s single birds were reported at Katanning, Badgebup, Dragon Rocks Nature Reserve, and west of Brookton (*Western Australian Bird Notes* No. 35: 7, 44: 9, 65: 3). Breeding still occurred near Northam and at Dryandra (ibid. 48: 2, 60: 7-8).

The factor most deleterious to the bush stone-curlew has been stated to be predation by the fox and feral cat (*The West Australian* 6.9.1930: 4; Bignell 1997: 70; Storr 1991: 65), based on its ground-nesting habit and small clutch of 2 eggs. Evidence against cats as a significant factor in the decline of the stone-curlew comes from Balladonia, where the bush stone-curlew disappeared within 'a few years' of the arrival of the fox in 1917, whereas feral cats had been present there at least since the 1890s (Richards and Short 1998). Orton (1939) stated that foxes were gradually extirpating this species in Moora district. In South Australia, the decline of the bush stone-curlew correlates with the establishment of the fox (Gates and Paton 2005).

With widespread baiting against foxes on public lands and in many farming districts since 1994, the bush stone-curlew should re-establish more widely in south-west WA. However, there is so far no evidence of broadscale recovery. Perhaps the presence of a single bird in the suburb of Warwick north of Perth in 1998, and breeding by one pair since 2001 near Pingrup (*Western Australian Bird Notes* No. 86: 3, 115: 26), represent the first sign of this predicted revival.

Other deleterious factors include poisoning of water to control rabbits, and accidental capture in rabbit traps (*The West Australian* 23.8.1930: 4).

Vanellus tricolor banded lapwing

Oldtimer information Although all oldtimers were familiar with, and most reported, the banded lapwing (Fig. 6), many noted a decrease in abundance, from hundreds in paddocks to 0-12 birds at present. Local extinction of many populations was evident by the 1940s and 1950s (Fig. 6). One oldtimer thought that the original habitat of this species was the bare ground around salt lakes (F. Smith pers. comm.).

Factors favouring the expansion in distribution of banded lapwings included the surge of clearing of vegetation that took place with the advent of bulldozers after 1945, and the adoption of subclover pastures following application of trace elements from the 1950s. Detrimental influences mentioned by oldtimers were the establishment of the fox and the introduction of large agricultural machinery in the 1960s and their use day and night (J. Stokes pers. comm.).

Distribution and abundance The banded lapwing originally did not occur in south-west WA. It was first reported in 1869 (Krefft 1869: 7) and again in the 1890s (Milligan 1904: 11; Lawson 1905: 136; Leake 1962: 76; Storr 1991: 53). During the period 1904-7 it was considered to be of local occurrence only, with specimens collected near York (Ogilvie-Grant 1910: 182-3). The combination of sufficient cleared land, presence of farm dams, and the accidental arrival of birds presumably led to establishment near Kellerberrin in c. 1908 (B. Leake, *The Western Mail* 12.4.1923: 6) or 1912 (Leake 1962), and nesting near Mingenew in 1907-8 (Serventy 1929a: 194). It was first noted (c. 7 birds) in 1907 near Broomehill, and by 1908 there were 40 birds present, with the first breeding there reported in 1909, and hundreds present in 1910 (T. Carter in North 1913 vol. 4: 274; Carter 1923: 132). This species was becoming plentiful as clearing progressed within a 30 mile radius of Moora (Orton and Sandland 1913: 76). It colonized Dirk Hartog Island '[a] few years' before 1918 (Whitlock 1921: 173). By 1920 it was considered to be spreading and increasing generally (Le Soeuf 1920).

It arrived at Busselton 'a few years' before 1919 (Carter 1920: 695). Before 1921 it had 'recently' become common on cleared land at the foothills about Gingin but was not yet present near Perth (Alexander 1921: 158). This species has been present in Yuna district since 1921 (Dell and McGauran 1981: 74). In 1924 it was seen near Perth in paddocks near Cannington/Queen's Park (DL Serventy in *The Farmer* 5.6.1924: 36), and in 1930 was reported on land newly cleared for an aerodrome west of Subiaco (*The West Australian* 3.5.1930: 4).

From 1918 this species, like all plovers, was protected from shooting north of Moore River between June and September each year (*Government Gazette* 9.11.1917: 1796). Local declines attributed to fox predation were first reported in the mid 1920s (Serventy 1927: 182).

The increasing tempo of clearing in the 1920s probably

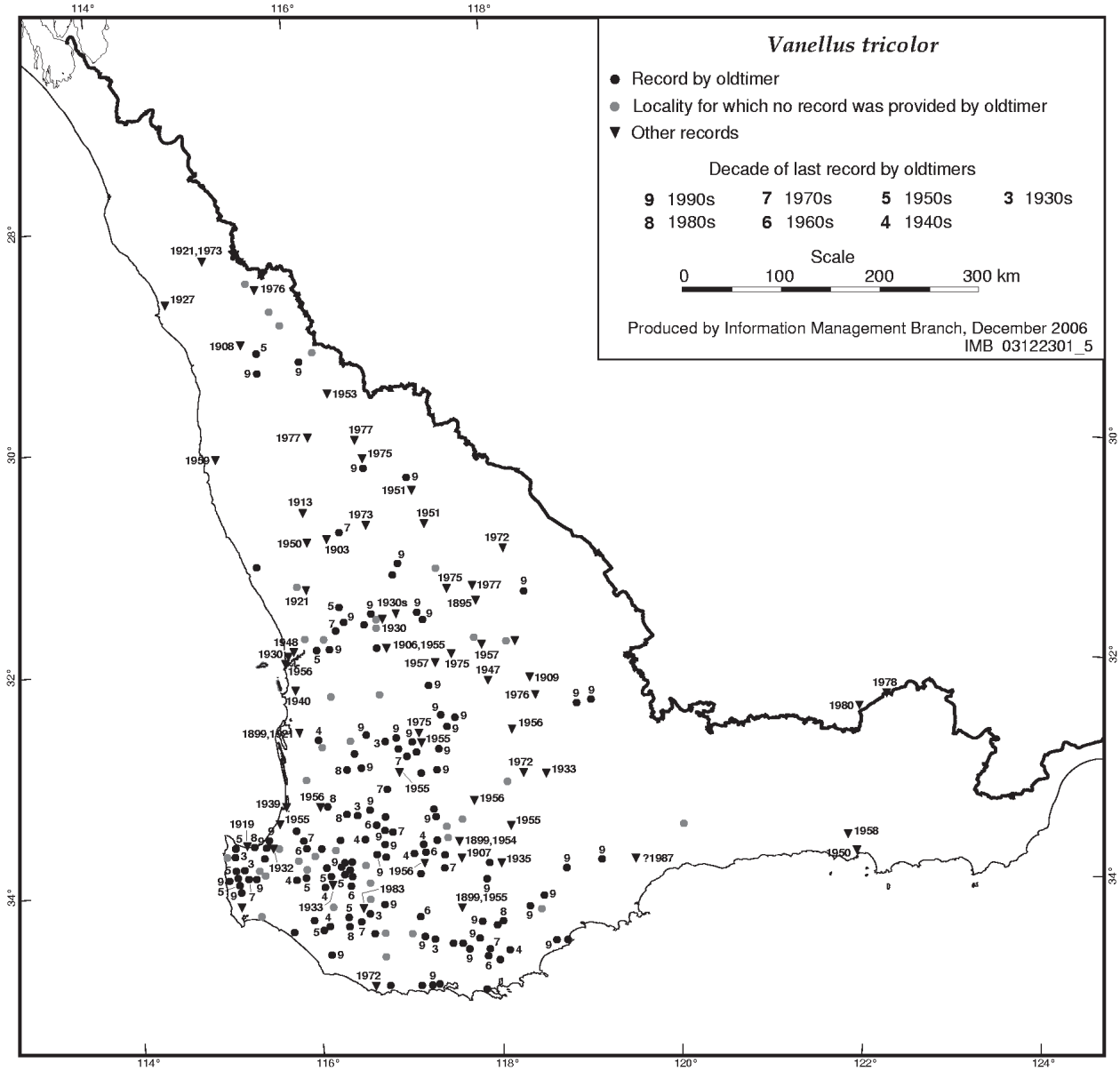

Fig. 6 Distribution of Vanellus tricolor. *Additional records not already cited in text: Ashby 1930; Crossman 1909; Dell 1980a; Dell 1981; Ford and Stone 1957; Harold and Dell 1979; Harris 2002; Kitchener* et al. *1975; Loaring 1952; McKenzie* et al. *1993; Reid 1951; Sedgwick 1947, 1952, 1953, 1962; Sedgwick and Sedgwick 1950; Serventy 1948, 1958.*

led to rapid increase in distribution and abundance. It was recorded near Alexandra Bridge once pasture was established with Group settlement (Payne 1987: 43-4). By the 1930s very large flocks of up to 100 birds and widespread nesting were reported (Carnaby 1933: 104; Jenkins 1931: 31; Masters and Milhinch 1974: 234; M. Oates, Tutunup, in *Our Rural Magazine* 7, 85; Repton 1999: 311; Stokes 1986: 204; Whitlock 1939: 51; Whittell 1933: 185). In 1939, banded lapwings were common throughout Moora district even though predation on eggs and young by foxes was evident (Orton 1939). By 1948 flocks of up to 50 birds could be seen on the eastern part of the Esplanade, Perth (Serventy and Whittell 1948: 145). This species was common and widespread between Busselton and Augusta in 1953-4 (Storr 1954).

The experienced ornithologist F. Whitlock considered that this species had benefited from agricultural progress (*The Westralian Farmers' Gazette* 11.10.1928: 11). In the previous 20 years it had become more common and widely diffused than formerly. Before c. 1908, it was more common only east and south-east of Geraldton and since then had extended its range.

Subsequent decline By the mid-1950s banded lapwings were still generally distributed, but not always as abundant, as previously:

- 'almost extinct', Capel district (*Fisheries Department Bulletin* 2/4, 1955)
- not increasing, Katanning district (*Fisheries Department Bulletin* 2/4, 1955)

- largest flock seen in Boyup Brook district only 12 birds (*Fisheries Department Bulletin* 3/1, 1955)
- not plentiful in Wickepin district and decreasing in Beverley and Merredin districts (*Fisheries Department Bulletin* 3/4, 1956)
- 'now only occasional' in Collie (*Fisheries Department Bulletin* 5/1, 1959)
- 'once fairly numerous' (Ewers 1959: 97)
- very scarce in Upper Blackwood district (*Fisheries Department Bulletin* 5/1, 1958)
- although present all year on a farm at Narrikup, no more than *c.* 12 birds constituted a flock (*Gould League Notes* No. 18, 1958-9).

In a survey of 22 wheatbelt reserves in the 1970s, this species was recorded on only one reserve (in woodland) and was uncommon in paddocks adjacent to several others (Kitchener *et al.* 1980; Dell and Johnstone 1976; Dell 1977; Dell 1978; Dell 1979a; Dell 1979b; Dell 1980). During the 1970s and 1980s, banded lapwings were rated as 'common' around Manjimup (Christensen *et al.* 1985: 39). By 1987-90 this species was widely distributed in the wheatbelt, being recorded there by c. 70% of observers and on c. 35% of recording weeks (Saunders and Ingram 1995: 91).

Before clearing in Yuna district, this species was restricted to samphire flats or open areas (Dell and McGauran 1981). It was recorded along the shoreline of Lake Richmond by Sedgwick (1940: 148-9), on salt flats, samphire and creek edges by de Rebeira and de Rebeira (1977: 81), and in very open mallee by Newbey and Chapman (1995: 50). Its favoured habitats include all types of farmland, including cultivated paddocks, stubble fields, pasture and orchards, and sports grounds (numerous references).

Three factors are known to be inimical to the banded lapwing:

- Mechanical destruction of nests: Nests placed on the ground at the beginning of the breeding season (May) run the risk of being ploughed over (Wellard 1983: 172)
- Vulpine predation: Foxes prey on the nest of 3-4 eggs (Ewers 1959: 97; Leake 1962: 88; Stokes 1986: 204), even though nesting lapwings have a distraction display (Serventy and Whittell 1976: 201)
- Management of pasture: Pasture with too much grass or with long grass is unsuitable habitat (Garstone nd; Masters and Milhinch 1974: 234)

The banded lapwing should recover in distribution and abundance in response to widespread baiting of foxes since the mid 1990s. However, I have regularly traversed the highways between Perth and Manjimup during this period and this species is noticeably absent from adjacent farmland. This species breeds and is common on cleared areas associated with the naval base on Garden Island and occurs regularly on Rottnest Island (Wykes *et al.* 1999: 71; Lauri 2006). Foxes are absent from both islands. Although breeding has also been recorded on cleared land in several southern suburbs of Perth (Rutherford 2002), the occurrence of this species elsewhere on the Swan Coastal Plain in the past ten years remains sporadic (*Western Australian Bird Notes* No. 82: 7, 104: 5, 108: 15, 113: 5).

Calyptorhynchus banksii naso karrak/forest red-tailed black cockatoo

I did not question oldtimers about this subspecies of the red-tailed black cockatoo, as a broadscale survey had been completed recently (Abbott 1998a). However, 27 volunteered information about the extent of any change in local status from the 1920s to the 1990s: decrease (8); increase (10); or no change (9). Two oldtimers stated that they shot (as children) birds for their tail feathers (one received 2s 6d per tail).

This subspecies has disappeared from the northern and eastern portions of its range (due primarily to habitat loss) but has only recently been recorded exploiting opportunities provided by fruits of exotic plant species (pines and eucalypts planted in gardens and parks). Such novel items are utilized sporadically. I am not aware of any records of consumption of apples or pears.

Abbott (2002-7) provides online a full historical account, together with distribution maps based on three recent surveys.

Cacatua pastinator manatj/manyte/western long-billed corella

Oldtimer information Very few oldtimers had seen western long-billed corellas in earlier times (Fig. 7). Several reported flocks of 'hundreds' in the 1920s and 1930s, with indication of seasonal movement to burnt ground on the south coast (in summer), and return inland (at the end of summer) to between Lake Muir and Boyup Brook (see Abbott 1999: 19). The paucity of recent records in upper south-west WA (Fig. 7) is an artefact because I interviewed few oldtimers from this subregion. This species is currently widespread between Geraldton, Mullewa, Bruce Rock and York (Saunders and Ingram 1995: 122) and has been expanding its range there, with oldtimers recording this species recently at Dalwallinu (in c. 1969), Kalannie, and Mt Helena (1997).

Farmers at Tonebridge district regarded this species as a pest because large flocks remove wheat seed from paddocks (following sowing) and eat the seed from crops ready for harvesting (F. de Landgrafft pers. comm.).

Distribution and abundance At the time of European settlement the western long-billed corella was distributed widely (Fig. 7), and probably occurred throughout south-west WA except for the jarrah and karri forests (Abbott 1999). Evidence comes from several sources:

- John Gilbert failed to provide any commentary on this species – a sure indication that he met this species nearly everywhere he travelled in 1839-40 and 1842-3 (see Abbott 2001a: 435 for a map of his collecting sites)
- Exploring parties and other travellers made numerous

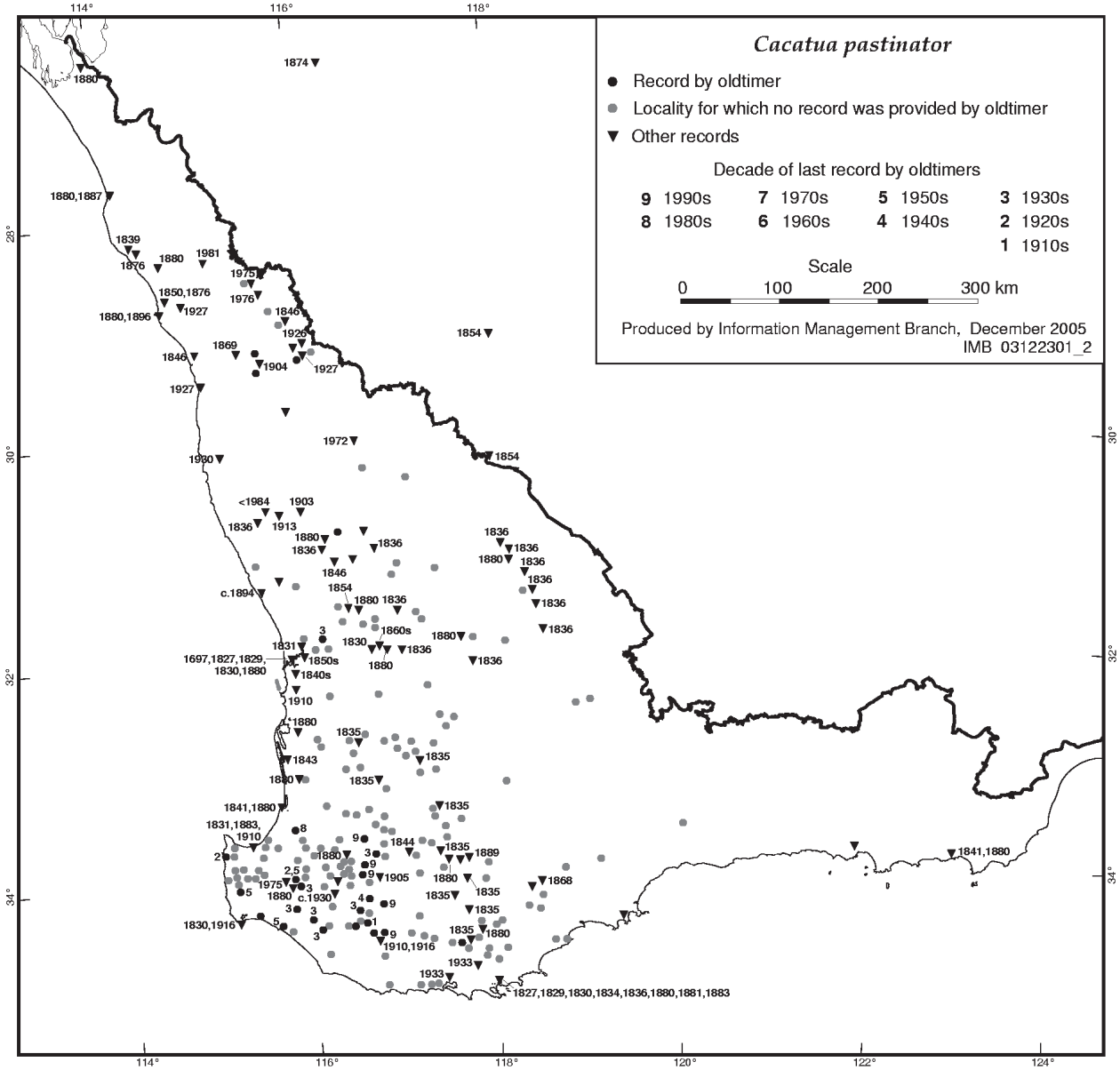

Fig. 7 Distribution of Cacatua pastinator. *Additional records not already cited in text: E. Ashby in North 1912; Austin 1855; J. Benson 1933 in* Our Rural Magazine *8: 145; Bolton* et al. *1991; Carter 1888; Christensen* et al. *1985; Crook* et al. *1984; Dell 1979a, 1979c; Dell and McGauran 1981; Fitzroy 1839; Forrest 1875; Hasluck 1931; Krefft 1869; Milligan 1905; O'Connor 2001; North 1892; E. Norton 1933 in* Our Rural Magazine *8: 295; Smith 1979: 46; J. Stirling 1827 in Shoobert 2005: 34.*

ad hoc reference to 'white cockatoos' (W. Vlamingh 1697 in Robert 1972: 68; E. Lockyer 1827 in Shoobert 2005: 19; C. Fraser 1827 in Shoobert 2005: 51; C. Barker 1830 in Mulvaney and Green 1994: 376; JW Hardey 1830 in Shoobert 2005: 186; E. Pearce c. 1830 in Jennings 1983: 68; J. Bussell 1831 in Shoobert 2005: 268, 270; C. von Hügel 1834 in Clark 1994: 87; Breton 1834: 25; J. Harris 1835 in Shoobert 2005: 403-404; J. Roe 1835 in Shoobert 2005: 477, 481, 511, 515, 517, 522, 524; Wilson 1835: 322; G. Moore 1835 in Cameron 2006: 370; Roe 1836: 32, 34, 35, 38, 48, 49, 63, 66, 68, 70; G. Moore 1836 in Exploration Diaries **2**: 430; H. Bunbury 1836-7 in Bunbury and Morrell 1930: 86; R. Austin 1841-3 in Roth 1903: 64; Grey 1841 vol. 2: 20; F. Humphry 1844 in Exploration Diaries **3**: 761; Eyre 1845: 57; F. Helpman 1846 in Exploration Diaries **4**: 9; A. Gregory 1846 in Gregory and Gregory 1884: 7, 9; Landor 1847: 164; F. Weld 1869 in Lovat 1914: 175; Taunton 1903: 36, 47; G. Broome 1883 in Hasluck 1963: 48; Grant Watson 1968: 76)

- Many old residents advised Carter (1912: 628) that this species occurred 'about the Northern [Railway, completed in 1894] and all along the Great Southern Railway [completed in 1889] districts from York to Albany'
- Aboriginal names of this species were noted from

many locations in c. 1880 (Curr 1886: 308-90) and before c. 1900 (Bates unpubl.): mouth of Murchison River; Northampton; Champion Bay [Geraldton]; Victoria District [Geraldton]; Carnamah; Dandaragan; New Norcia; 30 miles north-east of Mogumber; Victoria Plains [Calingiri]; Gingin; Perth District; Guildford; Mt Stirling; '200 miles north-east of Newcastle' [=Mangowine]; Toodyay; Northam; Meckering; York; Beverley; Pinjarra; Harvey; Williams River; Bridgetown; Capel; Vasse; Eticup; Kojonup; Katanning; Kendenup; Denmark; Albany; 50 miles north-west of Jerramungup; Bremer Bay; Esperance; Frenchman Peak.

Western long-billed corellas were reported as abundant in colonial times:

- 'in large flocks' (C. Fraser 1827 in Shoobert 2005: 51)
- 'numerous in the whole plain [near the Canning River] and were seen every day' (A. Collie 1829 in Shoobert 2005: 87)
- 'many' (JW Hardey 1830 in Shoobert 2005: 186)
- 'numerous', 'great numbers' (1830, Berryman 2002: 147, 153)
- 'a great number' (E. Pearce c. 1830 in Jennings 1983: 68)
- 'in greater multitudes than I have ever witnessed before' (J. Bussell 1831 in Cross 1833: 194)
- 'so numerous as almost to prevent conversation by their noise' (1835, Cameron 2006: 370)
- 'an immense quantity' (A. Hillman 1835 in Shoobert 2005: 393)
- 'so abundant and noisy, that the party could scarcely hear each other speak at the distance of ten yards' (J. Harris 1835 in Shoobert 2005: 404)
- 'numerous' (J. Roe 1835 in Shoobert 2005: 477)
- 'numerous' (Roe 1836: 38)
- a large flock (Roe 1836: 49)
- in great numbers (Roe 1836: 63)
- abundant (Roe 1836: 70)
- 'in great numbers' (J. Eyre 1841 in Eyre 1845: 57)
- 'plenty' (F. Humphrey 1844 in Exploration Diaries **3**: 761)
- large flocks (A. Gregory 1846 in Gregory and Gregory 1884: 9)
- one flock of 5 000 to 6 000 birds, but more usually in flocks of many hundreds (R. Salvado 1846 in Stormon 1977: 39, 198)
- 'immense flights' (Landor 1847: 164)
- 'numerous' (Byrne 1848 vol. 2: 326)
- 'so plentiful' (1874, Muir Diaries 8.2.1874)
- 'immense flocks' (1876, Taunton 1903: 47)
- 'flocks' (G. Broome 1883 in Hasluck 1963: 48)
- 'countless numbers' ('old residents', Carter 1912: 628).

'Hundreds' of birds were also reported in the period 1907-14 by Serventy (1929: 194), Carter (1912: 630) and Le Soeuf (1915).

Taken together, this information does not support the supposition by Storr (1991: 87) that this species originally occurred in small, widely separated colonies, and was confined in the northern sector to valleys of major watercourses.

Flocks of this species showed seasonal mobility:

- Recorded in November 1831, 'the first I had seen this year' (J. Bussell in Shoobert 2005: 268)
- Only a few stragglers to be seen at Millendon in October 1832 (Cameron 2006: 172)
- Arrived at Picton in 1843 in February (J. Wollaston in Bolton *et al.* 1992: 37)
- Very common near Dandaragan in summer but breeds farther north (Orton and Sandland 1913: 77)
- Departed from the coastal plain to breed in the inland (Alexander 1921: 163).

Explorers and travellers in the 1830s and 1840s were aware that the presence of this species was a reliable indicator of water (JW Hardey 1830 in Shoobert 2005: 186; J. Roe 1835 in Shoobert 2005: 477, 481, 511, 515; Roe 1836: 5, 34, 63; F. Helpman in Exploration Diaries **4**: 9; Gregory and Gregory 1884: 7; Moore 1842: 50). It was also noted by JW Hardey *(*ibid.*)* that it was most numerous 'on the best lands', i.e. the grassy York gum woodlands. Franklyn (nd) noted its occurrence on burnt ground. An 1832 reference to cockatoos being fond of a red root (Cameron 2006: 170) almost certainly is to this species eating bulbs of *Haemodorum spicatum*.

Interactions with humans Aborigines placed feathers of this species round their headbands or in their hair. These records relate to Albany (1832, Dale 1834; 1836, Fitzroy 1839: 626), Bunbury district (R. Austin 1841-3 in Roth 1903: 64), Toodyay district (1854, Austin 1855: 6), Cannington (1907, Bates 1992: 34) and unlocalized (WH Bunbury 1836-7 in Bunbury and Morrell 1930: 86).

No records of Aborigines eating this species were found, although it is implied as hundreds of cockatoos could be killed in a few hours using a wounded decoy at a pool of water in summer (Stormon 1977: 158). Consistent with frequent hunting, one early settler noted that this species was shy (J. Bussell 1831 in Shoobert 2005: 270). European settlers also ate this species (Berryman 2002: 153; Jennings 1983: 68; Johnstone 1962: 107; Roe 1836: 66: Taunton 1903: 36), and it was considered 'very wholesome food' (JW Hardey in Shoobert 2005: 186), and making 'capital broth' (Millett 1872: 220-1) and 'an excellent stew' (Carter 1912: 634).

The noisy and inquisitive behaviour of this species is presumably the basis for its Noongar name being used by Noongars to apply to police officers (*manatj*, Whitehurst 1992: 44; *monarch*, Gare 1966: 32, Winmar 1996: 20).

This species' habit of feeding on 'the roots of *Orchideous* plants, to obtain which it scratches on the ground to a considerable depth' (C. Fraser 1827 in Shoobert 2005: 51) pre-adapted it to rapidly becoming an agricultural nuisance:

- 'becoming very troublesome upon the wheat…One is obliged to keep a boy to drive them away, or to make some contrivance to frighten them' (G. Moore, June 1835 in Cameron 2006: 382)
- Use of gunpowder placed under wheat sheaves in one of the southern districts to destroy cockatoos, presumably this species (*The Perth Gazette* 24.10.1840)
- 'cockatoos that come in flocks to pick up the newly sown [wheat] grain', shot by a boy ready at sunrise (E. Brown, May 1848 in Cowan 1977: 81)
- They dig up grain just sown (1860s, Millett 1872: 220-1)
- Very destructive to wheat fields, York and Albany districts, probably 1870s (Monger nd; Franklyn nd)
- Farmers complain of them eating up their wheat (1883, Hasluck 1963: 89)
- A pest of newly planted wheat, c. 1905, Mayanup. Children had to guard the fields until germination occurred (Schorer 1968: 262)
- Because of destruction to wheat crops (before 1905), boys were employed to shoot and frighten the birds away (Broomehill, Carter 1912: 628; Carter 1924: 223)
- Hundreds of birds feeding in wheat crops, on top of stooks; crop also trampled (Lake Muir, December 1911, Carter 1912: 630). Arrived on farm in March to feed on newly sown wheat seeds (Carter 1912: 630; Carter 1924: 223).
- Recorded eating wheat, Lake Muir, January 1916 (Carter 1920: 713)
- Damaging young wheat plants, Perenjori (*The Western Mail* 24.6.1926: 2)
- Flock often visiting a farm, probably at Wilgarrup, when crops ripening (Whittell 1933: 186).

The most effective control was evidently the provision of poisoned grain, which eliminated entire flocks. In 1883, farmers laid grain poisoned with arsenic in their wheat fields near Bunbury and Busselton, so that birds 'sometimes drop, apparently out of the sky, dead at your feet' (Hasluck 1963: 89). E. Ashby collected a specimen in June 1889 near Broomehill killed by eating poisoned wheat (North 1911 vol. 3: 95) and Carter (1912: 628; 1924: 223) states that poisoned wheat was laid to reduce populations. Poisoning was recommended in a newspaper article (*The Western Mail* 24.6.1926: 2). Poisoning was probably the reason for comment that they 'soon leave civilized country & go further north' (Monger nd) and 'Seem to have left the settled Districts of late years' (Armstrong nd).

This species then contracted rapidly in breeding range, and was last reported in various localities as follows: at eastern end of Stirling and Porongurup Ranges, c. 1900 (Carter 1912: 629); Mogumber-Wongan Hills, < 1903 (Milligan 1904:11; Lawson 1905: 136); Brookton, < 1903 (Hill 1903); between York and Albany, < 1905 (Ogilvie-Grant 1910; Carter 1912: 628); Lowlands, c. 1910 (Wellard 1983: 61); Busselton district, 1910 (Grant Watson 1968: 76); Perth district, < 1921 (Alexander 1921: 163); and Woodanilling district, 'left soon after the arrival of Europeans' (Bird 1986: 288).

The western long-billed corella seems to have disappeared from the older farmed areas in the Avon Valley before 1889, as it was not mentioned as a pest in evidence to the Commission on Agriculture (1891), or by farmers in the Toodyay, Wagin and Arthur River districts in 1895 (*Journal of the Bureau of Agriculture of WA* **2**, 385-92). This species apparently disappeared from Albany district between 1883 and 1889 (Campbell 1890; Sellick 1997: 139, 151) and was not recorded by subsequent collectors (Hall 1902a: 193-5, 1902b; Le Soeuf 1900: 199; Ogilvie-Grant 1910). This may have been connected, however, with the pet trade serviced by local collector William Webb (advertisement in *The Albany Mail and King George's Sound Advertiser*, 10.1.1883).

By c. 1900 only two populations were extant: one centred on Lake Muir and the other bounded approximately by Mingenew, Morawa, Moora and Cockleshell Gully. This latter population has since expanded greatly to the south (Saunders and Ingram 1995: 122). The Lake Muir population currently occurs in the area bounded by Dinninup, Mayanup, Lake Muir, Rocky Gully and Dwalganup (Abbott 1999: 19) and is showing indications of re-occupying its former range, although this recovery is impeded by illegal poisoning. Corellas in the Perth metropolitan area are not of this species, and since 2002 are in the process of being eradicated by the Department of Environment and Conservation.

The western long-billed corella was recorded as being kept as a pet by 1842 near Perth (Moore 1842: 50), in the late 1840s at New Norcia (Stormon 1977: 198) and in 1880, between Albany and Kendenup, and at Toodyay (North 1892: 151, 156). At York in 1853 domesticated cockatoos were said to be numerous. These birds were tamed but uncaged (Erickson 1983: 53). It is likely that this record pertains to the western long-billed corella. References to cockatoos being sold in 1880 to passengers on ships at Albany for 2 guineas each (North 1892: 168) probably include this species (cf. Hassell 1941). Caged birds were also reported at Mogumber, 1903 (Lawson 1905: 136) and Mullewa, 1927 (Ashby 1930: 186), and by Monger (nd).

In south-west WA this species was known to Aborigines south of Dandaragan-Victoria Plains as *manyte* and as *binagee, beenarn, y'nawara, nuggerlby and nanara* north of this line (see Wilson 1835: 322; Gilbert nd1; Curr 1886; Carter 1924a: 223; R. Wellstead in *The Western Mail* 14.5.1925: 1; Bates unpubl.; and Bindon and Chadwick 1992 for a full list of variant spellings).

The continued recognition of two subspecies (Storr 1991: 87) is untenable and is not justified by the evidence of a former continuous and widespread distribution across south-west WA (Fig. 7).

Cacatua leadbeateri djakaldjakal/Major Mitchell's cockatoo

I did not seek comment from oldtimers on Major Mitchell's cockatoo, because its current south-western range limits are well characterized (Storr 1991: 88; Saunders and Ingram 1995: 123), namely: Kalbarri, Three Springs, Coorow, Pithara, Bunketch, Wialki and Beringbooding Rock. Storr (1991) gives its original south-western limits as Mingenew, Wongan Hills and Mortlock River North, visiting Toodyay district.

This species was first reported by settlers in June 1836, 25 miles east of the Avon River at York (G. Moore 1836 in Exploration Diaries **2**: 430).

As noted by Storr (1991), J. Drummond (letter 25.7.1839) stated that the 'pink cockatoo' is common here, i.e. 25 miles north-east of Toodyay [hence near Goomalling], and came in flocks to the neighbourhood of the Avon River to feed upon flowers of marri *(Corymbia calophylla)*. This implies February and therefore indicates that this cockatoo was only a late summer visitor. A specimen was shot at Tipperary (York) in January 1841 (Burges 1841; de Burgh and de Burgh 1981: 51). A letter written by J. Gilbert on 9.10.1842 (Wagstaffe and Rutherford 1954) implies that 1841 was a dry year as Major Mitchell's cockatoos, budgerigars *Melopsittacus undulatus* and masked wood-swallows *Artamus personatus* were present in the settled districts of the Avon River in large numbers.

The first exploratory expedition made east of of the Avon Valley (departing from York on 5.10.1836) did not record this species until 1 November, north of Cadoux (five birds). The next report was on 3 November (twice), near Wongan Hills (Roe 1836: 57, 61, 63). Evidently this species did not occur between York, Narembeen, Lake Brown and Bencubbin. Consistent with this is the remark by Leake (1962: 78) that this species was first observed in the eastern wheatbelt in 1946-7, when birds came from the north or north-west as far south as Kellerberrin and remained for a 'short time'. Moore (1842: 35) noted that there is 'generally abundance of salt in the districts frequented by these birds'. Aborigines informed J. Drummond that this species nested in *Mallart [?Eucalyptus astringens]* trees 1-2 days to the east [?north-east] of Goomalling district.

Other records relevant to defining the original south-western range limits of this cockatoo are: the lower Murchison River (Carter 1888; T. Carter in North 1911 vol. 3: 83); upper Irwin ('a very hand-some cockatoo' shot, Burges nd); Champion Bay district and Port Gregory (Franklyn nd); c. 40 miles inland from Champion Bay [?towards Yuna] (J. Roe 1847 in Exploration Diaries **4**: 23; O'Connor 2001: 206); east of Strawberry, 1869 (Lovat 1914: 175); Woogoondy, north of Nangetty, 1907-8 (F. Whitlock in Serventy 1929: 194); c. 70 miles south of Dongara [?Three Springs] (Ashby 1930: 186); occasional at Carnamah, 1937 (*The Western Mail* 18.5.1937: 8); frequent at Caron (Sedgwick 1950); Berkshire Valley, 1883 (Hasluck 1963: 69); and New Norcia, late 1840s – 'seldom seen, and never in large flocks' (Stormon 1977: 198). This species did not breed close to Bolgart, as Lefroy in 1849 recorded that he had been trying for three years to obtain it (Buchanan 2003: 178). In conclusion, the original breeding range probably extended west only as far as Port Gregory, Yuna, Strawberry, Three Springs, Berkshire Valley and south to near New Norcia and Cadoux.

In colonial times this species was known by its onomatopoeic Noongar name, variously rendered as *Iacalyacail* (Moore 1836 *et al.* in Exploration Diaries **2**: 430), *chok(-)el-yok-el* (Roe 1836), *Jakkal-yakkal* (Moore 1842: 35), *Chokel Yokol* (J. Roe 1847 in Exploration Diaries **4**: 23), *Jockeljockel* (1848, Buchanan 2003: 138), *jack-a-la-ka* (Oldfield 1865: 269), *chocolocal* (Colonial and Indian Exhibition 1886: 20); *jockolattle* (de Burgh and de Burgh 1981: 51), *jockolokol* (Hasluck 1963: 69), *Chocolate* (Franklyn nd), *Joggle-Joggle* (Carter 1888), *Jak-kul-yak-kul* (Armstrong nd), and *Jak-kul-ya-ra* (Gilbert nd1). The terms 'Pink' cockatoo (Drummond 1839; F. Armstrong in *The Inquirer* 1.12.1841; Anon. 1842: 99; North 1892: 155; Buchanan 2003: 138), 'red cr[e]sted cockatoo' (Burges 1841), 'Pink-crested cockatoo' (Moore 1842: 35; Buchanan 2003: 176), and 'Tricoloured' cockatoo (Armstrong loc. cit.) were also used.

Aborigines used the feathers as ornaments at corroborees (Colonial and Indian Exhibition 1886: 20). Early records of this species being kept as a pet include 1849 and 1880, in Perth (North 1892: 155; Buchanan 2003: 178).

As noted by Saunders and Ingram (1995: 123), extensive removal of native vegetation and the taking of young birds from nest hollows are probably responsible for the contraction in range since colonial times.

Neophema splendida scarlet-chested parrot

The first record by Europeans of the scarlet-chested parrot was evidently at Bolgart in June 1836, when a parrot 'with splendid plumage' was shot (G. Moore *et al.* in Exploration Diaries **2**: 433). Gilbert (nd1) listed this species but without comment, and Gould formally described it in 1841.

The next report of this species was in 1844 by James Drummond, somewhere between Moore River and 75 miles farther north (Letter, 3.10.1844). It was found breeding and feeding on the seeds of '*Lawrencella lanceolata*', a daisy, growing in a 'rich, grassy country'. Six or seven pairs were seen, but only one bird (a male) was collected.

A male was shot somewhere south-west of Southern Cross on the Clarkson expedition of July 1864 (B. Clarkson *et al.* in Exploration Diiaries 5: 337). The next reports were of an adult male 4 miles west of Bullabulling in 1941 (Wilson 1954) and a small party seen near Kweda in 1949 (Serventy and Whittell 1976).

From the above information it appears that the scarlet-chested parrot may have originally bred as far south-west as Carnamah and ranged further south to near Bolgart, Kweda and Southern Cross.

Dacelo novaeguineae laughing kookaburra

The laughing kookaburra was introduced unofficially and officially into south-west WA from eastern Australia on several occasions, but details are vague. The first known record, based on the unmistakeable call, was at Albany in September 1883 (Sellick 1997: 151-2). Birds were also noted in June 1896 between Perth and Fremantle, and at Mullewa (G. Keartland in North 1898: 171). Interestingly, kookaburras were not recorded in 1889 at Albany, Karridale, Quindalup, Perth or Geraldton (Campbell 1890).

The first record of its official introduction was mention that it had been successfully introduced into Swan and southern districts in 1897 (Acclimatisation Board 1897: 4). A further 29 birds were liberated in 1898 (Acclimatisation Committee 1898: 4). Birds were recorded at Albany in 1898 (Sellick 1997: 215). The following year the birds were 'doing well where liberated and have bred this year at least in one locality' (Acclimatisation Committee 1899: 3). This Committee stated that it intended to introduce more birds 'to relieve the monotony of the bush silence' and because they are 'good friends to the agriculturalist, as they devour, besides snakes, numbers of noxious insects'. In their fourth and final Annual Report, the Acclimatisation Committee (1900: 3) noted that kookaburras had increased in numbers where liberated in pairs and had bred. In late 1900 this Committee intended to liberate 'several scores' so that they would have a chance to increase sufficiently to be of practical use to the agriculturalist.

Twenty years later, White (1921: 126) wrote that it is 'wonderful what a large scope of country [between Cape Naturaliste and Margaret River] it has now taken possession of'.

Kookaburras were recorded attacking chickens in 1913 (L. Glauert in *The Western Mail* 29.8.1929: 40) and in 1915 and 1918 (*The Western Mail* 13.6.1919: 5, 10.7.1919: 4), and eating tame ducklings in 1919 (Carter 1924a: 227). Others disagreed that chickens were eaten (*The Western Mail* 25.4.1919: 7, 16.5.1919: 5, 30.5.1919: 5).

Kookaburras were evidently absent from Esperance in 1926, as a request for a breeding pair was published in *The Western Mail* (28.10 1926: 1; see also 4.11.1926: 2). The species was first recorded at Narrikup in c. 1932 (E. Norton in *Our Rural Magazine* **8**, 295)

Details of the diffusion of this species from these introductions are provided by Storr (1991: 94). The laughing kookaburra now occurs throughout much of south-west WA (Saunders and Ingram 1995: 156).

Atrichornis clamosus djimolook/noisy scrub-bird

The noisy scrub-bird was searched for unsuccessfully in the period 1895-1925, mostly by visiting ornithologists, in the area bounded by Margaret River, Barrabup and Albany (Abbott 1999: 22-3; Abbott 2000: 287, 308; Jackson 1907; Whittell 1954a part 2: 25). I included FL Whitlock in this list (Abbott 1999) without any firm evidence, assuming that because he lived near Wilson Inlet between 1905 and c. 1924, he was likely to have searched for this species (Abbott 2000: 279).

In his weekly contribution in *The Western Mail* newspaper, Whitlock (10.11.1927: 11) wrote in a column headed 'The lost Noisy Scrub-bird' that more than 25 years ago [i.e. in 1905-6] he had made a close search around Torbay, and also further westward in the uncut parts of Denmark forests, but without any success. 'No one could anticipate the rapid dying out of this bird…for it is one of the most secretive habit, rarely venturing out of the shelter of the densest scrubs. One can imagine a bird of this nature driven from haunts around a busy saw-milling centre like Torbay was at the time of Mr. Campbell's visit [in 1889], but that it should so quickly disappear from other undisturbed country where it was never molested by human agency is a mystery which it is difficult to solve.'

Presumably Whitlock's unsuccessful search around Denmark and Torbay (White 2007: 106) was the reason another collector, SW Jackson, focused his attention on the Irwin Inlet – Mt Frankland district 40-50 km west of Denmark (Abbott 1998b: 373).

Whitlock would have to be rated as one of the most diligent, meticulous and astute ornithologists to have worked in Western Australia. This assessment is based on his numerous papers (cited in Whittell 1954a part 2), and is supported by contemporary opinion (White 2007: 32, 39, 41). His observations, as recorded in these papers, are of a very high order. Therefore it can confidently be concluded that if the noisy scrub-bird were still present in the vicinity of Denmark, Wilson Inlet and Torbay, it would have been detected by Whitlock.

In the newspaper article mentioned above, Whitlock wrote that 'bush fires which too often occur during the breeding season' and 'Bush cats have no doubt played their part in the destruction of these feeble flying birds [including the ground parrot *Pezoporus wallicus* and western bristlebird *Dasyornis longirostris*], but there is some additional cause of which we have no knowledge, for on the other hand small and more feeble birds manage to hold their own despite such conditions.'

Could epizootic disease have compounded the decline usually attributed to changed fire regime? The noisy scrub-bird is believed to have had a small geographical range, which is thought to have contracted in the period 1890-1910 (Abbott 1999, 2000a). The ground parrot in the 1840s (Gilbert nd1, nd2) and the night parrot *(Pezoporus occidentalis)* in 1854 and 1896 (Austin 1855; North 1898) were evidently widely distributed in WA and abundant enough to be noticed easily. Did these species and the narrow range western bristlebird and rufous bristlebird *Dasyornis broadbenti* contract in distribution for the same reason?

Is it possible that the stickfast flea *Echidnophaga gallinacea*, a pest of poultry, was involved? This species was described in 1875 from Ceylon, and was first collected in WA in 1904 at Kojonup (Dunnet and Mardon 1974: 24). The biology and vectors of this species are discussed

by Campbell (1923) and Ferguson (1923). A tick on poultry was first recorded in WA (at Roebourne) in c. 1888, apparently having been introduced from Singapore (*Eastern Districts Chronicle* 12.3.1898: 3). The tick first appeared at York in 1897, causing mortality of fowls (*Eastern Districts Chronicle* 18.1.1897: 5). Was a pathogen of poutry introduced in the 1890s? (cf. recent concerns about the increasing risk of transfer of disease from chickens to native birds in the Galápagos, Gottdenker *et al.* 2005).

Frank Thompson, who assisted Jackson in his search in 1912 for the noisy scrub-bird, later reported that 'people at the time' attributed their demise to feral cats, which 'had got right through the bush then'. Thompson instead attributed their local extinction to the fact that the country 'was never burnt…the natives when they were in the country…used to burn the country every three or four years…when we went there [in 1911] it was all big thickets' (Thompson 1975: 18). Aboriginal burning was 'in little patches, mostly' (Thompson 1975: 21). The allusion is to the belief that frequent, fine-grained patch burning by Aborigines had enabled the noisy scrub-bird to persist because some refuge areas always remained, whereas later wildfires burnt extensively as the phytomass increased with infrequent fires and left few refuges. Thompson's concept is supported by the failed management policy of fire exclusion that operated from 1961 to 2003. Two large scale wildfires in 2000 and 2004 near Albany killed large numbers of noisy scrub-birds (Comer and Burbidge 2006).

It is likely that the vegetation round Lake Seppings, Albany is where G. Masters collected his many specimens in 1866 (cf. Abbott 2000: 308). A golf course was developed there in c. 1899-1900 (Garden 1977: 240). However, it seems that the noisy scrub-bird became extinct west of Mt Gardner in the period between 1889 (when AJ Campbell heard several males and collected one near Torbay in the 'thick undergrowth of chiefly karri country', *The West Australian* 5.11.1920: 5) and 1895 (when ED Atkinson unsuccessfully searched for it around Albany, Whittell 1954a Part 2). The pastoralist JC Hassell (b. 1879) recorded in 1941 that William Webb, who lived in Albany from c. 1862 until his death in 1897, had collected specimens from near Torbay and near Mt Manypeak. As a 'lad', Hassell had often spent time with Webb on bird and egg hunts. He had spent a day with Webb at Marbellup Road near Torbay and had heard the noisy scrub-bird calling occasionally. Hassell and Webb had also spent a week collecting near Nornalup and heard it calling there. In addition, both had heard it calling 'in Albany'. Hassell only heard the noisy scub-bird calling in dense spearwood *(?Agonis juniperina)* thickets, which are difficult to walk through. Presumably Hassell's notes (Hassell 1941) refer to the early 1890s.

The population at Boodjidup Brook (near Margaret River) probably became extinct in 1896 when a goldmining syndicate prospected an area of 450 acres *(The Inquirer & Commercial Times* 18.9.1896*)*.

The Western Australian Museum offered the large sum of £20 for a specimen in c. 1900, but this reward was never claimed (Glauert 1941), not even by the celebrated collectors R. Hall, AW Milligan, JT Tunney and GC Shortridge active in the period 1899-06 (Hall 1902a: 137; Milligan 1902: 69; Ogilvie-Grant 1910; Abbott 2000: 308). The wealthy pastoralist and egg collector HL White in 1911-13 'kept up an uninterrupted search'. White also had a standing reward of £100 for skins, nest and eggs (White 2007: 157). All of these points are suggestive of extinction of many local populations known to have existed before the mid 1890s.

The noisy scrub-bird was rediscovered in October 1943 by the naturalist Charles Allen. While collecting eggs from an osprey nest, he heard and saw the species near a beach '28 miles from Albany'. Because Allen farmed at Cuthbert, his record was probably at Two Peoples Bay (Allen 1944). Allen mentioned his rediscovery to the ornithologist HM Whittell, but evidently did not take him or any other ornithologist into his confidence to the extent of seeking on the spot confirmation. This is puzzling, as Whittell had earlier behaved in exemplary fashion when the western whipbird was rediscovered in c. 1934 (see Whittell 1939). Allen's excessive caution bordered on secrecy, contrary to the spirit of scientific discovery, and was compounded by his failure to collect a specimen. In 1961, the next discoverer arranged for ornithologists to confirm his identification (Webster 1962), and so H. Webster is properly credited with the rediscovery of this species.

The suggestion that this species may have originally occurred on the south-facing slopes of the Porongurup Range (Abbott 1999: 26, 150) is now being tested: The first releases there took place in winter 2006 (Bondin 2006), with more planned for 2007 and 2008 (Department of Environment and Conservation 2006).

Tachyglossus aculeatus nyingarn/dononger de/ echidna/short-beaked echidna

Oldtimer information The echidna is still recorded widely throughout south-west WA (Fig. 8), but never in great abundance (i.e. it or its diggings are infrequently sighted). Many oldtimers commented that it had always been rare. Two oldtimers indicated that abundance had declined since 1970 (T. Busby, H. Hall pers. comm.). Predation by foxes was noted by V. Roberts (pers. comm.). Echidnas were stated to have been common near Piawaning, Bruce Rock, Merredin, Dragon Rocks, Hyden, Goomalling, Pumphreys Bridge, Boddington, Jarrahdale, Banksiadale, Buckingham, and east of Margaret River. Many oldtimers living south of a line joining Bunbury, Boyup Brook and Mt Barker had not seen the species (Fig. 8).

Distribution and abundance In colonial times this species was uncommon (Gilbert nd1; Austin 1855: 18; Whittell 1942: 221, 223), probably because it was prized by Aborigines as food (Leake 1962: 52; Erickson 1974: 2; Winmar 1996; see also Parker 1905: 30; Wood Jones 1923: 46; and Burbidge *et al.* 1988: 14). Noongars also used its fat to treat skin rash (Winmar 1996). Gilbert

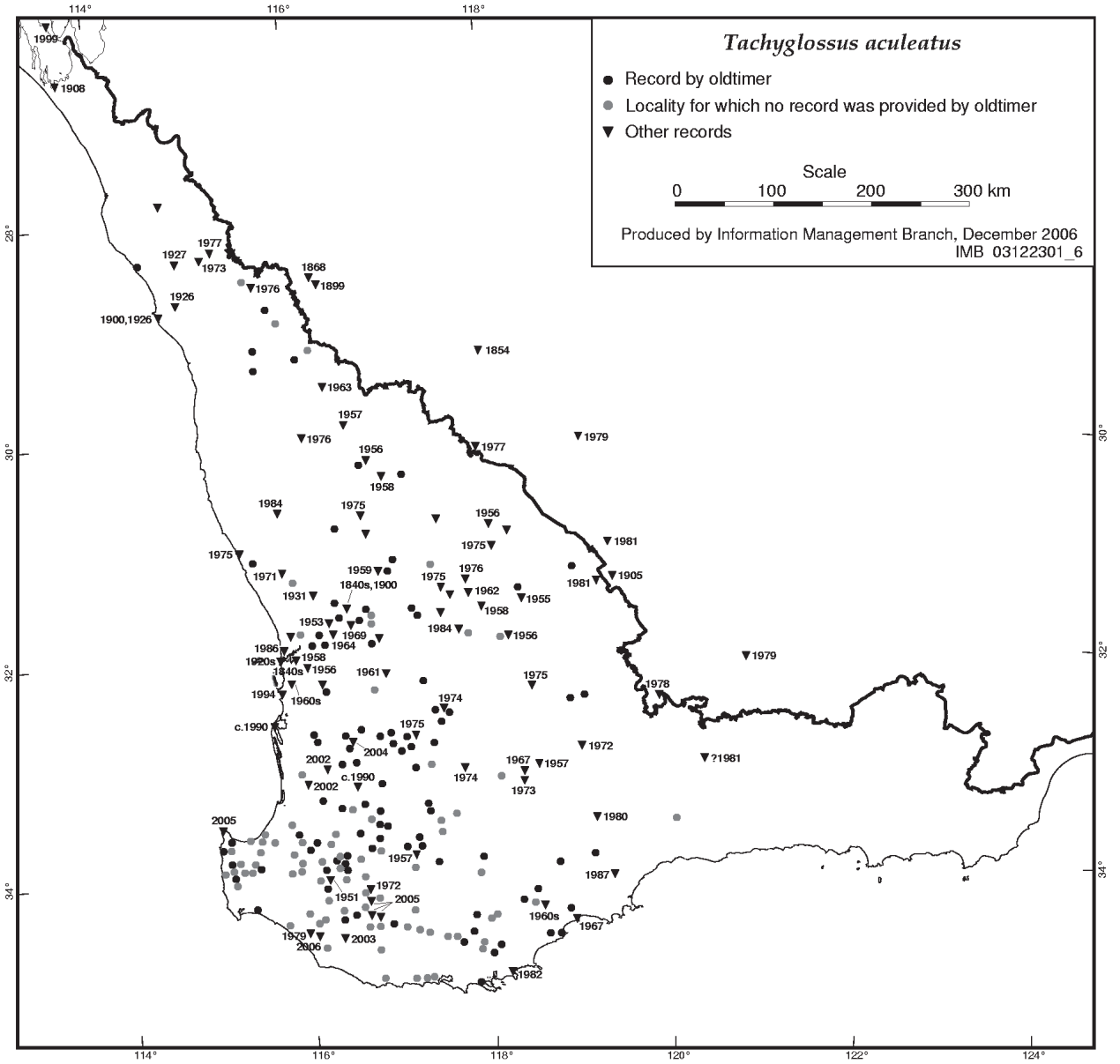

Fig. 8 Distribution of Tachyglossus aculeatus. *Additional records not already cited in text: Acclimatisation Committee 1899; Anon. 1989; Bannister 1969a; Burbidge* et al. *1978; Department of Conservation and Land Management files 015141F3803 vol. 1, 015555F3102 vol. 1; Carnaby 1954; Chapman 1995; Chapman and Kitchener 1978, 1981a, 1981b; Christensen* et al. *1985; Crook* et al. *1984; Crook and Burbidge 1982; Dell and How 1985; Drake and Kennealy 1996; NW Cooke 1868 in Exploration Diaries vol. 6;* Fauna Bulletin*;* Fisheries Department Bulletin*; How* et al. *1988; Kennealy nd; Kitchener and Chapman 1977, 1978, 1980a; Kitchener and Vicker 1981; McKenzie* et al. *1973; McKenzie and Rolfe 1995; McKenzie and Youngson 1975; Morris and Dell 1977; Morris and Kitchener 1979; Roe and Roe 1992;* The Northern Times *19.12.1908; Thomas 1906; WA Year Book 1900; A. Wills pers. comm.; Youngson and McKenzie 1977.*

still had not seen or secured a specimen by May 1840 (Whittell 1942: 223). The only specimen collected by him was from the 'upper part of the eastern branch of the Avon River' (Gilbert nd1). R. Salvado in the late 1840s (in Stormon 1977: 192-3) treated this species as if it occurred only in eastern Australia, and gives no indication of its presence at New Norcia. The echidna was not collected by George Masters during his two visits in the 1860s (Krefft 1867, 1869).

In 1899 it was stated to be absent from Gracefield district (J. Tunney, letter 19.4.1899) and during 1904-7 it was considered to be widely distributed, except in the extreme south-west corner, but nowhere plentiful (Shortridge 1910: 848). In the 1920s, echidnas were seen 'not infrequently' near Perth, South Perth, Claremont, and Cottesloe (L. Glauert in *The Westralian Farmers' Gazette* 28.7.1927: 23), a period before these areas were suburbanized. Kitchener *et al.* (1980: 205) recorded the species in 19 of the 23 reserves studied in the wheatbelt.

During the 1930s echidnas impeded the local

effectiveness of rabbit proof wire-netted boundary fences by digging under them. Many of the hollow logs used by females for breeding were burnt to prevent rabbits from breeding (Repton 1999: 309). I found no records of echidnas caught in rabbit traps, as was reported in New South Wales by Burrell (1920).

Inimical factors It is relevant to note that settlers in New South Wales considered this species very good eating (Mann 1811: 50; Bennett 1860: 147). In central eastern Queensland the echidna was tracked by tamed dingoes and was considered by Aborigines as a 'great delicacy' on account of its fat (Collett 1887: 937; Semon 1899: 45).

Wood Jones (1923: 46) regarded echidnas as nearly fox-proof, and in central Australia Finlayson (1961: 152) noted that this species has one of the highest survival rates of any native mammal species in fox-infested country. However, foxes (and dingoes) can turn an animal over and urinate on the face, thereby forcing it to unroll (Rismiller 1999: 96). A change in status from very common before 1920 to rare at present in the lower Murchison River district was attributed to the fox (Porter 2001: 51). Sightings of echidnas at Peron Peninsula have increased since fox baiting commenced in the 1990s (Morris *et al.* 2004: 214). At fox-baited Julimar, they are often captured in cage traps (K. Morris pers. comm.). Sightings between Bunbury and Metricup were reported to have increased since 2000 (*Busselton Margaret Times* 3.11.2005: 13). Four sightings in Manjimup district in 2005-6 (I. Wilson pers. comm.) are also consistent with a slow increase following 10 years of fox control.

Dasyurus geoffroii djooditj/ngooldjangit/badjada/chuditch/western quoll

Oldtimer information Chuditch (Fig. 9) were familiar to most oldtimers, usually as native cats or spotted cats. This is because they were once a pest of poultry (surplus killing of fowls to suck blood), were captured occasionally in snares set for possums or traps deployed for rabbits, ate rabbit skins, removed and ate pegged out possum skins from trees, and had a vicious temperament. For these reasons they were often shot. Once motorized vehicles came into general use, they were also noted occasionally as road-kills.

Chuditch were recorded as common until the fox established in the 1930s/40s, and then either disappeared or became very rare (1960s-90s). With widespread fox baiting since 1996, this species is in the process of recovering. One oldtimer thought that by 1999 at Buckingham it had got close to its level of abundance of the early 1930s (L. Carroll pers. comm.). Indeed, two oldtimers queried the value of allowing this predator to recover.

Two oldtimers offered comment on disease as a contributing factor in the species decline: no disease was evident (A. Muir pers. comm.); mangey animals were trapped in c. 1939 (G. Cowcher pers. comm.). Based on other evidence, Abbott (2006) suggested that chuditch declined in the northern parts of south-west WA in the 1890s as the result of an epizootic.

Chuditch were noted by one oldtimer (A. Marshall) to have lived west of Pingelly in boodie holes.

Interactions with humans This species came to the attention of colonists soon after settlement, and it was called the 'native cat' or 'weasel' (Moore 1842: 6, 117) but no mention was made of chuditch having been seen at Millendon taking poultry during the period 1830-41 (Cameron 2006). The Agricultural Society of WA resolved to pay a reward of 2s 6d for each 'barget, or native cat' on production of the skin to the Secretary (*Perth Gazette* 5.8.1837: 949). The Noongar name used indicates that chuditch were causing problems in the Avon Valley (Abbott 2001a). In 1842, it was proposed by a member of the Agricultural Society of WA that 'annual rewards be given for the greatest number of native dogs, [native] cats, or hawks shot by one individual' (*The Inquirer* 14.9.1842); this is suggestive of the chuditch being a recognized pest. However, it was 'very little known', 'most common in the Interior [Avon Valley]', and was said to destroy fowls (Gilbert nd3). Somewhat later, presumably in 1843, it was stated to be very destructive to poultry (Whittell 1954b: 105). Presumably the reference to 'wild cats,' for which the Agricultural Society paid a reward, is to this species (*The Perth Gazette* 10.9.1842). Evidently chuditch did not hinder the keeping of hundreds of fowls on a farm near Brookton in the 1850s (*The Western Mail* 23.6.1906: 4). The earliest definitive accounts of this species as a pest are: from Cowalla, attacking turkeys, ducks and fowls, in 1886 (de Burgh and de Burgh 1981: 245); 10 miles from Pinjarra, attacking pheasants, before 1887 (Commission on Agriculture 1891: 113); and Bunbury, attacking fowls and also a human, in 1888 (Carter 1987: 71-2). These seem to have been isolated incidents – only one farmer interviewed by the Commission on Agriculture (1891) reported problems caused by chuditch.

Once settlement intensified after the goldrushes, reports of chuditch attacking poultry became frequent: c. 1894 (Leake 1962: 43, 51); c. 1900 (Repton 1999: 309); 1900 (WA Year Book: 173); 1905 (Facey 1981: 42, 80); 1905-6 (Shortridge 1910: 839); 1906 (*The Western Mail* 2.6.1906: 5, 18.8.1906: 5); 1912 (W. Kingsmill WAPD **43**: 1344, 28.8.1912); 1915 (Flynn 2002: 340); 1920s (Blond 1987: 14, 59; *The West Australian* 2.6.1928: 5, 8.3.1929: 18); 1930s (Gardner 2000: 46, 62; Harris 2002: 76); and 1950s (Loaring 1954: 134; Fisheries Department file 71/49). See also similar records (though undated) in Schorer (1968: 214), Pederick (1979: 5), Pustkuchen (1981: 32), and Parnell (1982: 105). This species was recorded as killing more fowls than could be eaten and then sucking the blood of the prey (Loaring 1954: 134; Schorer 1968: 214; Richards 1978: 195; Carter 1987: 71-2). Advice on how to poison or trap 'native cats' was provided in 1906 (*The Western Mail* 2.6.1906: 5, 23.6.1906: 4, 1.9.1906: 6).

In the Game Act of 1912, the chuditch was the only marsupial not listed as game (i.e. it was not a protected species). It was '[k]illed off as much as possible in the agricultural and more thickly populated districts on account of being so destructive to poultry' (Shortridge 1910: 838-9). Once rabbits invaded south-west WA,

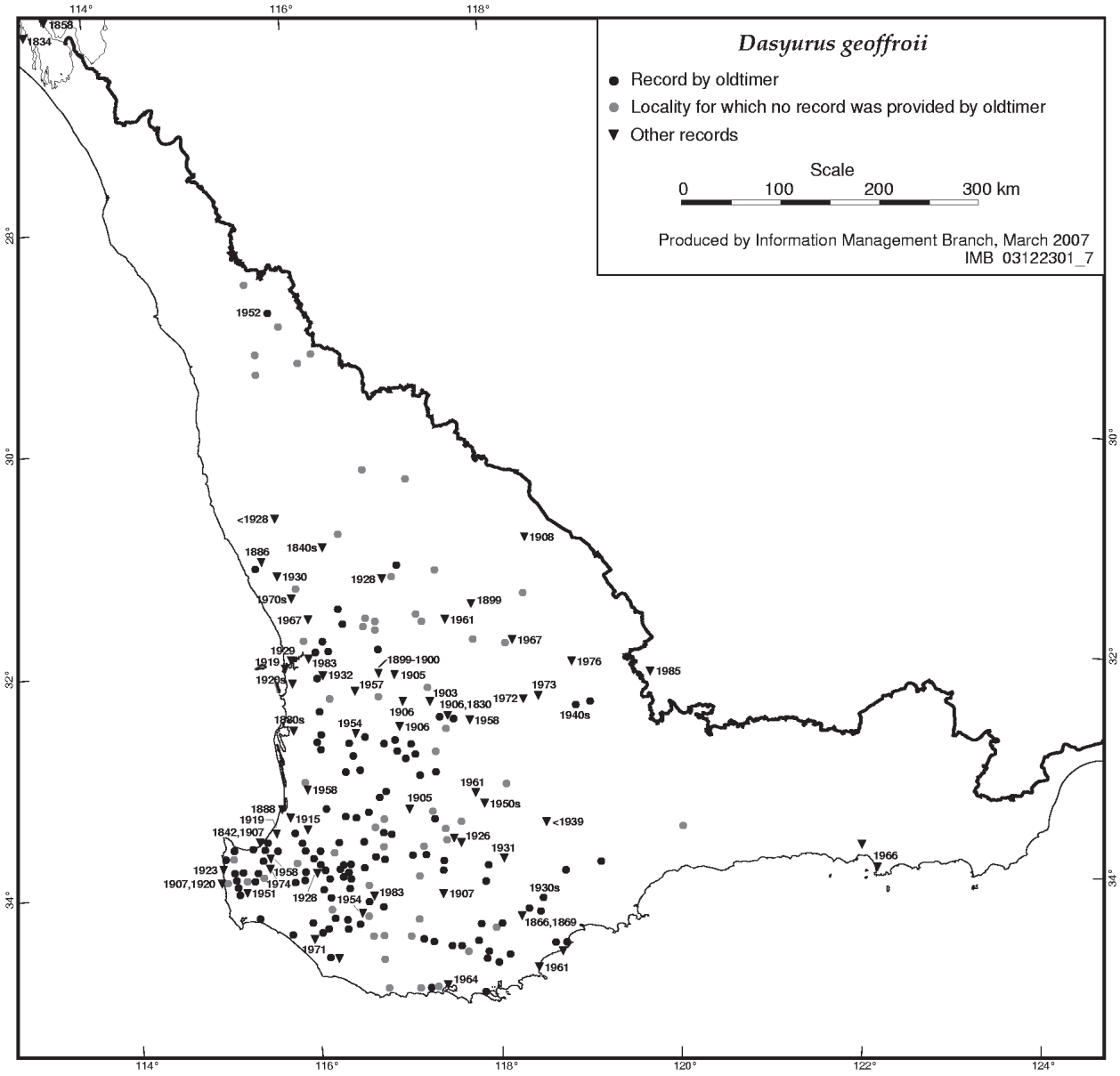

Fig. 9 Distribution of Dasyurus geoffroii. *Additional records not already cited in text: Aitken 1954; Anon. 1995; Christensen* et al. *1985; Crawford 1908d; Drake and Kennealy 1996;* Fauna Bulletin*; Fisher 1992;* Fisheries Department Bulletin*; Fisheries Department files 34/32, 83/50; Gibbs 2002; Haddleton 1952; How* et al. *1988; Jones 1954; Kitchener and Chapman 1977; Kitchener* et al. *1975; Kitchener and Vicker 1981; Knox-Thomson 1975; McCarthy nd; Nicholls 1926; Plunkett and Wimbush 1999; Putt nd; Roe and Roe 1992; HM Ommanney 1834 in Shoobert 2005: 359;* The Western Mail *18.8.1906: 4, 23.12.1926: 2, 21.6.1928: 6, 30.8.1928: 6; Thomas 1906; Shortridge letter 18.5.1906.*

chuditch were left unmolested by some (*The West Australian* 25.7.1925: 15).

The chuditch lived in a wide variety of habitats across south-west WA, including the coast where it fed largely on marine refuse along beaches (Shortridge 1910: 838), and Kings Park, a bushland reserve close to the city of Perth (*The West Australian* 8.3.1929: 18). It consumes mostly invertebrates, as well as *Macrozamia* seeds, quenda *(Isoodon obesulus)*, mardo *(Antechinus flavipes)*, wambenger *(Phascogale* aff. *tapoatafa)*, the introduced house mouse, black rat and rabbit, carrion, and birds (Parton 1952; Soderquist and Serena 1994).

It is difficult to ascertain whether chuditch became more abundant after 1900, following the widespread provisioning of a new food source (poultry) concentrated in towns and on farms. Chuditch were often found in roofs of suburban residences of Perth (Glauert 1933), with one record in a kitchen (Parton 1952), and must have been sufficiently numerous in the eastern wheatbelt for the advice that no bait should be presented when trapping dingoes, 'as this only attracts native cats…and may cause the trap to be snapped without catching the dog' (Crawford 1917: 21). This species was considered '[f]airly numerous in many parts' of south-west WA (Shortridge

1910: 837), 'common' at Narrogin Valley in 1916 (Warren 1983: 91), 'always plentiful in the southlands' (*The West Australian* 9.2.1924: 11); 'fairly numerous' at Warren River in the 1920s (*The Western Mail* 16.4.1925: 3), and 'numerous' in Karragullen district in 1932 (R. Oliver in *Our Rural Magazine* 7, 14). Individuals were occasionally caught in rabbit traps (McCarthy nd) and in possum snares (near Margaret River, 1920 – Short and Calaby 2001: 543; at Barronhurst, near Pemberton, probably in the 1920s; locality not specified, *The West Australian* 9.2.1924: 11), and were so ferocious that they were hard to release without killing them (Fox 1994: 72). At Jarrahdale, a chuditch bit and scratched a 3 year old girl but was repelled by a domestic cat (*The Western Mail* 13.5.1937: 8).

Although Pustkuchen (1981: 32) stated that chuditch were not killed for their skins, newspaper advertisements in the late 1870s promised that skins would be purchased in Northam and York 'in any quantity during the season', April-September inclusive (*The Eastern Districts Chronicle* 27.7.1878: 2, 2.8.1879: 4, 6.9.1879: 3). Sale prices of skins of 'native cats' were listed in *Dalgety's Review* from 9.10.1930 (at 3-4s/dozen) until 23.4.1936 (4-5s/dozen). Because sale prices of skins of domestic cats were also listed, it can safely be assumed that the chuditch was being referred to. The highest price attained was 6s/dozen in 1931. Of related interest is an account, presumably from Queensland, stating that 'some five dozen' native cat skins were used to make 'a most beautiful rug' (Neville-Rolfe nd: 89).

Decline in distribution and abundance There seems to have been an early, patchy decline:

- unrecorded in parts of the eastern wheatbelt, Victoria Plains and Moore River districts during the period 1913-28 (*The West Australian* 10.11.1928: 5). This decline was attributed to an epizootic (Abbott 2006).
- disappeared in c. 1899-1900 from Talbot and Dale districts south-west of York and Beverley. This was linked to a disease that affected possums at the same time (J. Reid in *The West Australian* 12.4.1930: 4).
- disappeared in c. 1900 from Armadale district, but later re-established and depredated chickens (*The West Australian* 28.6.1930: 4).
- disappeared 'many years ago' [?c. 1903] from Dandaragan district, where it was once 'fairly numerous' (Green 1928).

The operation of a regional fox-baiting program ('Western Shield') has shown that the fox was the major cause of this species' decline after the 1930s (Morris *et al.* 2003; Orell 2004; CALM Annual Report 2005: 181). By 1968 it was thought to be extinct in the upper Blackwood district (Schorer 1968: 214). During a comprehensive survey by staff of the WA Museum in the 1970s of 23 reserves in the wheatbelt, the chuditch was detected on only one reserve (Kitchener *et al.* 1980). The first attacks on poultry since the 1950s were reported in 1983 near Pickering Brook (Department of Conservation and Land Management file 015848F2022 vol. 7). Chuditch have also been translocated to several sites in south-west WA, but not always successfully (Morris *et al.* 2000).

Although mangey male chuditch have often been trapped during the breeding season, they appear to recover (K. Morris pers. comm.). Chuditch are known to have died from taking strychnine baits deployed to control dingoes in Merredin district in the 1960s (K. Morris pers. comm.). There is also a record of a domestic cat killing a 'native cat' under a house in Bassendean in c. 1919 (*The West Australian* 26.1.1924: 11).

To the list of Noongar names published by Abbott (2001: 445-7) for this species may be added *barget* evidently from Avon Valley (*Perth Gazette* 5.8.1837: 949) and *Chittich* from 'Warren River' (*The Western Mail* 16.4.1925: 3).

Phascogale sp. nov. aff. *tapoatafa* wambenga/balat/balawa/koming koming/wambenger/south-west brush-tailed phascogale

Oldtimer information Oldtimers knew this species (Fig. 10) as the squirrel, sometimes as the phascogale, or remembered it once its diagnostic features were described. Its presence in a district often became known when specimens were brought in by dogs (K. Smith) or cats (A. Ashcroft, K. Bessell, B. Darnell, W. Dunnett, V. Farmer, Gilbert Gardner, M. Marsh, J. Muir, K. Thorne and W. Young) or from road-kills (S. Garstone, L. Talbot).

Wambengers have persisted in the lower south-west region (particularly the southern jarrah forest), with numerous records of road-kills in the 1990s. One oldtimer considered that they were originally as common as chuditch (K. Smith pers. comm.). In the lower Warren they were common in 1935 but then declined, and this was attributed to disease (F. Bamess, George Gardner pers. comm.). However, two other oldtimers specifically linked its decline with the arrival of the fox (K. Bessell, C. Mitchell), with final observations in a number of localities in the 1930s and 1940s. Two oldtimers noted recovery of populations in the 1990s following fox baiting (K. Bessell, B. Darnell).

Wambengers were noted as eating mice, and being able to jump and leap 4-5 m, beyond the range (2-3 m) that a fox could leap up a tree trunk (E. West pers. comm.).

Distribution and abundance An 'outlier' specimen in the WA Museum collection from Nukarni was dismissed by Baynes (1979: 326-7) as an error. However there is no reason to query this record as the species was observed alive only 50 km distant (Leake 1962).

It seems that their numbers have fluctuated markedly: very often seen in the 1880s and early 1890s, becoming locally extinct near Kellerberrin by the late 1890s, but re-appearing in 1917-18 (Leake 1962: 51); not plentiful in the south-west in 1905-7, being collected only south of Busselton (Shortridge 1910: 839); one specimen trapped presumably near Kirup in 1909 was the first reference to this species in a readers' column published since 1904 in a widely circulating rural newspaper (*The Western Mail* 6.3.1909: 6); 'fairly numerous' at 'Warren River' (*The*

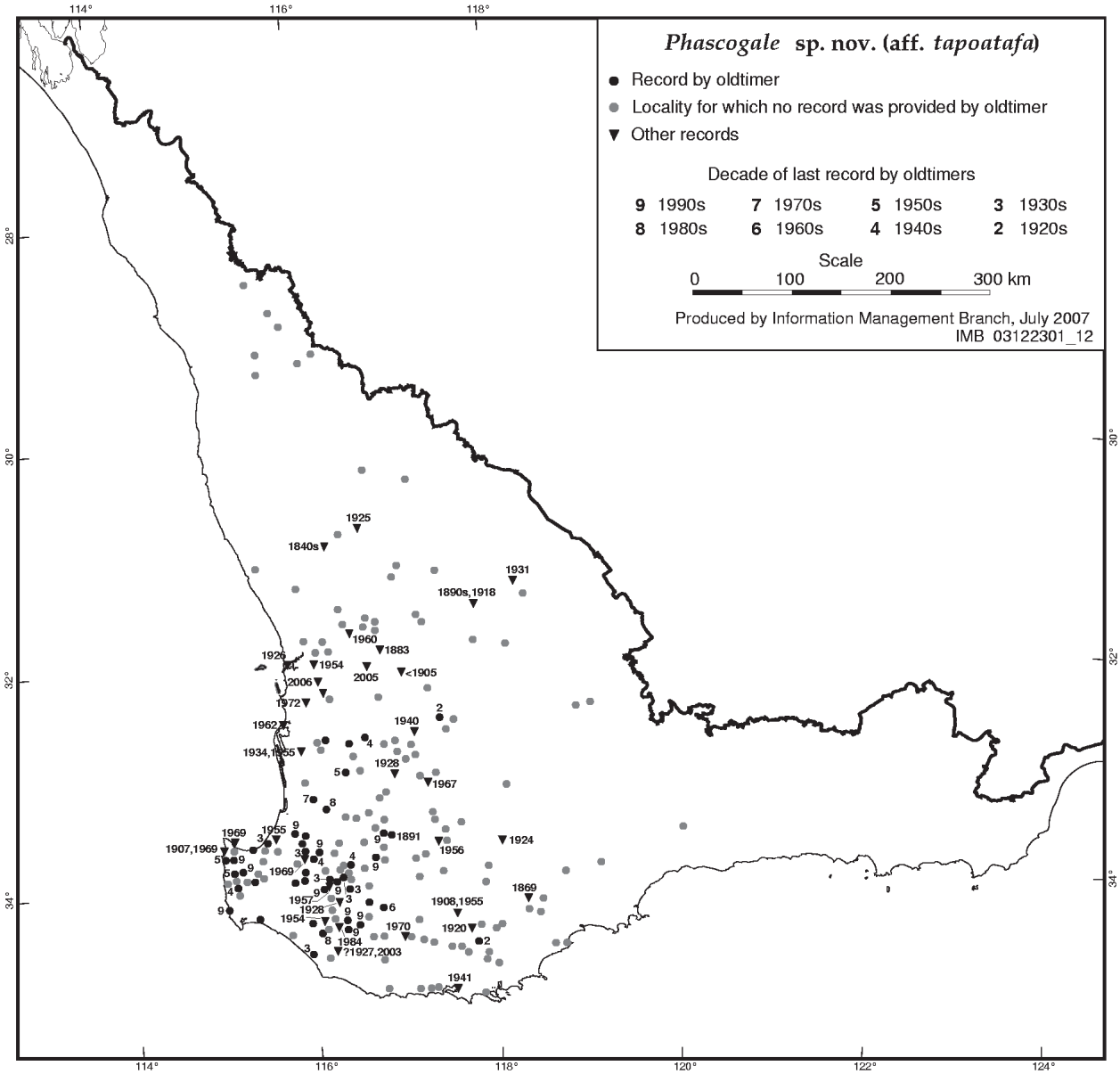

Fig. 10 Distribution of Phascogale *sp. nov. aff.* tapoatafa. *Additional records not already cited in text: Bannister 1969a; Christensen* et al. *1985; Daubney 2001a;* Fauna Bulletin*; Fisheries Department file 103/49; Hercock 2006 pers. comm.; Kitchener and Vicker 1981;* The Western Mail *12.6.1924: 7, 28.6.1928: 6.*

Western Mail 16.4.1925: 3); thriving in Kings Park (Nicholls 1926: 70); 'has become rather rare' in karri forest south of Jardee (*The Western Mail* 3.2.1927: 4); 'increasing in numbers' near Brookhampton - since 1925 cats had killed 'several dozen', before which they were unknown (*The West Australian* 14.5.1927: 7); during the 'last year or two' the WA Museum received more specimens than during the previous decades (L. Glauert in *The Western Mail* 16.5.1929: 48); first recorded in Piesse Brook/Bickley district in 1949 (Loaring 1954); numerous in 1954 in Manjimup district (*Fisheries Department Bulletin* 2/2 1955); and first seen by a long term resident of Cranbrook district in 1955 (*Fisheries Department Bulletin* 2/4 1955). The species was numerous east of Manjimup in the early 1990s (Rhind 1996) but was not recorded during an intensive fauna study in the Kingston area in the late 1990s (Morris *et al.* 2000) where foxes were baited. From 2000 wambengers were frequently sighted along roads and tracks and in townsites in Manjimup district (I. Wilson pers. comm.). These fluctuations may be linked to droughts (Leake 1962) or disease (Abbott 2006).

Interactions with humans In colonial literature this species was variously described as a 'small squirrel-like Opossum or grey Squirrel' (Moore 1842: 106) or a large 'opossum rat' (Hasluck 1963: 78). Shortridge (1910: 839), Nicholls (1926: 70) and Leake (1962: 521) referred to this species as squirrel or native squirrel. Wambengers are unafraid of humans and will enter farmhouses presumably in search of moths and cockroaches (Leake 1962: 51) and mice (Shortridge

1910: 839). Although Wood Jones (1923: 101) recorded *P. tapoatafa* as a chicken-killer in South Australia, and Gould (1863: 74) stated that it had been reported as killing fowls, no evidence for this behaviour was recorded in south-west WA (by Gilbert nd1, Whittell 1954b: 106, L. Glauert in *The Western Mail* 16.2.1928: 11, 16.5.1929: 48) and was in fact disputed by Krefft (1871). However, S. Gibbings in 1934 (*Our Rural Magazine* **9**, 202) saw a wambenger 'clinging to the body of a big hen which was dragging it round the [fowl]house and squawking'. There was also a recent report of 'a wambenger riding a chook around the yard, biting away' (*Western Wildlife* 8/2: 18, 2004). The wambenger when captured is 'very ferocious' and 'inflicts very serious wounds upon the hand' (Gilbert nd1).

Claims that logging of jarrah *Eucalyptus marginata* forest is detrimental to wambengers (Rhind 1996) were questioned by Armstrong and Abbott (1996), and are inconsistent with the high densities of trees of a size to provide suitable hollows for this arboreal species (Abbott and Whitford 2002). Moreover, the species is not averse to using habitat close to houses and roads. A number of specimens in the WA Museum represent road-kills or prey killed by domestic cats (Dell and How 1988).

Myrmecobius fasciatus noombat/wioo/numbat

Oldtimer information Records obtained from oldtimers of the occurrence of the numbat in south-west WA were consistent with available distributional data (Friend 1990), except for numerous records in the extreme south-west (Fig. 11). Many oldtimers had last observed numbats in the 1920s, 1930s and 1940s, and some linked this decline to the arrival of the fox. Several oldtimers made the point that the numbat could be readily observed before or soon after the fox arrived in the 1920s: e.g. between Woogenilup and Mt Barker (T. Ferry pers. comm.), in the grounds of Narrogin Agricultural College in 1912 (H. Hall pers. comm.) and on farmland near Towerrining Lake in the 1930s (L. Cochrane pers. comm.). One oldtimer had, as a child, kept numbats as pets. In some localities (other than Dryandra and Perup, where the species is still present), numbats continued to be recorded as late as the 1980s. Apart from the fox, other causes of mortality that were noted included dog, rabbit trap, and possibly disease.

Distribution and abundance This species was discovered by Europeans only two years after the settlement of Perth in 1829 (R. Dale 1831 in Shoobert 2005: 254; G. Moore 1831 ibid.: 261; Cameron 2006: 48). In the 1840s it was considered to be 'equally distributed' throughout the grassy wandoo woodlands and was never seen west of the Darling Scarp or south of Mt Barker (Gilbert nd3; Whittell 1954b: 109-110; although see *The West Australian* 5.3.1927: 11). However, it was not reported from New Norcia in the late 1840s (Stormon 1977). In the period 1905-6 it was also noted as occurring particularly in wandoo *Eucalyptus wandoo*/ jam country and not extending to the west coast (Shortridge 1910: 845-6). Subsequent records, however, have suggested otherwise (Fig. 11). Whether this signifies that the species has since expanded its distribution or was overlooked because transport difficulties hindered observation cannot now be ascertained. Moreover, it is now known that numbats have large home ranges (Christensen *et al.* 1984, Friend 1990) and exhibit long distance dispersal (Friend 1990). Roadkills and sightings of numbats were unexpectedly recorded during 1972-83 in the Jandakot/ Canning Vale district of the Swan Coastal Plain (Ninox Wildlife Consultancy 1986), although this species had been seen in the 1960s on the corner of Corfield and Lyminge Streets, Gosnells/Southern River (R. Roe pers. comm.). The vegetation type present here has not previously been reported as harbouring numbats. Whether this population was long established (but overlooked) or was newly established is uncertain, but the early collection of specimens from Byford (1934), North Dandalup (1935), Armadale (1942), Brunswick Junction (1944) and Pinjarra (1960) (Kitchener and Vicker 1981: 137-8) seems consistent with the former interpretation.

Second, it appears that the numbat may originally have occupied the western sector of the jarrah forest. Even discounting those specimens collected in November/ December, which are likely to represent newly independent, dispersing young (Friend 1990), there still remain numerous records (Connell 1985), the localities of which cannot be doubted as they are supported by details held in the specimen registers of the WA Museum: Bedfordale (breeding), Jarrahdale, Albany Highway (Bee Farm Rd), Drakesbrook reservoir, Roelands Hill and Worsley. Consistent with this is the fact that numbats at Perup live in jarrah forest and not wandoo woodland (Christensen *et al.* 1984). However, translocated animals released near Mt Dale persisted only in wandoo woodland and not in jarrah forest (Friend and Thomas 2003: 460). The western limits of wandoo are indicated in Fig. 12.

Although Calaby (1960: 187) thought that the distribution of numbats on the coastal plain was linked to the presence of wandoo woodland, the limited extent of this woodland type west of the Darling Scarp makes this unlikely.

Since the late 1990s, numbats in Manjimup district have been reported frequently crossing roads west to 7 km south-east of Bridgetown, and Winnejup, Dudijup, Mersea and Yardup forest blocks (north-east of Manjimup), and as far west as the highway linking Bridgetown and Manjimup, at Palgarrup (I. Wilson pers. comm.). These records are well to the west of wandoo woodland.

Because the numbat is an attractive animal, is not shy, and is active during the day, it was well known to rural settlers (Peacock 2006). Several local histories (Anon. 1999: 95, Broun 1995: 12, Haddleton 1952: 101-2, Leake 1962: 43, 47, and Parnell 1982: 4) and other accounts (E. Farr in *The Western Mail* 23.8.1928: 6; F. Green in *The Western Mail* 21.6.1928: 6; WG Pearce 1963 in Fisheries Department file 51/55) noted its presence in the early years of settlement. In the 1860s numbats were plentiful around Wagin but became less so 'later on' (C. Piesse WAPD **43**: 1341, 28.8.1912). In 1904-7 numbats

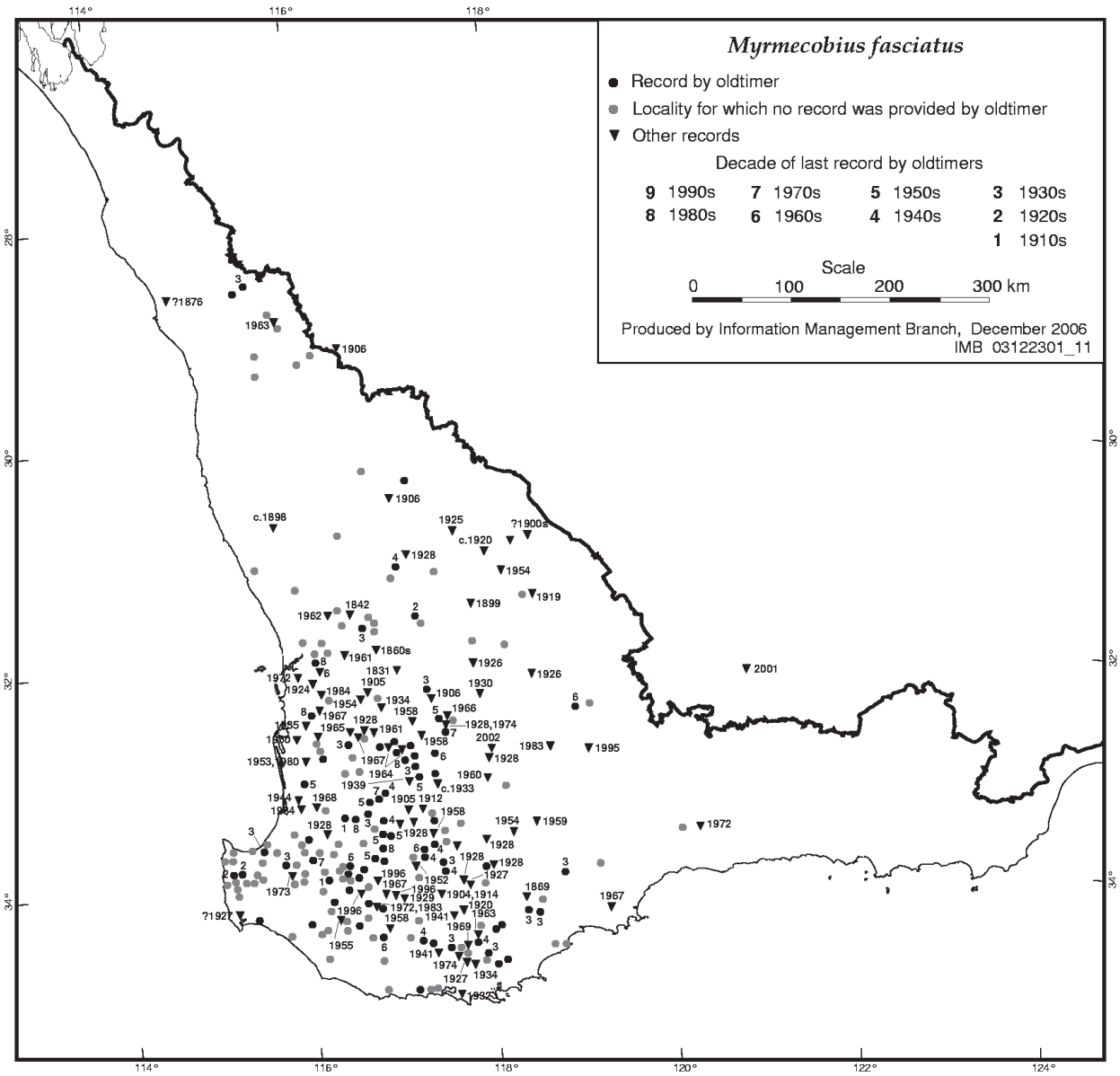

Fig. 11 Distribution of Myrmecobius fasciatus. *Additional records not already cited in text: Aitken 1954; Bannister 1969a; Department of Conservation and Land Management files 014982F0616, 2001F000814V01; Fisher 1992; Glauert 1950; Kitchener* et al. *1978; Payne 1987; Reid 1968; Short and Calaby 2001; Taunton 1903;* The West Australian *4.8.1928: 5, 9.2.1929: 6;* The Western Mail *5.8.1926: 40, 15.12.1927: 11, 9.8.1928: 6, 18.1.1940: 7, 15.2.1940: 8; Tunney letter 5.4.1904;* Western Wildlife *2003 7 (4): 17.*

were considered to be fairly numerous but scattered east of the jarrah forest, becoming rare to the north of Beverley (Shortridge 1910: 845). This species was apparently not plentiful in the eastern wheatbelt (Leake 1962: 47; Maddock 1987: 426) and was considered to be locally extinct by 1899 (Leake 1962: 43). It was fairly plentiful about Dandaragan in c. 1898 but was locally extinct by c. 1903 (F. Green in *The Western Mail* 21.6.1928: 6; Green 1928). At Gracefield in 1897 it was considered possible to obtain 'a couple of dozen' specimens by paying Aborigines 1s 6d per specimen (J. Tunney, letter 22.8.1897); by 1914 it was regarded as almost extinct in this district (J. Tunney, letter 28.5.1914). Numbats were stated to be present 'in fair numbers' in the south-west in 1912 (C. Piesse WAPD **43**: 1341, 28.8.1912), though they had not been seen for years near Dudinin (E. Farr in *The Western Mail* 23.8.1928: 6). They were common on uncleared land at Narrogin Valley in 1916 (Warren 1983: 91).

In the 1920s this species was noted as 'now becoming very rare and it is thought that it will be extinct within a few years' (DL Serventy in *The Farmer* 5.5.1923: 40) and 'not so numerous as they were 40 or 50 years ago' (*The West Australian* 26.3.1927: 9). However, in 1928 numbats were reported as numerous near Tambellup (Bradshaw 1928: 178), fairly numerous between Wagin

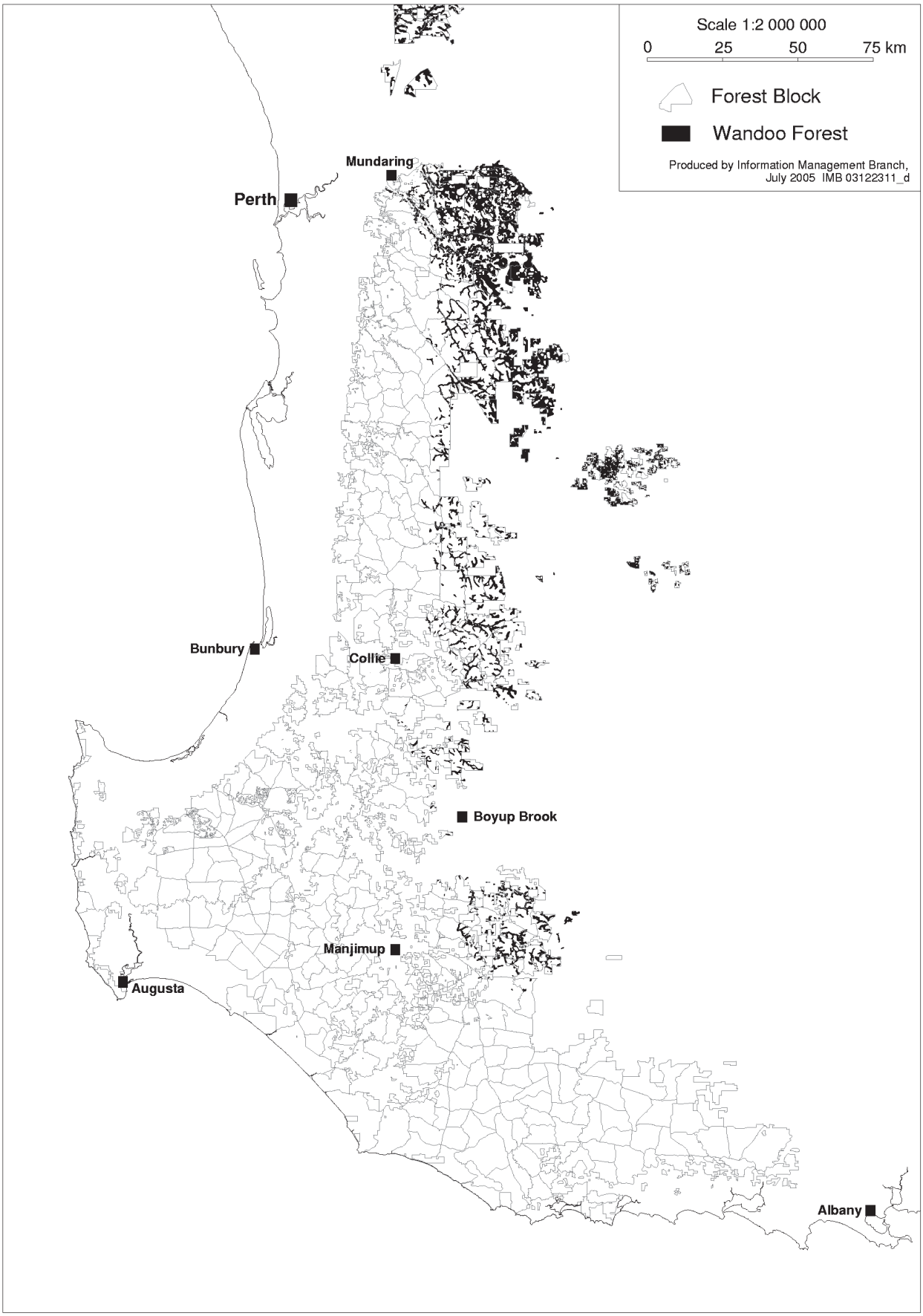

Fig. 12 Western limits of Eucalyptus wandoo, *the supposed main western limit of* Myrmecobius fasciatus.

and Arthur River (*The West Australian* 4.8.1928: 5), fairly common in Wandering district (T. Kent in *The Western Mail* 6.9.1928: 6; Kent 1928), and 'quite a lot' c. 30 km east of Pingelly (E. Gardner in *The Western Mail* 20.9.1928: 39). They were last seen near Corrigin in c. 1930 (*Fisheries Department Bulletin* 2/3 1969).

Numbats were reported in Wagin and Kojonup districts to be 'at present…far from extinct' (Barrett 1947: 48-9). In the early 1950s they were considered 'scarce' near Katanning (Haddleton 1952: 101-2). Numbats were recorded widely in the period 1951-74, based on information published in the *Fisheries Department Bulletin* and held in Department of Conservation and Land Management file 014800F3803. As a result, this species was not considered 'to be in any danger since it is known from a large number of areas' (AA Burbidge 1973 in Department of Conservation and Land Management file 014800F3803).

Inimical factors Explanations of this species' decline implicated clearing for agriculture (Glauert 1933: 22), bush fires (especially clearing burns) killing numbats because they do not burrow deeply or climb trees (Wood Jones 1923: 126; Fleay 1942: 7; Barrett 1947: 47), foxes, cats and dogs (Fleay 1942: 7), disease, cats and dingoes (L. Glauert in *The Western Mail* Christmas No. 1927: 55), clearing of logs, together with fumigation of burrows, for the control of rabbits (Calaby 1960: 204, 206), clearing, fire, firewood collectors and scientific collectors (Butler 1980: 40; Douglas 1980: 7-10), and fumigation of rabbit burrows (Wellard 1983: 113). In 1928 it was recorded that very often a hunter's dog will kill a numbat for sport (E. Gardner in *The Western Mail* 20.9.1928: 39; see also *The West Australian* 4.8.1928: 5). This species' early decline (c. 1903) in Dandaragan district along with several other species (Green 1928) is suggestive of an epizootic (Abbott 2006).

Nevertheless, adaptive management of the two largest populations remaining in the 1970s-80s, using ongoing baiting of foxes, demonstrated unequivocally that the major factor is predation by foxes (Christensen *et al.* 1985; Friend 1990). Furthermore, since 1985 numbats have been successfully re-introduced into nature reserves and forests within their original range within south-west WA, baited for foxes e.g. Boyagin, Dragon Rocks and State Forest east of Collie (Friend and Thomas 2001; Mawson 2004). In these areas feral cats are not controlled but have not impeded successful breeding and establishment of populations of numbats.

Interactions with humans As would be expected with an attractive, cat-sized animal that does not bite ('probably the most beautiful of the marsupials', Calaby 1969: 98), there have been several attempts to keep numbats as pets from the 1840s (Whittell 1954b: 109-110; Millett 1872: 186; Aflalo 1896: 70). These fail in a few days or weeks because of the specialized food requirements of the species. C. Piesse (WAPD **43**: 1341, 28.8.1912) stated that numbats cannot live in captivity, whereas Kent (1928) noted that 'It is the general opinion that they will not live long in captivity'. However, when fed on termites, a captive numbat could survive for as long as 13 weeks (L. Glauert 1935 in *Our Rural Magazine* **10**, 148).

Although Le Soeuf (1900: 193) stated that numbats were much sought after for their skins, I have found no other report that confirms this. In 1849 one settler used a skin to make a bag 'for a little girl' (Buchanan 2003: 163). One correspondent stated that he had skinned 20-30, noting that the skin made a fancy tobacco pouch, with tail included (*The West Australian* 9.4.1927: 8).

Additional to the list of Noongar names published by Abbott (2001: 451-2) for this species is 'Knumbat' (*The West Australian* 26.3.1927: 9). The numbat was officially made the faunal emblem of the State of Western Australia in 1973 (*Government Gazette* 2.10.1973: 3641).

Chaeropus ecaudatus boda/woda/boodal/pig-footed bandicoot

Because it is generally accepted that this species has been extinct in south-west WA for many decades, I did not ask oldtimers about it. It was last collected in this region in 1842 by Gilbert. Celebrated collectors such as Masters (fl. 1860s), Tunney (fl. 1895-1905) and Shortridge (fl. 1905-6) failed to collect it and astute observers such as Haddleton (1952) and Hassell (1975) make no mention of it. The species is not represented in the collection of the WA Museum (Kitchener and Vicker 1981).

Here I provide a full account of all records uncovered (Fig. 13).

In March or April 1842 Gilbert collected at least two specimens, c. 40 miles north-east of Northam, in 'Walyemara' district (Fisher 1992: 145, 325). Gilbert's notes (Whittell 1954b: 111) imply that it was common there, as he states that the thick vegetation hindered shooting and impeded hunting by dogs. In Gilbert (nd2) he is more explicit: 'I frequently started them out of their nests but from the closeness of the dense vegetation, I was always unable to either shoot or track it down'. He stated that these thickets formed the western boundary of its geographic range. This species was unknown to the oldest settlers (near Toodyay, York and Northam), which indicates that it did not occur along the Avon Valley. The Aborigines from York knew nothing of this species, and afterwards they met a tribe from farther inland; these people knew it as rare (Fisher 1985: 10). This species made a nest 'precisely like' the quenda and marl (Gilbert nd1) but with more leaves (Gilbert nd2).

In about 1850 'small antelopes or pig-footed animals' were first noted at pastoral stations on the Victoria Plains, and were said to be common on the back runs of the Irwin River (*Perth Gazette* 13.9.1861: 2).

The next recorded encounter was by R. Austin in 1854. Although not mentioned in the narrative of his expedition (Austin 1855), W.A. Sanford in a letter printed with the report did list it, as the 'chestnut-eared hog's-foot'. It was said to have been met in large numbers (Glauert 1950: 125). This discrepancy suggests that it was accidentally omitted from the narrative by Austin, but the record was verbally communicated to Sanford. The precise locality of the record is unknown.

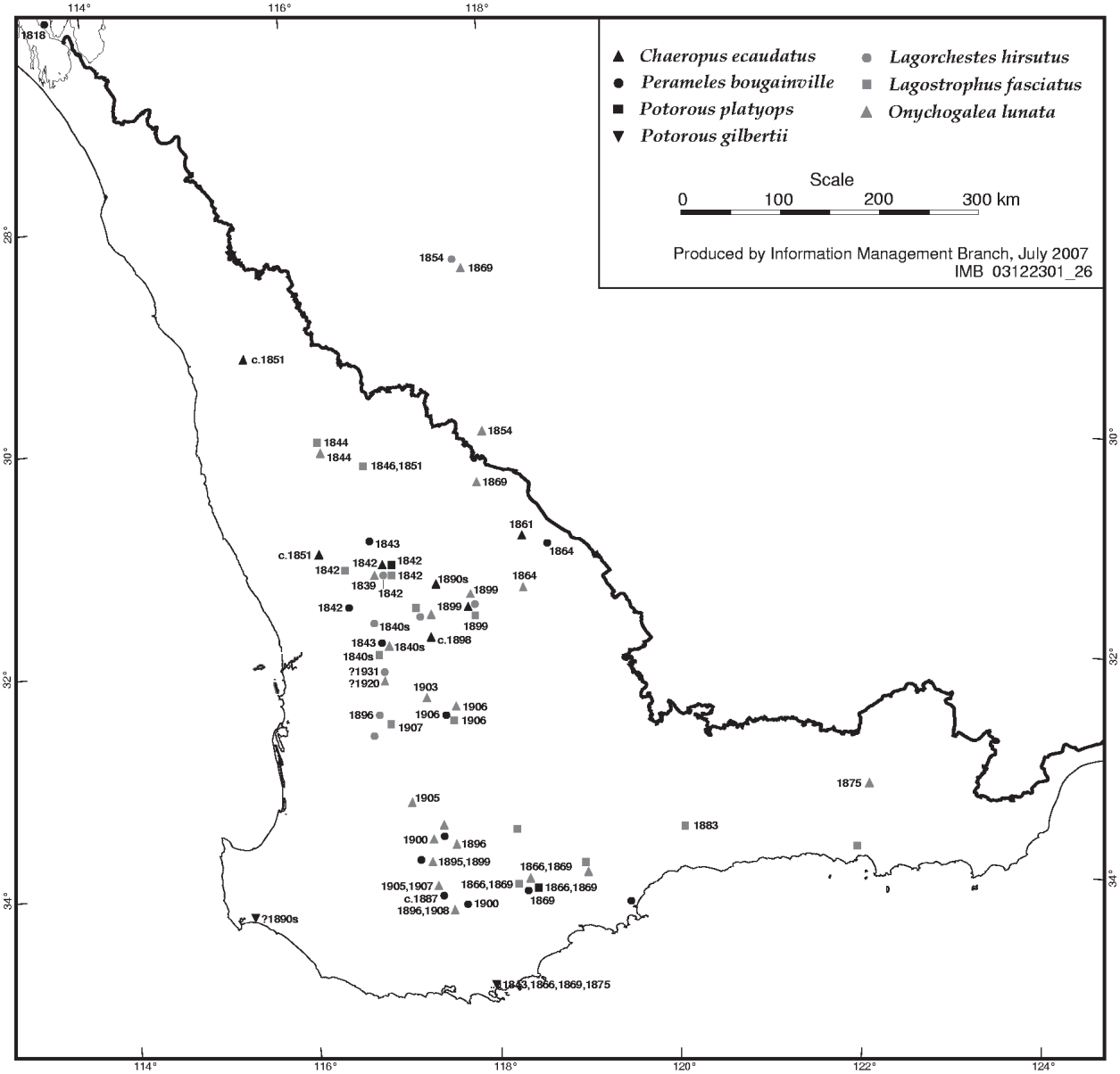

Fig. 13 Distribution of Chaeropus ecaudatus, Perameles bougainville, Potorous platyops, Potorous gilbertii, Lagorchestes hirsutus, Lagostrophus fasciatus *and* Onychogalea lunata. *Additional records not already cited in text:* Chaeropus ecaudatus *Gilbert nd1;* Perameles bougainville *Fisher 1992, Gilbert nd2, Kitchener and Vicker 1981;* Lagorchestes hirsutus *Austin 1855;* Lagostrophus fasciatus *Buchanan 2003: 72, 230;* Onychogalea lunata *Bird 1986, Drummond letters 25.7.1839, 3.10.1844, Tunney letter 25.2.1900.*

In July 1861 C. Dempster, during a journey of exploration, wrote 'Here we also saw an animal of peculiar description, being cloven-footed, ears long, colour grey, about the size of a half-grown rabbit; it bounds or jumps over the ground like a deer' (Exploration Diaries **5**: 32). This record has been placed near Baladjie Rock (Maddock 1998: 5) or north-east of Bullfinch (Brooker 2006: 34).

Leake (1962: 43, 46) quoted an Aboriginal name for this species from near Kellerberrin and stated that it disappeared in the period 1894-9. He provided an accurate description but evidently had not seen the species himself.

This species also occurred around Yorkrakine Rock in the 1890s, based on an accurate description provided by CG Jessup (Main 1967: 87). Jessup (b. 1881) spent his childhood in and around Northam (Butler 1963).

The final record of this species in the region was near Youndegin in c. 1898 (L. Glauert in *The Western Mail* 4.10.1928: 6). A correspondent provided an Aboriginal name *(Wod-di)*, noted that it was no bigger than a kangaroo rat, and was delicate in constitution (rough handling was fatal to it). It had front paws like those of a sheep. He thought it to be extinct.

B. Woodward (in WA Year Book 1900: 171) stated that this species was 'locally known as the "antelope"', but it was erroneously listed as occurring at Lagrange Bay [near Broome] (p. 177; see also Shortridge 1910: 836).

There is no record that this species was collected by J. Tunney, who visited this district in 1896. Shortridge (1910: 836) provided its common name (camel-foot) and an Aboriginal name from Beverley, probably from the eastward (see Short 2004 for details of his itinerary).

Based on the failure of Tunney, Haddleton, Masters and Hassell to note this species, it is generally assumed that it did not occur as far south as Kojonup, Katanning, Mongup and Jerramungup, respectively. Although a tail-less bandicoot 'new to me' was captured by A. Collie north of King George Sound (*The Perth Gazette* 16.8.1834: 340), in the absence of further information it cannot be assumed that *C. ecaudatus* was collected.

Abbott (2006) attributed the extinction of this species in WA to an epizootic.

Isoodon obesulus kwenda/quenda/southern brown bandicoot

Oldtimer information The quenda was also known to many oldtimers as the bandicoot, native pig, wild pig or bush pig (and rarely as boodie rat). This species has persisted through most of lower south-west WA (Fig. 14), but generally became less common from the 1940s. Up to that time it was considered a nuisance where potatoes were grown, digging them up (A. Dawson, W. Forrest, A. Torrent, L. Turner pers. comm.). One oldtimer reported finding dead animals in forest near Pemberton at the end of the 1930s (F. Bamess pers. comm.). Quendas were reported to have recently become conspicuous and even tame in farm gardens following

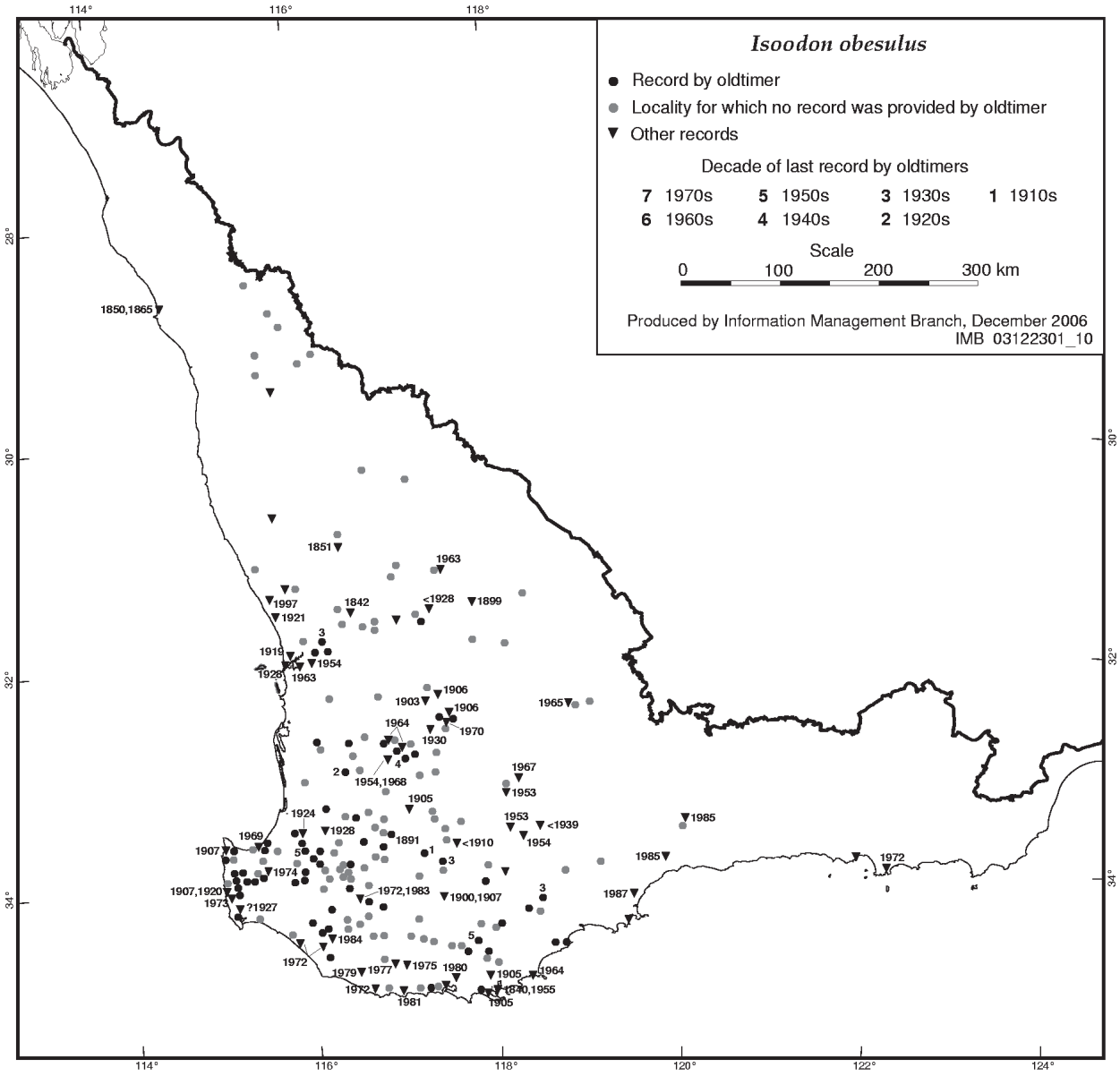

Fig. 14 Distribution of Isoodon obesulus. *Additional records not already cited in text: Aitken 1954; Bannister 1969a; Chapman 1995; Christensen* et al. *1985;* Fauna Bulletin*; Fisher 1992;* Fisheries Department Bulletin*; Job 1969; Kitchener* et al. *1975; Kitchener and Vicker 1981; Knox-Thomson 1975; Payne 1987; Putt nd; Serventy 1954; Short and Calaby 2001; Taunton 1903; Tunney letter 25.2.1900;* The West Australian *12.4.1930: 4;* The Western Mail *14.5.1925: 1, 23.2.1928: 11, 4.10.1928: 6, 6.4.1939: 10.*

fox baiting (T. Busby, B. Darnell, M. Tichbon and E. West, pers. comm.).

Distribution and abundance According to Gilbert (nd2; see also Gould 1863: 30), this species in the 1840s was abundant in every part of the colony (as then known) and occurred wherever dense ground cover was present in the landscape (i.e on ridges and riparian areas). Presumably this included Wongan Hills, from which there is no subsequent record. This species also occurred at Champion Bay (Oldfield 1865: 297), and other outlying areas (based on Aboriginal names collected by D. Bates and published by Abbott 2001a). It was common around New Norcia in the late 1840s, living in hollow logs and 'other hiding places' (Stormon 1977: 192). Later reports, made before the fox arrived, state that the habitat of the quenda comprised thickets in moist localities and swampy thickets (Shortridge 1910: 833; Nicholls 1926: 70).

Interactions with humans Quendas responded positively to settlement, feeding on grain and occurring in great numbers in stacked wheat (Gilbert nd2; see also Gould 1863: 30) and in stooks of harvested hay (Haddleton 1952: 100). Near Denmark this species burrowed under a wire-netted fence and foraged in a garden in which potatoes were being grown, and occasionally had to be trapped to protect this crop (F. Whitlock in *The Western Mail* 24.3.1927: 4). At Forrestdale Lake in the 1920s and 1930s, quendas dug up maize in gardens and ate off the roots (Giblett 2006: 68). Quendas were reported feeding on lupins on farmland along the Perup River adjoining Balban and Yackelup forest blocks (*CALM News* September 1993). 'Bandycoots', presumably this species, were said not to take strychnine baits (*The Western Mail* 27.7.1909: 7).

In colonial times this species was considered to be good eating, better than *Bettongia penicillata* or *Trichosurus vulpecula* (H. Bunbury 1836-7 in Bunbury and Morrell 1930: 88). It was a favoured food item of Aborigines (*The Western Mail* 16.4.1925: 2; Bird 1986: 289) and was eaten by settlers as late as 1926 (*The West Australian* 30.5.1925: 11; Gardner 2000: 62).

Inimical factors In the Piesse Brook-Bickley district (northern jarrah forest), the quenda had shown no notable decline by the early 1950s (Loaring 1954: 134-5) and it still occurred in the central and western wheatbelt in the 1960s. It has persisted in densely vegetated parts of the south-west, including the southern suburbs of Perth, in the face of predation by foxes. Their high reproductive potential of 10-15 young/female/year (Sampson 1971) has probably facilitated their persistence there. Widespread baiting of foxes since 1996 has resulted in increased abundance, digging activity in gardens and sightings during the day (Anon. 2005: 4; Huston 1999: 17; Kemp 2002: 16; Seaman 2002: 17; *Hills Gazette* 17.8.2002: 18; Pate 2003: 46; *Augusta Margaret Mail* 21.7.2004: 4; CALM Annual Report 2005: 174). Urban development around lakes south of Perth (Lake Banjup, Thompsons Lake) has led to their successful translocation to fox-baited national parks (e.g. Avon Valley) (*Cockburn Herald* 30.8.2003: 17) and nature reserves (Courtenay nd; Morris 2000: 65-6). Some 262 animals have been released in the Avon Valley since 2000 (Freegard *et al.* 2004). The release of 12 quendas into a 180 ha enclosure resulted in a population of c. 160 animals occupying upland jarrah forest as well as creek lines (Schmitz and Copley 1998). Thirty quendas were released in Nambung National Park in 2005. Quendas were also successfully established in fox-baited Tutanning Nature Reserve in 1991 (CALM Annual Report 2003-4: 142; Orell 2004).

This distribution of this species contracted markedly between the 1870s and 1890s. It was not found north of Gingin by the collector J. Tunney, and had disappeared from Kellerberrin district by 1899 (Leake 1962: 43), from Dandaragan district by c. 1903 (Green 1928), and from Katanning district before the rabbit or fox had arrived (Haddleton 1952: 100). However, it was still common along the Hotham River and at Pingelly in 1925 (*The West Australian* 30.5.1925: 11). Although the quenda may have declined near Katanning because of poisoned wheat put out to control parrots (Haddleton 1952), Abbott (2006) suggested that this species was one of a suite affected by disease. Quendas had disappeared from Armadale district in c. 1900, and had only re-appeared 'in fair numbers' in the late 1920s (*The West Australian* 3.5.1930: 4, 28.6.1930: 4). Quendas seem to have disappeared early from the suburbs north of the Swan River e.g. the last quenda known in Mosman Park district was killed in 1928 (Tuettemann 1991: xxiv). By the 1990s this species was known to occur in only seven areas north of the Swan River on the coastal plain, namely Bullsbrook, Ellenbrook, Pinjar, Wanneroo and Whiteman Park (Courtenay nd), Wilbinga (Hart 1998), and Landsdale (How and Dell 2000: 207).

Perameles bougainville mal/nymal/marl/western barred bandicoot

I did not seek comment about this species from oldtimers, as it was last seen (and collected) in 1906. It was first collected in WA in 1818 at Peron Peninsula by the *Uranie* expedition (Fig. 13). The species was noted by Gilbert in the 1840s near York, Toodyay and Wongan Hills in thickets, particularly those of *Casuarina* seedlings. The marl was not found west of the Darling Scarp (Gilbert nd1). On his second visit to WA, Gilbert found this species at 'King George's Sound'. It was next recorded near Bolgart ('Maloe,' 1849 in Buchanan 2003: 167) and Geelakin Rock (Hunt 1864: 10). The marl was evidently abundant in 1868-9 presumably at Mongup, where G. Masters collected at least 22 specimens (Krefft 1869: 7). The Macleay Museum in Sydney has three specimens collected by W. Webb in 1874. These are labelled King George Sound or Salt [Pallinup] River. Presumably this species was still extant in 1886 inland from, or east of, Albany, as W. Webb of Albany included three specimens in his cabinet exhibited in London (Colonial and London Exhibition 1886: 59). Tunney (letter, 28.6.1907) stated that it was numerous around Gracefield in c. 1887 but he could not obtain any specimens in 1900. Aborigines informed him that a few still occurred at that time near the Stirling Range.

According to Shortridge (1910: 834), the WA

Museum had a specimen from 'Kojenup (Darton)'. I have been unable to trace Darton and this name is unknown to the historian Merle Bignell (pers. comm.). Perhaps it represents a mistranscription of Barton (now known as Piesseville), c. 70 km north-east of Kojonup. Shortridge obtained the last specimen collected in south-west WA from Woyaline. He was told by Aborigines that it was still 'fairly numerous' in the Pallinup River district.

This species also occurred near Katanning but its year of disappearance there was not recorded by Haddleton (1952: 100-1). Because Leake (1962) did not list or discuss this species, it presumably had disappeared from Kellerberrin district well before 1890 [Leake was born in 1880].

The locality Marlamerup near West Mt Barren presumably incorporates the Noongar name (Forrest and Crowe 1996: 67).

This species was probably originally distributed in south-west WA east of a line joining Geraldton, Toodyay, Katanning, Cranbrook, and Bremer Bay, and disappeared rapidly from c. 1890. Abbott (2006) linked this early disappearance to an epizootic, whereas Thomas and Friend (2003) attributed it to predation by foxes and cats. The marl is at present known in WA only from Dorre and Bernier Islands and enclosures at Heirisson Prong, Shark Bay and Dryandra Woodland. It has been translocated to Fauré Island (CALM Annual Report 2006).

There does not seem to have been anything especially noteworthy about this species, as Gilbert (nd1) stated that it 'precisely resembles the [quenda] in its habits and manners that a separate description is unnecessary'.

Recent attempts to re-establish marl populations on the mainland (at Dryandra Woodland) have been hindered by a disease caused by a papilloma virus (Thomas and Friend 2003; Friend and Beecham 2004; K. Morris pers. comm.).

Macrotis lagotis djalkat/dalgyte/bilby

Oldtimer information The original distribution of this species, the dalgyte, was analysed in detail over a large part of south-west WA in a recent paper (Abbott 2001b). Subsequently I interviewed an additional 35 oldtimers and the information gained confirms the conclusions reached by Abbott (2001) that the dalgyte was of very local occurrence (only observed once at each locality) in the lower south-west (Fig. 15). For example, I obtained two records from Osmington (K. Bessell, T. Busby pers. comm.) with many null records from nearby localities (Fig. 15). Particularly interesting new records include a sighting on a farm in 1937-8 near Five Mile Brook, Pemberton district (M. Burrows), a skin sighted at Hawter's orchard c. 3 km south-east of Sawyers Valley in c. 1930 (R. Gray), and a few animals still present in 1928 in jarrah forest near Greenbushes (G. Dunn). This last record is the first confirmation of the distribution predicted from vegetation complexes (Abbott 2001b: 277).

The 17 additional records that were dated are as follows: 1928, 1929, 'late 1920s', 1930, 1931, c. 1934, 'mid 1930s', 1937, 1938, '1940s', 1946, '1950s', 'mid 1960s', before 1970. This extended period of last records is consistent with information presented by Abbott (2001b).

'A fair number' were caught when rabbit trapping, enough to cause a nuisance. These animals 'bit hard' (J. Stokes pers. comm.).

Causes of decline and apparent extinction (when offered by oldtimers) were as follows: drinking of poisoned water to kill rabbits, consumption of poisoned baits to kill rabbits (before the fox arrived), destruction by farmers of burrows once rabbits arrived, fox predation, and consumption of poisoned baits intended for foxes. This information conforms with the factors summarized in Abbott (2001b).

Early records of distribution and abundance The earliest documented sighting by a European was of its burrows south of the Williams River (J. Roe 1835 in Shoobert 2005: 467). The first specimen was collected in November 1836 by J. Mangles at 'Swan River' and sent to Britain (Largen and Fisher 1986) and presumably served as the type. Other early literature records include 'often' seen near Strawberry, up to 1876 (J. Watson in Bain 1975: 407) and plentiful around Northampton (undated, J. Drage in Bain 1975: 408). Dalgytes presumably occurred before 1880 in 'Upper Irwin district', as Aborigines used their tails and fur to make a head ornament (Melbourne International Exhibition 1880: 16). Observations in 1801 of burrows 'like those of rabbits' and piles of earth that 'must have been built up by some animals' (Cornell 1974: 168, 176) may allude to a hitherto undocumented population of dalgytes on the shore of Geographe Bay.

The dalgyte was a species well known in rural WA (e.g. *The Geraldton Advertiser* 22.7.1898, 25.7.1898, 3.8.1898, 12.8.1898; *The West Australian* 1.8.1898: 4, 25.7.1925: 15, 5.9.1925: 11; de Burgh 1976: 65, 187; Haddleton 1952: 98-9; Leake 1962: 50, Roe and Roe 1992: 2; Webb 1944: 123; F. Whitlock in *The Western Mail* 20.5.1926: 36, 23.12.1926: 2; Udell 1979: 328) and it is mentioned frequently in local histories, particularly of wheatbelt shires (Anon 1995: 22; Anon. 1999: 347; Crake 1985: 105; Eaton 1979: 150; Ewers 1959: 97; Field 1982: 80; Knox-Thomson 1975: 26; Ludbrook 2003: 6; Maddock 1987: 20; Pustkuchen 1981: 31; Repton 1999: 2, 308; Shiner 2003: 36; Stokes 1984: 103; Stokes 1986: 4; Warren 1983: 91).

Further evidence of its familiarity to settlers and prospectors are the numerous records of its Noongar name. Additional spellings of the Noongar name that are not catalogued by Abbott (2001: 455-6, 2001: 302-4) are *dalgert* (*Perth Gazette* 9.6.1838: 91), *Dalghiht* (*The Murchison Times and Day Dawn Gazette* 27.7.1909), *Dalghite* (Paris Universal Exhibition 1878: 12), *dilite* (*The Western Mail* 27.7.1907: 7), *Dirlgite* (*Science of Man* 22.2.1904: 10), *Dolgyt* (Anon. 1842: 95); *Dulegite* (Mason 1909: 22), *Dulghite* (*The Western Mail* 16.4.1925: 2), *dulgite* (*The Eastern Districts Chronicle* 19.4.1879: 4; T. Drage in *The Geraldton Advertiser* 25.7.1898, also 5.8.1898, 12.8.1898; *The Western Mail* 6.4.1939: 10; Eaton 1979: 150; C. Wansbrough 1919 in Fisheries Department file 34/32; J. White in *The Western Mail*

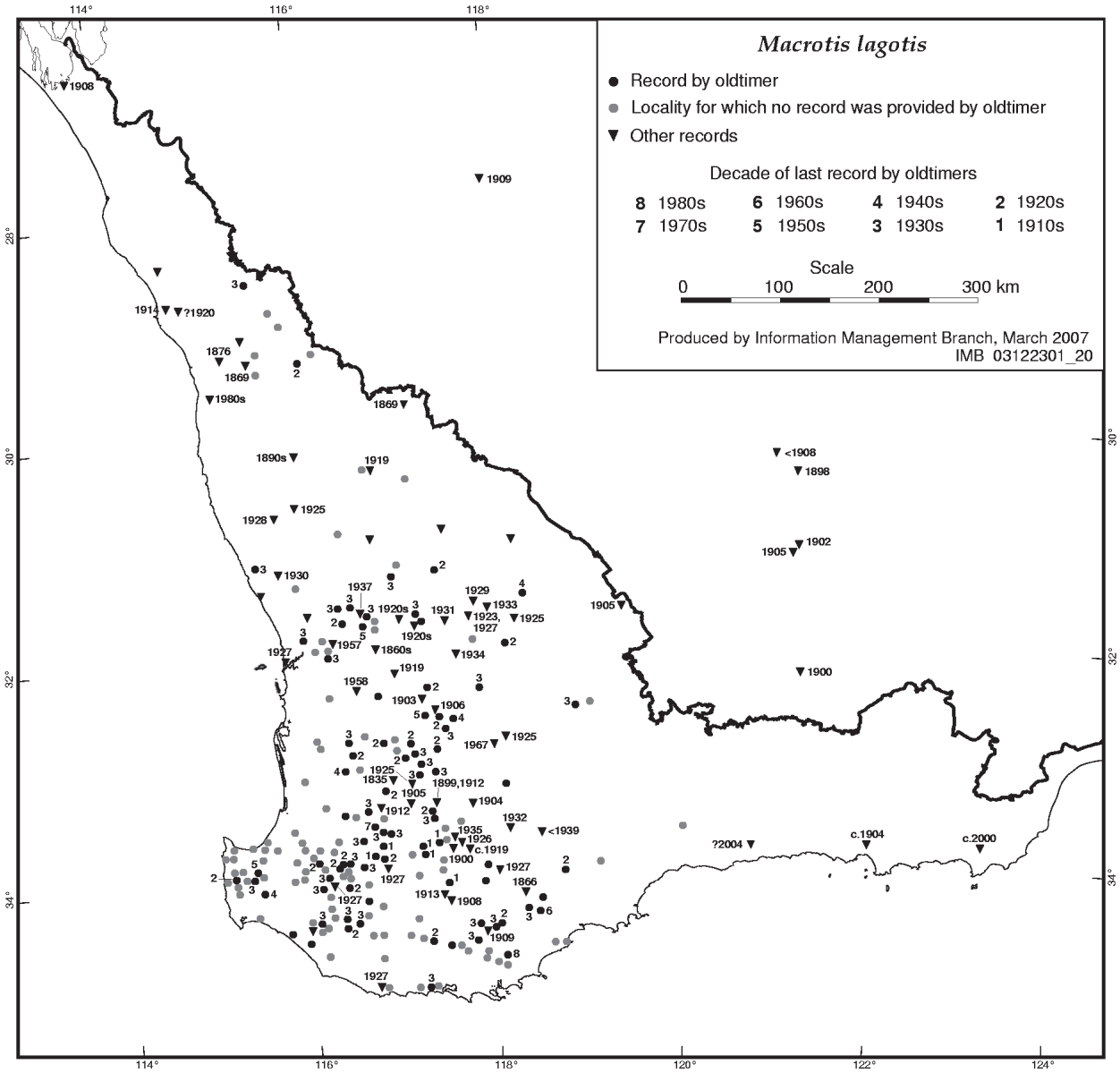

Fig. 15 Distribution of Macrotis lagotis. *Additional records not already cited in text: Acclimatisation Committee 1899, 1900; Dunnet and Mardon 1974;* Fisheries Department Bulletin*; Fisheries Department file 34/32; A. Forsyth* http://amol.org.au/runrabbitrun/oral.asp *[accessed 18.8.2005]; French 1989; Glauert 1950;* Kalgoorlie Miner *4.7.1905: 4; Le Soeuf and Burrell 1926; McCarthy nd; J. Nunn pers. comm.;* The Coolgardie Miner *15.6.1898: 4;* The Murchison Times and Day Dawn Gazette *27.7.1909;* The Northern Times *19.12.1908;* The Sun *23.2.1902;* The West Australian *5.11.1927: 7;* The Western Mail *8.9.1900: 5, 9.8.1923: 4, 23.12.1926: 2, 24.3.1927: 4, 18.8.1927: 34, 21.6.1928: 6, 6.4.1939: 10; Tunney letter 7.5.1913.*

15.9.1900:7; F. Whitlock in *The Western Mail* 20.5.1926: 36; Wilson 1904: 432), *dylghite* (*The Kalgoorlie Western Argus* 27.9.1900: 14), *tulgite* (J. Watson in *The Geraldton Advertiser* 22.7.1898), and *tulgych* (*The West Australian* 30.5.1925: 11). However 'dalgite' and 'dalgyte' are the spellings used most frequently. B. Leake stated that the correct pronunciation rhymed with 'dull' (*The West Australian* 26.1.1929: 6).

There are several records of the dalgyte and boodie living in the same warren (*The West Australian* 16.5.1925: 13, 30.5.1925: 11).

Value of fur Evidence available as to whether the pelt of the dalgyte was much sought after is contradictory. In the 1860s it was noted that the 'fur is very effective when bordered or lined with rose colour, but if exposed to much wear it soon becomes shabby' (Millett 1872: 170). One farmer made a rug of mixed dingo, dalgyte, rabbit and cat skins (Haig 1982: 80). Warren (1983: 6) noted that skins were sought after. Repton (1999: 2) stated that many of the earlier settlers trapped and sold dalgyte skins, which were prized in the fur trade. Support for this comes from advertisements advising that dalgyte skins would be purchased by traders in Northam and York 'in any quantity during the season', from April to September inclusive (*The Eastern Districts Chronicle* 27.7.1878: 2, 2.8.1879: 4, 6.9.1879: 3). In 1925 one correspondent

recalled an extensive trade in skins '[y]ears ago' (*The West Australian* 11.4.1925: 9). There was also a request for advice on how to preserve the colour by tawing the skin (*The Western Mail* 25.7.1908: 6) and how to tan the skin (*The Western Mail* 23.6.1927: 34), as well as praise for the product ('When properly tanned, skins…are very beautiful…soft and smooth…possesses a beautiful gloss', F. Whitlock in *The Western Mail* 20.5.1926: 36).

This is, however, contradicted by G. Shortridge (letter, 15.11.1905) who noted that the oiliness of the skin made it difficult to preserve; consequently trappers discarded these animals when caught in rabbit traps. The skin when dry was described as 'perfectly thin' (*The Western Mail* 16.4.1925: 2). Glauert (*The Western Mail* 26.1.1928: 11) recorded that dealers placed small value on dalgyte skins and Leake (*The Western Mail* 28.6.1951: 63) stated that the skin was tender and tore easily. According to Jenkins (1974) the fur was not popular with the trade because of the tenderness of the pelt and the persistent musty odour.

Dalgyte skins were first mentioned in *Elder's Weekly* on 23.7.1925 and during the period 30.7.1925 – 5.11.1925 1 817 'large' and 343 'small' skins were offered for sale (Fig. 16). I suggest that these were bycatch from the trapping of rabbits. The 5.11.1925 edition of this catalogue stated that furriers were not interested at present in small skins. Dalgyte skins seem to have paid low prices and after 1926 were scarcely remunerative. It was noted on 18.8.1927 that skins were often hard to sell and on 19.12.1929 that they were not worth consigning. Dalgyte skins were last listed in *Elder's Weekly* on 4.6.1936.

A Victoria Plains correspondent wrote that the dalgyte has 'rather a peculiar odour, which makes it unpleasant to handle alive or dead. I never saw a dog that would eat one, however hungry he might be' (*The West Australian* 1.8.1898: 4). Another contributor stated that a dog would not eat this species (*The West Australian* 4.5.1924: 13). Discarded carcasses and pegged out skins left near an ant nest were not eaten or cleaned (*The West Australian* 3.10.1925: 15). Despite this, there are reports of Aborigines capturing dalgytes, presumably for food (Forrest 1875: 64; Rowan nd: 77; Whittell 1954b: 110; Leake 1962: 50; Stokes 1986: 4; though see Bird 1986: 289), and of settlers eating them (Rowan nd: 77; Abbott 2001b: 302-3; Spencer 1966: 51).

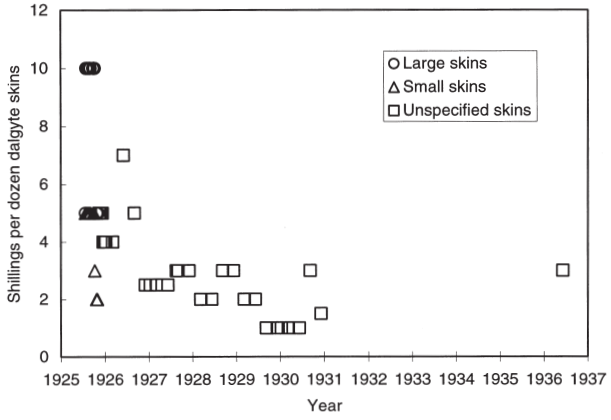

Fig. 16 Prices paid for skins of Macrotis lagotis. *Source:* Elder's Weekly, *supplemented by* The Westralian Farmers' Gazette *(various dates 1927-30). Where a range of prices was provided, only the maximum was graphed. After 5.11.1925 prices were no longer provided for large and small skins.*

Keeping of pets This attractive animal ('the most beautiful' of native mammals – L. Glauert in *The Westralian Farmers' Gazette* 17.3.1927: 10) seems frequently to have been kept as a pet. Some were aggressive (Abbott 2001b: 303), others more docile (Abbott 2001b: 304). Waterhouse (1846: 361) mentioned that a captive specimen was 'exceedingly savage, bit very severely, and would not readily unfix its hold of any thing it happened to seize with its teeth'. Rowan (nd: 62) considered the dalgyte as 'practically untameable'. One rabbit trapper regarded this species as 'vicious', stating that he had 'never been able to take one from a trap without first killing it' (*The West Australian* 25.4.1925: 11). Glauert (*The Western Mail* 24.10.1929: 40) noted that in the early days they were kept as pets about the place to destroy mice, cockroaches and other pests.

Records of a roadkill in a Perth street and a sighting in sandhills near Swanbourne Rifle Range (Glauert in *The Westralian Farmers' Gazette* 17.3.1927: 10; *The Western Mail* 26.1.1928: 11, 13.2.1930: 36) probably represent liberated or escaped pet dalgytes and are not evidence that the species was 'making its way back to its old haunts', as surmised by Glauert. Dalgytes are known to be able to disperse 4-10 km from the site of release (CALM *Conservation News* 8/2004).

Other interactions with humans Despite the high public profile of this species, only four references to this species as a pest were found. Three of these relate to its large, deep burrows damaging cultivated areas (Reid 1837; *Fauna Bulletin* 1969; Jenkins 1974). Dalgytes also destroyed wheat crops but would not take strychnine baits (*The Western Mail* 27.7.1907: 7).

Two accounts stated that dalgytes were used in the control of rabbits. One animal put down a rabbit warren would chase the rabbits out at the other end, where they would be killed (Eaton 1979: 150; Ludbrook 2003: 188). WJ Collins stated that when a dalgyte inhabits a main rabbit warren, the rabbits leave (*The West Australian* 25.4.1925: 11).

The record of a leveret 2-3 weeks old at Gnowangerup by a farmer from South Australia (*The Western Mail* 30.8.1923: 7), where hares are plentiful, surely refers to the dalgyte.

Decline in distribution and abundance

Numerous factors accounting for the decline of the dalgyte in south-west WA have been suggested:

- Fox predation (Glauert 1954: 131; WG Pearce 1963 in Fisheries Department file 51/55; Jenkins 1974; Stokes 1984: 103; Roe and Roe 1992: 2; Ludbrook 2003: 6). In 2003 nearly 40 animals were released into Dryandra Woodland (baited monthly to limit fox predation) and breeding has subsequently taken place (CALM *Conservation News* 8/2004).

- Usurpation of burrows by rabbits (F. Whitlock in *The Western Mail* 20.5.1926: 36, though contradicted by 'WER' in *The West Australian* 16.1.1926: 13).
- Fumigation of rabbit burrows: accidental death of dalgytes (Glauert 1954: 131; Jenkins 1950, 1974; Wellard 1983: 113; Roe and Roe 1992: 2).
- Trapping for rabbits: accidental death or mutilation of captured dalgytes (Shortridge 1910: 833; *The West Australian* 11.4.1925: 9, 11.7.1925: 13, 25.5.1929: 6, 15.6.1929: 6); *The Western Mail* 3.3.1932: 40; Leake 1962: 50; Pustkuchen 1981: 31; Field 1982: 80).
- Distribution of poison baits for rabbit control: accidental death of dalgytes (L. Glauert in *The Western Mail* 24.10.1929: 40; Haddleton 1952: 99; Pustkuchen 1981: 31; Roe and Roe 1992: 2; Udell 1979: 228).
- Destruction of rabbit warrens by deep ripping (Jenkins 1974; Ludbrook 2003: 6).
- Poisoning of water sources for rabbit control (L. Glauert in *The Western Mail* 24.10.1929: 40).
- Cattle and sheep, 'probably through their holes being trodden on' (T. Drage in *The Geraldton Advertiser* 25.7.1898).
- Successive droughts (Thomas 1906: 770-1).
- Clearing of vegetation for cultivation (Le Soeuf 1900: 193; *Fauna Bulletin* 1969; Jenkins 1974), though contradicted by 'GPO'R' and 'WER' in *The West Australian* 16.5.1925: 13, 16.1.1926:13.
- Predation by dogs and cats (Stokes 1984: 103).
- Disease (In Coorow district, very plentiful in the early 1890s but shortly after became comparatively scarce - *The West Australian* 14.11.1925: 15; L. Glauert in *The Westralian Farmers' Gazette* 17.3.1927: 10; *The Western Mail* 2.1.1928: 11; Abbott 2006). This disease evidently exterminated the dalgyte in many areas in c. 1897 but the species recovered to some extent before the arrival of the fox (e.g. near Moora and Wickepin, *The West Australian* 10.10.1925: 15, 12.12.1925: 15). Dalgytes were 'numerous' about Brookton until c. 1912, when they 'disappeared for a time. Now they are again plentiful.' (*The West Australian* 16.1.1926: 13).

Declines appear to have been caused initially by disease, followed by factors related to rabbit control from c. 1920, and then the establishment of the fox in the late 1920s. In 1927, before the fox had established in Brookton district, the dalgyte was considered to be the only [conspicuous] mammal species that had 'held his own in this district' (*The West Australian* 24.12.1927: 5).

Recent sightings of dalgytes have been reported near Munglinup River (2004, J. McKenzie pers. comm.) and in Cape Arid National Park (?2000, K. Tiedemann pers. comm.), but are as yet unconfirmed.

Dalgytes obtained from the Pilbara and Kimberley regions of WA have been successfully established at Dryandra Woodland, despite predation by the carpet python and the use of their burrows by koomal (Friend and Beecham 2004). It is planned to translocate this species to an area east of Nannup, Perup, Lake Magenta Nature Reserve, and Fitzgerald River National Park (Department of Environment and Conservation 2006).

Amplification Abbott (2001: 278) cited two references that stated that the town of Morawa is named after an Aboriginal word for this species. This is further supported by Carter (1987: 84), who cited *marawa* as the Aboriginal word in use in 1888 at Minilya River, by FFB Wittenoom, who noted *Marowera* in c. 1890 at Murgoo (Lefroy 2003: 38), *Murrawa* (*Science of Man* 22.2.1904: 10), and *Marroowah* (Mason 1909: 22). On the Murchison River the Aboriginal name was given as *morowa* (*The Western Mail* 23.4.1925: 4). This word is Yamadgee, not Noongar.

Correction The rather vague record of a dalgyte in Lovat (1914: 175-6) was misinterpreted by Abbott (2001: 303). Further research by me places this record at Whitfield's station at Yandanooka in 1869.

Bettongia lesueur boodi/boodie/burrowing bettong

Oldtimer information Very few of the oldtimers interviewed had seen a boodie, although a number of others had been shown boodie warrens by their fathers, who had seen their inhabitants. Many oldtimers responded, however, by acknowledging that they were familiar with 'boody rats'. Close questioning revealed considerable risk in automatically equating 'boody rat' with *B. lesueur*, as discussion indicated that *B. penicillata*, *Isoodon obesulus* or *Setonix brachyurus* was actually being described. To minimize confusion and error, I accepted records only if oldtimers mentioned burrows, 'boodie', or the presence of a white tip to the tail (Fig. 17).

Several oldtimers mentioned that this species was the first to disappear from the south-west of WA, recalling being told this by a parent or other person. Interviewees were aware of disused boodie camps on their farms, noting that these burrows were occupied when the land was selected by their fathers (A. Batt, B. Butler, F. Carter, W. Chitty, S. Cook, G. Cowcher, C. Fawcett, J. Fletcher, George Gardner, H. Hall, M. Marsh, F. Mitchell, B. Moir, A. Pollard, B. Stokes, H. Whistler, K. White, and T. Wilding, pers. comm.). The mounds around boodie burrows were stated to be larger than those produced later by rabbits (C. Fawcett pers. comm.). Boodie warrens were subsequently taken over by rabbits.

Boodies were reported as being present in their hundreds (D. Bradford; A. Marshall; 10-15 boodies to 1 dalgyte, N. Candy pers. comm.) until disease apparently reduced their distribution rapidly in the period 1900-30 (e.g. 'fleas killed them', W. Chitty pers. comm.; 'went overnight', N. Rajander pers. comm.). Until then boodies were a pest of farm gardens, orchards and the small paddocks used to grow wheat and oats for domestic consumption in that period. It was necessary to build stake fences to keep them out from newly sown seed and also

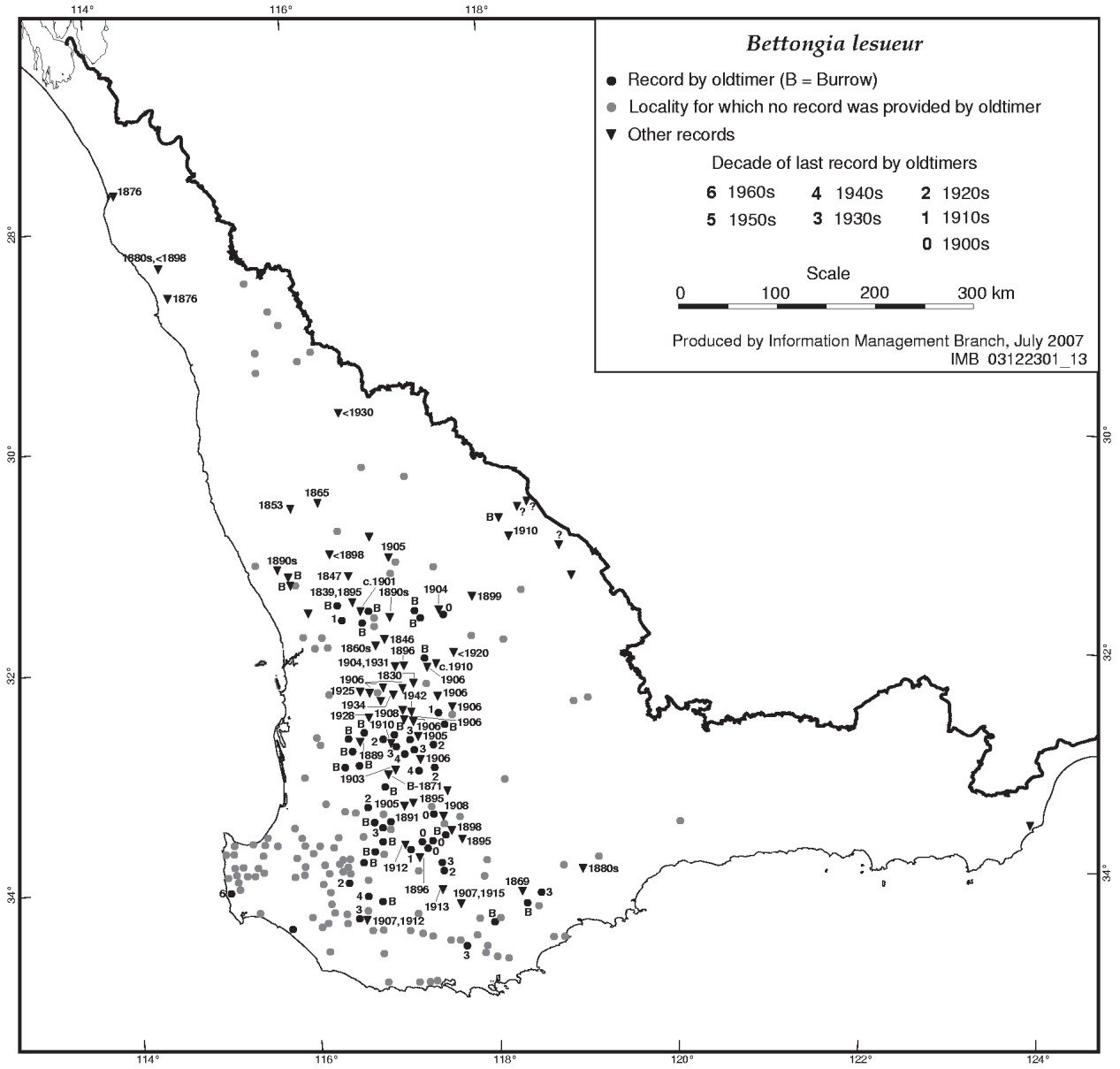

Fig. 17 Distribution of Bettongia lesueur. *Additional records not already cited in text: Anon. 1995; Bignell 1997; Cowin 1971; Drummond letter 25.7.1839; Gardner 2000; Hammond (1896: 812); Kitchener and Vicker 1981; Krefft 1867, 1869; Repton 1999; Roe and Roe 1992; Short 2004;* The Perth Gazette *27.1.1865;* The Western Mail *16.1.1930: 36.*

to poison them with strychnine (A. Marshall pers. comm.). Boodies also dug up potatoes (V. Roberts pers. comm.). Boodies were occasionally caught in rabbit traps (J. Dhu, K. Smith pers. comm.)

Oldtimers reported that boodies persisted in the South Dale, Cuballing, Narrogin, Lake Towerrining, south Kojonup, west Tambellup, and Perup districts until the 1930s-40s (N. Candy, L. Cochrane, A. Giblett, D. Moir, A. Muir, J. Muir pers. comm.), with one extraordinary record from c. 1968 near Boranup (V. Roberts pers. comm.). Their demise at Deeside in the early 1930s was attributed to disease (A. Muir pers. comm.), just before the arrival of the fox. Their extinction near Narrogin in c. 1942 was variously linked to feline enteritis, provision of poison baits for rabbit control, and the fox (D. and B. Bradford pers. comm.). East of Dryandra Woodland, boodies 'went suddenly in the early 1930s' (A. Hunter pers. comm.).

Boodie holes were noted as being prevalent in moist sand in well drained York gum/rock sheoak/jam country (N. Beeck pers. comm.), under large granite rocks (M. Marsh, G. Warren pers. comm.) or in sheoak thickets (G. Warren pers. comm.). Boodies were not eaten by farmers (A. Marshall pers. comm.). For such an abundant animal, only two instances were found of a boodie kept as a pet (1922, K. Smith; early 1930s, J. Muir pers. comm.).

What is a boodie rat? As with the oldtimers interviewed, the term 'boody rat' was used frequently in recent publications. The earliest published use found of this term was in 1897 by L. Lindley-Cowen (in *Journal of*

the Bureau of Agriculture of WA **4**, 1234), followed by Potts (1905), Crawford (1905: 487), in 1906 at Narrogin (*The Western Mail* 25.8.1906: 7), in 1910 near Busselton (Grant-Watson 1968: 76) and in an advertisement for 'boody rat netting' (*The Western Mail* 30.7.1910: 9), and in c. 1910 in the lower south-west (Fyfe nd: 35). In the period from 1839 to the early 1890s the term 'boodie' had been used exclusively (Abbott 2001a; see also Paris Universal Exhibition 1878: 12). Additional variants of the Noongar name, not noted by Abbott (2001: 461-2), are *pordie* (*The Eastern Districts Chronicle* 20.4.1878: 3), *bwerdy* (*The West Australian* 30.5.1925: 11), and *Budi, budye* and *Burdie* (Buchanan 2003: 97, 102, 103). B. Leake stated that boodie was pronounced by Aborigines to rhyme with 'moody' (*The West Australian* 19.1.1929: 6).

The term 'boody rat' was considered to be a 'bewildering expression, which may indicate either *[B. lesueuri]* or *[B. penicillata]*' (WE Gilbertson in *The Western Mail* 22.5.1930: 9). Therefore without further detail it should not be presumed that 'boody rat' in historical literature can be unequivocally attributed to *B. lesueur*. Many records discovered of the 'boody rat' have not been depicted on Fig. 17. Nor is it correct to assume that even published records of 'boodie' necessarily refer to *B. lesueur* (e.g. *Government Gazette* 1922: 1455; L. Glauert in *The Western Mail* 23.12.1926: 2).

Distribution, abundance and behaviour The records of oldtimers, when combined with those from published sources, indicate that the boodie occurred throughout most of south-west of WA, excluding the Swan Coastal Plain south of Perth, the western jarrah forest and most of the southern forests (Fig. 17). It is likely that unoccupied burrows, several acres in extent, on the upper Tone River and attributed to *Macrotis lagotis* (*The Western Mail* 16.4.1925: 2) were instead made by boodies.

The boodie was first recorded reliably by Europeans in August 1830, when R. Dale and G. Moore described numerous holes resembling badger earths on the banks of the Avon River near York (Shoobert 2005: 167; Cameron 2006: 47).

The parts of the landscape selected by boodies for their warrens have been described as: 'a bank sloping down to a river or small brook, for instance, all along the banks of the Avon their burrows are met with' (Gilbert nd1); 'sometimes inhabiting the rocks' like the rock wallaby (Gilbert nd2); 'where the soil is light' (Gilbert nd3); in the ground or in holes in rocks (J. Drummond, letter 25.7.1839); in deep, sandy/loamy patches in woodland and jam country, scrub and thicket, scooping out holes under granite rocks (Leake 1962: 45); usually near water, among rocky outcrops of granite, with pioneer settlers positioning their wells over a boodie hole (Eaton 1979: 44, 144); and sandy, rocky places amongst clayey hills (Pustkuchen 1981: 18).

According to Gilbert (nd1; see also Gould 1863: 278), the boodie was 'truly gregarious, living in very large families in burrows [which have] entrances in various directions all around, the earth is brought out, and raised into large mounds at the entrance holes; the entrance to these burrows [is] not merely round holes, but is dug out into channels or canals, with perpendicular sides, as perfect and even as if dug by man with a spade…I have made several attempts to dig them out, but have in each case completely failed. [T]heir burrows at a depth of 6 to 8 feet are very extensive, and wind and turn about into each other in endless confusion'. Detailed descriptions of how Aborigines extracted boodies from their burrows are available from 1847 (Buchanan 2003: 106) and from c. 1868 (*The West Australian* 15.12.1928: 5).

Apart from reference to the burrowing habitat, other characteristics mentioned as diagnostic of the boodie are: the 1½" white tip to the tail (*The West Australian* 30.5.1925: 11, 2.1.1926: 9, 1.12.1928: 5, 15.12.1928: 5; 12.1.1929: 6, 26.1.1929: 6, 9.2.1929: 6; Kent 1928); the small ears (*The West Australian* 30.5.1925: 11), shorter than any mammal for its size (*The Geraldton Advertiser* 3.8.1898); its light grey coloration (*The West Australian* 12.1.1929: 6; Haddleton 1952: 98) tending towards deep brown (*The Geraldton Advertiser* 3.8.1898); its thick and heavy looking head, and tail like that of a kangaroo in its thickness and presence of very short hair (*The West Australian* 12.1.1929: 6); the loud thumping noise made when hopping along the ground (Gilbert nd1, nd2); and its unique alarm call (Gilbert nd1), given as a grunt (Shortridge 1910: 822), 'a noise like the sharp bow [?blow] of a motor horn' (*The West Australian* 30.5.1925: 11), 'curr curr' (Leake 1962: 45) or 'toot, toot, toot' (Broun 1995: 12).

Interaction with humans As well as being widely distributed, boodies were very abundant and tame (Leake 1962: 45). They were attracted to campsites by the 'hundred' and could not be kept away by dogs (*The West Australian* 9.2.1929: 6). Boodies were a nuisance and an economic pest on farms. In the early 1840s, they were noted as one of the most destructive of WA mammals as they ate most garden vegetables, particularly peas and beans (Gilbert nd1). They could be easily shot as they emerged from their warrens (Gilbert nd1). In July 1846 172 boodies were caught in nine consecutive nights on a farm near York (Burges 1846: 47-48), with as many as 40 captured in one night (Hasluck 1931: 38). In the 1860s they would enter buildings and consume flour, sugar, pork, candles and soap (Millett 1872: 201). This species was 'very numerous' in c. 1898 in Dandaragan district (Green 1928).

This led to the construction of 'boody' fences, which were saplings and jam posts driven into the ground side by side. These fences were in common use in Beverley district (Thomas 1946: 40). Near Katanning a fence made of jam c. 2 m tall was used (Haddleton 1952: 9). Wire netting did not come into general use until the 1880s (Abbott 2004).

In the 1860s near Katanning, boodies would not eat germinating wheat but instead broke down the straw of ripe wheat in order to obtain the grain (Haddleton 1952: 58). In 1878 boodies were described as 'little wretches which torment us at seed-time and harvest, and all the year round if they can possibly get at our gardens or anything else'. It was recommended that wheat, flour,

bread or doughballs, put down at the entrance of their warrens and effectively poisoned, would destroy them (*The Eastern Districts Chronicle* 20.4.1878: 3). Another correspondent referred to the 'sad complaints every year about the great destruction caused among the newly sown corn [wheat] by rats *[B. penicillata]* and pordies' and the unexpected killing of large numbers by wheat soaked in bluestone for five weeks before sowing (*The Eastern Districts Chronicle* 6.7.1878: 2). The editor then summarized the situation by stating that 'it is an acknowledged fact that the losses to the farmers...are something enormous, and if any remedy can be applied to rid them of these pests it is worth a trial' (*The Eastern Districts Chronicle* 17.8.1878: 2). In 1889, G. Cowcher stated that he was unable to grow field peas on his farm near Marradong because boodies ate the germinants (Commission on Agriculture 1891: 183). Up to the 1890s boodies often ate germinating wheat crops, showed a 'love of all things grown in the station garden', and were thus poisoned with pollard/arsenic baits (Leake 1962: 45), particularly when grass was scarce in a dry season at the beginning of winter (B. Leake in *The West Australian* 26.1.1926: 6). Taking of sown seed and consumption of melons was recorded in the 1890s in the Wagin-Arthur and Toodyay districts respectively (R. Gell in *Journal of the Bureau of Agriculture of WA* **2**, 387, 1895; B. Woodward ibid. **2**, 391, 1895). Boodies were also a pest around Katanning (R.Taylor ibid. **2**, 389, 1895). They were stated to be a 'curse' in c. 1899 near Beverley where they were trapped and hundreds were also poisoned (C. Wansbrough 1919 in Fisheries Department file 34/32).

Boodies were a pest near Pingelly in 1905, eating potatoes and flour in a tent (Potts 1905), near Brookton in 1906 (*The Western Mail* 18.8.1906: 5), near Westbrook and Pingelly in 1906 (*The Western Mail* 25.8.1906: 7), and at Deeside in 1907 (J. Tunney, letter 29.3.1912). Recipes for poisoning boodies were published in a widely circulating rural newspaper in 1906 (*The Western Mail* 25.8.1906: 7; 1.9.1906: 5). It appears that boodies came onto newly established farms from the surrounding uncleared land (B. Woodward in *Journal of the Bureau of Agriculture of WA* **2**, 391, 1895). Boodies were tame enough to be knocked over while feeding (Pustkuchen 1981: 18). Other references to their destructive effects or their control by poisoning can be found in *The Western Mail* (23.6.1906: 5, 29.12.1906: 5, 9.3.1907: 6, 23.3.1907: 5, 23.7.1907: 7), Shortridge (1910: 822-3), L. Glauert in *The Westralian Farmers' Gazette* 29.3.1928: 26, Schorer (1968: 329), Bird (1986: 224), Maddock (1987: 425) and Broun (1995: 12). Boodies were considered to be easy to trap (*The Western Mail* 2.6.1906: 5, 27.4.1907: 4). Nonetheless, WC Grasby in 1907 summed up the situation: 'The boodie problem seems rather a troublesome one' (*The Western Mail* 9.3.1907: 6).

Boodies were also shot by boys, apparently for sport, on bright moonlight nights around granite hills (*The West Australian* 26.1.1929: 6). One settler near Narrogin killed boodies (and woylies) and boiled them down to be fed to poultry, thereby increasing egg production (*The Western Mail* 6.4.1907: 4).

Boodies had the habit of picking up wheat and *Gastrolobium* seed and burying it, resulting in clumps of seedlings (*The Western Mail* 1.9.1906: 5-6). After poison bush was grubbed out and the holes filled in, boodies uncovered the roots and the poison plants shot up again (B. Dodds in Cooke 1911: paragraph 494). Boodies also harvested fallen fruits of sandalwood *(Santalum acuminatum)* and quandong *(S. spicatum)* and planted the seed near their burrows (Leake 1962: 46).

Wedge-tailed eagles have been reported as feeding on boodies in Nelson district (W. Walter in *Journal of the Bureau of Agriculture of WA* **3**, 813 1896) and on Bernier Island (Richards and Short 1998). According to one colonial account, the rapid increase in boodie numbers in the 1870s was a result of Aborigines no longer needing to dig out boodies for food, the settlers' destruction of the dingo, and widespread persecution by farmers of the wedge-tailed eagle, a predator of lambs (*The Eastern Districts Chronicle* 20.4.1878: 3).

Only one record was found of boodies being captured for their skins (1847, Buchanan 2003: 97, 102, 103, 106), of the tanning of a boodie skin (Paris Universal Exhibition 1878: 12), and of the boodie being kept as a pet (L. Glauert in *The Western Mail* 1.11.1928: 6; see also Kent 1928). Boodies were eaten by Aborigines (Taunton 1903: 69; Bignell 1971: 9; Erickson 1974: 2) and by convicts (Pelloe 1929: 10). According to Bignell (1971: 9), the skin was used by Aborigines to make a *coota* (bag).

Decline and extinction on mainland south-west WA There are several accounts that document the early disappearance (after 1876) of this species from the northern sector of south-west WA:

- before 1898, near Northampton (Bain 1975: 408)
- many years before 1898, Victoria Plains (*The West Australian* 1.8.1898: 4)
- c. 1903, Dandaragan district (Green 1928)
- before 1905 (Shortridge 1910: 822-3).

Extinction in the southern sector of south-west WA commenced later:

- 1898, near Katanning (Haddleton 1952: 98)
- during the 1890s, near Kellerberrin (B. Leake in *The West Australian* 26.1.1929: 6)
- c. 1899, near Kellerberrin (Leake 1962: 43)
- 1899, Avon Valley (Leake 1962: 43)
- c. 1899-1900, in Talbot and Dale districts south-west of York and Beverley (*The West Australian* 12.4.1930: 4)
- c. 1900, near Brookton (*The West Australian* 24.12.1927: 5)
- 1904, near Beverley (C. Wansbrough 1919 in Fisheries Department file 34/32)
- before c. 1910, Mukinbudin district (Maddock 1987: 425)
- 1913, Kojonup and Lake Muir (J. Tunney, letters 12.2.1913, 7.5.1913, 3.7.1913); 1915, Cranbrook (J. Tunney, letter 19.3.1915)
- before c. 1920, Yoting district (Eaton 1979: 144)

- Boodies in the 'South-West' [?Williams district] went from being present in hundreds in 1903 to 'practically extinct' by 1918 (JA Greig WAPD **56**: 689, 5.3.1918)
- The mammalogist HH Finlayson failed to observe this species at Cuballing and Popanyinning in 1926 (Finlayson 1958) and was unfortunately unaware that small populations still persisted within 10 km.

Factors relevant to this decline include disease (Abbott 2006), poisoning by farmers (see above), provision of poison baits to control rabbits (Pustkuchen 1981: 31), the arrival of the fox, and perhaps local trapping for skins (*The Western Mail* 25.1.1908: 20). WE Robinson (*The West Australian* 24.12.1927: 5) noted that boodies had re-appeared after nearly 30 years and could be found c. 30 miles west of Brookton [?Westdale] in 1925. A. Kent (*The Western Mail* 22.11.1928: 48; also Kent 1928) noted that 'for many years' boodies were 'practically extinct' in Wandering Brook district, with their warrens deserted or inhabited instead by *Macrotis lagotis* and *Dasyurus geoffroii*. Boodies had 'recently' become plentiful again, and their warrens (as evidenced by the heaps of earth piled near them) had once again become inhabited. The last known active boodie warren in south-west WA was photographed in 1942 near Pingelly (*Western Wildlife* 2001: 19).

In 1998 20 boodies from Dorre Island were put in an enclosure at Dryandra Woodland, and the population then steadily increased (Friend and Beecham 2004). In September 2003, 21 boodies were released into the wild at Dryandra Woodland, but most were taken by wedge-tailed eagles and other native predators (T. Friend pers. comm.). It is planned to translocate this species to Perup and Lake Magenta Nature Reserve (Department of Environment and Conservation 2006).

Bettongia penicillata woli/wol/woylie/brush-tailed bettong

Oldtimer information As discussed above under *B. lesueur*, the common name 'boody rat' is equivocal. Before confidently assigning a record of a 'boody rat' provided by an oldtimer to the woylie, I expected the interviewee to articulate one or more of the following features. In order of importance, these are that this species does not live in a burrow; it builds a grass nest and lives in pairs in these nests and when disturbed bolts explosively; it carries nest material by curling up its tail; it is called the woylie, kangaroo rat or rat kangaroo; and in size and coloration it is like a miniature brush wallaby (grey, with a long tail with a crest of black hairs and terminating in a brush). This process of identification was expedited when an oldtimer knew also of the boodie.

This species was vividly recalled by many oldtimers. In the early days they were eaten by settlers (K. Nix pers. comm.) but not by later generations (E. Shanhun pers. comm.).They were considered to be difficult to skin (J. Farmer pers. comm.). Several oldtimers had kept woylies as pets (J. Dearle, H. Green, M. Marsh, K. White pers. comm.). One oldtimer stated that the woylie was not an agricultural pest on his farm (Donnelly River), as it did not eat crops (Lew Scott pers. comm.).

Oldtimers recollected that they last saw this species in c. 1930 (A. Marshall), early 1930s (A. Muir), late 1930s (C. Adams, F. Bamess, F. Brockman, L. Court, L. Torrent, J. Whyte), c. 1943 (C. Armstrong), 1940s (J. Enright, C. Miles), and 1950s (H. Whistler). It was last seen near Bridgetown in 1912 but persisted at Kingston (K. Smith). According to J. Farmer, the woylie disappeared from Boddington district after the boodie. Few oldtimers had a view on which factor had caused the decline of this species: A. Muir noted that it experienced disease and C. Armstrong and W. Forrest implicated the fox.

Distribution and abundance The geographical range of the woylie in south-west WA was originally slightly more extensive than that of the boodie (Fig. 18), with the woylie occurring on the Swan Coastal Plain. The statement that this species had not previously been recorded north of Perth (Lundelius 1957: 174) is incorrect.

The term 'kangaroo rat' was in frequent use in colonial times (various records 1829-30 in Berryman 2002: 96, 103, 105, 154; W. Preston 1829 in Shoobert 2005: 83; *The Perth Gazette* 12.7.1834: 319; Roe 1836: 38; J. Smithies 1841 in McNair and Rumley 1981: 16; J. Wollaston 1841 in Bolton *et al.* 1991: 142; Grey 1841 vol. 1: 321; Gilbert nd3; Wollaston 1843 in Bolton *et al.* 1992: 116; R. Salvado 1840s in Stormon 1977: 40-1; Hasluck 1973: 39; Millett 1872: 194; *The Eastern Districts Chronicle* 20.4.1878: 3, 6.7.1878: 2; G. Moore 1832 in Cameron 2006: 113; W. Cowan 1850 in Cowan 1978: 51). On the basis of Millett's (1872) clear account of the morphological and behavioural differences between the woylie and boodie, I have no hesitation in assigning literature records of kangaroo rats to this species (also see below). A. Warburton; 'JW', G. Horsfall, W. Robinson and M.McMahon distinguished 'kangaroo rat' from 'boody'/'boodi rat' (*The Western Mail* 1.11.1923: 4; *The West Australian* 30.5.1925: 11, 1.12.1928:5, 15.12.1928: 5, 9.2.1929: 6; see also Kent 1928), and F. Whitlock used the terms 'boody rat' and 'kangaroo rat' to refer to this species (*The Western Mail* 29.4.1926: 32, 7.4.1927: 30). DL Serventy stated that 'boodie rat' referred in south-west WA to this species (*The Farmer* 5.5.1924: 49).

In the first few years of settlement at Swan River, it was noted that kangaroo rats were very common, 'in size and appearance similar to the hare, but the head is like that of the common rat' (A. Stone, November 1829, Fremantle in Berryman 2002: 96). This species in the early 1840s was common 'in all [known] parts of the Colony, inhabiting the beds of the dried up Rivers, and follow parts of the sandy or loose soils, makes a small nest of dried grass either under a tuft of grass, or dead branches of a hollow tree, or in a hole in the ground with the top of the nest just even with the surface' (Gilbert nd3). This species was also noted as 'giving the preference perhaps to White gum *[Eucalyptus wandoo]* forests' (Wagstaffe and Rutherford 1955: 16). An Aboriginal name was recorded from Perth (Gilbert nd1).

In the 1870s, kangaroo rats were present, presumably

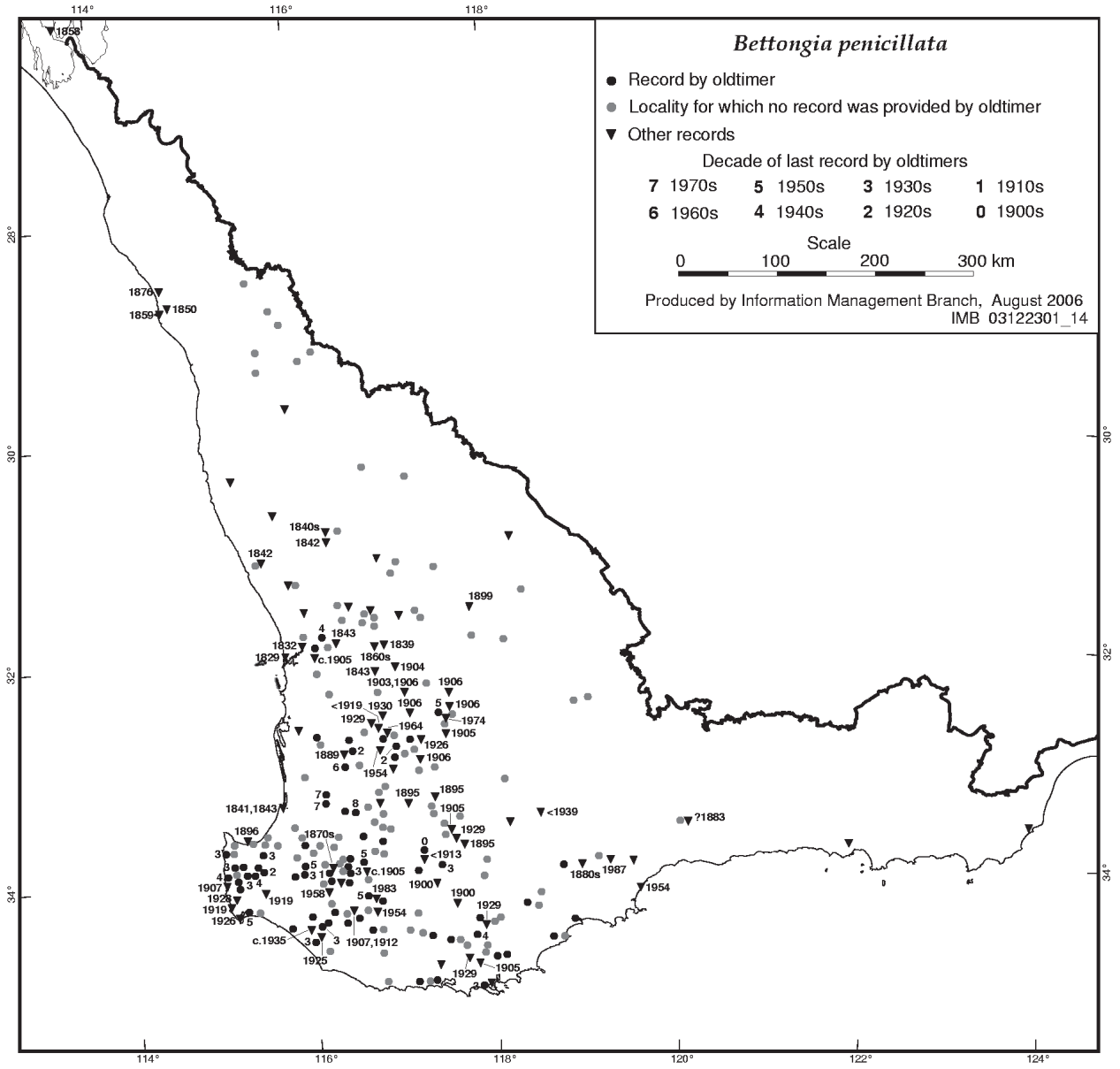

Fig. 18 Distribution of Bettongia penicillata. *Additional records not already cited in text: Aitken 1954; Bannister 1969a; Baynes 1979; Department of Conservation and Land Management file 022693F3807 vol. 1; Chapman 1995; Fisher 1992;* Fisheries Department Bulletin*; Hill 1903; Jones 1954; Kitchener and Vicker 1981; Oldfield 1865; Taunton 1903;* The Perth Gazette *14.2.1851;* The Western Mail *6.4.1939: 10.*

in Beverley district, 'in thousands' (*The West Australian* 15.12.1928: 5), and in c. 1878 were 'so common throughout the Great Southern' (*The West Australian* 12.1.1929: 6).

Unlike the boodie, the home of the woylie was 'anywhere' (*The Eastern Districts Chronicle* 20.4.1878: 3). According to Fountain and Ward (1907: 151) this species was 'found everywhere' in the district of King George Sound in 1889. During the 1890s there were 'tens of thousands' of 'kangaroo rats' in jarrah forest near Dwellingup (H. Tuckey WAPD **126**: 1273, 18.10.1950). In the period 1904-7 this species was considered to be very plentiful in the south-west but becoming scarce in settled districts (Shortridge 1910: 821-2). The 'Rat-Kangaroo' was said to have been abundant in the Piesse Brook-Bickley district (northern jarrah forest) in the early days of settlement, probably c. 1905 (Loaring 1954: 132-3). In c. 1914, at Margaret River, woylies were evidently common as they were recorded every evening around the camp fire, searching for potato peelings, cabbage leaves, and meat bones (L. Glauert 1936 in *Our Rural Magazine* **11**, 167-170). Woylies were frequent and numerous along the Blackwood River valley, from Darradup to Augusta, in 1919 (Perry 1971: 47). The kangaroo rat was 'fairly numerous' at 'Warren River' in 1925 (*The Western Mail* 16.4.1925: 3). This species was numerous at Cuballing in 1926 (Finlayson 1958: 274).

Consistent with this wide geographical distribution,

many local historians record the 'kangaroo rat' as present in the early years of colonial settlement (Bignell 1997: 140; de Burgh and de Burgh 1981: 65, 75, 76; Facey 1981: 42; Ferrell 1992: 23-4; Flynn 2002: 55-6; Gardner 2000: 62, 115; Haddleton 1952: 97; Leake 1962: 43, 45; Maddock 1987: 20; Schorer 1968: 8, 262; Sewell 1998: 167; Spencer 1966: 75).

As noted above for the 1800s, the term 'kangaroo rat' was still in widespread use in the 1900s in the sense of referring to the woylie, based on clear descriptions provided in *The Western Mail* in 1906 (11.8.1906: 5; 18.8.1906: 4; 25.8.1906: 7), *The West Australian* 30.5.1925: 11 and by Kent (1928), HS Gilbertson in 1930 (comment recorded in WA Museum register for specimen #1302), WE Gilbertson (*The Western Mail* 22.5.1930: 9), Glauert (*The Western Mail* 1.11.1928: 6, 22.11.1928: 48; 31.1.1929: 48), GWS Horsfall, WE Robinson, BS Radford and M. McMahon (*The West Australian* 1.12.1928: 5, 15.12.1928: 5, 12.1.1929: 6, 9.2.1929: 6), and H. Tuckey (WAPD **126**: 1273, 18.10.1950).

Interaction with humans The woylie was frequently recorded as a pest of crops (grain and foliage) and vegetables (cabbages, cauliflowers, potatoes, peas and maize) in gardens from 1842-3 (de Burgh and de Burgh 1981: 65, 75) until the early 20th century (Schorer 1968: 8, 262; *The Eastern Districts Chronicle* 20.4.1878: 3, 6.7.1878: 2; G. Cowcher 1889 in Commission on Agriculture 1891: 183; G. Fee 1891 in Flynn 2002: 55-56; Piggott 2004: 30; Dr Hungerford in *Journal of the Bureau of Agriculture of WA* **2**, 385, 1895; R. Gell ibid. **2**, 387 1895; C. Piesse ibid. **2**, 385, 1895; Shortridge 1910: 822; F. Whitlock in *The Western Mail* 7.4.1927: 30). Vertical timber slab fences were used to exclude woylies from crops (Schorer 1968: 8, Ferrell 1992: 23-24), and animals were poisoned with strychnine baits (*The Western Mail* 11.8.1906: 5, 18.8.1906: 5, 25.8.1906: 7, 1.9.1906: 6, 23.3.1907: 5, 27.7.1907: 7), as well as trapped and snared (Shortridge 1910: 821-2, F. Whitlock in *The Western Mail* 29.4.1926: 32; E. Taylor in *The Western Mail* 6.12.1928: 48, L. Glauert in *The Western Mail* 20.6.1929: 48). In c. 1900-6, 'boodie rats' 'haunted stables and haystacks at night' and attacked the haystacks for the grain in the wheat-ears (Webb 1944: 123). In 1922 woylies were declared as vermin (although erroneously listed as 'boodies') in the *Government Gazette* (11.8.1922: 1455). Glauert noted that 'a continuous war has been waged upon the Bettongias' (*The Westralian Farmers' Gazette* 29.3.1928: 26). The woylie was a 'great pest' at Chorkerup (T. Sims in *The Western Mail* 7.2.1929: 48). An advertisement for 'Boody Rat Proof' wire-netting was published in *The Westralian Farmers' Gazette*, 29.1.1930: 14. When disturbed, the explosive noise made by woylies as they bolted from the nest caused bushmen to name them 'farting rats' (Kent 1928).

According to one colonial account, the rapid increase in woylie numbers in the 1870s was a result of Aborigines no longer needing to catch them for food, the settlers' destruction of the dingo, and widespread persecution by farmers of the wedge-tailed eagle, a predator of lambs (*The Eastern Districts Chronicle* 20.4.1878: 3). One of the reasons advanced by farmers for the woylie being a pest in the 1890s was the widespread shooting and poisoning of the common predator and scavenger species, the wedge-tailed eagle (M. Cronin in *Journal of the Bureau of Agriculture WA* **2**, 385, 1895; M. Cronin ibid.**3**, 812, 1896; E. Lock ibid. **3**, 812, 1896; W. Walter ibid. **3**, 813, 1896). It is relevant to note that 'rat-kangaroos' were also recorded as being predated by raptors at Ooldea, South Australia (Le Soeuf 1921: 140). Wedge-tailed eagles were also recorded in recent times preying upon woylies at Perup (Christensen 1980).

The skins of 'Boodie Rats' were sold between 1927 (for 4-5s/dozen) and 1929 (for 1-2 s/dozen, *The Westralian Farmers' Gazette* (28.7.1927 to 10.10.1929). Because prices for skins of the euro, 'wallaby', 'tamar' and brush wallaby were also listed, I assume that the woylie is the species referred to.

Woylies also scavenged around campsites at night (Shortridge 1910: 822; *The West Australian* 21.1.1928: 6, 9.2.1929: 6; Serventy 1954: 137) and could be enticed with bread (Finlayson 1958: 274). Woylies were stated to be one of the most favoured articles of food among Aborigines (Wagstaffe and Rutherford 1955: 16). They were also eaten by settlers (1829, Berryman 2002: 96, 105; 1843, de Burgh and de Burgh 1981: 76), being considered 'very good for eating' (Moore 1842: 72). I found only two published records of this species being kept as a pet (G. Moore 1832 in Cameron 2006: 113, 116, 119; A. Kent, Wandering Brook in *The Western Mail* 1.11.1928: 6; see also Kent 1928), possibly because animals were already abundant and tame around homesteads.

Woylies appear to have been important dispersers of seed. They carried wheat seed in their cheek pouches into the bush, where it would germinate (*The Western Mail* 1.9.1906: 6; Gardner 2000: 62). Sandalwood seed was eaten (H. Bunbury c. 1836 in Bunbury and Morrell 1930: 47) and could be carried up to 81 m from the fruiting tree (Murphy and Garkaklis 2005).

The woylie was recorded as easily out running a 'fairly good' kangaroo dog where vegetation was thick (H. Tuckey WAPD **126**: 1273, 18.10.1950).

Decline The woylie showed a three phase contraction in geographical range and concomitant reduction in abundance. The first appears to have been caused by disease (Abbott 2006):

- 1880-3 'paddymelon' practically extinct, Ravensthorpe (TG Mitchell 1919 in Fisheries Department file 34/32).
- 1894-9 disappeared from the eastern wheatbelt near Kellerberrin (Leake 1962: 43).
- 1899 'kangaroo-rats' near Harvey and on the coast disappeared. In the 1870s they had been present in 'thousands' (*The West Australian* 10.12.1927: 6).
- c. 1899-1900 disappeared from Talbot and Dale districts (south-west of York and Beverley), apparently associated with a disease that caused possums to 'practically die out' (J. Reid in *The West Australian* 12.4.1930: 4).

- c. 1900 'kangaroo-rats' disappeared from Brookton district, but re-appeared in c. 1925 30 miles west of Brookton [?Westdale], near Brookton, and c. 10 miles east of Brookton (*The West Australian* 24.12.1927:5, 7.1.1928: 8), and near Narrogin in 1927 (*The West Australian* 21.1.1928: 6).
- 1903/4 suddenly disappeared from Woogenilup district after being noted as plentiful in 1902 (WG Pearce 1963 in Fisheries Department file 51/55).
- 1904 extinct near Beverley (CP Wansbrough in Fisheries Department file 34/32).
- 1911 could not be collected near Margaret River, compared to 1908 when it was plentiful (B. Woodward in Select Committee 1911).
- 1912 disappeared from Gracefield near Kojonup and from Deeside near Manjimup (J. Tunney, letter 29.3.1912).
- 1919 none east of Nannup, in comparison with having been very numerous around Bridgetown in the 1870s (FG Allnutt 1919 in Fisheries Department file 34/32).
- 1919 rare at Deepdene near Augusta, having been commoner 8 years earlier (FG Allnutt 1919 in Fisheries Department file 34/32).
- 'many years' before 1928, died out around Bridgetown but still persisting at Perup River (*The West Australian* 2.6.1928: 5).
- c. 1935-40 'disease swept through the native fauna [in Pemberton district], reducing it almost to the point of extinction and virtually wiping out the Woylie in the area, similar to our 1912 experience in the wheatbelt [near Tutanning]' (Gardner 2000: 116).
- 1938-44 A 'catastrophic collapse' of woylie populations was attributed to disease (Perry 1973: 128)
- Before 1950 This species had died out [?near Dwellingup] (H. Tuckey WAPD **126**: 1273, 18.10.1950).

The second phase is the local extinction around farms through poisoning programs in the early pioneering era as selectors struggled to establish a viable farm (1870s-1900s).

The third phase was extinction in most of the lower south-west following the colonization of the fox. By 1973 it persisted only as scattered populations in the eastern jarrah forest/wandoo woodland. In 1967-70 the population at Tutanning nature reserve was studied (Sampson 1971) and it was concluded that the fox was not threatening the woylie population at that time. However, the large home ranges estimated (means of 35 and 23 ha for males and females respectively) indicate, with the benefit of subsequent knowledge, that woylies were already being suppressed by fox predation.

The population at Dryandra Woodland was close to extinction in 1979 as none were spotlighted (AA Burbidge in Department of Conservation and Land Management file 006959F2006 vol. 3). The impact of fox predation was clearly demonstrated at Perup when woylies were translocated successfully from south Perup to fox-baited north Perup in 1977 and to Batalling in 1982 (Leftwich 1983). Between 2000 and 2002 more than 200 woylies were translocated to fox-baited public and private lands in the Avon Valley (Freegard *et al.* 2004). This species has also been translocated to many sites in south-west WA (Mawson 2004; Orell 2004; CALM Annual Report 2006). The populations at Dryandra Woodland, Greater Kingston and Perup have declined in the period 2000-5, for reasons unknown (K. Morris pers. comm.). In my view this is another recurrence of an epizootic which has previously reduced populations of woylies over a wide area (v.s.).

It is not known why woylies persisted into the 1970s only at three localities. Taylor (1990: 37) speculated that the dense ground cover hindered the ability of the fox to capture woylies and that its food (ground fungi) was well supplied in these areas. Yet, the persisting population in Moopinup forest block increased markedly once fox-baiting commenced in 1996 (CALM Annual Report 2003-4: 136).

It does not appear that predation by cats was anything but a minor impact in the decline of the woylie. Indeed, Finlayson (1958: 274-5) described how cats and woylies ignored one another around a homestead. Woylies translocated to Peron Peninsula have persisted in the presence of cats, albeit in low numbers (P. Christensen pers. comm.).

An additional spelling of the Noongar name for this species was found (Abbott 2001a: 462-4): *Woylye* (R. Wellstead, Gnowangerup in *The Western Mail* 14.5.1925: 1).

Potorous platyops moda/broad-faced potoroo

I did not seek information from oldtimers about this species as it has not been collected or seen alive since 1874, and is thus presumed extinct. The broad-faced potoroo (Fig. 13) was first collected in 1842 near Lake Walymouring by Gilbert, who stated that it occurred in thickets surrounding this salt lake (Gilbert nd1). Aborigines at King George Sound had told Gilbert that the one specimen collected by them was caught in sandy scrub and that this species made a nest similar to the woylie (Gilbert nd3; Gould 1863).

A specimen was collected by J. Drummond in the 1840s (Letter, 22.7.1844). The next collections were by G. Masters in 1866 (one specimen) and in 1868-9 (1 skin, 2 adults in spirit) (Krefft 1867: 6; Krefft 1869: 7). No locality was specified but I assume that they came from Mongup. W. Webb collected five specimens from King George Sound district in 1874. These are held in the Macleay Museum, Sydney.

The Noongar name of this species (attested by Gilbert) was also provided by Shortridge (1910: 826) and EA Hassell, the Colonial Secretary of WA, and J. Drummond (Abbott 2001a: 464). The provenance of these records is respectively: coastal scrub to the east of Albany; ?Jerramungup; Toodyay sub-district; and

?Toodyay district. These localities are too imprecise to plot in Fig. 13.

Apart from Gilbert's brief notes, neither Masters nor Webb left any account of the species. Shortridge's (1910) notes are evidently based on information supplied by Aborigines, *viz.* it was gregarious, similar to the quokka in its habits, and was formerly plentiful but was extinct by 1905.

Skeletal remains of this species have been found at Hunter River near Bremer Bay, but mixed with bones of sheep, rabbits and foxes (Butler and Merrilees 1971).

Synthesizing this scant information, it appears that this potoroo species occurred in colonial times from near Goomalling south-east to Borden and Bremer Bay throughout what later became the wheatbelt. I suspect that it declined in the 1890s when an epizootic swept through its geographical range (Abbott 2006). I am not convinced that feral cats and bushfires caused its extinction, as proposed by Shortridge (1910).

Potorous gilbertii ngilkat/Gilbert's potoroo

Only one oldtimer knew of Gilbert's potoroo (Fig. 13). V. Roberts reported that his elder brothers had spoken of the 'nilgyte' being present in coastal vegetation at Scott River in the 1890s, but he had not personally seen it. This species had disappeared well before the fox colonized.

This species inhabited, along with the quokka, dense thickets of spearwood *(?Agonis juniperina*) and rank vegetation bordering swamps or running streams. Aborigines often killed 'immense numbers' by beating the bushes, yelling and driving the animals to previously trampled areas where waiting Aborigines speared them (Gilbert nd2; Gould 1863). Gilbert apparently met with this species only near Albany, where it was collected in June 1843 (Fisher 1992: 338-9). It may have occurred in Margaret River district in 1845, as an Aboriginal born there at that time was named *Ngilgie* after a swamp wallaby (Tilbrook 1983: 229). This name is very similar to the Noongar name of Gilbert's potoroo (Abbott 2001: 464).

James Drummond noted that his son had '12 or 14' specimens ready to send to John Gould, with no information disclosed about the place of collection (Letter 22.7.1844).

Shortridge (1910: 826) thought that the *wurrark,* said by Aborigines to occur around Margaret River in marshy country, was probably this species. It was stated to have been numerous in the past. This name, however, was tentatively attributed to *Lagostrophus fasciatus* by Abbott (2001: 464-5). Bussell had noted that the *wurark* was a very scarce, small brown wallaby, a description that does not fit Gilbert's potoroo.

This species was also collected by Masters in 1866 (?5 or 8 specimens) and 1868-9 (2 specimens), presumably from Albany district (Krefft 1867: 8; Krefft 1869: 7), and by Webb in 1874 from King George Sound. This last specimen was purchased for 5s by Macleay in 1875. In the catalogue of the Macleay Museum, Sydney, this specimen is referred to as 'Nel[indecipherable]ite'.

Gilbert's pororoo was not obtained by Shortridge in 1904-7 or by Tunney in the 1890s and 1900s in their extensive collecting on the south coast near Albany. It is unlikely that these naturalists collected around Mt Gardner 30 km east of Albany, where a small population was discovered in 1994 (Sinclair *et al.* 1996).

Abbott (2006) hypothesized that the decline of this once numerous species between 1875 and 1904 was caused by an epizootic disease.

Recent information about the only known surviving population is available in Friend (2003). Proposals to recover the species are detailed in Courtenay and Friend (2004). Attempts to translocate animals to Bald Island commenced in 2005 (*Albany Advertiser* 19.4.2005: 4; 11.8.2005: 2).

Lagorchestes hirsutus woorap/wurrup/rufous hare-wallaby

As this species had been last collected in south-west WA in 1896, I did not seek information about it from oldtimers.

The wurrup (Fig. 13) was first collected in 1842 at Walyemara (Gilbert nd2; Gould 1863: 262). This is modern day Lake Walymouring near Goomalling. Its habitat was stated to be the low thick scrub c. 2 feet tall (thickets) surrounding salt lakes. It fed in open country adjoining these thickets. Gilbert obtained only two specimens and in one of his letters stated that the species is 'doubtless a great rarity' and mentions that L. Burges (a settler interested in natural history) had seen only one (Wagstaffe and Rutherford 1954: 492). This species (as *Worrup* or Whistler) was noted as having once occurred in Cunderdin district (*The Western Mail* 4.10.1928: 6).

The species was last collected in south-west WA by Tunney in 1896 at Hastings, near Wandering (WA Museum Register). Wurrup were said to possibly still occur in 1906 very sparingly, although it had recently been very plentiful, on sandplains to the east of Beverley and York (Shortridge 1910: 819). They were stated to have been present but 'never a lot about' c. 10 km west of Beverley in the 1910s (Broun 1995: 12). This species may have persisted very locally until c. 1931, as there is an eyewitness record from c. 50 miles south-east of Perth in 1931 (ALH Ainsworth 1959 in Department of Conservation and Land Management file 014800F3803).

The failure of Tunney, Haddleton, Masters and Hassell to mention this species may be taken to indicate that it did not range as far south as Kojonup, Katanning, Mongup and Jerramungup, although Abbott (2001: 464-5) suggested that it possibly occurred between Capel and Margaret River.

Once disturbed the wurrup repeatedly uttered a distinct whistle ('ting ting', Gilbert nd2; Broun 1995: 12; Leake 1962: 47; ALH Ainsworth 1959 in Department of Conservation and Land Management file 014800F3803). This gave rise to its common name in colonial times of 'whistler' (Shortridge 1910). When disturbed from its seat, this species could easily outpace

hunters with their kangaroo dogs by suddenly jumping sideways (Leake 1962; Broun 1995).

The factors involved in the extinction of this species on mainland south-west WA remain unclear, as it appears to have persisted into the period when the fox established. Abbott (2006) speculated that it may have been one of a suite of species impacted on by a disease epizootic in the 1890s.

In 1998, 19 animals from the Tanami Desert in the Northern Territory (where the species is known as *mala*) were placed in an enclosure at Dryandra Woodland. Although breeding occurred, some animals were taken by wedge-tailed eagles (Friend and Beecham 2004). It is planned to translocate this species to Tutanning and Dongolocking Nature Reserves (Department of Environment and Conservation 2006).

Lagostrophus fasciatus maning/marnine/ banded hare-wallaby

No information was sought from oldtimers about this species, which was last collected on mainland south-west WA in 1906; no oldtimer volunteered any information about it. The marnine (Fig. 13) was first collected by Preiss at either Wongan Hills or York (Fisher 1992: 341), in 1842 by Gilbert at Lake Walymouring (Fisher 1992), in 1842 by Drummond and Gilbert c. 50 miles north of Toodyay (J. Drummond, letter 7.9.1842) and then by Drummond in 1844 c. 75 miles north of Moore River (J. Drummond, letter 3.10.1844). Although abundant on the large islands in Shark Bay in 1801, none were found on the adjacent mainland (Cornell 2006: 95).

A small purse-like net, made by Aborigines to catch small animals 'about the size of a rabbit', found north-east of York and not known to any Aborigines 'in any of the located parts' of WA (GF Moore in *Perth Gazette* 14.3.1840), may relate to this species.

They lived in thickets with the more abundant *Macropus eugenii* and 'many miles of these thickets' were burnt at intervals of c. 3 years by the Aborigines in order to procure them for food. It was noted that treading down an open space by Aborigines as at Albany was not practical (Gilbert nd1, nd2). Gilbert obtained only one specimen. He was apparently unsuccessful in 1843, as he again emphasized its habitat of dense thick scrub on flats and edges of swamps 'so thick that it is almost impossible for a man to force his way through; its runs being under this, the animal escapes even the quick eye of a native. The only possible means of obtaining it is by having a number of natives to clear the spot and two or three with guns and dogs to watch for it' (Wagstaffe and Rutherford 1955: 9). Additional evidence that this species was not rare is indicated by a settler near Bolgart shooting for skins in 1849-51 and making a tippet of 'Marnine' skins (Buchanan 2003: 148, 167, 230).

Later observers also stressed the association of this species with thick scrub (Shortridge 1910: 818; Leake 1962: 47).

This species occurred farther south than the similar *Lagorchestes hirsutus*, as it was collected at Woyaline in 1906 (Shortridge 1910: 818), presumably at Mongup by Masters in the 1860s (Krefft 1867: 6; Krefft 1869: 7), and its Noongar name was recorded near Ravensthorpe in c. 1883 (TG Mitchell 1919 in Fisheries Department file 34/32), and near Nyabing, Jerramungup and Esperance (Abbott 2001a: 476). It does not appear to have occurred near Katanning or Kojonup, as neither Haddleton (1952) nor Tunney's letters held in the WA Museum mention it.

Presumably this species was still extant in 1886 inland from, or east of, Albany, as W. Webb of Albany included four specimens in his cabinet exhibited in London (Colonial and London Exhibition 1886: 58). Aborigines stated that this species still occurred in 1906 east of Wagin and at Pallinup River (Shortridge in Short 2004). It still occurred near Pingelly in 1907, where it lived on newly germinated wheat and was controlled by wire netting, snaring, or shooting (*The Western Mail* 27.7.1907: 7). The attribution of 'Perth' to this species (see Helgen and Flannery 2003: 201-2) is incorrect and has probably arisen because 'Swan River' on a specimen label, meaning 'Swan River Colony' i.e. WA, was misinterpreted to signify the capital city of WA.

The pattern, timing, and causes of the decline of this species are obscure. It was extinct in the eastern wheatbelt by 1894-9 and was not recorded anywhere in south-west WA after 1906. Abbott (2006) speculated that this species disappeared after an epizootic passed through south-west WA in the period 1880-1910.

In 1998 and 1999 a total of 18 animals (procured on Dorre Island) were released into an enclosure at Dryandra Woodland. This population slowly increased in numbers but predation, presumably by raptors, was significant (Beecham and Friend 2004). It is planned to translocate this species to Tutanning Nature Reserve and Stirling Range National Park, subject to effective control of exotic predators (Department of Environment and Conservation 2006).

I discovered five references to the Aboriginal name additional to those names listed in Abbott (2001: 476). These are: *Murnin* (one specimen collected in 1874 by W. Webb of King George Sound and purchased by the Macleay Museum, Sydney for 5s), *Morning* (very numerous prior to 1880 and presumably extinct by 1883) from Ravensthorpe (TG Mitchell 1919 in Fisheries Department file 34/32), *murine* and *murang* from Pingelly (*The Western Mail* 27.7.1907: 7), and *marne* (apparently from Cunderdin district, L. Glauert in *The Western Mail* 4.10.1928: 6).

Macropus eugenii dama/bonin/tammar

Oldtimer information The tammar[5] (Fig. 19) was well known to many of the oldtimers interviewed, although there was some confusion with the quokka. Those records were discarded.

[5] Although invariably known as 'tammar wallaby' in current literature, the term 'wallaby' is superfluous. It seems to have been used to avoid confusion with the plant species tamma, *Allocasuarina campestris*. 'Tammar' should of course be pronounced as *tâmā*.

This species was shot for sport and food, being considered 'good eating' by A. Marshall, D. Moir, D. O'Halloran and K. Smith (pers. comm.). It was also snared for skins (C. Mottram pers. comm.) and hunted with kangaroo dogs (A. Batt pers. comm.). Tammars were a pest of crops, scratching up seedlings (D. Bradford, A. Marshall pers. comm.), and thus 'tammar drives' were frequent (J. Loney pers. comm.).

In the wheatbelt, destruction of thickets by clearing burns and from the 1950s by bulldozers contributed to its decline (N. Candy, E. Fletcher pers. comm.). In the lower south-west, it disappeared before the arrival of the fox (V. Roberts, E. West, W. Young pers. comm.).

The testimony of oldtimers indicates that tammar populations in south-west WA became extinct locally over an extended period: < 1920, 1 record; < 1930, 4 records; < 1940, 11 records; < 1950, 6 records; < 1960, 2 records; < 1970, 4 records; < 1980, 4 records; and < 1990, 4 records. This protracted process is consistent with a range of threatening factors (disease, shooting, habitat destruction, fox predation).

Distribution and abundance Tammars occurred throughout almost the entire south-west of WA, except for the Swan Coastal Plain and the karri forest (Fig. 19), as well as on several islands (Abbott and Burbidge 1995). In the early days of settlement they were abundant (Gilbert nd1; Gould 1863; H. Lefroy 1865 in Exploration Diaries **5**: 242-3; Shortridge 1910: 812-3; Podmore 1909: 21; J. Drummond in Select Committee1911: 7; TG Mitchell 1919 in Fisheries Department file 34/32; WE Edwards

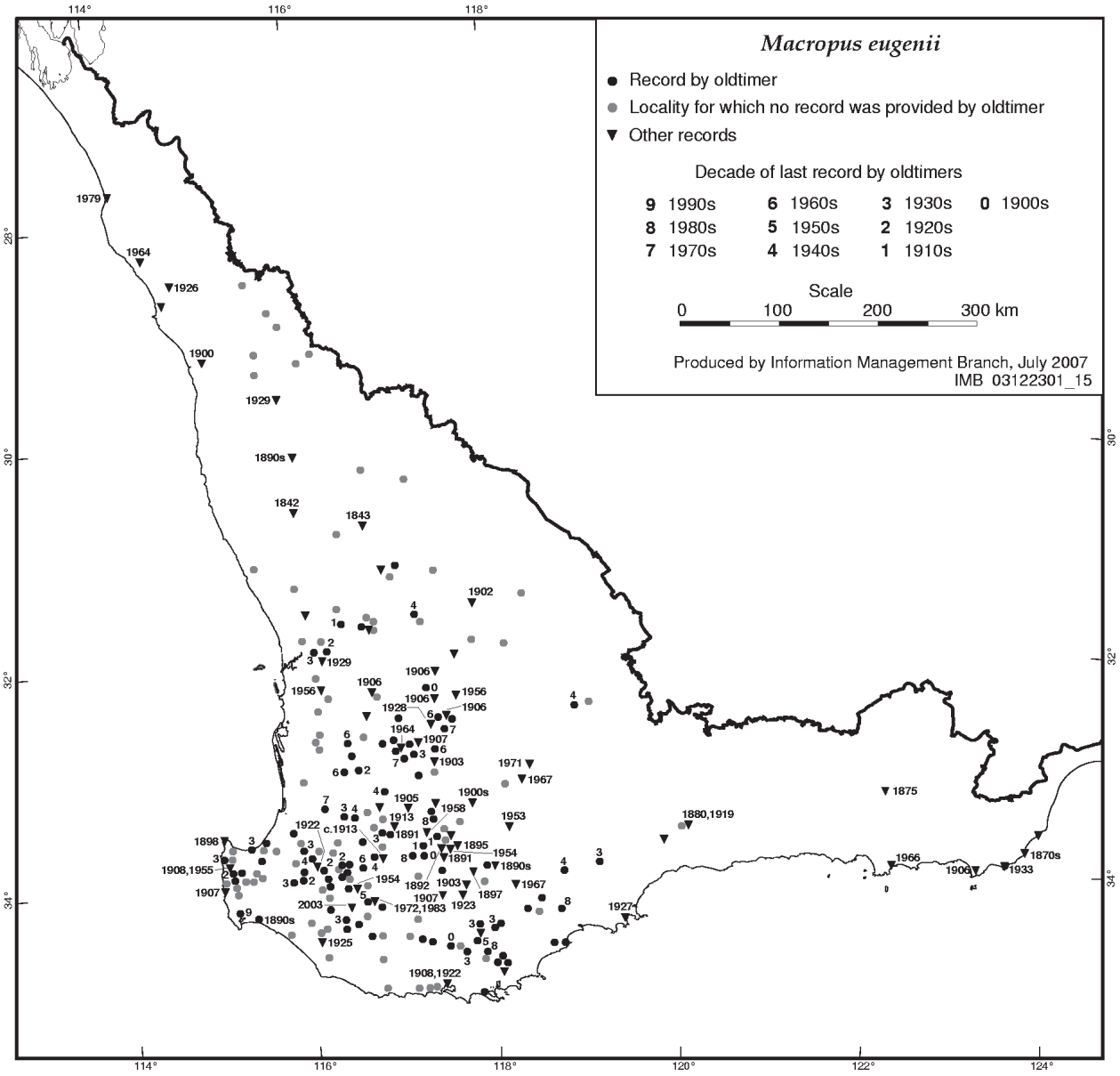

Fig. 19 Distribution of Macropus eugenii. *Additional records not already cited in text: Bignell 1997; Drummond letter 7.9.1842;* Fauna Bulletin*; Fisher 1992;* Fisheries Department Bulletin*; Fisheries Department file 64/69; Hill 1903; Kitchener* et al. *1975; Kitchener and Vicker 1981; McKenzie* et al. *2000; WG Pearce 1963 in Fisheries Department file 51/55; Price 1896; Spencer 1966;* The Western Mail *6.12.1923: 4, 16.4.1925: 3; Whittem 2000.*

in *The Western Mail* 4.7.1929: 48; Stevens 1933: 30; Haddleton 1952: 97; Aitken 1954: 139; Pederick 1979: 5; Bignell 1981: 112; Marshall 1993: 90; Anon. 1999: 375; Gardner 2000: 62, 65; de Burgh 2006: 5).

According to H. Lefroy (Exploration Diaries **5**: 242, 1865), its habitat comprised so-called 'Tamar' thickets, named after this species. Its dependence on dense thickets was noted also by: Gilbert (nd1 and in Wagstaffe and Rutherford 1955: 15-16); Thomas (1906: 768); WA Year Book (1906: 568); *The Western Mail* 22.9.1907: 9, 15.2.1908: 18, 7.7.1921: 4; L. Glauert in *The Westralian Farmers' Gazette* 27.10.1927: 27; Webb (1944: 123); Haddleton (1952: 97); Aitken (1954: 139); Leake (1962: 39); Bignell (1971: 10); Eaton (1979: 158); Kelsall (1965); Christensen *et al.* (1985: 18); Anon. (1995: 22); Anon. (1999: 347); and Gardner (2000: 65). Several observers noted its pads running from these thickets to its feeding grounds, like footpaths (Gilbert nd1; Stevens 1933: 30; Leake 1962: 39). These thickets were described as consisting of clusters of sheoak saplings never more than 10 or 12 feet high and packed closely together (Webb 1944: 123) or 20-30 feet tall (Kelsall 1965: 51). Christensen *et al.* (1985) stated that the feeding grounds comprise grass in or near thickets.

Interactions with humans The tammar was recorded as a pest of crops as early as the 1860s (Haddleton 1952: 9), eating wheat (Lindley-Cowen 1897: 144; *The Western Mail* 13.7.1907: 6, 19.12.1908: 6, 4.7.1929: 48; Gardner 2000: 62), damaging fruit trees (Anon. 1896), and ring-barking young pine trees (Forests Department 1929: 7). Tammars were said not to take strychnine baits (*The Western Mail* 27.7.1907: 7). Fences of vertical timber slabs were used by pioneers to keep tammars out of wheat crops (Ferrell 1992: 23-4), as well as wire netting, snaring, and shooting (*The Western Mail* 27.7.1907: 7).

In 1896 it was noted that the tammar was not protected under the Game Act of 1892 and may be 'destroyed whenever and wherever found' (Anon. 1896: 685). This species was later declared to be vermin in the Balingup Road Board district (*Government Gazette* 6.1.1922: 2), the Denmark vermin board district (*Government Gazette* 11.8.1922: 1455), and the Upper Chapman vermin district (*Government Gazette* 13.8.1926: 1581). However, it appears highly likely that the references to tammar in Balingup and Denmark districts actually relate to the quokka (see below).

Tammars were eaten by Aborigines and settlers. Aborigines could not use their dingoes to hunt them in mallee as it was too thick; they therefore hunted them as a group (H. Lefroy in Exploration Diaries **5**: 242-3, 1865). Women and children rushed upon the thicket, resulting in the animals fleeing along paths where they were intercepted by the men (Bignell 1971: 10). Pitfalls were also dug on their trails, brush fences were built at right angles to their trails, and vegetation was set alight in order to facilitate hunting (Leake 1962: 39). Large triangular fences were in use near Geraldton (O'Connor 2001: 238). Wedge-tailed eagles also preyed upon tammars (Christensen 1980).

European visitors regarded tammar meat to be very good food, eating like young hares (1844, Bradshaw 1857: 69; 1830, G. Bayley in Statham and Erickson 1998: 138 on Garden Island). References to their consumption by settlers on mainland south-west WA may be found in *The Western Mail* (15.2.1908: 18 'excellently edible', 7.7.1921: 4), Webb (1944: 123), Pustkuchen (1981: 31), Parnell (1982: 64, 79), Bird (1986: 140), Marshall (1993: 69) and Anon. (1999: 347). 'When we first came into "the bush" years ago, there was a large 'tamma thicket' just outside our boundary, and for a time we lived principally on' tammars (near Kojonup, *The Western Mail* 7.7.1921: 4). Marshall (1993) noted that tammar meat was lean. The method of obtaining tammars was described as involving a man with a gun being stationed in the middle of a thicket while another man beat the hounds and drove the animals towards the centre (Webb 1944: 123).

The pelt of the tammar was not without commercial value (Fig. 20), with the earliest and last explicit trade references found (in terms of price per dozen skins) being in September 1923 and September 1947. There is a reference to 'Tama' skins in *Producers' Review* for 1909-10, but the prices are expressed as d/lb. The royalty on tammar skins was ½ d. per skin in 1915, 1920 and 1922 (WAPD **50**: 770, 20.1.1915; *Government Gazette* 23.4.1920: 730; 6.10.1922: 1885). Interestingly, the accountant of one of the large skin dealers stated that there was no business in tammar skins (W. Loutit in Select Committee 1911: 19). Under the Fauna Conservation Act, which came into force in July 1952, tammar were declared to be a protected species and their skins could no longer be sold legally. I have been unable to locate any information on the number of skins that were handled each year by dealers.

Nonetheless, shooting for sport or for the fur trade was a popular activity, as it is noted frequently in historical accounts from 1878 (*The Eastern Districts Chronicle*

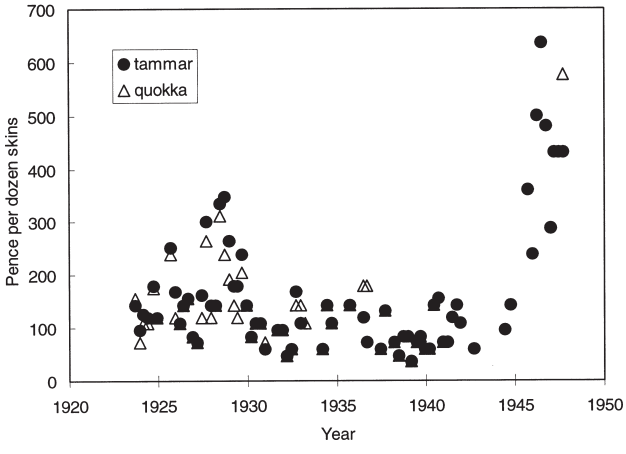

Fig. 20 Prices paid for skins of Macropus eugenii *and* Setonix brachyurus. *Source:* Elder's Weekly *for March, June, September and December, supplemented by* The Westralian Farmers' Gazette *1938-40. Maximum price graphed. Note that in the trade magazines the term quokka is not used: I have assumed after eliminating euro, tammar, and brush wallaby, which are named, that 'wallaby' applies to the quokka.*

27.7.1878: 2; *Eastern Districts Chronicle* 29.9.1894: 2; Podmore 1909: 41; Leake 1962: 42-3; Bignell 1971: 156; Bignell 1977: 215, 253; Bignell 1981: 112; Parnell 1982: 84; Stokes 1986: 31; Dimer 1989: 256; Ferrell 1992: 4; Bird 1990: 259; Gardner 2000: 65). Bird (1986: 188) included a photograph showing the results of a tammar shoot. Tammars in Tutanning Nature Reserve were considered to be 'very alert' and very difficult to capture relative to populations on islands, and were quick to flee into cover at night and difficult to see during the day (Kelsall 1965: 25, 92).

Decline The factors identified in published accounts as causing the decline of the tammar are disease, clearing of thickets for cultivation, and the arrival of the fox.

- Disease is implicated by their early disappearance in some districts before the other two factors came into operation (early 1880s, north-east of Esperance, *The West Australian* 25.12.1909: 5; 1883, Ravensthorpe, TG Mitchell 1919 in Fisheries Department file 34/32; 1890s, Coorow, *The West Australian* 14.11.1925: 15; c. 1902, Kellerberrin, Leake 1962: 43; 1902-3, Margaret River, W. Loaring quoted in White 1952; 1928, Warren River, Muir 2006: 17; lower Blackwood Valley, between Darradup and Augusta, Perry 1971: 47; see also Abbott 2006). S. Phillips (WAPD **18**: 1676, 14.11.1900) noted that 'During the last five years…tamars…had died out [in Irwin district] from some unknown disease'. A 'catastrophic collapse' of tammar populations in jarrah forest in the period 1938-44 was attributed to disease (Perry 1973: 128).
- Clearing of vegetation. In the period 1950-70 large areas of south-west WA were bulldozed of their original vegetation, and the tammar persisted only in nature reserves, national parks, State forests, and some remnants on private property. Tammars were found on only one of 23 wheatbelt reserves surveyed in the 1970s (Kitchener and Chapman 1976: 61-7). The largest remaining populations before the Western Shield program was initiated in 1996 were at Dryandra and Perup. WA Year Book (1906: 568), Shortridge (1910: 812-3), J. Drummond (in Select Committee 1911: 7), WE Kemp (1919 in Fisheries Department file 34/32), Eaton (1979: 158) and Bird (1986: 200) provide further information.
- Fox. By about 1960 the tammar seemed very close to extinction on mainland south-west WA (Kelsall 1965: 1). Evidence from adaptive management of surviving populations at Dryandra and Perup, using broadscale use of poison baits to control foxes, indicated that tammar populations recovered rapidly. In 1993 they began to damage oat and lupin crops along the Perup River near Balban and Yackelup forest blocks (*CALM News* September 1993). This species has also become a pest of pasture and crops since 1995 on farmland adjoining Tutanning Nature Reserve (Department of Conservation and Land Management file 01550953101). Since the introduction of the Western Shield program in 1996, > 400 tammars have been translocated from Tutanning to parts of south-west WA where they would have once occurred e.g. Nambung National Park in 2004-5. More than 250 tammars were relocated to the Avon Valley in 2001-4 (Freegard *et al.* 2004). Other translocation sites are listed by Mawson (2004).

The tammar was removed from the third schedule of the Vermin Act (1918) in 1950 (Government Gazetted 27.10.1950: 2422) and from the State's threatened species list in 1998 (Start *et al.* 1998).

As with several of the oldtimers interviewed, I found published instances of apparent confusion between the tammar and quokka. A specimen of a 'Tammar' forwarded from Capel River to the WA Museum was actually a quokka (L. Glauert in *Our Rural Magazine* **3**, 354, 1928). See also L. Glauert in *The Western Mail* 21.3.1929: 48; *Fauna Bulletin* 2(1) 3/1968; Snell (1986: 35), and Gabbedy (1988: vol. 2 186). It is considered likely that the declaration of tammars as vermin in Balingup and Denmark districts (see above) actually refers to the quokka. 'W.C.G.' (*The Western Mail* 2.12.1926: 3) noted: 'In the South-West the name "tamma" is often applied to another little marsupial which lives in the swamps and is known by some as the quagga'.

An albino tammar was captured on Garden Island in 1895 (*The West Australian* 20.6.1895: 4).

Macropus fuliginosus yongka/western grey kangaroo

Oldtimer information Although still widely distributed in south-west WA, the western grey kangaroo was reported by oldtimers to be absent in the 1990s from numerous localities (Fig. 21). Opinion was divided as to whether this species had changed in abundance since the 1920s/30s. The majority of interviewees stated that it was more common in the 1990s because of extensive clover pastures, the eradication of the dingo, and the fact that few kangaroos are now shot for food or skins. One oldtimer suggested that the density of kangaroos in the 1920s/30s in virgin bush was only 'one animal per square mile' (J. Enright pers. comm.) and that it was necessary to hunt for hours or even days to obtain one (H. Mewett pers. comm.). Estimates of their current (high) abundance were of mobs of 30-40, 50-60, 60-70, and 80-100, except where landscapes had been more or less cleared entirely of their original vegetation. Kangaroos now obtain their shelter in native vegetation but feed and drink in pastures (A. Muir pers. comm.).

Kangaroos were noted as a pest of wheat crops when in ear, as they trampled the crop (A. Marshall pers. comm.). This was especially the case in the early days when areas cropped were small (D. O'Halloran pers. comm.). Recently burnt country was recorded as being attractive to kangaroos.

One oldtimer recalled that this species did not seem to have been preyed on by foxes (K. Smith pers. comm.), as carcasses of young animals were not found around fox dens.

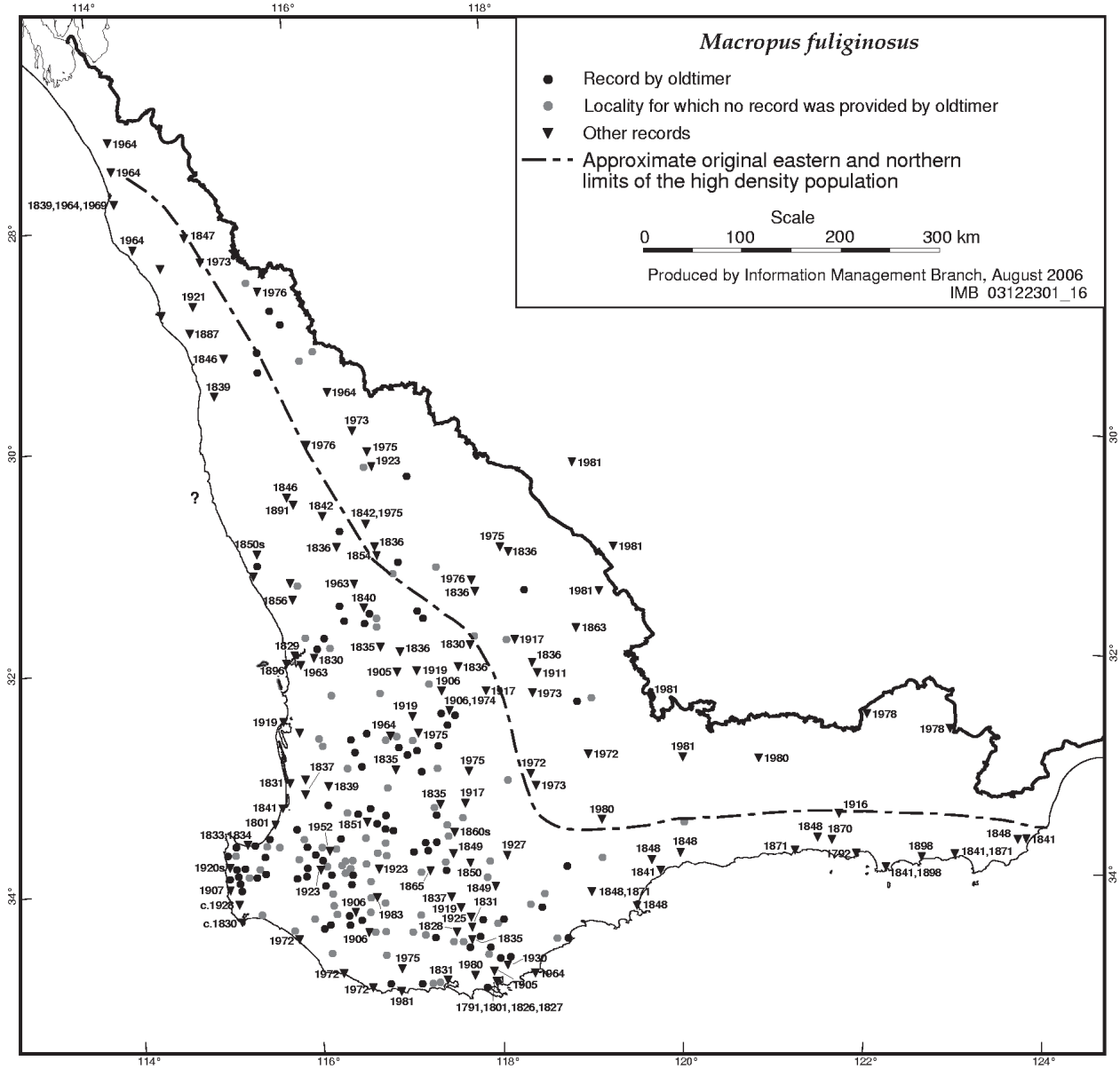

Fig. 21 Distribution of Macropus fuliginosus. *Additional records not already cited in text: Bannister 1969a, 1969b; Bolton* et al. *1991; Department of Conservation and Land Management files 014550F3530, 014548F3530; Chapman and Kitchener 1978, 1979a, 1979b, 1981a, 1981b; Crook and Burbidge 1982; W. Preston 1831 and A. Collie 1831 in Shoobert 2005: 247; Dell and How 1985; Drummond letter 25.7.1839; Duyker and Duyker 2001;* Esperance Chronicle and Dundas and Norseman Advertiser *12.2.1898; Eyre 1845; Fisher 1992; Forrest 1872; Forrest 1875; Gregory and Gregory 1884; Hasluck 1955; A. Hillman 1837 in Exploration Diaries vol. 3; How* et al. *1988; Kitchener and Chapman 1976, 1977, 1978, 1979; McKenzie and Kitchener 1979; McKenzie and Rolfe 1995; McKenzie and Youngson 1975; McKenzie* et al. *1993; Morris and Dell 1977; Morris and Kitchener 1979; J. Roe 1847 in Exploration Diaries 4: 23; Roots 2003; Rosenman 1987; Royal Commission 1917a, 1917b; F. Ludlow 1834 and A. Hillman 1835 in Shoobert 2005: 347, 392, 443; Vallance* et al. *2001; Wakefield 1828; W. and F. Whitfield in* The West Australian *1.10.1891: 2.*

Another oldtimer described how a pair of wedge-tailed eagles jointly harrassed a female kangaroo and killed it 'in a few minutes'.

Distribution and abundance As is to be expected for the largest herbivore present in south-west WA, the information found in historical literature is voluminous. This species occurs throughout south-west WA (Fig. 21; Aboriginal names cited in Abbott 2001a: 466-470).

First visitors in the period 1791-1826 rarely saw kangaroos on the coast but they either found fresh faecal pellets to be plentiful (Cornell 1974: 168; King 1827 vol. 1: 18; Labillardière 1800: 270; Lamb 1984: 352; Lockyer 1827: 464) or interpreted the behaviour of the few individuals seen as shy (Flinders 1814 vol. 1: 64). However, in the lower south-west explorers and other travellers found this species very abundant everywhere in the 1830s/40s/

50s (Prince 1984; Buchanan 2003; Mann 2006: 204), consistent with landscapes that were then frequently burnt by Aborigines. Kangaroos favour feeding in areas burnt in the previous year (Leake 1962: 41; Christensen and Kimber 1975: 99). Quantitative estimates of mob size are variable, however: 10-12 in 1830 (Berryman 2002: 154); c. 200 in 1835 (MacDermott 1874: 39); c. 100 in 1840 north-east of Albany (Stokes 1846 vol. 2: 231); 2-5, 30-50, or 500 in the early 1840s (Wagstaffe and Rutherford 1955: 12-14); 'hundreds' south of Kojonup in 1865 (Stow 1981: 88); and c. 4 000 in the 1860s (Brockman 1987: 14). Kangaroos were most abundant in parts of the landscape with grass-dominated ground vegetation. For example, at Augusta the kangaroo was 'a rarity' in 1831 in contrast to Vasse (Shann 1926: 61, 74, 93, 97, 158). Kangaroos were evidently abundant at Mt Lesueur and Dandaragan (*The Inquirer* 26.12.1849, 13.11.1850).

Kangaroos occurred at very low densities east of a line joining (approximately) Botherling- Mt Stirling-Althorpe Peak-Mt Bebb-east of Dumbleyung-Nyabing/Pingrup-15 miles north of Point Malcolm (Aitken 1954: 138; Austin 1855: 8; R. Dale 1830 in Shoobert 2005: 182; C. Dempster 1861 in Exploration Diaries **5**: 41; Hunt 1864; H. Landor and H. Lefroy 1843 in Exploration Diaries **3**: 735; Leake 1962: 17, 19; H. Lefroy 1863 in Exploration Diaries **5**: 230, 250; Roe 1836: 8, 12, 17, 49, 57; Roe 1852: 21). This is attributable to the absence of surface water (H. Lefroy 1863 in Exploration Diaries **5**: 317) and the low frequency of fire (Abbott 2003). The line dividing high from low density populations has been extended as far north as to the east of Port Gregory on the basis of slender evidence (J. Roe 1847 in Exploration Diaries **4**: 23), which is contradicted by information for Champion Bay district (B. Bynoe in Stokes 1846 vol. 2: 390).

The western grey kangaroo is one of the few mammal species that has persisted throughout its geographical range in south-west WA, being locally extinct only in and near towns and cities and in districts almost entirely cleared of native vegetation (Arnold 1990), and reduced in numbers in parts of the forest because fires are too infrequent (Christensen and Kimber 1975; Ward *et al.* 2001). Initially they greatly increased in numbers in agricultural areas because of the provision of dams (earth tanks), clover pastures, and extensive cereal crops, and the near extinction of the dingo. The decline of the wedge-tailed eagle in farming areas, an important predator (Briggs 1917: 102; Carter 1923: 138; *The Western Mail* 27.2.1930: 48), may also have contributed. The rapid decline in Aboriginal populations following contact with European diseases in the 1840s-1880s should also have resulted in local increase in kangaroo populations (near Geraldton, J. Drew WAPD **32**: 1675, 13.12.1907; cf. Kerr 1872: 172). Once clearing became excessive and remnant patches of native vegetation consequently became smaller, as in the wheatbelt, the western grey kangaroo declined sharply in abundance (Arnold 1990).

The detrimental impact of drought on abundance was confirmed for a population studied for six years at Tutanning Nature Reserve (Arnold and Steven 1988). High intensity wildfire kills and injures many animals and temporarily removes nearly all edible vegetation (S. Evans in Holland 1982: 8).

This species was recorded in forest on all surveys and varied little in abundance during 1972-81 at Perup and near Lake Muir (Christensen *et al.* 1985: 17). Kangaroos were found on 16 of the 23 wheatbelt reserves studied in the 1970s by Kitchener *et al.* (1980: 205). Large numbers were reported in paddocks in the wheatbelt in 1972 (McKenzie *et al.* 1973: 7) and 1980 (Crook and Burbidge 1982: 21). Aerial surveys of much of south-west WA in 1981 found that density averaged 0.2 kangaroos/ 100 ha over a large portion of the wheatbelt, increasing to 0.8 animals/ 100 ha nearer the coast (Short *et al.* 1983). However, density in remnant vegetation near Kellerberrin was one kangaroo per 5-20 ha (Arnold *et al.* 1991). Relative abundance (density of faecal pellets) increased as the proportion of native vegetation in the landscape increased (Arnold *et al.* 1995). The home range is probably fixed and of 30-100 ha (Arnold and Steven 1988). In 2004, nearly half of the population of western grey kangaroo in WA occurred in the south-west forests (CALM Annual Report 2005: 176).

At Durokoppin Nature Reserve, this species preferred kwongan (heathland) and open woodland without a herbaceous ground cover (Arnold *et al.* 1994).

Human food The kangaroo was important to Aborigines and European settlers alike. Kangaroos were 'highly esteemed' by Aborigines as food (Nind 1831: 30). The methods that they used to hunt or trap kangaroos have been summarized from historical accounts by Meagher (1974: 15-16), to which may be added descriptions by E. Pearce c. 1830 (in Jennings 1983: 68), A. Collie 1832 in Shoobert 2005: 315, J. Molloy 1833 in Shoobert 2005: 327, W. Shenton and R. Wells 1837 in Exploration Diaries **3**: 614, J. Drummond (*The Inquirer* 15.2.1843), R. Salvado (in Stormon 1977: 152-3), Perry (1971: 46), and G. Giblett (in Muir 2006: 90). Aborigines lived seasonally on kangaroo (*The Perth Gazette* 5.7.1834: 315; Irwin 1835: 22) and occasionally hunted them with dingoes (Irwin 1835: 22).

Europeans recognized as early as September 1829 that kangaroos were 'excellent eating' (J. Morgan in Berryman 2002: 78). This meat was highly sought after by settlers (Carter nd: 53-57), who were reluctant to kill their small numbers of stock for food. However, swift and powerful hunting dogs were needed to obtain kangaroos (J. Henty 1829 in Bassett 1954: 121; G. Moore 1831-4 in Cameron 2006: 14, 34, 83, 158, 356; WN Clark in *The Inquirer* 20.10.1841). In 1830 it was noted that kangaroos 'have been procured only by means of a particular breed of dog obtained from New South Wales, their haunts being too close for shooting' (Berryman 2002: 154). Another source from 1830 simply stated that they were generally caught by dogs (Devenish 1996: 83). Shortages of meat in 1834 intensified hunting pressure, with several thousand pounds weight being procured (Cameron 2006: 356).

The largest specimens reached body weights of 120-160 lb, according to R. Salvado (in Stormon 1977: 192), H. Trigg (in Devenish 1996: 91), W. Tanner (in Statham

1981: 20), J. Wollaston (in Bolton *et al.* 1991: 276), and J. Gilbert (in Wagstaffe and Rutherford 1955: 12-14). One exceptionally large male weighed 180 lb (Gilbert nd1). When properly prepared the kangaroo was considered to be excellent food, 'resembling in flavor the English hare' (G. Dashwood 1832 in *The Sunday Times* 26.9.1926: 10), 'as good as beef' (L. Bussell 1834 in Shann 1926: 74), and tasting like beef without fat (JW Hardey in Shoobert 2005: 186). Only the hindquarters and tail were eaten, with the forequarters being given to dogs and Aborigines (J. Wollaston 1843 in Bolton *et al.* 1992: 149; 1844-50, Bradshaw 1857: 82). Kangaroos were no longer to be found close to Fremantle by February 1830 (Roberts 1834: 100) and were depleted at Upper Swan by January 1832 (Carter nd: 54). Aborigines at Perth complained that settlers' dogs had driven the kangaroo 'far away' (*The Perth Gazette* 7.9.1833: 142). By 1836, kangaroos were 'getting alarmingly scarce' in settled districts, forcing Aborigines to procure European foods (F. Armstrong in *The Perth Gazette* 12.11.1836: 797). Kangaroos, which had once formed a 'standing dish with the settler' (*The Perth Gazette* 1.2.1834: 225), had been driven from the vicinity of Albany by the 1840s (Browne 1856: 488).

During the period 1829-35 kangaroo meat was sold in the Perth and Fremantle markets for as high as 1s 6d per lb (WA Year Book 1900: 172), with the average in 1830 stated as 8-9d per lb (Devenish 1996: 91). Kangaroo meat retailed at 1s 8d per lb in 1832 (Cottesloe 1979: 89) and 1s-1s 4d per lb in 1833 (*The Perth Gazette* 18.5.1833: 77, 27.7.1833: 120, 10.8.1933: 128), decreasing to 6-10d per lb in 1836 *(Swan River Guardian)*, and was always cheaper than mutton, beef or pork. It retailed at 4d per lb in 1845 (Johnston 1962: 82) and 1847 (*The Perth Gazette* 2.10.1847), and in 1848 was the same price as mutton (*The Perth Gazette* 1.7.1848).

C. Harper suggested that kangaroos should be farmed for their meat on 20 000 acres of fenced poison *(Gastrolobium)* lands (*The Western Mail* 20.6.1891: 6).

Pioneer settlers relied on kangaroos for food while establishing their selections (e.g. Augustin 1912: 36). In the early 1920s near Nornalup, kangaroo meat was the only meat eaten for the first 3-4 years after settlement, with a very large greyhound used to catch 400 kangaroos in seven years (Swarbrick 1975: 6). There were sometimes complaints by settlers in south-west farming districts about the difficulty of obtaining kangaroo meat (T. Hayward WAPD **32**: 1974, 19.12.1907; J. Mitchell WAPD **3**: 1918, 19.12.1907; G. Taylor WAPD **32**: 1975, 19.12.1907; Chitty 2004: 169).

Pelts and other products Fat collected from kangaroos was used by Aborigines to dress their hair, and kangaroo teeth and sinews were used in the construction of spears (Stormon 1977: 141, 146-7, 149). Sometimes a 6" long kangaroo bone was stuck through the septum of the nose (Clark 1994: 37). Many words for parts of the kangaroo used by Noongars are listed by Grey (1840).

Kangaroo skins were used by Aborigines and settlers (Birks 1921: 7 provides a photograph of a properly prepared skin). Aborigines made four products: a cap (*The Perth Gazette* 26.7.1834: 327); the *gundir*, a bag suspended over a woman's shoulders and used to carry a child; the *gota*, a bag used by women as a carry-all; and the *buka*, a protective cloak.

This cloak was variously made from the skins of male kangaroos (Nind 1831: 25), the soft skins of three female kangaroos (Moore 1842: 14, 30, 32, 74), or the skins of 3-4 female kangaroos (Smyth 1878: 237; Stormon 1977: 144). The reference to seven skins by Bates (1938: 60) presumably is to portions (cf. Roth 1903: 63). The cloak was thrown over the shoulders (frontispiece to Stokes 1846 vol. 1; sketch in Smyth 1878: 236-7; photograph in Stormon 1977, opposite p. 188), being fastened on the breast with a rush or skewer of kangaroo bone, and reaching below the middle. In cold and wet weather the fur was worn outwards (Nind 1831: 25; J. Roe 1835 in Shoobert 2005: 480; Browne 1856: 535; Stormon 1977: 144; Thompson 1975: 20); this was to prevent the (untanned) flesh side of the cloak from becoming wet and then hard and stiff (CW Schürmann in Woods 1879: 211). Cloaks were not worn north of the Arrowsmith River (Grey 1841 vol. 2: 56; cf. Stokes 1846 vol. 2: 395, although see J. Roe 1847 in Exploration Diaries **4**: 32, F. Helpman in *The Inquirer* 19.12.1849, and M. Clifton in *The Perth Gazette* 13.2.1852: 5), at Mangowine (Curr 1886 vol. 1: 380) or c. 80 miles east of York (*The Perth Gazette* 21.2.1851). Cloaks were only worn in winter at New Norcia (Stormon 1977: 144), and at Swan River were optional for men (RM Lyon in *The Perth Gazette* 30.3.1833: 51; Backhouse 1843: 532) or were worn by women and old men and occasionally during winter by young men (Milligan 1837: 316). At Geographe Bay, the use of this cloak, even in winter, seemed optional (Cornell 2006: 62, 69, 75). At Albany Aborigines were 'seldom seen without their cloaks' (Nind 1831: 25; see also Backhouse 1843: 525; Bennett 1860: 425; Cornell 2003: 123). Cloaks were also used to wrap neonates in (Stormon 1977: 136). Aborigines did not make rugs for their own use (Forrest 1876: 318), but later made them for sale to Europeans (Parnell 1982: 74). The kangaroo skin cloak was 'a form of dress which is almost confined to the tribes of the west coast and its vicinity' (Curr 1886 vol. 1: 328; see also CW Schürmann in Woods 1879: 210).

Although advertisements for the purchase of kangaroo skins appeared in the press (e.g. *Perth Gazette* 3.11.1838: 174, 13.7.1839: 110; *The Inquirer* 15.12.1841), it seems that settlers used skins only for domestic or local purposes until 1843, when 320 skins were exported (Garden 1977). In 1847 more than 8 000 skins were exported from Albany's hinterland (Garden 1977: 78). At that time each skin was worth 8s (*The Perth Gazette* 2.10.1847). A letter by JL Stokes critical of the extent of destruction of kangaroos in Albany district was published in *The Inquirer* (13.9.1848). In 1851 29 000 skins were exported. A Kangaroo Ordinance was brought in by Government in 1853. This imposed an export duty of 1s per skin (Prince 1984: 16) without limiting the ability of Aborigines and settlers to hunt kangaroos for food. This ordinance was apparently to limit kangaroo hunting as it was feared that kangaroo numbers were being reduced to the extent that

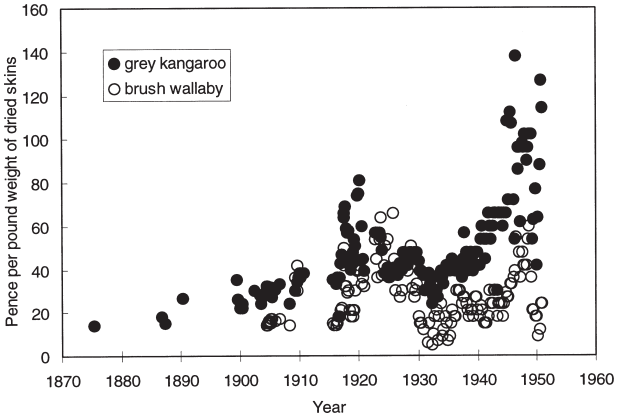

Fig. 22 Prices paid for skins of Macropus fuliginosus *and* Macropus irma. *Source:* The Western Australian Times *4.6.1875: 3;* The Western Mail *20.11.1886: 14; Bridge 2004: 60;* Eastern Districts Chronicle *3.6.1899, 2.9.1899, 13.1.1900, 28.4.1900;* Australian Advertiser *5.5.1890;* The Western Mail *16.6.1900; 1902* West Australian Farmers' Gazette and Market Report*; 1903-8 (Dalgety and Co., from the* Journal of the Department of Agriculture of WA*); 1909-10 (CH Fielding in* Producers' Review*); 1915-20 (Elder, Smith and Co., Dalgety and Co.); 1922-1950 (*Elder's Weekly, *supplemented by* The Westralian Farmers' Gazette*). Maximum price graphed, for first grade if differentiated. Data from March, June, September and December have been used.*

Aborigines would then have turned to sheep (*The Australian Advertiser*, 5.12.1892). In 1858 a 'great many' Aborigines were catching kangaroos in the bush around Albany (David 1995: 288). Settlers at Albany in 1864 petitioned for the lifting of the export duty on kangaroo skins because Aborigines no longer bartered kangaroo skins but instead actively killed kangaroos for food and left the skins to rot (CSOLR 6.2.1864, vol. 545). The ordinance was not repealed until 1878.

Kangaroo skins sold for 6d each in the 1850s (*The Australian Advertiser* 5.12.1892) and 3-8s per dozen in 1869 (*The Inquirer and Commercial News* 16.6.1869). In the early 1870s skins were variously stated to be worth 1s (Bird 1986: 43), 5s (McConnell *et al.* 1993: 72) and 12s each (Erickson 1974: 255), increasing in the 1880s to 6s each (*The Inquirer and Commercial News* 22.6.1888) or 30s each (Erickson 1974: 255). By the early 1890s skins were worth 10s each on average (*The Western Mail* 20.6.1891: 6) or 2s 6d per lb, a high price considering that a skin when dried weighed c. 2½ lb (male) or c. 1½ lb (female), and c. 16 animals could be processed in a day (Briggs 1917: 119-120). From 1903, information on the price per pound weight of kangaroo skins traded is well documented (Fig. 22).

However, it is very difficult to establish accurately how many skins were traded. An 1848 advertisement sought 20 000 kangaroo skins (*The Inquirer* 1.3.1848). In 1851, 29 500 skins were exported from WA, but no further separate record was kept until 1892 (WA Year Book 1900: 172), when kangaroos were first listed as native game under the Game Act of 1892. This may indicate that the duty curtailed the export industry until c. 1890. The newspaper published in York first advertised that kangaroo skins would be purchased for cash in 1878 (*The Eastern Districts Chronicle* 16.3.1878: 4, 27.7.1878: 2). More than 500 000 skins were traded during 1883-7 at a store at Arthur River (Bird 1990: 105). In 1883 and 1885 the Albany tannery sought to purchase 4 000 and 10 000 kangaroo skins respectively (*The Albany Mail and King George's Sound Advertiser* 11.4.1883, 3.2.1885). In 1887 near Busselton one man made £40, a sum that would take a long time to earn as a farm-worker (J. Cookworthy in Commission on Agriculture 1891: 155). Such ready economic benefits must have increased the intensity of hunting close to settlements.

The soft and durable leather made from tanned kangaroo skins was used extensively for boot-making (Knight 1870: 47), as well as leggings, purses and handbags (W. Loutit in Select Committee 1911: 18). Advice on methods of tawing and tanning skins was provided in *The Western Mail* (15.6.1907: 5, 28.2.1913: 6, 7.3.1913: 5). There is also a reference in 1847 to one settler making a kangaroo skin carpet for a hut (Buchanan 2003: 102).

Skins apparently again became a valuable article of export in the mid 1880s. By 1888 kangaroos in the south-west were undergoing 'wanton and wholesale slaughter' and 'shameful, wholesale and indiscriminate destruction' (*The West Australian* 31.3.1888, 5.4.1888). By 1889 'the time was not far distant when there would be no kangaroos in the colony' (H. Venn WAPD **17**: 263, 29.11.1889). In the southern districts (?near Albany), kangaroos were now scarcely seen when a few years before they occurred 'in droves' (L. de Hamel WAPD **17**: 263, 29.11.1889). In Williams district, c. 1.5 million kangaroos were killed in the period 1887-91, and the species was considered to be rare and at risk of extinction (F. Piesse WAPD **2**: 85, 15.12.1891). L. de Hamel (WAPD **2**: 150, 21.12.1891) thought that a closed season would not be effective, given that the young is 'on the teat' from October to February and then remains in the pouch until August/September. A ban on killing kangaroos for 4 years south of a line from Geraldton and the South Australian border was preferred.

It seems likely that the sudden influx of gold-seekers and settlers in the mid-1890s caused further depletion of kangaroo numbers in south-west WA. E. Fawcett (in *Journal of the Bureau of Agriculture of WA* **4**, 1255, 1897) stated that ' a few years ago' kangaroos were 'slaughtered scandalously' by hunters who made a livelihood out of skins. He was concerned that they may become extinct without protection.

Alternative perspectives were that kangaroos would always be sufficiently protected because small skins are of no commercial value (*The West Australian* 18.4.1888), the amount of poor country is great (J. Hassell WAPD **2**: 86, 15.12.1891; W. Glasheen WAPD **74**: 824, 8.9.1926), and as the density of kangaroos was reduced, hunting effort would decrease and populations would recover (J. Cookworthy WAPD **2**: 151, 21.12.1891; *The Inquirer and Commercial News* 22.1.1892). Others saw no purpose

in even endeavouring to protect kangaroos (T. Cockburn-Campbell WAPD **17**: 263, 29.11.1889), as their destruction would increase the carrying capacity of the land for sheep (J. Forrest WAPD **2**: 150, 21.12.1891). Sheep were considered much more valuable than the kangaroo (A. Forrest WAPD **2**: 152, 21.12.1891).

Kangaroo hunters were criticized for leaving the carcasses to provide food for dingoes (*The Inquirer and Commercial News* 22.6.1888; *The Western Mail* 20.6.1891: 6; T. Quinlan WAPD **2**: 151, 21.12.1891; J. Amherst WAPD **2**: 195, 21.12.1892) and blowflies (*The Western Mail* 20.6.1891: 6). Later, carcasses were either buried or burned in heaps (Birks 1921: 67).

In 1899 the Government moved to protect the kangaroo by declaring a Kangaroo Reserve south of a line joining Murchison River and Mt Ridley (*Government Gazette* 20.10.1899: 3300-3301). Kangaroos could be killed in this reserve for food but not for sale or barter. This reserve was later reduced in area, to south of a line joining Mt Lesueur, Kellerberrin and Fitzgerald River (*Government Gazette* 15.3.1901: 1066), but later expanded to include Esperance district (*Government Gazette* 5.1.1917: 1). Further adjustment included all land south of a line joining North Point, Kellerberrin, Mt Stirling, mouth of Fitzgerald River and east of Mt Madden (*Government Gazette* 9.1.1920: 44, 1.8.1924: 1371-2). Maps of these and later reserves are provided by Prince (1984: 20-21). One observant visitor who spent c. 1 month travelling in south-west WA in 1899 saw no kangaroos in the wild (Le Soeuf 1900: 193). In Northampton district populations had been reduced from hundreds to less than a dozen in a few years (*The Geraldton Express*...17.10.1902). W. Thompson in 1906 advocated protection of the kangaroo in Geraldton district, as farmers were using the sale of kangaroo skins to pay for rents and fencing wire (*Journal of the Department of Agriculture WA* **13**, series 1: 54).

Gale (1905: 7) estimated that 0.5 million kangaroos had been killed in the previous 4 years in south-west WA. Nonetheless, extinction was considered 'an impossibility' because with settlement kangaroos are driven further back, and hunters will only stay in a district so long as they could collect sufficient skins to pay them. Gale characterized the dilemma as: if kangaroos were protected or a closed season was declared, this created hardship as settlers relied on kangaroo meat for food; if settlers were allowed to kill for food and not for sale or barter, a marketable commodity (skins) was destroyed.

At Deeside, east of Manjimup, one farmer recorded that 'I may...ride all day & scarce see a Kangaroo...[which are all] shot by the White Hunters' and 'Kangaroo...are so scarce' (T. Muir 1906 in Colonial Secretary's Department files 332/06 and 558/06). Kangaroos were reported in Esperance district as 'fast being swept away' by kangaroo shooters, thereby affecting the livelihood of Aborigines (Aborigines Department 1906). By 1907 it was recognized that protection in settled districts was necessary (J. Drew WAPD **32**: 1675, 12.12.1907) as the kangaroo was rare and not a pest (E. Clarke WAPD **32**: 1674, 13.12.1907). Kangaroo hunters had entered reserves and shot large numbers for skins, and when detected claimed that the animals had been killed for their meat (J. Connolly WAPD **32**: 1672, 13.12.1907). Sir John Forrest noted that kangaroos between Bunbury, Kojonup and Katanning had been 'largely thinned out for the sale of their skins' (*The Western Mail* 1.2.1908: 19).

Before c. 1914 three or four 'boomer' winter skins, properly prepared, were worth about one week's wages (Chitty 2004: 104).

The annual harvest of skins in the period 1910-70 was 50 000-100 000 for most years, but was very low in the early 1920s, 1934 and 1943-4, and declined to 10 000-30 000 after 1954 (Prince 1984: 30). There is a strong correlation between the unit skin price and the number of licenses issued for the period 1920-34 (Prince 1984: 68). Skins were carefully graded and traded accordingly (d/lb): e.g. first winters 37, first incomings 33, first summers 30, second summers 24, heavies 17 (*The Westralian Farmers' Gazette* 4.9.1930). Harvesting levels since 1981 have been well below the estimated population size (CALM Annual Report 2005: 176).

The royalty per skin was 2d from 1914 (*Government Gazette* 20.3.1914: 1414), 2s in 1920 (*Government Gazette* 23.4.1920: 730, subsequently modified to apply to sound skins weighing ½ lb or more and 6d for damaged skins or skins weighing less than ½ lb, *Government Gazette* 21.5.1920: 1027), 6-12d (*Government Gazette* 20.8.1920: 1372), and 3-12d south of Dongara in 1922 depending on the size of the skin (*Government Gazette* 3.2.1922: 142).

Pets Early records of this species being kept as tame include an orphan joey in 1831 near York (Cameron 2006: 45), a 'little kangaroo' in 1834 at Millendon (Cameron 2006: 357), a kangaroo in a paddock in c. 1839 near Toodyay (Gilbert nd1), and a small pet in 1849 near Bolgart (Buchanan 2003: 166).

Pests Local conflict between settlers and kangaroos developed once cereal growing and fruit growing became important industries. According to Caughley (1987: 174), 1.5 kangaroos are roughly equivalent to one sheep. The first reports found were of kangaroos eating wheat in the 1860s near Katanning (Haddleton 1952: 9), and one can only imagine their impact in the 1880s in Williams district, which was described as 'absolutely alive' with kangaroos (Briggs 1917: 107). Kangaroos were reported as keeping bare choice patches of the best sheep feed (*The West Australian* 18.4.1888). Reports of damage to crops became numerous in the 1890s (J. Talbot, A. Stevens in *Journal of the Bureau of Agriculture of WA* **4**, 1256, 1897), to the extent that 'it will be a happy day...when...the kangaroo disappear[s]' (G. Simpson WAPD **2**: 256, 14.1.1892) and 'the majority of the settlers would be much better off without the kangaroo' (J. Walter in *Journal of the Bureau of Agriculture of WA* **4**, 1256, 1897). In 1906 one visitor 'met with droves of kangaroos who are the best judges of the quality of the pasture' (Melia and Bosworth 1997: 178). After a tour of the country between Bunbury, Kojonup and Katanning, Sir John Forrest welcomed the 'destruction' of kangaroos, noting that '[w]hile the kangaroos lived there was no grass, but now

there was splendid pastoral country' (*The Western Mail* 25.1.1908: 18).

Damage to crops by kangaroos occurred near Capel in 1908 (*The Western Mail* 28.11.1908: 6). On one pioneer farm, kangaroos ate an entire 10 acre clearing of horse feed (1911, Bristow 1988: 140). Reports of local damage to fences (J. Mitchell WAPD **48**: 3934, 16.12.1913) resulted in the extreme view that 'the sooner it is cleared out…the better' (W. George WAPD **32**: 3938, 16.12.1913). Complaints of kangaroos knocking down crops and stripping 3 year old fruit trees were recorded from numerous localities (Royal Commission 1917). One politician asserted that it was 'quite impossible' to exterminate kangaroos and that 'the only place where the kangaroo should be permitted to exist is the Zoological gardens' (C. Sommers WAPD **56**: 493, 20.2.1918).

In 1919 kangaroos were plentiful east of Beverley (L. Hicks 1919; AA Wood 1919 in Fisheries Department file 34/32), near Cranbrook (AG Hill 1919 loc. cit.) and near Ravenswood (CA Forsberg 1919 loc. cit.) but were diminishing greatly west of Pingelly because of cultivation (WE Kemp 1919 loc. cit.) or had been shot out close to Capel (FJ Hardey 1919 loc. cit.). Kangaroos were very scarce and wild in 1920 near Margaret River (Short and Calaby 2001: 543).

It can be assumed that differing expectations among districts must have posed a challenge to any holistic approach by Government. For example, at Eradu in 1921 kangaroos were regarded as 'worse than rabbits' owing to the lack of shooting (itself linked to the combination of high royalty and low state of the skin market). The Government responded by reducing the royalty to 2d per skin north of a line joining Dongara, Mingenew and Gutha (*Government Gazette* 3.2.1922: 142). On the other hand, a farmer at Kulikup wanted the royalty increased because hunters were slaughtering kangaroos (linked to a recent increase in skin prices) and leaving the carcasses, thereby exacerbating the blowfly problem. Whenever skin prices decreased, there were calls for the royalty to be reduced because of hardship to pioneers still dependent on kangaroos as a source of meat. Rises in the price of mutton also led to increased hunting of kangaroos (Fisheries Department file 13/32).

Reports of kangaroos eating grain, trampling crops, consuming vegetables in gardens, and damaging fences (and thus allowing sheep out into poison country) are widespread from the 1920s (Anon. 1992: 136; Beecham nd: 59, 73; Bignell 1997: 124; Bird 1986: 200; Blond 1987: 59; Crake 1985: 111; Ferrell 1992: 65; Harris 2002: 38; Jenkyn 1999: 118; Lowrie nd: 24; Payne 1987: 125; Pustkuchen 1981: 31; Taylor 2000: 134; Whittem 2000: 145). The politician CP Wansbrough requested the Government to activate Clause 7 of the Game Act (1912), which enabled the Governor to proclaim part or parts of WA into districts for the purpose of temporary control of kangaroos (WAPD **70**: 622, 4.9.1924). Protection for kangaroos was subsequently withdrawn for short periods in particular districts (Table 1). In addition, the western grey kangaroo was declared as vermin under the Vermin Act Amendment Act (1925), commencing with Moora district in 1927 (Table 1).

Even as late as 1926, opinion was that kangaroos caused more damage in wheat crops and pasture than rabbits (W. Glasheen WAPD **74**: 824, 8.9.1926; J. Drew WAPD **73**: 876, 9.9.1926). By 1930 kangaroos were doing considerable damage in agricultural districts and it was considered that 'there are more kangaroos in the country than ever there were' (A. Piesse WAPD **85**: 2280, 2501). The Government position was that the kangaroo was a 'menace' in some districts but needed protection in many districts (P. Ferguson WAPD **85**: 2501, 10.12.1930). The opinion was expressed that the outcry against the kangaroo, as a serious pest in agricultural areas, rises to its zenith when the price for skins is high. Depressed prices in 1930-1 meant that 'not much is heard of the kangaroo pest' (Serventy 1932: 225). It is not clear how widely shared was the view of the noted ornithologist and farmer H. Whittell, who wrote in 1950 that 'the proper place for kangaroos is in National Parks' (Fisheries Department file 66/49), but one farmer cleared the last remnant of bushland on a farm because it provided shelter for kangaroos (Anon. 1989: 132). In 1952 kangaroos damaged newly planted pine trees at Grimwade (Fisheries Department file 72/49).

Recent scientific research indicates that the western grey kangaroo selectively eats many species of native plants, as well as pasture grasses and crops (Halford *et al.* 1984; Arnold *et al.* 1989). In one study crops > 400 m from woodland were unaffected because kangaroos rarely moved farther than this distance (Arnold *et al.* 1989). In contrast, in another study few kangaroos were seen more than 100 m from native vegetation (Arnold and Steven 1988). A 1 m high ringlock fence topped by three wires (barbed, plain, barbed) provided the greatest protection to crops relative to four other types of fence tested (Arnold *et al.* 1989).

Sport Kangaroos were also shot for 'sport', with this practice starting soon after settlement, near Guildford in 1833 (Carter 1986: 44). The first advertisement advising of a gathering of the 'Kangaroo Hunt' was published in *The Perth Gazette* 22.6.1833: 97. A kangaroo hunt near Moora in 1877 involved five hounds and five horsemen, and resulted in three dead kangaroos from four runs (Broad and Broad 1992: 194-5). A day's 'kangarooing' in Northampton district involved seven or eight runs, each involving a chase on horseback with a pack of dogs and resulting in a 'boomer' being killed (*The Victorian Express* 30.1.1884). Kangaroo shooting was stated to be the main recreation around Mt Helena in the 1880s (Elliot 1983: 79). In the 1880s it was noted that kangaroo hunting around Perth 'used to be capital' and that it was [now] necessary to 'go a good long way' (Hasluck 1963: 136). For example, this species was last seen in Mosman Park in 1896 (Tuettemann 1991: 19). During 1904-7 kangaroos were noted as not being plentiful in the vicinity of towns (Shortridge 1910: 805-6).

In 1916 there were complaints about 'wholesale destruction' of kangaroos in Wanneroo district by weekend visitors from Perth (Chambers 1991: 35). With the

Table 1

Increased abundance of the western grey kangaroo in the period 1925-50, as evidenced by exemptions to the proclamation issued on 30.7.1924 under the Game Act (1912-13) or proclamation as vermin under the Vermin Act Amendment Act (1925).

RD = Road District; VD = Vermin District

Locality & period (if nominated)	**Relevant Act of Parliament**	**Proclamation in *Government Gazette* (Date & page)**
Moora VD	Vermin	15.7.1927: 1655
Area outside a radius of 30 miles from the centre of Perth (13 –31.10.1933)	Game	20.10.1933: 1594-5
Dumbleyung VD	Vermin	10.11.1933: 1717
Lake Grace VD	Vermin	22.12.1933: 1951
Mingenew VD	Vermin	7.12.1934: 1865
Wagin VD	Vermin	11.1.1935: 22
Defined area near Gingin (25.10-30.11.1935)	Game	25.10.1935: 2018-9
Defined area near Gingin (1-31.12.1935)	Game	13.12.1935: 2297
Part of Gingin RD west of Midland railway line	Game	12.7.1940: 1359-60
Part of Gingin RD west of Midland railway line (1.1-31.3.1941)	Game	10.1.1941: 25
Part of Gingin RD west of Midland railway line (18.9-31.12.1942)	Game	18.9.1942: 891
Part of Gingin RD west of Midland railway line	Game	7.12.1945: 1151
Part of Gingin RD west of Moore River	Game	14.12.1945: 1170
Part of Gingin RD west of Moore River (21.6. –31.12.1946)	Game	21.6.1946: 769
Part of Gingin RD west of Moore River (14.2. –30.4.1947)	Game	14.2.1947: 273
Gingin RD (10.2.-10.8.1950)	Game	10.2.1950: 236
Gingin (18.8.1950-18.2.1951)	Game	18.8.1950: 1912
Wongan-Ballidu VD	Vermin	14.5.1937: 741
Dandarragan RD	Game	12.7.1940: 1359-60
Dandarragan RD (1.1-31.3.1941)	Game	10.1.1941: 25
Defined area near Dandaragan (4.6.1948-3.6.1949)	Game	11.6.1948: 1324
Sussex Land District	Game	12.7.1940: 1359-60
Sussex Land District	Game	26.9.1941: 1329
Sussex State Electoral District	Game	22.12.1944: 1325
Sussex RD (1.11.1944-31.1.1945)	Game	24.11.1944: 1101
Kent RD	Game	23.8.1940: 153
Kent RD (20.6.-31.12.1941)	Game	20.6.1941: 833
Kent RD (19.2.-19.5.1943)	Game	19.2.1943: 165-6
Kent RD (19.5.-31.12.1943)	Game	4.6.1943: 542
Kent RD (1.-30.11.1946)	Game	22.11.1946: 1434
Kent RD (1.-31.12.1946)	Game	13.12.1946: 1539
Kent RD (25.7.-31.12.1947)	Game	25.7.1947: 1316
Kent RD (20.2.1948-31.12.1949)	Game	20.2.1948: 427
Kent RD (1.1.-31.12.1950)	Game	16.12.1949: 3237
All land east of a line joining Lake Magenta and the mouth of the Fitzgerald River	Game	1.11.1940: 1949
All land east of a line joining Lake Magenta and the mouth of the Fitzgerald River (1.11.1941-30.4.1942)	Game	31.10.1941: 1575
All land east of a line joining Lake Magenta and the mouth of the Fitzgerald River	Game	31.5.1946: 551
All land east of a line joining Lake Magenta and the mouth of the Fitzgerald River	Game	9.5.1947: 767
All land east of a line joining Lake Magenta and the mouth of the Fitzgerald River	Game	9.5.1947: 767
All land east of a line joining Lake Magenta and the mouth of the Fitzgerald River (1.6.1948-31.5.1949)	Game	21.5.1948: 1090
All land east of a line joining Lake Magenta and the mouth of the Fitzgerald River	Game	24.6.1949: 1354
10 miles radius of Wellington Mills	Game	9.10.1942: 939
10 miles radius of Young's Siding (1.10.-31.12.1946)	Game	11.10.1946: 1249
10 miles radius of Young's Siding	Game	5.9.1947: 1690
Mt Marshall VD	Vermin	16.1.1948: 82
Kondinin VD	Vermin	5.3.1948: 523

increasing use of motor cars in the 1920s, illegal kangaroo shooting increased in the Chittering area, especially at weekends (Buchanan 2000: 228). In the 1950s near Bailup, hunters from the Perth metropolitan area took 'a heavy toll at weekends' (Carnaby 1954: 132), whereas in Piesse Brook-Bickley district kangaroos had increased in numbers (Loaring 1954: 132, 136). In 1959 shooting for pet food companies had reportedly reduced populations (*Fisheries Department Bulletin* 5/1 1959) and this continued in some localities until the 1960s (Passfield 1988: 71). Some kangaroos were also shot for craybait and pig feed (Passfield 1988: 18, 175). With a reversal of social values evident since c. 1970, most West Australians now abhor shooting and culling and this has led to the marked increase in kangaroo populations close to rural towns, e.g.: Busselton (*Busselton-Margaret River Times* 5.8.2004: 1); Capel (*The Countryman* 28.10.2004: 7); Albany (*Albany and Great Southern Weekender* 5.8.2005: 5); and Yanchep (*North Coast Times Community* 18.7.2006: 3). A high density population in a fenced nature reserve in metropolitan Perth (Thompsons Lake) had to be culled from an estimated 450 kangaroos down to 30 animals (*The West Australian* 24.4.2006: 5).

Disease The earliest report of disease found was from near Esperance, with many kangaroos affected with eaten away lungs, liver and kidneys and 'large globes of water' in place of the lungs and liver (*The Western Mail* 21.10.1911. p. 5). This is suggestive of hydatids (A. Thomson pers. comm.). In 1996 blind kangaroos were reported widely across south-west WA though at low incidence, caused by an orbivirus spread by biting midges (Department of Conservation and Land Management file 04397OF3803 vol. 2).

Macropus irma kwara/koora/western brush wallaby

Oldtimer information The brush wallaby was generally rated by oldtimers to have once been widespread (Fig. 23) and plentiful, beginning to disappear locally in the 1930s (S. Doust, W. Forrest, G. Gardner, K. Wellstead, J. Williams pers. comm.), becoming generally rare in the 1960s, and then common by the 1990s. Being a rapid moving species, this species was regarded as 'good sport' and was hunted during the Great Depression with dogs. Two oldtimers considered that the meat of this species did not taste as well as that of the western grey kangaroo; its meat was also found to be infested with worms.

Common name The vernacular name 'brush kangaroo' was first used in the late 1820s (Nind 1831: 29) and remained in rural and trade use well into the 1940s. 'Brush' refers to its habitat and not its fur (A. Warburton in *The Western Mail* 1.11.1923: 6). Additional variant spellings were found of the Noongar name: *Kora*, pronounced as in Dora (*The Western Mail* 28.8.1930: 32); *Querr* (*The Western Mail* 1.11.1923: 6); *Quorra* (*The Western Mail* 16.4.1925: 3); and *Qurr, Qurrr* (*The Western Mail* 9.7.1925: 25).

Distribution and abundance According to Gilbert (nd3; Wagstaffe and Rutherford 1955: 14-15), the brush wallaby was found equally abundant in almost all parts then known to settlers, generally inhabiting scrubby places. It occasionally fed on open plains but always took to the scrub when hunted. The lack of reference to this species by early explorers seems to indicate that it remained well hidden in thickets as explorers passed by. The brush wallaby was more common around King George Sound than the western grey kangaroo (Nind 1831: 43). In 1899, this species was common in the (soon to be cleared) wheatbelt (Le Soeuf 1900: 193). The brush wallaby is very common in jarrah forest with an open understorey, but absent from high rainfall areas with dense understorey, including karri forest (Christensen *et al.* 1985: 17-18).

Shortridge (1910: 809) incorrectly thought that it had a geographical range identical to that of the western grey kangaroo. However, he noted that it was apparently absent between Capes Naturaliste and Leeuwin. This supposition was later confirmed when a specimen collected in 1915 from near the mouth of Margaret River was exhibited as 'a great curiosity' (L. Glauert in *The Western Mail* 7.3.1929: 48). It was stated to have increased in numbers since 1917 at Yallingup (G. Forrest 1919 in Fisheries Department file 34/32). In addition, the collector C. Hoy did not record it at Margaret River in 1920 (Calaby and Short 2001).

J. Tunney's failure to collect it at Mingenew or Geraldton in the 1890s probably fixes its original northern limits. On a journey south from Carnarvon, Carter (1888: 194) first noted this species at 'Henry River', a locality no longer traceable but evidently to the south of Irwin River and probably nearer Hill River (Carter 1987: 52). Nonetheless, Aboriginal names stated to have come from Champion Bay, Northampton and Murchison district are known (Abbott 2001a: 470-2).

Interactions with humans Aborigines captured this species in three ways: First, by the use of fire in summer to flush animals from thickets and spear them; Second, in spring, by breaking down a track around a thicket, blocking the exit paths, and then sending in one or two hunters with their dingoes. As the animals flee they become entangled in the trampled vegetation and are clubbed; Third, with pitfalls covered with bushes and set in wet places, mostly away from the coast (Nind 1831: 28, 30).

Although there are few reports of settlers eating the brush wallaby (*The Western Mail* 7.7. 1927: 36; Pustkuchen 1981: 31; Bristow 1984a: 14), the flesh of animals that had been feeding on cultivated land was considered 'good eating' and 'quite equal to that of a rabbit', with only the hindquarters providing sufficient meat (F. Whitlock in *The Western Mail* 14.4.1927: 30). The average body weight of this species is only c. 8 kg (Strahan 1995: 343). The meat tasted like hare (Bristow 1984a: 14; Giblett 2006: 65) and was 'tasty', with soup and brawn being made from the tail (Atkins 1993: 15).

This species seemed to be only an occasional pest, with the first complaints found dating from 1917, when it was reported that it had done much damage to crops in Corrigin district (Royal Commission 1917a). In 1922-24 it was stated to be 'a serious curse to the settlers' (Fisheries Department file 13/23). In 1924 a vegetable

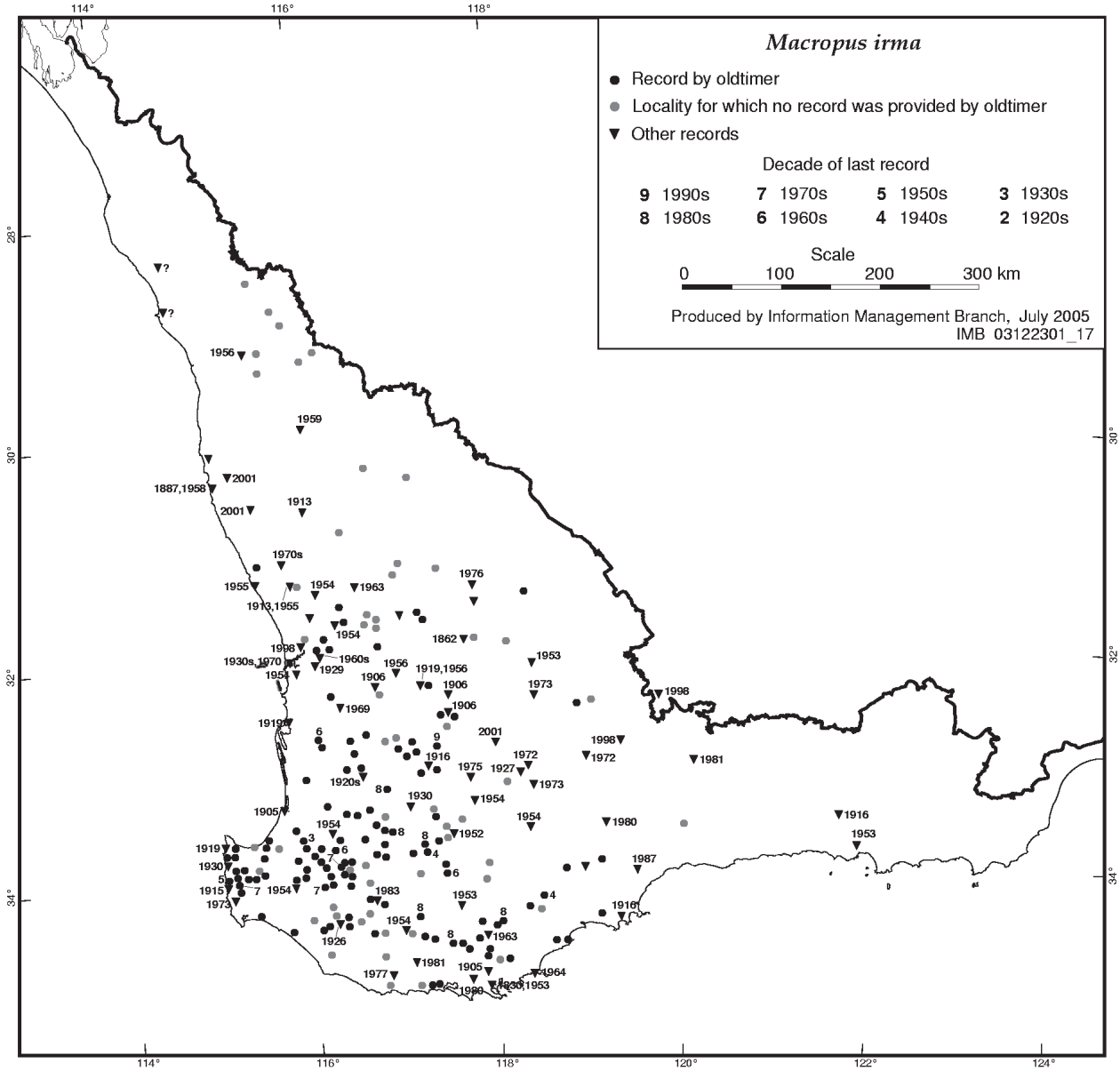

Fig. 23 Distribution of Macropus irma. *Additional records not already cited in text: Bannister 1969a; Chapman 1995; Chapman and Kitchener 1977, 1978; Crook and Burbidge 1982; How* et al. *1988; Kitchener and Chapman 1976, 1977, 1978; Kitchener and Vicker 1981; Lowrie nd; McKenzie 1973; McKenzie and Youngson 1975; Royal Commission 1917b; Warren 1983; Whittem 2000; Wootton and Jacob 1992.*

garden by a river near Metricup had to be fenced (Lowrie nd: 24). It was later recorded that brush wallabies eat leaves of apple trees (but not those of plum or pear trees) and will gnaw developing fruit buds (F. Whitlock in *The Western Mail* 14.4.1927: 30). They also eat wheat shoots (*The Western Mail* 7.7. 1927: 36). This species was declared vermin in 1927 in Moora and Katanning districts (*Government Gazette* 15.7.1927: 1655, 21.10.1927: 2352). In 1928 brush wallabies were recorded as biting off the tip of young pine trees, though this seldom killed the pine, which developed a new leader (Forests Department 1929). Damage in orchards near Mt Barker was recorded in 1936 (*The Western Mail* 14.5.1936: 49), and advice on how to snare (including a diagram) was provided in *The Western Mail* 21.5.1936: 45.

The brush wallaby seemed to be most valued for 'sport'. When pursued it runs very fast (Gilbert nd3) and is quick in its movements, being able to turn and double like a hare (Shortridge 1910: 809-810) as well as turn at right angles (Groser 1927: 213). Perry (1971: 46-70) related how his kangaroo dog was set up to be killed when pursuing a brush wallaby. Until the early 1930s, when the fox became common in settled areas, this species substituted for the fox by hunt clubs (e.g. *The West Australian* 21.5.1906: 2, 31.7.1922: 9, 7.8.1922: 8, 27.6.1934: 4; Gabbedy 1972: 58; Jenkins 1988: 6; Uren 1975: 34). In one instance an animal was pursued for 30 minutes by a pack of hounds before it was caught and killed (*The West Australian* 7.6.1920: 6). The proclamation in 1941 that protected all 'native game'

present within a 15 mile radius of Perth city prevented the brush wallaby being hunted or shot (*Government Gazette* 2.5.1941: 561).

Although the brush wallaby was exploited for its pelt, it nearly always attracted a lower price than the western grey kangaroo (Fig. 22). The annual harvest for the commercial trade experienced an upsurge in the 1920s (70-150 000 skins), declining in 1930 to 30 000 skins (Prince 1984: 31). Skins consigned to the trading houses were carefully graded and valued (d/lb): e.g. first furs 66, second furs 51, first tanners 36, second tanners 24 (*The Westralian Farmers' Gazette* 12.9.1925: 4). Presumably 'tanners' were subsequently used to make rugs. The royalty to Government from 1914 was only 1d per skin (*Government Gazette* 20.3.1914: 1414), increasing to 2d per skin in 1922 (*Government Gazette* 29.9.1922: 1880), and reverting to 1d per skin by 1942 (*Government Gazette* 13.2.1942: 175). Trading in skins was prohibited from July 1952.

Changes in distribution and abundance The brush wallaby exhibits one of the most complicated responses to settlement of any mammal species in south-west WA. In 1904-7 it was remarked that this species was '[n]ot apparently dying out or disappearing even in the more thickly populated districts to the same extent as the smaller marsupials' (Shortridge 1910: 810). Indeed, before 1908 it did not occur north or east of Mt Stirling, and the subsequent extension of its range to Kellerberrin and beyond was attributed to agricultural development (Leake 1962: 41-2). Reports in 1978 from Kalbarri and Nerren Nerren pastoral station, south-east of Shark Bay (K. Morris pers. comm.) may also represent response to clearing. Unlike the western grey kangaroo, however, the brush wallaby will live entirely without access to water (Haddleton 1952: 97). This implies that clearing and the establishment of new food sources, and not the provision of artificial water sources, is the relevant factor. Consistent with this is its expansion into the extreme south-west corner (south of Busselton) with the development of Group settlements there from 1924.

The brush wallaby in the core of its range fluctuated inexplicably in abundance from time to time. 'Thousands' died after 1918 in the Gingin area (S. Fraser in Roe and Roe 1992). In 1930 in Arthur River district animals had 'many' worms in their stomachs (Bird 1990: 345). Large numbers were reported to be dying in the bush in 1971 at Unicup (Department of Conservation and Land Management file 015126F3803). Such mortality is suggestive of outbreaks of disease. Abundance in forests is greatest in recently burned areas (Christensen and Kimber 1975: 99).

Consensus in 1919 was that this species was plentiful, with reports from east of Beverley, Cranbrook and Ravenswood (CA Forsberg, L. Hicks, AG Hill, A. Wood 1919 in Fisheries Department file 34/32). It was 'fairly numerous' at 'Warren River' (*The Western Mail* 16.4.1925: 3) and 'still common' between Albany and Denmark (*The Western Mail* 29.4.1926: 32). However, along the Avon Valley between Midland and Toodyay in July and August 1946, '[v]ery few' were seen (Shipway 1947).

In 1950 the brush wallaby was removed from the third schedule of the Vermin Act (1918), under which it had previously been listed as vermin in Moora and Katanning districts (*Government Gazette* 27.10.1950: 2422).

The brush wallaby was still very plentiful in Katanning district in the early 1950s (Haddleton 1952: 97) and was reported to be generally recovering in many localities (*Fisheries Department Bulletin* vol.1-3, 1954-6), with the exception of Mingenew and Gingin. It was stated in 1962 to have not been seen 'for years' at Aldersyde (Fisheries Department file 78/50), to have declined recently in Piesse Brook-Bickley district (Loaring 1954: 132) and in Nyabing-Pingrup district (Aitken 1954: 139), to have not changed in status in Bailup district since 1945 (Carnaby 1954: 132), but to be increasing and appearing in districts near Manjimup from which it had been absent for many years (Jones 1954: 140).

WG Pearce (1963 in Fisheries Department file 34/32) recorded that the brush wallaby was 'reasonably common' in Woogenilup district up to 1930, disappearing gradually after the arrival of the fox. But, by 1963, it seemed to be increasing in numbers. East of Mundaring Weir during the 1960s it was seen regularly in thickets in wandoo forest (R. Underwood pers. comm.), and was abundant in 1969 (as evidenced by roadkills) along Albany Highway between Canning Dam turnoff and Bannister (*Fauna Bulletin* 1969 3/2). Their average abundance in a series of transects between Wanneroo and Walpole in 1970 was 10.4 animals/100 km, and its numbers remained stable at Perup and near Lake Muir in the period 1970-81 (Christensen *et al.* 1985: 17-18). However, in the wheatbelt in the 1970s brush wallabies were recorded on only five of the 23 nature reserves surveyed (Kitchener *et al.* 1980: 205).

Concerns about a decline in sightings were first expressed in March 1980 by N. Beeck (WA Wildlife Authority minutes, Department of Conservation and Land Management file 015126F3803) and were confirmed when transect counts were repeated in 1990 and recorded only 1.1 animals/100 km (Christensen *et al.* 1985; Christensen 1991). The suspicion that the fox was the key threat to this species was confirmed within 2 years of the commencement in 1996 of the Western Shield Program, when sightings and roadkills once again increased (Orell 2004). A decline to near local extinction near Gidgegannup in the period 1970-90 was reported by Taylor (1990: 36-7).

Unexpectedly for a large conspicuous species, the brush wallaby persisted in bushland within and on the outer margin of the Perth metropolitan region, perhaps consistent with its ability to elude capture by dogs and its 'wonderfully strong' nature (F. Whitlock in *The Western Mail* 14.4.1927: 30). For example, it still occurred in c. 1918-20 in Como (Gothard 1988: 32), remained common near Perth in the early 1930s (Glauert 1933: 32), was reported in the late 1930s near Wireless Hill and near North Lake Road (Uren 1975: 34), was still found in 1955 near Bibra Lake, North Lake and Jandakot (*Fisheries Department Bulletin* 3/1, 1956), was present at Melville lakes up to the 1960s (Drake 1996: 25), was

recorded at Hamersley in 1969 (Stranger 2003: 39, 57), and still occurred in 1970 at Wireless Hill (Melville, near Bicton) and in 1985 at Lesmurdie (Dell and How 1988). Many roadkills were reported in the 1980s with increasing urban development, as at Leda and in wetland/heath vegetation at Kewdale-Welshpool, Bibra Lake and south Yangebup (Department of Conservation and Land Management files 015126F3803, 2001F000561V01). The largest Perth metropolitan region population, at Whiteman Park, is protected by regular baiting of foxes.

The viral blindness disease that affected western grey kangaroos in 1996 in south-west WA also infected a few individuals of the brush wallaby in a large portion of the south-west (Department of Conservation and Land Management file 04397OF3803 vol. 2).

Macropus robustus bikada/euro/common wallaroo

The euro was recorded by oldtimers on rocky country mostly in the north-east sector of south-west WA (Fig. 24). The record from near Yealering was considered to represent an incursion in the 1990s from farther east (R. Rigby pers. comm.).

'Euro' is an Aboriginal name from the Flinders Ranges, South Australia (Dixon *et al.* 1990: 67). It was not used in WA until the 20th century. When explorers first encountered this species in south-west WA, it was given the descriptive name of 'red kangaroo'.

The first record by an explorer of a 'red' kangaroo was near Welcome Hill in 1836 (Roe 1836: 29). It was

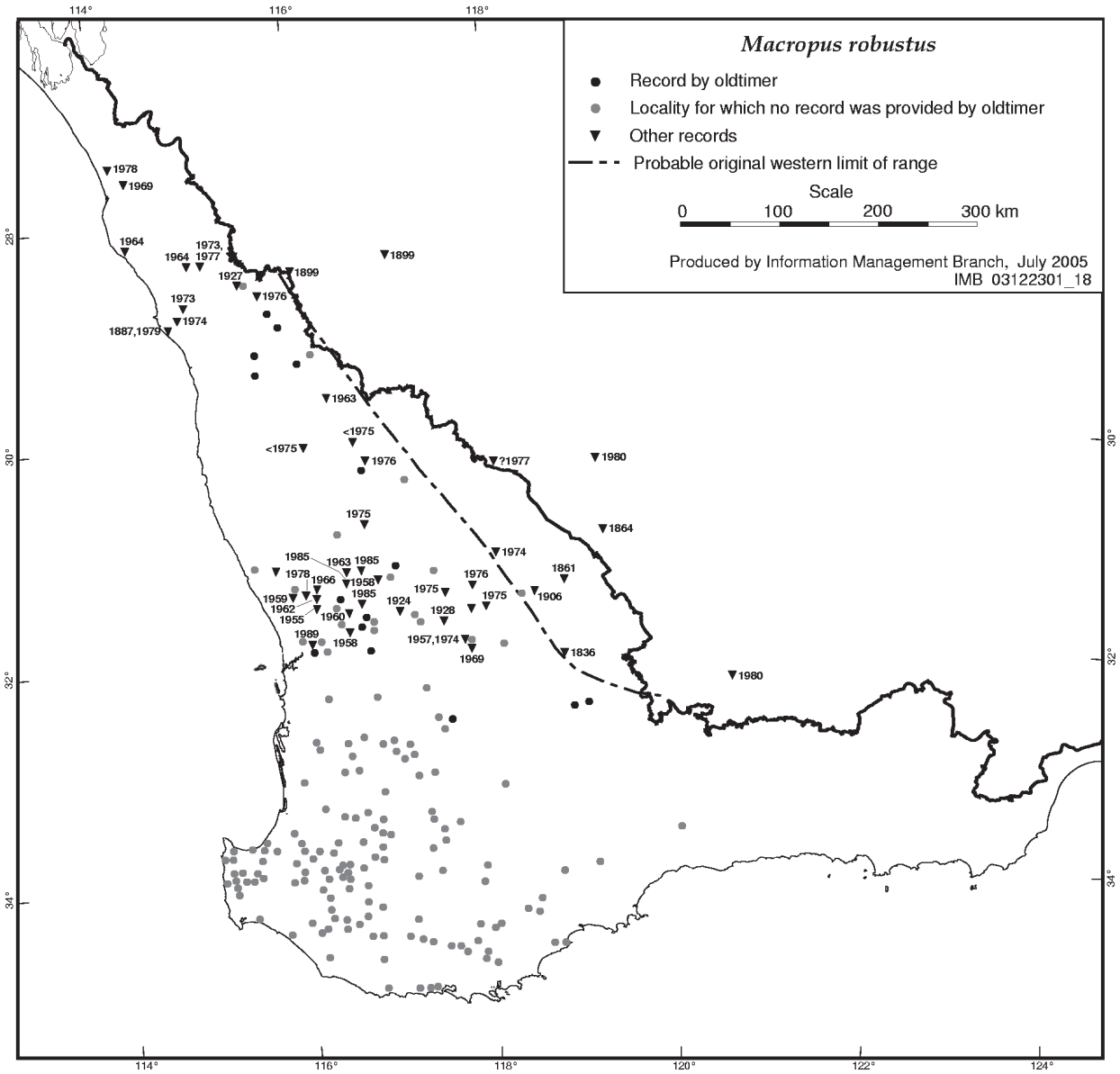

Fig. 24 Distribution of Macropus robustus. *Additional records not already cited in text: Bannister 1969a, 1969b; Barker 1958; Baynes 1979; Burbidge* et al. *1978, 1980; Department of Conservation and Land Management file 014782F0616; Chapman and Kitchener 1978, 1979a, 1979b, 1981b; Dell and How 1985;* Fisheries Department Bulletin*; Fisheries Department file 42/55; How* et al. *1988; Kitchener and Chapman 1979, 1980a; Kitchener and Vicker 1981; McMillan 1962; Moore* et al. *1985; Morris and Dell 1977; Roe and Roe 1992; Stokes 1986; Youngson and McKenzie 1977.*

next reported in 1861 between Merredin and Lake Deborah (probably north of Bullfinch - Brooker 2006: 34), again as a 'red' kangaroo (C. Dempster *et al.* 1861 in Exploration Diaries **5**: 32). Hunt (1864: 12) noted numerous tracks of the 'red' kangaroo near the eastern end of Lake Deborah. As all of these records precede settlement, it seems that the euro occurred in south-west WA only east of Bonnie Rock-Hyden.

The only other nineteenth century record was from c. 30 km north of Irwin River, of 'red' kangaroos in flocks in 1887 (Carter 1888: 193). Presumably this species is different from the 'Great Red', also mentioned, which I take to be *Macropus rufus.* This district had been settled for nearly 40 years, and it appears that euros had penetrated to the west from the inland.

This assumption is supported by comments of Leake (1962: 41) that 'Red Kangaroo' or 'Euro' were originally confined to the north and north-east of Kellerberrin. With agricultural development, they colonized areas south to Kellerberrin, inhabiting the thicker scrubs and feeding on the edge of open country. In this district they now occur at a density of one euro per 5-20 ha (Arnold *et al.* 1991). In Durokoppin Nature Reserve euros showed a strong preference for York gum/wandoo/jam woodland with a herbaceous ground layer and areas of *Allocasuarina* or dense kwongan (Arnold *et al.* 1994).

Gilbert did not record any euros on the rocky hills of the Avon Valley in the 1830s/40s and Shortridge (1910: 808) thought that they only occurred in south-west WA near Southern Cross, Wongan Hills and lower Murchison River. J. Tunney (letter, 4.8.1906) quoted a secondhand report from a reliable source of the 'red kangaroo' near Burracoppin. The only records of Aboriginal names from south-west WA are from Dongara district and east of Katanning; these names were collected by D. Bates in the early 1900s and may not be accurately localized (Abbott 2001a).

The colonization of much of the northern half of south-west WA by the euro seems to have been underway in the 1920s, following clearing for wheat-farming, attaining its full extent in the 1960s (Fig. 24). However, none were recorded in 1946 along the rugged and hilly country in the Avon Valley between Toodyay and Midland (Shipway 1947). Euros were first recorded at Mokine in 1954 (confirmed by a zoologist in 1957 - Barker 1958) and at Culham in 1960 (McMillan 1962).

Commercial use of euro carcasses ceased in 2003, resulting in increased abundance and damage to crops, particularly near Bonnie Rock (*The West Australian* 18.8.2005: 40).

Macropus rufus red kangaroo

The red kangaroo was reported by only three oldtimers (Fig. 25), all from near the eastern margin of the south-west region of WA.

This species was first recorded in WA by AC Gregory in 1852, as a large species of red kangaroo, near Hamelin Pool, Shark Bay (Birman 1979: 60). Gregory noted that he had not seen this species on his earlier expedition to the north of Perth. It was next recorded several times by the explorer R. Austin 2 years later, again extra-limitally (Austin 1855: 42, 49, 52, 53, viii, ix). Although referred to as the red kangaroo, it is clear that *M. rufus* and not *M. robustus* was seen. His two Aboriginal guides from the south-west had not seen this species before and were reluctant to eat it. Austin thought that it was better eating than the western grey kangaroo because its meat had more fat. The third report of this species was by E. Hooley in 1866, who first sighted it in the journey north from Geraldton between Yallalong and Billabong on the Murchison River (Exploration Diaries **6**: 172).

The red kangaroo was first reported in south-west WA in 1887 when numbers of the 'Great Red Kangaroo' were seen on the north side of the Murchison River during an overland journey from Carnarvon to Geraldton (Carter 1888: 193). In 1899 it did not appear to occur west of Pindar (based on Tunney's series of specimens collected there). By the 1920s it was present at Mullewa (Kitchener and Vicker 1981: 66).

The red kangaroo has not spread as far west as the euro. The suggestion that the town of Milo, 20 km east of Dongara, is named after this species (Bain 1975: 144) does not necessarily imply that it occurred there in pre-colonial times.

I tentatively accept that the red kangaroo originally occurred in only the extreme northern portion of south-west WA (Fig. 25).

Onychogalea lunata worong/wurrung/crescent nailtail wallaby

I did not seek information from oldtimers on the crescent nailtail wallaby or wurrung, as it was according to records then available last noted in south-west WA in the period 1899-1908 (Fig. 13).

According to Gilbert (nd3), the 'Kangaroo Rabbit' (named after its soft fur and long ears) was considered a 'very rare' species as the collector [presumably a York farmer, see Gilbert nd1] of a specimen given to Gilbert had only seen two other live animals. The Aborigines stated that this species occurred north of the (then) settled parts of the Avon Valley. All specimens seen by settlers had been brought in by Aborigines. On his second visit Gilbert found the species in thickets at Wongan Hills (Gilbert nd1).

It is now known that the wurrung ranged west to the south-west of Beverley (Broun 1995: 12) and Arthur River (Shortridge 1910: 815-6), and south to about Cranbrook (Kitchener and Vicker 1981: 67), Mongup (Krefft 1867, 1869) and Jerramungup (Abbott 2001a: 472-3).

This species lived in thick vegetation, making it difficult to collect by shooting or with the aid of dogs (Gilbert in Wagstaffe and Rutherford 1954: 493). The wurrung was recorded in dense cypress thickets by Austin (1855: 14, 16) and it seemed to prefer lower and more scrubby thickets than the tammar, with which it occurred (Thomas 1906: 768). It lived in a squat like a hare and was always seen alone (*The West Australian* 6.6.1925: 11; Webb 1944: 123). According to Haddleton (1952: 97) it mainly lived

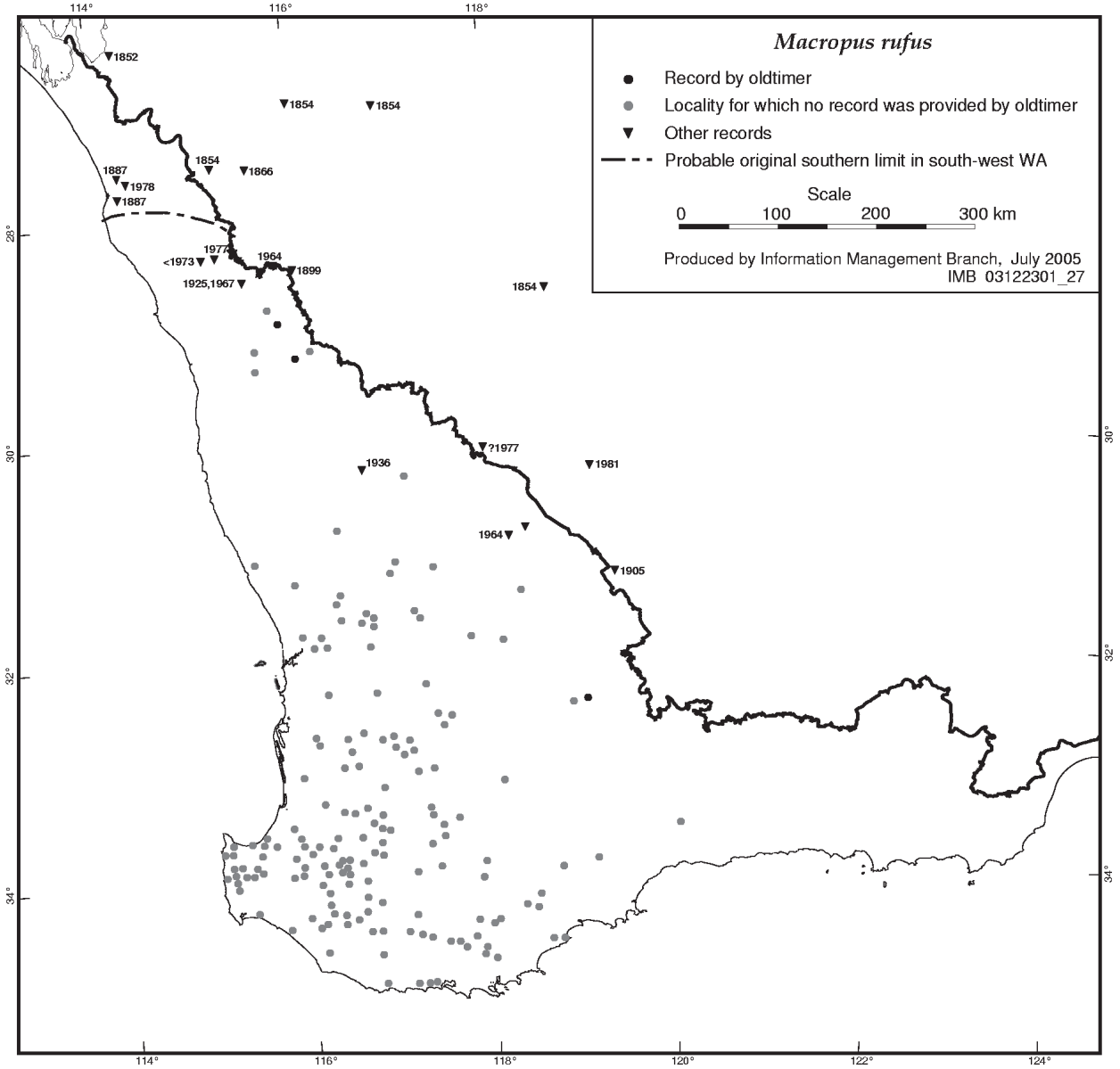

Fig. 25 Distribution of Macropus rufus. *Additional records not already cited in text: Burbidge* et al. *1978, 1980; Carter 1888; Dell and How 1985;* Fauna Bulletin*; Maddock 1987; Short 2004; Youngson and McKenzie 1977.*

in sheoak or stinkwood *(Jacksonia furcellata)* country, eating grass.

The wurrung was said to be a favoured food of Aborigines (Bird 1986: 289) and was noted as 'very good eating' by Forrest (1875: 263). The meat was 'white, something like chicken, although more like rabbit to the taste' (Webb 1944).

Very little information is available about the behaviour of this 'small and very beautiful species of kangaroo' (Austin 1855: 14). Wurrungs sunned themselves in open glades (Gilbert nd1), made a nest on the ground like the woylie (Gilbert nd3), and when chased by dogs they ran into a hollow log (Gilbert nd1; Shortridge 1910; Haddleton 1952; Knox-Thomson 1975: 26), a burrow (Shortridge 1910), or a hole at the base of a tree and climbed up inside the tree (Haddleton 1952, Leake 1962: 46). The Aborigines would then light a fire and smoke the animal out (Leake 1962). According to Bignell (1971: 10), they always ran with one paw extended, as if 'carrying something special', and were 'always in a hurry' (*The West Australian* 6.6.1925: 11).

Although the wurrung was less plentiful than the tammar (Le Soeuf 1900: 193; Shortridge 1910), it was very numerous in some localities (Thomas 1906). It was last recorded near Kellerberrin in 1894-9 (Leake 1962), near Katanning in 1900 (Haddleton 1952), at Gracefield in 1907 and Cranbrook in 1908 (Kitchener and Vicker 1981), but was still present near Aldersyde in 1903 (Knox-Thomson 1975) and c. 10 km south-west of Beverley before c. 1920 but dying out (Broun 1995 and pers. comm.; her informant, L. Bartram, was born in 1913). There is also a vague second hand report from

Jitarning district in 1925 (*The West Australian* 25.7.1925: 15).

Knox-Thomson (1975) thought that clearing of vegetation was responsible for its extinction. Abbott (2006) attributed its sudden decline to a disease outbreak. Evidence consistent with this, and not available to Abbott (2006), comes from north-east of Esperance. In 1875, when a road was being cleared between Esperance and Fraser Range, 'every thicket on the way was fairly alive' with this and other 'small' mammals. In 'a few years the animals had mysteriously and completely died out. Why?...the thickets...were silent as the grave five or six years later, there being not even a track to be seen' (*The West Australian* 25.12.1909: 5).

Seven additional variants of the Aboriginal name have come to light since the synthesis published by Abbott (2001: 472-3): *woorrong* (B. Clarkson *et al.* 1864 in Exploration Diaries **5**: 336); *warrang* (*The West Australian* 25.12.1909: 5); *warrine* (*The West Australian* 6.6.1925: 11); *warung* (Webb 1944); *Warren* (Broun 1995: 12); *wurren* (Knox-Thomson 1975: 26); and *warrun* (L. Glauert in *The Western Mail* 4.10.1928: 6).

Petrogale lateralis mooroorong/bokal/black-footed rock-wallaby

Oldtimers reported rock wallabies (Fig. 26) from granite rocks at Mokine (before 1920, T. Wilding pers. comm.) and on Kokerbin Hill, near Kwolyin (until c. 1950, P. Stone pers. comm.). Their disappearance from Kokerbin Hill (by 1970, according to Kinnear *et al.* 1988: 437) was attributed to fox predation (P. Stone pers. comm.).

In colonial times this species was known either as the rock kangaroo (J. Drummond in *The Inquirer* 1.3.1843;

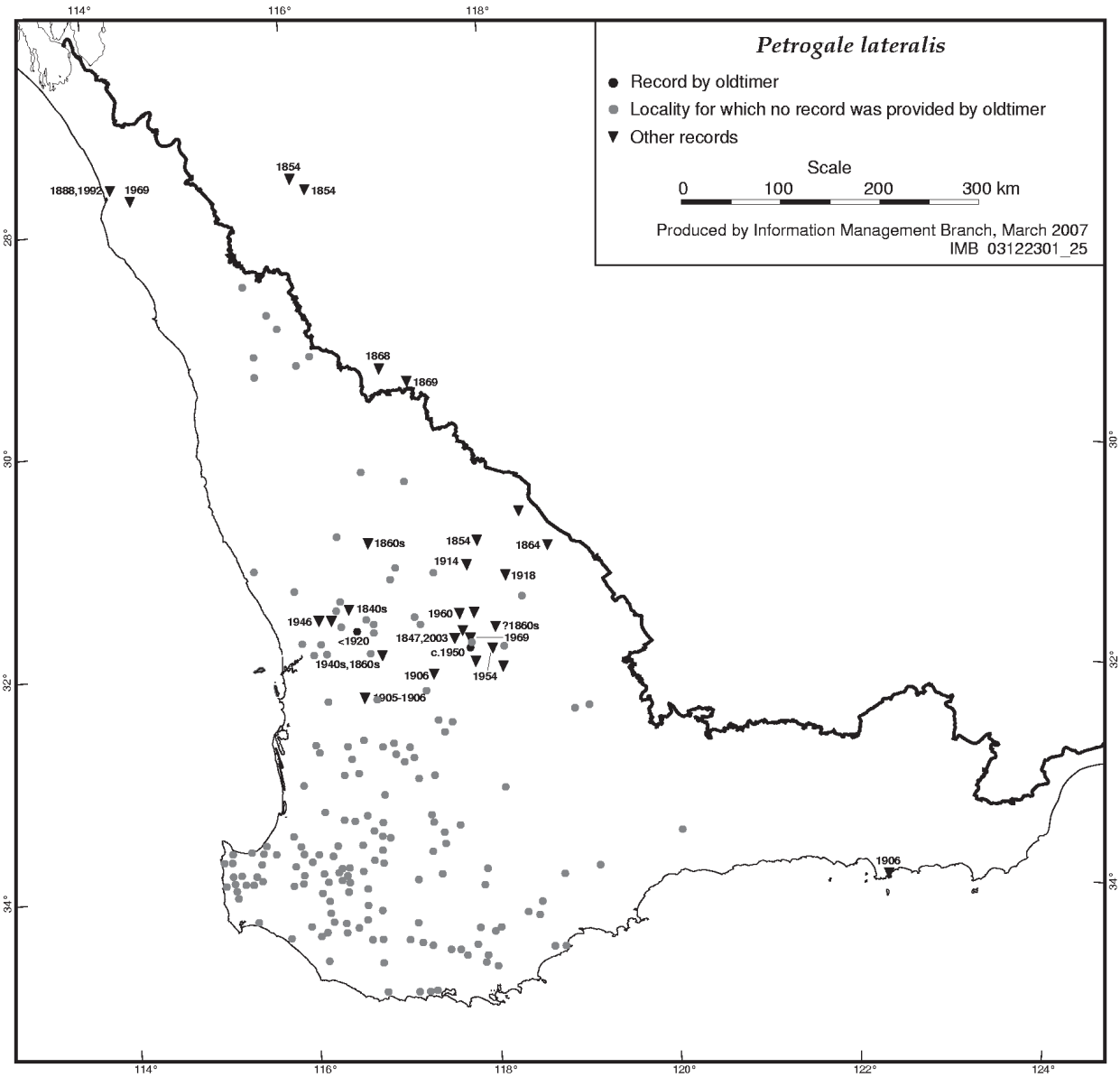

Fig. 26 Distribution of Petrogale lateralis. *Additional records not already cited in text: Bannister 1969b; AA Burbidge 1979 in WA Wildlife Authority minutes in Department of Conservation and Land Management file 006959F2006; Chitty 2004: 5;* Fisheries Department Bulletin*; Kitchener* et al. *1975; Kitchener and Vicker 1981; Law 1961; Maddock 1987.*

Austin 1855: 11, 49; B. Clarkson *et al.* 1864 in Exploration Diaries **5**: 338; Forrest 1875: 48, 63; Hunt 1864: 10; Millett 1872: 200; J. Monger and G. Monger 1868 in Exploration Diaries **6**: 220j) or by its Aboriginal name *moororong* (Abbott 2001a: 473-4; see also *Kalgoorlie Miner* 30.12.1902 for the additional variant *mooradong*). The Aboriginal name *Gunar* recorded by Gray (1837) is not a Noongar name.

Rock wallabies were common in their rather limited range in south-west WA (Gilbert nd1; Gould 1863: 231; Drummond 1847: 225; Carter 1888: 193; Shortridge 1910: 813; Ewers 1959: 99; Law 1961: 8). In 1847 there were 'thousands' inhabiting the hills centred on Mt Caroline and Mt Stirling (J. Drummond in *The Inquirer* 3.11.1847).

Doubt remains about the original extent of the geographical range of this species. Drummond explicitly stated that hills east of Mt Caroline were not inhabited (now known to be incorrect). Gilbert (nd1) noted its absence north of Toodyay (but J. and G. Monger recorded them at Goodenow Spring, thought to be near Wongan Hills) and its absence south of the 'head of the Dale River' [?Beverley]. Shortridge indicated that they were apparently present on coastal hills between Phillips River and Esperance (but J. Tunney failed to see any near Hopetoun or on the Phillips River, though he was told of a 'small black wallaby' found inland from Bremer Bay [J. Tunney letter, 4.8.1906]. This similarity in coloration to rock wallabies on islands in the Archipelago of the Recherche may have led to the attribution). The striking disjunction between its occurrence east of Esperance and Bruce Rock appears to be genuine and I question whether some of the Aboriginal names recorded by D. Bates (in Abbott 2001a: 474) are accurately localized. Insufficient information is available to resolve whether the gap in range between Toodyay and Kalbarri existed in colonial times.

The black-flanked rock wallaby lives in rocky hills with deep cavities between boulders and thus necessarily has a discontinuous distribution. In colonial times it was recorded foraging at night in patches of grass around the rocks or up to c. 300 yards from the base of rocky hills (Gilbert nd3; Leake 1962: 42). Recent molecular ecological studies have revealed that individuals can disperse 8 km between rocky hills (Eldridge *et al.* 2001).

J. Drummond (*The Inquirer* 3.11.1847) stated that, as well as eating grass, they 'feed on almost everything that comes their way – even Gastrolobium'. Since 1999, following 17 years of fox baiting, rock wallabies have increased to the extent that they have expanded their distribution and become a pest of wheat and lupin crops on farmland around Mt Caroline and Querekin (Department of Conservation and Land Management file 045948F2002V01). This presented a dilemma to the authorities, as it was not possible to issue a damage licence for a vulnerable species. Since 2001, 163 animals have been translocated to the Avon Valley (Freegard *et al.* 2004).

I have found no records that settlers shot rock wallabies for food. Millett (1872) made a large hearth-rug from several skins but noted that the soft, long and pretty fur was less durable than that of the western grey kangaroo.

Experimental studies have conclusively demonstrated that fox predation is responsible for the marked decline of this species in the period 1930-82 (Kinnear *et al.* 1988, 1998). Leake (1962) reported the ability of the fox to penetrate caves and crevices just as well as the rock wallaby.

This species has been successfully translocated to a granite rock in Bruce Rock district (Morris 2000: 67), as well as Avon Valley, Walyunga and Cape Le Grand National Parks (CALM Annual Report 2003-4: 52).

Setonix brachyurus kwoka/bangop/quokka

Oldtimer information The quokka was well known to most oldtimers in lower south-west WA (Fig. 27), with their observations defining its range as from Gingin Brook south and east to Sawyers Valley [Greystones Pine Plantation], Wuraming, Buckingham, Deeside on Yerraminup River, Perup River, Kent River c. 10 miles south of Muir Highway, north-east of Porongurup Range, and Warriup.

Within most of this geographical range the species was considered to be common and widely distributed in thickets and swamps and along coastal creeks. Many oldtimers described their pads and tunnels in swamp vegetation. Near Dwellingup, Bridgetown, Middlesex and Pemberton their runways went up the hills from the creeks (T. Birmingham, L. Court, B. Hanekamp, K. Smith pers. comm.).

In the early days quokkas were shot (or caught by hunting dogs) for sport and food. They were considered to be 'good eating', with a taste similar to that of the western grey kangaroo (J. Sobott pers. comm.). They were also snared for skins and food (T. Birmingham pers. comm.), fed to dogs (S. Garstone pers. comm.) and were stated to be the easiest of the macropods to catch, as dogs simply chased them out of swamps (G. Dunn, L. Torrent pers. comm.).

Several oldtimers noted that quokkas were becoming scarce before the fox became common. During 1930-5, E. West of Cowaramup recalled noticing orange spongey material on the belly, which he attributed to disease. Some oldtimers noted sudden declines in the late 1920s (F. Brockman), early 1930s (A. Muir), c. 1932 (L. Cluett), 1934 or 1935 (A. Taylor), 1934 (C. Armstrong), c. 1935 (T. Birmingham, L. Butterly, E. West), late 1930s/early 1940s (B. Nilsson), 1940 (F. Bamess, C. Mitchell), 1940-5 (A. McEvoy), or undated (J. Muir). A. Muir attributed this decline to disease. In 1931 at Middlesex, quokkas were affected by disease, as they moved in circles until they died (B. Hanekamp). In the mid 1930s, quokkas with eyes puffed up and ears and noses running were reported at the Donnelly River near Peerabeelup (L. Scott). Many sick and dead animals were seen in Grasmere district between 1934 and 1936. Hair could be easily pulled out and pus was present between the inner and outer layers of skin, as well as in the nose (A. Taylor). Other oldtimers attributed the decline of the quokka to the fox (F. Bamess, D. Blythe, R. Brockman, A. Dawson, C. Mitchell, L. Warner).

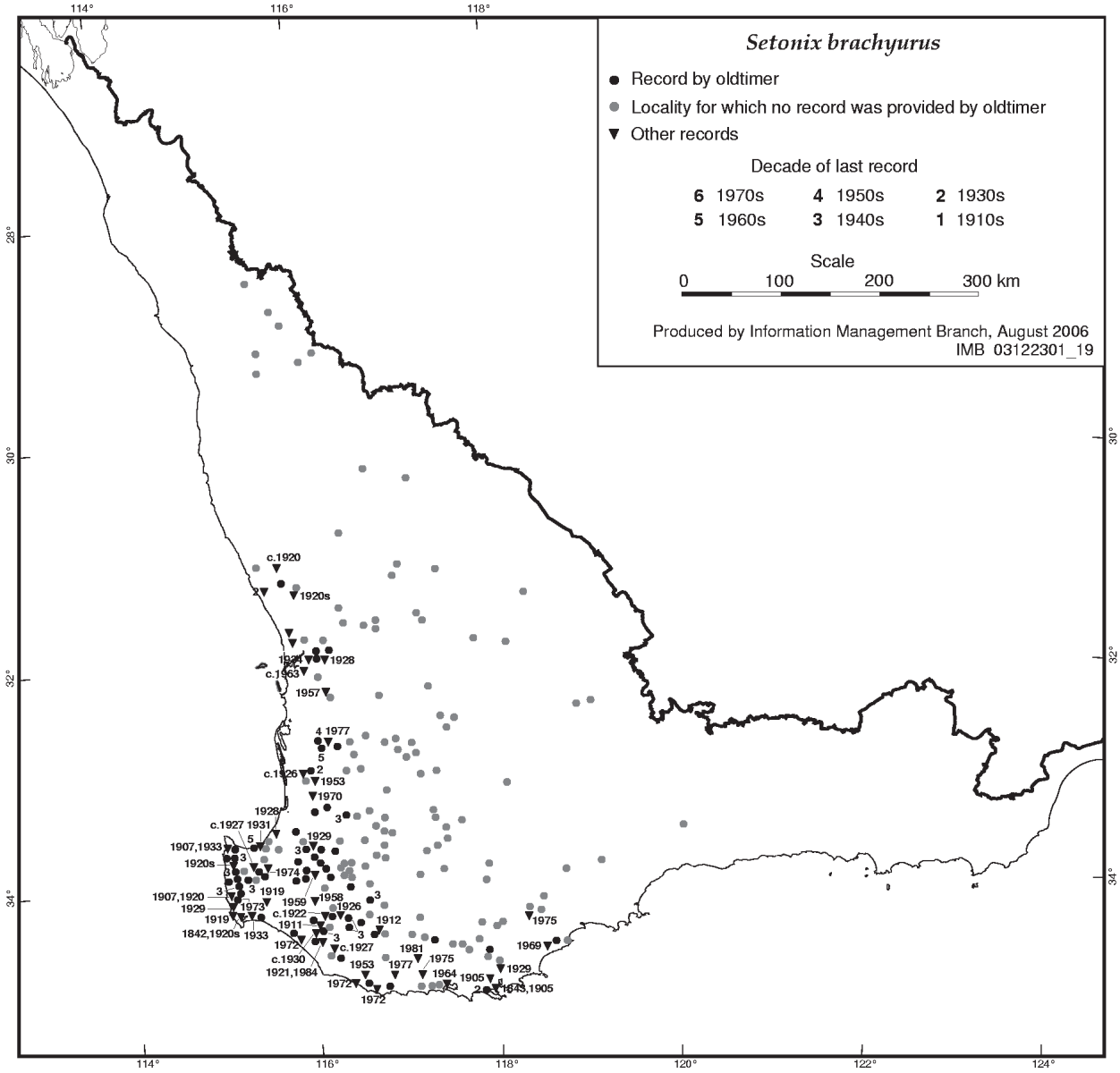

Fig. 27 Distribution of Setonix brachyurus. *Additional records not already cited in text: Department of Conservation and Land Management files 022693F3807, 015096F3803 vol. 2; Fisher 1992;* Fisheries Department Bulletin*; Department of Fisheries and Wildlife file 65/50; Forests Department 1928; Kirke 1983; Kitchener and Vicker 1981; Prince 1981; Southcombe 1988; Stewart nd;* The Western Mail *21.2.1929: 48; Wootton and Jacob 1992.*

Quokkas were a pest of garden crops (M. Burrows, Lew Scott, W. Young), young pine trees in plantations (R. Gray, D. Perry), and orchards (L. Cluett). Those in pine plantations were trapped or poisoned with strychnine (T. Ball, R. Gray).

Distribution and abundance The association of this species with swamps was first recorded by Gilbert (nd1, nd3) at Augusta and Albany. He did not collect any specimens near Perth or Fremantle but was told by Aborigines that they seldom saw the species near these localities. Moore (1842) noted that this species 'is now rarely if ever found' on the coastal plain near Perth. In 1904-7 quokkas were also recorded in coastal thickets and swamps (Shortridge 1910: 813). Neither Gilbert nor Shortridge collected this species inland (i.e. at Wongan Hills, Avon Valley, Arthur River), nor was it mentioned by Haddleton (1952) as occurring near Katanning. It was evidently absent from Balgarup, near Kojonup (*The Western Mail* 1.11.1923: 4). The quokka was not known closer than c. 40 miles to Gracefield, according to Tunney (letter, 3.11.1911). An Aboriginal name for this species collected by D. Bates (Abbott 2001a: 475) probably relates to the lower section of the Moore River, possibly near Guilderton (de Burgh 1976: 187).

In the 1890s quokkas were plentiful in thickets in valleys in jarrah forest and in swamps on the Swan Coastal Plain near Rockingham and Mandurah (H. Tuckey WAPD **126**: 1271, 18.10.1950). Quokkas were abundant in

gullies around Bridgetown in the 1890s-1900s (RE Doust 1966 in Fisheries Department file 51/55) and very numerous in coastal country at Margaret River in the early 1900s (W. Loaring in White 1952). In 1905 this species occurred in swarms around Albany and was considered to be the only plentiful native mammal species in the district (G. Shortridge letter, 24.4.1905). East of Mundaring Weir quokkas were abundant in the 1920s in dense low vegetation, mainly around swamps and along creeks, from the valley of the Helena River east to its junction with the Darkin River (Perry 1973: 28).

The visiting collector C. Hoy in 1920 considered that the quokka near Margaret River was not rare but simply seldom seen because of its nocturnal activity and its habitat of thick vegetation in swamps (Short and Calaby 2001: 543, 549). In 1919 this species was frequently seen and was numerous in the Blackwood Valley between Darradup and Augusta (Perry 1971: 47), and was plentiful in gullies near Bickley in the 1920s (W. Loaring in White 1952). At Barronhurst near Pemberton it was numerous in 1921 and there were beaten tracks criss-crossing over the hills and down through the gullies (Fox 1994: 71). At 'Warren River' in the early 1920s it was considered 'fairly numerous' (*The Western Mail* 16.4.1925: 3), and in 1927 runways (evidently of this species) were found throughout coastal vegetation near Deep River (*The West Australian* 5.11.1927: 7).

A significant indicator of high abundance is the familiarity of settlers with the species, evidenced by widespread use of the Noongar name. Bush folk knew and used the Noongar name, although it was spelled in a bewildering array of homophonic variants (see also Abbott 2001a: 474-6): *cwagga* (J. Hackett WAPD **43**: 1338, 28.8.1912); *kwagga* (Milligan 1901: 68); *quokker* (Lowrie nd: 23-4); *quaka* (Anon. 1892a: 144; *The Western Mail* 29.4.1926: 32); *quacker* or *quagger* (*The Western Mail* 1.11.1923: 6); *quarka* (*The Western Mail* 16.4.1925: 3); *quorker* (*The Western Mail* 14.5.1925: 1); *quagga* (M. Troy WAPD **72**: 1428, 20.10.1925; Fisheries Department files 23/29, 56/21); and *quogga* (LN Weston 1921 in Fisheries Department file 56/21; J. Drew WAPD **73**: 2233, 26.11.1925; Nicholls 1926: 70; Drake-Brockman 1960: 23). The modern spelling *(quokka)* was first used by the zoologist Shortridge (1910).

Before Europeans settled, the major predators of the quokka were Aborigines, wedge-tailed eagles and dingoes. Aborigines killed many quokkas by firing the vegetation and spearing them as they fled (Gilbert 1843 in Wagstaffe and Rutherford 1955: 12). Predation by wedge-tailed eagles was observed at Barlee Brook in c. 1912 (Fyfe nd: 29) and near Margaret River in c. 1913-15 (L. Glauert in *The Western Mail* 6.12.1928: 28; see also Glauert 1929).

Interactions with humans Another indicator of the early abundance of the quokka is the numerous accounts of it as a local pest. These records are arranged chronologically and all refer to quokkas in the original documents unless stated otherwise:

- 1893, Nanarup, wire netting erected around drained swamp land on which potatoes were grown, to exclude 'wallaby' (Piggott 2004: 30).
- 1907, Mullalyup, 'boodies' [?misidentified quokkas] came from a swamp into an adjoining orchard and damaged trees (*The Western Mail* 23.2.1907: 8).
- 1910, Capel, 'tammas' [misidentified quokkas] ate bark and broke branches of small apple trees (*The Western Mail* 4.6.1910: 8).
- c. 1920, Augusta, Denmark and Manjimup, 'wallabies' frustrated attempts to grow potatoes and other vegetables and ring-barked fruit trees in summer (Glauert 1921: 113-4); 'wallabies' were declared vermin in Balingup Road Board district (*Government Gazette* 6.1.1922: 2) as were tammar in Denmark Vermin Board district (*Government Gazette* 11.8.1922: 1435). These gazettals probably refer to quokkas.
- 1920s, Cowaramup Group Settlement No. 20, nightly depredations discouraging (Blond 1987: 59)
- c. 1925, Fly Brook, West Pemberton Group Settlement No. 89, attacking vegetables (French 1989: 19).
- c. 1926, Nornalup, 'wallabies' in vegetable garden, ring-barked fruit trees in orchard, and ate fodder crops and pasture (Bellanger 1980: 20, 53).
- 1927, Group Settlement No. 138, 40 miles west of Denmark, garden eaten off (Burton 1975: 1).
- c. 1927, Northcliffe, new seeding of grass and clover eaten (Daubney 2001a: 143).
- 1927-9, pine plantations east of Mundaring Weir, eating bark of 2-5 year old pine trees and killing them (Forests Department 1928: 16, 1929: 7; L. Glauert in *The Western Mail* 30.5.1929: 48).
- c. 1929, Napier, 'wallabies' stripped bark off young apple trees (Whittem 2000: 124).
- 1920s and 1930s, Forrestdale Lake, feeding on young sown green feed (Giblett 2006: 69).
- 1930, near Metricup, vegetable garden had to be fenced (Lowrie nd: 24).
- 1931, Pemberton, 'wallabies' ate potatoes and other vegetables (Gabbedy 1988 vol. 2: 482).
- 1932, Big Brook, damaging young pines where not rabbit netted (Stewart 1936; nd: 11).
- 1933, Albany Vermin district, 'Quokkas' or 'Short Tailed Wallabies' declared vermin (*Government Gazette* 11.8.1933: 1162).

Rural people in localities such as Balgarup, Warren River and Gnowangerup in the 1920s equated the term 'wallaby' to the quokka (*The Western Mail* 1.11.1923: 6, including an accurate description of the species; 16.4.1925: 3; 14.5.1925: 1). In that period the brush wallaby was always known as the brush kangaroo. It is therefore likely that advertisements for wallaby-proof netting (e.g. *The Western Mail* 21.7.1927: 37; *The Westralian Farmers' Gazette* 29.1.1930: 14) refer to the quokka.

An additional indicator of the abundance of the quokka until the 1930s is the frequent reference to them

being hunted by settlers (Gilbert in Gould 1863 and Wagstaffe and Rutherford 1955: 12; Drake-Brockman 1960: 23; Blond 1987: 60; Cresswell 1989: 193; Daubney 2001a: 115; de Tores *et al.* 2007), in particular for food (White 1952; Burton 1975: 4; Bellanger 1980: 53; Lowrie nd: 23) or their skins (Bellanger 1980: 53; Fox 1994: 71; Owens 1994: 63; Daubney 2001b: 80; Fisheries Department file 23/29). Dogs and guns (White 1952; Drake-Brockman 1960: 23) or snares (White 1952; Fox 1994: 71) were used. Quokkas had a different flavour from the brush-tailed possum (Cresswell 1989: 193), and according to W. Loaring (in White 1952) were excellent eating. The visiting botanist W. Harvey noted in 1854 that it was 'not unlike a rabbit in taste' (Ducker 1988: 121).

No records of the annual harvest of quokka skins have been found. The highest prices paid for skins were in the years 1928-9 and 1947 (Fig. 20). The royalty paid to Government was only ½ d per skin (*Government Gazette* 20.3.1914: 1414). After the quokka was fully protected from July 1952, its skins could no longer be sold legally.

The only record found of this species being kept as a pet came from Rottnest Island, in 1854 (Ducker 1988: 121).

Decline The geographical range of the quokka has contracted, as it no longer occurs on the Swan Coastal Plain. Its disappearance from the northern extremity of its range (Gingin Brook-Beermullah) has been variously dated at: after 1901 (by E. Horan, b. 1879), c. 1915-20 (by S. Fraser, b. 1895), c. 1920 (by E. Harris, b. 1920), and after 1927-8 (by A. Edgar, b. 1898) [Roe and Roe 1992]. Of these, only E. Horan offered an explanation – rabbit poison (see also Udell 1979: 228). de Tores *et al.* (2007) provide a detailed analysis of the contraction in geographical range.

The quokka gradually disappeared from Nornalup district in the early 1930s, but persisted in the national park (Bellanger 1980: 53). This species was said to have been last sighted at Scott River in 1933 (Cresswell 1989: 193). After c. 1927 their numbers were reduced by foxes, which used quokka pads to gain access to their thickets (Daubney 2001a: 13). Quokkas 'seemed to die out suddenly everywhere' in Napier district, presumably in the 1930s (Whittem 2000: 271). In 1950 the quokka was removed from the third schedule of the Vermin Act (1918), under which it had previously been listed as vermin in Albany, Balingup and Denmark districts (In these last two districts as 'wallabies') (*Government Gazette* 27.10.1950: 2422). By 1955 it no longer presented a problem with the establishment of pine plantations (AJ Milesi in Anon. 1955: 9-10).

Elsewhere the quokka remains widespread but is now only locally common in the lower south-west sector of its range, occurring in riparian areas in karri forest and in tea tree thickets on the upper reaches of creeks in jarrah forest (Christensen *et al.* 1985: 18). In the northern jarrah forest the quokka probably originally occurred as a metapopulation, in which dispersal between suitable habitat took place frequently (Hayward *et al.* 2004). At one stage it was thought that the quokka was extinct on the mainland (*The West Australian* 17.4.1957: 5). This newspaper article elicited a report for the swampy headwaters of Manjedal Brook, and this was confirmed by scientists (Barker *et al.* 1957).

Dead bodies of 'wallabies' in gullies around Bridgetown, apparently the result of disease, were noted in the early 1900s by RE Doust (1966 in Fisheries Department file 51/55). Dead quokkas, seen along the Warren River in 1921 and around Northcliffe in the early 1920s were attributed to a disease outbreak (LN Weston 1921 in Fisheries Department file 56/21; G. Gardner in How *et al.* 1987: 565). Tammars [?quokkas] 'seemed to die out' in c. 1928 at Warren River (Muir 2006: 17). The fox had not yet arrived at these localities. Many deaths at Yallingup were also thought to have resulted from disease ('Mr' Dawson 1933 in Fisheries Department file 56/21). At Canal Rocks (near Yallingup) they declined suddenly between 1933 and 1937 and then became extinct there 'within a few years' (White 1952). Foxes caught quokkas by entering thickets via the pads made by quokkas (Daubney 2001a: 13). Earlier, Stewart (1936) noted that quokkas were more abundant in karri regrowth than in oldgrowth karri forest; he attributed this difference to the thick cover protecting quokkas from predation by dingoes and foxes.

The quokka had died out in valleys in jarrah forest and in swamp land on the coastal plain near Rockingham and Mandurah before 1950. 'This has not been brought out by shooting…but may have been caused by disease…' (H. Tuckey WAPD **126**: 1271, 18.10.1950). White (1952) acknowledged the bushman's view that the rapid decline of the quokka in c. 1937-40 resulted from disease, supplemented by the fox, rabbit, fire and habitat destruction. A 'catastrophic collapse of populations' during the period 1938-44 was attributed to disease (Perry 1973: 128).

Explaining the pattern of disappearance of the quokka is not straightforward. Swamps on farms would have been cleared of their vegetation for potato-growing and such habitat destruction would have caused local extinction of any quokkas present. Outbreaks of disease caused periodic reductions in some local populations but probably did not cause any extinctions. The laying of poison baits to kill animals eating garden produce may also have extirpated some populations on farms. The fox, however, has probably been the most persistent and widespread threat. It has taken many decades for its cumulative impact to have become significant, probably because the thick vegetation in swamps has impeded opportunities for sustained predation by foxes. It also seems logical that disturbances such as high intensity wildfires (burning out entire swamps) and logging or roading activities close to isolated swamps may have facilitated predation by foxes (de Tores *et al.* 2007).

Trapping of quokkas before and after burning of *Agonis* swamps in jarrah forest near Dwellingup demonstrated that habitat in a totally burnt swamp did not become suitable for c. 5 years, whereas in a patchily burnt swamp quokkas were abundant as soon as one month after the fire. Quokkas were no longer present in a

swamp that had not been burnt for 15 years (Christensen and Kimber 1975: 98). Subsequent studies of *Agonis* swamps in the northern jarrah forest have confirmed that the presence of quokkas is associated with effective fox control and a mosaic of recently burnt vegetation, producing nutritious food but not improved shelter, and not recently burnt vegetation, providing shelter (de Tores *et al.* 2004; Hayward *et al.* 2007).

Trichosurus vulpecula koomal/common brushtail possum

Oldtimer information Few oldtimers did not know the koomal, probably because of its ready association with humans to the extent of being a nuisance (e.g. living under roofs and thus leaving urinal stains on ceilings; living in hay sheds on farms; eating the pulp of oranges; eating apples in orchards and apples in storage sheds; stripping buds from cherry trees and the terminal shoots of grape vines; and eating lettuces and cucumbers).

Possums were recorded eating foliage (and occasionally blossom) of flooded gum *Eucalyptus rudis*, York gum, wandoo, jam, 'tingle' and peppermint *Agonis flexuosa*. Possums could jump from tree to tree (H. Moyes pers. comm.). Opinion as to their suitability as food for humans seemed divided: They were considered 'good eating', especially those ¾ grown (K. Smith pers. comm.); 'tastier than rabbit' (A. Muir pers. comm.); or 'not tasty meat' (E. Shanhun pers. comm.).

Most oldtimers at some time had snared this species, particularly during the Great Depression when its pelt provided an important income supplement. Possums were also shot at night when silhouetted against a full moon. The skins were collected by buyers and used to make rugs and coats. The usual pelage colour was grey, with black possums occurring at a frequency of c. 1/60 (L. Avery pers. comm.). During the 1920s-30s skins were worth £3, £3-4 or £4-5 per dozen (W. Chitty, C. Mitchell, L. Avery pers. comm.). During the Great Depression one dozen black skins was worth £20 (C. Tozer pers. comm.).

Several oldtimers drew my attention to an early decline which they attributed to an outbreak of disease:

- Many skeletons of possums found in hollows in trees in 1903 when woodland on farms in Wickepin district was being cleared for the cultivation of wheat (Father of H. Hall, H. Hall pers. comm.).
- Disappeared from Kulikup district in the 1920s because of disease. Possums were abundant in 1908 when settlement took place (Father of J. Torrie, J. Torrie pers. comm.).
- Dying possums noted in 1931 near Shannon and possums around Deeside unable to climb trees in the early 1930s (A. Muir pers. comm.).
- Dead possums and possums too weak to climb trees found in forest near Pemberton at the end of the 1930s (F. Bamess pers. comm.).
- Sick and dead possums between 1934 and 1937 near Grasmere. When grabbed, the hair pulled out and pus was present between the inner and outer layers of skin, and also in the nose. Few possums in the bush survived, whereas those living in sheds and on farms persisted (A. Taylor pers. comm.).
- Possums with sores on the belly and running eyes and noses in Nannup district in the early 1940s, resulting in local populations being wiped out (F. Brockman pers. comm.).

Most oldtimers stated that this species was once very common and was now very scarce. Up to c. 1930 every large marri tree had possum scratch marks on the bole (W. Young pers. comm.). Other factors cited to explain this decline include fox predation and trapping.

Distribution, habitat and food The koomal probably originally occurred throughout the entire south-west region of WA (Fig. 28), although Aborigines reported (erroneously) in 1843 that none occurred east of Lake Dumbleyung (H. Landor and H. Lefroy in Exploration Diaries **3**: 735). This species was found very generally in those parts of the region traversed in the late 1830s-early 1840s (Gilbert nd3; Whittell 1954b: 111). However, near Augusta in 1831 it was reported as 'a rarity' (J. Bussell in Shann 1926: 93).

Possums lived chiefly in 'lofty and thick woods' around Albany (Nind 1831: 32) and were mostly seen in 'the Gum trees' (Gilbert nd3). They utilized hollows in a wide range of eucalypt species: wandoo (Haddleton 1952: 103; Sampson 1971; Pustkuchen 1981: 32); marri (Thomas 1906: 475; E. Horan in Roe and Roe 1992); morrell (Repton 1999: 307); jarrah (Inions *et al.* 1989), and tuart *Eucalyptus gomphocephala* (Jones and Hillcox 1995). They also used holes in the ground (Gilbert nd1, Shortridge 1910: 831, *The West Australian* 26.9.1925: 11), hollow logs on the ground (Gilbert nd1); caves (C. Hoy, 1920 in Short and Calaby 2001: 543), boodie burrows (W. Edwards in *The Western Mail* 18.7.1929: 37), dalgyte warrens (*The West Australian* 5.9.1925: 11); rabbit warrens (S. Lilford 1932 in *Our Rural Magazine* **7**, 340; J. Smith 1933 ibid. **8**, 230; Aitken 1954: 139), as well as under rocks (Sampson 1971). The 'ground possum' was described either as longer in body, with shorter legs and brownish fur on the legs compared to the usual form, or with very red fur underneath (*The West Australian* 3.7.1926: 9, 17.7.1926: 8).

There are surprisingly few early records of the food of possums. Gilbert (in Whittell 1954b) recorded feeding at night on 'tender shoots' of the upper branches of eucalypts, and C. Piesse (WAPD **46**: 783, 27.8.1913) reported feeding on the young growth of eucalypts. The flowers of jam were a 'favourite food' as they made the animals fat (Hassell 1975: 19), as did the flowers of marri (Ferrell 1992: 54-5). Possums also fed on York Road poison (Spencer 1966: 76). Unexpectedly, no records of feeding on mistletoe were found (cf. Reid 1997), although Chitty (2004: 70) stated that possums in the early 1900s kept mistletoe under control.

The method used by the wedge-tailed eagle (at least in Victoria) to detect this species in a hollow in a tree was described in detail by Hannaford (1860: 30).

Aboriginal use The koomal was an important component of the diet of Noongars (*The Perth Gazette*

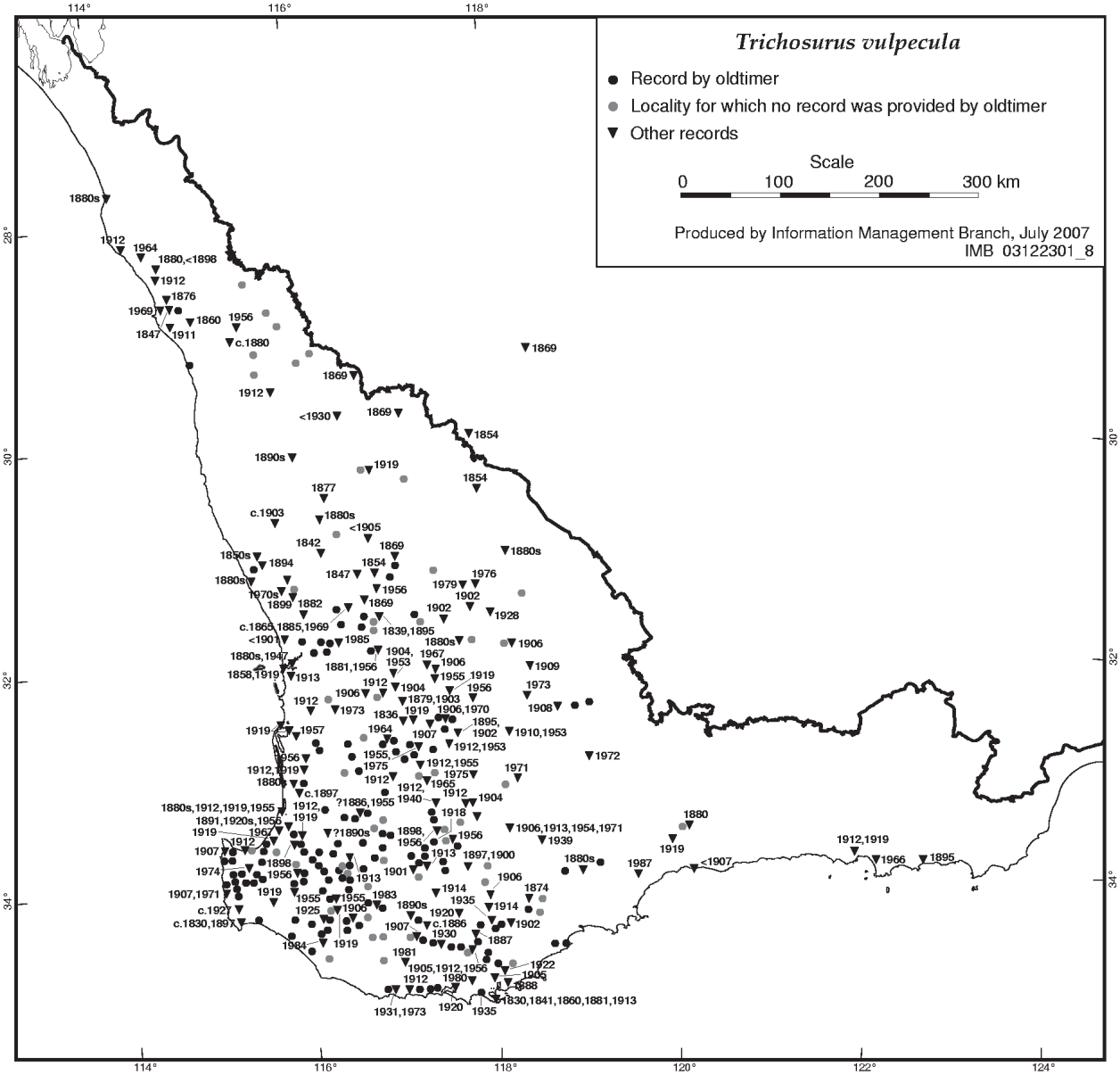

Fig. 28 Distribution of Trichosurus vulpecula. *Additional records not already cited in text: Abbott 1998b; Anon. 1947; Bannister 1969a; Bignell 1977, 1997; Carter 1923; Chapman 1995; Chapman and Kitchener 1978; Chase and Krantz 1995; Clemens 2000; de Burgh 1976; Fisher 1992; Flynn 2002; Forrest 1875; Frost 1976; Hill 1903; Jennings 1983; Keefe 1995; Kitchener and Chapman 1976, 1977, 1978; Kitchener and Vicker 1981; Kitchener* et al. *1975, 1980; Klemm nd; McKenzie* et al. *1973; AW Milligan in* Morning Herald *16.10.1902: 6; Morris and Kitchener 1979; S. Norrington pers. comm.; O'Connor 2001; Perry 1971; Royal Commission 1901; Stranger nd: 126;* The Western Mail *16.1.1930: 36, 6.4.1939: 10; Thomas 1999.*

5.7.1834, 28. 5.1842; G. Moore 1836 in Exploration Diaries **2**: 383; Austin 1855: 6; *The Western Mail* 28.9.1907: 6, 26.10.1907: 8; cf. Krefft 1866: 17), being easier to capture and thus a more reliable source of food than the western grey kangaroo or emu (Bignell 1971: 11). Nind (1831: 32) stated that it was frequently hunted with dingoes by moonlight, being speared presumably on the ground or on the limb of a tree, or jabbed when in a tree hollow. Sometimes a hole was then made so as to insert a torch of burning leaves, forcing the animal to leave the hollow. Most descriptions of the hunting of possums (see Meagher 1974: 17) refer to this as a diurnal activity. Sometimes the possum was extracted from a hollow bole once a hole was made with the stone-hatchet (Stormon 1977: 156).

Trees in use by possums were detected by the *warda*, scratch marks or fresh particles of sand left by the claws on the bark (Nind 1831: 32; Moore 1842: 73; F. Armstrong in *The Perth Gazette* 5.11.1836: 793; R. Salvado, late 1840s in Stormon 1977: 155-6; Armstrong 1871; Smyth 1878: 248). Wet weather facilitated the observability of these marks on the bark (Stormon 1977: 156; Buchanan 2003: 95).

There are numerous descriptions of *dendang*, the

method used by Aborigines to climb trees (Bradshaw 1857: 99; Moore 1842: 19; Smyth 1878: 245; Cleland 1890: 155-156; *The Western Mail* 4.11.1926: 1; Leake 1962: 49; Bignell 1971: 3-4; Hassell 1975: 15; Stormon 1977: 148, 156; Ferrell 1992: 2), as well as records by explorers and early settlers of notched trees (J. Roe 1835 in Shoobert 2005: 472; H. Bunbury 1836 in Exploration Diaries **2**: 416; Haddleton 1952: 103; Ackland 1965: 104). The presence of a possum in a hollow in a tree was confirmed by the Aboriginal poking a stick into the hollow and sniffing it (Bignell 1971: 11; N. McKail in *The Western Mail* 8.4.1926: 4) or detecting a small piece of fur on the stick (Stormon 1977: 156). As noted by Glauert (*The Western Mail* 25.4.1929: 48), their tracks on trees indicate that possums spend time on the ground. Possums were sometimes burnt out of their tree hollows (H. Bunbury 1836 in Exploration Diaries **2**: 416; G. Moore 1839 in Cameron 2006: 469; Bradshaw 1857: 99).

The statement by Erickson (1974: 3) that the flesh of possums was not attractive to, and was not greatly prized by, Aborigines is contradicted by the wealth of evidence presented above.

Aborigines also used possum fur to make: the *nulbarn, cut-a-by* or *Dhutie*, a rope-like girdle worn around the waist and which held the stone-edged knife, boomerang, and stone hammer-hatchet (Moore 1842: 62; Austin 1855: 6; Browne 1856: 535; Melbourne International Exhibition 1880: 17, 19, 20; Curr 1886 vol. 1: 328; Roth 1903: 65; Hassell 1975: 13; Sanders 1975: 101; Stormon 1977: 143); the *kunyi*, a band worn round the head (Moore 1842: 46; Roth 1903: 64; Jenkyn 1999: 14; Stormon 1977: 141); the *woortill*, *bururo*, or *nool-u-wana*, a neckband (Nind 1831; 25; Moore 1842: 16; Melbourne International Exhibition 1880: 16); the *yatto*, with the tail worn as an ornament on the head or hanging from the hair (Moore 1842: 82; Curr 1886 vol. 1: 337); an armband (Roth 1903: 64; Stormon 1977: 143); a bag to hold red earth in paint (G. Moore 1832 in Cameron 2006: 125); the roof of huts (Austin 1855: 16); a rug beaten like a drum by women during the corroboree (Pasco 1897: 136); and string (Roth 1903: 67).

None of the first contact sources from south-west WA mention Aborigines wearing cloaks made from possum skins, in contrast to numerous records from South Australia (G. Taplin in Woods 1879: 79; Yelland 1970: 79), Victoria (Haygarth 1864: 105; Lee 1915: 109; Curr 1883: 48), and New South Wales (Macquarie 1815: 97; Henderson 1851 vol. 2: 9, 105-6, 152). Only four references were found of Aborigines in south-west WA wearing a possum skin rug as an overcoat: from the 1830s (Irwin 1835: 23), early 1840s (Anon. 1842: 109), 1880s (Cleland 1890: 154), and 1890s (Sellick 1997: 191-3). Possum skins were also used by Aborigines to wrap up neonates (Stormon 1977: 136).

Aborigines also used the fat collected from a possum to dress the hair on the head (Stormon 1977: 141). The front tooth of the possum was used in making and carving weapons (Curr 1886 vol. 1: 337). By the 1880s the koomal was an important source of wealth to Aborigines, supplying them with nutritious meat, comfortable clothing and bedding, and the surplus skins being sold for money (*The West Australian* 18.4.1888).

Settlers' use Koomal were common enough to be important as food, sport, companions, pests, and fur products in the life of European settlers, particularly those who were under-capitalized. Until c. 1950, they were known as opossums, a name misapplied from the Algonquian tribe of Virginia (*Oxford English Dictionary*).

• Food

Possum meat was not so tender as rabbit but very good (G. Moore 1832 in Cameron 2006: 141), was 'vile eating' (G. Moore 1835 in Cameron 2006: 378), or had a strong aromatic taste (H. Bunbury 1836-7 in Bunbury and Morrell 1930: 88). 'There is no tastier meal than a fat possum' [compared to a kangaroo or duck] (Anon. 1999: 354); 'They were really good eating' (Muir 2006: 39). In 1921, near Pemberton, possum was only eaten occasionally, after soaking in water overnight in order to remove the gumleaf taste (Fox 1994: 46). Possums were eaten by starving immigrant farmers as late as the 1920s/1930s (Burton 1975: 4; Gabbedy 1988 vol. 2: 506; Cresswell 1989: 193; Lathwell 2001: 226).

• Sport

Possums were also shot for 'sport' (and for their skins), with the earliest record found from 1853. Shooting of possums seems to have been a rite of passage for boys (F. Wittenoom, c. 1866 in Lefroy 2003: 3; 1870s, Lefroy 1941: 3). Hunting was done by moonlight when the possum, sitting on a branch with its tail hanging down, could easily be seen in silhouette (Anon. 1999: 347; Brassey 1889: 245; A. Wood 1877 in Broad and Broad 1992: 192; Carter 1987: 65; Erickson 1974: 255; Erickson 1983: 53-54; Schorer 1974: 229; Shortridge 1910: 831; Taunton 1903: 20; *The Eastern Districts Chronicle* 2.8.1879: 2). This activity was known as 'mooning' (M. Gath pers. comm.; cf. Macdonald nd: 182; Neville-Rolfe nd: 94; Froggatt 1904: 932). Alternatively, a dog was used (on moonlit nights) to discover a possum feeding on the ground. Once disturbed, the possum ascended a tree (Carter 1987: 65; FJ Hardey 1919 in Fisheries Deaprtment file 34/32; Schorer 1974: 229). Evidently shooting involved some waste, as T. Carter noted dead possums remaining suspended by the tail from a branch and thus inaccessible (Carter 1987: 65). Carcasses were fed to the dogs (Erickson 1983: 54; Ewers 1959: 97).

• Pets

Several records, nearly all from the 1840s-60s, were found of possums kept as pets (Battye 1924: 461; Buchanan 2003: 9; Erickson 1983: 53; Pustkuchen 1981: 32; Sellick 1997: 106; Stormon 1977: 190-1; Williams 1984: 44). A possum was kept in a house in South Perth in the 1920s (Hungerford 2003: 11, 114).

• Pests

The koomal also became a nuisance to settlers, with the earliest records found coming from Deeside in 1874 (apples knocked down, Muir Diaries 21.1.1874), York district in 1879 ('destructive', 'the extent of injuries to vegetation which they inflict', *The Eastern Districts Chronicle* 6.9.1879: 3), Brookton district in the 1870s (eating grapes, *The West Australian* 3.7.1926: 9), and Candyup in 1888 (possums 'fattened splendidly in the white man's orchard', *The Australian Advertiser* 30.7.1888). In 1895 possums in vine and fruit growing areas were regarded as vermin (Clairs 1895; Woodward 1895), but farmers felt that there was no need for any bonus for their destruction because their skins could be sold and their meat eaten (Gell 1895; Hungerford 1895). Apples were eaten in Narrogin district (Pustkuchen 1981: 32) and damage to orchards and cereal crops was recorded in Bunbury district (Lindley-Cowen 1897: 33). Possums were considered 'troublesome' in Katanning district and 'a nuisance' in many parts of Broomehill district (Lindley-Cowen 1897: 132, 144). Possums destroyed wheat crops near Pingelly and were poisoned with strychnine baits (*The Western Mail* 27.7.1907: 7). Possums were recorded as damaging fruit trees and vines at Wagin in 1913 (C. Piesse WAPD **46**: 783, 27.8.1913), damaging apples stored in sheds at Harvey in 1919 (R. Hayward 1919 in Fisheries Department file 34/32), eating garden plants (Burton 1975: 1), damaging garden plants and entering houses from Kings Park (*The West Australian* 8.12.1928: 8), eating fruit in an orchard at Quairading (*The Western Mail* 22.7.1937: 49), tearing off thin bark near the crowns of pine trees at Ludlow in 1958 without causing 'serious damage' (Fisheries Department file 29/24), defoliating apple trees at Kirup in 1965, ringbarking citrus trees at Roleystone in 1966, damaging orchards at Pickering Brook in 1968 and at Cowaramup in 1972, and damaging grape vines near Busselton and Cowaramup in 1971 (Department of Fisheries and Fauna file 51/55).

There is a record of a possum entering a tent and eating jam (Webb 1944: 123).

There were numerous records of possums producing urine stains on ceilings and making noise at night in metropolitan and rural areas from 1942-71 (Department of Conservation and Land Management file 014698F3502). Such damage was also noted by Glauert (1933), Pustkuchen (1981: 32) and Hungerford (2003: 127).

No record of possums killing chickens in WA was found (cf. *Victorian Naturalist* **52**, 118, 1935).

• Pelts

The skins of this species were probably always used by settlers to make rugs and coats for domestic use (Knight 1870: 47; Erickson 1983: 54; Buchanan 2000: 99; Mann 2006: 299, 478). There are numerous references for the years 1849-51 in the diary of G. Lefroy to tanning, scraping, drying, currying, squaring, cutting out, and sewing possum skins together to make rugs and tippets. On 20.5.1850 there is reference to 56 skins being curried (Buchanan 2003). One Group settler in the 1920s made a knee-length fur coat from 14 skins (Gabbedy 1988 vol. 2: 543-4). Rugs were marketable, being worth £4 in 1854 (Ducker 1988: 100) and £5 in the 1890s (Frost 1976: 22). Aborigines were reported selling rugs at Mt Barker railway station in 1905 (Parnell 1982: 74). In c. 1897 a rug consisting of c. 90 skins was purchased from a 'half-caste' (*The Sunday Times* 15.10.1922: 17). Birks (1921: 7) provides a photograph of a properly prepared skin.

In the late 1840s and early 1850s enterprising settlers were collecting skins (using Aboriginal labour) to send to England (Buchanan 2003: 95; Mann 2006: 235). An export trade in possum skins first developed in the hinterland of Albany in the 1850s, supplying passengers on steamships at Albany. Skins were brought into Kojonup by Aborigines in exchange for tobacco and flour, and then tanned (Ducker 1988: 100). An advertisement published in 1864 by Perth Tannery promised highest prices for 'hides and kangaroo skins' without mentioning possum skins (*The Inquirer and Commercial News* 27.1.1864). An export trade at Fremantle does not seem to have developed until the 1870s. The first advertisement found relating to purchase of possum skins (*The Western Australian Times* 29.2.1876) notified readers that G. Throssell of Northam would buy skins from April to October. In 1877 advertisements for possum skins to be delivered at Toodyay, Northam or Perth were published. One of these advertisements advised that skins, which were to be well pegged out, properly dried, and with the tail left on, would be purchased 'in any quantity' (*The Western Australian Times* 1.5.1877). Another advertisement stated that skins 'must be perfect with the heads and tails on, and free from shot marks' (*The Eastern Districts Chronicle* 22.6.1878: 2).

Advice from a London merchant was that 'a good market' for possum skins 'at very fair prices' now existed (*The Inquirer and Commercial News* 30.4.1879), viz. (in shillings per dozen): 12-18 for 'sound good colour winter-season skins'; 4-6 for skins of poor colour (reddish and yellow sides); and 1-2 for third class skins (inferior and badly rubbed and tainted). Detailed instructions were also provided for preparing, bundling, and transporting skins. Advertisements published by merchants based in York and Northam sought 10 000 skins (*The Eastern Districts Chronicle* 22.6.1878: 2) and 'skins in any quantity' (*The Eastern Districts Chronicle* 27.7.1878: 2). Later in 1879 it was noted that the trade 'keeps going on in an incredible manner' and an estimated 20 000 possums were killed in the Eastern districts [Toodyay, Northam and York] between April and July 1879 (*The Eastern Districts Chronicle* 2.8.1879: 2). It was said that c. £600 worth of skins were traded in 1879 by a merchant based in Northam (*The Inquirer and Commercial News* 25.8.1880). It was not considered unusual for large numbers of skins (40-100 dozen) to be delivered in one lot to buyers (*The Eastern Districts Chronicle* 2.8.1879: 2, 14.5.1880: 2).

Skins from the 1879 season arrived in London 'in an excellent state of preservation', with the agent advising that he was willing to receive 200 000 skins collected

during the 1880 season (*The Eastern Districts Chronicle* 9.4.1880: 2). In 1881 a storekeeper at York purchased 8 500 dozen possum skins from hunters and trappers active between Northam and Mourambine (*Eastern Districts Chronicle* 8.4.1881). There is also an 1881 record of Aborigines at Jayes (east of Bridgetown) collecting possum skins (CSOLR 9.1.1881, file 1314-67). An agent at Toodyay in 1886 offered to buy 200 000 dozen possum skins (*Eastern Districts Chronicle* 15.5.1886: 4). In Toodyay, Northam, York and Albany, advertisers stated that they would purchase possum skins 'in any quantity' (*The Western Australian Times* 21.5.1878; *The Inquirer and Commercial News* 5.1.1881; *The Eastern Districts Chronicle* 19.4.1879:4, 19.3.1880: 4, 15.4.1881, 30.5.1885; *The Australian Advertiser* 23.9.1889).

Traders recognized an unofficial season for obtaining skins, April-September inclusive (*The Eastern Districts Chronicle* 2.8.1879: 4, 14.5.1880: 1; *The Western Mail* 2.6.1900: 7), probably because skins would have been best developed in winter. Advertisements by dealers advised that they would accept skins 'in any quantity during the season' (*The Eastern Districts Chronicle* 19.4.1879: 4, 30.8.1879: 3, 14.5.1880: 4). Skins were graded, pressed in woolbales, and sold to shippers at Fremantle or shipped to London (*The Northam Advertiser* 17.4.1929: 3).

Possum hunting was highly remunerative: 'A couple of dozen skins in one night is about fair sport for two boys, and this would pay very well if they knocked off about midnight' (*The Eastern Districts Chronicle* 2.8.1879: 2). After a day's work 1-2 dozen skins would provide 'not a bad addition to the day's wages' (*The Eastern Districts Chronicle* 14.5.1880: 1).

Official information about the value of skins exported was first published in 1892 and continued until 1904 (Fig. 29), as before and after this period 'skins' were not differentiated into the component species of kangaroo, sheep, etc (WA Year Books, WA Blue Books, Statistical Registers of WA). In the period 1892-1902 most exports

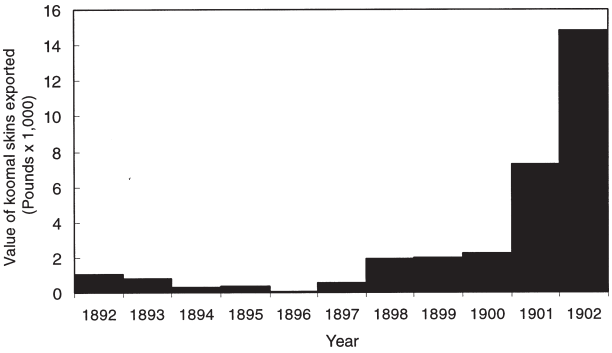

Fig. 29 Value of skins of Trichosurus vulpecula *exported. Source: WA Year Books; WA Blue Books.*

of possum skins, as reckoned by value, were to the United Kingdom (80%), New South Wales (14.5%), and South Australia (4.9%). There was a large increase in value of possum skins exported in 1901 and 1902 relative to 1899 and 1900 (Fig. 29). Although this upsurge in exports may represent a change in fashion (Haebich 1988: 23), it seems more likely that it reflects a downturn in goldmining activity, with disappointed prospectors turning to farming.

By 1905 there were five trading houses operating from Fremantle and vigorously advertising for possum (and other) skins (e.g. *The Western Mail* 7.10.1905: 5, 9; 14.10.1905: 3, 4). The Russo-Japanese war curtailed demand, resulting in higher prices for possum skins (*The Western Mail* 7.10.1905: 9, 4.11.1905: 10; Birks 1921). A political insurrection in Russia in 1905 caused prices for possum skins in London to fall in 1906 (*The Western Mail* 28.7.1906: 9). In 1908 they had increased by nearly a third (*The Western Mail* 4.4.1908: 8).

In 1909 c. £30 000 worth of skins were traded (C. Gale in Select Committee 1911: 7). Trapping of possums was unrestricted until September 1910, when a closed season was introduced. In 1914, the first of nine open

Table 2

Periods when, and areas where, koomal *(Trichosurus vulpecula)* could be captured and killed legally.

Period	Area (approximate northern boundary)	Proclamation in *Government Gazette* (date & page)
1.6.1829-31.8.1909	Unrestricted	9.7.1909: 2018 [implied]
1.9.1909-31.8.1910	Unrestricted	20.8.1909: 2723
7.12.1914-31.8.1915	Unrestricted	11.12.1914: 4531
1.5.1920-1.7.1920	Bunbury, Collie, Bowelling, Wagin, Dumbleyung, #2 Rabbit Proof Fence, coastline	23.4.1920: 725
1.10.1921-30.11.1921	Peel Inlet, Pinjarra, Dwarda, Narrogin, Toompup, Pallinup River, coastline	20.9.1921: 1783
1.10.1922-30.11.1922	Unrestricted	6.10.1922: 1881
1.11.1925-7.12.1925	Unrestricted	30.10.1925: 2175
21.11.1927-21.12.1927	Unrestricted	18.11.1927: 2512
23.11.1929-23.12.1929	Unrestricted	22.11.1929: 2573
1.11.1932-30.11.1932	Unrestricted	18.11.1932: 1713
15.9.1941-31.10.1941	Unrestricted	5.9.1941: 1238

Table 3

Factors influencing Government policy about possum hunting (extent of trapping zone, length and timing of open season, size of royalty).

Factor	Context
Unemployment relief	1914 – industrial unrest 1914-18 - spending power of money eroded by inflation (cost of living increased faster than wages) 1915 – closure of many timber mills during Great War 1919 – return of soldiers from Great War; post-war inflation 1920s – impoverished immigrant dairy farmers (Group settlement) 1922, 1924 – orchardists unable to sell fruit on London market 1932 – Great Depression; rural poverty
Widespread failure of wheat crop	1914 – unprecedented drought in south-west WA
Damage to orchards by possums	1920, 1922 – numerous complaints from fruitgrowers
Animal cruelty, especially to dependent young	1920 – extensive public criticism (letters and articles in newspapers; letters to Colonial Secretary)
Revenue for Government via royalties	1920s, 1941 – high prices paid for skins (1922-9 highest royalties)
Recovery of populations after disease and previous open seasons	1920, 1921 – exclusion zones defined
Quality of skins	Winter skins more valuable than those from later in the year; skins from cooler parts of south-west (with dense fur) more valuable
Interference with availability of farm and forest labour	Shearers and sleeper hewers could earn more money from possum hunting
Ring-barking and clearing of vegetation for farming	With increasing settlement, possums would die anyway from habitat loss; therefore better to make economic gain from them

Sources: Cresswell (1989); Crowley (1973, 1974); Department of Conservation and Land Management file 014603F3528.

seasons, during which possums could be captured and killed legally, was permitted (Table 2). The factors that influenced decisions by Government to allow hunting are summarized in Table 3.

Open seasons lasted 4-8 weeks, except for the first (35 weeks in 1914-15, Table 2). Despite a thorough search of existing files (Department of Conservation and Land Management file 0146033F3528) and trade magazines *(Elder's Weekly, Dalgety's Review, The Producers' Review, The Westralian Farmers' Gazette)*, information on the numbers taken remains sketchy: variously stated as 52 000, 101 625 or > 200 000 skins (1914-15 open season); 125 273 (1920); 143 692 (1921); 204 922 (1922); incomplete: 16 600 offered for sale on 23.12.1927; incomplete: 28 000 offered for sale in the week before 19.1.1928 and in the week before 26.1.1928; 130 000 (1932, Jenkins 1934: 225); and 41 504 (1941). AJ Fraser (in Anon. 1954: 39) stated that in 'earlier years [?before 1910], anything up to 250,000 or 300,000 skins per year were marketed in Western Australia.'

In contrast, extensive information is available on the monetary value of possum skins in the period 1903-41 (Fig. 30), with the only uncertainty being the definition of the various trade names for skins. Evidently 'firsts' refers to first quality (i.e. winter) furs, 'supers' indicates large male furs; grey, red and black refer to predominant colours in furs, with paler skins attracting less money at sales. At some stage black possums were thought to be a distinct species, but Tunney (letter, 25.3.1905) noted that young black possums had been found in the pouch of grey possums. Melanistic possums were said to be more frequent (20%) in the lower south-west (Shortridge 1910: 831), 'very rare' in Darkan district (Spencer 1966: 76), 1 black to every 60 grey (J. Tunney, letter 29.3.1912), 1 black to every 36 grey (J. Tunney, letter 11.4.1912), and 1 black to c. 20 grey (*The West Australian* 20.7.1929: 5). Le Soeuf (1915) noted that a 'black race' was found in heavily-timbered forest in Collie and Yallingup districts.

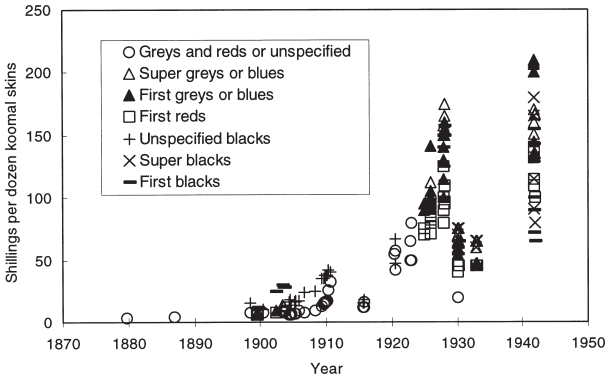

Fig. 30 Prices paid for skins of Trichosurus vulpecula. *Source:* The Western Mail *20.11.1886: 14, 16.6.1900: 6; 1902* West Australian Farmers' Gazette and Market Report*; 1903-8 Dalgety and Co.; H. Wills in* Journal of the Department of Agriculture of WA*; 1909-10 CH Fielding in* Producers' Review*; 1915 Dalgety and Co.; 1920 Elder, Smith and Co.; 1922-41* Elder's Weekly. *Prices graphed are maximum values for each class, for March, June, September, and December of each year.*

Gilbert (nd1) had erroneously claimed that young animals were black and very old males were red.

The trading firms graded skins consigned to them to a very fine degree (Birks 1921: 51 includes a photograph showing skins being classed). The following example (in shillings per dozen) is from *Dalgety's Review* (29.12.1927: 4): super blues 157s 6d-160s; super blacks 152s 6d-155s; first blues 147s 6d-150s; first blacks 130-140s; first greys 120-125s; first pale 95-100s; first reds and second blacks 90-100s; second greys 85-95s; ¾ grown 75-80s; second reds 65-75s; second pale and first roughs 70-80s; first rumpers 65-70s; small 45-55s; second roughs 40-45s; and damaged 35-40s. Although no definition of these terms has been located, they obviously relate to pelage colour, size and condition. For example, in 1932 possums from the lower south-west and from Mt Barker district were worth 30-35s per dozen in comparison to those from Narrogin and northwards (26-28s, *Elder's Weekly* 1.12.1932: 897). C. Hoy in 1920 noted that skin colours varied from light blue black, through brown to almost black specimens (Short and Calaby 2001: 543).

Many early prices of possum skins are not documented to a particular month. Prices are quoted as shillings per dozen skins:

- 1876 4s 6d (Taunton 1903: 39)
- 1879 3s cash (*The Eastern Districts Chronicle* 6.9.1879: 3)
- ?1880s 2s 6d-3s (Schorer 1968: 285)
- 1888 c. 9s (grey); 7-10s (Carter 1987: 65)
- 1890s 4s (Schorer 1968: 292)
- ?1890s 2s 6d-4s (Watkins 1990: 34)
- c. 1897 9s (Vivienne 1901: 104)
- c. 1901 3s (Schorer 1968: 240)
- 1902 12s (Facey 1981: 17)
- 1904 2s 6d-7s 6d (Marshall 1993: 155).

Payment of a royalty to Government from the sale of possum skins was legislated in the Game Act Amendment Act, 1913 (expressed as shillings per dozen):

- 1914 3s (*Government Gazette* 20.3.1914: 1414, to apply from 1.4.1914)
- 1915 3s (R. Underwood WAPD **50**: 770, 20.1.1915)
- 1920 12s (*Government Gazette* 23.4.1920: 730)
- 1922 12s (*Government Gazette* 29.9.1922: 1880)
- 1922 18s (*Government Gazette* 6.10.1922: 1885)
- 1929 18s (*The Westralian Farmers' Gazette* 12.12.1929: 12)
- 1932 9s (*Government Gazette* 18.11.1932: 1718)
- 1941 9s (*Government Gazette* 13.2.1942: 175).

Trapping or snaring was preferred to shooting, as it damaged the fur less (Lindley-Cowen 1897: 654). Snaring involved a 1 m long stick with a loop of wire at the end placed on the ground and leant against the bole of a standing tree. The possum descends head-first from (or ascends to) the tree via the stick, snares itself and chokes itself to death by hanging (further details in Shortridge 1910: 831; *The Western Mail* 10.10.1929: 42; Pustkuchen 1981: 32; Payne 1987: 54; Haebich 1988: 23; Cresswell 1989: 150; Ferrell 1992: 54-5; Fox 1994: 71).

Skins were spread to dry out on a tree trunk at least 6 feet above ground to stop dingoes gaining access, and it took c. 8 hrs for skins to dry (Facey 1981: 19). Furriers preferred skins to be pegged as square as possible, with the tail left on (illustrated in *The Western Mail* 25.12.1905: 54). Such skins fetched a higher price than poorly prepared skins (Cresswell 1989: 150). It is also evident that some rural folk themselves prepared skins for furs, as information about tanning was either sought or published (*The Western Mail* 11.6.1910: 7, 6.8.1910: 9, 28.2.1913: 6, 14.3.1919: 4, 21.8.1919: 4).

A good hunter could snare 3 dozen possums per night, with one hunter earning £145 in 2 weeks (Bignell 1971: 206). When wages were £2 per week (Atkins 1993: 11), it was possible to make £100 per week from possuming (Broun 1995: 12). Cresswell (1989: 150) mentioned two settlers in the early 1900s snaring 80 possums out of 200 snares set each day. In 1902 Facey (1981: 17) stated that on the first night 22 possums were caught out of 200 snares set. In 1910 trappers were said to earn > £100 per week from the sale of skins in a well-stocked district (*The West Australian* 19.1.1911: 3). Rural workers could catch up to 100 possums per night, with workers at timber mills setting snares after their day's work (H. Clifford 1919 in Fisheries Department file 34/32). It is more likely, however, that most trappers had more modest objectives. For example, three brothers featured in an article about a possum trappers' camp each operated a 'dozen or so' snares (*The Sunday Times* 23.7.1922: 17). Possum trappers in 1922 were said to make £10-12 per week (E. Johnston WAPD **66**: 1448, 8.11.1922). Two men at Forest Hill snared 1400 possums in a fortnight in the 1929 open season (Whittem 2000: 271); These skins may have been worth £300. A school teacher in Northcliffe district started a 'possum run' in order to make ends meet (Hutchins 1981: 57). Other workers made more money out of possum hunting than from their regular employment (Daubney 2001b: 80). In c. 1925, the basic wage was £4 per week (McRobb 1984: 38).

However, in 1929, market prices for skins fell and trappers were advised that the royalty (18s per dozen) was not likely to cover their costs for some grades (*Elder's Weekly* 5.12.1929: 1461; *The Westralian Farmers' Gazette* 12.12.1929: 12).

The pressure on Government to re-open hunting of possums after the 1910 closure was unremitting:

- In 1913 it was suggested that the three year ban on trapping had led to possums becoming a 'nuisance' (E. Johnston WAPD **48**: 3941, 16.12.1913).
- In 1919-20 returned soldiers requested an open season (*The Sunday Times* 31.8.1919: 5) on the basis that closure had lasted six years and in the eastern states closed seasons were never longer than two years. Additional justification was the damage caused by

possums in orchards (*The Sunday Times* 6.11.1921: 9; Department of Conservation and Land Management file 014603F3528).

- A letter published in *The West Australian* (7.1.1920: 8) noted that if disease recurred, 'hundreds of thousands' of possums would die with great loss of value of the skins to the community and the Government.
- In 1922 it was stated that re-opening would alleviate unemployment in Greenbushes district (P. Williamson, Department of Conservation and Land Management file 014603F3528).
- In 1932 an open season was held to assist the unemployed during the Great Depression (A. Gillam, Department of Conservation and Land Management file 015013F3803).

Indeed, the development of the south-west was attributed to trapping of possums, as it provided an income for settlers to improve their holdings (F. O'Connor WAPD **43**: 1340, 28.8.1912). This parliamentarian called for an open season on the grounds that, because clearing was reducing the habitat of the possum and reducing their numbers, it was expedient to secure their skins. However, some members of parliament saw possum catching as a distraction from farming (C. Piesse WAPD **32**: 1673, 13.12.1907, **43**: 1340-1, 28.8.1912: 32). As previously noted, labourers could make more money per day from possum hunting than from their day jobs (Daubney 2001b: 80).

Some members of the public called for continued protection (*The West Australian* 16.1.1920: 9). Letters referred to 'an orgy of slaughter', with 'a large proportion of the population engaged in trapping on a scale absolutely unprecedented' (*The West Australian* 4.6.1920: 9), 'a cruel war of extermination' (*The Sunday Times* 27.11.1921: 9), and 'The War on Opossums. Slaughter of the Innocents' (*The Sunday Times* 15.10.1922: 17). A file note relating to Augusta referred to 'wholesale slaughter and destruction' as large numbers of men left their regular employment and 'swarmed all over the bush'. Children left school. Many skins were ruined by careless handling, faulty pegging and blowflies. Often animals were forgotten and were left to suffer and die in the snare. Young were left to perish or were killed and hence wasted (W. Ellis 1922, letter on Department of Conservation and Land Management file 014603F3528).

Illegal snaring (i.e. outside the designated open seasons in the period 1914-41) was rife (W. Mottram in *The Western Mail* 8.9.1927: 35; L. Glauert in *The Western Mail* 16.2.1928: 11; Lange 1981: 312; Owens 1994: 89; Roots 2003: 255). There was one report of a storekeeper at Balingup being offered > 150 dozen skins at the commencement of the open season in October 1922 (Department of Conservation and Land Management file 014603F3528). It was, however, legal for skins to be held back from sale once a royalty was paid and the skins had been stamped (*The Western Mail* 2.1.1930: 39). These would be consigned to a dealer once the price rose (Muir 2006: 4).

The most appropriate season for catching possums was regarded as from May to August inclusive, because the winter fur is thicker than in summer (Lindley-Cowen 1897: 654). Young are present from April to November (C. Gale in Select Committee 1911: 10), or more correctly from March to May, and from August to October (Sampson 1971). The May-June open season in 1920 was criticized because young would be in the pouch at that time (DJ Parker, letter to Chief Inspector of Fisheries, Department of Conservation and Land Management file 014603F3528). There was further criticism about the October-November open season in 1921 because the doe would have its young by its side then, the small skin would be commercially useless, and the young animal would be unable to live without its mother (*The Sunday Times* 6.11.1921: 9, 27.11.1921: 9; *The West Australian* 17.10.1922: 8). Another argument raised against snaring in October/November was that possums would suffer because of blowflies (*The Sunday Times* 27.11.1921: 9).

In 1923, between open seasons, *The Sunday Times* (5.8.1923: 23) published a detailed illustrated article explaining how to trap possums and prepare the skins for market. This article referred to two types of snare (one set on a log, catching the possum by the head and strangling it; the other set on the ground, catching the possum by the foot) and two types of traps (rabbit trap; American jump trap).

The decline in possums in the late 1890s and early 1900s led to a proposal to farm possums (by harvesting mostly males, *The West Australian* 4.8.1910: 7, 19.1.1911: 3) or establish farms for the breeding of possums on commercial lines (J. Drew WAPD **46**: 727, 26.8.1913; W. Angwin WAPD **46**: 3933, 16.12.1913). Few details are available: The carrying capacity was grossly overstated (at c. 100-200 possums/ha, *The West Australian* 4.8.1910: 7) and there was an element of naïvety in the concept of providing nest boxes and growing kale and maize for their food. A comprehensive set of regulations concerning the farming of native game was published in *Government Gazette* 4.9.1914: 3903-5. W. Kingsmill and E. Antoine arranged for some 3 000 possums to be captured and released on Molloy Island in the period c. 1921-24, but the enterprise failed because their numbers did not increase to any extent, possibly because the possums swam the short distance to the mainland (*Kalgoorlie Miner* 5.3.1923: 5; AJ Fraser 1948 in Fisheries Department file 128/46; Cresswell 1989: 150). Another explanation was the flawed assumption that an excess of females over 'about a dozen males' would result in a harvestable yield (Colebatch 2004: 163-4). One farmer speculated that 'the value of the furs from the opossums he would have bred would have equalled the value of his wool' (B. Rodway, cited by E. Johnston WAPD **66**: 1449, 8.11.1922).

Decline The distribution and abundance of the koomal has altered to differing extents across south-west WA. As Aboriginal populations declined abruptly in the 1860s following epidemics of measles and influenza, populations of possums (an important prey species) should have increased (cf. Backhouse 1843: 476; Bennett 1886,

MacPherson 1886) and this probably stimulated their commercial hunting in the 1870s.

There are numerous records of the scarcity of possums from the early 1900s (almost always without further information as to why):

- Ravensthorpe, after 1880 (TG Mitchell 1919 in Fisheries Department file 34/32)
- Victoria Plains, before 1898, 'have disappeared for many years now' (*The West Australian* 1.8.1898: 4)
- Coorow, plentiful in the 1890s but then disappeared (*The West Australian* 14.11.1925: 15)
- Armadale, c. 1900 disappeared 'for a good many years' but by the late 1920s became 'comparatively plentiful' (*The West Australian* 28.6.1930: 4)
- Wanneroo, before 1901 (Kennealy 1994: 4)
- Gingin, 1901 (Roe and Roe 1992)
- Kellerberrin district, 1902 (Leake 1962: 49)
- Dandaragan district, c. 1902 - 'very numerous' prior to this; by 1928, a few present in wandoo clumps (Green 1928)
- Beverley, 1904 (CP Wansbrough 1919 in Fisheries Department file 34/32)
- Cumminin district, 1907-09 (Crossman 1909: 85)
- Kondinin-Kalgarin-Hyden district, having died out in 1908 (Webb 1988: 37)
- Piesse Brook-Bickley district, ?1908 (Loaring 1954: 135)
- 15 miles east of Beverley, Aborigines and old residents reported that none seen since at least 1909 (L. Hicks 1919 in Fisheries Department file 34/32)
- Toodyay, Northam, Meckering, Dowerin, Merredin, Bullfinch, Quairading (all 1913, none seen); Hopetoun 1907; Collie 1912 (Department of Aborigines and Fisheries file 992/1913)
- 1911, 'you hardly ever hear of them in the Eastern districts' (J. Drummond in Select Committee 1911: 6)
- Esperance district, 1912, only seen on rare occasions (Department of Aborigines and Fisheries file 992/1913)
- Mingenew and Mullewa, 1912, none (Department of Aborigines and Fisheries file 992/1913)
- Ravensthorpe district, 1912, 'very scarce' (Department of Aborigines and Fisheries file 992/1913)
- Greenough, 1913, 'so scarce here that a number of people have never seen one' (Department of Aborigines and Fisheries file 992/1913)
- Three Springs, 1913, 'practically extinct' (Department of Aborigines and Fisheries file 992/1913)
- Northampton district, 1913, only found near Lynton and Nabawa (Department of Aborigines and Fisheries file 992/1913)
- Cunderdin, 1913, 'very few, if any…I have been informed that they have never been hunted or trapped here' (Department of Aborigines and Fisheries file 992/1913)
- Kalgan Plains, c. 1914 (WG Pearce 1963 in Fisheries Department file 51/55)
- Gracefield, 1914 (JT Tunney, letter 28.5.1914)
- Mumballup, 1917, 'practically extinct in this locality. During the last eight years I have been continually travelling the timber country and have…only seen 4 opossums during that time in the Jarrah country' (M. McCamish in Department of Conservation and Land Management file 014603F3528)
- Darkan and Williams district, 1917, 'getting very scarce' (M. McCamish in Department of Conservation and Land Management file 014603F3528)
- Albany, 20 mile radius around, 1919 (AV Shanhun 1919 in Fisheries Department file 34/32)
- Collie-Darkan-Arthur River-Boyup Brook-Bridgetown-Nannup-Augusta, 1917-19 (H. Clifford 1919 in Fisheries Department file 34/32)
- Collie, 1919, 'an unknown quantity [i.e. none seen] for many miles round Collie as a centre' (A. Stevenson 1919 in Fisheries Department file 34/32)
- Cranbrook, 1919, 'not one to be seen'; formerly 'in a good number' (AG Hill 1919 in Fisheries Department file 34/32)
- Dwellingup-Waroona, 1919 (FC Sunderland 1919 in Fisheries Department file 34/32)
- Albany district, within 20 miles, 1919, 'very scarce' (AV Shanhun in Fisheries Department file 34/32)
- Esperance district, 1919 (JJ Ryan 1919 in Fisheries Department file 34/32)
- Ravenswood, 1919 (CA Forsberg 1919 in Fisheries Department file 34/32)
- Collie-Darkan-Bridgetown, 1921 (*The Sunday Times* 27.11.1921: 9)
- Burnside, Margaret River district, 1921 (FL Brockman in Department of Conservation and Land Management file 014603F3528)
- 1924, 'I have travelled over a good deal of the South West and find that the opossums are not near so plentiful as previous years' (AL Clifford in Department of Conservation and Land Management file 014603F3528)
- Brookton district, 1926 current rarity contrasted with their abundance 'in thousands' in the 1870s (*The West Australian* 3.7.1926: 9)
- Warren River, c. 1928 'seemed to die out' (Muir 2006: 17)
- Along the Avon Valley between Toodyay and Midland, 1946, 'complete absence' (Shipway 1947).

The factors that have reduced koomal populations are, in probable order of decreasing importance, as follows:

• Disease

The disappearance of possums from the northern sector of south-west WA is most likely due to this factor alone, as available evidence indicates that the koomal had disappeared from there by 1898-1905 (Ackland 1965: 104; Bain 1975: 408; Kennealy 1994: 31; Roe and Roe 1992; *The Western Mail* 21.5.1928: 6). Reports of tree hollows with skeletons of possums (Abbott 2006) are consistent with mass mortality caused by disease.

There seem to have been episodes of severe outbreaks of disease from time to time in parts of the lower south-west:

- c. 1893, near Meckering, some contagious disease spread amongst the possums and they all died out (Department of Aborigines and Fisheries file 992/1913)
- c. 1895, Irwin district, 'During the last five years opossums…had died out from some unknown disease' (SJ Phillips WAPD **18**: 1676, 14.11.1900)
- c. 1899-1900 in Talbot and Dale districts south-west of York and Beverley, 'a disease broke out among the possums, and in nearly every hollow tree I could find a dead possum. They practically died out...[but] gradually came back' (J. Reid in *The West Australian* 12.4.1930: 4)
- < 1900, near Toodyay, Northam, York and Beverley, 'had just learned that all the opossums in the Eastern Districts had died' (J. Forrest WAPD **18**: 1675, 14.11.1900)
- c. 1901 near Bridgetown, dozens of dead possums in rocky outcrops (RE Doust 1966 in Fisheries Department file 51/55)
- c. 1904-07, reports of some epidemic that 'at times clears them [possums] out of districts where they were plentiful previously; when this occurs it often takes years for them to recover in numbers' (Shortridge 1910).
- 1905, Ludlow, report of dead animals (RH Banfield 1919 in Fisheries Department file 34/32).
- 1911, '[a] few years ago a disease [had] killed off many thousands' (*The West Australian* 19.1.1911: 3)
- 1911-12, Kojonup district (AE Ward in *The Western Mail* 22.8.1913: 6; A. Abjornssen 1913 in Fisheries Department file 34/32)
- 'a disease…periodically appears amongst these animals' (*The West Australian* 7.1.1920: 8)
- 'About the middle 1930's some form of epidemic – I do not know its type – appeared to take very large toll of the opossums. It was before my time in Western Australia, but reports in the Department indicate that vast numbers of opossums were found dead in areas where, previously, they had been quite abundant' (AJ Fraser in Anon. 1954: 39).
- late 1930s-early 1940s in Northcliffe district, an outbreak of cat flu wiped out the cat population and also affected possum numbers (Daubney 2001a: 13).
- 1938-44, 'a catastrophic collapse' of populations of this species in jarrah forest was attributed to disease. By c. 1945 this species 'had practically disappeared from the Jarrah and Karri forests' (Perry 1973: 128).
- c. 1947, Manjimup district – 'Approx 12 years ago [1935] in our Karri and Redgum [marri] Forest oppossums were plentiful…In my opinion there must have been a disease among them as I doubt if you would see an oppossum Tree [a tree with a line of freshly exposed bark made during ascent and descent] anywhere south of Manjimup' (DK Johnston in Fisheries Department file 34/32).
- 1964, on a farm near Bridgetown, possums dying apparently from a disease. Animals curled up, went to sleep and refused to drink (SE Hardisty in Fisheries Department file 34/32).

• Trapping

As already indicated, no controls were placed on trapping until 1910, and even then regulation seems to have been perfunctory and ineffective. Possums could be trapped at any time of year, and on the assumption that most trapping took place in winter (to obtain the best quality fur), this would have killed many young. However, it is unlikely that all animals would have been taken, as once trapping returns became low trappers would have moved elsewhere. A slow increase in population size (the species has only one young per year) should have followed. During the Great Depression (1929-35), there was probably much increased pressure on populations as well as a black market trade in skins. Legal trapping ceased in 1941 and with rural prosperity after 1945 it seems unlikely that there would have been any further significant level of illegal trapping.

Reductions explicitly linked to trapping were noted as follows:

- 1899, in settled districts nearly all shot and snared (Le Soeuf 1900: 193)
- 1905-07, 'getting very much thinned out in many places by trappers' (Shortridge 1910)
- 1906, Deeside, 'so scarce', 'it is now rather hard times for the natives now to get their living in the Bush', possums 'all trap[p]ed' (T. Muir in Colonial Secretary's Department files 332/1906 and 558/06)
- 1907, Bridgetown district, possum 'gone' because of ruthless trapping for skins (Brockman 1987: 272)
- 1910, possums 'appear to have been threatened with extermination' (Chief Inspector of Fisheries in Department of Conservation and Land Management file 014603F3528)
- 1911, 'almost exterminated by trappers' (*The West Australian* 19.1.1911: 3)
- 1912-13, between Jarrahwood and Ludlow, possums

had not recovered from trapping by 1919 (RH Banfield 1919 in Fisheries Department file 34/32)

- 1915, near Tenterden, thinned out by trapping (*The West Australian* 16.1.1920: 9)
- ?1915, 'several old residents of the Great Southern district…state that if [possum trapping is permitted] there is a danger of exterminating the opossum so far as the Great Southern districts are concerned' (E. Johnston 1.3.1920 in Department of Conservation and Land Management file 014603F3528)
- 1916, Albany district, much trapping as times are bad and work is scarce (G. Linton Fisheries Department file 58/43)
- 1919, County Peak east of Beverley, very scarce owing to trapping (A. Wood 1919 in Fisheries Department file 34/32)
- 1920, along Great Southern Railway, 'The unrestricted catching of years ago…nearly wiped all the possums out' (HB Rodway in Department of Conservation and Land Management file 014603F3528)
- 1920, 'in the greater part of the open district were severely thinned (but in parts of the karri and coast areas barely at all)' (*The Sunday Times* 27.11.1921: 9)
- 1922, 'from Nornalup to Mt Barker and round to the Stirling Range', possums reported by trappers as 'skinned out everywhere' (G. Linton in Department of Conservation and Land Management file 014603F3528)
- 1922, 'in some parts west of the Great Southern railway which have been open for opossum trapping three years running', the koomal was 'being exterminated' E. Johnston WAPD **66**:1449, 8.11.1922)
- 1922, Darkan district, 'nearly exterminated' by trapping (HB Rodway in Department of Conservation and Land Management file 014603F3528)
- 1922, Margaret River district, 'rapidly decreasing & at the rate they are being trapped will soon be exterminated in this district' (Department of Conservation and Land Management file 014603F3528)
- 1922, Forest Hill, 'if the few opossum that are now left had another two years to breed up they would recover themselves' (A. Muir in Department of Conservation and Land Management file 014603F3528)
- 1923, Bunbury district, 'unless Opossums are given at least 4-years period of grace in which to breed up, they will become extinct' (H. Moore in Department of Conservation and Land Management file 014603F3528)
- 1923, Manjimup, 'very nearly extinct…they had a terrible doing last year and will take many years to breed up again' (W. Mottram in Department of Conservation and Land Management file 014603F3528)
- 1927, Deep River near Nornalup Inlet, 'wiped out' (*The West Australian* 5.11.1927: 7)
- 1928, Stirling Range, thinned out by trappers (Bradshaw 1928: 178)
- 1930s, Stirling Range, trapping continued after the 1932 open season on a black market basis and possum numbers never recovered (A. Gillam in Department of Conservation and Land Management file 015013F3803 vol. 2).

Recovery was evidently local:

- 1912, Dumbleyung (Department of Aborigines and Fisheries file 992/1913)
- 1912, Katanning (Department of Aborigines and Fisheries file 992/1913)
- 1912-13, Wanneroo and southern suburbs of Perth (Department of Aborigines and Fisheries file 992/1913)
- 1912-13, Williams district, complaints of nuisance (Department of Aborigines and Fisheries file 992/1913)
- 1912-13, Wagin (Department of Aborigines and Fisheries file 992/1913)
- 1912-13, Bunbury, causing havoc with cabbages in gardens (Department of Aborigines and Fisheries file 992/1913)
- 1912-13, Narrogin (Department of Aborigines and Fisheries file 992/1913)
- 1912-13, Mt Barker (Department of Aborigines and Fisheries file 992/1913)
- 1913, West Dale (Department of Aborigines and Fisheries file 992/1913)
- 1913, Darkan district, becoming a nuisance (EB Johnston WAPD **48**: 3941, 16.12.1913)
- 1913, Gnowangerup (Department of Aborigines and Fisheries file 992/1913)
- 1913, Busselton (Department of Aborigines and Fisheries file 992/1913)
- 1915, Helena and Darkin River district [west of York], a large number of persons trapping but only 'fair averages' recorded (*Eastern Districts Chronicle* 22.1.1915)
- 1918, between Boyanup and Elgin (PE Port in Department of Conservation and Land Management file 014603F3528)
- 1919, Blackwood Valley (Darradup to Augusta), numerous (Perry 1971: 47)
- 1919, increase noted in only a few districts (Department of Conservation and Land Management file 014603F3528)
- 1919, increases noted near Manjimup, Nannup-Augusta, and Margaret River (A. Sears, W. Cahill, GB Forrest 1919 in Fisheries Department file 34/32).

- 1919, Bunbury district, doing well in less settled parts (WJ Duffell 1919 in Fisheries Department file 34/32)
- 1919, Margaret River-Cape Leeuwin, most possums seen (H. Clifford 1919 in Fisheries Department file 34/32)
- 1919, Pingelly-Wandering, some damage to gardens (WE Kemp 1919 in Fisheries Department file 34/32)
- 1920, Margaret River district, plentiful (C. Hoy in Short and Calaby 2001: 543)
- 1920, Manjimup district, pest of orchards (*The West Australian* 5.3.1920: 5)
- 1920, Harvey district, pest of apples, pears, peaches, oranges and rosebuds (*The West Australian* 18.6.1920: 8)
- 1920, Nelson district, 'now increasing splendidly' (W. Mottram in Department of Conservation and Land Management file 014603F3528)
- 1920, Boyanup district, destroying fruit crops (Department of Conservation and Land Management file 014603F3528)
- 1922, a large number of permits issued to destroy possums because of serious damage to orchards and gardens (R. Sampson WAPD **66**: 1053, 12.10.1922)
- 1922, Boddington, 'I am no friend of the opossum and if the last one were destroyed [it] would be of a very great advantage to me[.] But I have no desire to see wilful waste of wealth' (H. Firnes in Department of Conservation and Land Management file 014603F3528)
- 1924, Mundaring Weir, 'getting very plentiful' in gardens (W. Grace in Department of Conservation and Land Management file 014603F3528)
- 1924, east of Pingelly, first possum seen on the farm where George Gardner had lived since his birth in 1912 (Gardner 2000: 16)
- 1924, south-west and southern portions of WA, 'fairly numerous' (Chief Inspector in Fisheries Department file 29/24)
- 1920s, lower Kalgan district, 'ate all they could get at so we had to cover bins and packing cases' (Piggott 2004: 75)
- 1928, Woogenilup, possums had recovered from trapping to 'fair numbers' (WG Pearce 1963 in Fisheries Department file 51/55)
- 1942, a nuisance at Blackboy Hill army camp near Northam (Hungerford 2003: 207)
- 1942-7, suburbs of Perth, West Popanyinning, Katanning and Albany, first records on file of permits issued to destroy nuisance possums (Department of Conservation and Land Management file 014698F3502)
- 1953-9, many parts of the lower south-west, increasing (Serventy 1954: 128; Fisheries Department files 51/55, 78/50, 83/50, 71/49, 64/49)
- 1967-9, many parts of the lower south-west, increasing (*Fisheries Department Bulletins, Fauna Bulletins*)
- 1973, forest, roadkills and possum trees easy to locate (Perry 1973: 120).

• Arrival of the fox

Because the koomal is not exclusively arboreal, it was subject to ongoing predation by foxes from c. 1925. AJ Fraser (in Anon. 1954: 39) stated that 'Somewhere about the early 1930's the foxes commenced to make inroads'. There is also evidence from adaptive management that baiting of foxes leads to a rapid increase in abundance of possums (Christensen *et al.* 1985: 20-1; Morris *et al.* 2000; CALM Annual Report 2005: 174; Anon. 2005). The fox probably held back any sustained recovery of possums after legal trapping ceased in 1941.

WG Pearce (1963 in Fisheries Department file 51/55) noted that numbers declined after 1928, attributing this to the fox. Haddleton (1952: 103) stated that foxes were responsible for the destruction of many possums. Nonetheless, the introduction of 1080 rabbit baiting seems to have reduced fox populations, as possums were increasingly reported from 1956 in south-west WA (Department of Conservation and Land Management file 014698F3502) and were once again reported as damaging fruit in the 1960s, sufficient to lead to requests from orchardists for an open season (which was refused).

Since the widespread introduction of fox baiting in the 1990s, koomal populations have either increased or maintained high numbers in several monitored sites (e.g. Tutanning Nature Reserve, Dryandra Woodland, Porongurup National Park, Greater Kingston, south Perup) but have not responded at other sites (e.g. Hills Forest; Batalling, Moopinup, Noggerup, and Giants forest blocks; Lake Magenta Nature Reserve) (P. Orell, A. Wayne pers. comm.).

• Clearing of trees for farming

'To-day the greatest enemy of [the possum] is the conditional purchase-holder', who is compelled under regulation to ringbark the timber for cultivation (C. Piesse WAPD **46**: 782, 27.8.1913). This factor would have removed habitat, den sites, and food (foliage), although the erection of buildings on farms and the establishment of gardens and orchards would have partially compensated. Burning off was cited as one cause of the decline of possums in Beverley district before 1913 (Department of Aborigines and Fisheries file 992/1913)

• Suburbanization

In the 1920s possums thrived in Kings Park (Nicholls 1926: 70) and were 'fairly abundant in the vicinity of Perth' (L. Glauert in *The Western Mail* 25.4.1929: 48). They were present in the 1920s in bushland that was later

cleared for the suburb of Kensington, as well as in South Perth (Hungerford 2003: 11, 17, 127), and remained 'plentiful' in bush parks within the Perth metropolitan area (Anon. 1947: 113). Although still found in the central metropolitan area, they live under the roofs of houses in some of the older suburbs and no longer occur in bushland (Drake 2000: 44).

• Broadscale deployment of poison baits to kill dingoes and rabbits

This factor probably was important in agricultural areas but not in forests or suburban areas. Strychnine/cyanide dingo baits laid on sheep farms had destroyed possums in parts of Yallingup-Margaret River district (GB Forrest 1919 in Fisheries Department file 34/32). WG Pearce (1963 in Fisheries Department file 51/55) killed 'a great number' of possums after he poisoned rabbits using apples treated with Grim®, which at the time (?1930s) was 'the only effective method of controlling rabbits then known'. RE Doust (1966 in Fisheries Department file 51/55) mentioned finding 'dozens of dead possums' after poisoning rabbits with treated apples. Other records of possums found poisoned relate to Woodanilling district in the 1930s (Bird 1986: 303) and Wagin district in the 1940s (Pederick 1979: 60). Rabbit poisoning was considered by N. Beeck (1948, in Fisheries Department file 233/48) and Haddleton (1952: 99) as responsible for destroying most possums in Katanning district.

Several records were found of trappers illegally using cyanide to catch possums at Palgarrup in 1925 and Boranup in 1929 (Fisheries Department file 23/29).

• Logging

There is an immediate local reduction in abundance in proportion to the intensity of logging (Morris *et al.* 2001; A. Wayne pers. comm.). Provided there is suitable forest regeneration and adequate fox control, the koomal population recovers in the medium term. Recovery is also facilitated by the proximity of mature forest habitat and the network of older regrowth forest in coupe buffers.

By 1950 the koomal was regarded as 'almost extinct' at Pickering Brook. The causes suggested were (not in priority order) predation by foxes, trapping, and diseases (R. Owen WAPD **126**: 939, 26.9.1950). In some 'large tracts of country where they were plentiful there was no trapping done. Nevertheless they died out. The only 'possums I know of are those in the roof of the Pinjarra hospital' (H. Tuckey WAPD **126**: 1273, 18.10.1950).

Near Northcliffe by the 1980s, there was 'little evidence that the possums have become re-established, despite the fact that a lot of the country has been abandoned for settlement…At one time [?in the late 1920s] you would see opossum scratches on nearly every red-gum [marri] tree, but now I can't find a trace of them' (Symes nd: 57).

Despite cessation of trapping in 1941 and introduction of fox-baiting programs in 1994, the koomal has not yet regained on all public lands the abundance it had in the early 1870s when a trapping industry was commenced and supported for several decades (Orell 2004). There is an abundance of suitably-sized hollows throughout the forests of south-west WA (Abbott and Whitford 2002), so this factor can be discounted. It is, however, possible that populations were so depleted by trapping and then poisoning from rabbit control that the Allee effect has operated, i.e. population growth has declined irretrievably because local population sizes fell below a threshold level of abundance. Enzootic disease may also be retarding the recovery of populations. Even when large numbers of possums have been translocated (as from suburban Perth to Julimar Conservation Park in 1993-4), the population has persisted in low numbers only (Morris 2000: 68).

Pseudocheirus occidentalis ngwayir/womp/woder/ngoor/ngoolangit/western ringtail possum

Oldtimer information Ngwayir were not well known by oldtimers outside the lower south-west region of WA (Fig. 31; see also map in de Tores *et al.* 1998: 31). The main recollections about this species were:

- its highly localized occurrence, particularly near the coastal towns of Capel, Ludlow, Busselton, Dunsborough, and Margaret River, along the river near Katanning (N. Beeck pers. comm.), in peppermints in swamps at Middlesex (B. Hanekamp pers. comm.), at Scott River (V. Scott pers comm.) and in sheoaks near Highbury (G. Warren pers. comm.).
- Its poorer quality fur compared to *Trichosurus vulpecula*, making it not worth trapping (C. Fawcett, A. Giblett, A. Muir, J. Muir, and K. Smith pers. comm.). Indeed, because this species cannot stretch as far as the koomal, K. Smith would not put his snare against a tree with ngwayir tracks.
- Its predilection for nesting in balga *(Xanthorrhoea preissii)* crowns in unburnt jarrah forest (A. Muir, D. Perry).

Ngwayir were considered to have been originally more abundant around Deeside than the koomal (J. Muir), but by the late 1920s it was much rarer. In contrast, ngwayir were reported as less abundant than koomal at Forest Hill (G. Elverd), Mt Royal (E. Young), south-east of Kojonup (J. Palmer), and west of Pingelly (A. Marshall). Both species were regarded as equally common near Margaret River (S. Garstone, B. Nilsson) and south of the Porongurup Range (J. Shanhun).

The ngwayir showed some measure of adaptability, being recorded in a pine plantation at Margaret River in the early 1950s (D. Rowe), at Ludlow in the 1960s nesting in *Pinus pinaster* needles hanging in forks (L. Talbot), and eating grapes at Busselton (W. Forrest). They were considered to make as good a pet as a cat (B. Pugh, E. Shanhun). There was one report of a blanket edged with the tails of this species, 1940s (D. Morgan).

Oldtimers advanced a number of factors instrumental in the decline and local extinction of the ngwayir: fox

predation, disease, and clearing. Around Deeside this species was reported to have fluctuated noticeably in abundance in the early decades of the 20th Century. Its disappearance in the late 1920s and early 1930s was attributed to disease, before the arrival of the fox (J. Muir, W. Young). Other dated records of its disappearance are: late 1930s (Margaret River, J. Whyte); c. 1939 (Forest Hill, G. Elverd); and 1960s (near Kirup, A. Foan). At Grasmere, this species was less affected by disease than the koomal (A. Taylor pers. comm.).

Distribution and habitat Nind (1832: 32) stated that the ngwayir and koomal were 'not often found in the same districts' around Albany, with the former frequently found in swamps and surrounding low vegetation. Eyre (1845: 56) mentioned two possums caught in the crown of tea trees growing along a coastal stream, a habitat indicative of this species. Gilbert stated that this species was very generally distributed over the whole colony [visited by him] but was more abundant in vegetation in the banks of rivers or other moist places, noting its occurrence in hollows of standing trees, in holes in the ground or in hollow logs as well as its ball-like nest in the upper branches (Gould 1863: xx; Whittell 1954b: 112).

Later observations are also quite diverse:

- References to this species pulled 'out of a hole in a tree' and bulky nests in the tops of bush saplings and trees (Carter 1987: 65, based on observations made in 1888 near Busselton).
- Plentiful in coastal districts. Bulky, domed nests often noticed in thick vegetation, mostly near watercourses (Le Soeuf 1900: 194; D. Le Soeuf in Thiel 1901: 188 – observations made in 1899).

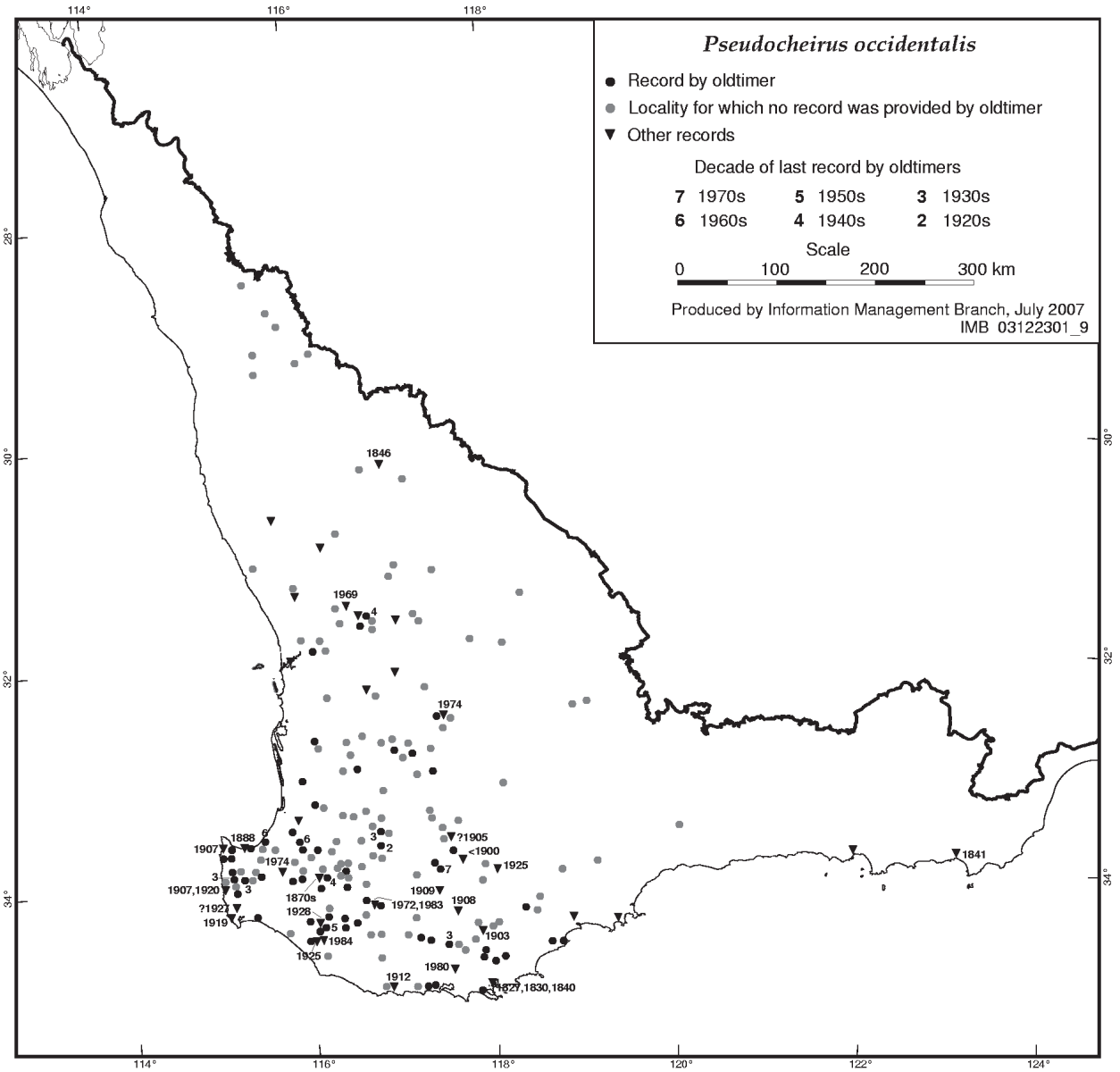

Fig. 31 Distribution of Pseudocheirus occidentalis. *Additional records not already cited in text: Fisher 1992; Gibbs 2002; Kitchener and Vicker 1981; WA Year Book 1900.*

- Always found in sheoak *(?Allocasuarina huegeliana)* or stinkwood *(?Jacksonia furcellata)* country in Katanning district. Lived in a hollow tree or sometimes built a nest with a few sheoak leaves in the fork of an old sheoak (Haddleton 1952: 99-100; observations made before c. 1905).
- Chiefly confined to banks of rivers and swamps, in tea trees and peppermints *(?Agonis flexuosa)*, making a nest of grass and sticks among the bushes. Nesting occasionally in hollow trees. Not observed in 1904-5 around Albany but 'fairly plentiful' in 1907 in Margaret River district (Shortridge 1910: 827-9).
- Readily found in the crowns of balga (FG Allnutt 1919 in Fisheries Department file 34/32; observations made in 1911 at Deepdene near Augusta).
- Nests found in a whipstick wattle *(?Acacia pentadenia)* sapling and in epicormic shoots on the side of a tingle tree (S. Jackson 1912 in Abbott 1998b: 385).
- Formerly built a conspicuous nest in the forks of low teatrees but because of hunting has altered its habits and now lives in the hollow spouts of larger forest trees (C. Hoy 1920 in Short and Calaby 2001: 550).
- Sticknests in Banksia or tea tree (F. Whitlock in *The Western Mail* 15.7.1926: 40).
- A nest in a paperbark *(Melaleuca)* and speargrass [?sedge] swamp at Barronhurst near Pemberton (L. Glauert in *The Western Mail* 1.11.1928: 6).
- Found in freshwater swamplands, hollow logs and crowns of balga (L. Glauert in *The Western Mail* 9.5.1929: 48).
- Generally lived in nests along waterways (Schorer 1968: 224).
- Seems to prefer hollows in trees to the building of dreys. Also noted in pine plantations and karri regrowth (?dreys) (Christensen *et al.* 1985: 22).

Human use and interactions with humans The fur varied in colour from very light grey to very dark brown to nearly black (Gilbert in Gould 1863: xx; Haddleton 1952; Schorer 1968: 224; Whittell 1954b). Melanism was less frequent inland (Shortridge 1910). An interesting observation was made by E. Dunham (*The Western Mail* 30.5.1929: 48), who stated that he had caught hundreds of this species and he had never seen one without the white tip to the tail.

Aborigines did not use the fur of this species (Nind 1831: 32) nor did they eat the meat, which has an offensive or distinctive musky smell (Bignell 1971: 11; Meagher 1974: 17; Shortridge 1910). I found no official statistics relating to fur prices of this species. Settlers considered its fur as poor and its skins were of little market value (T. Carter in Carter 1987: 65; F. Whitlock in *The Western Mail* 15.7.1926: 40). Nevertheless, Schorer (1968: 224) stated that skins were worth c. 1s per dozen. This species will enter snares (L. Glauert in *The Western Mail* 25.12.1927: 55) and many were probably snared accidentally as bycatch from efforts to obtain *Trichosurus vulpecula* (Payne 1987: 56; C. Hoy in Short and Calaby 2001: 550; WG Pearce 1963 in Fisheries Department file 51/55). This possibility has also been advanced for the population in South Australia (Finlayson 1934: 218). The only other information found on the price of skins sold was: 3-4s per dozen (*The Western Mail* 4.12.1909: 8); first ringtails 30-35s, second ringtails 20-25s per dozen (*Dalgety's Review* 29.12.1927: 4).

The ngwayir was occasionally kept as a pet (Mulvaney and Green 1994: 343; L. Glauert in *The Western Mail* 1.5.1930: 9). Echoing Wood Jones (1924: 179), Glauert thought that it was a very stupid animal.

As in South Australia (Wood Jones 1925: 178), the ngwayir has not been recorded as living in the roofs of houses, and there is only one record of it damaging fruit. However, observations in the late 1990s reinforce the concept of the adaptability of this species. Animals near Albany were observed eating the flowers and foliage of a variety of exotic plant species (Gunby 2004). Animals near and in Manjimup were reported nesting in exotic trees and feeding on garden flowers (I. Wilson pers. comm.).

Decline and local extinction The ngwayir is one of those species that declined before the arrival of the fox or before habitat destruction had increased:

- Although plentiful at Woogenilup in 1902, it was last seen there in 1903 when one was caught and made into a skin (WG Pearce1963 in Fisheries Department file 51/55).
- 'apparently disappearing' in many places and very local by 1904-7 (Shortridge 1910).
- In Katanning district, not seen since the early years of the 20th Century [?1905] (Haddleton 1952: 99-100).
- Very numerous around Bridgetown in the 1870s-80s but in recent years [?since 1915] none seen east of Nannup, and not as numerous at Deepdene as in 1911 (FG Allnutt 1919 in Fisheries Department file 34/32).
- Scarce at present, no locality stated (F. Whitlock in *The Western Mail* 15.7.1926: 40).
- At the present time this species seems 'very rare' as no specimens have reached the WA Museum since 1914 (L. Glauert in *The Western Mail* 9.5.1929: 48).
- There was 'a catastrophic collapse' of populations of this species in the period 1938-44 and this decline was attributed to disease. By c. 1945, this species 'had practically disappeared from the Jarrah and Karri forests' (Perry 1973: 128).

Glauert (*The Western Mail* 9.5.1929: 48) thought that the ngwayir was verging on extinction in 1829, but this inference is contradicted by the observations made in the 1800s by Nind, Gilbert, Eyre, Haddleton and Le Soeuf (see above), as well as those by Schorer (1968), Hoy 1920 (in Short and Calaby 2001: 543) and Perry in 1919 (Perry 1971: 47). Glauert (1933: 24) held the view that its occurrence in small, isolated colonies indicated that it was on the verge of extinction through natural causes.

After consideration of the available records, my view is that several factors have operated to lead to a decline in the distribution and abundance of the ngwayir:

1. Bycatch, from snares set to capture the koomal, the fur of which was highly valued, particularly from the 1890s as settlement advanced. As noted for South Australia by Finlayson (1934: 218), snares do not discriminate between the two possum species.
2. Disease, particularly during the period 1900-20.
3. Predation by the fox, from the 1930s.

Although bushfires and predation by feral cats are likely to kill animals (Shortridge 1910: 845; L. Glauert in *The Western Mail* 25.12.1927: 55), these factors are best viewed as contributory rather than driving causes of decline. Utilization of swamplands by farmers was also proposed as an additional factor (L. Glauert in *The Westralian Farmers' Gazette* 26.1.1928: 15). Wildfire in the absence of fox control, and logging without a high level of fox control, are both detrimental (Wayne *et al.* 2006).

With the introduction of 1080 rabbit poison in the 1950s, this species was noticed as re-appearing over widely scattered areas around Manjimup in 1958 *(Fisheries Department Bulletins)*. The ngwayir declined abruptly at Perup after 1973, correlated with an increase in the abundance of foxes (Christensen *et al.* 1985: 22). From the late 1990s (following broadscale fox baiting) many sightings have been reported in Manjimup district, with some from localities in which the species had not previously

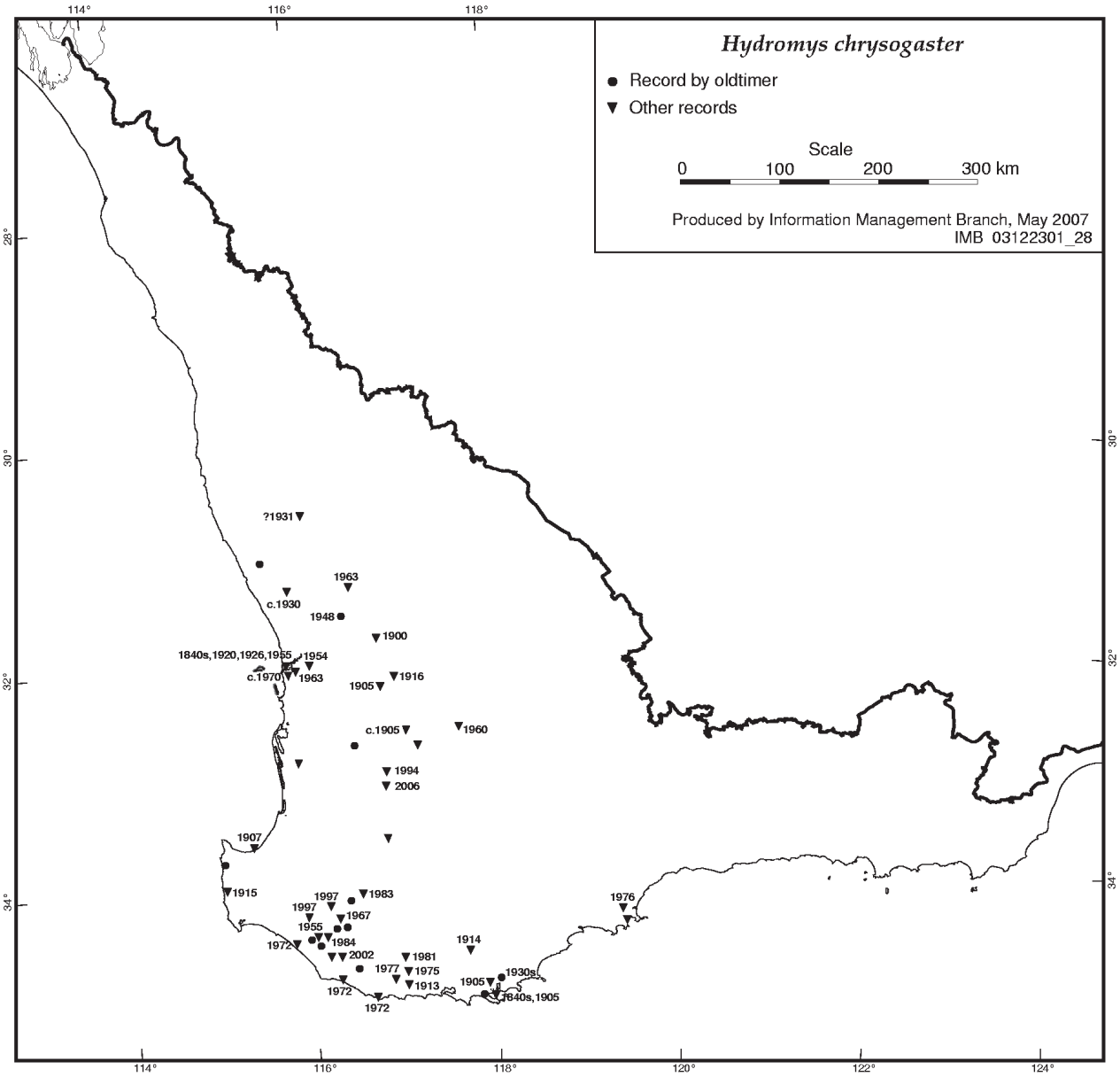

Fig. 32 Distribution of Hydromys chrysogaster. *Additional records not already cited in text: Acclimatisation Committee 1900; Bannister 1969a; Bird 1990; Burbidge pers. comm.; Chapman 1995; Daubney 2001b;* Fauna Bulletin*;* Fisheries Department Bulletin*; Giblett 2006: 82; Gilbert nd1; Kitchener and Vicker 1981; Lange 1981; Loaring 1954; Mitchell pers. comm.; Roe and Roe 1992;* The Western Mail *16.4.1925: 3.*

been known to occur (I. Wilson pers. comm.). However, translocation of 106 animals into Leschenault Peninsula Conservation Park during the period 1991-8 was successful only up to 1998, the reason for this being obscure (de Tores *et al.* 2004).

Three variants of the Noongar name were found, additional to those provided by Abbott (2001: 456-8): *Gnwar* or *Nu-are* (Warren River, *The Western Mail* 16.4.1925: 3), *Waamp* (Gnowangerup, *The Western Mail* 14.5.1925: 1), and *Woomp* (near Kalannie, Buchanan 2003: 71).

Hydromys chrysogaster ngoodjo/ngwiridjin/wamp wamp/ngangaritj/water-rat

The water-rat was not a species about which I sought information from oldtimers. However, because its pelt was of some commercial value, ten oldtimers volunteered information. W. Chitty last observed it on the Avon River in c. 1948 and J. Hunt noted it on the Kalgan River in the 1930s (Fig. 32).

In the 1830s/40s this species was recorded as 'tolerably abundant in fresh water streams and about the neighbourhood of Perth' (Gilbert nd3), although Moore (1842: 57) stated that they were rare and shy. This species was still present on the Swan River in 1899 (Le Soeuf in Thiel 1901: 189), 1920 (C. Hoy in Short and Calaby 2001: 543), and 1926 (Nicholls 1926: 70). In 1905-7, water-rats were not uncommon in estuaries and swamps, and occasionally occurred along beaches as well as ranging as far inland as the sources of the small permanent rivers (Shortridge 1936: 745). From this information it is presumed that its inland limit was approximately Moora-Wongan Hills-Cunderdin-Yealering-east of Dumbleyung-Ongerup-Jerramungup.

Food of this species includes ducklings (Moore 1842: 57), carrion and goldfish (R. Breeden in *Busselton-Margaret Times* 11.10.2001: 31), and marron (S. Jackson in Abbott 1998b: 385). Water-rats will travel considerable distances from water at times (Christensen *et al.* 1985: 28) and will forage in paddocks (R. Breeden in *Busselton-Margaret Times* 11.10.2001: 31). Water-rats were troublesome to some marron farmers in Northcliffe district (Daubney 2001a: 257).

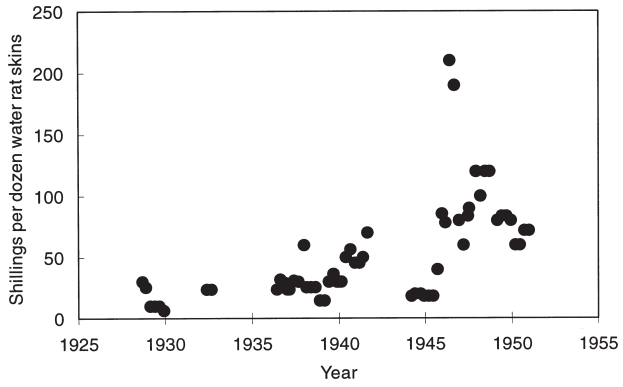

Fig. 33 Prices paid for skins of Hydromys chrysogaster. *Source:* Elder's Weekly, *supplemented by* The Westralian Farmers' Gazette *1928, 1929, 1939. Maximum price in March, June, September and December graphed.*

According to Winmar (1996), Noongars did not eat water-rats but did use their fur. The first sales of skins of this species found were reported in the 2.8.1928 edition of *Elder's Weekly*, based on 'good enquiry' from furriers in the eastern states (Fig. 33). It seems that unemployed men during the Great Depression trapped this species heavily. Water-rats were recorded as very numerous along brooks near Gingin up to c. 1930 (Udell 1979: 328). It is probably fair to say that this species was trapped to 'commercial extinction' in the 1930s-40s, though it appears to have recovered throughout much of its original range. The fur was used for women's coats and trimmings (*The Western Mail* 6.8.1936: 52). This reference mentioned that the high demand was caused by shortage of fur from Russia. The best method to trap water-rats was described in detail in this reference. *Elder's Weekly* mentions Government restrictions [?on the sale of skins] and no demand for skins in the period 5.3.1942-2.12.1943. From July 1952 it was declared illegal to be in possession of, or to offer for sale, skins of this species. Severe penalties applied, as well as confiscation of skins.

This species was reported to have become extinct in Perth district sometime after the 1970s (Drake 2000: 44). It disappeared after 1960 from permanent freshwater streams in the eastern part of its range as these became saline (e.g. Sanders 1991: 22). Snell (1986: 35) stated that it was extinct in Waroona district and Roots (2003: 200) implied that it no longer occurred in the Hotham River near Cuballing. It appears that destruction of habitat along freshwater rivers and salinization in inland areas are the major factors responsible for contraction in geographical range of the water-rat.

Water-rats are preyed on occasionally by dogs (Loaring 1954: 136) and by cats (L. Glauert in *The Western Mail* 7.2.1929: 48).

Leporillus apicalis lesser stick-nest rat

Although I did not seek information on this species from oldtimers, two reported the occurrence of disused sticknests near Morawa and 7 km east of Canna, in the north-west sector of south-west WA (Fig. 34). These nests contained nuts of quandong *Santalum spicatum* and sandalwood *S. acuminatum*.

Most records of sticknest rats are of the nests or the black faeces (pseudobitumen, see Bridge 2006), and all known to me are depicted in Fig. 36, assuming (on the basis of the range map published in Strahan 1995), that they refer to *L. apicalis*. This species occurred only on the very eastern fringe of the south-west WA region.

Sticknest rats were first seen alive in south-west WA in July 1861 near Baladjie Rock. Gum or pitch [pseudobitumen] was oozing from rock in a cave. Twenty miles east north east [c. 10 km north of Bullfinch] a small grey rat was captured and large nests of sticks, stones, and grass in hollow trees contained large quantities of York nuts [quandong] and sandalwood nuts (C. Dempster in

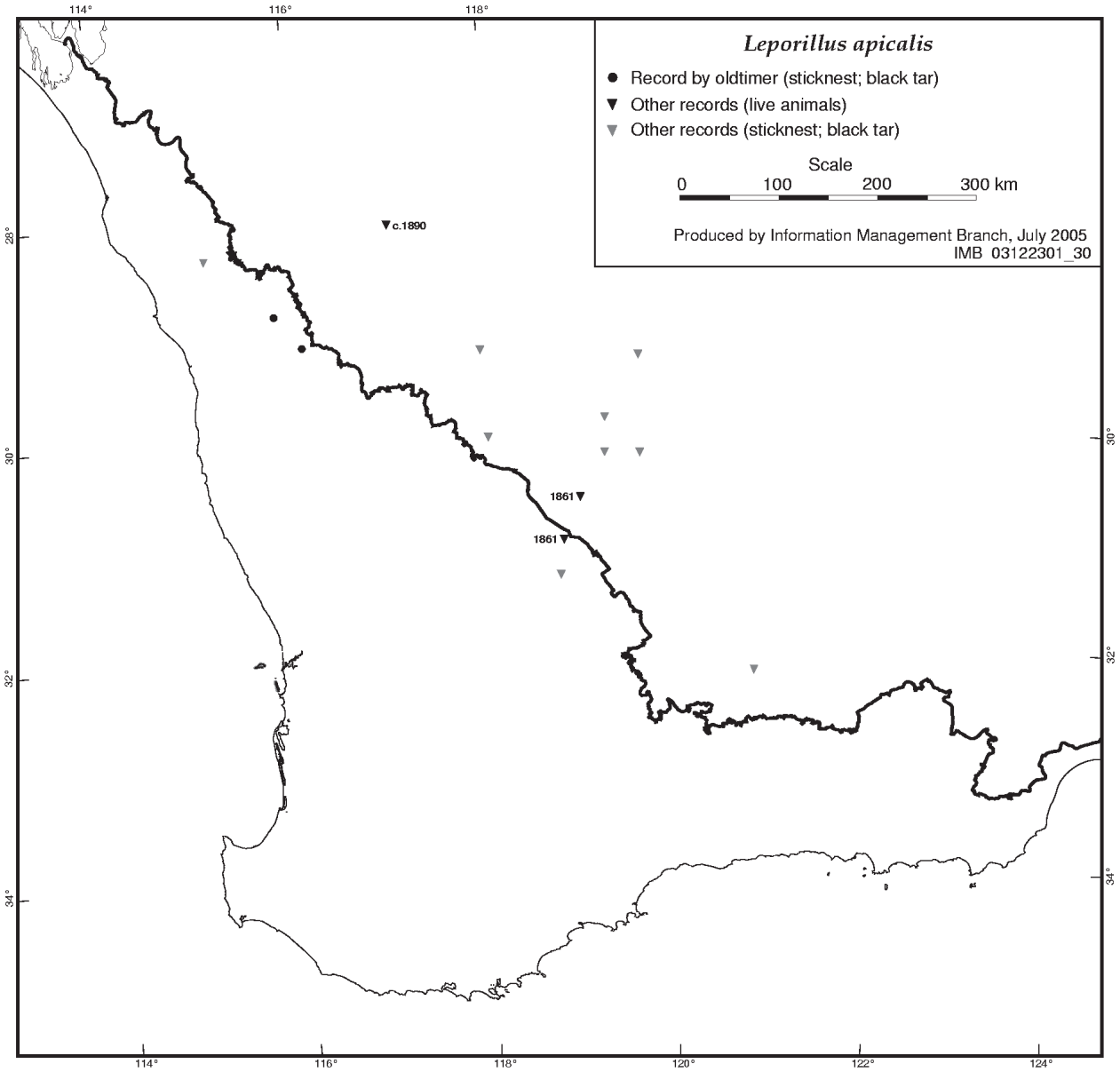

Fig. 34 Distribution of Leporillus apicalis. *Additional records not already cited in text: Austin 1855; Burbidge* et al. *1995; Chapman and Kitchener 1981b; Dell and How 1985; How* et al. *1988; Tuffin 1993; Wellard 1983; Youngson and McKenzie 1977.*

Exploration Diaries **5**: 32). Several rats (one female and two young) were caught six days later, apparently north of Lake Deborah East (Brooker 2006: 40). The lack of a pouch and the presence of four teats were noted (C. Dempster ibid.: 34). This meagre information about reproductive biology may be all that was ever recorded (see Copley 1999: 526).

Abbott (2006) proposed that this species disappeared from the area mapped in Fig. 34 in the 1880s as the result of a disease outbreak. Other factors that have been suggested include a decline of sandalwood nuts from unsustainable exploitation (Douglas 1980: 113) or habitat degradation resulting from grazing by rabbits and sheep, combined with drought (Copley 1988: 513). However, neither explanation seems to fit the timing of the decline.

Canis lupus doot/dingo

Books by Breckwoldt (1988) and Corbett (1995) present little information about dingoes in south-west WA.

Oldtimer information The dingo was recorded by oldtimers throughout much of south-west WA (Fig. 35), and was locally familiar through its nocturnal howling, its killing of lambs, calves, heifers and poultry, and the damage it did to the udder and tail of cows. Successful control (eradication) had occurred in numerous localities, particularly those intensively settled and through poisoning and trapping programs to protect livestock.

Dingoes increased in local abundance once sheep were introduced to a locality and it was then necessary to yard the sheep at night (C. Mottram) or erect a boundary fence

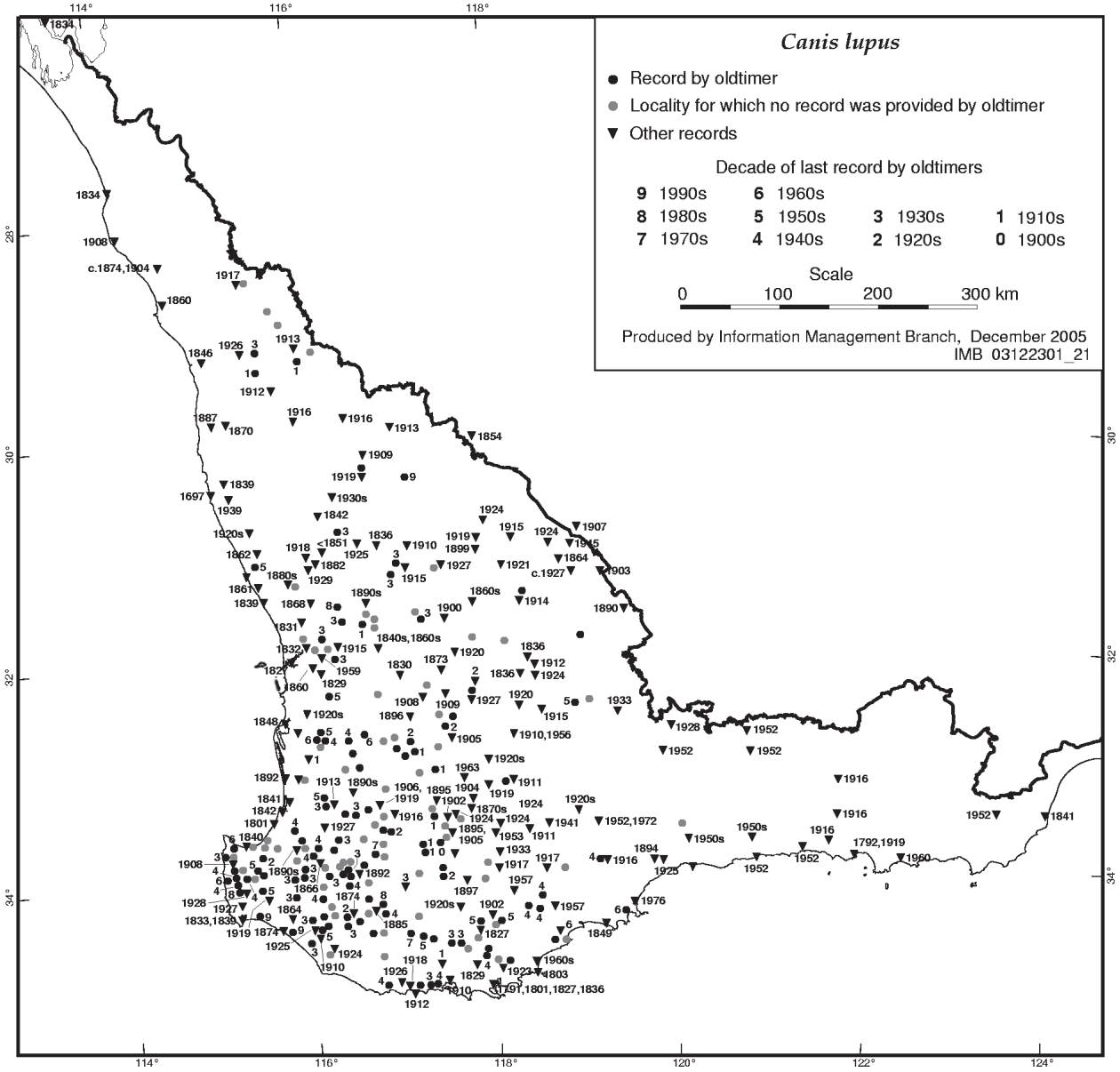

Fig. 35 Distribution of Canis lupus dingo. *Additional records not already cited in text: Abbott 1998b; Anon. 1959, 1999; Bellanger 1980; Bird 1986; Briggs 1917; Broad and Broad 1992; Brockman 1987; Carter 1888; Clifton 1981; Cornell 2003; Crawford 1908b; Crook and Burbidge 1982; R. Dale 1830 in Shoobert 2005: 167;* Fisheries Department Bulletin*; Flynn 2002; Frost 1979; Gabbedy 1972; Gervas 1997, 1999; Goldsmith 1961; Haig 1982; Harris 2002; Hasluck 1977; Henderson and Henderson 1988; Heydon 1988, 1996; Joukovsky-Vaisvila 1978; Mr Ross in* Journal of the Department of Agriculture of WA *10: 29 (1904);Knox-Thomson 1975; Lange 1981; Lefroy 2003; Manners 1992; AW Milligan in* Morning Herald *16.10.1902: 6; O'Connor 2001; Perry 1971; Prince 1981; Quicke 1979; Rice 1993; Royal Commission 1917b; Stevens 1996;* The West Australian *4.4.1882; Tomlinson and Moore 1952; Wedge 1984; Whittem 2000.*

high enough to exclude dingoes (F. Brockman, M. Marsh pers. comm.).

Harnesses had to be brought in at night, otherwise dingoes would destroy them in the process of obtaining salt (D. Andrews).

Domestic dogs that had become feral were said to have infected dingoes with distemper (F. Mitchell).

The literature published on the dingo in south-west WA is voluminous. It demonstrates that the dingo was ubiquitous in this region, as do the numerous Aboriginal names recorded for this species (Abbott 2001a: 479-84). The term 'dingo' is not Noongar, being the Aboriginal name from Port Jackson, New South Wales (Collins 1798 vol. 1: 614). In south-west WA the vernacular names used by settlers or early visitors were 'dog', 'native dog' or 'wild dog' (e.g. Nind 1831: 29; G. Collaert 1697 in Robert 1972: 80; Wilson 1935: 240; G. Moore 1832 in Cameron 2006: 125, 155; Irwin 1835: 22, 57; J. Drummond

15.10.1840 letter). The term 'dingo' was not used until the 1890s, when many 't'othersiders' came to WA to seek gold.

Pelage References to the coat colour by early visitors such as navigators and pioneer settlers, before domestic dogs were introduced or would have spread far, are as follows:

- 1697, near Jurien Bay: 'a yellow Dog' seen on the beach (G. Collaert in Robert 1972: 80).
- 1826, King George Sound: 'handsome red-haired dogs' reported by an English sealer (D. d'Urville in Rosenman 1987: 51).
- 1831, near York: 'yellow' native dog (G. Moore in Shoobert 2005: 262).
- 1832, Perth district: '[T]here seems to be as great variety (almost) among them as our dogs. Some are like black & white 'Colies'. Many of them are yellow & large' (Cameron 2006: 155).
- 1832, near the Lakes west of York: one native dog 'of a dark colour approaching to black' (J. Roe in Shoobert 2005: 325).
- 1836, Albany: 'In…colour…like a fox' (Fitzroy 1839: 627).
- Late 1830s, settled parts of south-west WA: 'a very great many varieties varying from the reddish brown or true Dingo to black - white - light brown - and black & white' (Gilbert nd1; J. Gilbert in Gould 1863: 402).
- 1840, Perth: 'a light tan colour, with a little white on the tip of the tail, and a few black hairs sprinkled in the brush; there was a little black also about her face' (Stokes 1846 vol. 2: 222).
- 1842, Picton: tawny colour (J. Wollaston in Bolton *et al.* 1991: 187).
- Late 1840s, New Norcia: 'for the most part they are reddish-brown' (Stormon 1977: 189).
- 1849, near Bolgart: one nearly white (Buchanan 2003: 155).
- 1864, Keokanie Rocks: Aborigines with six dingoes 'of all colours' (Epton 2001).
- 1864, extralimital near Lake Lefroy: one puppy in a litter had unusual colouring – legs, belly, small blaze down face and collar: white; rest: 'quite black' (Hunt 1864: 34). Millett (1872: 238) refers to two of these puppies as black.
- c. 1868, Brookton district: one pure white and one 'quite black' dingo poisoned (*The Western Mail* 23.8.1923: 5).
- 1880s, between Margaret River and Donnelly River: black dingoes with white brush paws and chest; a little larger and with softer hair than the yellow dingo. The black dingoes were stated not to have originated from cross-breeding with domestic dogs (T. Hutton in *The Western Mail* 9.8.1923:4).
- 1880s, Jerramungup: 'just like the sable collie' (Hassell 1975: 14).
- 1890s, no locality mentioned: 'varying much in colour' (Nicolay 1896: 128).
- ?1890s, Kellerberrin district: pure dingo varies in colour from light to reddish yellow; a few black (Leake 1921; Leake 1962: 17).
- 1899, no locality mentioned: generally darker than those found in eastern Australia (Le Soeuf 1900: 193).
- 1900, no locality mentioned: varies from creamy white to nearly black, usually uniformly light reddish, or yellowish brown (WA Year Book 1900: 174).
- c. 1900, no locality mentioned but somewhere along the #2 RPF: 'mostly the pure ginger type' (Webb 1944: 123).
- 1927, Deep River, black animals caught more often than black and tan or yellow animals (*The West Australian* 5.11.1927: 7).

These early references to animals with black do not support speculation by Shortridge (1936: 745) that such colours probably indicate interbreeding with domestic dogs, though the situation does become less clear with numerous sightings of black animals in long-settled areas (e.g. Babakin, E. Bee in *The Western Mail* 12.7.1923: 8). White animals were noted very rarely (Hasluck 1981: 111).

Dog or wolf? Although most early observers regarded the dingo as a dog, some noted characteristics of the wolf or fox:

- 'snapping like a fox' (Nind 1831: 29)
- 'prowl like wolves' and 'a sad nuisance' like foxes (G. Moore 1833 in Cameron 2006: 240, 317); 'having the stealthy habits of a fox' (Moore 1842: 25)
- 'the native dog, or wolf' (Breton 1834: 26)
- 'These dogs vary considerably in size, and, from their bushy tail and short pricked ears, resemble the fox' (Irwin 1835: 22)
- 'a native dog, which in size, colour and shape was like a fox, except that the nose was not quite so sharp, nor the tail so bushy' (Fitzroy 1839: 627)
- 'a sort of wolf, rather than between a fox and a wolf'; combines the cowardice of wolf and cunning of fox (J. Wollaston 1842 in Bolton *et al.* 1991: 223, 248)
- 'like the European fox in that he is not merely rapacious but cunning' (R. Salvado, late 1840s in Stormon 1977: 189)
- 'half wolf, half greyhound' (O'Reilly 1879: 20)
- 'would be mistaken for a fox if it were seen in an English county' (Lindley-Cowen 1897: 58)
- 'In its habits it should rather be compared with the fox than with the wolf' (WA Year-Book 1900: 174)
- The dingo does not bark like a dog but instead howls mournfully (Stormon 1977: 189), described as a slow crescendo, held on the top note for 5 sec., and then descending down a scale (Cannon 1983: 85).

Similar comparisons were also made in New South Wales, Victoria and Queensland: 'approaches near to the

original of the species, which is the wolf' (White 1790: 196); 'of the fox kind' (D. Blackburn in Whitley 1975: 4); 'not unlike a wolf, both in size and appearance' (Barrington 1795: 57); 'a smaller species of the wolf' (Wentworth 1819: 3); 'a small species of wolf' (Atkinson 1826: 23); 'like a wolf in appearance' (Dawson 1830: 176); 'the wolves of the Colony' (Bennett 1834: 230); 'of very wolfish aspect' (Backhouse 1843: 507); 'a species of wolf, about the size of a Newfoundland dog' (Haydon 1845: 57); 'more like a fox than a dog' (Kirkland 1845: 197); 'very like the fox in ears, face, teeth and expression; in habits much more so: it sneaks, crawls, stinks, is a coward and, though sometimes seen hunting in packs, generally a solitary or only with its mate' (Hodgson 1846: 161); 'somewhat like the English fox' (Henderson 1851, vol. 1: 206); 'in every way resembling the English fox' (Mackenzie 1851: 67); 'in size, shape, and cunning, resemble the English fox' (Lancelott 1852 vol. 1: 142); 'in form and colour much resembling a gigantic fox, but partaking more of the wolfish development' (Sidney 1852: 297); 'a species of fox, or perhaps, rather, wolf' (Diaper 1999: 61); probably bears most resemblance to the wolf, though with similarities to the dog and jackal (Haygarth 1864: 116); 'partakes of the nature of the fox and of the wolf, neither of which, however, he precisely resembles, for, not so finely made, and hardly so cunning as the fox, he is neither so bold nor so powerful as the wolf' (Kerr 1872: 171); 'half dog, half wolf' (Stamer 1874: 261); and 'neither more nor less than wolves' (Grant 1881 vol. 1: 71).

Association with Aborigines Aborigines tamed dingoes (E. Lockyer 1827 in Shoobert 2005: 19; RM Lyon in *The Perth Gazette* 30.3.1833: 51; Irwin 1835: 22; F. Armstrong in *The Perth Gazette* 5.11.1836: 794; Moore 1842: 25; Cameron 2006: 155, 288) and used them to hunt quenda, brush wallaby, and koomal, but they were too slow to catch the emu or western grey kangaroo (Nind 1831: 29). However, R. Salvado in the late 1840s reported that Aborigines at New Norcia trained dingoes to help in hunting and also recorded that a dingo would attack a kangaroo by surprise and wear it down (Stormon 1977: 189). There is an early report of Aborigines setting their dingoes onto some domestic pigs (*The Perth Gazette* 25.5.1833: 83). CC Hunt in 1864 at Keokanie Rocks came across a party of five Aborigines 'who had never seen white people or horses'. They had six dingoes with them (Epton 2001). In contrast, Fountain and Ward (1907: 200) never saw more than three dingoes per Aboriginal party in 1889-90. Aborigines kept dingoes as watchdogs (Nind 1831: 29) and 'as a friend' (J. Forrest WAPD **3**: 514, 22.12.1892).

Aborigines ate dingoes (Austin 1855: 29; Mulvaney and Green 1994: 311; Stormon 1977: 156, 160), particularly pups (Grey 1841 vol. 2: 279). Aboriginal women suckled pups with their own milk (Bradshaw 1857: 104; Clark 1994: 38; Mulvaney and Green 1994: 354; Stormon 1977: 156; Taunton 1903: 88) and sometimes carried a pup in their *gundir* (Browne 1856: 537; Clark 1994: 37). Dingoes were 'admitted to a share of their bed' (Nind 1831: 28) and permitted to enter huts (G. Moore 1832 in Cameron 2006: 124). Aborigines wore the tail around the temples, *dyer* (Anon. 1842: 116; Browne 1856: 536; Hassell 1975: 13; Melbourne International Exhibition 1880: 20; Millett 1872: 364; Moore 1842: 26; Nind 1831: 25; Roth 1903: 64; Stormon 1977: 134, 141) and used the tail to make a bracelet (King 1827 vol. 2: 143).

Distribution and abundance Despite occurring throughout south-west WA, the dingo was seldom seen by early visitors who invariably comment only on its frequent 'traces', i.e. dung and spoor (G. Vancouver 1791 in Lamb 1984: 336; B. d'Entrecasteaux 1792 in Duyker and Duyker 2001: 124; N. Baudin 1801 in Cornell 1974: 174; R. Brown 1801 in Vallance *et al.* 2001: 92, 93, 96; Wilson 1835: 240; Grey 1841 vol. 2: 109), or mention hearing dingoes at night (J. Stirling 1827 in Shoobert 2005: 34; W. Preston 1829 in Shoobert 2005: 82-3). In his first 23 months in WA, G. Moore had only seen three (Cameron 2006: 155). Gilbert (nd1) considered this species to be 'a very common animal over the whole of the Colony' (as it was known in c. 1839).

Several chroniclers noted the close association of the dingo with water in the inland parts of south-west WA (Roe 1836: 63; Austin 1855: 24), although Moore (1842: 82) implied that this was related to the presence of thickets in such places. Dingoes are known to be able to travel 30-40 miles in one night, evidenced by animals with deformed feet and hence distinctive spoor (Wedge 1984: 68). Early settlers at Moodiarrup thought that dingoes moved to Manjimup/Rocky Gully district in summer, a distance of c. 70 km (Bird 1990: 176). Drought drove them in from the interior (Crawford 1912: 44; Bird 1990: 220) and very wet years in the south-west attracted them from the interior (Leake 1962: 26). Much of the damage caused to stock in southern WA was attributed to dingoes coming from the Nullarbor Plain, 'an immense breeding ground' (Department of Agriculture 1951: 38).

Estimates of densities of dingoes are few: 27 caught in one year (?1910) within a mile of Lake Muir, and c. 90 trapped in five weeks between Lake Muir and Nornalup Road, a distance of c. 25 km, in c. 1920 (Muir 1975: 7-8). There were said to be hundreds present in 1936 in Margaret River-Cowaramup district (*The Western Mail* 31.12.1936: 48).

One of the more improbable explanations for increased numbers of dingoes in 1911-13 is that they fed on butter and bacon washed ashore from the wreck of *SS Pericles* in 1910. When this food was consumed they began to attack calves up to c. one year old (Fyfe nd: 16).

Impacts on livestock and poultry Once animals were brought ashore, it did not take long for the dingo to attack stock and poultry, and become anathematized by settlers:

- October 1827, Albany: several sheep taken from fold and several pigs apparently taken (Wakefield 1827b)
- October 1829, Fremantle: six sheep killed in one night, presumably by dingoes (Berryman 2002: 99)
- November 1830, Albany: sheep and goat attacked (Mulvaney and Green 1994: 356)

- June 1832, Millendon: one lamb 'so much injured by the native dogs' (Cameron 2006: 125), a few days after the number of sheep held on this farm increased from one to 34, including 10 lambs (Cameron 2006: 123)
- July 1833, Millendon: seven lambs killed and two lambs torn to pieces in the sheepfold (Cameron 2006: 260)
- November 1833, Upper Swan: 81 chickens killed (Cameron 2006: 295)
- March 1834, Upper Swan: four geese killed in daylight (Cameron 2006: 317)
- Before 1835: 'the only animal' ducks and geese 'have to fear' (Irwin 1835: 57)
- May 1838, Millendon: all but two ducks taken (Cameron 2006: 444)
- July 1838, Millendon: first reported attack on sheep during the day (Cameron 2006: 447)
- March 1839, near Augusta: sheep 'worried' (Turner 1956: 132)
- ?1839: 'when driven by hunger it is a bold fellow and will not at this time scruple to go into fold among a flock of sheep, but its general mode of attack is to follow a flock, and if a lamb drops behind immediately pounces upon it and carries it off' (Gilbert nd1; J. Gilbert in Gould 1863: 404)
- July 1839, Perth townsite: one trapped in a fowl-yard, with reference to the 'havoc these animals have committed within the last few months' (*Perth Gazette* 20.7.1839: 115)
- June 1840, Vasse: goats and hens depredated (Shann 1926: 185)
- April-June 1841, Tipperary (near York): three lambs taken during one night (*The Inquirer* 2.2.1842)
- June 1841, Australind: one hen taken (Johnston 1962: 57)
- June 1842, ?Bunbury: six goats killed (Bolton *et al.* 1991: 228)
- c. 1843, 'most destructive' in the poultry yard (Gilbert nd2)
- March 1843, York: two sheep killed in fold (de Burgh and de Burgh 1981: 71)
- June 1846, Wedderburn: 24 fowls taken (Joske 1989: 35)
- April 1848, Murray district: sheep, pigs and poultry attacked; 'now not safe for a cow to calve in the bush' (*The Inquirer* 26.4.1848)
- May 1848, Bunbury: 23 sheep killed; beginning to attack calves (Mann 2006: 61)
- Late 1840s, New Norcia: sheep and fowls killed; 'if he manages to get into a flock at night-time he wreaks terrible havoc' (Stormon 1977: 189)
- 1850, Vasse: calves and young horses killed (*The Inquirer* 24.4.1850, 22.5.1850)
- 1860, Roleystone: pigs did well in the bush until dingoes killed them (Popham 1980: 37)
- c. 1865, Balgarup: 30 sheep left out at night were killed by dingoes for 'amusement' (A. Warburton in *The Western Mail* 31.8.1924: 6)
- 1865, near Mt Barker: 'extremely destructive and in our ill populated Colony very hard to get rid of' (Crabb nd: 102)
- 1866, Forest Hill: five sheep bitten, two killed and 10 missing (Muir Diaries, 16.6.1866)
- 1870s, lower Gordon River: anything up to a 2 year old steer would be attacked by dingoes when very hungry and in packs of 6-7 animals (A. Warburton in *The Western Mail* 31.8.1924: 6)
- 1874, Warren district: pigs, young calves and sheep killed (*The Western Australian Times* 10.7.1874)
- 1878, outlying parts of York district, such as at Kellerberrin: becoming so numerous as to make it impossible to farm sheep (*The Eastern Districts Chronicle* 1.6.1878: 2)
- 1895, unoccupied country between Lake Muir and the south coast: 'They even kill the calves' (*The Australian Advertiser* 11.3.1895)
- 1895-6, many localities, significant depredation (various authors in *Journal of the Bureau of Agriculture of WA* **3**, 782, 1896; ibid. **4**, 1259, 1897).

Because these depredations continued and expanded as settlement increased from the 1840s to the 1950s, it was essential for pastoralists or farmers to shepherd sheep during the day and fold them at night (Anon. 1895: 431; Beecham nd: 69; Broomhall 1983: 277; B. Clarkson WAPD **3**: 512, 22.12.1892; de Burgh and de Burgh 1981: 70; Eaton 1979: 148; Facey 1981: 25, 80; Jenkyn 1999: 75; Klemm nd: 7; Lamond 1986: 112; Lindley-Cowen 1897: 110-1; Moran 1995: 37; Parnell 1982: 58; Sewell 1998: 187; Southern Scribes 1999: 174, 331). To be fair, however, to the dingo, it is likely that such events are more a result of inadequate precaution by settlers. Where landholders did anticipate depredations, losses were inconsequential. For example in 1835 A. Trimmer of York stated that 'it is a very rare occurrence to lose a sheep' (Irwin 1835: 94).

In general, shepherded sheep were comparatively safe from dingo predation, provided that one or two sheep dogs were present to guard the yard and flock. Once fencing and paddocking displaced shepherds, mortality of sheep could be substantial (*The Western Mail* 31.3.1906: 9):

- 50 lambs killed by two dingoes in one night, c. 1895, near Katanning (Haddleton 1952: 21)
- 1078 sheep presumably taken by dingoes from a flock of 2000 sheep, Blackwood district (Fowler 1896)
- 85 lambs and 10 ewes killed in one night, c. 1904, Moore River (de Burgh 1976: 110)
- Heavy losses of sheep, north of Kellerberrin (*The Western Mail* 30.3.1907: 6)

- Hundreds of goats, as well as foals and calves, killed, 1908, near Bullfinch (Stevens 2001)
- c. 100 sheep killed by pure dingoes, 1908, near Broomehill (*Great Southern Herald* 13.5.1908)
- 405 sheep killed within a 5 mile radius of Wannamal (*The Western Mail* 3.4.1909: 10)
- 280 lambs killed by two dingoes in one night, c. 1910, Lake Muir (Muir 1975: 7)
- Of 100 sheep in 1910, only five left by 1915 (Ackland 1965: 120)
- > 400 sheep killed in 4-5 weeks, 1921, Moulyinning district (Timperley 1996: 413)
- Of 200 sheep, many killed, early 1920s, Harrismith district (Taylor 2000: 181)
- 50 sheep killed, 1927, Dandaragan district (McConnell *et al.* 1993: 137)
- 75 sheep killed in one night, early 1930s, Babakin (Ewers 1959: 97)
- c. 100 sheep and lambs killed , 1949, near Pingrup (Beecham nd: 130)
- All young lambs killed in one night, 1957, Baramba (de Burgh 1976: 182)
- 250 sheep killed in 6 months, 1960s, northern part of Westonia Shire (Maddock 1998: 676)
- many sheep killed or maimed, 1960s, Wellstead district (Anon. 1989: 23).

Sometimes dingoes maimed many sheep for sport, opening up holes in their sides between the ribs and hips, tearing out the kidneys, and puncturing the lungs of lambs (Atkins 1993: 16; Cameron 1989: 155; Ewers 1959: 98; Taylor 2000: 181).

These losses forced some settlers to concentrate on cattle (Jefferson 1902: 409; Gliddon 1908: 283) or wheat farming (Langfield 1924), and almost made sheep farming impossible in some districts (Royal Commission 1917b: 8, 17, 25, 36, 38; Podmore 1909: 36; M. Troy WAPD **72**: 1425, 20.10.1925; Wedge 1984: 62; Cheyne Bay, 1960s, Plunkett and Wimbush 1999: 150), and even resulted in abandonment of farms (Tone River, 1880s, Schorer 1968: 325; Lake Bryde, 1920s, Bird 1992: 196). Some farmers sold out of all their sheep and kept cattle instead (Gliddon 1908: 283).

In 1871 a *Destruction of Native Dogs* Bill reached the second reading stage but did not become law (WAPD 1870-1: 118, 16.1.1871). One settler advocated that total eradication would not be achieved until settlers simultaneously laid strychnine baits in unsettled country between farms (*The Perth Gazette* 20.6.1873). In 1886, there was 'a general consensus of opinion that the sooner he [the native dog] is made to disappear from the face of the earth the better will it be for the sheep farmer' (*The Western Mail* 13.3.1886: 13). However, it may be that cross-breeding with settlers' dogs (implied by *The Perth Gazette* 14.10.1837: 989) resulted in a more aggressive animal. In the early years of the development of the wheatbelt, sheep were an adjunct to wheat farming, providing meat, manure and helping keep the land free of weeds. Hence only small numbers of sheep were kept per farm (Richardson 1895). The presence of dingoes made it very difficult to keep even small numbers of sheep (J. Drew WAPD **73**: 2337, 2.12.1925).

Dingoes caused problems for Group settlers in the southern forests in the 1920s, killing fowls and calves (Payne 1987: 44; French 1989: 21; Daubney 2001a: 20, 145). 'Ricketty' cattle were eaten alive in the 1950s on coastal grazing leases (Ipsen 2000: 37).

Methods used to limit the distribution and abundance of dingoes Farmers responded in several ways to the threat caused by dingoes to sheep.

• Trapping and shooting under a bounty scheme

The Agricultural Society, which was established in 1831, did not then include in its objectives or strategies control of pest animals (Cooper *et al.* 2004: 6-7). In 1834 its members decided to pay 5s out of its funds for every dingo killed, subject to certification by another member (*The Perth Gazette* 15.11.1834: 392). Evidently attacks on sheep were unimportant, as only two claims were submitted in the following three months (*The Perth Gazette* 7.2.1835: 438) and dingoes were not mentioned in the annual report (*The Perth Gazette* 26.12.1835: 622-3) or in a subsequent synopsis about the state of farming (*The Perth Gazette* 4.6.1836: 705). Rewards were paid for the destruction of 24 native dogs in the year up to 4.8.1837 (*Perth Gazette* 5.8.1837: 949) and for 58 native dogs in 1837 (*Perth Gazette* 3.2.1838: 18). This premium was later reduced to 2s 6d (*The Perth Gazette* 7.10.1837: 984) but was restored to 5s in the following year (*Perth Gazette* 4.8.1838: 121). In 1839 many rewards were paid (*Perth Gazette* 10.8.1839: 127). The York Agricultural Society was formed in 1840 and one of its stated functions was 'the destruction of native dogs', for which 10s would be paid *per capita* if certified by a member (*The Inquirer* 12.8.1840: 7). By September 1842, it was foreshadowed that the reward was to be rescinded (*The Perth Gazette* 10.9.1842). Rewards were suspended from December 1842 until June 1843 (*The Inquirer* 4.1.1843, 5.7.1843), when it was decided to reward with £10 the person each year with the most scalps produced and certified (Anon. 1843 Appendix: xvii).

The earliest records found of payments made by government are 5s per head in 1841 (de Burgh and de Burgh 1981: 90), evidently authorized under the Dog Act (1841). Payment was only 6d per head in 1850 (Richards 1978: 259). So concerned was the York Agricultural Society that it decided to expend all disposable funds as rewards for the destruction of native dogs in place of awarding prizes at its annual show (*The Inquirer* 20.10.1847). The reward, available for York and Toodyay districts, was 5s for adult dingoes and 2s 6d for puppies (*The Inquirer* 1.12.1847), later reduced to 3s per dog (*The Inquirer* 20.11.1850). This scheme had evidently lapsed by the 1870s (*The Perth Gazette* 20.6.1873). There were calls for a more stringent Dog Act (*The Western Australian Times* 28.7.1876), including a reward of 4-5 s per dingo tail financed by the Government but managed

by the various agricultural societies (*The Inquirer and Commercial News* 29.5.1878). Such a reward was expected to encourage any person to destroy dingoes (*The Eastern Districts Chronicle* 27.7.1878: 3, 7.9.1878: 2). Sometimes a substantial reward was offered, e.g. £20 for the skins of two dingoes running with a settler's sheep (*The Victorian Express* 30.4.1879).

The Dog Act was consolidated and amended in 1883 and a 10s reward (upon presentation of the tail to a Justice of the Peace) was offered for the destruction of 'wild dogs' in Central district [i.e. between Moore River and Murray River and east to the limit of settlement] and 5s elsewhere (see also WA Year Book 1893: 144-6). In 1891 £1 660.18.6 were paid in rewards for native dogs (J. Forrest WAPD **3**: 515, 22.12.1892). Parliamentarians discussed if the reward should be increased by 5s or 10s (WAPD **3**: 509-17, 22.12.1892). Where native dogs were plentiful, it was considered that 10s was sufficient reward to induce people to destroy them. Where they were scarce and thus difficult to get, a reward of £1 may encourage destruction of their breeding camps (F. Piesse WAPD **3**: 510, 22.12.1892; A. Richardson WAPD **3**: 511, 22.12.1892). In 1895 farmers were still pressing for this reward to be increased to £1 in order to induce people to apply themselves to 'the extermination' of dingoes (Piesse 1895). The Vermin Boards Act of 1909 re-affirmed the bounty of 10s (adults) and 5s (pups), and from 1913 the Government authorized payment of 10s per scalp in the South Western Division and 5s elsewhere (*Government Gazette* 31.1.1913: 273-8).

Abuse of the bounty scheme was often reported (WAPD **3**: 509-517, 22.12.1892), including: cutting off the tail, placing a bell on the animal, and releasing it so that its pups could be readily located (*The Bunbury Herald* 10.3.1896); amputating the tails of animals trapped outside Central District and presenting these in Central District to obtain the higher payment (*The West Australian* 22.5.1884); manufacture of a tail from pieces of skin (WAPD **3**: 509-517, 22.12.1982; *The West Australian* 7.7.1894: 5); and purchase from Aborigines of tails from dogs that are not destroyed (*Government Gazette* 20.9.1895: 1500). It was not until 1899, however, that presentation of the scalp, ears and tail was required before the reward would be paid (Dog Act Amendment Act 1899).

The merit of offering a reward was debated (*The Inquirer and Commercial News* 30.7.1879), particularly if it was to depend on a tax on sheep. One view was that sheep farmers themselves should pay for the destruction of dingoes (*The Inquirer and Commercial News* 25.8.1880). There were occasional calls for the abolition of the bonus, as 'it is only encouraging indolent settlers who would not help themselves and do so at the expense of the ratepayer' (*The Bunbury Herald* 28.4.1896).

Asafoetida was recommended as an attractant to be smeared over steel traps (*The Western Australian Times* 28.5.1878). A substance (presumably a lure), known as 'Dingo Trail', was exempted from Customs duty in order to encourage its use (*Government Gazette* 17.11.1899: 3774-5). Its efficacy was praised (*The Western Mail* 11.5.1907: 5).

In 1904 it was recommended that the trap be buried on the beat of a dingo (Anon. 1904: 82). Later, the necessity of tying a poison bait to the trap was advocated, and it was recognized that special precautions were required in unsettled areas in order to avoid contamination of the soil around the trap with human scent (Leake 1921). One farmer advised that he successfully trapped male and female dingoes by smearing the trap with urine and dung of a female dog (*The Western Mail* 24.5.1923: 4). A diagram showing the use of a decoy when trapping was published (*The Sunday Times* 23.11.1924: 25 and *The Western Mail* 5.3.1925: 1). Suitable months for trapping were considered to be from January to August, with March to June the best because dingoes are most mobile then (Leake 1921).

From 1916 there are numerous records of bounties being set by local government districts and matched by the State Government (Crake 1985: 111). They are highly variable, ranging from the standard 10s per head to 30s (1917-20, Crake 1985: 111), £3 (1916, Bird 1990: 299), £5 (1920, Chase and Krantz 1995: 214), £3-5 (C. Baxter WAPD **84**: 788, 1.10.1930), £10 (1925, Ackland 1965: 66, and £20 (W. Glasheen WAPD **84**: 1056, 15.10.1930). This variation presumably reflected local differences in the value of the assets being protected and the local capacity to pay for hundreds of bounties (see H. Maley WAPD **69**: 1740, 29.11.1923), as well as the effort required to catch the few remaining dingoes in a district. There is a photograph in Voigt (1996: 160) of a pile of 451 scalps being burnt in 1919 at Esperance.

Some farmers formed a dingo club (*The Western Mail* 12.8.1937: 47; Beecham nd: 62; de Burgh 1976: 130; Timperley 1996: 413; Schorer 1968: 91), funded by a 5s voluntary levy per 100 sheep owned by each member. The funds raised were used to employ a trapper. The earliest dingo club was in Mullewa district in 1917 (Keefe 1995: 110). Often a higher reward was paid for the scalp of female dingoes (e.g. £4 for female, 30s for male, and £1 for a pup, 1930s, Gingin – Udell 1979: 286). Two trappers were paid £40 to kill two 'cunning' dingoes in Nyabing district (*The Western Mail* 18.9.1924: 30). Some dingoes, identifiable by malformed paws, caused havoc and the bounty for such animals could reach £75 (Buchanan 1997: 233). Kwobrup dingo club paid £700 to trappers for dingoes caught in a 17 year period (Ackland 1965: 66).

Arnold (1922) thought that Vermin Boards should have paid a uniform bonus per scalp. This may have ensured more consistent effort in trapping and poisoning of dingoes across the settled parts of south-west WA. However, differences between Vermin Districts in numbers of dingoes and livestock and levels of damage done by dingoes to stock would have hampered equality of control across districts.

References to bounties on dingoes were found in numerous districts (Bain 1975: 252; Broomhall 1983: 261, 267; Buchanan 2000: 166; Cresswell 1989: 151; Coy 1984: 227; Facey 1981: 82; Ferrell 1992: 291; Gabbedy 1988 vol. 2: 409; Laurie 1994: 38; Maddock

1987: 235, 426; Maddock 1998: 506; Mingenew 1988: 83; Sewell 1998: 187; Spencer 1966: 80). In the 1920s a dingo scalp was worth nearly a week's wages. Therefore finding the den of a dingo was a special prize (Wedge 1984: 12). The bonus remained at £2 through the 1930s (WAPD **85**: 1879, **107**: 552). By 1950, the bonus was only 25s (Vermin Act 1950, Sect. 103).

In farming areas the number of scalps obtained declined from 4 250 in 1928 to only 251 in 1954 (Gooding 1955: 434). In 1941 only 230 scalps were paid for in 16 local government areas, down from 1499 ten years earlier (F. Wise WAPD **107**: 543, 10.9.1941). By 1947-54 relatively few bonus payments were made in south-west WA (Tomlinson 1955). Only six trappers, funded by a Government trapping scheme, were operating in the wheatbelt in the 1940s (Department of Agriculture 1946: 41). The bonus system was eventually regarded as a 'costly failure' as it substituted commercialization for eradication (Tomlinson 1955). It was replaced by organized district control work.

• Dog-proof fencing

The *Journal of the Bureau of Agriculture of WA* in 1894 (**1**, 170) republished from a South Australian newspaper the description of an effective 4-wire fence. Each wire was 6 inches apart, with the wire closest to the ground (6 inches above ground) and the third wire above the ground being barbed. Improved standards of fencing were one widespread response to continuing depredations on sheep by dingoes, but the nominated features of an effective fence are contradictory.

A 'low' sheep-fold was considered sufficient in the 1840s as dingoes did not have 'the art of jumping or clambering over a fence' (near Popanyinning, Landor 1847: 253; also Kendenup, *The Western Mail* 28.7.1906: 6) but would instead try to force their way through or under a fence. In the 1860s an upright 'Jam Fence' (height not stated) kept out dingoes (*The Perth Gazette* 22.11.1867). According to Leake (1962: 18), the dingo in its pure form rarely jumped over fences 3 ft high, whereas JL Stokes observed a pet dingo able to leap twice its height (Stokes 1846 vol. 2: 223), R. Hamilton reported seeing a dingo climb 14 ft up a tree and also jump a fence (*The Western Mail* 11.6.1910: 7), and Braid and Forbes (1997: 78) stated that dingoes could climb up 6 ft high netting. It was claimed that dingoes would not crawl or get through the barbed wires. However, dingoes could scratch under a fence (Richardson 1895) and could crawl between barbed wires only 5 inches apart (Leake 1921: 9). At Dangin a netted fence topped with a barbed wire was apparently adequate to protect sheep from dingoes (*Eastern Districts Chronicle* 6.5.1899: 3). A fence consisting of 3 ft of netting and 3 wires (the netting being laced to two of the wires at the top and bottom, with the third wire placed above the netting) was also effective against dingoes (WA Year Book 1906: 564). A rabbit-proof fence with two barbed wires was regarded as dingo proof (Royal Commission 1901: 37-38).

The essential elements of an effective fence were further discussed by farmers (*The Western Mail* 9.2.1907: 5, 31.8.1907: 6, 15.2.1908: 7, 28.11.1908: 8, 1.10.1910: 8, 15.10.1910: 9, 22.10.1910: 8).

Another variant of dingo-proof fencing consisted of a barbed wire at ground level, 3 ft of netting (4" mesh) attached to a plain wire at the top and bottom, 6" above which ran a barbed wire with a plain wire 6" above the barbed wire. The bottom barbed wire was optional and the height of the wire netting could be reduced to 2'6" to reduce costs and the distances between the top wires increased to 8" and 7" respectively (Government of WA 1914: 45-46).

Cooke (1911) examined 82 witnesses in an inquiry into the settlement of land with poison peas. Instructive details of fencing in use and whether dingoes were present were supplied by 27 witnesses. Where dingoes were absent, fences consisted of 3-7 plain wires, sometimes in combination with a barbed wire at the base or with 3 ft high wire-netting. Where dingoes were present, nearly all used 1-5 barbed wires in combination with 2'6"-3' high wire-netting and plain wires. Langfield (1924) described a successful fence consisting of 2 barbed wires, one plain wire and rabbit-proof netting 3ft high, with the lower barbed wire securely fastened to the top of the netting. Diagrams of a dingo-proof fence were published in *The Western Mail* (23.4.1925: 1, 27.12.1928: 37). The latter fence was 6 ft high with a 2 ft overhanging verandah on the outside of the fence and one barbed wire on the top. Perhaps these were the fences in use near Narembeen in 1931 (Bristow 1984b) and at Emuning Rock in 1932 (Sewell 1998: 181). A fence in use near Merredin in c. 1924 (4'2" high, with rabbit netting to 3', a barbed wire 4" above, a plain wire 5" higher and another barbed wire on top) was effective for 15 months until it was modified to a lesser standard by removing the wires (*The Northam Advertiser* 6.4.1929: 4).

On farms it was of course only necessary to erect a dingo-proof fence around the boundary (e.g. 1909, Facey 1981: 185; 1910, Laurie 1995: 128; 1912, Ewers 1959: 38). For the undercapitalized farmer, this could be expensive and so few farmers erected one (Webb 1988: 125). Sometimes a dingo-proof fence was only constructed around yards where sheep were kept at night (1924, Bristow 1988: 95; 1931, Bristow 1984b; c. 1933, Cameron 1989: 155).

Wartime shortages of strychnine during 1914-18 apparently diverted effort to the erection of netting fences (Laurie 1994: 87).

Some settlers along the rabbit-proof fence were permitted in 1907 to add a barbed wire between the top wire and the netting in order to make the fence dingo proof (Crawford 1907a: 35). In 1912 it was proposed to add two additional barbed wires to parts of the rabbit proof fence in order to prevent dingoes coming in from the east during droughts and killing sheep (Crawford 1912: 44). By 1914 some 325 miles had been made dingo-proof (Crawford 1914: 74). In 1919, Government decided to finish making the No. 1

rabbit proof fence dog-proof up to 621 miles north of Burracoppin (Crawford 1919: 38). It was reported in 1923 that few dingoes were found west of the No. 1 and No. 2 rabbit proof fences in contrast to east of the No. 1 fence. Settlers on the west side of the No. 1 fence could leave their sheep in paddocks at night, whereas those on the eastern side had to yard them each night (Arnold 1923: 32).

The Royal Commission into Agriculture (1918: xvi) suggested that Government should investigate whether a dog-proof fence on the frontier line of southern settlement, between Cape Leeuwin and Albany, could be constructed. No action was taken.

The agricultural editor of *The Western Mail* (12.4.1923: 4) forcefully argued that fencing alone would not control dingoes. It was one component of a program that needed to include neighbourhood co-operative poisoning and employment of expert trappers. Inexperienced trappers would merely educate dingoes to avoid traps.

A photograph of a model of a fence 4'6" high, with another 2 ft section fixed upwards and outwards was published in *The Western Mail*, 4.3.1926: 33. By 1930, a dingo-proof fence had to be 6'6" (rabbit-proof netting surmounted by a series of wires, plain or barbed) above ground for a landholder to be exempted from paying rates levied by local Vermin Boards. An overhang was no longer required (C. Baxter WAPD **84**: 789, 1.10.1930; H. Yelland **84**: 925, 9.10.1930).

• Distribution of poisoned baits

The first recorded use of 'nux vomica' (strychnine) and arsenic in WA was in 1833 (Cameron 2006: 243, 255), but several months later was ineffective (Cameron 2006: 317). Poisoning may have been in general use in south-west WA in the late 1840s/early 1850s, as dingoes were then being poisoned with strychnine in Victoria and New South Wales (Townsend 1849: 30; Mundy 1852 vol. 3: 285; Krefft 1866: 2; Brown 1959: 350). The use of strychnine in South Australia to kill dingoes was publicized in 1853 and it was noted that it could be purchased in Perth and that the Government had ordered some from England for distribution among the settlers (*The Inquirer* 27.7.1853). The next earliest record found of poisoning of dingoes in south-west WA is 1854 (Ducker 1988: 92). In 1861, strychnine was sold 'to a great many settlers for…destroying native dogs' (*The Perth Gazette* 11.1.1861: 3). Other records of use in the 1860s include Kellerberrin (Leake 1962: 17), Forest Hill (Muir Diaries 16.6.1866), Knight (1870: 118), and Gordon River (A. Warburton in *The Western Mail* 31.1.1924: 6). Poisoned baits were laid in May 1874 at Deeside (Deacon 1951: 64). Around York and Beverley, dingoes were 'ruthlessly' poisoned in the 1890s, with the usual method of distributing strychnine baits involving dropping them from a buggy or from horseback if no boodies or kangaroo rats were present. Otherwise the baits were placed in a forked stick 18 inches to 2 ft above the ground (Lindley-Cowen 1897: 58, 383; *The Western Mail* 27.7.1907: 5). Dingoes at Cocanarup were less abundant in 1883 owing to 'constant use' of traps and baits (*The Albany Mail and King George's Sound Advertiser* 31.1.1883). Baits used in 1898 near Katanning caused the local extirpation of dingoes (Haddleton 1952: 21). Subsequent advice was to poison all meat left in paddocks at night (Anon. 1908a; Anon. 1910: 5).

In the days of shepherding of sheep (1860s), shepherds at Balgarup would not lay poison for fear of killing their dogs. Poisoned baits were therefore set on outside places and waterholes where shepherds were unlikely to go. By this method a section of the Gordon River was free of dingoes within one year, with the poisoning of the carcass of a calf resulting in 20 dingoes being killed (A. Warburton in *The Western Mail* 31.1.1924: 6).

Dingoes were considered to be 'too cunning' to take poisoned baits in Warreup district (J. Wray 1894 in *Journal of the Bureau of Agriculture of WA* **1**, 109) and 'so wary of taking poison' in Lower Blackwood district (C. Brockman in Conference of Producers 1898: 38). There were occasional reports of particular animals averse to taking baits (e.g. *The Western Mail* 18.10.1923: 3; *The Sunday Times* 23.3.1924: 16; *The Western Mail* 22.1.1925: 3).

Strychnine was in short supply during the Great War, and there was little poisoning done. This led to a large increase in the dingo population (Laurie 1994: 87). Strychnine was unprocurable or too expensive to purchase after 1918, resulting in extensive losses of sheep (Crawford 1920: 33). Presumably poisoning constituted the 'extreme measures' used by the Department of Agriculture against the dingo during 1918-19 between Yallingup and Denmark (Glauert 1921: 114). Hutchins (1981: 18) implied that extensive poisoning in south-west forests took place in the 1920s. More than 130 dingoes were poisoned in c. 1920, between Lake Muir and the south coast (Muir 1975: 8). From January to April 1921, all owners/occupiers of land in the South West and Denmark Vermin Districts were ordered to suppress/destroy dingoes on their holdings and adjacent roads, by poisoning and/or trapping (*Government Gazette* 10.12.1920: 2211).

In 1921 systematic trapping and poisoning could keep dingoes under control, sufficient to not need to yard sheep at night (Leake 1921). This is an early instance of the success of what is now known as integrated control.

In 1934, poisoning was (still) recognized as the first line of defence, to be continuously carried out all year over a wide area (Arnold and Herbert 1934). Strychnine was still in use in the 1940s and 1960s (Wild 1948, Anon. 1961), with 15 000 baits made per week (Wild 1948). Advice in the 1950s was to bait all breeding grounds in order to destroy pups, particularly from July to September when pups start to fend for themselves (Moore 1953, Tomlinson and Blair 1954). By 1972 strychnine had been replaced by compound 1080 (Anon. 1972: 61).

Lures and other methods to attract dingoes to take poisoned baits were described in *The Western Mail* (11.5.1907: 5, 29.2.1908: 5, 14.8.1909: 7, 1.11.1923: 5) and also advertised (15.4.1926: 2).

• **Increased clearance of native vegetation**

The increase in extent of cultivated areas would obviously reduce the availability of shelter for dingoes and, in combination with poison baiting, would force the dingo to the perimeter of settled areas (Pustkuchen 1981: 32). By 1931, much land in many districts in the eastern wheatbelt had been cleared of its original vegetation, depriving the dingo of shelter (Leake 1962: 20, 25).

Ecological impact of dingo control One of the consequences of control or elimination of dingoes was that their prey increased in abundance. WJ Roberts (*The Bunbury Herald* 28.4.1896) stated that the dingo aided farming by keeping down the 'vermin'. In the southern forests between Yallingup and Denmark some 5 000-6 000 dingoes were destroyed in the period 1918-20. This apparently resulted in 'wallabies' [?quokkas] and tammars increasing markedly (Glauert 1921: 114). Emus, koomal and kangaroos presumably also increased, as dingoes depredated these species (*The West Australian* 15.3.1930: 4, 29.3.1930: 4, 12.4.1930: 4, 26.4.1930: 4). It is also possible that the fox and feral cat increased in abundance in south-west WA concomitant with the demise of the dingo (cf. Read 2003: 260-1). Reduced numbers of dingoes may have had knock on effects, with foxes and possibly cats causing population declines of marsupials (Johnson *et al.* 2007).

Baits deployed for dingo control may also have been taken by chuditch (K. Morris pers. comm.).

Beneficial impacts on dingoes As well as the farm animals noted earlier, dingoes killed kangaroos (Moore 1842: 82) and rabbits in large numbers (Crawford 1907b: 59). Dingoes benefited from: the hunting of kangaroos (for skins), as the carcasses were discarded (M. Quinn in *The West Australian* 31.3.1888; Aborigines Department 1907: 7; McConnell *et al.* 1993: 137); the development of water supplies (farm dams); and the incursion of rabbits (Royal Commission 1901: 37; Leake 1962: 18). For example, dingoes were said to be 'more numerous now [1890s] than they used to be' in Williams district, thought to be because of 'wholesale slaughter' of kangaroos (Lindley-Cowen 1897: 110-1). Later increases, in 1918-19, were attributed to a shortage and higher cost of strychnine (Crawford 1920: 33). In South Australia the average litter increased from two to six pups with the arrival of rabbits (McGilp 1921a).

Interactions with humans Dingoes are both curious and fearless, evidenced by their habit of coming close to farmhouses (Payne 1987: 44), stealing from a meat safe (Cameron 2006: 373), entering pigsties and carrying off or killing suckers (Ewers 1959: 98), taking meat or food scraps from campsites (G. Moore 1831 in Cameron 2006: 52; Eyre 1845 vol. 2: 38; Schorer 1974: 227), searching a boat (Cameron 2006: 155), stealing a bridle and horse rug (Roe 1836: 18), and licking the feet of sleeping men (Shorter 1987: 120). Dingoes have also been known to gnaw horse tether ropes (Roe 1836: 18), axe handles (Shorter 1987: 120), well-oiled harnesses (Parnell 1982: 64; Marshall 1993: 70; Shiner 2003: 70) and boots (Schorer 1974: 227), presumably for the salt or fat.

The earliest record of attacks by dingoes on humans comes from near the mouth of the Donnelly River in 1874 (*The Western Australian Times* 10.7.1874). Dingoes have been reported pulling a horse rug off a sleeping man (Taunton 1903: 57), following children walking home from school (1928-9, Warner Glen – Hartley 1982: 13), chasing a horse and cart carrying meat (Snell 1986: 149), and chasing a cyclist (Marshall 1903: 101-2). Dingoes have been recorded digging up graves to feed on human corpses (J. Drummond 30.10.1844 letter; Roe 1852: 49; Austin 1855: 16). One cross-bred animal was recorded as attacking a man (Ipsen 2000: 51).

Perhaps the animals recorded in the above situations are the 'miserable, half-starved…with the mange' animals noted sniffing and scratching around tents (L. Clifton 1841 in Russo 1995: 209, 222).

Interbreeding with domestic and feral dogs Once rabbits reached Southern Cross district, wild dogs (dingo x kangaroo dog cross) became very numerous, and killed 300 lambs in one night (*The Southern Cross Times* 9.2.1907). At Mt Jackson, the wild dogs 'are of every breed conceivable, from the poodle upwards' (*The Southern Cross Times* 18.7.1908). Near Kellerberrin the first cross-breeds between dingoes and dogs were noted in 1912. These were 'very troublesome' every year from 1915 to 1931, would not eat strychnine baits, and could jump over netting fences 4'3" high (Leake 1962: 18, 20; see also Royal Commission 1917a). By 1921 it was recognized that none of the dingoes found in settled districts were 'pure' (Leake 1921). It was claimed that cross-breeds had less white at the tip of the tail than the pure dingo, with light and dark yellow always predominating over other colours (Leake 1962: 5, 25). Breeds of dogs inter-breeding with the dingo include the: kangaroo dog (1887, 'of great size', able to pull down a yearling calf, Carter 1987: 69; *The Western Mail* 19.8.1926: 4; able to take cattle as old as 12-15 months, Crawford 1916: 30); kelpie (black and tan, Leake 1962: 6); collie (Royal Commission 1917a); Alsatian (1934, killing sheep, Yerecoin, Erickson 1971: 151); red setter (Passfield 1988: 145); and setter, Alsatian, blue heeler, husky and Airedale (Ipsen 2000: 51, 52, 57).

Nonetheless, it was claimed that most of the 12 'wild dogs' killed between Mundaring Weir and York had 'the typical characteristics of pure bred dingoes' (Anon. 1959: 432).

Dingoes and hybrids still cause problems for sheep farmers in the outer wheatbelt (Maddock 1998: 676). Since aerial delivery of baits has largely replaced trapping and baiting by doggers, attacks on sheep have escalated in the 1990s as a result of increased movement of dingoes from inland (*The Australian* 25.3.2004: 8; *Farm Weekly* 6.5.2004).

Conservation Because the dingo did not co-evolve with *Gastrolobium* poison peas, having arrived in WA only c. 3.5 ka BP (Corbett 1995: 17), it could never be re-established in its original range while 1080 baits are in use because of its sensitivity to fluoroacetate. It is unlikely that any populations remain in south-west WA free of genetic contamination by feral dogs (Corbett 1995: 166).

Thus the suggestion that 'positive management of dingoes should be seen as an essential element of biodiversity conservation in Australia' (Johnson *et al.* 2007: 345) is not useful in the context of south-west WA.

The dingo ceased to be a pest or became locally extinct within a few decades of closer settlement: Balardong, 1860s (Millett 1872: 239); Katanning, Esperance, Swan district, Geraldton-Mullewa, 1890s (Lindley-Cowen 1897: 132, 151, 169, 197); Woodanilling, 1902, east Narrogin, 1904, Trayning, 1911 (Royal Commission 1917a); Mt Erin, Yuba, Hutt, Upper Chapman, Perenjori, Merkanooka, Eradu, Dalwallinu, Bolgart, Balkuling, Gobblegutting, Yorkrakine, Meckering, Quairading, Brookton, Pingelly 1917 (Royal Commission 1917a); Bridgetown, Roelands 1918 (Royal Commission 1918); Goomalling, 1920s (Sewell 1998: 47); Dulbelling, 1924 (Eaton 1979: 73); Tammin, 1930 (Repton 1999: 308-9); Bruce Rock, early 1930s (Ewers 1959: 97); Cancanning district, early 1930s (Pederick 1979: 107); Quinninup, 1940 (Hales 1999: 56); Gingin, 1940s (Udell 1979: 329); Chowerup and Tonebridge, c. 1950 (Tuckett and Tuckett 2004: 7); Cowalla, 1957 (de Burgh 1976: 182); Esperance district, 1950s (Moran 1995: 372-3); Ravensthorpe, c. 1960 (Archer 1979: 58); Wellstead, 1960s (Anon. 1989); and Dandaragan, 1970 (McConnell *et al.* 1993: 219). The Fitzgerald River district was 'dogged' in the 1950s/60s (Chapman 1995: 92). By 1976, south-west WA was considered to be 'virtually without dingoes' (Whitehouse 1976: 88).

Several localized variants of the Noongar name for the dingo were found, additional to those published by Abbott (2001: 479-84): *yackine* (*The Bunbury Herald* 10.3.1896); *Moiler* (dingo); and *Pwert, Poort* (tame dingo) (R. Wellstead, Gnowangerup in *The Western Mail* 14.5.1925: 1).

Morelia spilota wakarl/carpet python

I overlooked discussing the carpet python with oldtimers but this was compensated by numerous references in historical literature and a thorough analysis of distribution based on specimens held by the WA Museum (Smith 1981). According to Smith (1981: 213) and Storr *et al.* (2002: 65) this species occurs throughout south-west WA north to Geraldton. Additional records discovered are mapped in Fig. 36.

Carpet pythons, often termed 'diamond' snakes, seem to have been easily observed by visitors and settlers. In 1791 two were noted near Albany (Lamb 1984: 353; Menzies 1791: f. 65) and one was killed and partly eaten by the ship's crew. Carpet pythons were seen in the same district in 1831 and some were killed and eaten (Mulvaney and Green 1994: 385). These observers noted this species as 'very handsome' and 'beautiful'. Carpet pythons were first recorded by settlers at Swan River in 1830 (Berryman 2002: 154; Devenish 1996: 90), and were stated to be 'quite harmless'. This species was eaten by Aborigines (Nind 1831: 31; 1839 – Cameron 2006: 476; 1841 - J. Neill in Eyre 1845 vol. 1: 417; 1842 – Bolton *et al.* 1992: 8).

The food of carpet pythons includes woylies, quenda, mice, birds and lizards (*The Inquirer* 29.10.1845), and numbat, koomal and marl (Pearson *et al.* 2002). On islands this species will also eat tammar, rodents and lizards (Pearson *et al.* 2002). One python, 'of marvellous circumference', disgorged a full grown possum (*Eastern Districts Chronicle* 1.12.1894: 5), another was discovered swallowing a live possum (*The Southern Cross Times* 27.2.1909), and another had recently swallowed a possum (*The West Australian* 7.4.1928: 3). In the period 1910s-1930s, carpet pythons were kept as pets (Erickson 1964a : 137; Hasluck 1977: 35; Knox-Thomson 1975: 55) and were left unmolested in haystacks and sheds in order to control mice (Anon. 1999: 59; Bird 1986: 285; Crawford 1921: 26; Groser 1927: 267; Hasluck 1977; Richards 1993: 271; Timperley 1996: 313). A carpet python was kept in an orchard to frighten fruit-eating birds away (Broun 1995: 13) and control a rat plague (Slee 1979: 129). They also ate rabbits and poultry (*Eastern Districts Chronicle* 26.1.1901; L. Glauert in *The Westralian Settlers' Gazette* 27.9.1928: 18-19).

The carpet python lived in a great variety of habitats e.g. 'rocky, dry places, near salt water' at Albany (J. Neill in Eyre 1845 vol. 1: 417), coast hills south of Perth (*The Inquirer* 29.10.1845), sandhills around Cottesloe in the late 1890s (Conigrave 1938: 16), jarrah forest (Richards 1993: 630), on a beach (Marshall 1993: 11) and around granite rocks in the eastern wheatbelt (Leake 1962: 99).

Body length of specimens observed or killed was noted as follows:

- 'as much as fifteen feet' (R. Salvado, late 1840s in Stormon 1977: 203)
- 15' (Groser 1927: 267)
- 14' (*The West Australian* 6.10.1923: 9)
- c. 14' and as thick as a man's thigh (*The Inquirer* 29.10.1845)
- 10' 2" (Knox-Thomson 1975: 55)
- 9½' and nearly as thick as a man's arm (*The Inquirer and Commercial News* 21.5.1873)
- > 9' (Berryman 2002: 154)
- 8-9' (Devenish 1996: 90)
- 8' 9" (1848, Buchanan 2003: 138)
- c. 8' (Lamb 1984: 353)
- 8' (McCarthy nd; *Morning Herald* 16.10.1902: 6; *Eastern Districts Chronicle* 1.12.1894: 5)
- 6-9' (Anon. 1842: 100)
- 6'1½ - 7'10" (from label information for seven specimens collected 1914-1942 and lodged in WA Museum)
- 7' 7", 5" in circumference, 'the largest one any one about here [Bolgart] has ever seen' (1846, Buchanan 2003: 67)
- 7'7" (*Eastern Districts Chronicle* 22.12.1894: 8)
- 7'6" (*The West Australian* 7.4.1928: 3)
- 7'4" (Cameron 2006: 476)

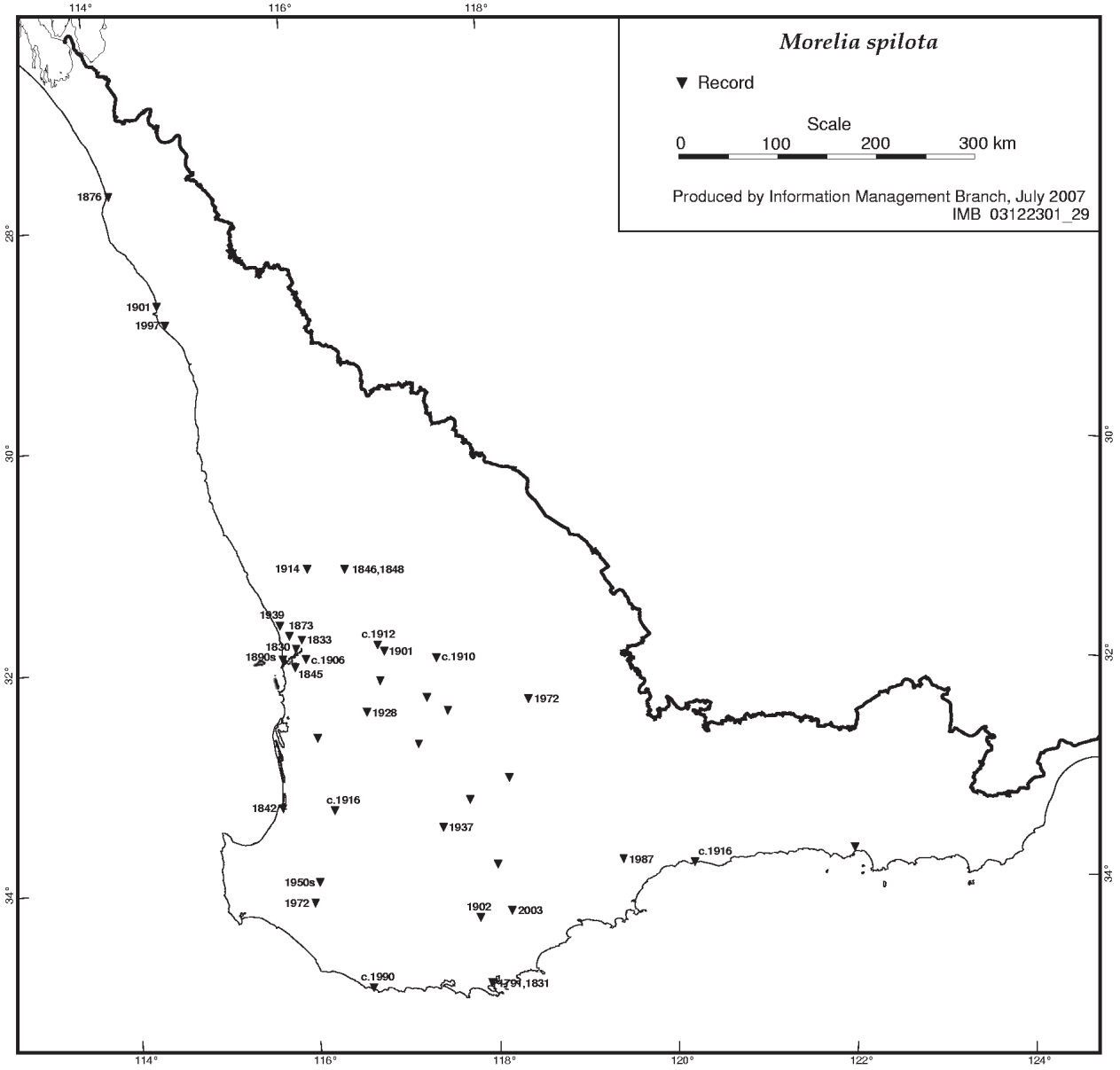

Fig. 36 Distribution of Morelia spilota. *Additional records not already cited in text: Clemens 2000; Gardner 2000; Haddleton 1952; O'Connor 2001; Roots 2003; Taunton 1903.*

- 7'2" (Cameron 2006: 288)
- 7' (*Eastern Districts Chronicle* 25.11.1899: 2)
- 6'2" (*Eastern Districts Chronicle* 26.1.1901)
- 6½' (Lamb 1984: 353)
- 6-9' (*The Inquirer* 29.10.1845)
- 6' (Bolton *et al.* 1992: 8)
- almost 5' (Moore 1884: 157)
- c. 5' (Buchanan 1997: 186; Leake 1962: 99)
- 5' (Devenish 1996: 90)
- 3'6" (L. Glauert in *The Western Mail* 29.11.1928: 48; *Eastern Districts Chronicle* 9.1.1897: 3).

Some of the above records may refer to other python species (see Storr *et al.* 2002), namely *Antaresia stimsoni* (Stimson's python) and *Aspidites ramsayi* (woma). Both species occur in the northern sector of south-west WA and resemble the coloration of the carpet python. However, these pythons rarely exceed 1.1 m and 2.2 m respectively. The woma, moreover, does not have the reticulate carpet pattern characteristic of the carpet python.

Carpet pythons climbed trees in pursuit of small birds and young possums (J. Neill in Eyre 1845 vol. 1: 417) and 'with astonishing dexterity…gliding through the branches and over the leaves in a most surprising manner', apparently lying in wait for the approach of honeyeaters feeding on the blossoms (*The Inquirer* 29.10.1845). There is a specimen in the WA Museum (#5765) collected 12' up a mallee, near Cunderdin. One near York was found in a peach tree (*Eastern Districts Chronicle* 26.1.1895: 5). Leake (1962: 99) noted that they could climb trees, rough walls and haystacks.

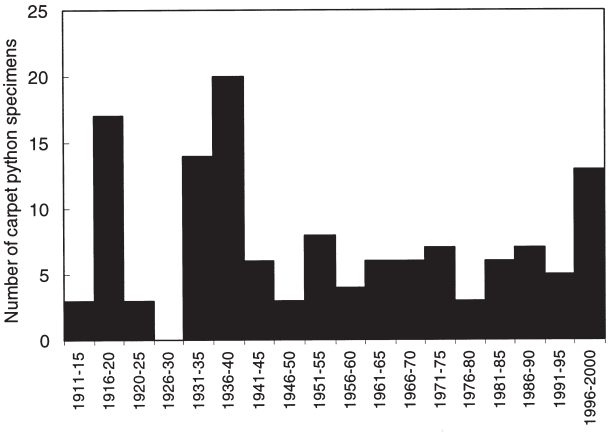

Fig. 37 Number of specimens of Morelia spilota *accessed into the collection of the WA Museum. Source: WA Museum database.*

This species appears to have declined in abundance by c. 1940:

1. I found no references in historical literature to the species after the 1930s;
2. The number of specimens incorporated into the WA Museum collection (1911-2000) decreased after 1940 (Fig. 37);
3. Biological surveys in the 1970s and 1980s noted that it was very infrequently sighted (Chapman and Dell 1977: 52; Christensen *et al.* 1985: 53; Chapman 1995: 100) or not recorded (McKenzie 1973: 17; McKenzie *et al.* 1973; Dell and Harold 1977: 99; Dell and Chapman 1977: 82; Youngson and McKenzie 1977; Burbidge *et al.* 1978; Burbidge *et al.* 1980; Crook and Burbidge 1982).

It is possible that this decline is a result of predation by the fox. Consistent with this hypothesis is the maximum length of only 2.54 m [8.3'] recorded in the 1990s at Dryandra Woodland (D. Pearson pers. comm.), an increase in the number of specimens submitted to the WA Museum in the period 1996-2000 (Fig. 37) after a broadscale fox-baiting program was introduced in 1996 in the publicly-owned lands of south-west WA, and the first sightings (three snakes) in 2003 in Stirling Range National Park, all c. 1.5 m in length (1080 baiting began there in 1996 and observations commenced in 1997, G. Harnett pers. comm.).

The Noongar name for this species is *wackul* (Nind 1831: 31, 49), *Wakel* or *Wa-a-kel* (J. Neill in Eyre 1845 vol. 1: 417), *waarkle, warkle* or *wagl* (*The Western Mail* 14.5.1925: 1, 9.7.1925: 2, 24.7.1930: 32, 28.8.1930: 32), *Wakel* (*The West Australian* 14.7.1928: 5), and *wakarl* (Whitehurst 1992). Names supplied by Moore (1842: 47, 75, 111; also in Cameron 2006: 288) appear to be incorrect.

Ornithorhynchus anatinus platypus

Oldtimer information Although I did not seek comment on the platypus from any of the oldtimers interviewed, one offered comment. B. Mitchell stated that he saw a platypus in 1944 in a permanent pool in a first order affluent of the North Capel River at Wellington Location 3215 (c. 3 km north-west of Newlands). In 1961 he shifted to a farm c. 6.5 km south-west of Newlands (Wellington Location 2538), and he and his wife in 1962 saw a platypus in a permanent pool in a first order affluent of the South Capel River. He was confident that these observations (some 6 km apart) were not of misidentified water-rats. Subsequent damming of both brooks has destroyed these pools.

Early reports A specimen, supposedly collected 'from the neighbourhood of Swan River' by MC Friend and described as a new species (*Proceedings of the Zoological Society of London* **1831**, 149-150), presumably came from Tasmania and became mixed with specimens of other species actually collected in WA. G. Moore in September 1831 in the Avon River 'observed something stirring, which we conjectured to be a platypus, but naturalists have not yet ascertained that it exists here' (Cameron 2006: 47). This was probably a sighting of a water-rat. A letter by 'GH' (London, 16.8.1832), seeking information on the mode of reproduction of the platypus and echidna, was published in *The Perth Gazette* 9.2.1833: 22. The collector J. Gilbert noted in January 1839, after having been in WA for several months, that the platypus was not found in WA. However, in May 1840 he qualified this by writing more cautiously: 'at least not hitherto been seen or killed…or observed' (Whittell 1942: 221, 223).

The earliest suggestion that platypus be introduced to WA, in this instance to some of the southern rivers, was in 1925 (*The West Australian* 25.7.1925: 15).

Official introduction The only other information located was a report by Fleay (1980: 51-2) that in c. 1940 he captured two platypus in Victoria for the Government of WA. These were flown to Perth and released 'in Mundaring Weir'. Grant (1995: 14) considered that this pair had neither survived nor left offspring.

Elliot (1983: 242), based on a newspaper report (*The West Australian* 6.3.1951: 1), stated that these two animals had arrived at Perth Airport and were released by the State Gardens Board into a new dam constructed in Mahogany Creek in John Forrest National Park. The upper end of the dam had been wired across to prevent their going upstream; however, platypus are adept at bypassing barriers (T. Grant pers. comm.). Photographs were published of the two animals (*Daily News* 6.3.1951: 2) and of the release event (*The West Australian* 7.3.1951: 2).

This introduction was 'an experiment in the hope that the platypus might succeed in becoming acclimatised' (Letter 2.9.1948 to D. Fleay from WC Hobson, Managing Secretary of State Gardens Board, Department of Lands and Surveys, now on Department of Conservation and Land Management file 015100F3806). The platypus were captured under permit issued by the Chief Inspector of Fisheries and Game, Victoria, and authorized by the Hon. Minister. It seems likely that the timing of this request was linked to publicity arising from the successful transport of three platypus to the USA in April 1947 (cf. Moyal 2001: 178).

The platypodes introduced to WA in 1951 were said to have been last seen in either 1955 (*The Sunday Times* 29.6.1958: 15) or 1957 (*The West Australian* 9.6.1958: 8), but the fresh marks of their webbed feet were seen in June 1958 by WA Museum officer A. Douglas (*The Sunday Times* 29.6.1958: 15). At this time a 6 ft x 40 ft strip of the bank had disappeared and the park superintendent thought that the platypus had scratched it away with their bills and feet (*The West Australian* 9.6.1958: 8). These latter remarks are questionable – platypus fold back the web of the front feet when walking and so the footprints, which are rarely seen, do not show distinctive webbing (T. Grant pers. comm.).

Other records Reports of platypus in the Canning River, at Kent Street Weir, before February 1956 remain unconfirmed. The Chief Warden of Fauna wrote in March 1956 that he was 'sure that there have been other attempts to acclimatize [platypus] in Western Australia', noting reports from Manjimup district. These reports and later ones in 1964 and 1966 were unverified and all are assumed to be referable to water-rats. However, the record from Manjimup district may refer to a sighting of a platypus swimming in Smith Brook, a perennial tributary of the Warren River, near Middlesex. This sighting was reported to B. Whittred, who informed me (pers. comm. 2006) that the record was from a reliable person who is no longer contactable.

In August 1961 a fauna officer observed a platypus for 3 minutes at close range in a small lake on the upper reaches of the Brockman River, near the 48 mile peg [from Perth] on the Great Northern Highway. This is some 50 km north of the Mahogany Creek release site, thus raising the question of whether a platypus had dispersed overland from this creek. Platypus have been known to travel at least 5 miles from a stream (Burrell 1927: 140), as well as leave a stream and cross a road (Fenton 2004: 69).

The most recent observation of a platypus in south-west WA is from Gardner River near its junction with Maringup Creek, on 19 April 2006 (D. Breen pers. comm.). His notes describe 'a distinct symmetrical fan shaped portion where the beak attaches to the body' and 'a stubby tail'. The animal 'appeared dark brown almost black in colour'.

In conclusion, there was only one authorized attempt and at least two unauthorized attempts at introducing the platypus to WA.

Thylacinus cyanocephalus thylacine

I did not request information from oldtimers about sightings of thylacines for fear of trivializing my research program. Several interviewees did, however, volunteer information and it seems reasonable to accept that some striped animals have been seen from time to time.

One oldtimer, an experienced dogger and bushman, described how he had seen and handled foxes with mange. These animals had scratched themselves against logs and boles covered with charcoal. The black had transferred to the ribs, which are prominent on emaciated foxes, resulting in stripes down the side of the fox (K. Smith, pers. comm.). Clearly, these stripes are fewer than, and slope in a different direction from, those of a thylacine.

Thylacines did of course occur throughout mainland Australia, but the youngest dated occurrence in south-west WA (from Murray Cave, c. 40 km north of Perth) is 3 090 ± 90 years BP (Archer 1974). This is c. 500 years after the dingo *Canis lupus dingo* was introduced into Australia. It is usually assumed from the persistence of the thylacine in Tasmania, from which the dingo is absent, that thylacines were outcompeted by dingoes (Troughton 1967; Corbett 1995). A recent theory is that the dingo may have introduced a parasite that exterminated the thylacine (Freeland 1993: 176).

Early visitors to, and settlers of, WA were often explicit about the absence of felid-like animals:

- 'We have no wild beasts', March 1830 (Berryman 2002: 171)
- 'There is [sic] no animals whatever to hurt any one', May 1831 (Berryman 2002: 221)
- 'No lions or tigers we here dread to meet'; 'There are no ferocious beasts here', September 1831 (Moore 1884: 65)
- ' the absence of large carnivores' (von Hügel, 1833, in Clark 1994: 54)
- 'the…Native Tiger [is not] found here' (J. Gilbert, letter of 14.1.1839 in Whittell 1942: 221); also repeated in a letter of 4.5.1840, to which 'at least not hitherto been seen or killed' was added (Whittell 1942: 223)

Published records of striped animals in south-west WA are usually vague and fail to satisfy minimal scientific standards for sightings of rare animal species, such as a sketch made on the spot and notes made immediately after sighting (Hutchinson 1988: 147-8; Lathwell 2001: 232; Snell 1986: 36). A shot specimen is never produced. Sometimes observers will not reveal where or when the animal was seen (e.g. Strahan 1986); such secrecy is of course incompatible with the customary openness of scientific enquiry. Sometimes the style of writing hints at misguided motives, such as attempting to mislead or ridicule scientists, engage in self-publicity, or blame predators for losses of stock rather than admit to mismanagement or neglect. In the particular case study presented by Douglas (1986), inconsistencies between photographs of an alleged live thylacine led Webster (1986) to conclude that the photographer 'is either a very slow stalker or a very poor faker'. This photographer wanted a large sum of money before showing the original photographs in the sequence in which they were taken or disclosing to a zoologist where the photographs were taken (Strahan 1986).

A careful study of files held by the Department of Environment and Conservation and others of alleged thylacine sightings demonstrated that the first sighting in south-west WA was in 1936, followed by a marked increase from the late 1960s (Heberle 2004). The year 1936 was soon after the fox became common in south-west WA (see below, under *Vulpes vulpes*) and fits with the explanation offered by Ken Smith for sightings of striped animals (see above). The year 1969 was when the

broadscale use of 1080 poison for rabbit control was reduced in south-west WA, because of the introduction of the Spanish rabbit flea to spread myxoma virus at all times of the year.

In conclusion, the weight of evidence is against the presence of the thylacine in south-west WA in historical times:

- The skilled observer John Gilbert did not report its presence during his visits in 1839-40 and 1842-3
- Aborigines did not disclose its existence
- There are no Aboriginal names recorded for such an obvious animal
- None of the early visitors, explorers or pioneer colonists wrote of its occurrence
- There are no reports of striped animals before the arrival of the fox
- No specimen has ever been trapped, poisoned or shot, and its skin exhibited to an expert.

Introduced species

Mus musculus house mouse

Although the earliest specimen held in the Western Australian Museum is dated 1914, the house mouse was probably introduced into WA in 1826 and 1829. This inference is based on the 1841 record of a ship being over run with mice nearly 3 weeks after leaving Cape Town (Bolton *et al.* 1991: 87; see also Cleland 1918: 53). This species may also have been introduced by way of Dutch shipwrecks in 1656 and 1712 (Plomley 1972: 364).

House mice were probably spread by settlers as goods were carted to newly established farms, pastoral leases, military outposts, and sandalwooders' campsites. The dispersal pattern outlined on p.126 for the feral cat may also apply to the house mouse.

Because the house mouse, at c. 15g, is smaller as an adult than any native species of rodent likely to be present in the 1820s at Fremantle, Perth, Albany or York, observations of mice by settlers and visitors can be reliably ascribed to this speces:

- Fremantle, 1829 – provisions and clothes ravaged by mice (J. Henty in Bassett 1954: 158).
- Albany, 1830 – destruction of seeds by mice and the occurrence of mice in a drawer (C. Barker in Mulvaney and Green 1992: 247, 250).
- Burrswood (near Perth), 1830 – 'rodents' causing havoc with provisions and wardrobe (Nind 1987: 69).
- Upper Swan, 1831-2 – domestic situation, 'abundant and but for my cat would do serious mischief', 'very troublesome' (Cameron 2006: 14, 119), 'destructive' (Moore 1884: 140). Additional records in 1836 (very abundant in house) and 1837 (very common in wheat stack) (Cameron 2006: 406, 421).
- Perth, 1838 – storeroom (Cameron 2006: 457).

Later records are of mice in huts in the 1840s near York (de Burgh and de Burgh 1981: 57) and near New Norcia (Stormon 1977: 46), specimens collected from 'King George Sound' in 1874 (held by Macleay Museum, Sydney), mice in a building in Fremantle in 1880 (Hillman 1990: 383), and mouse plagues in Coolgardie in 1894 (*Eastern Districts Chronicle* 17.3.1894) and in Perth in c. 1903 (Cunningham 1982: 30). It is possible, however, that some of these observations refer to marsupial 'mice', *Sminthopsis* species.

By 1904-8 house mice were ubiquitous in and around habitations and feral far from settlement (Cleland 1918: 40; Short 2004; Shortridge 1936: 748; *The Western Mail* 29.8.1908: 8; Whitlock 1937: 113). Mice remain widespread in south-west WA (Kitchener and Vicker 1981; Christensen *et al.* 1985: 30).

The earliest records found of a plague causing ruin to agricultural produce were in 1916 (bagged wheat, Royal Commission 1917b: 33) and 1917 (stacked wheat, Bristow 1984b). The reason for this appears to be that good seasons had led to a bumper wheat harvest and the surplus remaining after export and local consumption was some 9 M bushels (Smith 1984: 67). Mice were reported as abundant under stooks in c. 1926 (Cameron 1989: 66).

Although house mice had the opportunity to introduce diseases from 1829, no first contact extinction pulse of native mammals is evident in south-west WA (at least up to the second visit of J. Gilbert in 1842-43).

Rattus rattus black rat

The first specimens of the black rat from south-west WA were collected during 1903-7 (Kitchener and Vicker 1981; Shortridge 1936: 748). However, it is likely that this species was introduced earlier, perhaps in 1800 when a whaling vessel infested with 'ratts' anchored for nearly a month near Albany (Dickson 2006), but more likely in the late 1820s, as many ships inadvertently transported it (cf. King 1827, vol. 2: 91, 184; Backhouse 1843: 285; Lancelott 1852, vol. 2: 147; Cleland 1918: 53). In November 1829 and January 1830 rats were present at Fremantle (Henty 1829; Anon. 1931: 4) and were reported destroying shoes and making holes in mattresses (J. Dodds 1830 in Heal 1988: 44). At Upper Swan in 1832, one was brought into a house by a cat (Cameron 2006: 155). Rats were noted in a house at Augusta in 1833 (Jennings 1983: 63). However, the possibility that these records refer to the native rats *Rattus fuscipes* and *R. tunneyi* or various *Pseudomys* species or even the marsupials *Antechinus flavipes* and *Parantechinus apicalis* cannot be ruled out.

Rats were present on a ship conveying cargo from Lockeville and Quindalup to Esperance in c. 1874 (Oldham 1992: 412). In 1884 rats were becoming 'exceedingly numerous' in Geraldton (*The Victorian Express* 6.2.1884). Deaths from bubonic plague at Fremantle in 1900 (Bain 1996: 223) were presumably associated with the presence of this species, as at that time *R. rattus* was plentiful around the larger seaports (Shortridge 1936).

This species had apparently not yet spread far inland by 1906 (Cleland 1910: 16, 1918: 45; Shortridge 1936: 748), but by the 1970s they were widespread in the forest (Christensen *et al.* 1985: 30) and wheatbelt (Morris and Kitchener 1979; Kitchener and Chapman 1980 a,b). In contrast, the other introduced rat *(R. norvegicus)* is known only from the Perth metropolitan area (Kitchener and Vicker 1981; WA Museum 2005).

Although rats had the opportunity to introduce diseases from 1829, no first contact extinction pulse of native mammals is evident in south-west WA (at least up to the visit of J. Gilbert).

Oryctolagus cuniculus rabbit

Rolls (1969) provided a detailed history of the introduction and establishment of the rabbit in Australia, with emphasis on eastern Australia. His analysis of WA was, however, superficial: only five references relating to WA were cited, and no WA newspapers or Hansard were examined. A detailed chronology was offered by Long (1988).

Oldtimer information Although the rabbit was first recorded by oldtimers in south-west WA in 1915-17, most first sightings were in the period 1925-30 (Fig. 38). Boodie warrens and dalgyte holes were taken over by rabbits (B. Butler, J. Palmer pers. comm.) and chuditch were reported as preying on young rabbits (T. Ball pers. comm.). There was a 2-3 year lag between the first sighting of a rabbit and plague levels (N. Rajander pers. comm.). Plagues were first recorded by most oldtimers in the 1930s (Fig. 39). Plagues were not reported from jarrah forest (A. McEvoy pers. comm.). Because plagues coincided with the Great Depression, rabbit meat (obtained from trapping, shooting or hunting with dogs) provided important sustenance. Skins were worth 2s per head (N. Candy pers. comm.). Slaughtered rabbits were fed to pigs (D. Andrews pers. comm.).

Broadscale poisoning (pollard baits laced with phosphorus; cut apples with aniseed oil and strychnine) was effective locally and for short periods. The impact on native birds and mammals that consumed these baits was, however, substantial (N. Candy pers. comm.). Ripping was locally effective in destroying the burrows of rabbits but the only truly effective control was construction of rabbit proof wire-netting fences around farm boundaries.

Newly planted pines at east Kirup had to be fenced to protect them from rabbits (B. Beggs pers. comm.).

Early introductions Early settlers brought rabbits to WA as a source of food, but few rabbits survived the long voyage from Britain (either because they were eaten or the weather was unfavourable):

- Only one out of 17 was landed, 1829, Fremantle (Henty 1829)
- 'We lost...rabbits in abundance', 1829 (Berryman 2002: 98)
- One passenger with rabbits, 1829 (Kellam 1831: 7)
- Six rabbits brought from Cape Town, 1829 (Bassett 1954: 92)
- One rabbit brought, 1829 (J. Whatley in Burton 1930: 21)
- One landed alive, 1830, Augusta (Turner 1956: 83)
- One landed, 1830, Fremantle (Chate 1952: 15)
- A settler at Bayswater had two rabbits, c. 1830 (May 1997: 12)
- Two rabbits landed, Albany, 1831 (Stephens 1951: 69)
- Rabbits had young on board ship but all died, 1834 (Fairbairn 1946: 47, 49)
- Seven rabbits on farm of R. Spencer, 1834, Albany (Clark 1994: 78)
- Rabbits bred at Vasse, 1837 – some eaten (Shann 1926: 79)
- Four rabbits (gift), 1839, Middle Swan (Greenslade 1983: 26)
- One rabbit remaining, 1841, Australind (Johnston 1962: 48, 57)
- Two rabbits listed in inventory of stock, 1843, Australind (J. Wollaston in Bolton *et al.* 1992: 95).

In April 1830 rabbits were offered for sale at 20s (?per pair) (Berryman 2002: 176).

As early as 1839, it had been suggested that rabbits should be introduced as a useful food supply for settlers as it was thought that the climate and sandy soil would be suitable (Ogle 1839: 105).

Rabbits were caught at Chidlow in c. 1850 and one farmer at Coondle had two pet rabbits in c. 1853 (*The Western Mail* 25.7.1913: 5-6). In the 1850s 'there were plenty of rabbits on the Canning and Swan Rivers. In the neighbourhood of Bunbury they were found by the dozens, and at the head of the [Leschenault] Estuary too…they have all disappeared' (T. Hayward WAPD **22**: 2286, 18.11.1902). JM Craig (b. 1850) reported that, as a boy, he kept rabbits, which 'did no harm [and] would not increase' (Royal Commission 1901: 14). In the 1860s rabbits were reported to be numerous in Perth (*The Western Mail* 25.11.1920: 42). Rabbits also occurred at Burswood in 1878 but subsequently disappeared (*The West Australian* 4.2.1896: 3). Tame rabbits were reported (undated, probably late 1880s) to be living under stacks of sandalwood in York district (Royal Commission 1901: 14). An increase in the number of these rabbits was said to be checked by predation by chuditch (Leake 1962: 29) [Leake was born in 1880]. In c. 1883, > 200 rabbits were released at Tenterden but they did not increase and gradually died out (*Kalgoorlie Miner* 5.3.1908: 4). WC Grasby speculated that the failure of domestic rabbits to establish resulted from a lack of selective pressure from drought (*The Western Mail* 30.6.1906: 10).

In 1873 RT Muir of Albany imported two adult and four young rabbits from Melbourne. These were probably pets, as the male had fur 3 inches long (Muir 2005: 80).

Rabbits were present on 10 south-west WA islands in the 19th Century, apparently having been placed on those along the southern coast by whalers who wished to obtain fresh meat (*The Australian Advertiser* 12.5.1890):

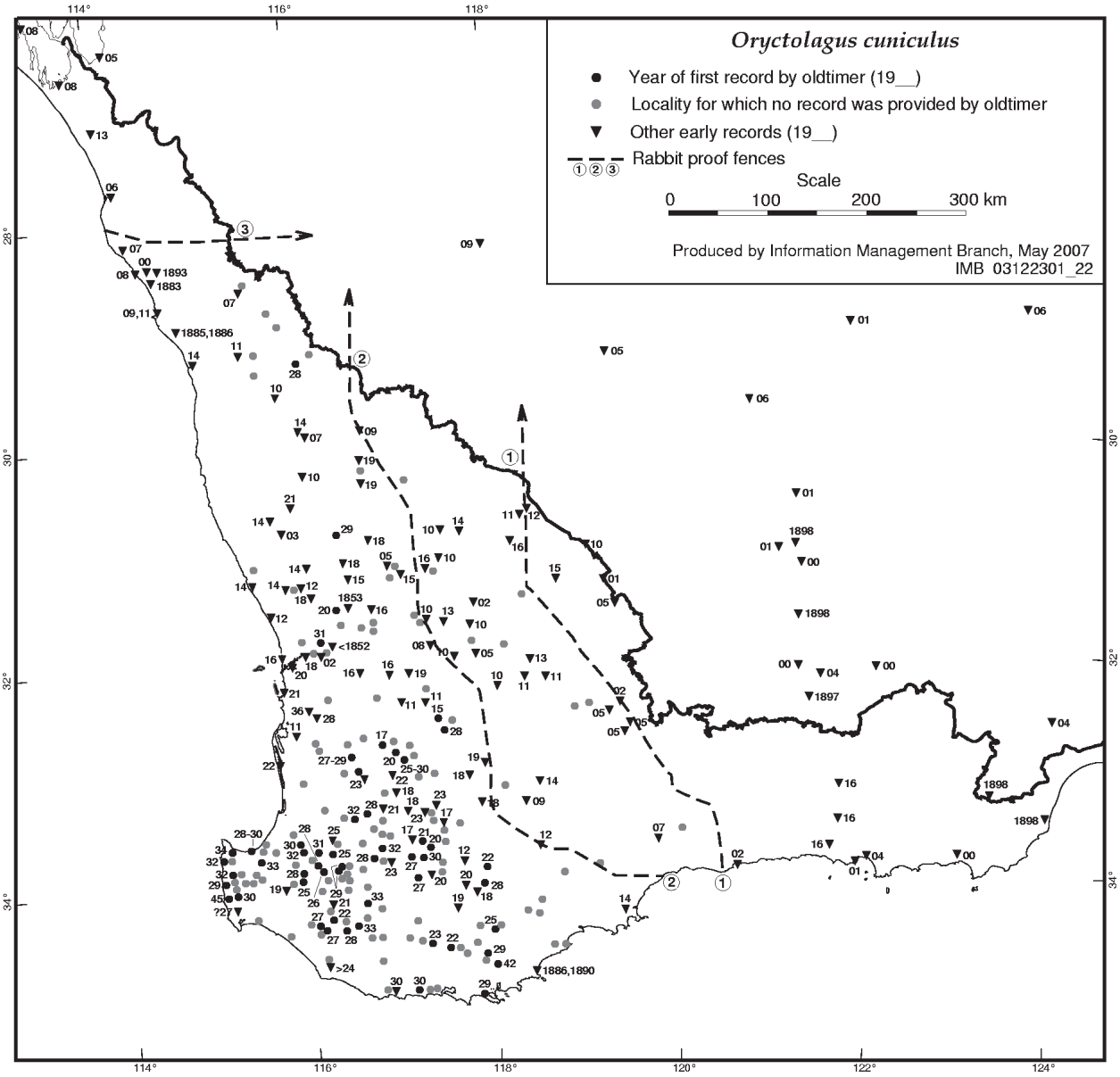

Fig. 38 Early distributional records of Oryctolagus cuniculus. *Additional records not already cited in text: Bellanger 1980; Bristow 1984a; Coy 1984; Crawford 1916; Crocker 1954; Donaldson and Elliot 1998; Draper 1997; Fisheries Department file 34/32; Gardner 2000; Gilbert nd = 1973; Gothard 1988; Grant Watson 1968; J. Greig WAPD* **56***: 688, 5.3.1918; Gunning 1952; Kitchener and Vicker 1981; Kitchener* et al. *1978; Laurie 1994; McMahon 1972; Payne 1987; Reid 1933; Rice 1993; A. Crawford and S. Logue in Select Committee evidence 1918; Stevens 1998; Taylor 2000; Teakle 1979;* The Farmer *February 1910: 13;* The Kalgoorlie Miner *14.8.1900: 7;* The Kalgoorlie Western Argus *31.1.1905: 11;* The Murchison Times *14.3.1901;* The Murchson Times and Day Dawn Gazette *30.10.1909;* The North Coolgardie Herald *17.10.1900: 3, 16.1.1901: 2, 14.7.1906;* The Northern Times *19.12.1908;* The West Australian *16.8.1898: 3, 22.12.1928: 5;*The Western Mail *25.7.1908: 4, 7.8.1909: 14, 21.8.1909: 4, 20.8.1910: 4, 11.7.1913: 7; Tunney letter 19.10.1904; Whitlock 1937.*

- Mistaken Island, 'traces of rabbits' in 1830 (Mulvaney and Green 1992: 279); white rabbits present in 1834 (C. von Hügel in Clark 1994: 83); abundant in February 1841 despite the lack of freshwater on the island (*The Inquirer* 25.8.1841)
- Carnac Island[6] , rabbits present from December 1842 (*The Perth Gazette* 3.12.1842; Hasluck 1931: 69)
- Dirk Hartog Island, rabbits liberated in 1858 by Captain H. Denham of *HMS Herald*; these rabbits

[6] The claim that rabbits occurred on Carnac Island in 1827 (Abbott *et al.* 2000: 342) is incorrect. It is based on the mispunctuated, presumably mistranscribed, phrase and misspelled word 'hair' in 'hares, seals, and muttonbirds' in a report by C. Fraser (see Shoobert 2005: 54). A second version of Fraser's report refers to 'hair Seals' (Shoobert 2005: 57). A hair seal is the sealers' (obsolete) term for the Australian sea lion. Some other visitors to Carnac Island in the 1820s and 1830s recorded hair seals but none noted any rabbits (Appleyard and Manford 1979: 136; Cottesloe 1979: 45, 51; Shoobert 2005: 35, 61; *The Perth Gazette* 20.8.1842).

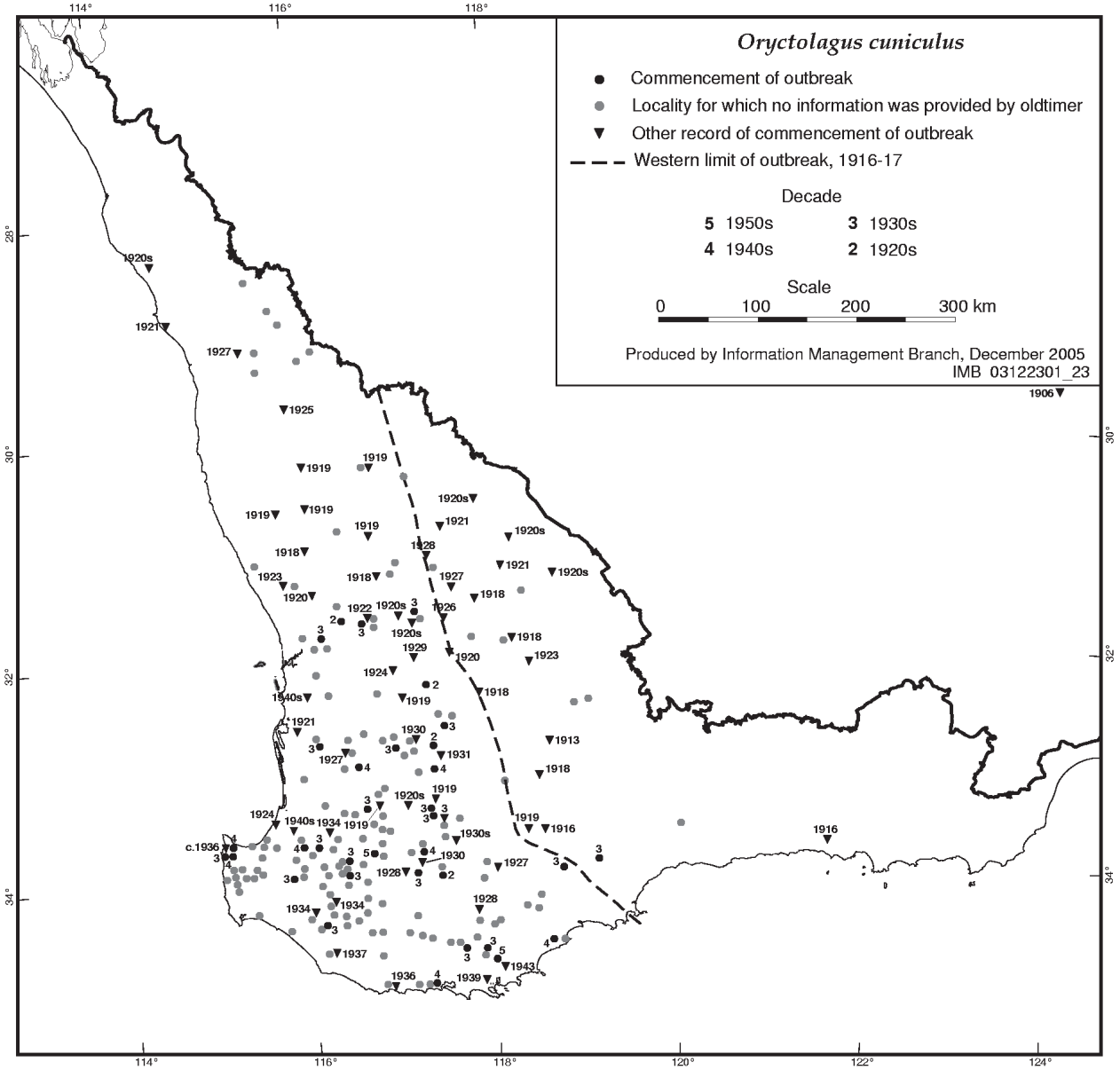

Fig. 39 Commencement of outbreaks of Oryctolagus cuniculus. *Additional records not already cited in text: Ackland 1965; Adams 2004; Beecham nd; Bignell 1981, 1991, 1997; Bird 1986, 1992; Bradshaw 1928; Braid and Forbes 1997; Bristow 1984b; Buchanan 1997, 2000; Cameron 1989; Chase and Krantz 1995; Coy 1984; Crake 1985; de Burgh 1976; Donaldson and Elliot 1998; Facey 1981; Ferrell 1992; Forests Department 1927; Garden 1979; Gibbs 2002; Haig 1982; Heydon 1988; Joukovsky-Vaisvila 1978; Lange 1981; Laurie 1995; Leake 1962; Lowrie nd; Maddock 1987,1998; McConnell* et al. *1993; Mingenew 1988; Pederick 1979; Repton 1999; Roots 2003; Royal Commission 1917a, 1917b; Sewell 1998; J. Smith WAPD* **93**: *622, 26.9.1934; Spencer 1966; Stokes 1984, 1986; Teakle 1979;* The West Australian *22.12.1928: 5; Thomas 1999; Watkins 1990; Whittem 2000.*

had been obtained from the Furneaux Group in Bass Strait in 1857 (David 1995: 281, 298)

- Pelsaert and Gun Islands, Houtman Abrolhos, rabbits established from a shipwreck c. 1878-82 (M. Brown WAPD **8**: 446, 3.9.1883; Rabbit Inspectors' Reports 1893, 1897; Helms 1898:428; A. Crawford in Select Committee Evidence 1918: question 1338); however FC Broadhurst stated that rabbits had been placed on Pelsaert Island in 1853 and were present in 1886 (*The Western Mail* 24.10.1908: 10)
- Breaksea Island, rabbits present in 1881 (Sellick 1997: 136)
- Bald Island, rabbits present before 1886 (*The Western Mail* 5.6.1886: 11)
- Michaelmas Island, rabbits present by 1889 (J. Wright WAPD **17**: 148, 18.11.1889)
- Goose Island, Archipelago of the Recherche, rabbits present in 1883 and 1889 (*The Albany Mail and King George's Sound Advertiser* 21.3.1883; Andrews 1959)

- Rabbit Island, Archipelago of the Recherche, rabbits evidently present by 1897 when the island was officially named (British Admiralty chart No. 2984).

Several attempts were made to introduce rabbits to Rottnest Island, but without success (Somerville 1966: 131). References to rabbits there in 1842 imply that they were penned (*The Perth Gazette* 12.2.1842; Devenish 1996: 27; Green and Moon 1997: 20).

Legislation by the Parliament of South Australia in 1875 to suppress rabbits may have alerted interest in the matter in WA. Yet, in 1877, a Select Committee of the Legislative Council did not recommend any legislation concerning the prevention of the spread of rabbits 'until the danger against which it is sought to guard becomes apparent'. This would have been an opportune time, however, to plan and erect a barrier fence at the WA/South Australian border, some 17 years in advance of the arrival of rabbits. By emphasizing that 'legislation of a stringently repressive character would be highly unpopular', this committee had evidently focused its attention on control of rabbits on private property (Select Committee 1877).

The Legislative Council of WA in 1881 re-affirmed this wait and see approach until the threat became more apparent (L. Gifford WAPD **6**: 232, 12.8.1881). However, reports from Victoria, New South Wales and South Australia of the damage being caused by wild rabbits to crops and the reduced carrying capacity of land for sheep were well publicized in WA. This led to the Destruction of Rabbits Act 1883, which declared it illegal to import or keep rabbits on mainland WA or on any island 5 miles or less offshore. In December 1885 the first police officers were appointed as inspectors under The Destruction of Rabbits Act, 1883 (*Government Gazette* 3.12.1885: 641). This Act was subsequently amended to make it illegal to keep rabbits on any island within the territorial limits of WA (Destruction of Rabbits Amendment Act 1885). It was argued that if rabbits were numerous on islands 'almost barren of vegetation, what would they do on the mainland?' (AR Richardson WAPD **12**: 289-91, 3.8.1887).

In 1886 a small area near an old whaling station at Cheyne Beach was reported infested with rabbits (C. Taylor, *The Western Mail* 5.6.1886: 11). These rabbits had probably been brought from Bald Island about one year previously. Taylor was concerned that these rabbits may spread from this source throughout Plantagenet district in 1-2 years. He suggested that Parliament should authorize funds to enable this population to be destroyed. The sum of £350 was put on the estimates to complete the eradication at Cheyne Beach and to erect a rabbit-proof fence across the peninsula (AR Richardson WAPD **12**: 289, 3.8.1887). This population was presumed exterminated in 1887 (M Fraser WAPD **12**: 276, 2.8.1887). However, rabbits were again reported 'in large numbers' at Cheyne Beach in 1890, and were presumed to have been brought from the adjacent islands, where they are numerous, by 'some evil disposed person' (*The Australian Advertiser* 12.5.1890). These rabbits were living in bushes on a limestone cliff 2 miles from the whaling station (C. Taylor, *The Australian Advertiser* 28.5.1890). Further poisoning took place in 1891 (Rabbit Inspectors' Reports 1892) and the population was apparently extirpated (Rabbit Inspectors' Reports 1893, 1894, 1896, 1897).

Rabbits were still being kept in Perth, as there is reference to construction of a hutch for rabbits in 1881 (Hillman 1990: 526) and of an escaped rabbit in 1904 (*The Western Mail* 17.12.1904: 7). Despite being prohibited by the Rabbit Act, Angora rabbits were kept for their fur in the 1890s (Marshall 1993: 69; Parnell 1982: 60). Pet rabbits brought by immigrants were destroyed (*Esperance Chronicle* 26.8.1896; Ackland 1965: 113). In 1908 a live rabbit was found in Albany (*The Western Mail* 26.9.1908: 4).

Early perceptions There is no evidence that any of these mainland populations showed signs of increase or expansion, and this led to complacency that rabbits could not survive in the wild in south-west WA:

- The Rabbit Act, 1883 presumed that Crown land would not support rabbits in contrast to farmland and pastoral land
- The land between Esperance and Albany was 'only scrub, and never likely to be settled'. It would not do 'much harm' if rabbits established there and it was unlikely they would thrive there (A. Forrest WAPD **12**: 289, 3.8.1887; see also A. Forrest WAPD **9**: 1207, 23.10.1896)
- One Parliamentarian stated that he had done all he could on his farm to encourage rabbits but was unsuccessful – 'it would be found impossible to make them grow in this colony' (T. Fawcett WAPD **12**: 290, 3.8.1887)
- 'I maintain that no rabbits will be able to acclimatise themselves in Western Australia, for the simple reason that the poison plant [*Gastrolobium* species] would destroy them almost immediately' (Gell 1896: 807)
- 'the whole of the country to the immediate west of…[Cape Arid] up to within ten miles of Esperance…is altogether of too rough and poisonous character for rabbits to subsist in it' (*The Western Mail* 21.4.1900: 5)
- the arid and waterless nature of much of Western Australia would be unfavourable to rabbits (Glyde 1898: 9; see also Wilson 1902a: 98)
- 'did not think Western Australia a good land for rabbits, because most of the soil was sandy, and when the rabbits burrowed, the sand would fall in upon them' (F. Crowder WAPD **14**: 899, 16.8.1899).

Even as late as 1900, the Premier stated that 'he was not an alarmist in regard to the rabbit invasion' (J. Forrest WAPD **18**: 1677, 14.11.1900). The Chief Inspector of Stock, under whom control of rabbits was placed, also dismissed some reports as 'alarming and sensational and exaggerated' (Royal Commission 1901: 67-70). Similar perceptions lingered: 'a square mile of this country couldn't feed a rabbit', 1910, Bruce Rock district (Ewers 1959: 100); there was a common assumption that the

many natural enemies in Western Australia would not allow the rabbit to thrive (A. Richardson in Select Committee Evidence 1918: question 931).

Colonization and spread Rabbits colonized mainland south-west WA from two directions. The earliest records were at Greenough in August and December 1885 (*The Victorian Express* 8.8.1885, 26.12.1885) and in sandhills between the Greenough Flats in February 1886 (*The West Australian* 12.2.1886; Bain 1975: 407). The last rabbit seen was apparently killed in October 1886, between Greenough and Geraldton (Rabbit Inspectors' Reports 1892). The absence of any reports from Northampton district in 1891, 1892 and 1893 (Rabbit Inspectors' Reports 1892, 1893, 1894, 1897) was evidently incorrect, as rabbits were noted at Northampton in c. 1893, and as far north as Point Cloates in 1898 (*The West Australian* 18.7.1898: 7). Rabbits were recorded at Lynton and Mullewa in 1907, and at the mouth of the Bowes River in 1908 (O'Connor 2001: 264). Breeding was reported in 1909 within one mile of Geraldton (*The West Australian* 14.9.1909: 5). The rabbits at Lynton were apparently brought by boat from the Abrolhos Islands either 20 years previously or at intervals during the previous 30 years (Crawford 1907c: 324, 1908: 25, 1908: 147), or even 40-50 years previously (*The Western Mail* 10.10.1908: 11).

The major source of rabbits was overland from South Australia. One Parliamentarian called for steps to be taken to check their progress before they reached the border (T. Cockburn-Campbell WAPD **10**: 400-1, 24.9.1885). In 1886 rabbits were 304 miles east of the WA border, at Laura Bay in South Australia (*Government Gazette* 8.4.1886: 220). In 1893 rabbits (stragglers) were stated to be 120 miles (Jeffery 1979: 89), 90 miles (*The West Australian* 8.7.1893: 3, 5.8.1893: 2) or 36 miles (A. Hassell WAPD **4**: 245, 3.8.1893) east of the border. These reports were dismissed as hearsay by the Premier (J. Forrest WAPD **4**: 246-7, 3.8.1893). No rabbits were found in August 1893 between Eucla and a point 105 miles east (the head of the Great Australian Bight), although evidence of their past occurrence there was found (Stephens 1893). Conflicting reports continued as to whether rabbits had reached the border (W. Marmion WAPD **6**: 123, 7.8.1894). Rabbits probably crossed the border in 1895 (Royal Commission 1901: 21). Judging by their tracks, they were 'getting numerous' in sandhills at Eucla in late 1895 (*The Australian Advertiser* 11.10.1895), and were reported at Eyre by February 1896 and at Twilight Cove, c. 180 miles west of Eucla, by August 1896 but no more than c. 25 miles inland (Mason 1897: 45). In 1897 rabbits were detected near Norseman and between Balladonia and Israelite Bay (Rabbit Inspectors' Reports 1897). Rabbits had reached Thomas River by December 1900 (White 1901).

The impact on vegetation of plagues or 'tidal waves' of rabbits in WA (between Eyre and Eucla) first became evident in 1903-4: 'in millions...absolutely ruining the country as they go' (Aborigines Department 1903: 9); 'country is being eaten bare' (*Kalgoorlie Miner* 30.10.1903: 7); 'nothing but the bare ground being visible' (*The Kalgoorlie Miner* 19.1.1904: 2); 'all the herbage' consumed and trees ringbarked (*The Kalgoorlie Western Argus* 19.7.1904: 18). Despite these reports, community acceptance of the need for co-ordinated and universal action was lacking. The politician JW Hickey spoke scathingly: 'for quite a time we have been living in a fool's paradise in Western Australia. In spite of the experiences of the Eastern States, and in spite of our knowledge of what must inevitably follow here, we were quite satisfied and content to sit back so long as there were a couple of rabbit-proof fences across Western Australia. The inevitable result has come. The rabbits have been knocking at our door for years. Unfortunately, we have been asleep for the greater part of that time, and have made little or no effort to help ourselves' (WAPD **56**: 690, 5.3.1918). But the view persisted that it was the 'nation's business, not the business of the settlers on the land' to deal with rabbits (T. Walker WAPD **58**: 359, 18.9.1918).

Rabbits can breed nine times in a year, each with an average of 6/litter (Crawford 1919: 36, quoting official information from New South Wales). Wheeler and King (1985) and Twigg *et al.* (1998) found that the number of offspring born per adult female rabbit per year averaged 25-30 in coastal south-west WA. In south-west WA most breeding takes place between June and October (Craig 1928). However, breeding is possible anytime between April and December (Twigg *et al.* 1998). Assuming a gestation period of 28 days, and maturation in 3 months (Tomlinson and Crawford 1951), one pair could produce seven pairs in 5 months, assuming further that each pair produced the same litter size, comprising an equal number of males and females (M. Williams pers. comm.). Although the rabbit is a critical weight range (CWR) species, its rate of increase is faster than that of any native CWR species, and thus they recover in numbers more quickly than native species (Shortridge 1936: 749).

There was often a significant gap between (1) the year a rabbit was first seen (Fig. 38), (2) when the first wave arrived, and (3) when plagues became persistent and caused economic damage in a district (Fig. 39). This lag is well illustrated by the following examples from various districts: (1) 1910, (3) 1920-1 (Eaton 1979); (1) 1911, (3) 1921 (Richards 1993); (1) 1911, (3) 1918 (Ewers 1959); (1) c. 1914, (2) c. 1930 (many burrows being dug) (Repton 1999: 308); (1) 1917, (2) 1923 [first burrow found], (3) c. 1930 (Bignell 1971; 1991); (1) 1918, (3) 1927 (Bignell 1977); and (1) c. 1935, (3) 1937-42 (Muir 2006: 94, 117). Near Southern Cross, isolated records of rabbits in 1901 and 1903 had by 1905 increased to 'almost a daily occurrence'; by 1906 rabbits were 'somewhat troublesome' and in 1907 were becoming plentiful to the extent that crops required fencing with wire netting (Stevens 2001). The 'frontier of spread' (Stodart and Parer 1988) should not be taken to equate with impact. A practical definition of 'plague' is provided by the descriptions 'so thick the whole ground appeared to move when one approached' (Bignell 1997: 93), and 'the sides of hills appearing as a seething moving mass of rabbit fur' (Garden 1979: 224).

By 1925 rabbits were found in every part of south-west WA (Craig 1925).

Natural factors affecting rabbit populations

The plagues that occurred periodically in south-west WA between 1917 and 1955 developed when food supplies increased following relatively wet winters and were temporarily checked by relatively dry winters (reducing food supplies and the availability of drinking water). There was not one continuous plague, but a series of plagues, as populations gradually recovered after periodic mass mortality.

Rabbits breed only after rain and when green feed is available (Crawford 1911; Craig 1926; Wheeler and King 1985). Numerous observers recognized the link between the availability of luxuriant, green feed and rains during summer, a wet winter, and early and late rains, as well as the infrequent combination of all three circumstances (M. Ryan in Royal Commission 1901; 51; Braid and Forbes 1997: 400; Department of Agriculture 1943; Department of Agriculture 1945; Department of Agriculture 1949; Leake 1962: 29; Sewell 1998: 232).

The following periods were recorded as wet and associated with increased populations of rabbits: 1900, 1902-04, 1913, 1915-17, 1921-22, 1923-24, 1932, 1941-44, and 1947-48 (A. Arnold in Select Committee Evidence 1918: question 112; Arnold 1924; C. Craig in Select Committee Evidence 1918: question 11; Crawford 1913, 1916, 1922; Department of Agriculture WA 1942, 1943, 1945, 1949; Leake 1962; Royal Commission 1901: 51; Sewell 1998; Wilson 1903, 1904). However, flooding in wet winters either drowned rabbits (Bird 1986: 304, 1990: 400; Leake 1962: 31) or forced them into the open where they were killed by foxes (Leake 1962: 31). High rainfall years, however, would have very likely overridden previously applied control measures.

The following periods were recorded as dry and associated with the decline or disappearance of rabbits: 1905-06, 1909-12, 1914, 1919-21, 1922-23, 1926-27, 1935-40, and 1943-46 (Aborigines Department 1906: 5; Arnold 1923; Bolton and Hutchison 1979: 13; Braid and Forbes 1997: 137, 374; Broomhall 1991: 135; Crawford 1910, 1912a,b, 1915, 1920, 1921b; Craig 1927; Department of Agriculture 1937, 1938, 1939, 1940, 1946, 1947; Maddock 1987: 226; *The Southern Cross Times* 12.7.1911: 2; *The Western Mail* 18.12.1909: 4; Wilson 1906). Rabbits were so scarce east of Number 1 Rabbit Proof Fence in 1914 that residents on the goldfields could not obtain sufficient for food (Crawford 1915).

The other major natural factor that affected rabbit populations is soil type. Sandy soils underlying kwongan vegetation and limestone outcrops, around playas, and along the coast facilitate the construction of warrens (Bird 1986: 267; Bradshaw 1928: 178; Craig 1918; Crawford 1913, 1917; 1919; Repton 1999: 308; Royal Commission 1917a: xxii). Rabbits were never numerous in the heavy textured soils underlying gimlet *Eucalyptus salubris* and salmon gum *E. salmonophloia* woodland (Leake 1962: 32), nor did they occur in jarrah and karri forests (B. Beggs, J. Havel, J. Meachem, S. Quain, G. Styles pers. comm.). 'The land in itself before it is cleared will not keep even a rabbit. The only place in which a rabbit can live is on the land that has been cleared' (Royal Commission 1917a: 695).

Rabbits also readily used (?abandoned) boodie warrens for shelter (Wilson 1906).

Anthropogenic factors favourable to rabbits

Several factors under the control of humans have operated to the benefit of rabbits. The earliest was the introduction from South Australia of rabbits by teamsters travelling to the newly discovered (1890s) goldfields of Coolgardie and Kalgoorlie, for the purpose of providing a source of fresh meat for prospectors (Upfield 1949: 18). The most important factor was the vast extent of unallocated Crown land, together with the failure of legislation to bind the Government to erect rabbit-proof wire-netting fences and lay poison baits on Crown land (Beecham nd: 35; Ferrell 1992: 292; Parnell 1982: 161; Royal Commission 1917a: xxii-xxiii; Sewell 1998: 186).

Probably the next most important factor was the failure of less conscientious landowners and occupants to take the threat seriously (Crawford 1907a: 35; H. Hickmott WAPD **58**: 361, 18.9.1918; Parnell 1982: 161). Such neglect and apathy quickly nullified the earnest efforts of the minority of landholders. By 1917 it was suggested that responsibility for destroying rabbits should rest with local Vermin Boards, supported by an increase in the number of inspectors from 4 to 12-15 (Crawford 1917).

In 1918 a Select Committee of the Legislative Assembly criticized:

- successive governments for not adequately resourcing the 'war of extermination'
- the Rabbit Act, which did not empower the Department of Agriculture to destroy rabbits (it only had the power to see that settlers destroyed rabbits)
- Ministers for suppressing prosecutions by inspectors against selectors
- lack of energy and commonsense co-operation by Government agencies
- apathetic farmers and settlers, who viewed rabbits as a source of cheap meat. When provided with free poison they failed to distribute it and most farmers did not take up the Government's offer to purchase wire-netting on generous 20 year terms (Select Committee 1918).

These concerns resulted in the Vermin Act, 1918. Vermin Boards were, however, reluctant to use their greatly increased powers to deal with settlers 'who do not do their full share in rabbit destruction'. Few Boards appointed an inspector. Furthermore, 'as the poison carts worked by the Government increased, the work done by private individuals decreased', and as rabbit numbers decreased, many settlers ceased poisoning (Crawford 1919: 36). Other criticisms were that excellent work done by some Vermin Boards was minimized by adjoining Boards doing nothing (Crawford 1921b: 20), some Boards stopped control in winter, and conscientious inspectors made influential enemies and were dismissed (Arnold

1923). By 1926, however, nearly all Vermin Boards had appointed inspectors (Craig 1926).

Much land was left abandoned by settlers who failed to make a living, or by men (either farmers or farm labourers) who enlisted to fight in the Great War and in the 1939-45 war (Crawford 1919: 36; Department of Agriculture 1942, 1943; Garden 1979: 237; Laurie 1995: 188; McLaren and Cooper 2002: 187; Royal Commission 1917a; Thomas 1999: 161, 210). The Great Depression of the early 1930s led many rural families to either subsist on farms and not attempt to control rabbits or move to the Perth metropolitan area or particular rural centres where sustenance work was available (Bird 1990: 299; Bristow 1988: 61, 162; Broomhall 1983: 282; Garden 1979: 223; Laurie 1995: 79; Royal Commission 1945: 5). Because many settlers were unable to pay rates, local Government had few financial resources available for rabbit control (Department of Agriculture 1933; Garden 1979: 224; Maddock 1987: 227). These factors were probably the basis of 'the growing seriousness of the rabbit menace' (A. Hawke WAPD **94**: 2253, 20.12.1934). Wartime shortages in the supply of wire-netting, poison, and fumigant also frustrated effective rabbit control (Crawford 1919: 36; Department of Agriculture 1945: 40; McLaren and Cooper 2002: 187). These circumstances led to 'the fast increasing gravity of the rabbit menace' (V. Doney WAPD **111**: 2357, 28.1.1943).

During 1931-39 the Department of Agriculture loaned poison carts, paid the wages of poison cart drivers, and supplied pollard and poison to Vermin Boards to assist in the control of rabbits on abandoned farms (Department of Agriculture 1932: 8, 1935: 23, 1936: 29, 1937: 75, 1939: 22).

In 1945, a Royal Commission into the Vermin Act found that most of the Vermin Boards were 'apathetic or incompetent', and proposed centralized control with one inspector per district to regiment the activities of farmers. Criticism was also directed at professional rabbit trappers, the lack of attention to the destruction of warrens, and the Government for failing to set an example on Crown lands: 'The destruction of vermin on Crown land being everybody's business became nobody's business' (Royal Commission 1945).

The early 1950s was a period of prosperity for farmers, with high wool and wheat prices. This provided incentive and capital for landholders to control rabbits (Leake 1962: 31). Tractors came into general use and doubtless served to destroy the shelter of rabbits (warrens and fallen timber) more efficiently.

Methods used to limit the distribution and abundance of rabbits The Rabbit Act (1902) forbade the keeping of live rabbits or their liberation, payment of any bonus or scalp money as a reward for the destruction of rabbits, and west of RPF#1 the selling of any dead rabbit or the possessing of any rabbit skins. These measures were to prevent the spread of rabbits or the placing of any value on rabbits, dead or alive. The overall strategy of Government was to check, at least temporarily, the invasion of rabbits by construction of a barrier fence; to provide netting and financial assistance to settlers so that farm boundaries could be made secure against rabbits; and to provide advice to settlers so that any rabbits that did gain access to farms could be quickly killed by the use of suitable poison (see WAPD **24**: 2492-4, 8.12.1903; 2584-5, 9.12.1903). Eventually 12 methods were used to control rabbits. Experience in South Australia indicated that most had not worked (*The Western Mail* 11.3.1905: 10). Most Government initiatives failed to gain widespread community support. Even as late as 1918, the great majority of settlers believed that rabbits would not become a pest, and when legislation was enforced by inspectors, farmers complained to the Minister (C. Baxter WAPD **56**: 487, 20.2.1918). Newspapers provided lengthy advice on methods used elsewhere to control rabbits (e.g. *The Western Mail* 17.1.1919: 7-8).

- ***Erection of barrier fences***

The concept of constructing rabbit-proof fences (RPF) was adopted from the eastern colonies, where the first fences were erected in the 1880s. The optimal design consisted of 1¼" mesh embedded 2 ft into the ground and standing 4 ft above the ground (*The Inquirer and Commercial News* 24.2.1886). The earliest suggestion that a RPF be erected in WA (from Eucla to 150-200 miles northward) was made in a letter published in a newspaper in 1893 (*The West Australian* 5.8.1893: 2). Despite the exclusion of rabbits by a barrier fence being a logical solution, the Premier thought that such a fence would be both ineffectual and expensive: 'I hope we shall not get scared as to rabbits by every report that comes to us from persons who have not seen them' (J. Forrest WAPD **4**: 246-7, 3.8.1893).

The Minister for Lands suggested erection of an RPF 80-100 miles west of the rabbit invasion (*The West Australian* 4.2.1896: 3). In June 1896 the Government sent a party of three men to look for a natural barrier that would complement the effectiveness of a rabbit-proof fence (Mason 1897: 33). Rabbits were found travelling (but not burrowing) 15 miles west of Twilight Cove and 17 miles north of Wilson Bluff. Mason's recommendation (p. 45) that a fence be constructed 'somewhere between Points Dover and Culver, and running in a Northerly direction on a bearing of about 15°' was ignored (Royal Commission 1901: 54), probably because it was unrealistic. It appears likely that goldseekers travelling overland to the WA goldfields at Coolgardie (established 1892) and Kalgoorlie (1893) may have liberated young rabbits at favourable places (Royal Commission 1901: 15, 33, 34; Leake 1962: 29).

The following year W. Ponton of Balladonia recommended construction of two RPF, one from Point Culver and one on the border so that rabbits between them could be exterminated during summer (*The West Australian* 6.10.1897: 7). In January 1898, the Government sent HJ Page to establish how far west rabbits had encroached; rabbits were found to be numerous on the coast 23 miles north-east of Israelite Bay. This meant that rabbits had already crossed into south-west WA (Fig. 38). Page recommended construction of a fence from

Esperance via Norseman, Kalgoorlie and Menzies to Geraldton (Glyde 1898: 10). Community support for a RPF was strong: 'If rabbit proof fencing was not an infallible means of preventing the spread of rabbits, it did more to check their advance than anything else' (Conference of Producers 1898: 104).

However, there was further procrastination and inaction by Government (Royal Commission 1901: 53), and resultant criticism (*Journal of the Bureau of Agriculture of WA* 1897 **4**, 1276; Conference of Producers 1898: 104; *The Western Mail* 22.9.1900: 5-6, 27; 1.12.1900: 6; *The Sun* 23.12.1900). The Government held a Royal Commission to determine the best means of dealing with the incursion and to devise methods to stop the advance of rabbits into settled areas. This Commission recommended construction of a wire-netting fence 4'2" wide (i.e. 3'6" above ground and 6" below ground level), made of 1½" mesh and with plain and barbed wires on top, at 36" and 48" above ground level respectively (Royal Commission 1901). A mesh of 1½" was recommended because fences of 1¼" 'are so much more expensive', even though small rabbits were known to pass through 1½" mesh (Royal Commission 1901: 21, 28, 38; see also Lindley-Cowen 1897: 629).

Surveying of the route of what later came to be known as the number 1 rabbit-proof fence (hereafter #1 RPF), running north from Hopetoun, did not commence until 1901. The Rabbit Act, 1902 authorized the construction of Government fences and also specified the definition of private fences, permitted subsidy of the transport costs of wire-netting for private fences, re-affirmed the duty of owners/occupiers of land to suppress and destroy rabbits, and made the leaving open of gates on the RPF an imprisonable offence. Although clearing of vegetation for the erection of #1 RPF commenced in December 1901, the netting did not arrive until July 1902 (Wilson 1902a, 1903). Details of the construction and maintenance of #1 RPF are available in Broomhall (1991).

The orientation of this fence was criticized. It was instead suggested that the fence should have run north-east so as to contain the rabbits (*The Western Mail* 11.3.1905: 10).

Rabbits were present at Starvation Boat Harbour near the southern terminus of the fence in August 1902 (Wilson 1903: 415). Erection of #1 RPF in south-west WA (Fig. 39) was completed by October 1903 and soon after rabbits were present along its eastern side. Waves of arriving rabbits were deflected northwards by this fence (Crawford 1907a: 35, 1908a: 26). The height of the netting above ground varied from 2'6" to 3', the depth of the netting below ground was 6-8" (12" where sandy), the mesh was 1¼", and a wire was placed 12" above the netting (Crawford 1907a: 35; A. Crawford in Select Committee Evidence 1918: question 626). According to Wilson (1902: 97), the mesh size initially used was 1½". Patrols by boundary riders on bicycles were intended to trap, poison and dig out any rabbits located along the fence (Wilson 1904, Crawford 1907a).

A tour of inspection of #1 RPF late in 1904 found rabbits 'fairly plentiful, judging from their tracks' on the eastern side, although damage to the fence by emus was evident (Crawford 1904). The inspector's opinion was that 'if the outside barrier fence is thoroughly looked after and kept efficient, we will be able to stop the incursion'. He thought that abundant populations of feral cats to the west, as well as dingoes, goannas and raptors, would assist in this. Boodie burrows east of Morawa allowed rabbits to cross under the fence 'for a considerable distance' (Wilson 1906).

Construction of a second line of fence was under consideration by Government in late 1903 (WAPD **24**: 2246, 25.11.1903). The south-west WA component of this inner fence (hereafter #2 RPF, Fig. 39) was erected north of Point Ann via Cunderdin by 1905 (Crawford 1905: 12). However, rabbits had been found in many places between the two fences and had in some places reached the #2 RPF and therefore the activities of 12 rabbiters were discontinued (Crawford 1905: 35). Criticism of these barrier fences (*The West Australian* 16.11.1905: 6) by a dismissed boundary rider led to the Government appointing an expert from South Australia to inspect the fences. He saw no rabbits along #2 RPF except near Cunderdin and found no fault with the standard of construction (*The West Australian* 4.12.1905: 4, 19.12.1905: 7, 9.2.1906: 2). Rabbits occurring coastwards from Jerramungup were reported as 'dying rapidly, and are mangy and unhealthy' (*The Western Mail* 4.8.1906: 6).

By 1907 no rabbits had been reported west of #2 RPF, apart from those north of Geraldton (Crawford 1907b: 59). 'With the present fences kept in good order regularly patrolled by boundary riders, proper inspection, and the co-operation of the settlers all over the State, I am thoroughly convinced that the farmers have but little to fear' (Crawford 1907b: 60).

The short #3 RPF (Fig. 39) was completed in 1907 (Anketell 1907). The length of the three rabbit-proof fences was 1139 miles (#1), 725 miles (#2), and 171 miles (#3). Lobbying by graziers for the construction of a barrier fence from Coorow to north of Dandaragan to the west coast was unsuccessful (*The Western Mail* 2.3.1907: 8).

By March 1907, #1 RPF was reported to be in good order except where floods, fires, fallen trees, termites or salt spray (near the coast) had destroyed posts or wire netting, and where self-latching gates had not closed (Crawford 1907c: 323-4). By June 1908 it had become obvious that rabbits would not be eradicated between the two fences. The agricultural district at that time (the area west of #2 RPF) was free of rabbits (Crawford 1908a: 26). A proposal for a small south-western extension of #3 RPF, to enclose a coastal population of rabbits north of Lynton, was not adopted (Crawford 1908b: 147-8). By 1911 rabbits were being widely reported west of #2 RPF (Fig. 38). It seems that some settlers showed indifference to the threat, as wire-netting was stolen from sections of the RPF, water was stolen from tanks installed for the exclusive use of boundary riders, and gates were continually left open (Crawford 1912a, 1912b). Gates were even propped open, and rabbits were also seen being carried in motor cars and on trains (J. Mitchell WAPD

56: 401, 13.2.1918, C. Baxter ibid. 487, 20.2.1918). Nevertheless, the barrier fence concept was working, for in 1918 rabbits occurred 'in tens of thousands' on the eastern side, whereas they were 'very rarely' seen on the western side of #2 RPF (EB Johnston WAPD **56**: 407, 14.2.1918).

The Government had spent £352 000 on construction of the three rabbit-proof fences and £12 000 on their annual maintenance in the period 1905-30 (P. Ferguson WAPD **87**: 4630, 14.10.1931). The #1 and #2 RPF were in 'satisfactory condition' in 1946 (Department of Agriculture 1947). In 1950 #2 RPF was repaired (Department of Agriculture 1951) but it was abandoned in 1959 (Timperley 1996: 7).

• *Fencing of farm boundaries and water supplies*

Once rabbits reached settled areas the necessity for fencing the boundaries of farms with wire netting (to a depth of 6") became apparent (Bignell 1991: 99, 1997: 159; Webb 1988: 125). However, this was expensive to erect and maintain and was an impossible task for under-capitalized selectors (e.g. Royal Commission 1901: 46; Sewell 1998: 232). Some thought that the large sum of money expended on the construction of barrier fences should have been spent assisting settlers to fence their selections (*The West Australian* 12.5.1906: 4). Some landowners built a rabbit proof boundary fence within a year of the first rabbit being reported in a district (Ewers 1959: 100), sometimes even well before their arrival (Royal Commission 1901: 62; Lefroy 2003: 59), but more often netting of farms was left until plagues developed in the 1930s (Garden 1979: 225; Pederick 1979: 54; Chitty 2004: 86) and 1940s (Adams 2004: 119).

The Rabbit Act, 1902 and subsequent regulations (*Government Gazette* 25.9.1903: 2664-5) and tenders (*Government Gazette* 11.2.1904: 509) specified the standard required for private fences (wire-netting at least 42" tall, mesh 1¼"). From 1903 the Government approved the subsidized supply of wire netting to any settler, on terms, being: at cost price, the loan extending up to 20 years, at 4% interest, with 1/40 of the amount having to be paid off every 6 months (*Government Gazette* 25.9.1903: 2664-5; Crawford 1908a: 26). Applications from west of #2 RPF for netting from Government on terms were refused (Crawford 1910: 12).

The Vermin Boards Act, 1909 authorized the Government to form vermin districts, each with a Vermin Board with the power to levy a vermin rate on all holdings larger than 100 acres. The monies raised could be used to erect fences or improve existing fences by affixing wire-netting, search for and destroy vermin, and grant bonuses for the destruction of vermin. The first vermin district constituted in south-west WA was that centred on Williams (Vermin Boards Act Amendment Act, 1915).

Landholders/occupiers were supposed to net around water sources so that rabbits would die of thirst during summer. Crawford (1910: 12) advocated legislation compelling farmers in drier districts to fence in all water supplies, as this 'would be one of the most effective and cheapest methods in keeping the pest down'. This conclusion was based on the mass mortality of rabbits observed between #1 and #2 RPF during the very dry summer of 1909-10. There was concern that, as agricultural development progressed, the increase in farm dams would extend the breeding season of the rabbit (Crawford 1911). In 1915, plenty of netting was available but few settlers took advantage (C. Baxter WAPD **56**: 486, 20.2.1918). The Great War, however, resulted in a shortage of wire-netting (Select Committee 1918). In 1917 it was re-affirmed that rabbit-proof netting was the only effective method of control and was also cheaper than the annual cost of poisoning (Crawford 1917). By 1918, the Government had fenced nearly all Government dams in areas infested by rabbits (H. Lefroy WAPD **56**: 406, 14.2.1918). Section 85 (1) of the Vermin Act, 1918 mandated the enclosure of all water supplies with rabbit-proof fencing (1¼" mesh) by owners/occupiers once a district was proclaimed vermin-infested. Although netting continued to be seen as the best, cheapest and most long-term form of protection of farms against rabbits (Crawford 1921b: 20), few settlers had taken advantage of the subsidy by 1921 (Crawford 1921b: 20).

In 1923 the Federal Parliament legislated the Advances to Settlers Act, which established a trust account to advance finance to the States for the purchase of wire-netting. The Wire and Wire Netting Act, 1926, authorized the supply of fencing wire and wire netting to settlers by the WA Government, not exceeding £606 945. Some 2 106 miles of wire netting were supplied during 1926-7 (Craig 1927: 39), making 3 337 miles to date. In 1927-8, 2 285 miles of wire netting were supplied (5 660 miles cumulative) (Craig 1928: 46). One company spent £45 on rabbit eradication, mainly fencing, in 1927-8, but increased expenditure to £1 314 in 1929-30 (McConnell *et al.* 1993: 137). Lefroy (1935) recommended that farm boundaries should be fenced with 1¼" mesh, but subdivision fences should be netted with 1½" mesh.

Craig (1928: 19-20) provided a 'back of an envelope' calculation that demonstrated that the cost of fencing prevented loss of crops, compensating for repayment of the loan for purchase of the netting. Additional advantages included: no local vermin rate to be paid; less poisoning required; increased carrying capacity for stock; a fence better suited for all kinds of stock; and no more killing of rabbits that came from neighbouring farms.

• *Poisoning of water*

This method, using strychnine, had been tried in the pastoral zone of New South Wales 'with considerable success' (Anon. 1892b). In dry areas of south-west WA potassium cyanide was used to poison water (Crawford 1908c: 337). The technique used was that fences around dams were left open for a few nights, and then closed with poisoned water left outside (Braid and Forbes 1997: 266). A Royal Commission (1918: xvi) recommended the use of cyanide poisoning at farm dams. Poisoning of water was still being used in 1926, 1928 and c. 1935 (*The*

Western Mail 4.2.1926: 2; Craig 1928: 46; Broomhall 1983: 282).

• *Distribution of poison baits*

Recipes for preparing and laying poison baits (phosphorus, arsenic or strychnine), based on experience in the eastern states, were publicized in 1901 (Bruce 1901), 1904 (*Journal of the Department of Agriculture of WA* **9**, 392-6) and 1913 (Crawford 1913). In 1906 the Government was using three poison carts (Wilson 1906: 355). The poison cart was a light cart fitted with a share to turn up a small furrow and to deposit phosphorized pollard baits automatically. One man with a horse and poison cart could lay 20 miles of baits per day (Crawford 1917: 9). Phosphorized pollard (Grim® mixed with pollard and bran) was considered to be both cheap and effective, though strychnine, arsenic, and phosphorus ('toxa' and 'SAP') were also satisfactory (Crawford 1908c: 336; see also Bignell 1991: 47; Gervas 1997: 118; Gooding 1956; Moran 1995: 19). Poison carts were first advertised in *The Western Mail* of 18.7.1908: 7. Before 1919 the use of poison carts appears to have been limited and local (Craig 1918; Haddleton 1952: 44), possibly because the Great War resulted in a shortage of poison (F. Willmott WAPD **55**: 34, 24.7.1917; Select Committee 1918; Thomas 1999: 161).

By 1907 it was apparent that some settlers had not complied with the requirements of the Rabbit Act: 'There seems to be a tendency on the part of many settlers to expect the Government to destroy the rabbits on their properties, instead of starting to do it themselves as soon as rabbits are discovered' (Crawford 1907a: 35). Even in 1918, many farmers expected Government to lay poison baits for settlers (C. Baxter WAPD **56**: 486, 20.2.1918).

Attempts were made in 1908 to exterminate, presumably by poisoning, the isolated rabbit population north of Lynton. This was the only locality at the time where rabbits had established inside the #2 RPF (Crawford 1908b: 146-8).

The Vermin Act, 1918 authorized the formation of Vermin Boards, which purchased and deployed poison carts (e.g. Archer 1979: 133; Bristow 1984b; Crake 1985: 109; Ferrell 1992: 292; Garden 1979: 193; Gooding 1956; Maddock 1998: 321; McConnell *et al.* 1993: 86; Mingenew 1988: 83; Stokes 1986: 188; Udell 1979: 228). By early 1918, the State Implement Works had supplied seven poison carts to farmers and nine to the Department of Agriculture, and had the capacity to construct six carts each day (W. George WAPD **56**: 408, 14.2.1918). Poison carts were first advertised in *Elder, Shenton & Co., Ltd Weekly Report* in 6.2.1918 and in *The Producers' Review* in May 1919.

The Vermin Act (1918) was assented to in January 1919, and within a few weeks Vermin Boards issued (under Section 96) formal rabbit destruction orders to owners or occupiers of land in Dowerin, Ninghan, Moora, Mullewa, Dalwallinu, Lake Grace, Dandaragan, Gingin, Merredin, and Victoria Plains Vermin Districts (*Government Gazette* 24.1, 7.2, 14.2, 28.2.1919). These directives applied variously to the period February to June, and required not less than 2 miles of phosphorus pollard in baits to be distributed, not more than 4' apart and each week, for each thousand acres or part that is owned or occupied (example paraphrased for Dowerin Vermin District). The penalty for non-compliance was up to £50 (under Section 97). Rabbit destruction orders were first issued by Bruce Rock, Geraldton, Katanning, Toodyay, and Upper Irwin (1920), Wyalkatchem (1921), Greenough, Meckering, Swan, and York (1922), Kununoppin-Trayning, Nungarin, and Wagin (1923), Carnamah, Gnowangerup, Kent and Kulin (1925), Kondinin, Mingenew, Mt Marshall, Northam, Quaraiding and Tambellup (1926), Beverley, Cuballing, Narembeen, Upper Chapman and Wongan-Ballidu (1927), Westonia and Wickepin (1928), Koorda (1929), Dumbleyung and Goomalling (1930), Geraldton (1931), Chittering, Corrigin, Kellerberrin, Northampton and West Arthur (1932), Phillips River (1933), Upper Blackwood (1934), Mukinbudin, Balingup, Bridgetown and Greenbushes (1935), Broomehill (1937), Drakesbrook (1938), Wandering (1939), and Harvey (1940) Vermin Districts. Avon and York Vermin Districts had affirmed their intention to lay rabbit poison on all roads, vacant and Crown lands, and all Reserves under their jurisdiction (*Government Gazette* 30.12.1921: 2673, 16.2.1923: 345).

Following the recommendation of the Royal Commission (1917a: xxii), the Government had 9 808 lb of poison at hand in September 1918 and had 100 000 lb of phosphorus poison and 1 000 oz of strychnine on order from England (H. Lefroy WAPD **58**: 448, 26.9.1918). Four tons of phosphorus poison were expected to arrive in WA in late October 1918 (C. Baxter WAPD **58**: 605, 15.10.1918). Government supplied 49 212 lb of poison to settlers in 1918-19 (Crawford 1919: 36). However, much of this was 'greatly wasted' and 'never used'. In 1919-20, therefore, Government charged a small amount per container; 'only' 12 560 lb were requisitioned by settlers (Crawford 1920: 32). Some Vermin Boards purchased poison and supplied it free to farmers on application (Pederick 1979: 39); others subsidized the cost (Beecham nd: 58). Although the Government recognized no responsibility for rabbit destruction on Crown lands (because of the prohibitive cost, JA Greig WAPD **57**: 1121, 10.4.1918), it did assist Vermin Boards undertake poisoning there (F. Willmott WAPD **56**: 362, 18.9.1918; Crawford 1920, 1921). Sixty poison carts were at work in 1918-19 in salt lake districts on Crown Land (Crawford 1919: 36). By the early 1930s, 80 and 130 poison carts were operating in Goomalling and Wagin districts respectively (Sewell 1998: 232; Pederick 1979: 54). Grim® was in use at least until 1955 (*Journal of the Department of Agriculture of WA* **4** (series 2), 228). Another indication of the scale of operations was that in Northam district in 1922 40 000 acres of land were poisoned each month during summer (Garden 1979: 224)

Prodigious quantities of poison were distributed: 11 350 tins of phosphorus poison in 1923-4 (Arnold 1924: 32); with one tin possibly weighing 2¼ lb (*The Westralian Farmers' Gazette* 4.10.1928: 16); 180 tons of phosphorus

poison in 1924-5 (Craig 1925a: 32); 286 tons in 1926-7 (Craig 1927a: 39); 53 648 lb in 1927-8, a 'record output' sufficient to make up bait to lay a trail of 164 000 miles (Craig 1928: 46); 18 000 tins in 1928-9, an amount sufficient to lay a trail of baits five times the distance round the earth (Craig 1929: 45); and 204 144 tins in 1929-30 (Sutton 1930: 7). In Northam district, 6 100 miles of poison (requiring 77 bags of pollard and 808 tins of poison) were laid from November 1928 to May 1929 (*The Northam Advertiser* 8.5.1929: 2). By March 1933, 52 cases of poison, estimated to be sufficient to lay a trail 10 000 miles long, had been sold at the Corrigin Road Board office (Haig 1982: 88). In 1943 the annual requirement for strychnine was c. 8 000 oz (F. Wise WAPD **112**: 99, 24.8.1943). This more than doubled in 1944 (H. Kitson WAPD **113**: 325, 30.8.1944).

Phosphorus and strychnine were superseded after 1954 by Compound 1080, which was successfully tested on rabbits in Manjimup and Pemberton districts (Tomlinson *et al.* 1954). This poison was used widely in the period from 1955 until the early 1970s (Fig. 44; Anon. 1999: 96; Antonio-Crake 1974: 80; Bignell 1977: 273; Bird 1986: 304; Crake 1979: 84; Mingenew 1988: 83; Pederick 1979: 70; Repton 1999: 118; Spencer 1966: 83; Tomlinson 1959; Watkins 1990: 45). From 1955, three 'free' feeds were supplied in a furrow, followed by 1080-impregnated oats. In 1960 this method was replaced by 'one-shot' baiting, in which both poisoned and unpoisoned oats are laid simultaneously in the same trail (Gooding and Harrison 1964).

Poisoning was undoubtedly effective at a local scale: a 15 000 acre farm (Yathroo) in the Midlands was treated with phosphorus pollard and strychnine carrots in a period of 4 months, resulting in 100 000 rabbits killed and an estimated 150 000 dying in their burrows (*The Western Mail* 27.2.1930: 47). Nonetheless, Lefroy (1935) stated that the poison cart was 'nothing more than a palliative'. It appears that baits were not distributed in jarrah and karri forests, as rabbits were never in plague there because suitable feed was lacking (B. Beggs, J. Havel, J. Meachem, S. Quain, G. Styles pers. comm.).

After several decades of continuous usage of 1080 baits to poison rabbits, some populations in south-west WA are evolving genetic resistance (Twigg *et al.* 2002).

• *Trapping*

State-subsidized trapping and payment of bonuses for scalps were condemned by Royal Commission (1901: 6). Trapping as a method of control was criticized as ineffective because the intent was to catch the most marketable animals, i.e. the males, as these made the largest skins (Wilson 1902b; Crawford 1917; Sewell 1998: 187). The professional trapper's object was to make money, and therefore to perpetuate and not exterminate rabbits (Wilson 1902b; Crawford 1917). However, advice as to how best to prepare skins was provided in *Journal of Agriculture WA* **10**, 163. Trapping for commercial uses became legal in 1917, but only west of #1 RPF (C. Baxter WAPD **58**: 729, 22.10.1918). However, ambivalence remained in not allowing professional trappers but permitting settlers to sell a limited number of rabbits (E. Wittenoom WAPD **58**: 643, 16.10.1918). Many settlers were inclined to take a line of least resistance, and trap rabbits and kill them for export (V. Hamersley WAPD **58**: 682, 17.10.1918). The obvious way to resolve this conflict was to commercialize rabbits in winter and poison them in summer (E. Clarke WAPD **58**: 721, 22.10.1918). Skins of poisoned rabbits could be sold just as readily as those of trapped rabbits (JA Greig WAPD **57**: 1129, 10.4.1918). Professional trappers, however, remained active in a district as long as rabbits were abundant (Craig 1928), so that trapping constituted a form of rabbit farming (Department of Agriculture 1950: 51). The Royal Commission into the Vermin Act recommended that professional trappers be prohibited from operating in WA (Royal Commission 1945: 8).

The only occasion when the Government rewarded trapping was for 3 months in 1900 when a bonus of 2s 6d per scalp was paid for each rabbit killed in a 6 week period within a 50 mile radius of Norseman and Kurnalpi (*The Western Mail* 15.9.1900:7; G. Throssell WAPD **17**: 500, 19.9.1900; Royal Commission 1901: 36). The Vermin Act, 1918 prohibited Vermin Boards and any member of the public from granting bonuses for the destruction of rabbits, thus reinforcing the same provision made in the Rabbit Act (1902).

Application of the Rodier system in WA, involving the killing of all female rabbits and the release of all male rabbits, was rarely called for (*The Western Mail* 21.3.1908: 4). Investigations in New South Wales had demonstrated its ineffectiveness (Hatten 1905; Stewart 1906).

• *Fumigation of warrens*

The earliest record found of the use of a fumigant (carbon bisulphide) is from Crawford (1917), but the Great War seems to have caused a shortage (Select Committee 1918; Crawford 1919: 36). Fumigators (horse or tractor-drawn carts for blowing poisonous gas into burrows) came into general use in 1922 (Mingenew 1988: 86; Spencer 1966: 79), although supplies of cyanide and carbon bisulphide were unobtainable in 1925 (C. Latham WAPD **72**: 539, 26.8.1925). There are numerous references to fumigation of burrows from the 1920s (Cameron 1989: 64; Craig 1928: 4; *Elder's Weekly* 29.10.1925: 8; Ewers 1959: 100; Garden 1979: 224; Maddock 1987: 207; Mingenew 1988: 83; *The Western Mail* 8.4.1926: 2, 6.1.1927: 1, 10.10.1929: 42), 1930s (Roots 2003: 434; Sewell 1998: 232) and 1940s (Bignell 1977: 272; Braid and Forbes 1997: 400; Roots 2003: 457). Presumably fumigation was undertaken only on farms that had rabbit-proof boundary fencing, although burrows were fumigated in adjoining bush paddocks prior to boundary netting (Adams 2004: 118). Fumigation of burrows was an activity undertaken in winter (Garden 1979: 224).

Carbon monoxide gas (obtained from wood and water) and Cyanogas® (cyanide dust) were in use from the mid 1920s (advertisements in *The Western Farmers' Gazette* 23.9.1926: 13, 26.1.1928: 9). Cyanogas was

recommended by Stead (1935: 71, 79) because it could be delivered with a portable apparatus.

Fumigants may have helped to minimize proliferation of blowflies, as they left no rabbit carcasses on the surface.

• ***Destruction of warrens***

The major disadvantage of poisoning is that it left the burrows of rabbits in good order for re-occupation (Royal Commission 1945: 11). However, ripping did not become feasible until the advent of tractors, as it was considered too dangerous to use a horse in this operation (Buchanan 1997: 361).

Before the 1940s burrows were either dug out after poisoning (Cameron 1979: 137; Crawford 1908c: 337, 1919: 9; Gooding 1955) or were exploded (Crawford 1917; Broomhall 1983: 282).

Records of burrow ripping are numerous from the 1940s (Bignell 1977: 272; Maddock 1998: 40) and 1950s (Buchanan 1997: 361; Garden 1979: 243; Moran 1995: 20; Sewell 1998: 274; Spencer 1966: 83). Burrow destruction was presumably undertaken only on farms that already had rabbit-proof boundary fencing. January was regarded as a suitable time to rip warrens, as the soil is dry and flows well into cavities made by a ripper (Anon. 1964).

• ***Protection of natural enemies of the rabbit***

The advisability of protecting all natural enemies of the rabbit was recognized quite early (Royal Commission 1901: 20-21). The Rabbit Act (1902) allowed the Governor to 'declare any animal [sic], bird, or reptile to be a natural enemy of the rabbit, and prohibit, within any area to be specified…[their] wounding, killing, or capturing, selling, or disposing…'. Predators of rabbits include feral cats, goannas, carpet pythons, and owls (Crawford 1917), dingoes (Crawford 1907a: 35), wedge-tailed eagles (T. Carter in North 1912 vol. 3: 206; Carter 1920: 706), whistling kites *Haliastur sphenurus* (Sandland and Orton 1922: 136), little eagles *Aquila morphnoides* (Carnaby 1933: 105) and brown hawks *Falco berigora* (Carnaby 1933). Crawford (1919: 9) thought that feral cats and goannas provided the greatest natural check on rabbits. Section 115 of the Vermin Act, 1918, authorized the Governor to declare any species to be a natural enemy of the rabbit and prohibit its killing. In 1923, Flynn (2002: 437) thought that natural enemies would prevent rabbits from becoming a pest near Lake Clifton.

Goannas, chuditch and dingoes were plentiful in Kellerberrin district until 1894-5, when small marsupials disappeared during an epizootic (B. Leake in *The Western Mail* 31.12.1904: 8; Abbott 2006). Rabbits had recently been reported in this district, and Leake's point was that they had few natural enemies to oppose them.

The suggestion that feral cats and other enemies would be sufficient to control rabbits on the mainland (*The Western Mail* 14.11.1908: 7) is considered implausible.

• ***Removal of above-ground shelter***

In 1904-6 Shortridge (1936: 748) noted that rabbits lived in the hollows of fallen logs and often occurred in greater numbers than the quantity of their burrows would imply. Government policy was that 'all hollow logs and dead lying timber should be burnt, and as far as possible all scrubs that will afford shelter and protection should be destroyed' (Crawford 1917). Comparatively few references to these activities were found (Cameron 1979: 137; Knox-Thomson 1975: 80; Lefroy 1935; Parnell 1982: 147; Stokes 1986: 176; Tomlinson and Crawford 1951: 124; *http://amol.org.au/runrabbitrun/agriculture.asp*).

• ***Removal of below-ground shelter***

In 1918 it was suggested that the entrance holes to boodie warrens be filled in before rabbits colonized (J. Greig WAPD **56**: 689, 5.3.1918). No action appears to have been taken, probably because labour would have been unaffordable.

• ***Use of dogs and ferrets***

Dogs were considered to be of little use (*The Western Mail* 1.9.1900: 6) as they merely frightened rabbits instead of killing many, and soon tired of eating rabbit (*The Western Mail* 11.3.1905: 10). Fox terriers and Irish terriers were used to locate rabbits by scent, and kangaroo dogs then captured the rabbits disturbed by the terriers (Crawford 1908c: 337). Bignell (1991: 49) also recorded the early use of a rabbiting dog. However, dogs were only of minor importance in rabbit control (Tomlinson and Crawford 1951). In contrast, Lefroy (1935) considered that dogs played an important part in rabbit control once their warrens and cover had been destroyed.

Ferrets were used in Mingenew, Kojonup and Beverley districts (Mingenew 1988: 83; Bignell 1997: 159; Broun 1995: 12). Seven animals were offered for sale in Goomalling district (*The Western Mail* 30.12.1926: 1). Ferrets were considered to be expensive (Crawford 1917) and only of minor importance in rabbit control (Tomlinson and Crawford 1951).

• ***Introduction of disease***

Naturalists opposed the introduction of chicken cholera into Australia as a means of destroying rabbits, concerned about the risk of extinction to native fauna (*Victorian Naturalist* **4**: 198, 1888). One physician was concerned about the uncertainty, dangerous nature of chicken cholera, and risks to livestock, crops, and insectivorous birds (Wigg 1889). Evidence was subsequently found of mortality of some indigenous birds following inoculation with chicken cholera (Katz 1890). Chicken cholera was successfully used locally in Queensland to kill rabbits (Pound 1897a, 1897b). Pasteur's inoculation system was proposed as suitable for rabbit control in WA (*The Western Mail* 8.7.1898: 27, 8.9.1900: 6), but with a risk to poultry. The use of disease to control rabbit populations was advocated by H. Brockman (*The West Australian* 20.11.1900: 3), JS Hicks (WAPD **19**: 535, 18.7.1901), and Harper (1901: 117). They suggested spreading to rabbits the disease that had recently killed possums.

There was also early local interest by farmers and pastoralists in bringing a bacteriologist (Jan Danysz) to Australia to determine if a disease could be introduced to destroy rabbits without injuring other (stock) animals (*The Western Mail* 14.4.1906: 13; *Journal of Agriculture WA* **13**, 292, 1906). Some were concerned that such a disease may spread to native species, and that in any case the rabbit would not be exterminated because animals not susceptible to the disease would survive and multiply (*The Western Mail* 11.2.1905: 8; Anon. 1906a; Giddings 1906; Steel 1906: 613-5). There was also concern that disease would stop the consumption of rabbit meat and jeopardize the trapping industry (*The West Australian* 12.2.1906: 7; *The Western Mail* 28.4.1906: 11). The Commonwealth Government thus prohibited the import of rabbit disease micro-organisms into Australia without approval of the Minister for Trade and Customs (*Commonwealth of Australia Gazette* 6.6.1906: 781). Progress with, and criticism of, Danysz' experiments on Broughton Island, New South Wales, were presented by Tidswell (1906, 1907) and Johnson and Giddings (1906, 1907), and reported in detail in *The Western Mail* between September 1906 and November 1907. Crawford (1907a: 57) recommended to Government that it not join with the other States in funding Danysz' experiments because WA is too dry and the chance of disease spreading to rabbits was considered to be too low (see also *The West Australian* 21.5.1907: 7).

In 1908 a conference in Sydney of chief medical officers from all States decided that the virus used by Danysz would be of little use because epizootics would only be of short duration (*The Western Mail* 29.2.1908: 6, 7.3.1908: 19). No permits to conduct experiments on mainland Australia were issued (A. Chapman Commonwealth of Australia Parliamentary Debates **45**: 10081 2.4.1908).

Infection centres for the myxoma virus were established in WA in August 1951, and by 1954 some 27 000 rabbits had been infected in 21 centres (Button 1952; Calaby *et al.* 1960). The first surveys, in March 1952, demonstrated high mortality only near Geraldton and Dale River, resulting in a pessimistic assessment of myxoma as an effective method of rabbit control in WA. Cyclonic rainfall in February 1955 resulted in widespread flooding, which facilitated breeding and dispersal of the two species of mosquito that are important vectors of the virus (Tomlinson 1959: 39). By 1956 rabbits were no longer abundant (Beecham nd: 84; de Burgh 1976: 181; Erickson 1971: 152; Moran 1995: 20; Stokes 1986: 239).

The Spanish rabbit flea was introduced in 1969 and spread rapidly, proving more effective in winter as a vector of myxoma virus than mosquitoes (King *et al.* 1985).

• *Introduction of other biological control agents*

Proposals to introduce a 'flesh-eating ant' to Australia from South Africa appear not to have proceeded (*Journal of Agriculture WA* **14**, 281-4, 1906). This ant was supposed to destroy young rabbits (D. Blackburn in *The Western Mail* 30.6.1906: 10; V. Hamersley WAPD **58**: 682, 17.10.1918), but there were concerns that it would destroy lambs as well (E. Wittenoom WAPD **56**: 723, 22.10.1918). In 1907 one newspaper reader enquired about the suitability and procurability of the mongoose (*Herpestes*) for controlling rabbits (*The Western Mail* 15.6.1907: 6). The importation of stoats and weasels (presumably *Mustela erminea* and *M. nivalis*) was prohibited in 1909 under the Customs Act (*Commonwealth of Australia Gazette* 22.5.1909: 1123).

Benefits of rabbits The establishment of rabbits produced several economic and biodiversity conservation benefits.

• *Human food source*

Aborigines were quick to respond to the arrival of rabbits, as they were recorded consuming rabbits in 1903 near Southern Cross (Stevens 2001: 79). On the goldfields rabbits provided sport and variation in diet in a country practically devoid of game (*The Western Mail* 15.9.1900: 4). In 1906 trappers could earn £8-10 per week. Because trapping did not require skilled labour, the suggestion was made to 'let the rabbit have all the unoccupied country for the unoccupied people to make a living out of' (*The West Australian* 12.5.1906: 4). During the Great Depression, rabbit meat ('underground mutton') was an important food item in rural communities in south-west WA (Buchanan 2000: 248; Clemens 2000: 197; Crake 1985: 110; Daubney 2001a: 132; Ferrell 1992: 292; French 1989: 36; Gabbedy 1988 vol. 2: 396; Garden 1979: 223; Hales 1999: 62; Roots 2003: 199; Symes nd: 57; Thomas 1999: 209). Presumably these rabbits were caught in areas where or at times when no poison baits were distributed. Rabbits were hunted in the 1930s in bush near the Perth suburb of Mt Lawley (Cooper and McDonald 1999: 268), probably to alleviate poverty during the Great Depression. Catching rabbits was a popular pastime for teenage boys even in suburban Perth. In the case of Mosman Park, 1940s, carcasses were delivered to the local butcher (Wallace 2006: 13-15).

Carcasses were worth 4-6d during the Depression (Bird 1992: 312; Roots 2003: 199), and export of frozen carcasses became an important local industry (Pederick 1979: 5-6). The sale of rabbit meat for human consumption was prohibited when myxoma virus and 1080 poisoning came into use in 1952 (Pederick 1979: 6; Thomas 1999: 210). Most trapped rabbits, however, were gutted, boiled and fed to pigs (Broun 1995: 40; Clemens 2000: 47; Daubney 2001a: 309; Lange 1981: 523; Roots 2003: 302; Chitty 2004: 83) and hens (Daubney 2001a: 309).

• *Skin trade*

The Rabbit Act (1902) prohibited the possession of (and hence trading in) rabbit skins west of #1 RPF. By 1915 the Government was considering permitting rabbits to be trapped and used commercially for fur (and food) (WD Johnson WAPD **50**: 1604, 18.2.1915). From 1917 the Government permitted the marketing of trapped rabbits upon payment of a license fee of 2s 6d (Select Committee 1918). The earliest record found of commercial trapping

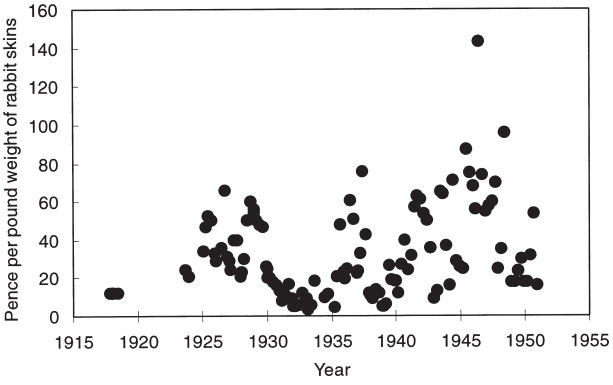

Fig. 40 Prices paid for skins of Oryctolagus cuniculus. *Source: Elder, Shenton and Co. Weekly Report 1917-18,* Elder's Weekly *1923-50, supplemented by* The Westralian Farmers' Gazette *1939. Maximum prices for highest graded skin for the first week of March, June, September and December are graphed.*

of rabbits for their skins was in the 7.11.1917 issue of *Elder's Weekly*, when it was noted that much larger quantities were now coming forward. Confidence was expressed that a more active market would develop. Skins were used to make imitation fur ('French Coney') and felt for hats (Lange 1981: 506; Roots 2003: 241).

It took c. 4-5 or 6 rabbit skins to make 1 lb (Haig 1982: 80; Skemp 1952: 214). Skins were carefully graded by trading companies, presumably on the basis of size and condition of the pelt. For example, prices in d/lb selected at random, are: winters 16, first incomings 12, second incomings 9, first boardies 8½, first does 8, racks 5½, damaged first 5½, ½-¾ grown 5, second boardies 5, second does 4½, butchers 4½, kittens 4 and damaged second 3 (*The Westralian Farmers' Gazette* 4.9.1930: 12). Careful skinning and drying was needed if the best price was to be obtained (*The Westralian Farmers' Gazette* 31.10.1925: 5). Birks (1921: 17) describes the correct preparation of skins and provides a photograph. Winter furs always attracted higher prices than those collected at other times and were profitable at times (Maddock 1987: 115), with £60 being made by landholders in some weeks (Repton 1999: 362). Prices decreased sharply in late 1930 (Fig. 40), with buyers advising trappers not to consign further skins for sale. Prices recovered in 1935 but later slumped, particularly in 1938-9 and 1942. According to Bird (1992: 312), skins reached £1/lb just before the 1939-45 war.

I have been unable to locate statistical data concerning the number of skins sold each year. The rabbit skin industry became significant from about October 1924, with nearly 2 tons of skins catalogued in the winter months of 1925 (*The Westralian Farmers' Gazette* 31.10.1925: 5).

Advice as to how to prepare a rabbit skin so as to attract the highest price was presented, together with a diagram, in *The Westralian Farmers' Gazette* (12.9.1925: 4) and *Elder's Weekly* (2.8.1928: 893). Repton (1999: 362) and Roots (2003: 199) also provide further detail. Vans were sent from Perth every second day to collect skins and carcasses (Maddock 1987: 115). Carcasses were sent by rail from Northam district to Perth from April 1934 (Garden 1979: 225), and by motor transport three times a week from Toodyay to Perth (Chitty 2004: 83).

• Biodiversity impacts

The establishment of rabbits should have increased the abundance of a number of bird, mammal and reptile species (see also the earlier section concerning natural enemies of the rabbit). Native animals large enough to prey on rabbits (raptors, owls, dingoes, varanids, snakes) found a novel source of food. Carrion feeders (certain raptors and invertebrates) also benefited.

In 1903 it was feared that invading populations of rabbits would drive 'millions and millions of tamma *[Macropus eugenii]*' into settled areas near the Great Southern Railway. Construction of #2 RPF would therefore alleviate this concern (CA Piesse WAPD **24**: 2494, 8.12.1903). Concern was also expressed that many small marsupial species would become extinct following the rabbit invasion (*The Western Mail* 25.12.1905: 85).

Rabbits cause permanent changes to floristic composition and vegetation structure (Peacock 1908), and these may have impacted indirectly on native fauna (Morton 1990). However, it does not appear that plagues of rabbits overwhelmed or outcompeted cursorial species of native mammals for food or shelter, as *Dasyurus geoffroi, Perameles bougainville, Macrotis lagotis, Bettongia lesueur, B. penicillata, Onychogalea lunata* and *Leporillus conditor* persisted on the Nullarbor Plain for 30-45 years after the arrival of rabbits (Boscacci *et al.* 1987). Furthermore, dietary studies have demonstrated minimal overlap between the boodie and rabbit at Heirisson Prong, Shark Bay (Robley *et al.* 2001).

Direct and indirect economic damage caused by rabbits It was clear soon after #1 RPF was erected that palatable native plant species such as grass and saltbush were reduced in abundance on the eastern side of the fence (Crawford 1907b: 61; 1908: 516).

Before 1954, rabbits cost WA 'several million pounds' each year in reduced stock-carrying capacity and were depriving farms of at least 25% of the overall pasture production in agricultural areas (Tomlinson 1959: 42). It was estimated that one rabbit ate c. 1 bushel of wheat per year (Sewell 1998: 187), 8 rabbits ate as much pasture as one sheep (C. Baxter WAPD **56**: 524, 21.2.1918; McConnell *et al.* 1993: 136), and 50 rabbits could eat as much as one cow (Skemp 1952: 212). When rabbits reached Toodyay district in 1927, carrying capacity of one farm was estimated to have been reduced by nearly 90%. Carrying capacity was not improved until c. 1935 when the farm was wire-netted and rabbits present were poisoned (Thomas 1949: 49).

No serious damage to crops had been reported before June 1913 (Crawford 1913). The earliest records of crop losses are from Pingrup in 1915 (Haddleton 1952: 44), the wheatbelt in 1916-17 (Select Committee 1918), Kellerberrin in 1918 (Leake 1962: 30), and between #1

and #2 RPF in 1918-19 (Crawford 1919: 36). Up to 1921 there were no reports of damage to the west of #2 RPF (Crawford 1921: 20). From the 1920s records are numerous: Moorine Rock, c. 1926 (Cameron 1989: 64); crop eaten back c. 15 m from the edge in one day in winter 1926 (Repton 1999: 362); inroads on the fringes of the crop in c. 1927 (Broomhall 1983: 35); much damage in 1927 (Ackland 1965: 74); and in 1928 entire paddocks of crops were eaten (Braid and Forbes 1997: 266). Consumption of crops continued until the early 1950s (Beecham nd: 55, 122; Craig 1928: 46; Haig 1982: 29; Parnell 1982: 185; Roots 2003: 389; Stokes 1984: 32).

Crop damage varied from year to year but was not quantified. It seems that 1918-19 (Crawford 1919), 1927-8 (Craig 1928), 1931-2 (Department of Agriculture 1932), 1932-3 (Department of Agriculture 1933), 1933-4 (Department of Agriculture 1935a), 1934-5 (Department of Agriculture 1935b), 1941-2 (Department of Agriculture 1942) and 1942-3 (Department of Agriculture 1943) were years with extensive damage to crops.

The earliest record of pasture losses (1916) came from Dalyup, where rabbits had kept down the grasses in a paddock in which 20 horses had been previously kept all year round . The paddock had to have a rabbit-proof fence constructed around it (Royal Commission 1917b: 47). From the 1920s pastures were eaten out (Bignell 1977: 267, 1997: 93; Chase and Krantz 1995: 223; de Burgh 1976: 147; Department of Agriculture 1940: 27; Parnell 1982: 161; Richards 1993: 501), with stock having to be hand-fed in summer (Repton 1999: 362). One farm that had supported 4 000 sheep in 1924 had only 1 000 sheep in the 1930s (Bird 1986: 272).

Rabbits also ate vegetables (Royal Commission 1917a; Richards 1993: 501; Thomas 1999: 209) and vines (Royal Commission 1917a); and exterminated native grasses on river flats (Southern Scribes 1999: 297). Fruit trees were killed by rabbits ringbarking them at the base (Adams 2004: 118; Anon. 1992: 136; Parnell 1982: 161; Wootton and Jacob 1992: 54). Sandalwood plantations 'suffered severely' (Forests Department 1927: 21). Rabbits in 1929 were still not common enough in areas on the Swan Coastal Plain and Darling Plateau to impact on young pines in plantations (Forests Department 1929: 7).

Rabbit burrows were inimical to horses (Haig 1982: 29; Chitty 2004: 85) and could even result in a broken leg (Crake 1985: 110). Rabbit grazing also impacted on poultry (Knox-Thomson 1975: 27). Poisoning of rabbits resulted in many carcasses, which favoured proliferation of blowflies (Abbott 1913; Royal Commission 1918: xvi).

Off-target impacts of poisoning, trapping, and habitat removal Poisoning of pigs, horses, cows and sheep, after they consumed poisoned rabbit carcasses, seems to have been first reported in 1918 (Ewers 1959: 100). Stock chewed on dry rabbit carcasses and ate the bones of poisoned rabbits and developed toxic paralysis (Ackland 1965: 72; Haig 1982: 125; Leake 1962: 31; McLaren and Cooper 2002: 154; Taylor 2000: 184; *The Western Mail* 15.6.1933: 44, 13.7.1933: 34).

In New South Wales, the deployment of poison baits was thought to have caused the local extinction of natural enemies of the rabbit, particularly varanids and quolls *Dasyurus viverrinus* and *D. maculatus* (Abbott 1913). Poison baits (phosphorized pollard) exacerbated the decline of several marsupial species, including dalgytes, boodies, quokkas, and koomal. One of the probable reasons several mammal species persisted much longer in the jarrah and karri forests than elsewhere in south-west WA is that poison baits for rabbits did not need to be distributed in the forests because rabbits were either absent or occurred very sparsely.

It was known from New South Wales that poisoned water was a danger to native birdlife (*Journal of the Department of Agriculture of WA* 1904 **10**, 266), particularly pigeons (Froggatt 1914: 33). Crawford (1913: 12) cautioned that poisoned water needed to be placed so that birds could not access it. 'We advise great care in the use of these two poisons [arsenic, cyanide] as there is a danger of destroying the native bird life when poisoning water' (Select Committee 1918: 8). Crawford was opposed to poisoning of water because it may kill feral cats and goannas, both predators of rabbits (Crawford 1919: 10).

Concerns had also been expressed in Victoria about insectivorous birds being killed after taking poison baits (*Emu* **5**, 51; *Victorian Naturalist* **30**, 111, 1913; **31**, 1, 38, 1914). The earliest concern expressed in WA about wholesale poisoning destroying the balance of nature was in 1918 (JM Smith WAPD **56**: 399, 13.2.1918): 'to poison birds and animals [sic] which play a far greater part in the scheme of nature that we, with our lofty disregard for the principles of science, are ready to recognise' (W. Kingsmill WAPD **56**: 685, 5.3.1918). This sentiment was expressed even more forcefully a few months later: 'The indiscriminate poisoning of rabbits and with them all of the small fauna of the State is I venture to say, a crime against nature. Crimes against nature never go unpunished.' (W. Kingsmill WAPD **56**: 723, 22.10.1918).

Fumigants would have killed those mammal species that lived in burrows (dalgyte, boodie) and hollow logs (echidna, numbat). Indeed, an advertisement for the Langarwil® rabbit exterminator boasted that it 'cannot fail to kill everything alive in burrows, hollow logs, or in closed spaces' (*The Westralian Farmers' Gazette* 23.9.1926: 13). The cessation of fumigation with the change to 1080 poisoning from 1955 benefited the native fauna.

Trapping is known to have mutilated and killed dalgytes (p. 49). Netted enclosures every few miles along the RPF also resulted in mortality of young emus, echidnas, as well as parrots and goannas, as the top of these enclosures was netted (*The West Australian* 24.1.1925: 11, 4.4.1925: 13).

The removal of rabbit harbour, i.e. thickets of vegetation and fallen (hollow) logs, would have impacted on tammar and brush wallaby, and echidna and numbat, respectively.

A comprehensive synthesis of the ecology of the rabbit, although based on research performed in south-eastern Australia, is available (Andrewartha and Birch 1984).

Canis familiaris dog

The earliest records of the dog in south-west WA are from Geographe Bay in 1801, where a hunting dog was unintentionally abandoned by a French expedition (Cornell 2006: 81), and from King George Sound in 1826, where a sealer used dogs to hunt kangaroos (Rosenman 1987: 34-5).

It is a reasonable assumption that most settlers brought one or more dogs with them, probably to serve as companions, hunters of game, and protectors. Examples include:

- 1829, 50 dogs on board the *Warrior* when it departed from England (Berryman 2002: 52)
- 1829, 10 dogs (A. Butler in Bolton and Gregory 1999: 2)
- 1830, two dogs (Roberts 1834: 59)
- 1830, three dogs – bloodhound, lurcher and retriever (J. Bussell in Jennings 1983: 300)
- 1830, one dog (L. Lukin in Cooper and McDonald 1989: 6)
- 1830, three dogs (G. Robb in Berson 1978: 25)
- 1830, one dog, which had 9 puppies on board (Moore 1884: 6)
- 1831, 18 dogs (H. Hall in Richards 1978: 57)
- 1834, 'a few Kangaroo dogs' brought by ship from Sydney (*The Perth Gazette* 4.1.1834: 210)
- 1834, eight harrier dogs and one sheep dog imported from England (*The Perth Gazette* 26.4.1834: 274)
- 1841, three dogs – bloodhound, mastiff and cocker spaniel (Landor 1847: 10).

Kangaroo dogs were also offered for sale in Perth, including some that were 'warranted to kill and shew' (*The Perth Gazette* 16.2.1833: 28, 26.10.1833: 172). Dogs were also obtained from unusual sources. For example, four kangaroo dogs were purchased from a U.S. whaler in 1841 (Bolton *et al.* 1991: 142).

Hunting dogs were highly valued because settlers in the early 1830s could not afford to kill their stock for food (Erickson 1974: 36) or purchase meat (beef, mutton, pork) because of its unavailability (Cameron 2006: 83, 132, 142). Dogs were also expensive (at c. £15) and difficult to procure (Kellam 1831: 52; G. Moore 1831 in Cameron 2006: 10, 34). Even in 1834, one dog was purchased for £30 (Cameron 2006: 336). Dogs were used to hunt possums (J. Wollaston 1842, Picton in Bolton *et al.* 1991: 248) and kangaroos (J. Kent 1829 in Berryman 2002: 126-7; J. Henty in Bassett 1954: 121; C. Barker 1830 in Mulvaney and Green 1994: 289; G. Moore 1831 in Cameron 2006: 14). This led to Aborigines complaining that the dogs of settlers had destroyed most of their game, and thus justified their substitution of mutton and beef for possum and kangaroo (Martin 1836: 336).

The first reference found to 'kangaroo dog' was from December 1829, at Albany (2 dogs, Wilson 1835: 237). This seems to have been a generic term for several cross breeds: greyhound x lurcher (Bolton *et al.* 1991: 142); greyhound x mastiff (Millett 1872: 199); greyhound x bloodhound (H. Bunbury 1837 in Bunbury and Morrell 1930: 124; Landor 1847: 168, 331); greyhound x staghound (Timperley 1892: 71); greyhound x deerhound (G. Shortridge 15.11.1905); and foxhound x Scottish deerhound (Millett 1872: 199). It is worth noting that elsewhere in Australia a kangaroo dog was defined as a large variety of greyhound (Atkinson 1826: 23; Dawson 1830: 141), a greyhound x mastiff or sheepdog (Dawson 1830: 141; Henderson 1851 vol. 1: 206), a large half-bred greyhound (Melville 1851: 307; Haygarth 1864: 115), or a greyhound x bloodhound-foxhound-staghound (Stamer 1874: 252). The advantage of the kangaroo dog for hunting was that it was bold, powerful and swift (Landor 1847: 168, 331; Timperley 1892: 71). H. Bunbury's dog hunted three days per week and killed two kangaroos on each day (Bunbury and Morrell 1930: 124). Kangaroo dogs could catch kangaroos 'much more easily' than Aborigines could (Bunbury and Morrell 1930: 174). The hunting method used is described in Cameron (2006: 158).

Large numbers of dogs were kept by settlers for protection against Aborigines. For example, 20 kangaroo dogs were present on a remote farm at Williams River in 1839 (Grey 1841 vol. 1: 317). Shepherds also camped with dogs around watering points (Maddock 1998: 56).

Dogs, along with horses, were the first European animals to be taken to unsettled parts by exploring parties (e.g. JW Hardey, six dogs, 1830 in Shoobert 2005: 186; two kangaroo dogs 1854, Austin 1855: 17; J. Forrest 1869 in Forrest 1875: 37). Sometimes dogs wandered away for short periods (G. Moore 1831 near York, in Cameron 2006: 49) or failed to return to camp and were left behind (JW Hardey 1830 ibid.: 191; J. Roe 1835 Doubtful Island Bay, in Shoobert 2005: 508). One dog lost near Eliot Vale travelled 100 miles west to Mandurah in three days (J. Roe 1835 in Shoobert 2005: 470). Dogs were also considered essential for the proper management of sheep by shepherds, especially as the size of flocks increased (Cameron 2006: 410).

Dogs appear to have had few enemies. Some were injured or killed by large kangaroos when cornered (Shann 1926: 74; G. Moore in Cameron 2006: 358; H. Bunbury in Bunbury and Morrell 1930: 124; Anon. 1842: 95; Gilbert nd2; Bolton *et al.* 1991: 142; Landor 1847: 258, 336; *The Western Mail* 31.3.1906: 10; *The West Australian* 28.3.1925: 13; Knox-Thomson 1975: 33; Stormon 1977: 191; Torrent 2001: 28; Buchanan 2003: 112, 155) and by wedge-tailed eagles (Plunkett and Wimbush 1999: 77). Dogs evidently quickly became a nuisance in Perth and Fremantle (*The Perth Gazette* 12.1.1833: 6). There was further reference to savage dogs in and near towns in 1846 (*The Inquirer* 30.12.1846), 1848 (*The Inquirer* 2.2.1848), 1849 (*The Perth Gazette* 15.6.1849), and 1850 (*The Inquirer* 16.1.1850).

At first, Aborigines in the Swan River district were 'very fearful' of, 'extremely afraid of approaching our dogs', and 'much alarmed' at European breeds of dogs, but by 1833 they were not so terrified though still holding them in great respect (*The Perth Gazette* 12.1.1833: 8;

Breton 1834: 24; Berryman 2002: 123, 156). At Cape Lesueur (Peron Peninsula), Aborigines were reported 'much terrified at our Dogs' (H. Ommanney 1834 in Shoobert 2005: 357).

Concern was expressed about the rapid increase of European dogs and the custom of some settlers supplying them to Aborigines (*The Perth Gazette* 26.10.1833: 169). It was feared that these dogs would attack sheep and poultry (*The Perth Gazette* 8.2.1834: 230, 15.2.1834: 235). The Government then cautioned the public against continuing this practice (*The Perth Gazette* 22.2.1834: 237), evidently to little effect (*Perth Gazette* 22.4.1837: 887, 14.10.1837: 989, 30.12.1837: 1033; Cameron 2006: 315, 368, 449). 'The natives are fond of their [European] dogs, but they make no effort to procure food for them. The poor creatures roam about in a miserable state, and are ready to devour any thing which comes within their reach' (*Perth Gazette* 30.12.1837: 1033). Dogs in Perth continued to be a 'serious nuisance', and imposition of a dog tax was seen as one solution to preventing 'the increase of curs' (*Perth Gazette* 10.3.1838: 38). European dogs were much more valued than native dogs by Aborigines 'when persons are unwise enough to give them to the Aborigines' (Moore 1842: 25). One reason given for Aborigines seeming to prefer to own dogs of European breeds was that their bark served as a signal of danger (Freycinet 2001: 94, 130). Kangaroo dogs also strayed and had been taken up by Aborigines (e.g. *Perth Gazette* 19.5.1838: 77; *The Inquirer* 8.12.1841). Dingoes at New Norcia were reported to be afraid of European dogs (R. Salvado, late 1840s in Stormon 1977: 189).

The Government legislated in 1841 to reduce the annoyance caused by dogs in towns by requiring every dog to be licensed (otherwise the owner was fined £1-5), and paying 5s upon presentation of the head of a dog to a Justice of the Peace (Dog Act 1841). Puppies and sheep dogs were exempted from registration, but the latter provision was repealed in 1847. Although the revenue from dog licenses for the period January to March 1842 inclusive amounted to £41 (*The Perth Gazette* 9.4.1842), it later declined, forcing the Government to issue a reminder to constables to enforce the Act (*The Perth Gazette* 12.11.1842). This led to officious behaviour (*The Perth Gazette* 17.12.1842). License fees were reduced by the Dog Act (1847).

Because of the great increase by 1845 of European dogs in the possession of Aborigines and frequent injuries on sheep, the Governor offered a reward to constables of 1s per head (dog) or 6d per head (puppy) found in the possession of any Aboriginal (*Government Gazette* 24.10.1845). This issue was close to getting beyond control, according to *The Perth Gazette* (30.12.1846) and the York Agricultural Society in 1847 (Markey 1976: 126). An amended Dog Act (1847) stated that any person convicted of giving a dog to an Aboriginal would be fined. Reports were published of a group of Aborigines in Murray district with 27 'English dogs' (*The Inquirer* 19.4.1848) and of a native camp near Perth with c. 100 kangaroo dogs (*The Inquirer* 4.9.1850). Cross-breeds with dingoes were considered in the 1850s as more of a problem than dingoes because of their lack of fear of humans (Richards 1978: 259). In 1876 the politician JG Lee Steere advocated that legislation was needed to compel the owner of every dog to keep on the animal a collar showing whether it was licensed or not. Dogs found unlicensed should then be destroyed (*The Herald* 20.5.1876). At Northampton it was noted that Aborigines 'more frequently hunt for their dogs than the dogs hunt for them' and that 'one dog is surely sufficient for one native to lavish his or her affection upon' (*The Victorian Express* 8.8.1885).

Further adverse comment on the dogs of Aborigines, dogs in the country, and town dogs was made in 1886, 1895 and 1906 (*The Western Mail* 13.3.1886: 13, 11.5.1895: 4, 7.4.1906: 12). F. Piesse (WAPD **3**: 510, 22.12.1892) noted that Aborigines' dogs often became wild and even more cunning than, and caused as much trouble as, dingoes. According to J. Forrest (WAPD **3:** 514 22.12.1892), Aborigines kept European dogs as friends. By the 1890s, Aborigines were said not to need dogs for hunting as they then lived upon the provision of the settlers (H. Lefroy WAPD **3**: 514, 22.12.1892). By 1885 a male adult Aboriginal could lawfully keep only one dog, provided that it was free of mange and other contagious disease (Dog Act Amendment Act 1885, 1899).

Cross-breds (dog x dingo) were not unusual as early as 1905 in country between Dongara and Hill River (*The Western Mail* 16.3.1939: 10). These animals either hunted in packs and readily killed calves (*The Kalgoorlie Western Argus* 12.7.1910: 13) or hunted sheep alone (*The Western Mail* 27.10.1932: 9). Interbreeding of wild dogs with dingoes remained an ongoing concern (Woodward 1907: 18). Dogs such as collies, kangaroo dogs and alsatians, kept in timber workers' camps, had interbred with dingoes, resulting in a 'ruthless, dangerous and daring type of animal' capable of tearing apart foals and calves (Arnold and Herbert 1934). Calls for farm dogs to be desexed could not overcome public sentiment (*The Western Mail* 26.4.1923: 4). One cross-bred dingo paid a bounty of £25 (*The Northam Advertiser* 4.5.1929: 4).

Kangaroo dogs were noted as having killed 30 sheep near York in 1895 (*Eastern Districts Chronicle* 19.1.1895: 4), and an unspecified number near Tammin in 1909 (*The Western Mail* 5.6.1909: 11). Advice on the standard of fencing required to exclude sheep-killing dogs was published in 1908 (*The Western Mail* 7.11.1908: 8).

Even as late as 1911, Aborigines kept large numbers of dogs – 50 'mongrel' dogs were reported at Perup (*The Blackwood Times* 1.8.1911).

In 1865 'a great number' of dogs were reported to have died of distemper, apparently in Albany district (Crabb nd: 103).

Vulpes vulpes fox/red fox

Oldtimer information Foxes were widespread in south-west WA by the late 1920s/early 1930s, according to information obtained from oldtimers (Fig. 41). The fox generally arrived in a locality with or soon after the

rabbit, although west of Darkan the fox arrived first, in c. 1928 (N. Rajander pers. comm.). Five oldtimers reported that the fox became common in south-west WA in the 1930s. Prey recorded by 13 oldtimers included the woylie, koomal, brush wallaby, rabbit, sheep (as lambs), fox, domestic turkey, domestic fowls and guinea fowl. Surplus killing (of 18 domestic turkeys) was reported (F. Sounness pers. comm.).

After the 1939-45 war, wool prices increased and sheep became more valuable. Organized spotlight shooting of foxes then took place (H. Hall pers. comm.). The introduction of myxomatosis in the 1950s markedly reduced rabbit populations and probably intensified predation by foxes on marsupials. The introduction of 1080 baiting in the 1950s for rabbit control resulted in a decline in numbers of the fox, followed by recovery of some marsupial species (A. Foan, J. Fletcher pers. comm.).

Many informants were aware that low numbers of rabbits led to a major reduction in 1080 baiting in the 1970s. The fox then recovered (B. Mitchell pers. comm.). Re-introduction of 1080 baiting in the 1990s to reduce fox populations has led to obvious increases in abundance of brush wallabies, numbats, woylies, chuditch, koomal and western ringtail possums (usually evidenced by sightings of live animals and roadkills).

Colonization and establishment Variously stated to have been introduced into Victoria in 1870, 1871, or 1879 (Anon. 1906b; Rolls 1969; Jones 1994: 31), foxes

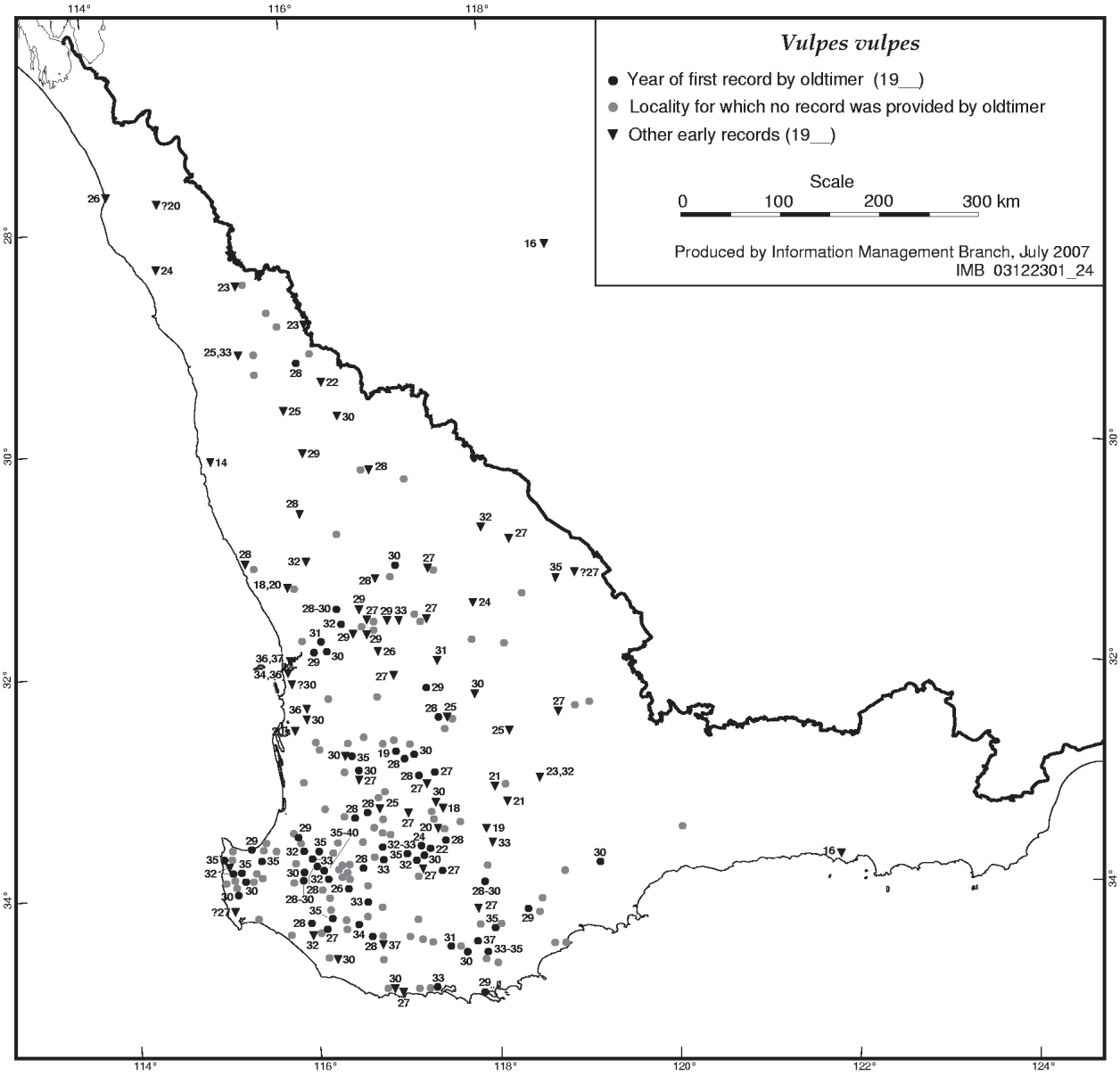

Fig. 41 Early distributional records of Vulpes vulpes. *Additional records not already cited in text: Atkins 1993; Bellanger 1980; Buchanan 2000; Crake 1985; Drake and Kennealy 1996;* Elder's Weekly *29.10.1925: 14; French 1989; Gardner 2000; Kitchener* et al. *1978; Kitchener and Vicker 1981; Ludbrook 2003; Maddock 1998; Mingenew 1988; Owen 1933; Payne 1987; Pollard 1928; Porter 2001; Rice 1993; Richards 1993; Stokes 1986;* The Western Mail *14.2.1919: 3, 7.6.1923: 8, 30.8.1923: 6, 26.12.1929: 39, 16.1.1930: 36; Udell 1979; Webb 1988.*

were causing concern in Victoria by 1885 (Jones 1994: 31). The fox was only 120 miles east of the WA border in early 1910 (*The Western Mail* 5.2.1910: 4). It reached the border in 1911-12 (Crawford 1912b: 44) and apparently isolated individuals had reached the west coast by 1914 (Fig. 41). The fox crossed into south-west WA on a broad front in c. 1916 (Fig. 41). The suggestion that colonization by the fox was facilitated by the construction and completion in 1917 of the Trans-Australian railway (Owen 1933: 136) does not fit the available data (Fig. 41). By 1918-19 Crawford (1919) knew of only three reports of foxes seen and there were no reports of any depredations on sheep. By 1920, the species was noted as present in many places (Crawford 1921). In 1921-2 foxes were 'more in evidence this year than previously', with 17 animals caught in one (unnamed) Vermin District (Arnold 1922: 40). By 1922-3 foxes were becoming numerous, especially in Geraldton district (Arnold 1923). In 1923-4 foxes were steadily spreading but were in greatest numbers in the northern sector of south-west WA (Arnold 1924), specified as an area bounded by Northampton, Geraldton and Mingenew (Craig 1925b: 98). In 1925-6 foxes were regarded as numerous only from Northampton to the south of Moora (Craig 1926).

By 1927 the fox was fairly common from Northampton south to the wheatbelt, Mt Barker and Albany (Craig 1927b). The outstanding feature of 1928-9 was 'the extraordinary increase' of foxes (Craig 1929). More than 30 foxes had been shot near Geraldton in the first three months of 1928 (*The West Australian* 14.4.1928: 3). In 1929-30, foxes were reported from 31 new districts, mostly in the lower south-west (Department of Agriculture WA 1930). This sudden increase was probably in response to large increases in rabbit populations (Garden 1979: 224), although Repton (1999: 309) also linked this increase to the elimination of the dingo. Thus, within 14 years of its arrival in south-west WA, the fox was present throughout this region (Fig. 41).

Although W. Le Soeuf (nd: 147) had predicted that the fox would gradually extend throughout Australia, E. Le Soeuf in 1911 thought that WA 'is not fox country, being too open and dry' and foxes 'will be more easily dealt with than they are in the Eastern States' (*The Western Mail* 22.4.1920: 9). L. Glauert stated that 'the fox menace does not appear to be as great on this side of the [State] boundary' (*The West Australian* 12.9.1929: 8).

Foxes were stated to be increasing in various districts as follows:

- 1925, Geraldton district and Midlands (M. Troy WAPD **73**: 1736, 3.11.1925)
- 1926, 'mid-north' (Serventy 1927: 182)
- 1926-7, Woodanilling district (Bird 1986: 304)
- 1927-8, Arthur River district (Bird 1990: 337)
- 1928, Moora district (Laurie 1995: 147)
- 1928, Goomalling district (Sewell 1998: 187)
- 1929, Northam district (*The Northam Advertiser* 29.5.1929: 2)
- late 1920s, Kellerberrin district (Leake 1962: 33)
- c. 1930, Merilup district (Timperley 1996: 270)
- 1930-4, Tammin district (Repton 1999: 309)
- 1932, Boddington district (Ferrell 1992: 293)
- 1932, Mt Marshall district (Broomhall 1983: 278)
- 1933, Cunderdin-Meckering district (Stokes 1986: 176)
- 1933, Corrigin district (Haig 1982: 88)
- 1933, Shire of Kent (Beecham nd: 49)
- 1939, Serpentine district (Coy 1984: 165)
- 1930s, Bruce Rock district (Ewers 1959: 97)
- 1930s, lower Moore River district (de Burgh 1976: 147)
- late 1930s, Argyle (Adams 2004: 115).

Economic impact Another indicator of large fox populations is an increase in the number of sheep killed:

- 1923, Mullewa district (*The Western Mail* 9.8.1923: 4)
- 1924-5, Moora-Northampton (Craig 1925a: 32)
- 1929, Clackline (*The Northam Advertiser* 22.5.1929: 2, 22.6.1929: 2, 29.6.1929: 2)
- 1929, Beverley district (McLaren and Cooper 2002: 157)
- 1933, Wagin district (Pederick 1979: 54)
- 1933, Great Southern region (*The Western Mail* 15.6.1933: 44)
- 1934-6, Calingiri district (Erickson 1971: 151)
- 1935, Cranbrook (*The West Australian* 4.9.1935: 11)
- 1935, lambing reduced from 85% to 35% on one farm near Toodyay (Thomas 1949: 49)
- 1935-6, considerable damage done to early lambs in almost every centre (Department of Agriculture 1936: 29)
- 1936, Kondut and Shackleton (*The West Australian* 7.5.1936: 16)
- c. 1936, foxes 'in last few years' attacking ewes and lambs (*The Westralian Farmers' Gazette* 5.3.1938: 15)
- 1938, Kukerin (Timperley 1996: 416)
- 1939, near Moorine Rocks (Cameron 1989: 171)
- 1940, Mukinbudin district (Maddock 1987: 248)
- 1941, c. 15 km north of Katanning (Haddleton 1952: 77)
- 1944, south-west generally, carrying capacity reduced and foxes 'multiplying…at an exceedingly rapid rate' (D. McLarty WAPD **113**: 636, 30.8.1944)
- 1946, 'This year the depredations of the foxes have been enormously above those experienced in previous years'. Near Pingelly, only 40 out of c. 250 lambs remained on one farm (H. Seward WAPD **117**: 1456, 22.10.1945).

By 1946, sheep farmers had accepted that foxes 'are equally as important, if not more so, in the matter of

damage and loss, as the other types of vermin' (A. Watts WAPD **117**: 1329, 16.10.1946). However, the evidence cited above conflicts with post-mortem examination of > 2000 lambs in 1963-4. This study found that predators were responsible for only c. 2% of deaths of lambs. Foxes appeared to act as scavengers, confining their attention to dying or dead lambs (Dennis 1965).

Foxes started killing fowls in 1929 in Northam district (*The Northam Advertiser* 22.6.1929: 2) and in 1930 near Moorine Rock (Cameron 1989: 117), near Serpentine in 1930 (*The Western Mail* 13.2.1930: 39), at Guildford in 1936 (*The Western Mail* 23.7.1936: 54), and in the late 1930s at Argyle (Adams 2004: 115). Surplus killing of lambs (17 dead in one night, undated) was also recorded (Ewers 1959: 98).

Predation by the fox could be distinguished from that done by dingoes, cats and dogs by the removal of the victim's tongue and by withdrawal of all of the internal organs from one hole on the body (F. Vanzetti in *The Western Mail* 19.6.1924: 7; *The Western Mail* 9.9.1926: 1; Dennis and Gooding 1965: 249; Bird 1990: 337; Repton 1999: 29).

Numerous records, mostly undated, were found of poultry (fowls, ducks, geese, turkeys) freely wandering around farms and of turkeys nesting in crops. However, once the fox established, poultry had to be shut up at night (Arundel 2003: 155; Bignell 1991: 68; Bird 1986: 199; Bird 1992: 178; Broun 1995: 20; Chitty 2004: 195; Daubney 2001a: 253; Ewers 1959: 98; Heydon 1988: 148; Leake 1962: 34; Lowrie nd: 33; Richards 1993: 501; Scottish Agricultural Commission 1911: 278).

Economic benefits The only benefits of the arrival of the fox are that it provided good sport for hunt clubs from the 1930s (Belmont, Mt Yokine – *The West Australian* 27.6.1934: 4, 19.7.1937: 4), well-furred skins for female attire, and 'good money' for 'numerous' men shooting and poisoning them (*The West Australian* 12.2.1930: 5).

The first record found of fox skin trading (Fig. 42) was 20.6.1929 *(Elder's Weekly)*, when it was stated that demand for well-furred skins from local trade was 'very strong'. First grade skins were worth 7-8s each and damaged and second grade skins were worth 2-5s each. I found no further records until 1935, possibly because until then it was more remunerative to present the ears and tail for scalp bonus and discard the skin. (Skins without tails would have been unmarketable as furs). A photograph of a properly prepared skin is provided by Birks (1921: 7).

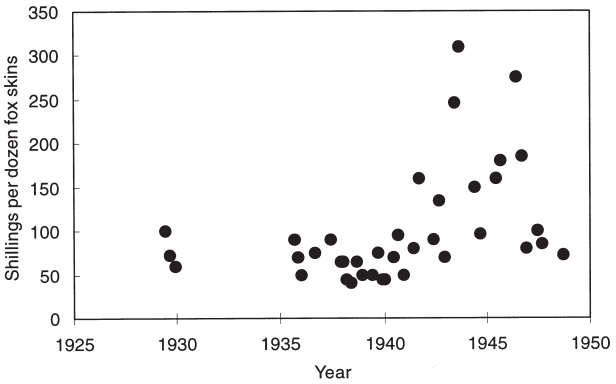

Fig. 42 Prices paid for skins of Vulpes vulpes. *Source:* Elder's Weekly *1929-50, supplemented by* The Westralian Farmers' Gazette *1929 and 1940. Maximum price for the first week in March, June, September and December is graphed. The absence of records between 1929 and 1935 is not due to missing data.*

Elder's Weekly (7.3.1940) and *The Westralian Farmers' Gazette* (28.3.1940) noted that it was not worth submitting skins as they were of poor quality ('summery'), being very short in fur. Destroying the skin and claiming the bonus was instead recommended. It was considered more appropriate to defer collecting of skins until June when the winter fur was developed.

Control The first response by the WA Government to the fox was to forbid its introduction (by an Order-in-Council, 17.7.1901, under the provision of the Stock Diseases Act, 1895; see *Government Gazette* 19.7.1901: 2774). This was apparently in response to a report that live foxes were to be introduced from Victoria to Kalgoorlie (C. Sommers WAPD **56**: 492, 20.2.1918). In the year that the fox reached WA, Crawford (1912: 44) proposed to convert the #1 RPF (as far north as 600 miles north of Burracoppin) to being fox-proof by adding two barbed wires. It was reasoned that, because the dry spinifex country offered no game for foxes to eat, foxes would be unlikely to reach the #1 RPF 'for many long years to come'. By 1913-14 some 325 miles of #1 RPF had been made fox-proof (Crawford 1915: 74).

The authorities (Crawford 1916) evidently did not realize that a fox could jump or scramble 6-8' up a tree (Hall 1901: 23; Le Soeuf nd: 147) or climb over a 6' fence (*The Western Mail* 19.6.1924: 7, 23.7.1936: 54). Netting on a 7' high wire-netting fence had to be turned outwards at the top at a sharp angle to prevent foxes getting over the fence (Craig 1927: 556-7). There is also a record in 1991 of a fox in the fork of a tree 3 m above ground (*Western Australian Bird Notes* No. 58: 8).

Successful methods for baiting foxes with powdered strychnine had already been worked out in Victoria (Anon. 1900a), South Australia (Anon. 1900b, 1901a) and New South Wales (O'Neil 1905; Anon. 1912 a, b). In 1921 poisoning, shooting and trapping were suggested as suitable methods that could be applied by settlers in south-west WA to control foxes (Crawford 1921: 24). Poisoning of carcasses with strychnine was advocated, as foxes were regarded as less cunning than dingoes and thus easier to poison (Crawford 1921a: 24; Ewers 1959: 98; *The Western Mail* 30.8.1923: 6, 19.6.1924: 7). Foxes initially did not fear humans and instead showed great curiosity and were thus easily trapped or shot (Clemens 2000: 89). The valuable skin provided further incentive for destruction of foxes (unlike dingoes). Later, it was noted that foxes could be attracted to dried poison baits (Craig 1925b: 98), and would even dig up rabbits that had been poisoned and consequently die (*The Western Mail* 27.5.1937: 52). Farmers needed to lay baits 1-2 months before lambing (Department of Agriculture 1948: 39; Tomlinson 1955), with simultaneous baiting by all landholders (Veitch 1958). Strychnine was still in use.

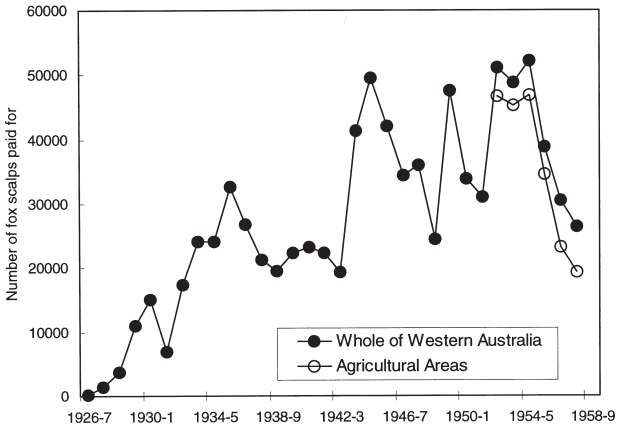

Fig. 43 Number of scalps of Vulpes vulpes *paid for. Source: Annual Reports of Department of Agriculture WA 1928-55; Annual Reports of Agriculture Protection Board 1951, 1955-8. Data for agricultural areas (i.e. south-west WA) are only available from 1952-3.*

The first bonus (reward) paid for a dead fox was in 1926-7, at £2 per scalp. This was decreased to £1 per scalp in 1930 (WAPD **85**: 1879), 10s per scalp in 1932-3 (2s per cub) and further reduced in 1933-4 (5s, 1s respectively) and in 1936-42 (2s 6d per scalp). By 1943 the bonus was 4s but payment (still at 4s) was withdrawn in 1959. These downward adjustments in the bonus offered doubtless reflect the increasing number of foxes killed (Fig. 43).

The largest bonus payments in south-west WA in the first year of operation (1928) were from Dandaragan, Perenjori, Mingenew, Geraldton, Mullewa, Upper Chapman, Northampton and Shark Bay districts (Gooding 1955). Only £910 had been paid in agricultural areas up to February 1928, in contrast to £4162 for 'dogs' (WAPD **78**: 98).

Bonuses were first paid in the northern jarrah forest in 1930 and in the lower south-west in 1931-4 (Gooding 1955). By 1931 the only districts that were yet to pay the scalp bonus were Sussex, Bridgetown, Nannup, Kojonup, Broomehill, Tambellup and Denmark. Nannup paid its first scalp in 1934. Although the Augusta-Margaret River Vermin Board paid on a scalp in 1929, no further payments were made until 1933 (Gooding 1955).

Although it was clear in the 1930s that bonus payments did not control foxes, the bonus system was retained until 1958. It was then decided that the money saved would be used to purchase poisoning units and organize co-ordinated fox-baiting drives over large areas in agricultural districts (Anon. 1958; Crawford and Veitch 1959; Veitch 1958). The optimal time to bait (with strychnine) was considered to be from February until April, when natural food and water were scarce.

Trials of 1080-baited apples (for rabbit control) in early 1954 quickly depleted fox populations (Tomlinson *et al.*1954). These deaths in most cases were due to foxes consuming the poisoned apples, with some mortality from eating poisoned rabbits detected in 1956 (Anon. 1956: 179).

As early as 1925, the official position of the Department of Agriculture was that 'the day is past for giving the fox the benefit of the doubt' (Craig 1925b: 98). However, some settlers considered that the fox was of great assistance in depredating young rabbits (Leake 1962: 33) and a lesser menace than the dingo (Department of Agriculture 1930: 7). This, and the increase in numbers of foxes, led to the bonus paid being reduced from £2 to £1 in 1930 (WAPD **85**: 1879). Even by the early 1930s many farmers still thought that destruction of poultry and lambs by foxes was more than compensated for by their value in destroying rabbits (Arnold and Herbert 1934). Farmers in the northern wheatbelt wanted the bonus removed for this reason (*The Western Mail* 6.7.1933: 43). Even as late as 1941 it was claimed that 'the fox has been a friend' (C. Latham WAPD **107**: 549, 10.9.1941). Some farmers were of the view that foxes would not attack lambs unless rabbit populations were depleted (Department of Agriculture 1945: 40; Royal Commission 1945: 15). The initial view in the less settled parts of the south-west was that the fox was not such a great danger to the sheep industry as was the dingo (W. Glasheen WAPD **84**: 1055, 15.10.1930).

Foxes killed lambs, particularly if the ewe was in poor condition (Leake 1962: 34). Increased predation of lambs in 1944-6 was linked with the scarcity of young rabbits (Department of Agriculture 1946, 1947) and in 1948-9 with the scarcity of green feed (Department of Agriculture 1950). Sheep were torn around the hindquarters and one ewe was seen alive with its tongue and lower jaw eaten (Harris 2002: 144). Foxes would also kill piglets (Daubney 2001a: 72).

Biodiversity impacts In south-east South Australia, concern was expressed in 1901 about the destruction of insectivorous birds by foxes; this process was said to be 'proceeding at an alarming rate' (Anon. 1901b: 1021). Concern in Victoria about the impact of the fox on native fauna was noted in 1906 and 1909, on the grounds of its rapid annual increase and its habit of killing animals, whether hungry or not (Anon. 1906b; Anon. 1909a). Soon after its arrival in New South Wales, the fox was noted as bringing about the destruction of the larger ground-nesting birds (Froggatt 1913: 41). In South Australia the fox was recognized very early as an important factor in the decline of the marsupial fauna (Wood Jones 1925: 358). However, Frith (1973: 153) cited counter examples from north-east and south-east New South Wales, where foxes as well as many species of native mammals remained abundant.

The wedge-tailed eagle may have been one of the few native species to have benefited from the establishment of the fox, as eagles have been recorded predating foxes (*Victorian Naturalist* **74**, 89, 1957; Chitty 2004: 128).

Concern about the impact on ground-feeding and ground-nesting birds of the recent spread of foxes into south-west WA was first expressed by DL Serventy (*The Farmer* 5.2.1926: 47). He was also dismayed by the apathy shown by farmers, compared to the great public concern shown about rabbits (*The Farmer* 5.7.1925: 55).

Between 1928 and 1930 foxes became plentiful at

Jurien Bay and apparently exterminated a colony of wedge-tailed shearwaters *Puffinus pacificus* breeding on a small promontory connected to North Head, Jurien Bay by a sandy isthmus (Sandland 1931). In Western Australia the increased number of foxes in 1932-3 was regarded as a 'serious and growing menace to bush birds' (Jenkins 1934: 224), and by mid 1934 numerous cases of depredation of ducks, swans and ground birds were reported (Jenkins 1935: 307). By the late 1930s, foxes were taking the eggs of the tortoise *Chelodina oblonga* from sand bars along the edge of the Avon River near Toodyay (Chitty 2004: 7). In 1937 foxes killed hundreds of black swans *Cygnus atratus* as parts of Lake Muir dried up (*The West Australian* 1.2.1937: 6; Sedgwick 1937: 323). A population of fleshy-footed shearwaters *Puffinus carneipes* breeding on the mainland opposite Shelter Island, Torbay became extinct in 1938 because of depredation by foxes (C. Allen in Warham 1958: 2).The fox was held responsible for the extinction of native mammals in Gingin district in the 1920s (Roe and Roe 1992) and the demise of the dalgyte and the reduction in populations of ground-nesting bird species (plover, curlew, pipit *Anthus australis*, quail and rainbow bird *Merops ornatus*) in Bruce Rock district (Ewers 1959: 98). Wedge Island, north of Lancelin, became accessible to foxes in 1960 when it joined to the mainland, resulting in the extinction of a small colony of wedge-tailed shearwaters nesting on its plateau. Foxes also preyed on bridled terns *Sterna anaetheta* (Ford 1965).

In Dongolocking district, the decrease in rabbit numbers following the introduction of myxomatosis was stated to have resulted in the fox predating native mammals and ground-nesting birds (Anon. 1999: 96). An alternative view was that fox populations decreased as rabbit populations decreased (Leake 1962: 34), with litter size reduced from 6-7 to 3-4 in 1955 (*Fisheries Department Bulletin* 2/3). Both perspectives are probably correct. For a few months after the collapse of rabbit populations in February 1955, foxes probably did intensify predation on other items of prey but the sudden removal of rabbits would have reduced litter size. 1080 baits to poison rabbits were in wide use in 1955, with foxes eating poisoned rabbits and striking reductions in sightings of foxes evident (*Fisheries Department Bulletin* 2/4, 3/1, 3/2, 3/3, 3/4). Fox populations increased in 1973-4 after poisoning of rabbits with 1080 ceased (Christensen 1980; Christensen *et al.* 1985: 30; see also Fig. 44).

It seems likely that reduced populations of rabbits following droughts in 1936 and 1940 intensified predation of foxes on easily captured, ground-dwelling native prey species, such as eggs of mallee fowl, and mammals (e.g. chuditch, numbat, dalgyte, woylie, tammar and rock wallaby).

Although widespread in the lower south-west, foxes were apparently most abundant close to towns (Christensen *et al.* 1985). By 1976 increased numbers of foxes were adversely affecting native wildlife (Department of Conservation and Land Management file 015848F2022 vol. 5). During a nine month period in 1985-6, 75 foxes were poisoned on a c. 300 ha nature reserve, an average of about two foxes per week. Baiting programs were

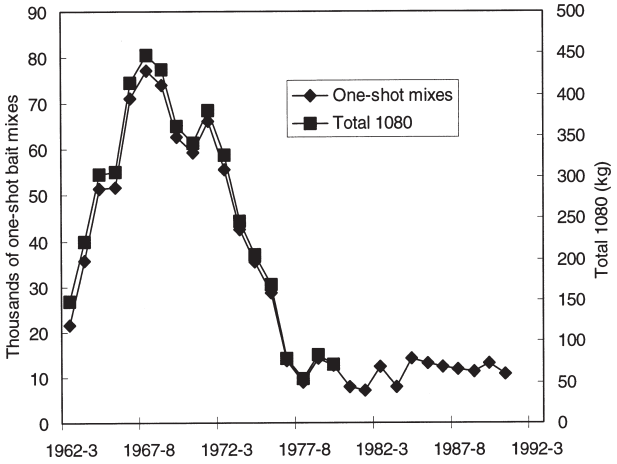

Fig. 44 Usage of Compound 1080 to control rabbit populations. Source: Annual Reports of Agricultural Protection Board 1980-94, particularly 1980: 8.

effective, with poisoned foxes quickly replaced by immigrant foxes, which in turn were poisoned (Kinnear *et al.* 1988: 439). A similar result was evident at Goodale Sanctuary (38 ha, near Coolup): Most or all of the 24 baits deployed every two months from 1995 were taken (Anon. 2005).

Aerial delivery of 1080 baits was trialled by the Department of Conservation and Land Management in 1994 in the northern jarrah forest with the Foxglove initiative. This method proved successful and was extended (as the Western Shield initiative) to 3.5 M ha of public lands in south-west WA in 1996. In recent years regionally co-ordinated baiting and shooting of foxes has taken place, extending in 2004 from Pingelly to Albany (*Wagin Argus* 18.2.2004: 4). This was broadened in 2005 to include 51 shires from Geraldton to Albany (*The Countryman* 24.2.2005: 2), resulting in an estimated 19 000 foxes being killed during April and May (*The West Australian* 26.5.2005: 42). Foxes have also proliferated in suburban Perth (where control options are limited by public safety), killing chickens and waterfowl (*The West Australian* 26.5.2004: 9). Foxes have occasionally gained entry to the zoo in South Perth and killed wallabies (*The West Australian* 17.6.2006: 2).

A white fox was observed at Spencers Brook in 1929 (*The Northam Advertiser* 29.6.1929: 2).

Felis catus cat

Oldtimer information Most oldtimers recollected that the cat was always present in the bush (though not necessarily common), a view consistent with the conclusion that the entire south-west region of WA had been colonized by feral cats by 1890 (Abbott 2002). It was also common practice to keep one or two domestic cats to control mice in buildings, as until the early 1930s grain was stored in bags.

Several oldtimers mentioned capturing feral cats in rabbit traps. The size of these animals was described as 'large' (M. Marsh, J. Torrie), 'big' (J. Sobott), 'twice the

size of a domestic cat' (D. Moir), 'as large as a dog' (K. Thorne, C. Tozer), 'as large as a fox' i.e. 6' in length from nose to tip of the tail (K. Smith), or c. 1 m in length from nose to tail (L. Carroll, L. Turner). These animals were considered 'ferocious' or 'savage' (D. Moir, J. Sobott). One oldtimer attributed sightings of 'black panthers' to occasional large, black feral cats.

Two oldtimers mentioned an outbreak of feline enteritis, in c. 1942 (D. Bradford) and in the early 1940s (M. Marsh), that considerably reduced the abundance of cats, both feral and domestic. It was noted that affected animals had the eyes and nose running.

In c. 1928 13 cats were found dead in a heartleaf *(Gastrolobium bilobum)* thicket. It was surmised that they had eaten bronzewing pigeons, which feed on the fluouroacetate-rich seeds of *G. bilobum* (K. Smith pers. comm.).

Introduction and spread Cats were on board the *Tranby* when she departed in 1829 from Hull for WA (Berryman 2002: 57). There was demand by early settlers for cats to assist in rodent control (H. Camfield, Burrswood, 1830 in Nind 1987: 69).

Dated references to cats in south-west WA are depicted in Fig. 45, with those additional to Abbott (2002) specially indicated (up to 1920). Early records of cats depredating poultry refer to the Midlands district in 1897 (Lindley-Cowen 1897: 185) and near Northampton in 1916 (Royal Commission 1917a: paragraph 7077).

Cats were probably taken by humans to dwellings as settlement proceeded. The following examples (based on the early establishment of farms, pastoral leases, military outposts, inns etc in various localities) are probably a fair representation of when and where cats were transported:

- 1820s - Albany, Fremantle, Perth
- 1830s - Augusta, Belmont, Beverley, Bolgart, Bunbury, Busselton, Candyup, Cape Riche, Guildford, Hay River, Kelmscott, Maddington, Melville, Mt Barker, Mundaring, Northam, Pinjarra, Toodyay, Wanneroo, Williams, York
- 1840s - Australind, Badji Badji, Brookton, Cardup Brook, Chittering, Dandalup, Donnybrook, Drakesbrook, Gingin, Kendenup, Jerramungup, Kojonup, Manjedal Brook, Meckering, Mogumber, New Norcia, Pingelly, Serpentine, Torbay, Walebing, Wungong Brook
- 1850s - Arrino, Arthur River, Balingup, Beaufort River, Bunketch, Dandaragan, Deeside, Dudinalup, Eticup, Forest Hill, Geraldton, Goomalling, Jalbarragup, Lake Muir, Lynton, Manjimup Brook, Margaret River, Mingenew, Mullewa, North Dandalup, Perup, Samson Brook, Wandering, Wilgarrup, Yandanooka, Yerriminup
- 1860s - Balbarrup, Boddington, Bremer Bay, Bridgetown, Carnamah, Chapman Valley, Cocanarup, Cumminin, Dangin, Darkan, Dingup, Doodlakine, Donnelly River, Esperance, Harrismith, Jayes, Kalamunda, Keysbrook, Kybellup, Mangowine, Marradong, Merryup, Moodiarrup, Mt Marshall, Shark Bay, St Johns Brook, Tanjanerup, Warren River, Wyalkatchem
- 1870s - Bannister, Corrigin, Cuttening, Dwalganup, Dumbleyung, Ennuin, Fanny Cove, Lake Grace, Mt Caroline, Thomas River, Wagin, Wogerlin
- 1880s - Chowerup, Collie, Cowcowing Lake, Dinninup, Kulikup, Walliston, Wannamal.

Feral cats were not reported at Upper Swan by the astute settler GF Moore during the 1830s (Cameron 2006) or in the parts traversed by the observant naturalist John Gilbert in the late 1830s/early 1840s (Gilbert nd1, nd2, nd3). The earliest eyewitness records of cats feral in the bush in WA are as follows:

- 1864, 'when we were out with Hunt we often came across their tracks [presumably between York and Lake Lefroy], and now they are to be found in scores all over the country.' (J. Cowan in *The Kalgoorlie Miner* 30.12.1902: 6).
- 1868, 'wild domestic cats were distributed all about [Cuminin station]'(B. Leake in *The Western Mail* 5.7.1951: 58). The first occupant of this pastoral lease near Narembeen was C. Smith in 1860 (Ewers 1959: 16); presumably domestic cats were brought to the area then.
- 1896, 'the home of the cat is in the jarrah forests' (*The Coolgardie Pioneer* 4.3.1896)
- 1897, Midlands district (Lindley-Cowen 1897: 185).
- 1899, many domestic cats have gone wild (Le Soeuf 1900: 195).
- 1902, is becoming as great a plague as the dingo (WA Year Book 1902 vol. 1: 217).
- 1903, 'the number of domestic cats now running wild in the bush', Mogumber district (Lawson 1905: 136).
- 1904, along the rabbit-proof fence [RPF], feral cats were captured in trap yards (prepared for rabbits) and were released by boundary riders as they were considered to be natural enemies of the rabbit: 'domestic cat grown wild is very plentiful', west side of #1 RPF (Crawford 1904: 486-7).
- 1904-05, domestic cats, gone wild, are preying on rabbits, Norseman district (Whitlock 1937: 106).
- 1904-07, in large numbers in most parts of WA visited (Shortridge 1910: 844, 1936: 745).
- 1907, 'wild cats...very plentiful' along #1 RPF between Burracoppin and the south coast (*The Western Mail* 25.5.1907: 5).
- 1908, domesticated cats gone wild, Broomehill (Carter 1908: 104).
- 1908, rabbits 'seem to be kept considerably in check by the wild domestic cats which abound through all the district', Lynton district (Crawford 1908a: 25-6).
- 1908, an officer liberated 45 cats along #1 RPF north of Burracoppin; 'most numerous' (Crawford 1908d: 516).

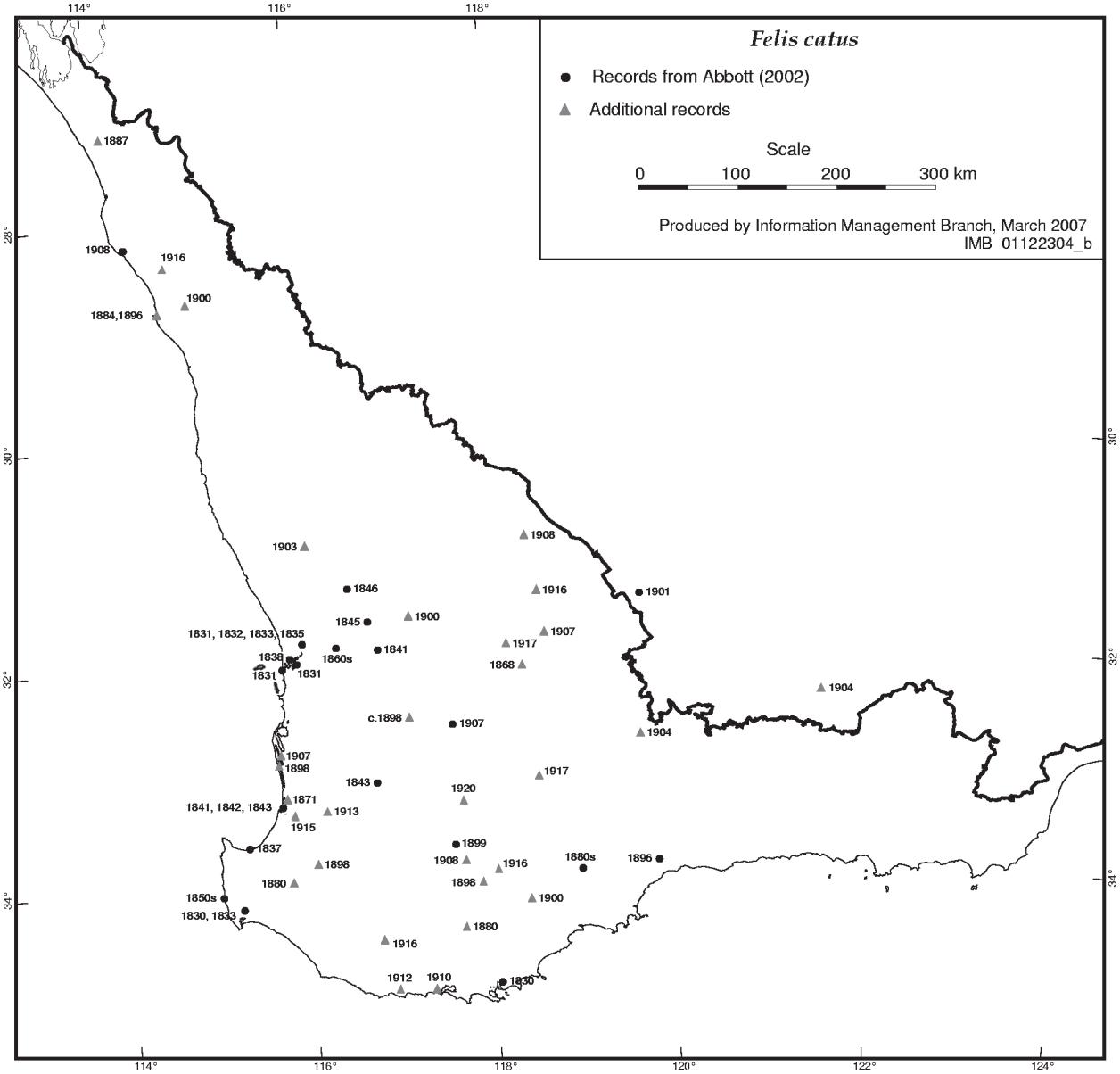

Fig. 45 Early distributional records of Felis catus. *Additional records not already cited in text: Abbott 1998b; Bird 1992; Carter 1888, 1908; Ewers 1959; Hasluck 1977; Helms 1898; Marshall 1993; North 1892; Stokes 1986;* The Western Mail *5.10.1907: 6, Tunney letters 19.2.1896, 20.6.1900.*

- 1909, 'a great number [of feral cats] about', east of #2 RPF near Wagin (*The Western Mail* 7.8.1909: 14).
- 1910, 'the wild domestic cat, large numbers of which are found in most out-of-the-way parts of the State' (Crawford 1910: 23-4).
- 1910, wild cats present in the bush (with a domestic cat mating with feral cats, and repeatedly having litters, eventually producing 33 kittens), near Pemberton (Prince 1981: 26).

Information from the period 1894-1942 is revealing about the ease with which cats were transported by people, and provides a plausible mechanism for earlier anthropogenic dispersal of the cat with advancing settlement:

- Cats captured in York and taken to Coolgardie to control mice (*Eastern Districts Chronicle* 17.3.1894).
- Pet cat transported by settler, Lake Toolbrunup, 1898 (Parnell 1982: 61).
- 200 cats released between Eyre Sand Patch and Mt Ragged wherever traces of rabbits were seen (*The Eucla Recorder* 29.4.1899: 6; G. Randall WAPD **14**: 771, 9.8.1899). These cats were procured in Adelaide, Albany and Esperance (*The Eucla Recorder* 24.6.1899: 5).
- The Department of Agriculture in Perth purchased cats (at 1s each) for release at Eucla (*The Western Mail* 18.6.1936: 5)

- Pet cat taken from Narembeen to Northam, 1911 (Bristow 1988: 153).
- Pet cat taken when owner transferred from Nippering to Tarin Rock, 1920 (Anon. 1999: 372).
- Pet cat conveyed by truck from Bicton to Boddington, 1926 (Ferrell 1992: 261).
- Some pet cats donated to Group settlers to control mice, Pemberton district, ?1920s (French 1989: 12).
- Pet cat transported on train from Perth to near Pemberton, ?1920s (Prince 1981: 4).
- Pet cat taken by car to Dumbleyung, 1942 (Anon. 1999: 12).

Predation extent and impact Records of cats having preyed on native birds and mammals are numerous (e.g. Whitlock 1911: 317; Carter 1920: 690; Troughton 1923; *The Western Mail* 29.4.1926: 32, 23.2.1928: 11, 3.5.1928: 11, 14.6.1928: 6. 8.12.1927: 11, 21.2.1929: 48, 24.4.1930: 9, 1.5.1930: 9; *The West Australian* 20.7.1929: 21; Whittell 1933: 184, 188). Specimens of 28 native south-west WA mammal species donated to the WA Museum in the period 1957-2001 had been killed by a cat (N. Cooper pers. comm.). These species ranged in weight from 7g to 1.1 kg.

The extent, however, to which predation by cat impacted on populations of native birds and mammal species in south-west WA remains questionable. In my view most of the comments in early literature are inferential, exaggerated and represent unwarranted inductive generalization. Examples include:

- Domestic cats which have become wild were held to be responsible for the destruction of bronzewing pigeons and quail (T. Hayward in *The West Australian* 4.3.1898: 3)
- 'I have observed such a decadence of the native avifauna to have been produced through the domesticated cat in Western Australia' (Helms 1900: 42)
- 'I fear, too, that many [small marsupial species] will become extinct before the invading rabbit, and in more settled districts the wild domestic cat' (*The Western Mail* 25.12.1905: 85)
- 'doubtless among the factors responsible for the increasing scarcity and approaching extinction [in 1907] of so many of the small and medium-sized indigenous mammals' (Shortridge 1936: 745).
- Extermination of the bustard in Geraldton district attributed to predation by feral cats (Woodward 1907: 18).
- Decrease in abundance of bronzewing pigeons and tammars attributed to predation by feral cats (EA Le Soeuf 1911 in *The Western Mail* 22.4.1920: 9).
- Speculation as to whether the decline in malleefowl by 1911 compared to the situation in 1861 was due to feral cats (C. Harper 1911 in *The Western Mail* 22.4.1920: 9).
- 'the local disappearance of more than one exceptionally interesting [bird] species may be safely set down to their depredations' (Whitlock 1911: 317).
- Declines in the abundance of the bustard and small marsupials attributed to predation by feral cats (B. Woodward, J. Hay in Select Committee 1911: 16, 21) without any discussion of other possible factors.
- The presumed extinction of the noisy scrub-bird 'was probably brought about by the introduction of cats' (Dakin and Alexander 1914: 85).
- Cats 'are destroying all the native fauna in every part of the State' (W. Kingsmill WAPD **56**: 687, 5.3.1918)
- Possums had been 'so thinned out by trapping that…they have been gradually exterminated by natural enemies, principally the domestic cat' (*The West Australian* 16.1.1920: 9).
- 'The primary cause [of the presumed extinction of the noisy scrub-bird], no doubt, is cats' (AJ Campbell in *The West Australian* 5.11.1920: 7)
- 'the domestic cat returned to a state of savagery, has rendered the successful rearing of good game almost an impossibility as well as destroying in very large numbers our rare and beautiful smaller fauna' (Kingsmill 1920: 35).
- 'Domestic cats, gone wild, are very plentiful on the coast [near Margaret River], and, as usual, destructive' (Le Soeuf 1920).
- 'A discussion showed unanimity of belief that the tame cat gone wild is the worst enemy of native bird-life' (Glauert 1921: 116).
- Decline of noisy scrub-bird, western bristlebird and western whipbird attributed to feral cats (DL Serventy in *The Farmer* 5.4.1923: 52-53).
- The honey possum *(Tarsipes rostratus)* had 'apparently vanished from the [Albany] district owing to the periodical burning off of the scrub and the ravages of cats' (Troughton 1923: 149).
- Decline in the abundance of *Malurus splendens* by 1922 relative to former years: 'Many people' attributed this to the presence of 'to[o] many cats' (T. Carter in Whitley 1971: 41).
- Disappearance of rock parrots *[Neophema petrophila]* at Albany was attributed to 'domestic Cats gone wild' (Carter 1924a: 225).
- The 'total extinction' of the rufous bristlebird *Dasyornis broadbenti litoralis* is being 'hastened by domestic cats in a wild state, which are becoming increasingly numerous in all districts' (Carter 1924b: 311).
- The honey possum is 'in danger of extermination by bush cats. Many specimens have been secured by female cats bringing them home alive to a brood of hungry kittens' (F. Whitlock in *The Western Mail* 29.4.1926: 32).
- Feral cats 'are playing havoc with our native fauna' (F. Whitlock in *The Western Mail* 7.4.1927: 30).

- 'It is unfortunate that so many of our smaller wild animals [mammal species] are being killed off by the domestic cat' (L. Glauert in *The Western Mail* 23.2.1928: 11).
- Speculation about the impact of feral cats on birds (e.g. noisy scrub-bird), based on the ubiquity of cats remote from settlement and observations of 'extremely heavy' predation at Perth Zoo (Le Soeuf 1931).

Similar extravagant comment was made for New South Wales (Froggatt 1901: 20; Le Soeuf 1912; Stead 1935: 97). It is also instructive to contrast the emotive comments about cats ('an unmitigated curse', 'a terrible scourge') made by Wood Jones (1925: 358-9) with the lack of any subjective comment by Ashby (1924: 296) and Finlayson (1961: 184). Kitchener *et al.* (1978: 82) were particularly cautious in their assessment: 'it is likely that the Domestic Cat…almost certainly played a principle [sic] role' in the disappearance of 'many mammal species'.

In contrast, cat predation on islands is more efficient. Rabbits on Mistaken Island had almost completely disappeared by 1896 following the introduction of cats (*The West Australian* 26.2.1896: 5), and rabbits on Pelsaert Island were exterminated by feral cats by c. 1897 (*The Western Mail* 24.10.1908: 10).

Size of feral cats Numerous references were found to the larger size of feral cats compared to domestic cats:

- Feral cats 'with each succeding [sic] generation increase greatly in size' (Anon. 1888: 118-119).
- They 'appear to have a tendency to increase in size after a few generations in a feral state' (1907, Shortridge 1936: 745).
- Cats near Perth have become 'fierce and powerful in build' (Cleland 1910: 16).
- Feral cats grow to a tremendous size (E. Le Soeuf in Select Committee 1911: 17).
- Many feral cats 'gigantic' when compared with household cats (*The West Australian* 20.10.1923: 13).
- Reference to a 'very large' cat that attacked children (Le Soeuf 1931: 189).
- Skins seen of cats as large as a fox, Margaret River (C. Hoy 1920 in Short and Calaby 2001: 544)
- Cats weighing as much as 25 lb were caught in rabbit traps at Salmon Gums in the 1930s (D. Barter in *Parade*, August 1972).

Benefits of cats Several favourable remarks were found about the cat. Feral cats were considered to play a useful role in preying on young rabbits (Anon. 1907a: 309). Cats could kill 2-3 rabbits per day (Royal Commission 1917a: paragraph 380). In 1907-8 rabbits in Lynton district 'seem to be kept considerably in check' by feral cats (Crawford 1908a: 25-6). As late as 1918, boundary riders were instructed not to kill any cats caught in traps set along the rabbit-proof fence, as 'The cat is our best friend now as regards the rabbits' (A. Crawford in Select Committee Evidence 1918: questions 831, 833). This viewpoint was revoked in 1921 and cats were declared

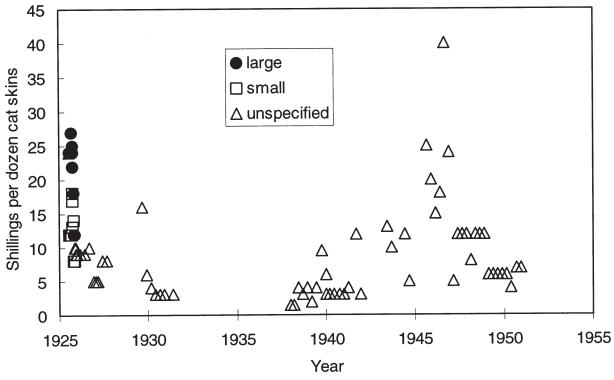

Fig. 46 Prices paid for skins of Felis catus. *Source:* Elder's Weekly *1925-50, supplemented by* The Westralian Farmers' Gazette *(various dates 1930, 1938-41). The maximum price is graphed, for March, June, September and December.*

vermin (Crawford 1921: 21). Feral cats may have prevented the establishment of pheasants and partridges (Kingsmill 1920: 37).

Domestic cats depredated rodents and small native mammals infesting store rooms (Erickson 1974: 36), helped protect stores, grain and horse feed from mice, which ate holes in bags (Cannon 1983: 87), and usefully kept down mice and rats in dwellings (L. Glauert in *The Western Mail* 3.5.1928: 11) and haystacks (Shiner 2003: 77). They were also an important source of specimens of native mammals for the WA Museum (L. Glauert in *The Western Mail* 3.5.1928: 11, 21.2.1929: 48).

Skins of feral cats were considered to be of little commercial value as they were hard to tan: in 1911 skins fetched 2s per dozen (W. Loutit in Select Committee 1911: 19). The first record in *Elder's Weekly* of trading in skins was in the 23.7.1925 issue. Subsequent quarterly records are shown in Fig. 46.

Although cats had the opportunity to introduce diseases from 1829, no first contact extinction pulse of native mammals is evident in south-west WA.

?Felis concolor/?Panthera pardus cougar/ leopard

Presumably large black cats are the basis for sightings of 'panthers', and wild dogs are the basis for sightings of 'cougars'.

- A big black cat lived under a building (?hall at Harrismith) and searched wheat stacks at night for mice. It was more like a panther than a domestic cat, late 1920s (Taylor 2000: 9).
- An 'all black thylacine' caught in a snare, 1943 (Slee 1987: 5).
- Sandy brown 'dog' seen with loping gait, near Broomehill, 1949 (O'Reilly 1981: 258-260).
- Big cat seen, light brown colour, with long tail curled up, near Latham, 1950 (O'Reilly 1981: 260).
- Description of a panther-like animal as big as a sheep dog, with the colour of a blue kelpie sheep dog, rounded ears, tail almost as long as the body; spat

like a cat. Another sighting of a 'panther' eating a dead kangaroo at the side of a road – Manyutup, south-west of Ravensthorpe, after 1967 (Southern Scribes 1999: 209-10).

- Sighting of a black panther north-east of Kalannie, ?1970s (Crake 1985: 207).
- Unsuccessful hunt for black panthers near Kulja (O'Reilly 1981: 41; Antonio-Crake 1974: 97).
- 'Cordering cougar' – sightings of a cat-like creature near Cordering, 1978 (O'Reilly 1981) and near Bokal, 1979 (Bird 1990: 418). More than 400 sheep killed (A. Lewis WAPD **220**: 3129, 19.9.1978), increasing to > 1000 sheep killed (T. Jones WAPD **226**: 3955, 24.10.1979).
- 'Kirup cougar' – loud hissing heard but animal not seen (Lathwell 2001: 232).
- Unsubstantiated statements of cougars either being released by U.S. servicemen at Bunbury and Fremantle during the 1939-45 war or escaping from a circus near Bridgetown (Department of Conservation and Land Management file 019522F3801). Additional information is provided by O'Reilly (1981) and Long (1988: 45).

An account sympathetic to the existence of a cougar was published by H. Evans (WAPD **224**: 2110-6, 22.8.1979) and O'Reilly (1981). The official Government perspective was presented by R. Old (WAPD **224**: 2116-9, 22.8.1979) and Agriculture Protection Board (1979: 4). No specimen of a cougar or panther was trapped, poisoned or shot and then submitted to an expert for identification. Reports of calls resembling a woman's scream (O'Reilly 1981: 8) are likely to refer to the barking owl *Ninox connivens*.

Feral dogs and foxes afflicted with mange often have altered appearance (Passfield 1988: 149). This may give rise to some reports of unfamiliar species.

Mustela putorius ferret/European polecat

The first record of the ferret being brought to WA was in February 1830 (W. Jay 1830 in Shoobert 2005: 128). These animals presumably served as pets and to chase native mammals from their burrows so that they could be shot for 'sport'. There is also a report of ferrets having got loose aboard a ship travelling to WA in 1834 and killing poultry (Fairbairn 1946: 48).

Although ferrets were recommended for release in rabbit-infested country following the incursion of rabbits into WA in the 1890s (Glyde 1898: 5), no records of official releases were found. Rabbits were being hunted with gun and ferret on the goldfields in 1905 (*The North Coolgardie Herald* 4.1.1905), but were expensive at £2 each (*The Kalgoorlie Western Argus* 31.1.1905: 11), and also in 1909 (*The Western Mail* 9.10.1909: 8). Ferrets were introduced into the Murchison in c. 1906-8 (J. Hickey WAPD **56**: 690, 5.3.1918). Ferrets were evidently in use in 1917 but were considered as more expensive and less effective than a fumigating machine (Crawford 1917: 5). Ferrets were in high demand, however, by settlers in rural parts of south-west WA at least during the period 1924-8:

- Two dozen sought by a reader in Corrigin (*The Western Mail* 14.8.1924: 6)
- Several requests (no details) for ferrets (*The Western Mail* 1.4.1926: 1)
- Enquiry from Goomalling and other unnamed districts (*The Western Mail* 29.4.1926: 3)
- One pair recently bought for rabbit hunting (*The Western Mail* 2.9.1926: 1)
- Goomalling correspondent seeking one pair (*The Western Mail* 23.9.1926: 3)
- Correspondent at Goomalling with seven ferrets for sale (*The Western Mail* 30.12.1926: 1)
- Request from Kondinin for information as to where to obtain ferrets (*The Western Mail* 16.6.1927: 33)
- Narembeen farmer with experience in Britain with ferrets seeking one pair for rabbit control (*The Western Mail* 3.5.1928: 11)
- Bruce Rock farmer seeking ferrets (*The Western Mail* 9.8.1928: 6).

Other records of ferrets being used to control rabbits were found in Tomlinson and Crawford (1951: 123), *The Esperance Express* 10.10.1984: 8, Mingenew (1988: 83, photograph), *The West Australian* 26.7.1994: 5, Broun (1995: 12, c. 10 km west of Beverley), Bignell (1997: 159), and Muir (2006: 39).

One oldtimer informed me that she had bred ferrets. A ferret was put down a rabbit burrow, the entrance was covered with netting and the rabbits captured were eaten (V. Farmer pers. comm.). Two ferrets were used in the Perth suburb of Mosman Park in the 1940s to catch rabbits (Wallace 2006: 14).

Ferrets were also imported in 1907 to catch rats in Perth, then recovering from the bubonic plague outbreak of the previous year (*The Western Mail* 2.3.1907: 4).

Sometimes ferrets that were put down rabbit burrows stayed temporarily underground (Wallace 2006: 14). Presumably this is how ferrets have become feral. One ferret was seen in 1972 near Diamond forest block, south of Manjimup (G. Liddelow pers. comm.). Ferrets were reported twice in the 1990s near the intersection of Bunbury-Cranbrook and Westbourne Roads, north-east of Manjimup (C. Lloyd pers. comm.). Other records are available in Kitchener and Vicker (1981: 137), Christensen *et al.* (1985: 30) and Long (1988: 41). Ferrets have so far failed to establish large populations in the wild in WA. It appears unlikely that cold winters are responsible for this, as was suggested for Victoria by Strong (1894).

Although ferrets had the opportunity to introduce diseases from the 1830s, no first contact extinction pulse of native mammals is evident in south-west WA.

Equus asinus donkey

The first record of the donkey in south-west WA is from 1833, when R. Spencer landed 'several mules and asses' at Albany (Johnson 1984: 16). Spencer had three mules in

January 1834 (Clark 1994: 78). A mule and a donkey were used to convey provisions on a short expedition to the north and west of Albany in February 1835 (J. Roe in Shoobert 2005: 411). Seven donkeys were landed at Fremantle in 1836 (*The Perth Gazette* 2.7.1836: 720). There were eight 'asses' present in WA in 1837 and 1838 (*The Perth Gazette* 8.12.1838: 195). Comparatively few were kept in south-west WA until the gold rushes of the 1890s, with 131 mules and donkeys (not separately itemized) in 1894, and 600 in 1903. By 1903 there were only 39 mules and donkeys in south-west WA, and most (23) were in the Plantagenet Magisterial District (WA Year Book 1906: 676).

A series of 11 articles published in *The Western Mail* from January to June 1907 compared the hauling power of donkeys and mules to bullocks, horses and camels. Donkeys replaced bullocks as beasts of burden, with the pulling power of two donkeys equivalent to one bullock (Hardie 1981: 194-5). Donkeys were used in teams to cart heavy loads and had the advantage over horses in that they could live on herbage (McDonald 1996: 16), did not stray at night and did not require shoeing (Hardie 1981: 194). Donkeys could be yoked four abreast and thus were capable of pulling a great weight (c. 7 cwt) per donkey (Barker 1964: 76). Their disadvantage was that they did not walk as fast as a horse (Dimer 1989: 43), and as a team became bogged more quickly than a team of bullocks (Hardie 1981: 194). With motorization of transport in the 1920s, donkeys were turned loose.

Although donkeys had the opportunity to introduce diseases from the 1830s, no first contact extinction pulse of native mammals is evident in south-west WA.

Equus caballus horse/brumby

Horses were introduced by the first settlers (Kimberly 1897: 46), with 57 present in south-west WA in 1829. Even by 1833 there were insufficient to plough land (Berryman 2002: 268). The number of horses first exceeded 1000 in 1842, and by 1861 more than 10 000 horses were present in south-west WA (Battye 1924). There were c. 48 000 horses (as livestock) in south-west WA in 1903, with about half present in the Katanning, Northam, Swan, Victoria, York and Perth Magisterial districts (WA Year Book 1906: 676).

At first, Aborigines 'were extremely afraid of approaching' horses (1830, Berryman 2002: 156). Aborigines first speared a horse in October 1830 (*Perth Gazette* 28.7.1838: 119). They were recorded as eating horse flesh in August 1832 (Berryman 2002: 265), and there were further reports of horses being speared (*The Perth Gazette* 23.3.1833: 46, 5.7.1834: 314; *Perth Gazette* 14.4.1838: 58, 7.7.1838: 106).

The horse, along with the dog, was the first non-native mammal to have penetrated the unsettled parts of south-west WA, for it was usually part of expeditions of exploration. Examples include:

- 1830, two pack horses (R. Dale in Shoobert 2005: 164); at least three horses (T. Bannister in Shoobert 2005: 202); 10 horses (JW Hardey in Shoobert 2005: 186)
- 1831, three horses (J. Roe in Shoobert 2005: 274)
- 1835, 12 horses and one pony (J. Roe in Shoobert 2005: 458, 509); one horse (J. Roe in Shoobert 2005: 411)
- 1843, two Timor ponies (H. Landor and H. Lefroy in Exploration Diaries **3**: 732)
- 1846, four horses (Gregory and Gregory 1884: 2)
- 1847, six horses (J. Roe in Exploration Diaries **4**: 21)
- 1848, 10 pack and 2 riding horses (Gregory and Gregory 1884: 16); 11 horses (Roe 1852: 3)
- 1854, 27 horses (Austin 1855: 3-4)
- 1861, 10 horses (C. Dempster in Exploration Diaries **5**: 28)
- 1863, 16 horses (H. Lefroy in Exploration Diaries **5**: 215)
- 1864, 23 horses (Hunt 1864: 2)
- 1869, 16 horses (Forrest 1875: 24)
- 1870, 15 horses (Forrest 1875: 83)
- 1871, 17 horses (A. Forrest 1872: 4).

Horses were also essential for transport and farming by pioneer settlers. In addition, horses were used by timber mills for hauling logs, probably from 1853 (Ednie-Brown 1896: 34).

The earliest record of a horse straying, albeit briefly, appears to have been in October 1832 (Cameron 2006: 167). In 1833 the first advertisement offering a reward for a stray horse was published (*The Perth Gazette* 16.2.1833: 25). The earliest records of horses becoming feral are: 1830, when two horses on Dale's expedition escaped west of Beverley (JW Hardey in Shoobert 2005: 191); 1831, when tracks of one horse were seen at Moorilup, on the upper Kalgan River (A. Collie in Shoobert 2005: 246); and 1835, when 'traces' were seen south of Wilson Inlet (J. Roe 1835 in Shoobert 2005: 493). Although consumption of foliage of *Gastrolobium* poison pea can kill a horse (J. Greig in *The Western Mail* 19.10.1907: 6), it does not seem to have diminished the population of feral horses.

By the 1840s and 1850s feral populations were widely distributed:

- Recent tracks seen three days' journey east of Albany, 1841 (Eyre 1845 vol. 2: 104)
- Bolgart, 1840s (Erickson 1964b: 58)
- Lake Dumbleyung, 1843 (H. Landor and H. Lefroy in Exploration Diaries **3**: 732)
- Avon Valley, 1845 (de Burgh and de Burgh 1981: 94)
- Between Wanneroo and Gingin, 1850 (de Burgh 1986: 34)
- Dalwallinu, 1850s (Crake 1985: 26).

These records are probably of populations formed by stray horses, as fencing was not then widespread. Horses had to be branded once an Ordinance was issued in 1852.

Subsequent records, grouped by decade, reinforce the impression of the ubiquity of feral horses:

- 1860s: Julimar Spring (Elliot 1978: 29); Moondyne Spring (Hasluck 1959: 66); Wanneroo (Stannage 1979: 108)
- 1870s: Balgarup (Bignell 1997: 21); Cottesloe (Briggs 1917: 15); Dangin (CSOLR 11.11.1873, vol. 753: 185); Eneabba (Heydon 1988: 118); Goomalling (Sewell 1998: 42); Lake Moore (Giles 1889 vol. 2: 237); lower Murchison River (Taunton 1903: 51); Moora (Laurie 1995: 27)
- 1880s: Chittering (Buchanan 2000: 103); Kalamunda (Slee 1979: 69); Kendenup (Brassey 1889: 247); Mt Helena (Elliot 1983: 79), Vasse (Carter 1987: 66); 'numerous in some of the scrubby lands' (Cockburn-Campbell 1886: 484); Wagerup (Eastcott 1938: 34); 'Wilgarup Run' (*Government Gazette* 11.6.1885: 279); Williams (Briggs 1917: 111)
- 1890s: Albany (Manning 1965: 79); Aldersyde (Knox-Thomson 1975: 9); between Pingelly and Brookton (*The West Australian* 2.1.1926: 9); Beverley (Thomas 1946: 100); Dalkeith (Williams 1984: 65); Kojonup (Bignell 1991: 65); Nedlands and Kings Park (McDonald 1996: 12); Peppermint Grove (Pascoe 1983: 29); Scarborough (Lofthouse 1989: 78); south-west of Toodyay (Chitty 2004: 66-7)
- 1900s: Beaufort River (Bird 1986: 96); Boscabel (Bignell 1997: 52); Bowelling (Bird 1990: 134, 220); Gingin (*The Western Mail* 29.2.1908: 6); Gull Rock (Pustkuchen 1981: 241); Helena Vale (*The Western Mail* 31.3.1906: 10); Katanning-Cranbrook (WA Year Book 1906: 574); Kojonup (*The Western Mail* 8.8.1908: 5); Koorda (Antonio-Crake 1974: 16); Mundaring Weir (Quicke 1978); Shenton Park (Williams 1984: 88); Stirling Range (A. Milligan in *Morning Herald* 16.10.1902: 6); Tone River (Bignell 1971: 186); Wongan Hills (Ackland 1965: 6).

Horse breeders allowed their animals to run wild in the bush for most of the year (Erickson 1988: 58). In summer, as waterholes dried up, wild horses were trapped in stockyards erected at springs and permanent pools, and then broken in and sold (*The Western Mail* 28.7.1906: 8, 2.2.1907: 9; Ackland 1965: 6; Antonio-Crake 1974: 16; Bird 1986: 96; Briggs 1917: 111; Carter 1987: 44; Chambers 1991: 81; Cowin 1971: 34; Erickson 1983: 237; Knox-Thomson 1975: 9: Lange 1981: 491, 543; Parnell 1982: 84; Pederick 1979: 85; Roots 2003: 201-2, 294; Sewell 1998: 42; Spencer 1966: 48; Taunton 1903: 54). There is an officially named Wild Horse Creek near Darkin, Wild Horse Swamp near Moodiarrup, and White Horse Hills near North Bannister.

By the 1870s, horse breeding was no longer a profitable business and pastoralists turned more to sheep breeding. Surplus horses were liberated into the bush (Bain 1996: 102; Erickson 1988: 58; Schorer 1974: 129). In the 1880s wild horses were so common that they competed with sheep for grass and water. A permit from a Magistrate was needed to kill a horse (Cowin 1971: 52; Erickson 1974: 249). With the opening of the goldfields in the 1890s, many horses were rounded up and sold to prospectors (Erickson 1971: 66).

In the 1920s many horses were turned out to graze in the bush as tractors and motor cars came into use (Harris 2002: 18-19). The relative merits and disadvantages of horses *vs* tractors were thoroughly canvassed in the press (e.g. *The Western Mail* 12.6.1924: 4; *The West Australian* 9.4.1930: 11; 12.4.1930: 18; *The Westralian Farmers' Gazette* (6 & 13.11.1930: 11, 9). Comparisons of haulage power with other animals, together with comparative costs, were discussed in *The Western Mail* of 1.6.1907: 7, 15.6.1907: 7, and 22.6.1907: 6.

Wild horses damaged crops, presumably by trampling (de Burgh and de Burgh 1981: 94; Pederick 1979: 105), damaged gardens (Russell 1983: 170), damaged young pines in plantations (Forests Department 1927: 16), competed with stock for grasslands and water supplies (Cowin 1971: 52; Erickson 1974: 249), broke down fences (L. Talbot in Underwood 1987: 47), and pulled dumps of wheat about (Braid and Forbes 1997: 180).

Brumbies were present in various districts as late as:

- 1920s, north of Marmion (Newell 1980: 81)
- 1930s, Lake Muir district (Muir 2006: 17)
- 1931, Woodada Well c. 70 km south-west of Dongara (Gerritsen 1994: 238)
- 1937, Dongara (McConnell *et al.* 1993: 143)
- 1939, Jingalup (Muir 2006: 222)
- 1930s, Jandakot (Giblett 2006: 80)
- early 1940s, Mullaloo (Chambers 1991: 81)
- 1943, Yanchep (Gardner 2000: 128)
- 1940s, between Porongurup Range, Warriup and Gull Rock (Piggott 2004: 99)
- 1950s, Kojonup (Bignell 1997: 128); Mt Solus (J. Havel in Underwood 1987: 42)
- 1960s, Three Springs (Crake 1979: 88); east of Mundaring Weir (R. Underwood pers. comm.); Thomsons Lake (Drake 1996: 48); between Lancelin and Jurien (Passfield 1988: 91)
- 1966, Eneabba (Heydon 1988: 103)
- 1967, Boxwood Hills (Johnson 1982: 164)
- 1974, Donnybrook Sunklands (Christensen *et al.* 1985: 31)
- 1981, Frankland River (Christensen *et al.* 1985: 31)
- 1990s, Long and Rocky forest blocks (E. Middleton pers. comm.).

Wild horses were shot for sport (Elliot 1983: 79), for craybait (Heydon 1988: 103; McConnell *et al.* 1993: 217), and for pet meat (Broun 1995: 33; Johnson 1982: 164; McConnell *et al.* 1993: 217; Roots 2003: 186; R. Underwood pers. comm.). Farm horses in the 1940s were shot and fed to pigs (Spence 2001: 233) and circus animals (Gervas 1999: 286), or sold to the Zoo (Haig 1982: 73) and to pig breeders (Roots 2003: 186).

Although horses had the opportunity to introduce diseases from 1829 (e.g. 40-50 ponies were introduced from Java in 1842, *The Perth Gazette* 15.1.1842), no first

contact extinction pulse of native mammals is evident in south-west WA.

Sus scrofa pig

Pigs were brought to Albany in 1826 (Lockyer 1827: 485; Shoobert 2005: 8) and Swan River in 1829 (e.g. Bolton and Gregory 1999: 2). By the end of 1829 there were 106 pigs present (Battye 1924). It took a further 10 years before the total exceeded 1000, and it was not until 1859 that more than 10 000 pigs were present (as livestock) in south-west WA. Pigs supplied fresh meat sooner than any other livestock (Henty 1829; G. Moore 1831 in Cameron 2006: 71).

Although pigs bred easily (Lockyer 1827a: 486-7) and did better than other livestock during the first year of settlement (Statham-Drew 2003: 180), they were preyed upon by dingoes (Wakefield 1827b), speared by Aborigines (1831, Cameron 2006: 55; 1832, Cameron 2006: 125, 127, 129; 1832, Berryman 2002: 262; 1832, Bolton and Gregory 1999: 8; 1832, Stirling 1894: 6; 1840, Richards 1978: 144), depredated by European dogs belonging to Aborigines (*The Perth Gazette* 22.4.1837: 887), shot by Aborigines and settlers (1840, *The Perth Gazette* 7.11.1840), and piglets were sometimes taken by wedge-tailed eagles (Moore 1842: 71).

On account of inadequate fencing or of gates being left open, pigs escaped into the bush (1831-3, Cameron 2006: 39, 40, 247; 1833, Shann 1926: 39, 53) and became feral as early as 1831 (*The Perth Gazette* 12.1.1833: 7). Wild pigs were subsequently reported at: Bolgart, 1840s (Erickson 1964b: 58); Nanamillup near Broomehill, 1860 (Stephens 1954: 49); Eneabba, 1870 (Heydon 1988: 118); lower Moore River, 1901 (de Burgh 1976: 110); and Wizard Peak near Geraldton, 1902 (O'Connor 2002: 263). These records relate to wild pigs being hunted for sport or damaging crops and fences. Some 200 pigs kept near the head of the Darkin River, south-west of York, in 'the early days' were fed on brumbies (*The Western Mail* 2.2.1907: 9).

Later records of wild pigs are from: North Dandalup, 1914 (Richards 1993: 340); south of Quindanning, 1920s (Atkins 1993: 31); Bremer Bay, 1927 (Bignell 1977: 253); Yanchep-Dongara, 1942-3 (Gardner 2000: 128); Chittering district, 1947 (Buchanan 2000: 276); Cervantes district, ?1950s (Passfield 1988: 128); Naval Base, 1959 (Russell 1983: 202); Kalbarri, 1969 (Bannister 1969b); and Grimwade and Donnybrook Sunklands, 1974 (Christensen *et al.* 1985: 31). Other distributional information is provided by Long (1988: 38-9).

The distribution of feral pigs has continued to expand, but not far inland because access to freshwater is limited. However, pigs are transported by hunters to public land in order to provide sport.

Domestic pigs were abandoned in the 1920s at Hazelvale by departing Group settlers (Tapley 1987: 20).

Although pigs had the opportunity to introduce diseases from 1829 (e.g. 75 were introduced from Java in 1842, and 30 were introduced from Bali in 1843, *The Perth Gazette* 15.1.1842, 2.9.1843), no first contact extinction pulse of native mammals is evident in south-west WA.

Camelus dromedarius camel/dromedary/one-humped camel

Although interest was expressed in 1837 (Cameron 2006: 433) and 1841 and 1843 by the WA Agricultural Society in procuring camels, no active measures were pursued (*The Inquirer* 8.1.1845). The offer by Government of £60 to the first importer of one male and two female camels landed in WA by January 1852 (*Government Gazette* 7.1.1851: 2) was evidently not taken up, as it was renewed in 1858 (*Government Gazette* 3.8.1858: 2), again without result.

The first entry of the camel into south-west WA was in 1875 when the explorer E. Giles reached Perth from South Australia via Mt Churchman with 17 animals. He then returned to South Australia via Berkshire Valley, Carnamah, Arrino, Dongara and Yuin (Giles 1889 vol. 2: 241). The next appearance of camels in WA was in 1879, when Tate (1879) briefly visited Eucla overland from South Australia.

Camels were introduced to WA in 1883, when 30 animals in 'good health' were overlanded from South Australia to work on the construction of a telegraph line northwards from Northampton (*The Victorian Express* 28.11.1883). It is not known if these camels were the result of the WA Government accepting an offer from an Adelaide trader to land camels at Albany or march them from Port Augusta. These animals had been imported from India earlier in 1885 and had been inspected for disease on their arrival at Adelaide (*Government Gazette* 9.7.1885: 336). In 1885, camels were formally classified as livestock under the Cattle Diseases Ordinance, 1865 and the Imported Stock Act, 1879.

Subsequent records of camels in south-west WA are as follows: six animals in Plantagenet district in 1891; 200 animals at Geraldton in 1892; and 252 at Geraldton, 217 at Fremantle, 308 in Perth and 45 camels in Plantagenet district in 1894 (WA Blue Book 1892, 1893, 1895). Most camels were employed in pastoral districts and on the goldfields, with considerable traffic on the Esperance-Coolgardie road in 1894-7 (Royal Commission 1917b: 116). Camels were used at Fremantle to convey wool bales landed at Rockingham (Fyfe 1983: 157). A pack camel can carry 5 cwt (Barker 1964: 91). The pulling power of a harnessed camel (10 cwt) exceeds that of a bullock (6 cwt, Barker 1964: 7). Camels were of course superior to other draught animals during a drought (Barker 1964: 77). The benefits and disadvantages of using camels in south-west WA (relative to other species) was discussed in *The Western Mail* of 12.1.1907: 7 and 26.1.1907: 6.

The only known recent occurrence of feral camels in south-west WA was in 1978 on Toolonga Nature Reserve near Shark Bay (Burbidge *et al.* 1980: 15). These animals are probably descended from herds abandoned in the 1920s when motorized transport became widespread.

Although surra disease was detected in 1907 at Port Hedland in camels imported from India (Seddon and

Albiston 1966: 75-77), there is no record of this disease in south-west WA in horses or dogs.

Bos taurus cattle/European cattle

In 1792 at Esperance Bay, 'excrements which very much resembled those of a cow' and 'prints of a cloven hoof, more than three inches in breadth' were noted by Labillardière (1800: 270-1). The prints of an animal with cloven hooves were seen in 1801 on the shore of Geographe Bay (Cornell 1974: 165, 168). These records may have resulted from cattle surviving from shipwrecks. It seems unlikely that cattle could have crossed from Sydney (the only settlement on the continent at the time) in 4-13 years.

However, Aborigines to the north-east of Toodyay informed James Drummond (letter 30.10.1844) that wild cattle originally came from the north-east before the European settlement at Swan River. According to Kimberly (1897: 147), Drummond discovered skulls of cattle 50 miles north-east of Toodyay. They had wide-branching horns not characteristic of the cattle brought by the early settlers. One Aboriginal, aged c. 40 years, remembered these animals as a child; this implies that cattle were present in 1817, and if correct is suggestive of a crossing overland from the settlement established in 1788 at Sydney. (It is relevant to note here that buffalo tracks were seen in the Kimberley region of WA prior to European settlement – Grey 1841 vol. 1: 242; *The West Australian* 19.3.1885).

The most probable first introduction of cattle to south-west WA was at Albany in 1826 (one bull and one cow – Wakefield 1827a) and at Swan River by the first settlers. At the end of 1829 there were 204 animals present. In 1838 and 1848 the number of cattle first exceeded 1 000 and 10 000 animals, respectively (Battye 1924). In frontier areas, cattle were usually preferred to sheep because they ate coarser feed, required less expensive fencing, and were less troubled by dingoes (Scouler 1929: 40). Other benefits and disadvantages of bullocks over other animals used for transport are discussed in *The Western Mail* of 12.1.1907: 7, 9.2.1907: 10, 27.4.1907: 8, 1.6.1907: 7, 15.6.1907: 7 and 22.6.1907: 6.

In 1831 the first report of a stray (or perhaps stolen) cow, near Fremantle, was published (*The Western Australian* 29.11.1831). A suitable cattle-proof fence of the 1830s is described in Cameron (2006: 474). However, because of inadequate and insufficient fencing, cattle soon strayed (Moore 1843: xxxviii; M. Bussell 1833 in Shann 1926: 39; Roberts 1834: 64, 84; Cameron 2006: 4, 6, 19, 463), discovered grass around springs and on land recently burnt by Aborigines, and became feral:

- 1830, between King and Kalgan Rivers, and upper Kalgan River (Mulvaney and Green 1994: 320, 358); Maylands peninsula (Cooper and McDonald 1999: 9); Middle Swan (Cameron 2006: 463)
- 1831, near Bald Head, Albany (Mulvaney and Green 1994: 387); junction of Avon and Swan Rivers (R. Dale in Shoobert 2005: 254; Cameron 2006: 51)
- 1831-2, upper Kalgan (1 bullock) and upper Hay (14 cattle) Rivers (A. Collie in Shoobert 2005: 246, 315)
- 1833, near Perth, first advertisements published about stray cows, with one found in the bush, and one missing with a £2 reward offered (*The Perth Gazette* 16.11.1833: 181, 14.12.1833: 197)
- 1834, Murray and Serpentine Rivers (*The Perth Gazette* 8.2.1834: 230; Cameron 2006: 316, 367)
- 1835, Pinjarra (*The Perth Gazette* 11.4.1835: 475); near Point Hood (*The Perth Gazette* 5.12.1835: 611); between Cranbrook and Mt Barker (J. Roe in Shoobert 2005: 483, 485); south of Wilson Inlet (J. Roe in Shoobert 2005: 493)
- 1836, Bejoording (G. Moore *et al.* in Exploration Diaries **2**: 433)
- 1836, Dandalup River (Bunbury and Morrell 1930: 176)
- 1837, between Dandalup River and Pinjarra (Shenton and Wells in Exploration Diaries **3**: 609)
- 1839, gorge of Murray River (Grey 1841 vol. 2: 237); c. 200-300 present (*Perth Gazette* 7.9.1839: 142)
- 1840s, south of Canning River and on adjacent Darling Plateau (Landor 1847: 166, 170)
- 1841, near Nornalup Inlet (*The Inquirer* 1.9.1841)
- 1843, Bothelling and Goongarrup (A. Durlacher in Exploration Diaries **3**: 748)
- 1846, Gordon River c. 50 km south-west of Kojonup (A. Gregory in Birman 1979: Map 2)
- 1848, near Hamersley River and near Cape Knob (Roe 1852: 34, 47)
- late 1840s, New Norcia, straying bullocks travelled 40 miles in three days (Stormon 1977: 150-1)
- 1848, York district, cattle 'met with, at large, in every direction, for want of boys and men to mind them' (*The Perth Gazette* 23.9.1848)
- 1854, Youlanging Spring (Austin 1855: 6)
- 1863, Darling Plateau east of Keysbrook (Hammond 1936: 7)
- 1869, Bridgetown district (*The Inquirer and Commercial News* 19.5.1869)
- 1874, Tone River, mob of c. 60 (Muir 2005: 172)
- 1875, Lake Moore (Giles 1889 vol. 2: 237)
- 1870s, lower Murchison River (Taunton 1903: 51-56)
- 1885, unoccupied Crown lands in Blackwood district (*Government Gazette* 1.10.1885: 466)
- c. 1886, Wagerup (Eastcott 1938: 34)
- 1890s, Aldersyde (Knox-Thomson 1975: 9).

The first regulation concerning stray cattle (June 1831) must have been inadequate, as an Act (the second in the Colony) was legislated in February 1832 making it lawful to seize and secure animals trespassing and damaging property but unlawful to wilfully destroy stray livestock (Trespassing Livestock Act 1832). Further Acts dealt with

the threat to the purity of breeding stock (1839) and to the public nuisance caused by the presence of large herds of feral cattle on unoccupied lands (1842). Per capita penalties for straying stock were legislated in 1847. Evidently straying of cattle had become even more significant by the 1850s and 1860s. An ordinance to regulate the branding of cattle was issued in 1852 and The Wild Cattle Nuisance Act was legislated in 1871. This was soon followed by applications to destroy feral cattle (*Government Gazette* 26.9.1871: 191).

At first, Aborigines were 'extremely afraid of approaching' cattle (1830, Berryman 2002: 156). Aborigines took to driving off and spearing cattle in various districts as follows:

- 1830-1, near Perth (Cameron 2006: 1, 17, 55)
- 1832, near Perth (Moore 1843: xxxix; Berryman 2002: 154)
- 1833, near Perth (*The Perth Gazette* 27.4.1833: 67)
- 1837, Canning River near Perth (*Perth Gazette* 16.12.1837: 1024)
- 1838, Hay River (Garden 1977: 84)
- 1846, near Albany (*The Inquirer* 5.8.1846)
- 1848, near Bunbury (*The Inquirer* 11.10.1848)
- 1851, near Busselton (Jennings 1999: 8-9)
- 1851, Bowes River (Bain 1975: 78, 80)
- 1851, Pallinup River (*The Inquirer* 2.7.1851)
- 1864, Strawberry (Bain 1975: 212).

Bullocks were an important work animal in the 1800s, being used for ploughing, carting of produce, and haulage of logs in the forest to bush tramway collection points (Harris 1884; Ednie-Brown 1896; Doyle 1977). Cattle do not need as high a quality food as horses and can forage in the bush (Owen 1933: 159; Bain 1975: 198; Richards 1993: 271). Cattle were also depastured in remote parts of the south-west, such as the south coast, from the 1860s. The earliest reference found of cattle (bullocks) being used in exploration was the 1865 expedition of CC Hunt. However, bullock teams were used from the late 1840s to cart sandalwood from inland (Sewell 1998: 48).

Deaths of cattle from eating *Gastrolobium* plants were first recorded in 1835 near Hotham River (J. Roe 1835 in Shoobert 2005: 462). Mortality from this cause seems to have been an ongoing occurrence (Carne *et al.* 1926). Deaths ('rickets') from eating foliage of *Macrozamia riedlei* were evident by the 1860s (Commission on Agriculture 1891: 110; various authors in *Journal of the Bureau of Agriculture of WA* 1894 **1**, 73-5, 119, 131, 175; Cullity 1979: 19).

Although cattle had the opportunity to introduce diseases from 1829, no first contact extinction pulse of native mammals is evident in south-west WA. The rinderpest virus was inadvertently introduced in 1923, when dairy herds near Fremantle were infected. It was suspected that cattle taken aboard ship in north-west Australia became infected from pigs taken on board at Singapore (Robertson 1923). This outbreak was eradicated.

Capra hircus goat

Goats were introduced in 1829 to Swan River (Bolton and Gregory 1999: 2) and one animal was also listed as present at Albany in 1829 (Stephens 1963: 51). Small numbers were landed in 1830 (Moore 1884: 21; Cooper and McDonald 1989: 6; Popham 1980: 14) and 1831 (Richards 1978: 57). One visitor in 1831 reported that goats seldom produced fewer than three young at birth (*The Perth Gazette* 12.1.1833: 7). In 1832 one colonist considered that the goat was the most useful domestic animal because it was cheap, frequently had two young, was more easily fed and managed than cows, and was not so liable to accidents (Cameron 2006: 136). Nonetheless, goats sometimes died after consuming *Gastrolobium* bushes (*The Perth Gazette* 16.8.1834: 338, 11.4.1835: 474; Cameron 2006: 336).

The number of goats present in WA then increased rapidly: 492 in 1834 (*The Perth Gazette* 10.1.1835: 423); 1690 in 1837; and 2436 in 1838 (*The Perth Gazette* 8.12.1838: 195); and 5615 (1842), and then declining to 3733 (1843), 3227 (1844), 2632 (1845), 2223 (1846), 1766 (1847) and 1431 (1848) (*Government Gazette* 19.12.1848: 9). By 1838 there was a large herd in the Nedlands area (Williams 1984: 21). Early records of goats straying into the bush are from Augusta, early 1830s (Shann 1926: 53) and from Picton, in 1841 (Bolton *et al.* 1991: 192).

Cashmere goats were introduced in 1839, and it was noted that goats thrive better in Perth district than in York district (*Perth Gazette* 13.7.1839: 111).

At first, Aborigines were 'very fearful' of goats (1829, Berryman 2002: 123). Goats were first recorded being 'carried off' by Aborigines in 1833 (Cameron 2006: 239). In 1834 Aborigines set their dogs at a herd of goats near Freshwater Bay (*The Perth Gazette* 1.3.1834: 243), speared goats at Upper Swan (*The Perth Gazette* 21.6.1834: 306), drove off goats at Canning River (*Perth Gazette* 8.7.1837: 932), and European dogs given to Aborigines killed c. 20 goats at Lake Monger, near Perth (*Perth Gazette* 30.12.1837: 1033). Another cause of mortality was browsing of poison peas (*Gastrolobium* species), with 55 and 13 goats in separate flocks dead in transit between the Swan Coastal Plain and Avon valley (Cameron 2006: 375, 377).

In 1879 and 1884 the townsite of Northampton was infested with hundreds of goats (*The Victorian Express* 22.10.1879, 3.12.1879, 16.1.1884), and in 1885 goats were considered 'a perfect pest' near Geraldton (*The Victorian Express* 8.8.1885).

By December 1903 there were only 2 244 goats (as livestock) in south-west WA, with most in the Geraldton, Murray, Northampton and Swan districts (WA Year Book 1906: 676). Most goats kept as livestock in WA occurred outside the south-west (WA Year Book 1906: 677).

Goats were considered to be useful in browsing scrub in forest near Balingup, at lower Warren and east of North Dandalup (*The Western Mail* 15.8.1908: 9, 22.8.1908: 6, 26.9.1908: 5).

More than 500 goats were present along the Avon

River west of Toodyay in the 1930s (Chitty 2004: 5). In recent decades, feral goats have been reported in south-west WA in Kalbarri National Park (Bannister 1969b), East Yuna and Bindoo Hill Nature Reserves (Chapman and Kitchener 1981b), near Mundaring, Jarrahdale and Donnybrook (Long 1988: 36), and north-west of Pemberton and near Lake Muir (Christensen *et al.* 1985: 31).

Although goats had the opportunity to introduce diseases from 1829, no first contact extinction pulse of native mammals is evident in south-west WA.

Ovis aries sheep

Some 8-10 sheep were first landed in WA in 1826 at King George Sound (E. Lockyer 1827 in Shoobert 2005: 7, 10; Wakefield 1827a). By 1829 the flock was 'improving fast' (Sleeman 1829b: 544), even though there was an 'apparent want of Grass or esculent herbage' (Sleeman 1829a: 527).

Sheep comprised 80% of the livestock present in WA in 1829, with 1469 animals present. The number of sheep soon exceeded 1000 and 10 000 animals, in 1830 and 1837 respectively (Battye 1924). In 1838 it was declared that 'Sheep breeding in this Colony has been successful almost beyond our hopes' (*Perth Gazette* 4.8.1838: 123). By 1862 there were 295 666 sheep present in south-west WA, comprising c. 83% of all livestock (Battye 1924).

Aborigines were recorded spearing or driving off sheep as early as October 1830 (*Perth Gazette* 28.7.1838: 119; Green 1984: 203) and March 1831 (Cameron 2006: 17, 55). This practice continued at least until 1864 (at Maddington, *The Perth Gazette* 15.6.1833: 94; at York, *The Perth Gazette* 7.9.1833: 142; at Canning River, *Perth Gazette* 8.7.1837: 932, 16.12.1837: 1024; at Albany, *The Inquirer* 5.8.1846; at Bowes River 1850, Bain 1975: 68; at Strawberry 1864, Bain 1975: 212). Stray sheep, noted as early as 1830 (Roberts 1834: 84) and the early 1830s (Shann 1926: 53), were unable to establish viable feral populations because of the presence of Aborigines living a hunter-gatherer lifestyle until the 1860s, the prevalence of dingoes, and the abundance of poison plants *(Gastrolobium)*. It was necessary to shepherd sheep (in flocks up to 500, Giles 1889 vol. 2: 257) in order to protect them from these adversities, as well as guide them to water. Even in a long-settled district, such as York, few sheep were kept in paddocks as late as 1867 (*The Perth Gazette* 22.11.1867). Shepherding became unnecessary once wire for subdivision fencing became available in the 1880s. The last known record of Aborigines stealing a large number of sheep in south-west WA was at Young River (near Esperance) in 1890 (*The Australian Advertiser* 7.7.1890).

Other natural enemies of sheep (as newborn lambs, which weigh c. 4-5 kg) include the wedge-tailed eagle (Moore 1842: 71; *The Inquirer* 20.6.1873; Carter 1908: 103; *The Western Mail* 15.8.1908: 6, 10.4.1909: 8, 9.7.1925: 4) and the Australian raven *Corvus coronoides* (*The Western Mail* 5.6.1909: 11; Orton and Sandland 1913: 80). At various times the Agricultural Society paid a reward for the killing of 'hawks' [?wedge-tailed eagles] (*The Perth Gazette* 6.2.1836: 646, 5.8.1837: 949, 10.9.1842). Until dingoes were controlled through close settlement by way of fencing, baiting, and trapping, it was difficult for selectors to keep sheep on freehold agricultural land (J. Mitchell WAPD **72**: 1482, 21.10.1925; de Burgh 1976: 107; Jenkyn 1999: 110-1; Maddock 1998: 605; Mingenew 1988: 13). Hence in many parts of south-west WA, sheep did not become a permanent component of farming until c. 1915-30 (Beckingham 1979: 31; Cannon 1983: 21; Jenkyn 1999: 110-1; Klemm nd: 38; Maddock 1998: 605; WA Year Book 1906: 623).

Another significant impediment to keeping sheep was poison plants, 'one if not the greatest drawback the Colony has' (Cowan 1977: 109). Special leases for 'Poison Lands' were introduced in 1872 and these were liberalized (with little success) in 1887 to accelerate the eradication of poison plants. Many sheep died from browsing poison plants. For example, 250 and 304 near Kojonup (*The Perth Gazette* 4.4.1840, 5.12.1840), from 100-300 at a time near York in the 1840s (Cowan 1977: 109), 1200 near Cape Riche before 1854 (Ducker 1988: 81), 300 near Cockleshell Gully in 1857 (Bain 1996: 100), c. 200 near Northam in 1868 (*Perth Gazette & W.A. Times* 9.10.1868), 300 at Thomas River in the 1870s (*The Eucla Recorder* 21.7.1900: 2), and 300 and 100 sheep near Yangedine and Quellington, respectively (*Eastern Districts Chronicle* 21.11.1896: 5, 5.12.1896: 5). The number of sheep killed annually by poison plants was stated to be 'simply awful' (*The West Australian* 20.6.1895: 6). Morrison (1897: 573) wrote that the loss sustained by WA and the detriment caused by these plants to its progress were 'of a magnitude not easily realised'. He quoted an example of 522 sheep poisoned in one flock of 900 sheep in a recently burnt patch of poison. One prominent farmer was of the view that south-west WA would carry 100 times more sheep were it not for these plants (Morrison 1897: 573). Although advice to farmers on the most effective way to exterminate poison plants was provided in *The West Australian* (6.2.1897: 10), *The Producers' Gazette and Settlers' Record,* 1898, **5**: 53-6, and *The Western Mail* (11.8.1906: 5, 18.8.1906: 5, 25.8.1906: 5-6, 1.9.1906: 5, 22.10.1906: 7, 16.2.1907: 10, 19.10.1907: 11, 9.11.1907: 5, 23.5.1908: 7), difficulties remained as a Board of Inquiry was later established to investigate the settlement of poison lands (Cooke 1911).

The final major adverse factor was extensive bushfire in summer, which destroyed the feed of sheep (*The Perth Gazette* 13.2.1841; Cameron 2006: 314, 317, 320, 354, 368-9). Ewes could not lactate their lambs, many of which died (*Perth Gazette* 23.5.1856: 2).

Sustainable grazing of sheep on 'unimproved land', i.e. native vegetation (including native grasses) was necessarily at a low density:

- c. 1 sheep to 3 acres on average (R. Bland in *The Perth Gazette* 10.1.1835: 423; Irwin 1835: 88)
- 'the best pasture will scarcely feed a sheep on three acres through the year', York (H. Bunbury 1836 in Bunbury and Morrell 1930: 28)

- 'It takes 3 acres on an average of our best land to keep a sheep throughout the year' (J. Drummond, Toodyay, letter 25.7.1839)
- 1 sheep per 6 acres (G. Lefroy, Walebing, 1847 in Bain 1975: 21)
- 1 sheep per c. 10 acres (WA Year Book 1892: 131)
- 1 sheep per c. 5-7 acres of 'natural state of average quality land' (R. Burges in *Eastern Districts Chronicle* 15.8.1896: 6)
- 1 sheep per 5 acres (H. Lukin in *Eastern Districts Chronicle* 5.9.1896: 5)
- 1 sheep per 3-5 acres (May 1905a)
- 1 sheep per 3 acres (WA Year Book 1906: 597)
- 1 sheep per 3-5 acres (1906, Melia and Bosworth 1997: 136, 164)
- 1 sheep per 10 acres (M. Ash in Cooke 1911)
- 1 sheep per 5 acres (median of 10 values, Royal Commission 1917a: 603, 651, 659, 663-5, 668, 673-4; Royal Commission 1918: 42)
- 1 sheep per 20 acres of bush (Schorer 1974: 168)
- 1 sheep per 5-6 acres (Heydon 1988: 27)
- 1 sheep per c.10 acres (Sewell 1998: 45).

Although there are records of grass along rivers being eaten down by sheep (A. Hillman 1838 in Exploration Diaries **3**: 626), shepherds continually kept their flocks on the move. It is unlikely that any of the native mammal species that depended on grazing and browsing of native vegetation were significantly impacted by sheep, except within 6-8 miles of water in summer (Williams 1962: 414). When Gregory and Gregory (1884: 1) wrote that the known country had by 1846 'become so nearly stocked to the full extent of its capability', this was in the context that one sheep needed 3-10 acres of native vegetation to feed it during one year, as well as regular access to water in summer. By 1848, it was considered that 'the increase and even existence of our flocks and herds is in imminent peril', which could only be averted by more exploration in land to discover pasture land (*The Perth Gazette* 1.7.1848).

Native animals did not begin to be affected detrimentally by sheep until pastoralism ceased. Paddocks were then formed, in which water was supplied, poison plants were grubbed out, and other native vegetation was removed. Most trees in paddocks were ring-barked to enhance the growth of grass (Commission on Agriculture 1891; Lindley-Cowen 1897: 214-23). These improvements increased the carrying capacity:

- 1 sheep per 2 acres; 1 sheep per acre in 'choice places' (WA Year Book 1892: 131)
- 1 sheep per acre on cultivated land (R. Burges in *Eastern Districts Chronicle* 15.8.1896: 6; H. Lukin in *Eastern Districts Chronicle* 5.9.1896: 5)
- 1 sheep per 2 acres all year (May 1905a)
- 1 sheep per 1.1-1.5 acres of ring-barked country, and 1 sheep per 0.1 acre of pasture (1906, Melia and Bosworth 1997: 136, 164)
- 1 sheep per 0.5 acre on cleared, worked and fertilized land (*The Western Mail* 26.1.1907: 6)
- 1 sheep per 0.5 acre (*The Western Mail* 6.3.1907: 7)
- 1 sheep per acre (J. Forrest in *The Western Mail* 25.1.1908: 18)
- 1 sheep per 1.5 acres of ring-barked wandoo woodland (*The Western Mail* 15.2.1908: 18)
- 1 sheep per 0.4 acre on land laid down to paspalum (*The Western Mail* 7.3.1908: 9)
- 1 sheep per c. 1 acre (O. Bignell in Cooke 1911)
- 1 sheep per 1.5 acres (M. Ash in Cooke 1911)
- 1 sheep per 2-3 acres (Royal Commission 1917a: xvii)
- 1 sheep per 0.05-0.1 acre (J. Holmes WAPD **73**: 2340, 2.12.1925; H. Stewart WAPD **73**: 2381, 3.12.1925)
- 1 sheep per 0.5 acre (Heydon 1988: 27)
- 1 sheep per 2 cleared acres of clover, lupin, top-dressed with superphosphate, 1950s (Sewell 1998: 273)
- 1 sheep per 0.25 acre following effective rabbit control in the 1950s (Lange 1981: 504).

Thus it was not the presence or density of sheep per se that despoiled the habitat of native fauna, but the related improvements made by farmers. In addition, the wheatbelt was cleared to grow wheat and other grain crops, not to farm sheep. When fallowing was considered an essential component of wheat-growing, a few sheep were kept to control weeds on fallow land (J. Drew WAPD **73**: 2336, 2.12.1925).

Although scab disease was inadvertently introduced from Van Diemen's Land in the early 1830s, there is no evidence of transference of this or other diseases from sheep to native mammals or of any early decline of native mammals to align with the rapid adoption of pastoralism based on sheep in the 1830s.

DISCUSSION

Historical ecology vs ecological history

Historical ecology tends to rely on scientific information (pollen, fossils, specimens collected and deposited in museums, publications in scientific journals), whereas ecological history uses personal experiences recorded in written sources (letters, diaries, newspapers, public records, reminiscences) or by oral sources. Species that were conspicuous to settlers (plant species that provided wood, fruit, or served as indicators of arable or pastoral land; animal species that served as food, sport, or pests) therefore offer a unique opportunity to link historical ecology and ecological history.

The writing of ecological history is beset with similar problems to the writing of local and regional history discussed by Crowley (1956), i.e. how to collect, select, arrange, and interpret the evidence. These problems can be overcome by a well thought out research program,

instead of only relying on available sources. Crowley viewed successful local and regional history as based on intensive digging for details and unnoticed facts in order to prevent distortion of perspective and generalization, without treating the details as isolated or of equal value. Crowley also recommended that historical research benefited by an inverse chronological approach, i.e. commencing with the contemporary and retracing developments to origins, thereby not magnifying and thus distorting early developments. I have not followed Crowley in this respect, preferring the traditional chronological presentation of information.

Modern assessments of faunal change in Australia can be categorized as follows:

- Ahistoric. Historical processes and legacies are ignored in assessing current status, particularly of species that remain common and widespread. Factors operating in the present, such as area of habitat or structural/floristic characteristics of habitat are measured and quantitative analysis is emphasized. The ecological literature is replete with such studies (e.g. Fox 1982; Catling and Burt 1995; Southwell *et al.* 1999).
- Inadequately historic. Historical processes and legacies are acknowledged, but are not integrated effectually with contemporary factors. The overlooked role of infrequent episodes of epizootic disease provides a good example.
- Insufficiently historic. Historical processes and legacies are invoked to explain changes in status of species. However, historical actuality is not satisfactorily researched or understood, and coincidental factors are not clearly differentiated from historically relevant factors (e.g. Marshall 1966a, 1966b; Johnson *et al.* 2002, 2007; Cardillo 2003; Fisher *et al.* 2003; Johnson 2006). This results in claims that a particular factor operated to an extent and at a time to have influenced the distribution and abundance of a species. An example is the proposition that the cat was introduced into Australia from Dutch shipwrecks on the WA coast in the 1600s-1700s.
- Effectively historic. A thorough understanding of regional and local human activities and how these changed in space and time provides the contextual framework ('the ecological theatre') into which scientific knowledge about the species being investigated ('the ecological cast and play') is integrated. Analysis tends to be qualitative, narrative-based, holistic, and rich in interdisciplinary convergence (e.g. Allen 1983). This paper has attempted such an approach.

The interpretation of explanatory factors that operated in historical times does not of course have the same degree of certitude as interpretations from modern ecological studies. In reductionist ecology, natural situations are simplified by isolating and manipulating one or a few components for a short period in a sample of small areas. Realism and generality are traded off for precision and statistical rigour. In historical ecology/ecological history, explanations should be treated as hypotheses with varying degrees of convincingness, dependent on the array of factual and observational evidence available and the quality of the inferences drawn. It cannot be fully established that the various factors described actually were the critical factors that determined population size and distribution during those periods. Deficiencies and imperfections in the historical record might mean that important factors have not been recognized, or the influence of factors has been lesser or greater than is deduced. Even in modern experimental ecology it can be difficult to sort out the critical influences on the population size of species being studied.

It is unfortunate that past attempts to acquire information on conspicuous species in south-west WA from oldtimers have not been systematic. WC Grasby, agricultural editor of *The Western Mail* from 1905 to 1928, and its agricultural adviser until his death in 1930, readily published incidental remarks on fauna submitted by readers, as did the columnists L. Glauert, J. Pollard and FL Whitlock. Specimens received at the WA Museum were often accompanied by a letter from the donor. However, these examples are essentially reactive. *The Western Australian Naturalist* in the 1950s published some information provided by oldtimers, but it is evident that there was no proactive attempt by naturalists and scientists to interview oldtimers and publish information that would have derived from the 1870s and 1880s. This was a missed opportunity that either resulted from a lack of strategic awareness or from an epistemological bias that treated oral information as anecdotal and unreliable.

Early impressions

For several reasons, when perusing historical accounts, restraint is needed to avoid over-interpreting incidental remarks and silences (what is not recorded – absence of a record does not necessarily demonstrate absence of a species or that a process was not occurring). First, most mammal species in south-west WA are nocturnal and would not be noticed unless disturbed from their diurnal resting places. Second, the conspicuous fauna of south-west WA may not have met the expectations of visitors and colonists from Britain, and so were judged not to merit particular attention. First impressions may therefore be misleading.

Nevertheless, near Albany in 1791, G. Vancouver noted the 'extreme shyness' of the birds and the 'wildness' of the mammals, both of which were attributed to hunting by Aborigines (Lamb 1984: 354). Likewise, F. Péron attributed the rarity and timidity of birds near Albany in 1803 to hunting by Aborigines (Cornell 2003: 112). R. Dale in 1834 referred to 'the scarcity of animation' in forests traversed and he attributed this to burning by Aborigines (Dale 1834: 13). G. Grey in 1839 in forest at the upper Harvey River was struck by 'so great a want of animal life as in these mountains' (Grey 1841: 321-2). The 'awful silence' in bushland near Picton in 1841-2 and the uncommonness of mammals was commented on (J. Wollaston in Bolton *et al.* 1991: 128, 276). Gould's

collector, J. Gilbert, wrote in 1840 that 'Western Australia is wanting in extraordinary novelties (Quadrupeds at all times and places may be said to be unabundant) as compared with other parts' of Australia (letter 4.5.1840 in Whittell 1942: 222). However, Gould (1863 vol. 1: 20) contradicted this, based on collections of *Macrotis lagotis* and *Myrmecobius fasciatus*.

In contrast, during the period from c. 1840 to c. 1890 there are comments about the abundance of mammals around campsites at night (W. Harvey 1854 in Ducker 1988: 97-8; Hassell 1975: 4), browsing impacts on fungi (J. Drummond, letter 7.8.1843), mammals encountered during exploration (F. Humphrey 1845 in Exploration Diaries **3**: 761; H. Lefroy 1863 ibid. **5**: 310), birds and mammals seen during excursions (F. Weld 1869 in Lovat 1914: 154), and animals seen on walks in bushland around homesteads (Hassell 1975: 225). Futher examples are provided under the individual species accounts in this paper, and also in Abbott (2006). At least one settler, M. Quinn of Williams, valued kangaroos, boodies, woylies and bronzewing pigeons, as these were regarded as keeping poison peas *(Gastrolobium)* in check (*The West Australian* 31.3.1888).

Mechanisms of historical change in distribution and abundance: Conflicting evidence and interpretations across Australia

Numerous naturalists and scientists have identified factors that have contributed to local and regional changes in status (increases, declines, and extinctions) of bird and mammal species in Australia (Table 4). In the period from the 1830s to the 1850s there were fewer factors operating, and there was thus greater clarity in distinguishing the importance of these factors in changing the status of species during this period. Subsequently, additional factors came into operation and some of the early ones ceased.

Although the occupation of the Cumberland Plain (near Sydney) was completed in 1823 (Garran and White 1985: 211), there were no reported declines of marsupials. Charles Jeffreys in 1820 (Jeffreys 1820), James Backhouse in 1834 (Backhouse 1843: 212), and Ronald Gunn in 1836 (Burns and Skemp 1961: 59) and in 1850 (West 1852: 323-330) in Tasmania, and Charles Darwin in 1836 (Darwin 1839) and John Gould in 1838-40 (Gould 1840-1848, 1845-1863, 1865) in New South Wales emphasized hunting for food and/or sport as the major factor operating at the time and threatening the persistence of large or conspicuous species such as the emu, Australian bustard, white-bellied sea-eagle *Haliaeetus leucogaster*, platypus, thylacine, Tasmanian devil, koala *Phascolarctos cinereus*, red kangaroo, and grey kangaroo.

In contrast, the retreat of the emu from near Melbourne by late 1837 was attributed to the flocks and herds of the settler (Backhouse 1843: 505). Batey (1907a) saw poisoning eliminate the dingo locally (Sunbury district, c. 30 km north-west of Melbourne) in the 1840s/1850s, pastoralism (involving sheep and cattle) cause declines in other (unspecified) mammals, and disease (?native or ?exotic) reduce the abundance of the eastern quoll *Dasyurus viverrinus*. One pastoralist in Victoria attributed the scarcity of animal food [probably kangaroo and emu] of Aborigines to 'our flocks and herds' (Patterson 1842). In the early 1850s, the grey kangaroo had 'entirely disappeared' from Mt Macedon district in Victoria, and the spot-tailed quoll *Dasyurus maculatus* had become 'very scarce' (Blandowski 1855: 69-70). By 1857 several species of native mammals had declined in north-west Victoria, this being attributed to sheep and cattle dispersing populations (Krefft 1866: 4, 12, 14, 18, 21). Presumably this referred to the destruction of habitat and food plants. This is in contrast to western Victoria, where kangaroos in the 1850s had become a 'serious nuisance to the squatter and farmer', apparently because Aborigines had decreased in population size and the few left were fed mutton (Bonwick 1858: 32).

Strychnine-poisoned lambs greatly reduced the abundance of wedge-tailed eagles in the late 1840s, and the emu was extinct at Sunbury by 1846 (Batey 1907b). The use of strychnine to poison dingoes in Castlereagh district in New South Wales had also killed many birds, goannas and smaller native mammals (Woolls 1879: 68).

In Tasmania, declines in the abundance of some mammal species were evident by the 1870s, as Allport (1878) reported that the 'majority of our indigenous mammals are gradually but surely becoming extinct'.

Backhouse, Gould, Batey, and Blandowski also observed many bird species taking advantage of new resources supplied by the livestock, crops and gardens of the settlers. Batey also witnessed increases in abundance of native mammal species such as the koala and brushtail possum. Blandowski recorded an increase in abundance of the eastern quoll (which he attributed to reduction of dingoes) and noted how the 'rabbit rat' *[Conilurus albipes]* was common, inquisitive, and fond of sugar and other stores. The eastern quoll was a pest species in the Botanic Gardens, Melbourne (Wilson 1857: 82). By 1872, Woolls (1879: 86, 91) was also aware of increased populations of marsupials 'of late' following the gradual disappearance of Aborigines and dingoes in Castlereagh district, New South Wales. An inverse relation between the abundance of dingoes and marsupials was also noted in Queensland (Anon. 1898: 118).

Later writers also attributed the increase of possums in the 1860s to the disappearance of Aborigines in Victoria (MacPherson 1886: 91; Bennett 1886) and in New South Wales (Norton 1886: 17). In the lower Wellington district of New South Wales, the decline of several bird species in the 1870s was ascribed to stocking of the country by sheep and (to a lesser extent) predation by feral cats (Bennett 1891). Increases in kangaroo populations in Victoria, New South Wales and Queensland in the 1880s relative to the 1840s (Demarr 1893: 187) were not attributed to any particular factor.

As more factors became operative, these were invoked to explain declines (North 1901; Shortridge 1910; Hoy 1923; McKeown 1923; Wood Jones 1923; Ashby 1924; Le Soeuf and Burrell 1926; Wilkins 1928; Troughton 1932; Boehm 1952). Sometimes these multifarious factors

Table 4

Factors influencing the distribution and abundance of fauna, based on contemporary observations, records and opinion (1800s-1920s).

Factor*	South-west WA**	Other parts of WA	Other parts of Australia
Drought	Gould 1865; Milligan 1904; Carter 1920, 1923; Leake 1961	J. Forrest 1896 WAPD **9**: 133; Shortridge 1910; Carter 1924c; Whitley 1971; Brooker 1977; H. Trotman 1894 in Smith 1979; McDonald 1996; Lefroy 2003	Gould 1848; Gould 1865; Caldwell 1887; North 1901; McIlraith 1903; Batey 1907b; MacAlister 1907; Bellchambers 1918; Longman 1923; Barnard & Barnard 1925; Berney 1929; Finlayson 1932: 151
Fire frequency	Thomas 1906; Shortridge 1910; C. Hoy 1920 in Short & Calaby 2001; Ashby 1921; Troughton 1923		Mitchell 1848
Fire intensity and scale	Whitlock 1911; Hoy 1920 in Short & Calaby 2001; Carter 1920, 1923, 1924b, 1924c; White 1921; Whitley 1971	Brooker 1977	Townsend 1849; Le Soeuf nd; Ashby 1924; Hall 1925; Kiddle 1961
Aboriginal predation/Demise of tribal Aboriginal life	O. Bull in Conference of Producers 1898: 42; J. Drew 1907 WAPD **32**: 1675	Campbell 1900; R. Sholl 1907 WAPD **32**: 1674; Ealey 1967; Lefroy 2003	Backhouse 1843; Mackenzie 1851; Bonwick 1858; Gould 1863; Krefft 1871; Kerr 1872; Woolls 1879; Grant 1881; Curr 1883; Haswell 1886; Macpherson 1886; Bennett 1886; Neville-Rolfe nd; Howitt 1890; Hamilton 1892; Macgillivray 1901; Bradshaw 1902; Batey 1907; Froggatt 1913; Barnard & Barnard 1925; Bligh 1938; Parris 1948; Kiddle 1961; Walker 1966; Quinlan 1967
Dingo predation/Trapping and poisoning of the dingo	A. Crawford in Glauert 1921	Richardson 1914; Brockman 1987; Lefroy 2003	Kirkland 1845; Townsend 1849; Mundy 1852; Sidney 1852; Blandowski 1855; Bonwick 1858; Kingsley 1859; Smythe 1869; Krefft 1871; Woolls 1879; Dawson 1881; Grant 1881; Curr 1883; Boldrewood 1884; Finch-Hatton 1885; Nicols 1887; Neville-Rolfe 1889; Watts 1890; Hamilton 1892; Demarr 1893; Archer 1897; Froggatt 1900; de Satgé 1901; Macgillivray 1901; Bradshaw 1902; Craig 1908; Lucas & Le Soeuf 1909; Froggatt 1909, 1913; Abbott 1913; Barnard & Barnard 1925; Le Soeuf & Burrell 1926; Hayward 1929; Kiddle 1961; Shumack 1967; Rolls 1969; Waterhouse 1984; Clarke 1986; Hrdina 1997
Natural disease***			Macgillivray 1901; Giddings 1906; Le Soeuf & Burrell 1926; Finlayson 1934
Provision of new foods (fruit, bark, vegetables, seed, sheep, poultry)	Campbell 1900; Hall 1902a; Milligan 1902; Carter 1920, 1923, 1924a, 1924b; Serventy 1927; Webb 1944; Whitley 1971; Cameron 2006; Mann 2006		Anon. 1827; Vigors & Horsfield 1827; Cunningham 1827; Bennett 1834; Gunn 1838; Darwin 1839; Backhouse 1843; Meredith 1844; Kirkland 1845; Townsend 1849; Mundy 1852; Blandowski 1855; Bonwick 1858; Bennett 1860; Diggles 1870; Ramsay 1875, 1876, 1877; Haswell 1886; Nicols 1887; Fenton 1891; Semon 1899; Campbell 1900; Dalton 1901; Batey 1907b; Lockwood 1907; Anon. 1908b; Craig 1908; Lucas & Le Soeuf 1909, 1911; Smith 1909; Littler 1910; Belcher nd; Lord 1918; Gill 1919; Le Soeuf & Burrell 1926; Anon. 1929; Hayward 1929; Gilmore 1934; Skemp 1952; Fullerton 1964, Atkinson 2001
Provision of new breeding sites (buildings, mine shafts)	Hall 1902a; Carter 1903, 1923, 1924a; Milligan 1903b	Whitlock 1910	Vigors & Horsfield 1827; Gould 1848; Townsend 1849; Anon. 1861; Diggles 1870; Campbell 1900; Littler 1910; Lucas & Le Soeuf 1911; Belcher nd; Chenery 1920; Kiddle 1961

Pastoralism	Oldfield 1865; Carter 1920; Leake 1962		Patterson 1842; Gould 1863; Krefft 1866; Bennett 1891; Campbell 1900; Berney 1906; Le Soeuf nd; Lucas 1908; Brown 1918; Barnard & Barnard 1925; Jarman & Johnson 1977; Hrdina 1997
Provision of water	Hall 1902b	Ealey 1967; Nixon & Lefroy 1988	Berney 1905; Bean 1925; McGilp 1929; Hrdina 1997
Vegetation clearing: farms	Le Soeuf 1900; Milligan 1902; Shortridge 1910; Carter 1920, 1923, 1924b, 1924c		Vigors & Horsfield 1827; Gould 1863; Woods 1879; Le Soeuf nd; Batey 1907b; Froggatt 1906, 1909; Littler 1910; Belcher nd; Crompton 1915; Bellchambers 1916; Spencer 1921; Le Soeuf 1923; McKeown 1923; Illidge 1924; de Warren 1928; Chisholm 1929; Atkinson 2001
Vegetation clearing: villages & towns	Hall 1902a; Carter 1924b		Campbell 1900; Froggatt 1901, 1906; North 1901; Crompton 1915; White 1919
Drainage	Carter 1924b		Anon. 1861; Campbell 1900; Froggatt 1901; Littler 1910
Hunting for food/sport	*The Western Mail* 20.6.1891:6; Carter 1903; Woodward 1907; *The Western Mail* 25.12.1908: 25; Carter 1923; Bunbury & Morrell 1930; Serventy 1927; Buchanan 2003; Cameron 2006; Mann 2006	Ealey 1967	Mann 1811; Evans 1822; M Currie 1823 in Field 1825; Cunningham 1827; Vigors & Horsfield 1827; Bennett 1834; R. Gunn 1836 in Burns & Skemp 1961; Gunn 1838; Darwin 1839; Backhouse 1843; Meredith 1844; Howitt 1845; Kirkland 1845; Haydon 1846; Hodgson 1846; Angas 1847; Gould 1848; Townsend 1849; Mackenzie 1851; Melville 1851; Mundy 1852; R Gunn in West 1852; Sidney 1852; Blandowski 1855; Howitt 1855; Kelly 1859; Bennett 1860; Anon. 1861; Gould 1863; Haygarth 1864; Gould 1865; Diggles 1870; Kerr 1872; Ramsay 1876; Woods 1879; Boldrewood 1884; Nicols 1887; Coles 1888; Neville-Rolfe 1889; Le Soeuf 1890; Bride 1898; Campbell 1900; Anon. 1901c; Froggatt 1901; North 1901; French 1902; Cambridge 1903; Steel 1906; Batey 1907b; Harrison 1908; Lucas 1908; Smith 1909; Littler 1910; Macgillivray 1910; Lucas & Le Soeuf 1911; Inglis 1912; Campbell & Campbell 1913; Belcher nd; Hamilton 1914; Bellchambers 1916, 1918; Burrell 1927; Bolam 1927; Hayward 1929; Gilmore 1934; Skemp 1952; Rolls 1969; Yelland 1970; Atkinson 1980; Waterhouse 1984; Atkinson 2001
Cat predation	Le Soeuf 1900; Glauert 1921; Carter 1923, 1924a, 1924b, 1924c; Le Soeuf 1931	Shortridge 1910	R Gunn in West 1852; Bennett 1891; Campbell 1900; North 1901; Littler 1910; Bellchambers 1918; White 1919; Spencer 1921; Hobler 1923; Le Soeuf 1923; Ashby 1924; Le Soeuf & Burrell 1926; McKeown 1923; Atkinson 1980
Introduced rodents		Shortridge 1910; Brockman 1987	Campbell 1885; Lucas & Le Soeuf 1909
Collection of specimens for museums or for study (including eggs)	Carter 1924c; Grasby 1925; W. Grasby in *The Western Mail* 3.6.1926: 2; J. Pollard in *The West Australian* 20.10.1928: 5		Caldwell 1887; Semon 1899; Campbell 1900; French 1902; Littler 1910; Hamilton 1914; D'Ombrain 1929; Waterhouse 1984
Trapping, shooting & poisoning of native animals eating seed, fruit, crops & stored products	Various authors in *Journal of the Bureau of Agriculture WA* **2**: 386-392 (1895); **3**: 806-7 (1896); Conference of Producers 1898: 41-2; Serventy 1929b; Webb 1944; Cameron 2006		Backhouse 1843; Meredith 1844; Gould 1848; R Gunn in West 1852; Mundy 1852; Wheelewright 1861; Gould 1865; Kerr 1872; Neville-Rolfe 1889; Norton 1890; Campbell 1900; Cambridge 1903; Littler 1910; Egger 1911; Hamilton 1914; Barnard & Barnard 1925; Chisholm 1925; Crowther 1926; Mackaness 1955; Kiddle 1961; Fullerton 1964; Shumack 1967; Waterson 1968

Table 4 (cont.)

Factor*	South-west WA**	Other parts of WA	Other parts of Australia
Poisoning of wedge-tailed eagles	Various authors in *Journal of the Bureau of Agriculture WA* **2**: 385-6 (1895); **3**: 811-3 (1896); **4**: 1233-6 (1897); Crossman 1909; Carter 1911, 1923; Hammond 1936	Brockman 1987; Nixon & Lefroy 1988	Bonwick 1858; Kingsley 1859; Diggles 1870; Grant 1881; Finch-Hatton 1885; Nicols 1887; Watts 1890; Hamilton 1892; Campbell 1900; Berney 1905; Batey 1907b; Craig 1908; Abbott 1913; Froggatt 1913; McGilp 1921b; Barnard & Barnard 1925; Bolam 1927; Shumack 1967; Rolls 1969
Hunting/trapping for pelts & feathers	Various authors in *Journal of the Bureau of Agriculture WA* **4**: 1255-6 (1897); Le Soeuf 1900; Grasby 1925; Brockman 1987; Mann 2006		Lesson 1824; Bennett 1834; Gunn 1838; Backhouse 1843; Meredith 1852; R Gunn in West 1852; Anon. 1861; Gould 1863; Ramsay 1876; Haswell 1886; Neville-Rolfe 1889; Norton 1890; *Victorian Naturalist* **8**: 128 (1891); Le Soeuf 1901; North 1901; Cambridge 1903; Anon. 1906c; Batey 1907; Mattingley 1907; Le Soeuf nd; Lucas 1908; Lucas & Le Soeuf 1909; Smith 1909; Anon. 1912c; O'Donoghue 1914; White 1917; Bellchambers 1918; Brown 1918; Lord 1918; Le Soeuf 1923; Longman 1923; AH Chisholm 1925; Hall 1925; Latham 1925; White 1925; Le Soeuf & Burrell 1926; Hrdina & Gordon 2004
Logging of forest	Hall 1902a		
Exotic animal disease***	Leake 1962	Shortridge 1910; Richards & Short 1996	Anon. 1861; Kerr 1872; 'Drover' in *The Western Mail* 8.9.1900: 5; Le Soeuf 1923; Le Soeuf & Burrell 1918, 1926; Wilkins 1928; Hrdina & Gordon 2004; Gordon & Hrdina 2005; White 2007
Capture of birds and mammals for pets & for zoos	*The Perth Gazette* 25.1.1834: 223, 28.5.1836: 700; Hall 1902a, 1902b *The Western Mail* 25.12.1905: 85; *Great Southern Herald* 25.3.1908; Serventy 1929b; Tyler 2003; Cameron 2006; Mann 2006	Carter 1888; *The Western Mail* 28.12. 907: 15; Whitlock 1910	L. Macquarie 1821 in Macquarie 1956; Cunningham 1827; Vigors & Horsfield 1827; Backhouse 1843; Howitt 1845; Gould 1848; Townsend 1849; Kelly 1859; Anon. 1861; Gould 1863; Haygarth 1864; Gould 1865; Sclater 1860, 1868, 1869; Diggles 1870; Schmidt 1880; Grant 1881; Norton 1890; Demarr 1893; Campbell 1900; North 1901; Cambridge 1903; Degen 1904; Craig 1908; Littler 1910; Lucas & Le Soeuf 1911; Birks 1921; Belcher nd; Hamilton 1914; Serventy 1929b; Evans 1975; Whitley 1975; Atkinson 1980; Waterhouse 1984; Chapman 1985; Atkinson 2001
Vegetation clearing: mining		Whitlock 1937	Gould 1863
Acclimatization	Acclimatisation Board 1897; Acclimatisation Committee 1898, 1899, 1900, 1902, 1903, 1904, 1905		Backhouse 1843; R Gunn in West 1852; Howitt 1855; *The Sydney Morning Herald* 3.12.1860: 4; Anon. 1861; Froggatt 1901; North 1901; Batey 1907b; Craig 1908; White 1919; McKeown 1923; Kiddle 1961; Atkinson 2001
Rabbits: competition for resources			Burrell 1927
Exotic plant disease			
Rabbits: bykill from trapping & poisoning	*The West Australian* 14.7.1923: 14; Le Soeuf 1931		Bisdee 1871; Campbell 1885; Macdonald nd; Verdon 1891; Froggatt 1900; North 1901; J. Wilson 1902; Steel 1906; Lucas 1908; Froggatt 1909; North 1909; Anon. 1911; Lucas & Le Soeuf 1911; Abbott 1913; Froggatt 1913; Hamilton 1914; Bellchambers 1918; Le Soeuf 1923, 1924; Bean 1925; Newland 1926; Burrell 1927; Troughton 1932; Shumack 1967

Fox predation	Le Soeuf 1931	McColl 1929; McDonald 1996; Richards & Short 1996	Campbell 1900; Anon. 1901b; North 1901; Le Soeuf 1902; Anon. 1906b; Froggatt 1906; Steel 1906; Le Soeuf nd; North 1909; Stephen 1909; Macgillivray 1910; Lucas & Le Soeuf 1911; Campbell 1913; Froggatt 1913; Belcher nd; O'Donoghue 1914; Bellchambers 1916; Cook 1916; White 1917; Bellchambers 1918; Brenan 1918; Brown 1918; Gabriel 1919; White 1919; Chenery 1920; Spencer 1921; Hobler 1923; Le Soeuf 1923; McKeown 1923; Le Soeuf & Burrell 1926; Newland 1926; Bolam 1927; Finlayson 1927; de Warren 1928; Troughton 1932; Short 1998

* The references supplied document the operation of the factor; some of the references also discuss impacts of the factor.
** See also accounts of the individual species in text.
*** It is usually unclear whether diseases are natural or exotic; I have assigned these references mindful of this uncertainty.

were ranked (Hoy 1923), but more usually they were considered in a way that implied equality of importance. Often there were differences in opinion about the order of precedence of detrimental factors (e.g. Anon. 1924). Moreover, interaction between these multiple factors was not explicitly evaluated, and the most readily discernible factors may have been given undue weight because of their obviousness. Conversely, inconspicuous or insidious factors may have been overlooked.

Modern ecology recognizes that local population dynamics are influenced by many interacting factors which operate at various scales. For example, drought and fox predation usually operate at a regional scale, but the resilience of local populations of native species should depend upon the extent of habitat available at the landscape scale within which each local population occurs. Unsustainable use (trapping for pelts or recreational shooting) is likely to apply only near villages and towns.

Scientific assessment of the causes of contractions in distribution of species in the avifauna of south-west WA has emphasized the permanent loss of habitat through the conversion of the original vegetation to cereal crops and suburban gardens (e.g. Abbott 1997; Abbott 1998a; How and Dell 1993; Kitchener *et al.* 1982; Saunders and Ingram 1995; Storr 1991). The original continuity of the vegetation is destroyed, and most of the remnants so formed are too small to support many species. Similar declines have occurred in woodlands elsewhere in southern Australia (Ford *et al.* 2001). It is also recognized that logging of jarrah and karri forests can change the abundance of some species but not usually their distribution (e.g. Abbott 1999; Abbott *et al.* 2003; Williams *et al.* 2001). This is similar to responses of bird species to logging of forests in south-east Australia (Kavanagh *et al.* 2005; Loyn 1985; Smith 1985).

Modern assessment of the relative importance of factors responsible for the decline of the mammal fauna of Australia commenced in 1958 (Table 5). The first regional study in WA was published in 1978. These studies provided a more scientifically advanced analysis than the more anecdotal or informal accounts offered during the period 1830-1930. In contrast to avian studies, however, the causes of declines have been controversial (Table 5), resulting in confusion and ambiguity. Part of the reason for this is that none of these 20 studies rigorously assessed change in status of each mammal species in relation to all relevant factors, and thus justified which factors were not of fundamental significance. This is perhaps understandable, given the size of the resultant matrix, the effort needed to collate the requisite distributional information, and the extensive reading of historical literature required to provide essential background. Such a particularized approach is more practicable when only one species is considered and the factors operating across a region or the entire geographic range of the species are analysed (e.g. Newsome 1975; Kerle *et al.* 1992; Lunney *et al.* 1997).

Most of the studies summarized in Table 5 have considered the kind of likely synergic interactions between causal factors, but usually in a perfunctory way. In contrast,

Table 5

Modern assessments of causes of declines and extinctions in the mammal fauna of various parts of Australia.

Fauna	No. species	Proposed causal factors	Status of all species systematically & explicitly assessed against all factors?	Interactions between factors explicitly considered?	Historical sequence of factors adequately considered?	Any key factor not assessed?	Reference
NSW, marsupials	52	Destruction or alteration of habitat (major); Predation by cats and foxes; Killing of animals for skins, sport, pest control (minor)	No	Yes (rainfall x vegetation cover)	No	No	Marlow 1958
central Australia (NT & SA)	63	Competition for food plants with livestock & rabbits; Fox predation; Increasing aridity commencing before European settlement; Hunting by Aborigines & settlers (minor); Cat predation (minor); Disease (minor)	No	Yes (rabbit x fox x feral cat)	Yes	No	Finlayson 1961
WA, northern Swan Coastal Plain	c. 33	Disease and predation by feral cats (major); Frequent burning of vegetation by wildfire; Destruction of habitat in moist areas	No	No	No	No	Kitchener *et al.* 1978
WA, south-west	52	Two waves of extinction caused by predation by feral cats and foxes	No	Yes (rabbit x fox; livestock x fox; rainfall x vegetation cover)	Yes	Disease	Baynes 1979
WA, Wheatbelt,	44	Homogenization of habitat patchiness by changed fire regime (major); Clearing of native vegetation; Area of native vegetation remaining;	No	Yes (vegetation type x remnant area)	No	Disease	Kitchener *et al.* 1980
WA, south-west Kimberley	51	Pastoralism (grazing and burning)	No	No	No	Disease	McKenzie 1981
NSW, western & Victoria, north-west	41	Pastoralism (change from small heterogeneous patches maintained by Aboriginal fire regime to large homogeneous patches), before 1880	No	Yes (fire frequency x rainfall x vegetation type)	Yes	Disease	Allen 1983
central Australia, pastoral areas	10 medium-sized species	Degradation of habitat by livestock; Competition from rabbits; Droughts; Loss of fine-grained patchiness of habitat previously maintained by Aboriginal fire regime	No	Yes (drought x livestock & rabbit grazing; Aboriginal depopulation x fire intensity)	Yes	Disease	Low 1986
WA, coastal country between Busselton & Albany	18 (marsupials & rodents)	Clearing of native vegetation; Wildfires; Introduced species; Disease	No	Yes (clearing x grazing; clearing x predation by cat, fox)	No	No	How *et al.* 1987

NSW, Bega district	23	Clearing of native vegetation; Wildfires; Introduced mammal species; Disease	No	Yes (x poisoning of rabbits; fox x rabbits; nutritional stress x disease; cat x disease)	Yes	No	Lunney & Leary 1988
Australia	50 (macropodids)	Homogenization of vegetation from changed fire regime; Predation by foxes; Drought. No universal single primary factor or combination of factors	No	Yes (fox x remnants; drought x fertile patches; dingo x fox x cat)	No	No	Johnson *et al.* 1989
Australia, south-east (SA, NSW, Vic), mallee region	60	Grazing by livestock, exacerbated by ater rabbit plagues	No	Yes (shelter x grazing & predation; mouse plagues x exotic predators; rabbit x fox x cat)	Yes	Disease	Bennett *et al.* 1989
WA, subdivided into 6 districts	102	Reduction in available environmental productivity (mean annual rainfall); Diversion of environmental resources to crops, livestock, rabbits & exotic predators	No	Yes (habitat x exposure to predation; fire regime x habitat patchiness)	No	No	Burbidge & McKenzie 1989
Australia, arid zone	72	After drought, recovery of vegetation in refugial habitats prevented by livestock and rabbits (major); Introduced predators and altered patterns of fires (minor)	No	Yes (rabbit x fox x cat)	No	Disease	Morton 1990
SA, Flinders Range	c. 47	Habitat degradation from overgrazing by livestock	No	Yes (grazing x drought)	No	Disease	Tunbridge 1991
NSW, Western Division	71	Two waves of extinction: Cat predation, then vegetation removal by livestock in combination with spread of the fox	No	Yes (different combinations of factors in different areas)	No	Disease	Dickman *et al.* 1993
Australia,	48 (conilurine rodents)	Predation by cats, foxes & dingoes, elevated and sustained by rabbits & house mice	No	Yes (shelter x fire; shelter x livestock grazing)	No	Disease	Smith & Quin 1996
NSW	5 (potoroid marsupials)	Predation by fox, 1890-1920	No	Yes (x drought; x livestock grazing; x rabbit)	Yes	Disease	Short 1998
NSW, Western Division	50	Habitat alteration by sheep, exacerbated by frequent drought, and followed by a rabbit plague and the establishment of the fox	No	Yes (artesian water supplies x fencing x overgrazing by sheep)	Yes	Disease	Lunney 2001
Qld, south-west	32	Irruption of *Rattus villosissimus* and extensive wildfire, followed by increased populations of cats & foxes	No	Yes (x La Niña)	Yes	Disease	Letnic & Dickman 2006
Australia	306	Regional productivity (mean annual rainfall), phylogeny, whether species shelters on the ground, body weight, period since fox established	No	Yes (in a statistical sense)	Yes	Disease	McKenzie *et al.* 2007

few offered any sophisticated analysis based on the actual or likely historical sequence of causal factors. It was also generally assumed that the last record, as represented by a specimen lodged in a museum collection, approximates the year of extinction. The one factor most commonly neglected, overlooked or superficially assessed as a possible causal factor is introduced disease.

The synoptic overview presented in Table 5 clearly demonstrates that consensus as to the dominant factors responsible for declines and extinctions of mammal species has remained elusive. Seldom has a single factor been regarded as both necessary and sufficient. There have also been interesting changes in the taxonomy of factors involved in the decline and extinction of Australian mammal species. For example, Le Soeuf (1923), who seems to have provided the first systematic classification, recognized only four factors: introduction of the fox, cat and rabbit; shooting and trapping for the fur market; opening up of the country by settlement (including rabbit poisoning); and disease. This was simplified to three factors by Marlow (1958): killing for skins, sport, or in pest control operations; predation by the fox and cat; and destruction and alteration of habitat. Two main factors were listed by Calaby (1969: 100): changes due to clearing and especially grazing by domestic stock, aggravated by the rabbit; and 'natural long-term environmental changes'. Three 'main' factors were recognized by Newsome (1971): competition for food, with sheep and cattle; removal of shelter, by sheep and cattle; and increased predation because livestock had decreased vegetation cover. Eleven factors were identified by Short (1999) as being relevant: livestock, rabbits, fire mosaic, removal and fragmentation of vegetation (these five causing habitat change); foxes, cats and hunting (predation); climatic change; extended drought; and disease. In this paper, although I recognize 29 factors, many of these actually represent a finer subdivision of factors discussed previously in the literature. (This number should not be considered complete, e.g. see Macgillivray 1901: 76; Berney 1906: 46; Rogers 1906; de Warren 1928: 113; Dickison 1928; Robertson and Scanlan 1932; Jenkins 1950).

Based on the individual species accounts for south-west WA presented earlier in this paper, my assessment of the relative importance of the 29 factors relevant to changing the distribution and abundance of species in south-west WA is summarized in Tables 6, 7 and 8. My conceptual framework (termed the 'fusion' model) involves a three-tiered hierarchy of relevant factors, and recognizes that one or two main factors operating at one time can explain the how, when, and where of species declines (Fig. 47). The main factor is not necessarily the same for each species.

Tertiary factors are those that are important only at local scales or which occur infrequently or slowly. Secondary factors are those that occur over a broader scale but act only occasionally or intermittently. Primary factors are those that are ongoing over large scales (relative to the original geographic range of each species in south-west WA). Where multiple factors have been identified, some operated sequentially and others operated concurrently. Factors can also act gradually and incrementally (e.g. predation by foxes, clearing of vegetation), or suddenly and spectacularly (e.g. epizootic disease, drought, wildfire).

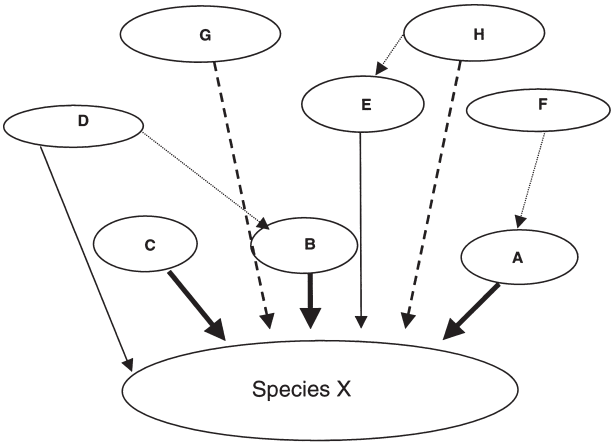

Fig. 47 The 'fusion' model. Diagrammatic representation of factors (A-H) influencing the distribution and abundance of a species (X), making the distinction between primary (A-C), secondary (D-F) and tertiary (G-H) factors, so that factors in the upper planes have less direct influence on species X.

The fusion model is not an eclectic or composite conceptual model that has been pieced together from previous studies. It attempts to give a sharper edge to the interplay of the various relevant factors.

Only one of the nine bird species assessed *(Neophema splendida)* was influenced by a single primary factor (Table 6). Three other species *(Burhinus grallarius, Vanellus tricolor* and *Cacatua pastinator)* were influenced by two primary factors operating in opposite ways. These factors were unequal and therefore did not neutralize each other, with the beneficial factor unable to compensate for the detrimental factor (fox predation). The remaining bird species assessed were influenced by two or more primary factors operating in the same direction, mostly concurrently, although sequentially in the case of *Leipoa ocellata* (Aboriginal predation of eggs would have ceased before clearing of vegetation had become important).

In contrast, modern syntheses of factors responsible for changes in distribution and abundance of these nine bird species usually treat all relevant factors as equivalent, and do not adequately consider interactions between factors (Marchant and Higgins 1993; Saunders and Ingram 1995; Johnstone and Storr 1998; Higgins 1999; Higgins *et al.* 2001).

Of the 27 mammal species assessed (Table 7), 11 are considered to have been influenced by a single primary factor (disease for 8 species, clearing of vegetation for 2 species, and predation by foxes for one species). The remaining 16 species were influenced by two or more primary factors, operating in the same direction for 15 of these species. These factors usually operated sequentially, with Aboriginal predation or disease preceding predation by foxes.

The framework presented here (of a series of primary

Table 6
Assessment of factors influencing the ecology in south-west WA of the bird species studied (- deleterious, + beneficial).

Species	Primary factor(s)	Secondary factor(s)	Tertiary factor(s)	Indirect factor(s)
Leipoa ocellata	- Aboriginal predation of eggs - Clearing of vegetation - Disease - Vulpine predation	- Drought - Shooting of birds by settlers for food	- Inappropriate fire regime - Feline predation	- Fox population increased by dense rabbit population and carrion
Ardeotis australis	- Predation by settlers - Vulpine predation	+ Crops and farm dams + Fires + Grasshopper plagues (unploughed farmland)		- Fox population increased by dense rabbit population and carrion
Burhinus grallarius	+ Clearing of vegetation - Vulpine predation	+ Provision of water	- Feline predation - Bycatch (poisoned water intended for rabbits) - Bycatch (capture in rabbit traps)	- Fox population increased by dense rabbit population and carrion
Vanellus tricolor	+ Clearing of vegetation - Vulpine predation	- Ploughing (nest destruction) - Inappropriate pasture management		- Fox population increased by dense rabbit population and carrion
Calyptorhynchus banksii naso	- Clearing of forests for farms - Usurpation of nest hollows by feral honeybees	- Aboriginal predation - Shooting of birds by settlers for food or sport	- Storms (nest trees blown down) + Strong winds (large branches or crowns broken off, thereby creating nest hollows) - High intensity wildfires (nest trees burnt down) - Logging of nest trees + *Phytophthora* infection (dead branches and trees provide nest sites)	
Cacatua pastinator	- Poisoning by farmers + Crops (sown seed and mature seed)		- Shooting of birds by settlers for food	
Cacatua leadbeateri	- Clearing of vegetation - Taking of young birds from nest hollows			
Neophema splendida	- Clearing of vegetation			
Atrichornis clamosus	- High intensity fire - Disease		-Vulpine predation - Feline predation	- Fox population increased by dense rabbit population and carrion

factors influenced by a contemporary set of attendant circumstances, Fig. 47) differs subtly from recent ones, which emphasize the accumulated effects of several factors acting in concert (How *et al.* 1987; Morton 1990) or in combination (Low 1986; Recher and Lim 1990; Kerle *et al.* 1992), and the effects and complex interactions of other factors (Kinnear *et al.* 1988). The perspective used in this paper (and also in Abbott 2001b) is most similar to Allen (1983), Bennett *et al.* (1989) and Lunney (2001), in which they identified one dominant factor (operating from the 1840s) as depleting populations of native mammals, making them vulnerable to collateral factors that began to operate in the 1880s and 1890s. In these case studies (western NSW and north-west Victoria, mallee region of south-east Australia, western New South Wales), the primary factor was the establishment of pastoralism and the secondary factors were the incursions of rabbits and foxes. However, these studies, unlike mine, did not attempt a species by species assessment against all relevant factors.

My study found little support for the key ingredient of the mutiple factors concept, that individual factors operate negligibly when separate but collectively become significant when operating simultaneously or in aggregate. Thus a confluence of factors may occur without all factors having equivalent impact. The collective impact of these factors may also accumulate incrementally and additively. The argument that extinction mechanisms are inherently synergistic, instead of there being a single dominant mechanism (Pimm 1996), should be rejected until all available historical information is assembled, analysed, interpreted with logical rigour and then synthesized.

Table 7

Assessment of factors influencing the ecology in south-west WA of the mammal species studied (– deleterious, + beneficial).

Species	Primary factor(s)	Secondary factor(s)	Tertiary factor(s)	Indirect factor(s)
Tachyglossus aculeatus	- Aboriginal predation - Vulpine predation		- Removal of shelter during era of rabbit plagues	- Fox population increased by dense rabbit population and carrion
Dasyurus geoffroii	- Disease (northern sector) - Vulpine predation	- Shooting by settlers if poultry kept - Bycatch in rabbit traps	- Bycatch (poisoned baits intended for dingoes and wild dogs)	- Fox population increased by dense rabbit population and carrion
Phascogale sp. n aff. *tapoatafa*	- Disease - Drought	+ Farms (house mice and insects)	- Logging of forests	
Myrmecobius fasciatus	- Disease (northern sector) - Vulpine predation	- Clearing of logs and fumigation of burrows for rabbit control	- Feline predation - Clearing of vegetation	- Fox population increased by dense rabbit population and carrion
Chaeropus ecaudatus	- Disease			
Isoodon obesulus	- Disease (northern sector) - Vulpine predation	+ Potatoes, garden vegetables + Grain - Aboriginal predation - Consumption by settlers - Bycatch (poisoned wheat intended for parrots)	- Feline predation	- Fox population increased by dense rabbit population and carrion
Perameles bougainville	- Disease			
Macrotis lagotis	- Vulpine predation - Disease (northern sector)	- Bycatch from rabbit traps - Trapping for pelt - Consumption of poison baits intended for rabbits - Destruction of burrows by deep ripping (rabbit control)	- Aboriginal predation - Usurpation of burrows by rabbits - Poisoning of water for rabbit control - Drought	- Fox population increased by dense rabbit population and carrion
Bettongia lesueur	- Disease - Poisoning - Trapping - Vulpine predation - Consumption of poisoned baits intended for rabbits	+ Crops + Gardens	- Shooting and poisoning of wedge-tailed eagles - Aboriginal predation - Consumption by settlers	- Fox population increased by dense rabbit population and carrion
Bettongia penicillata	- Disease - Poisoning - Trapping - Vulpine predation	+ Crops + Gardens - Bycatch from rabbit trapping	- Shooting and poisoning of wedge-tailed eagles - Aboriginal predation - Consumption by settlers	- Fox population increased by dense rabbit population and carrion
Potorous platyops	- Disease			
Potorous gilbertii	- Disease			
Lagorchestes hirsutus	- Disease	- Vulpine predation		- Fox population increased by dense rabbit population and carrion
Lagostrophus fasciatus	-Disease			
Macropus eugenii	- Vulpine predation - Clearing of vegetation - Disease	- Shooting by settlers for food + Crops - Shooting for skins for fur trade	- Aboriginal predation + Shooting and poisoning of wedge-tailed eagles and dingoes	- Fox population increased by dense rabbit population and carrion
Macropus fuliginosus	- Shooting by settlers for food - Shooting for skins for fur trade - Clearing of vegetation	+ Crops + Fruit trees (bark) + Frequent fires in grassy woodlands	- Aboriginal predation - Infrequent fires in forests, reducing green pick	

Table 7 (cont.)

Species	Primary factor(s)	Secondary factor(s)	Tertiary factor(s)	Indirect factor(s)
Macropus irma	- Clearing of vegetation - Vulpine pedation	- Shooting by settlers for food + Crops, fruit trees, pine trees - Hunting for fur trade - Disease	- Aboriginal predation - Hunt clubs - Infrequent fires in forests, reducing green pick	- Fox population increased by dense rabbit population and carrion
Macropus robustus	+Clearing of vegetation			
Macropus rufus	+Clearing of vegetation			
Onychogalea lunata	- Disease	- Clearing of vegetation	- Aboriginal predation	
Petrogale lateralis	- Vulpine predation	+ Crops adjacent to rocky habitat		- Fox population increased by dense rabbit population and carrion
Setonix brachyurus	- Disease - Vulpine predation	- Snaring for skins for fur trade + Garden crops, orchards, pine plantations - Poisoning in pine plantations and gardens - Bycatch from poison baits intended for rabbits - Clearing of swamp vegetation	- Shooting by settlers for food - Capture by hunting dogs - Aboriginal predation + Shooting and poisoning of wedge-tailed eagles and dingoes - Intense wildfire temporarily removing shelter - Infrequent fire resulting in habitat senescence	- Fox population increased by dense rabbit population and carrion
Trichosurus vulpecula	- Disease - Snaring for skins for fur trade - Vulpine predation - Clearing of trees for farming	+ Fruit, flowers, vegetables - Aboriginal predation - Bycatch from poisoning of rabbits and dingoes	-Shooting by settlers for food -Suburbanization	- Fox population increased by dense rabbit population and carrion
Pseudocheirus occidentalis	- Disease - Bycatch from snares set for koomal - Vulpine predation		- Clearing of vegetation in swamps - Feline predation	- Fox population increased by dense rabbit population and carrion
Hydromys chrysogaster	- Snaring for skins for fur trade - Salinization of streams and consequent reduction in aquatic food from clearing of vegetation			
Leporillus apicalis	- Disease			
Canis lupus dingo	+ Sheep flocks - Trapping and shooting (bounty) - Poisoning with baits - Clearing of native vegetation + Cross-breeding with dogs	+ Rabbit plagues as food source	- Aboriginal predation + Aboriginal hunting companions	

Imperfect understanding, conceptualized on the basis of complex, multicausal processes, should not be used to obfuscate the operation of a simple dominant mechanism.

Feedback loops, representing predation and hyperpredation (mesopredator release) between Aborigines, dingoes, foxes, feral cats, rabbits and house mice, are currently in vogue to explain declines and extinctions of native mammal species (Smith and Quin 1996; Glen and Dickman 2005; Johnson 2006). However, the supposed strength of these linkages does not always fit the historical evidence available for south-west WA and relevant ecological information from elsewhere in Australia:

- Aboriginal depopulation of south-west WA was a discontinuous process that occurred over a long period, from c. 1840 to c. 1900, and took place first around towns and villages as European diseases were introduced with the arrival of ships. Yet, feral cats

were not first reported close to the coast but farther inland, and at a time when Aboriginal populations there were still intact. Because native prey such as koomal and kangaroo remained abundant during most of this period, it is unlikely that feral cats ever formed a major portion of the Noongar diet.

- The presence of dingoes in the less settled interior portions of south-west WA in the 1910s and 1920s did not impede the colonization and establishment of the fox.
- In the 1950s and 1960s, dingoes did not prevent the fox from invading extensive areas of soon-to-be-cleared kwongan vegetation along the south coast (Archer 1979: 58; Anon. 1989: 2, 23, 132; Plunkett and Wimbush 1999: 5; Southern Scribes 1999: 182). In contrast, there is evidence from Northam/Tammin district of an inverse relationship between the abundance of dingoes and foxes (Repton 1999: 309; Abbott 2001b: 290).
- Although rabbit populations do elevate fox populations (Christensen 1980; Christensen *et al.* 1985: 30), marsupials were once again frequently recorded (implying an increase in abundance) in the early 1950s (Aitken 1954; Carnaby 1954; Jones 1954; Loaring 1954; Serventy 1954), *before* rabbit populations collapsed following the myxomatosis epizootic of 1955.
- Large populations of rabbits were not a necessary condition for the fox to cause declines and extinctions of prey species in jarrah forests, because rabbits were always scarce there.
- Foxes rarely eat feral cats (indicated by a review of 29 Australian studies published during the period 1963-2006); indeed, cats were not recorded in the stomachs or scats of foxes in 24 of these studies.
- Dingoes rarely eat foxes or feral cats (Whitehouse 1977; Breckwoldt 1988; Corbett 1995).
- Evidence of mesopredator (feral cat) release following baiting, exclusion, or natural absence of foxes is weak. Relative abundances of cats and foxes at two sites during 4-6 years in south-west WA (King and Wheeler 1985) offer no consistent support for this hypothesis. Feral cats are not consistently more common on the South Australian side of the dingo barrier fence; yet foxes are consistently less abundant and dingoes are present (Newsome *et al.* 2001). In an experimental study in central New South Wales, feral cats responded inconsistently in two areas from which foxes were removed (Davey *et al.* 2006). The prevalence of feral cats in the Northern Territory is not inversely related to that of the fox (Southgate *et al.* 2007).
- There is so far no evidence that impacts of feral cats on native mammals have increased since 1996 in the wetter portion of south-west WA following widespread poison baiting of foxes.

Current research being undertaken in the northern jarrah forest, Dryandra Woodland and Lake Magenta Nature Reserve on changes in diet, activity, and abundance of chuditch, carpet pythons, varanids and feral cats, following reduction of fox populations, should clarify the significance of mesopredator release in south-west WA.

Changes in distribution and abundance of the species assessed for this paper did not occur particularly rapidly (several decades, not a few years). This matches the relatively slow spread of epizootic disease into south-west WA from the north, north-east and east (Fig. 48), the patchy and slow rate of clearing as evidenced by the areal extent of wheat grown each year (Fig. 49), and the arrival and gradual establishment and increase of the rabbit and fox in the 1910s and 1920s respectively (Fig. 38, 39, 41, 42, 43). If a complex of factors were operating together, the process of decline should have occurred more rapidly.

Another questionable concept prevalent in the literature is that some factors operating at present to cause declines were operating in the 1800s. For example, some authors have retrospectively invoked predation by cats, based on Christensen and Burrows (1994) and Dickman (1996), to explain early declines of native mammals. However, observations in central Australia showed that declines there occurred after 1930 (Finlayson 1958), decades after the cat established in inland Australia in the 1880s (Abbott 2002). The factor that caused a species to decline initially may have been different from a factor operating at the present, or the factor that caused the terminal decline of a species (Allen 1983; Burbidge and McKenzie 1989). A sound knowledge of historical changes in land use and other human activities helps clarify the relevance, pervasiveness and transience of possible factors (Abbott 2004), and avert the development of unnecessarily complex explanations of faunal change.

The potential occurrence of 29 factors can easily lead to confounding and the masking of the important factor(s) by more visible and conspicuous factors. For example, fox predation exaggerates the need for cover by prey species. '[I]f this is not recognised and appreciated it can distort ecological judgements by fostering perceptions that equate refugia as representative of species habitat requirements. When this perception prevails, other factors, such as habitat loss, degradation…and fragmentation, are evoked as major causes and inappropriate mangement actions or inactions may ensue' (Kinnear *et al.* 1998: 87).

Historical explanations do not of course lend themselves to adequate experimental testing. Therefore, in developing a theory with a substantial historical basis, it is important that a proper balance is struck between simplicity and complexity. If only a single cause is proposed, the theory may be too over-simplified to be useful, have too many exceptions to be credible, or include too many incongruities to have heuristic value. If a complex set of factors is instead put forward, the spirit of Ockham's razor is subverted. The assumptions and limitations of the theory may not then be subjectible to critical inquiry and rigorous examination because so many factors (including unrecognized superfluities) can be accommodated in the conceptual model. An additional risk is that complicated theories may fail to differentiate factors properly. My approach, of distinguishing chains of

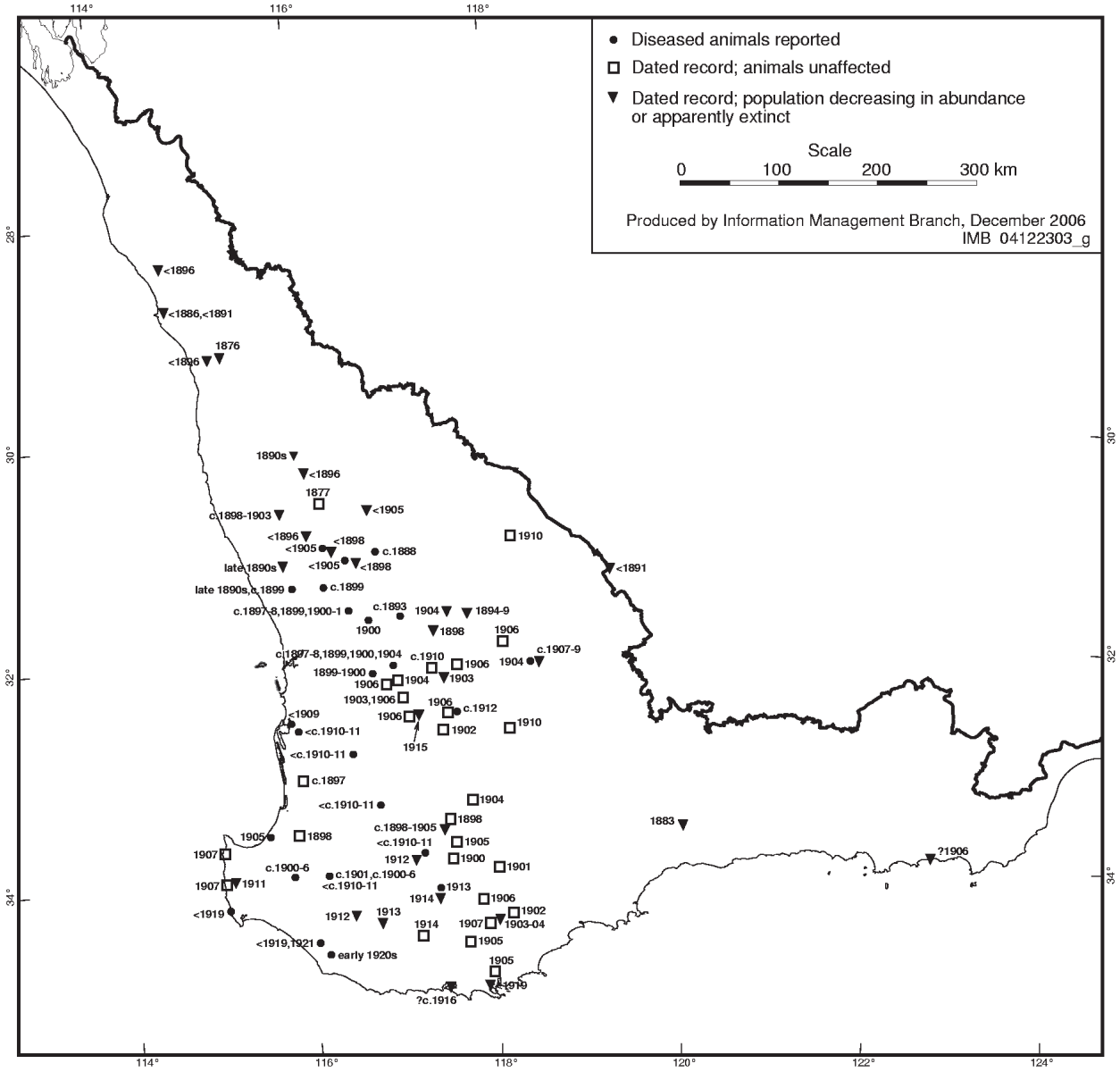

Fig. 48 Spread of an epizootic from the northern and eastern sectors of south-west WA in the early 1880s to the lower south-west sector by the early 1920s. Source: Abbott (2006); The West Australian *14.11.1925: 15.*

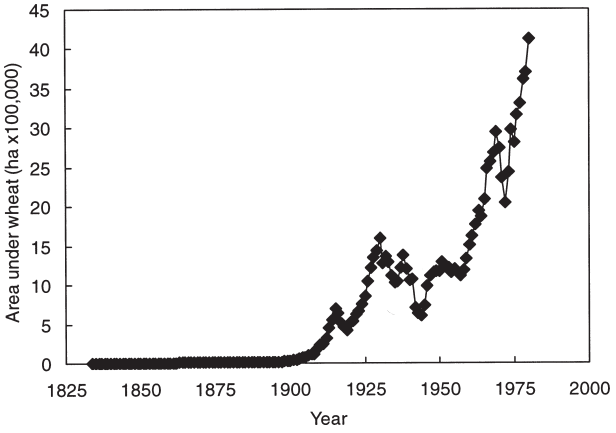

Fig. 49 Area planted to wheat in Western Australia, 1830-1980. Source: Dunsdorf 1956: 532-3; WA Year Book 1991: 280.

primary factors influenced by secondary and tertiary factors and of separating obvious factors from subtle or less overt factors, is intended to find the middle ground between simplistic/superficial theory and sophisticated/over-complicated theory.

Factors identified and how they operated in south-west WA in space and time

Based on previous analyses by Shortridge (1910, 1936), Baynes (1979), Kitchener *et al.* (1980), Christensen (1980) and Burbidge and McKenzie (1989), Abbott (2001) listed 15 factors relevant to explaining declines of mammal species in south-west WA. Further consideration has resulted in an additional 14 factors (Table 8).

The first six factors listed in Table 8 precede settlement by Europeans and are treated as natural

Table 8

Natural and post-settlement disturbances relevant to assessing changes in the distribution and abundance of fauna in south-west WA

Factor	Period																
	1830s	1840s	1850s	1860s	1870s	1880s	1890s	1900s	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s
Drought	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
Fire frequency	3	3	2	2	2	2	2	2	2	1	1	1	2	2	2	1	1
Fire intensity and scale	1	1	1	1	2	2	2	2	3	2	2	2	2	2	3	1	1
Aboriginal predation	3	3	2	2	2	1	1	1									
Dingo predation	1	2	2	2	2	2	3	3	3	3	2	1	1	1			
Natural disease	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Provision of new foods (fruit, bark, vegetables, seed, sheep, poultry)	1	1	1	1	1	1	2	2	2	2	1	1	1	1	1	1	1
Provision of new breeding sites (buildings, mine shafts)		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pastoralism	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1
Provision of water						1	1	2	2	2	2	3	3	3	3	3	3
Vegetation clearing: farms	1	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3
Vegetation clearing: villages & towns	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3
Drainage	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2
Hunting for food/sport	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
Cat predation	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2
Introduced rodents	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Collection of specimens for museums or for study (including eggs)	1	1					1	1	1	1	1	1	1	1	1	1	1
Trapping, shooting & poisoning of native animals eating seed, fruit, crops, stored products		1	1	1	1	1	2	2	2	2	1						
Poisoning of wedge-tailed eagles					1		1	1	1	1	1						
Hunting/trapping for pelts/feathers		1	1	1	2	2	3	3	2	2	2	2					
Logging of forest			1	1	1	1	1	1	2	2	2	2	2	2	2	2	1
Exotic animal disease						2	3	3	3	3	1	1	1	1	1	1	1
Capture of birds & mammals for pets & for zoos						1	1	1	1	1	1	1					
Vegetation clearing: mining						1								2	2	2	2
Acclimatization							2										
Rabbits: competition for resources									1	2	3	3	1	1	1	1	1
Exotic plant disease										1	1	1	2	2	2	2	2
Rabbits: bykill from trapping & poisoning										2	2	2					
Fox predation										1	2	3	3	3	3	3	1

Blank = absent, not relevant, negligible

1 = low level (limited extent, infrequent)

2 = moderate level (broadscale, recurrent)

3 = high level (widespread, frequent)

Note that numbers in columns and rows are not intended to be additive.

factors. As noted by Marlow (1958: 110), the fauna as a whole was adjusted to predation by marsupial carnivores and the dingo, and to environmental factors such as droughts and fires. These factors interrupted, rather than disrupted, the ecology of each species. It seems reasonable to expect a balance between the impact of these six natural factors: Drought years should have resulted in more intense fires (from lightning strikes) and increased predation by dingoes and Aborigines close to permanent water sources. Periods of above average rainfall would be expected to increase the amount of litter on the ground and the population of soil fungi on which many mammal species feed, reduce the incidence of fires initiated by lightning strikes, and increase predation by Aborigines in the interior of the south-west region. Cultural restraints exercised by Aborigines in terms of protection of totemic species and the recognition of *tapu* activities would have served as an additional check on impacts on any one species. The settler G. Moore in 1833 thought that without Aboriginal predation of young parrots (taken from nest hollows in trees), 'we should be overrun with them' (Cameron 2006: 299). In conclusion, there would have been localized increases and decreases in abundance of species and over time minor expansion and contraction of geographical ranges of species.

1820s-1860s

Settlement by Europeans in the late 1820s was a catalyst for change because it increased the number of factors from six to 29, but not all operated at once, equally importantly, or everywhere in south-west WA (Abbott 2004). Drought conditions were first recorded by settlers in 1838 (*Perth Gazette* 26.5.1838: 82; Cameron 2006: 443-4, 448, 455, 463) and subsequently in c. 22 years between 1856 and 1920 (Foley 1957). Aboriginal fire regimes probably did not alter much at this time, commensurate with the extent that tribal life remained intact (Abbott 2003). Dingo predation on stock was minimized by the shepherding of sheep during the day and confinement in temporary yards at night. Skirmishes between Aborigines and settlers arose within a few years of settlement (near Perth), resulting in Aboriginal recognition that settlement was to be permanent. Aboriginal populations were not impacted greatly by European diseases in the 1830s.

The larger native birds were first offered more generally for sale at the Perth market in 1833 (*The Perth Gazette* 2.3.1833: 35; see also Cameron 2006: 284). The biggest impact of settlement in the 1830s was the local reduction in kangaroo and cockatoo populations in and around settled areas (*The Perth Gazette* 7.9.1833: 142-3; Cottesloe 1979: 92; Berryman 2002: 130; Cameron 2006: 9). This eventuated because settlers were reluctant to slaughter their sheep, cattle and pigs until livestock populations had increased. Clearing of vegetation for the growing of crops was limited for practical reasons, including lack of export markets, shortage of labour, and unsophisticated technology (Abbott 2004). Weeds were inadvertently introduced (*The Inquirer* 13.7.1842, 27.7.1842, 3.8.1842, 22.2.1843, 8.3.1843, 19.4.1843, 17.5.1843, 6.9.1843). Plant species palatable to stock became scarce (*The Inquirer* 8.3.1843, 24.5.1843). Several Banksia species were the principal source of firewood for Perth and Albany and thus experienced population declines (*The Inquirer* 19.10.1842). Settlers in Middle and Upper Swan districts declared in 1836 that they had 'now accomplished the arduous difficulties of transforming a wilderness into a fruitful and civilized district' (*The Perth Gazette* 2.4.1836: 679). The European population in south-west WA remained low (2154 persons in 1839). Lands on which York gum occurred carried grassland (J. Drummond in *The Inquirer* 22.3.1843) and thus provided good sheep pasture (Moore 1842: 70).

An Agricultural Society was formed in 1831. It agreed to pay a bounty for the dingo in 1834 (*The Perth Gazette* 15.11.1834: 392) and the 'Hawk' in 1836 (*The Perth Gazette* 6.2.1836: 646). Rewards were paid for the destruction of 24 dingoes and 112 hawks for the 12 months to 4.8.1837 (*Perth Gazette* 5.8.1837: 949), or 58 dingoes and 233 hawks for 1837 (*Perth Gazette* 3.2.1838: 18). Following its union with the York Agricultural Society, the Society subsequently included as one of its ten objectives to 'promote the extirpation of noxious animals and plants' (*The Perth Gazette* 6.11.1841; The Western Australian Almanack 1842: 53).

Although the Governor agreed in 1831 to provide an endowment of land for a Western Australian Institution, which included 'a Museum for curiosities connected with the natural history of Western Australia' and a botanic garden (*Western Australian Farmers' Gazette and Market Report* **3 (8)**: 3-4, 1904), it appears that only a small collection of faunal specimens was assembled until 1892 (BH Woodward in Department of Lands and Surveys 1893: 35). The fate of bird collections made by settlers (*Perth Gazette* 4.5.1838: 69; *The Advertiser [=Perth Gazette]* 22.2.1840; *The Perth Gazette* 27.6.1840, 4.12.1841; *The Inquirer* 1.12.1841) is not known, but presumably these were lost to science. Packages of 'natural curiosities' were exported (*Perth Gazette* 20.10.1838: 167; *The Perth Gazette* 9.9.1848).

Nor could the collecting activities of Gilbert and Preiss have had anything but a minor and transient impact on fauna. These collectors did not gather large series of specimens, probably because their main objective was to obtain new species and not document variation. Logistics also limited the size of their collections, with specimens having to be transported to Fremantle on horseback.

With the arrival from 1829 of livestock and domestic animals in ships from Britain, South Africa, Mauritius, India, Bali, Java, Malaya, Singapore, Sydney, Timor, Launceston and Hobart (Berryman 2002: 56, 86, 89, 112, 116, 144, 148, 260; Cameron 1981: 102; *The Perth Gazette* 1833-43), some animal diseases should have been inadvertently introduced. Nevertheless, there is no indication from the collecting efforts of John Gilbert in 1839-40 and 1842-3 of bird and mammal species in or near settled areas being difficult to procure, or of records of sudden decline of conspicuous animals in letters and diaries of colonists or in articles published in local newspapers.

Apart from bringing livestock (sheep, cattle, goats, pigs, horses and donkeys), poultry, domestic pets (dogs, cats, ferrets, rabbits) and accidental introductions (house mice and black rats), as discussed in the species accounts, early settlers also brought canaries *Serinus canaria*, domestic pigeons *Columba livia* and the common pheasant *Phasianus colchicus* (1829: Kellam 1831: 7, Bassett 1954: 92, Moore *et al.* 1991: 124; 1830: Turner 1956: 83, Shoobert 2005: 128; 1831; Statham 1981: 207; 1841: Johnston 1962: 48; 1843: Bolton *et al.* 1992: 95). One vessel left England in 1829 with 16 deer for WA but none were landed in WA (Berryman 2002: 47). A vessel arriving from Calcutta in April 1839 included five deer, two hares, six peacocks and 12 guinea pigs in its cargo (*Perth Gazette* 20.4.1839: 62), but it is not clear if any of these were purchased locally.

In the 1840s settlers spread out from Perth, Augusta, Busselton, Albany, Toodyay and York, seeking grassy woodlands on which to depasture sheep and cattle. This occurred because the livestock of settlers had increased 'to the full extent of the pastoral capabilities of the known available country' (Gregory and Gregory 1884: 13; see also Cowan 1977: 96, 108; Mann 2006: 233). Grassland occurred, however, in isolated patches, except near Geraldton, Irwin River, Victoria Plains, Avon valley, Williams, Kojonup and Eticup (Cockburn-Campbell 1886: 482; see also *The Inquirer* 2.2.1842). Attempts were made to suppress Aboriginal firing of bushland from 1847. European diseases such as influenza began to increase mortality of Aborigines (Green 1984: 235). An export market in kangaroo hides commenced in 1848. The successful collecting efforts of Ludwig Preiss and John Gilbert in the late 1830s and early 1840s indicated few obvious impacts on bird and mammal species. By 1848, wetlands near Perth were perceived as stagnant and unhealthy, and consideration was given to draining them (*The Perth Gazette* 1.7.1848, 28.4.1854, 9.5.1856: 2). Previously, the expense involved was a deterrent (*The Perth Gazette* 10.10.1840).

Deployment of poison baits to repress dingoes became more widespread in the 1850s. The 1850s involved futher expansion of settlement, to Geraldton, with continuing incremental infilling around and along summer sources of water until the 1880s. Convict labour was available in the period 1850-68, resulting in improved road networks. However, the cost of transporting wheat to the coast was not competitive with imports of grain from South Australia (Battye 1929). Pastoralism remained the main industry. In older settled areas, such as York, native grasses had nearly disappeared but had been replaced by weeds and 'more useful' (?introduced) grasses, and springs of freshwater were appearing in many places (*The Perth Gazette* 16.9.1848; *The Inquirer and Commercial News* 20.1.1858). In 1863 settlement in WA first occurred outside the south-west.

Although the Agricultural Society of WA in 1843 was 'desirous' of introducing pheasants, partridges and camels (*The Inquirer* 5.7.1843; Moore 1843: lxi), nothing eventuated. In 1851 the Government announced that it was 'anxious' to encourage the introduction of camels and alpacas, and would pay a bonus for one male and two female camels (£60) and two male and eight female alpacas *Lama pacos* (£50) landed within 12 months (*Government Gazette* 7.1.1851: 2). Although the introduction of the alpaca was considered 'highly important' and 'useful' (*The Inquirer* 15.1.1851, 22.1.1851, 19.2.1851, 26.2.1851), and the York Agricultural Society expressed interest in introducing the alpaca (*The Inquirer* 5.2.1851, 4.6.1851; *The Western Mail* 11.1.1908: 6), no importation eventuated. The first offer to arrange for the collection of fish species in Victoria for introduction to WA was made (by F. von Mueller) at the close of this period (letter written in Albany, 28.10.1867, to FP Barlee, Colonial Secretary of WA [Home *et al.* 2002: 433-7]; *The Perth Gazette* 22.11.1867).

After the departure of Preiss in 1842 and Gilbert in 1843, there was no further collecting of faunal specimens until the two visits by George Masters in the late 1860s (Glauert 1950; Abbott 1999). He collected only in Albany district, and it is most unlikely he had any impact on the distribution and abundance of birds and mammals. All of his material was deposited in the Macleay and Australian Museums, Sydney.

1870s-1890s

It is unlikely that pastoral activities involving sheep had major impacts on native vegetation dominated by salmon gum, as these woodlands lacked permanent springs, and salt water was more frequently found than fresh in well sinking (JH Monger in Select Committee 1881). Salmon gum woodland was also grassless (Lindley-Cowen 1897: 62; Terry 1908) and 'absolutely bare of any kind of [sheep] feed' (Camm 1905: 16). Wandoo woodlands were 'blemished' or 'infested' with poison peas (Lindley-Cowen 1897: 75; Camm 1905: 16) and would have been avoided. However, in Greenough district, clearing of roadside vegetation was becoming noticeable after 25 years of settlement, compounded by lack of shelter left in paddocks (*The Victorian Express* 20.8.1879).

Aboriginal depopulation by European diseases continued in the 1850s and 1860s (Green 1984: 235-6), and removed an important check on their principal prey – kangaroos, wallabies and possums. This resulted in a profitable skin and hide industry in the 1870s. This time frame accords well with the increase in possums in Tasmania following the decrease in Aborigines from the 1820s and their removal in the early 1830s (Backhouse 1843: 476). In addition, this time frame is consistent with the 10-12 years nominated for New South Wales once natural checks on marsupials ceased following fencing of paddocks (Abbott 1913). In the early 1880s, near Beverley, wire fencing began to replace the wooden Harper fence, and ring-barking of trees commenced (*The Western Mail* 5.10.1907: 10, 26.2.1910: 9). As wire fencing was introduced, shepherding was phased out, resulting in increased populations of dingoes and wedge-tailed eagles. Economic losses to graziers escalated. Wire fencing also permitted subdivision of farms into paddocks and thus increased stocking rates. The subsequent ring-barking of

trees and clearing of understorey increased the abundance of native grasses (*Eastern Districts Chronicle* 9.5.1885: 3, 5.9.1886: 5; Lindley-Cowen 1897: 49, 214-223; Le Soeuf 1900: 192) and the occurrence of springs of freshwater (May 1905b, More 1906). Improvements in ploughs, and mechanization of reaping, by which the stripper replaced the sickle and scythe, took place in the late 1880s and the 1890s (Commission on Agriculture 1891; Taunton 1903: 37-38; Cranfield 1959; Erickson 1978: 219-221; Cooper *et al.* 2004: 121). Railways, linking the ports of Fremantle, Albany and Geraldton to farming districts inland, were constructed. This is the first time that broadscale impacts of clearing began to appear.

Depletion of bird species that provided good sport or game for the table became obvious by the 1870s, resulting in the Game Act (1874). This conferred protection during the breeding season only on emu, malleefowl, quail, waterfowl, 'bittern' (presumably Australasian bittern *Botaurus poiciloptilus*), Australian bustard, 'snipe' (banded stilt *Cladorhynchus leucocephalus*), pigeons, and Australian magpie *Cracticus tibicen*, although W. Hymus (*The West Australian* 18.9.1878) referred to the 'terrible onslaught' on ducks at the commencement of the open season.

A proposal to import ten pairs of monkeys from Java and release them near Mahogany Creek (*The Eastern Districts Chronicle* 9.11.1878: 2) appears not to have proceeded.

In the 1880s an exotic disease appears to have spread into the northern and eastern parts of the south-west and gradually penetrated the entire region (Fig. 48, Abbott 2006). Declines and some extinctions of mammal species resulted. In 1881 sheep numbers in WA were only 2% of the Australian total, with WA contributing only 1¼% of Australia's wool exports (Fyfe 1983: xvii). Aborigines were 'fast disappearing' in the more settled districts of south-west WA (Forrest 1884: 4).

Economic mining of lead, tin and coal commenced in 1850 (near Geraldton), in 1888 at Greenbushes, and in 1896 at Collie but no payable gold was discovered in south-west WA (Prider 1979). Logging of jarrah forest commenced in the 1850s near Busselton and in the 1870s near Jarrahdale. It is unlikely that this was detrimental to the fauna as only suitable large trees were logged.

In 1893 the capability of land for agricultural purposes was classified into four classes (GW Leeming in Department of Lands and Surveys 1894: 36), later modified to three grades and priced accordingly (May 1898: 65). It is likely that first class land (York gum and jam grassy woodland) was cleared for tillage before the poorer soils comprising second (wandoo, salmon gum) and third class (kwongan) land. Clearing of vegetation for agriculture had taken place in only a very small part of south-west WA by the 1890s. For example, in 1892, on the way to the newly discovered goldfield at Coolgardie, the last piece of cultivated land was only 15 miles east of York (Gaston 1939: 21). In 1893 country along the Great Southern Railway was still largely without agriculture (de Satgé 1901: 389), although Beverley district was described in 1893 as 'all green and dotted with wonderful little farming homesteads' (Bligh 1938: 25). In 1895, between Beverley and Albany, there were 'leagues of country upon which there is not a sign of stocking nor a single habitation' (Calvert 1897: 6), and 'many miles of this dreary wilderness were [only] occasionally lightened by extensive clearings or even by patches of cultivation' (Price 1896: 15). Much of the territory of the Midland Railway Company [i.e between Midland and Geraldton] was in 1895 still 'in a state of nature, and unoccupied except by a few cattle and sheep. (Calvert 1897: 158). The country between Meckering and Coolgardie was very little cleared in 1893 (GW Leeming in Department of Lands and Surveys 1894: 36-7) and in 1896 was described as 'an unoccupied waste' (J. Forrest WAPD **9**: 145, 21.7.1896). In 1896 the area under wheat in WA was only 1% of the Australian total (Dunsdorfs 1956: 206).

Wedge-tailed eagles increased once Aborigines ceased robbing nests of their young (*The Inquirer and Commercial News* 20.6.1873), growth of the kangaroo skin trade augmented the supply of kangaroo carcasses left to rot (*The West Australian* 31.3.1888), and the switch from shepherding to paddocking of sheep resulted in ewes running unattended in large paddocks and lambs lacking human protection against predation by eagles (cf. HL White in Mathews 1915-16: 103). One pastoralist was said to have had 500 lambs carried off during the lambing season (*The Inquirer and Commercial News* 20.6.1873). Farmers were greatly troubled in the 1890s by wedge-tailed eagles and 'ground vermin' (boodies, woylies and koomal), with debate about whether the destruction of eagles had led to the increase in marsupial pests of crops (various authors in *Journal of the Bureau of Agriculture of WA* **2**: 385-392, 1895; *Eastern Districts Chronicle* 31.8.1895: 6). In 1892, Government had introduced a reward of 2s for the destruction of wedge-tailed eagles, upon production of the head and talons (*Government Gazette* 28.4.1892: 318). Government assistance was frequently sought for increasing the bonus for destroying eagles and for provision of a bonus for the destruction of 'ground vermin' (ibid. **3**: 806-7, 1896). The bonus for wedge-tailed eagle destruction was rescinded after six years of operation (*Government Gazette* 18.11.1898: 3332). Landholders, however, continued to regard the destruction of eagles as essential to the survival of lambs (1896 – Tyler 2003: 243; R. Burges WAPD **21**: 2612, 3.12.1902; Carter 1908; Crossman 1909; Anon. 1909b: 248; G. Hester in *The Blackwood Times* 1.8.1911).

Ethical misgivings about trapping or shooting native animals appear to have first surfaced some 60 years after European settlement, for Section 79 of the Police Act (1892) made provision for penalties for a person who caused unnecessary pain or suffering 'to any living being'.

Although deer, hares, Angora goats and trout were introduced in the early 1870s (Anon. 1874: 35; FA Weld in Forrest 1875: 340), an Acclimatization Committee was not established by Government until 1896 (*Government Gazette* 10.7.1896: 1108). Attention was focused on procuring fish and oysters from Victoria and New South Wales and establishing a zoo (Acclimatisation Board 1897). Farmers and the Bureau of Agriculture opposed the proposal to release the brown hare, *Lepus capensis*

(Conference of Producers 1898: 103) and general criticism of acclimatization was expressed (*Northam Advertiser* 18.1.1905; *The Western Mail* 15.6.1907: 6). However, the laughing kookaburra, laughing turtle-dove *Streptopelia senegalensis*, spotted turtle-dove *S. chinensis*, red deer *Cervus elaphus* and fallow deer *Dama dama* were successfully introduced (Acclimatisation Committee 1898, 1899, 1900, 1902; *The Western Mail* 3.12.1910: 2). Although the biologist in the Bureau of Agriculture advocated, without success, the introduction of the mole, hedgehog, shrew and European toad (Helms 1897), he was generally critical of acclimatization and termed the introduction of deer a 'misdirected good intention' (Helms 1898).

Acclimatization activities in WA lagged well behind those in other colonies of Australia. Twenty species of birds were introduced to Melbourne in the period 1857-61 (Maroske and Gilfedder 1994), with ten species establishing (Emison *et al.* 1987), and 16 bird species were introduced into South Australia in the period 1863-1885, with seven species establishing (Sutton 1935). By 1890, after long experience in eastern Australia, the tide had turned against acclimatization. One influential parliamentarian in New South Wales concluded that 'unrestricted and inconsiderate attempts at acclimatisation, as a general rule, do much more harm than good' (Norton 1890).

William Webb, a natural history collector based at Albany, was active from the 1870s until the 1890s. He advertised in the second issue of Albany's first newspaper, *The Albany Mail and King George's Sound Advertiser* (10.1.1883). Some of his specimens are now in the Macleay Museum, Sydney, but most were lost to science. The fate of the cabinet of 102 bird specimens and 43 mammal specimens sent to the Colonial and Indian Exhibition, held in London in 1886, is unknown. It is improbable that his collecting activities had any impact on the bird and mammal fauna.

The newly-formed Australasian Association for the Advancement of Science established a committee in 1888 to investigate the protection of native birds and mammals (*Proceedings* **1**: xxxiii). Although this committee issued its first report in 1894 (*Proceedings* **5**: 241-2), it appears to have had little influence on the WA Government, possibly because it lacked a representative from WA.

1900s-1960s

The discovery of gold in the Kimberley (1885), Pilbara (1887) and Yilgarn (1887, 1893-4) caused an abrupt and unprecedented increase in the population of WA, assisted by drought and economic depression in South Australia and Victoria. Annual production of gold first exceeded 1M ounces in 1899 and peaked at 2.3 M ounces in 1903, although alluvial gold production had peaked in 1898. The Government attempted to retain these immigrant prospectors in WA by offering free 160 acre farms on the condition that specified developments were satisfied (Morris 1929). This led to expansion of agriculture eastwards from the Great Southern Railway from c. 1905, resulting in accelerated elimination of faunal habitat (Fig. 49). Fires set in February-March were used to clear native vegetation for wheat growing (Anon. 1909c; Turner 1957). In long-settled areas such as Northam district, destruction of timber over large areas was equated to vandalism by some, resulting in a plea to retain some patches (*The Western Mail* 18.1.1908: 7). The extent of rural change is well illustrated by two indicators. First, rapid development of the railway system, primarily to open up and service new agricultural districts: 1353 miles of track (1901), 2854 miles (1913), and 3538 miles by 1919 (Le Page 1986: 342-4). Second, the increase in area of ring-barked land as financed by the Agricultural Bank Act of 1894 and subsequent amendments: 17 595 acres (1896), 56 539 acres (1900), 885 867 acres (1910) and 2.4 M acres by 1920 (Statistical Registers for the years 1900, 1910, 1921).

By comparison, the privately-owned Midland railway and its adjacent land grants remained little cultivated (*The Western Mail* 3.12.1904: 5), owing to the higher sale price of these lands relative to Crown land.

The year 1900 saw the legislation of the Land Drainage Act, intended to encourage settlement on lands subject to an overflow of water. During the next few decades drains were created, widened, deepened and lengthened (Cooper 1979). This Act probably expedited the local destruction of habitat of the quokka and water rat. The first district to be affected was to be swamp land between Pinjarra and Harvey, west to the coast (J. Forrest WAPD **18**: 1715, 15.11.1900). Of the c. 10 000 wetlands on the Swan Coastal Plain, most (perhaps 70-80%) have been filled, drained or cleared of vegetation (Balla 1994).

Acclimatization activities continued, emphasizing species that would provide sport (deer, quail, partridge, pheasant, trout), ornamental value (doves, goldfinch), or supposed agricultural value (laughing kookaburra) (Acclimatisation Committee 1900, 1902, 1903, 1904, 1905).

Section 79 of the Police Act (1892) was repealed by the Prevention of Cruelty to Animals Act (1912). Section 19 stated, however, that this Act did not apply to the 'extermination' of rabbits, marsupials, wild dogs, foxes or vermin, nor did it apply to the hunting, snaring, trapping, shooting or capturing of any animals 'not in a domestic state'. This Act was replaced in 1920, and included cats in the list of species that could lawfully be exterminated.

Apart from the WA Museum curator Bernard Woodward (Woodward 1907), the agricultural journalist Catton Grasby (*The Western Mail* 28.11.1908: 6), and the Department of Agriculture bacteriologist John Cleland (*Proceedings of the Linnean Society of New South Wales* **33**, 635, 1908; Cleland 1910), strategic vision about the future of the fauna of south-west WA remained short-sighted or confused. For example, those concerned by the destruction of native fauna were dismissed by some farmers as 'sentimentalists' (*The Western Mail* 28.11.1908: 6. 19.12.1908: 6) or 'faddists' (*Great Southern Herald* 15.4.1908). Le Soeuf (1910) considered that WA had a lesser need for sanctuaries because of the sparse population,

but recognized the likely future impact of the fox on the avifauna.

Marsupials and birds at Kojonup were experiencing 'ruthless destruction' (*The Western Mail* 17.4.1909: 6). By 1910 possum numbers were so depleted by trapping and epizootic disease that a closed season was introduced. In 1913, the Government brought a measure of monitoring into the trade of marsupial skins by requiring a royalty to be paid (Game Act Amendment Act 1913). However, it does not appear that the initiative of the Australian Ornithologists' Union (Maclean 1909) influenced the legislative protection of bird species in WA, although in 1911 the Commonwealth Government prohibited the export of certain species of live birds, skins or eggs (*Commonwealth of Australia Gazette* 25.3.1911: 881-2). During 1914 much of south-west WA was affected by drought, the worst since European settlement commenced (Foley 1957). In the years immediately before the Great War, sheep numbers in WA and wool exports from WA were only 5% and 4% respectively of the national total (Fyfe 1983: xvii). Rabbit outbreaks first occurred in settled parts of south-west WA in c. 1915. The fox established throughout most of the region by the late 1920s. Logging of forests expanded from 1905 to service demand for sleepers for railway construction in India, the wheatbelt and from Kalgoorlie to South Australia. Section 43 (35) of the Forests Act (1919) regulated or prohibited the 'destruction, shooting, hunting, pursuing or snaring' of fauna in State forests and timber reserves. In 1925 the Vermin Act was amended to allow a species to be proclaimed vermin in any portion of WA. This would have resulted in local population decline of such species, compounded by increased clearing of vegetation (faunal habitat) and the establishment of the fox. By 1930, the area under wheat in WA had increased to 22% of the Australian total (Dunsdorfs 1956: 206).

From the 1920s complaints from primary producers about pest bird species became significant. These involved the emu, Baudin's cockatoo *Calyptorhynchus baudinii*, galah *Cacatua roseicapilla*, and several species of parrot (Serventy 1927, 1929, 1930b, 1932; Jenkins 1934, 1937, 1941).

Difficulties experienced by settlers in establishing dairy farms in jarrah and karri forests in the period 1921-5 were not due to competition from marsupials, as none of the witnesses interviewed by a Royal Commission (1925) mentioned problems caused by kangaroos or wallabies.

The WA Naturalists' Club was formed in 1924 (DL Serventy in *The Farmer* 5.11.1924: 53). In 1925 the Royal Society of WA established a committee for preservation of flora and fauna reserves (*Journal of the Royal Society of WA* **12**: xiii). Presumably these groups lobbied for improved protection of fauna. By the late 1920s, the Chief inspector of Fisheries and Game formed the opinion that the public conscience in terms of protection of native fauna had 'noticeably improved.' This was attributed to efforts of the nature study branch of the Education Department (Serventy 1928: 157), a sympathetic press willing to publish weekly notes on natural history (Serventy 1929: 283), and activities of the WA Museum (Serventy 1930b: 262). A Western Australian branch of the Gould League of Bird Lovers, sponsored by the Education Department, was formed in 1939 (Jenkins 1940: 188; Anon. 1944: 161).

In 1927 it was suggested that the superb lyrebird *Menura novaehollandiae* be introduced to Nornalup district (*The West Australian* 5.11.1927: 7). Opposition to the introduction of species to WA intensified in the 1930s (D. Serventy in *The West Australian* 7.5.1936:5, 12.5.1936: 19; Jenkins 1937). There was concern that '"innocuous" exotic species' were unprovided for in the Vermin Act (1918): the goldfinch *Carduelis carduelis* had become established around Perth in c. 1933 (Jenkins 1935), and a bullfinch *Pyrrhula pyrrhula* and chaffinch *Fringilla coelebs* had recently been seen in Perth (Serventy 1937). Presumably these birds had escaped from captivity. The 1930s was when a more scientific approach to bird conservation was advocated (Serventy 1940). This focused less on laws restricting shooting and egg collecting, and more on protecting habitat and minimizing its thoughtless destruction under the name of progress. Nevertheless, shooting must still have been prevalent in 1941 because all 'native game' within a 15 mile radius of the centre of Perth was gazetted as protected (*Government Gazette* 2.5.1941: 561). Shortage of ammunition during 1942-3 reduced the level of shooting (Anon. 1944: 161).

The second year of publication of the *Western Australian Naturalist* included a short paper that identified eight factors detrimental to the fauna (Palmer 1948). However, these factors were treated as equal. It was noted that native animals requiring water, grain or carrion had benefited from settlement. The large areas reserved for forestry and water catchments were regarded as important sanctuaries for fauna.

Until 1952, nature conservation was effected under the Game Act (1912-13), which had remained unamended for nearly 40 years. This Act was based on the old English Statutes to preserve certain wildlife for hunting by certain persons, and was considered to be 'too complicated' (Kinghorn 1929) and 'the most backward statute of its kind in Australia' (WAPD **126**: 796, 1138).

It had become obvious by 1950 that sanctuaries (areas of uncleared native vegetation), first legislated for in the Game Act (1892) and Permanent Reserves Act (1899), had not protected some species against epizootic disease and predation by foxes (C. Latham WAPD **127**: 1498-99, 31.10.1950). At this stage, habitat loss and shooting and trapping by humans were evidently still considered to be the main factors that caused species decline, although the 'axe kills more [fauna] surely than the gun' (Serventy 1956).

Although mining activity in south-west WA increased markedly in the 1960s (ilmenite, bauxite), removal of vegetation was localized.

Based on the understanding gained from the above historical account and of the individual species accounts presented earlier, a chronological synopsis of the key events that influenced the distribution and abundance of native mammal species is presented in Fig. 50. Secondary factors that constrain, facilitate or amplify the operation of primary factors are also shown.

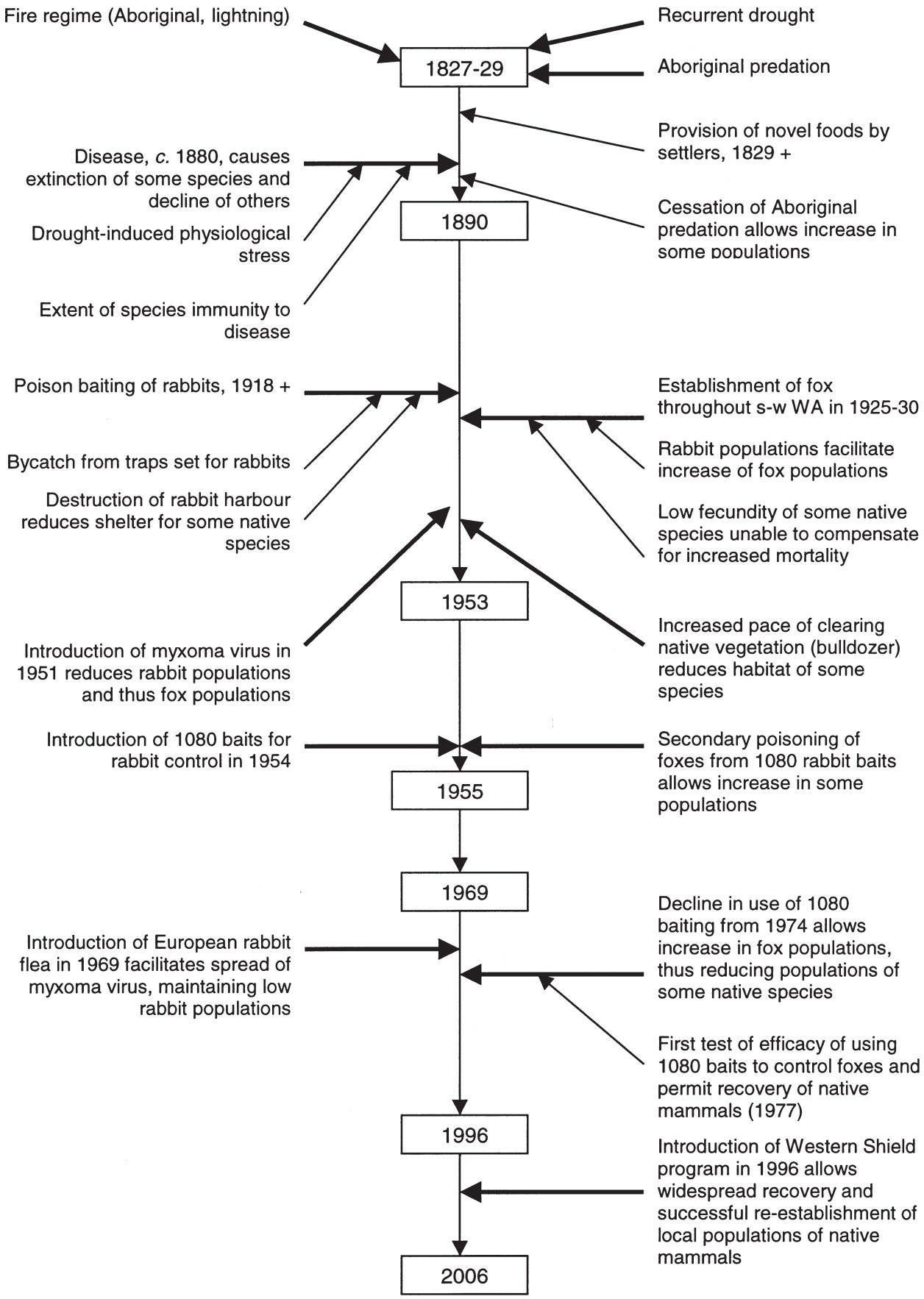

Fig. 50 Synthesis and chronology of key events in explaining changes in status of the native mammal fauna in south-west WA following European settlement.

Unintended or unanticipated outcomes

At times it is difficult to foresee the results of even simple actions. Important events may arise from insignificant ot trivial circumstances, and influential events may occur when least expected.

Wilson and Friend (1999) suggested that the combined and cumulative effects of factors tend to counter the degrees of resilience shown by mammal species to individual disturbance factors. The opening up of forests by roads and tracks associated with logging, together with the temporary removal of vegetation cover by the use of planned burning, may have facilitated access of exotic predators into forests.

This overstates the situation in most forests in south-west WA. The jarrah forest at the time of European settlement mostly consisted of a few large trees per hectare and scant undergrowth (Abbott 1999: 69, Abbott 2003: 137). It was easy for a human to walk or ride a horse through oldgrowth forest, except along riparian areas and close to and within swamps. This open character of the vegetation provided little shelter and thus predisposed many species to relentless predation once the fox established. Karri forest also consisted of a few large trees per hectare but the widespread and dense understorey (T. Bannister 1831 in Shoobert 2005: 214; *Government Gazette* 10.6.1886: 352-3; JTH Goodman in Surveyor General 1898: 27; *The Western Mail* 17.3.1906: 10) did buffer the impact of the fox.

In jarrah forest, only those mammal species more or less confined to dense vegetation (i.e. quokka, ngwayir) should have experienced increased risk of predation by foxes following planned burning and (unplanned) wildfires. Foxes established in jarrah forest in the late 1930s but planned (prescribed low intensity) burning was not introduced on a forest block basis until the late 1950s and early 1960s. Arboreal species (koomal, ngwayir) would have have been placed under increased risk of predation by foxes and feral cats when feeding on the ground in logged coupes, where the distance to refuges (standing trees) was increased, particularly in heavily logged areas. In karri forest the same three mammal species would have been affected. Since the mid 1990s these declines are being reversed and then minimized by increased intensity of baiting of foxes before and after logging and burning.

Perverse and unforeseen outcomes from human activity in south-west WA include the following, variously termed in the ecological literature as side, flow-on, and knock-on effects, and downstream impacts:

- Excessive removal of vegetation (in order to farm) in lower rainfall areas has mobilized salt stored in ground water (*Eastern Districts Chronicle* 12.2.1897: 3; Anon. 1907b; Despeissis 1909; *The Western Mail* 5.6.1909: 8, 3.7.1909: 7; Bleazby 1917). This has salinized streams and elevated water tables, killing remnant vegetation higher in the landscape, killing fresh water invertebrates, reducing riparian plant cover, and ultimately causing the local extinction of the water rat.
- Poison baiting of rabbits (with strychnine, phosphorus or arsenic) caused declines in bird and mammal species that ingested these baits. The species most affected were probably the squeaker *(Strepera versicolor)*, woylie and dalgyte.
- Trapping of rabbits would have accidentally captured similar-sized mammals such as the dalgyte and quenda and would have led to declines across settled areas.
- Efforts to limit the distribution and abundance of rabbits eventually failed; and it is likely that the great increase in rabbit populations from the 1920s to the 1940s sustained large populations of the fox and feral cat, exacerbating predation of native mammals in drier years when rabbit populations declined temporarily.
- Lengthy periods of drought would have reduced population sizes of native fauna and perhaps led to the permanent demise of 'sink' populations through intensified predation by foxes and feral cats interacting with chance events. The mechanism proposed by Kinnear *et al.* (1988) involved a decline in quantity and quality of food forcing animals to forage over a larger area, thereby increasing the risk of predation.
- Killing of dingoes (because they attacked sheep) probably contributed in a small way to the successful establishment of the rabbit (inimical to agriculture) and the fox (inimical to lambs and many native animal species).

Outcomes beneficial to species are indicated by the + signs in Tables 5 and 6, and corroborating evidence is presented and considered more fully under the accounts of the species concerned. Very few primary factors were beneficial, whereas a large number of secondary factors were.

Assessment of the role of poison peas in retarding extinctions of mammal species

The prevalence of poison peas *(Gastrolobium)* in south-west WA is well documented (Fig. 51), with 108 species present (FloraBase 2005), of which 102 are endemic to the region. Seeds and leaves contain the compound fluoroacetate, the same toxicant of compound 1080 baits used to poison foxes, wild dogs, and rabbits.

The first inexplicable deaths of sheep were reported in December 1830, with 184 dead (Cameron 1981: 137). Further mortality was reported in 1833 (*The Perth Gazette* 3.8.1833: 121, 21.9.1833: 151), with c. 100 in one flock dead (*The Perth Gazette* 28.9.1833: 154). Some cattle suddenly dropped down and had to be shot (*The Perth Gazette* 19.10.1833: 167). More deaths of sheep were reported in 1834 (*The Perth Gazette* 15.3.1834: 251), and it was noted that dogs fed on carcasses and guts or which licked the blood of affected sheep, or were fed cooked flesh of affected goats, or which ate the guts of bronzewing pigeons, also died (*The Perth Gazette* 22.3.1834: 254, 5.12.1840; *The Inquirer* 25.8.1841; Cameron 2006: 254, 336, 447). Settlers became more

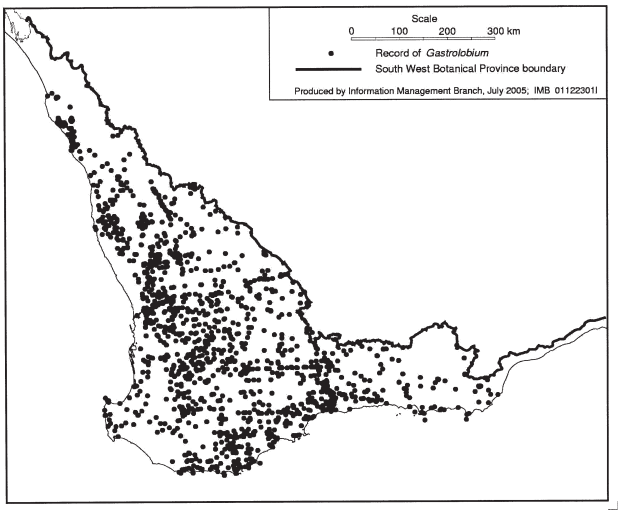

Fig. 51 Distribution of Gastrolobium *species (poison plants) in south-west WA. Source: WA Herbarium.*

concerned of the danger to livestock when more cattle, goats and sheep browsing foliage died in 1835 (Erickson 1969: 54; Shoobert 2005: 439-440, 462; Cameron 2006: 377). Despite debate about the cause (e.g. *Perth Gazette* 10.2.1838: 23, 24.3.1838: 47, 28.4.1838: 67), the link to *Gastrolobium* species was not ascertained until 1841 (*The Perth Gazette* 22.5.1841, 14.8.1841, 21.8.1841). One of the subsequent duties of herdsmen and shepherds was to ensure that stock was not permitted to feed indiscriminately in bush where poison peas occurred (e.g. Crabb nd: 102).

Calaby (1971) suggested that the occurrence of *Gastrolobium* species in south-west WA explained why certain mammal species persisted in this region, in contrast to other regions in which they became extinct following the establishment of the fox. The numbat, woylie and tammar continue to persist in parts of south-west WA, including the Perup jarrah forest and Dryandra wandoo woodland in particular, which have *Gastrolobium* species as primary components of the understorey. Calaby's hypothesis was investigated by Short *et al.* (2005) in some detail at sites sampled by GC Shortridge and Kitchener *et al.* (1980) during 1904-7 and the 1970s respectively. They examined species richness of mammals in relation to occurrence and prevalence of *Gastrolobium* thickets. The expected correlation was found to be weak.

The role of poison peas in conserving these mammal species has been overstated for the following reasons:

- The fox colonized south-west WA in the 1920s, decades after it had established in New South Wales, South Australia and Queensland. This delayed the full impact of this species in south-west WA. From the 1980s, the complete process of extinction of several mammal species was prevented from running its course in south-west WA only by management intervention.
- Declines in a number of bird and mammal species became apparent in the 1930s and 1940s (see species accounts).
- These declines resulted in local extinctions of some species, even in large nature reserves in which poison peas occurred in high densities (e.g. the 50 000 ha Dragon Rocks Nature Reserve, McKenzie *et al.* 1973).
- Compound 1080 became available in the early 1950s and was used to control rabbit populations in concert with the myxoma virus. Foxes eating rabbits that had taken 1080-poisoned baits would have died. This relieved to some extent predation of native fauna by foxes.
- When 1080 was phased out for rabbit control in the mid-late 1970s, there was a sudden decline in the abundance of numbats, woylies and tammars (Christensen *et al.* 1985, Friend 1990), so that by 1980 extinction of these species in south-west WA was imminent.
- The occurrence of large populations of poison peas in Perup (40 000 ha), Dryandra (28 000) and Tutanning (2 000 ha) did not prevent this sudden decline.

The fox has a higher fecundity (average of 5 young/female/year, Strahan 1995) than woylies, numbats and tammars (1-4 young/female/year). In addition, foxes killed by secondary poisoning (from preying on these native species) can be replaced each autumn by juveniles dispersing from the higher density populations of foxes occurring on adjacent farmland.

Dogs and cats die after eating boodies, woylies, possums and bronzewing pigeons (*The Western Mail* 5.10.1907: 6, 19.10.1907: 6, 2.11.1907: 6, 23.11.1907: 5, 14.12.1907: 6). Poison peas have also been invoked to explain why predation by feral cats has not caused declines and extinctions of native mammal species in south-west WA. Christensen *et al.* (1985: 17) suggested that the extensive thickets provide shelter from predation by feral cats. Short (2004) offered a different explanation. Cats feeding on bronzewing pigeons *(Phaps chalcoptera)* should die because the pigeons eat *Gastrolobium* seed, and therefore the presence of thickets of poison pea should reduce predation of native mammals by cats. However, cats have a higher fecundity (8 young/female/year, Forsyth *et al.* 2004) than that of woylies and numbats. Cats killed by eating native pigeons and native mammals that have browsed *Gastrolobium* foliage should be rapidly replaced by domestic cats on farms adjoining Tutanning, Dryandra and Perup.

Poison pea thickets occurred extensively in south-west WA and remained intact and unused by farmers because of the risk to livestock (e.g. 1.3 M acres of unselected poison land between Cuballing, Tambellup, Dinninup, Darkan, Williams and Wandering – Cooke 1911; Calvert 1897: 158). It was labour intensive and hence expensive to grub out plants (e.g. *The Western Mail* 24.9.1910: 9). Despite generous inducements offered by Government, poison lands were left idle while land free of poison plants was used preferentially for grazing. The widespread use of the bulldozer from the late 1940s probably accelerated

clearing of poison lands, leaving remnants only on publicly-owned lands.

Finally, recent substantial and rapid declines of woylies at fox-baited Dryandra Woodland (2001-2) and Perup (2004-5) were not deterred or prevented by the presence of poison pea thickets.

The persistence of many rare mammal species at Tutanning, Dryandra and Perup may have instead been a result of these areas being source populations. These areas may have been highly productive of the resources required by these species, so that fecundity and survival were sufficiently high to counteract moderate levels of predation by cats and foxes. This hypothesis could be tested by comparing the fecundity and survival of the woylie and numbat in fox-baited Dryandra and Perup with populations re-established in fox-baited Julimar Conservation Park (28 000 ha), Dragon Rocks Nature Reserve and Stirling Range National Park.

Differences between species in vulnerability

Vulnerability refers to a species' potential for experiencing harm from an impact caused by a factor, and is determined by exposure (duration, frequency and magnitude), sensitivity, and ability to adjust to the factor. That medium-sized mammal species had been the most severely affected was first recognized by Marlow (1958), based on a comparison of the original and modern geographical range of mammal species in New South Wales. This was confirmed by Baynes (1979: 212) and then quantified by the concept of 'critical weight range', referring to the fact that all mammals species that have declined or become extinct on mainland WA lie between the mean adult body weight (MABW) range of 35 g and 4.2 kg (Burbidge and McKenzie 1989). This is not a random sample, because in south-west WA most mammal species have an MABW < 200g (Fig. 52).

Baynes (1979) inferred from his equivalent of Fig. 54 that predation pressure from medium-sized mammalian predators was the most fundamental factor in the recent extinctions of native mammals in south-west WA. Baynes

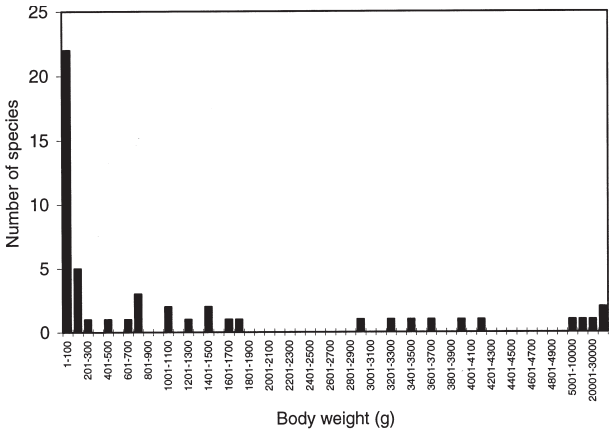

Fig. 52 Body weight of all non-volant native mammal species present in south-west WA in 1829. Note that the change in scale above 5 000 g masks the full extent of right skewness. Source: Burbidge and McKenzie 1989.

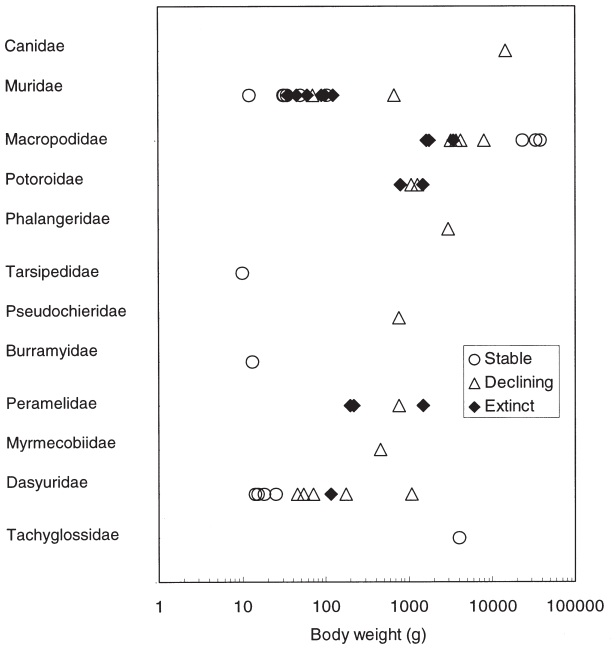

Fig. 53 Association between species extinctions/declines in south-west WA, taxonomy (Family), and species body weight of the native mammal fauna of south-west WA. Source: Burbidge and McKenzie 1989; How et al. *2001.*

(1979: 219) argued for feral cats being responsible for the first wave of extinctions. However, insufficient attention was given to disease as a possible determinant.

The mammal species becoming extinct (in relation to MABW) are not a random sample with respect of evolutionary lineage (McKenzie *et al.* 2007): extinctions have taken place only in the families Dasyuridae, Peramelidae, Potoroidae, Macropodidae and Muridae (Fig. 53). Abbott (2006) suggested that this association was due to whether or not species possessed genetic immunity to the epizootic that spread through a large part of WA in the period 1880-1920 (Fig. 48), and not because of a causal link with body weight.

The point in Fig. 53 and Fig. 54 for the Tachyglossidae (determined as *stable* by Burbidge and McKenzie 1989)

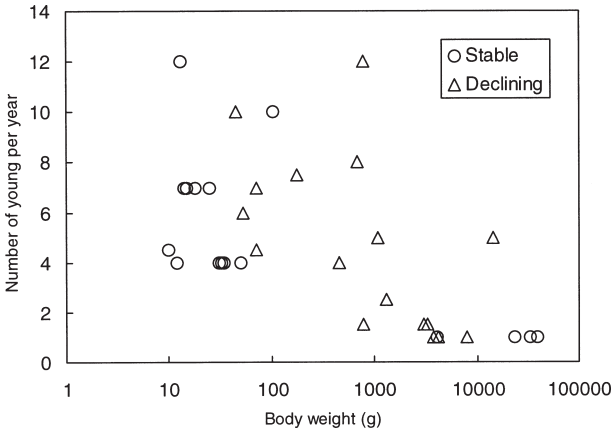

Fig. 54 Status in 1989 of non-volant native mammal species persisting in south-west WA in relation to body weight and the usual number of young produced per female per year. Source: Burbidge and McKenzie (1989); Strahan (1995).

should be re-assigned as *declining* on the basis of the response of the echidna population at Peron Peninsula to reduced fox predation (Morris *et al.* 2004). The point for Canidae is represented as *declining* solely because of human persecution and not through fox predation.

One obvious factor that should influence the association between MABW and current status is annual fecundity (Baynes 1979: 212). However, whether or not small mammals have declined does not appear to be strongly linked with fecundity per se (Fig. 54). Factors such as the effectiveness of shelter from predation, immunity to disease, and capability for taking advantage of resources provided by European settlers may override the expected major importance of fecundity.

Augmentation of knowledge

The 1880s saw the beginnings of scientific activity in WA, with Governor Broome noting in 1884 that 'Science in Western Australia is as yet in its infancy.' A museum of geological specimens was commenced in 1881 (Nicolay 1884), followed by a biological collection (1892), and the appointment of a taxidermist and collector (O. Lipfert, 1894). Following the prosperity brought by the gold discoveries of 1892-3, a new museum building was opened in 1895 (*The West Australian* 1.8.1895: 4) and naturalists, capable of writing up and publishing their observations and not just making collections, immigrated (R. Helms in 1896, AW Milligan in 1897, FL Whitlock in 1901, HE Hill in 1903). *The Journal of the Bureau of Agriculture* commenced publication in 1894 and included incidental notes on fauna from 1895. Updated lists of bird and mammal species (including distributional data for the latter) occurring in WA were published (Woodward 1900: 170-190). The first scientific society began in 1897, but confined itself to botany until 1904, and in 1905 published its first paper on fauna. The national ornithological journal, *The Emu*, was founded in 1901 and articles on south-west WA birds were soon published by local observers (Milligan 1901, 1902; Carter 1903; Hill 1903, 1904; Lawson 1905; Rogers 1906). The Museum did not begin publication of its *Records* until 1910.

Because biological survey invariably results in the discovery of previously unknown populations of mammals and birds, 'extinction' may reflect want of knowledge through lack of field work (Whittell 1939: 131) or may signify only 'hard to find' (Serventy 1970: 73). Negative evidence (that a species has been searched for but not found) needs to be interpreted with caution (Ford 1963; Weidensaul 2002). It is dangerous to assume that an extinction has occurred merely because a species has not been seen or collected (MacPhee and Flemming 1999: 357). This is well illustrated by the rediscovery after 72 years of the noisy scrub-bird in 1961 (*The West Australian* 25.12.1961: 2), and the rediscovery after 20-30 years and extension in geographical range of three other very rare bird species (*Pezoporus wallicus, Dasyornis longirostris and Psophodes nigrogularis*) in south-west WA (Johnstone and Storr 2004; Serventy and Whittell 1976). Nine Australian mammal species presumed to have become extinct since European settlement have also been rediscovered (Johnson 1999). An element of luck is often involved in locating populations of species presumed extinct. Hence greater activity in studying common mammal species would seem to be the best approach to detect populations of mammal species occurring at very low densities. It was long ago noted that many species in Australia are erratically distributed and so confined to limited areas that it is almost necessary to search 'every square mile' (Wilkins 1928: 20).

One of the most striking inferences that can be drawn about impediments to conserving populations of rare fauna is how recommendations by scientists were ignored by governments across Australia. Efforts to reserve samples of original vegetation and commence systematic biological survey across Australia were championed with only limited success by von Mueller (1890: 10), Froggatt (1921), Spencer (1921), Daley (1933), Anon. (1938) and Anon. (1940).

It is also important that an overly scientific requirement for rigour (as expressed, for example, by Caughley and Gunn 1996: 129, 259) does not obstruct or retard a proactive approach to managing populations of rare mammals. This occurred when the pioneering research of Christensen (1978, 1980a) on the impact of the fox on the woylie was assumed to be a false positive, and was not taken up until the results of the well-designed experimental investigation of Kinnear *et al.* (1988) became available. Christensen had demonstrated as early as 1977 that the fox was preventing the re-establishment of the woylie in an area in which it had recently become extinct (Leftwich 1983). This was probably one of the earliest uses of the adaptive management approach that is now widely accepted by policy-makers, land managers and ecologists. Continuation of monitoring from 1974 to 1999 of a range of rare marsupial species at Perup forest also demonstrated that prescribed fires have not impacted on the abundance of woylie, chuditch, quenda and koomal (Burrows and Christensen 2002).

The converse of the situation described above (the false negative) has also occurred. In a detailed study of the ecology of the numbat, Calaby (1960) incorrectly concluded that predation by foxes had been 'much over-rated' as a factor in the decline of the numbat. This assessment provided no impetus for management authorities to conduct trial 1080-baiting in parts of Dryandra Woodland, where Calaby conducted his study.

On occasion inference from the available evidence has led to premature selection of the major relevant factor. For example, Frith (1962: 14) concluded that foxes 'cause little or no decrease in the numbers' of mallee fowl, and instead proposed competition from sheep for herbs and seeds, and clearing of habitat as an alternative explanation. The key conservation measure recommended to protect this species was the provision of adequate reserves, fenced to exclude sheep and rabbits.

Inappropriate theories derived from research in the northern hemisphere should not be assumed to apply necessarily to south-west WA. This eventuated when the concept that a predator species in the Arctic could not eradicate its main prey species but instead followed its

prey in cycles of abundance and rarity was misapplied to south-west WA (Friend 1996: 129). Similarly, the abundance of ground-nesting birds in Europe, where foxes and cats are numerous, was used to claim that foxes and cats in Australia had been unduly emphasized as a cause of the disappearance of certain bird species from specified localities (Ashby 1924: 296).

Finally, studies of the diet of foxes in south-east Australia in the 1960s revealed that rabbits, lambs and invertebrates comprised the major component of stomach contents. It was not realized that impacts on native mammals had taken place in the previous 100 years, and vulnerable species had already become extinct. This misconceptualization gave the false impression that foxes posed no threat to native animals (Friend 1996: 130).

Emerging issues and implications for conservation

Historical information that does not illuminate the present is little more than antiquarianism (Holden 1997: 13). The distributional data presented in this paper demonstrate that many species *(Leipoa ocellata, Cacatua pastinator, Dasyurus geoffroii, Macrotis lagotis, Trichosurus vulpecula, Bettongia lesueur, B. penicillata, Potorous gilbertii, Lagostrophus fasciatus and Petrogale lateralis)* occurred more extensively than currently thought in the first few decades of European settlement, and other species *(Ardeotis australis, Burhinus grallarius, Macropus robustus)* were less widely distributed than they subsequently became (cf. distribution maps in Johnstone and Storr 1998, McKenzie *et al.* 2000, Strahan 1995). This information provides a sound setting for artificially dispersing (translocating) species into their former geographic ranges. For example, the malleefowl, boodie and dalgyte could be returned to large portions of fox-baited jarrah forest with great confidence. The retrospective analysis performed in this paper has shown which factors have been influential and how they have operated in space and in time following European settlement. Change should be seen as an incessant process. Although it is unreasonable to expect to predict the extent and direction of future change, some broad prospective suggestions are possible.

The past continuity in occurrence of western long-billed corella populations in south-west WA indicates that the subspecies currently recognized are invalid. Scarce resources should not be wasted attempting to conserve an invalid subspecies.

Weak links in conserving some bird and mammal species in south-west WA are apparent. It should not be assumed that conspicuous species that are at present abundant and widespread in the region (e.g. western grey kangaroo, red-tailed black cockatoo) will necessarily remain so. Some new pathogen could easily gain access from south-east Asia because current quarantine and border controls in WA are ineffective and indeed could never be made totally effective if diseases were transmitted by migrating species of waders. Animal diseases (other than for domesticated birds and mammals) have not been well studied and little is known of their management. Decisions taken (or not taken) in other jurisdictions could very easily aggravate the risk of animal diseases entering WA.

It is surprising how easy it has been to move fauna into WA. Native bird species not indigenous to the Perth metropolitan area can still be kept there. Sufficient birds have escaped (or were released) from cages and aviaries to allow feral populations of galah *Cacatua roseicapilla*, eastern long-billed corella *C. tenuirostris*, little corella *C. sanguinea*, sulphur-crested cockatoo *C. galerita*, rainbow lorikeet *Trichoglossus haematodus* and red-browed finch *Neochmia temporalis* to establish. Introgressive hybridization is likely to occur with WA subspecies of *C. roseicapilla* and with *C. pastinator*.

Native mammals and frogs from the eastern states of Australia have also been transported to WA:

- A koala *Phascolarctos cinereus* was brought from Queensland to Geraldton in 1914, and then taken to Albany in 1917, where it lived at least until 1923 (Faulkner 1923).
- A sugar glider *Petaurus breviceps*, brought from Tasmania, was kept as a pet in WA (*The West Australian* 12.9.1925: 15).
- At least two platypus were released in south-west WA before 1944 (see the species account).
- A female Tasmanian devil *Sarcophilus harrisii* was found alive under a car in the Perth suburb of Bayswater in July 1997. It had not escaped from any of the 16 licensees authorized to keep captive devils in WA (Department of Conservation and Land Management file 019523F3801 vol. 2).
- The frog *Limnodynastes tasmaniensis* was introduced inadvertently into northern WA, possibly from near Adelaide in c. 1971 (Martin and Tyler 1978).

Although these relocations may not have introduced diseases, it does demonstrate that the risk has been underestimated.

The resilience of some of the species investigated to climatic changes expected during the next 100 years remains uncertain. Decreased rainfall and higher maximum temperatures (IOCI 2005) may exceed the adaptive capacity of some species found in the moister parts of south-west WA.

Declines in geographical range and abundance in south-west WA need not be allowed to continue: WA is a wealthy and well educated community, operates five universities, and available knowledge about threats to biodiversity is adequate. What is not well developed is public sentiment in favour of effective biodiversity conservation, community willingness to value biodiversity over short-term pragmatism, commitment of the resources to apply the knowledge available, and the alacrity to implement the necessary adaptive management programs across all bioregions in south-west WA. All of these changes will be needed in order to create an alternative future for the fauna of south-west WA.

CONCLUSION

This retrospective examination of conspicuous species has provided an enlarged perspective and numerous insights as to how natural and anthropogenic events have altered their geographic range and abundance. Some historical events (disintegration of Aboriginal tribal life, provision of water and agricultural crops) had immediate but ultimately transient beneficial impacts.

Other historical events had decisive and prolonged impacts and their legacies remain. The epizootic that apparently swept through south-west WA from the 1880s resulted in irreversible change as several species became extinct. The establishment of the fox in the 1920s also radically transformed the ecology of many species, including those that are reported to have been recovering from an epizootic. The impact of the fox was fortunately more protracted than that of the epizootic, allowing management intervention at the eleventh hour to prevent extinction of the chuditch, numbat, woylie, and brush wallaby. Some of these impacts are now being reversed over large areas of public lands.

Nature conservation was subordinated to unenlightened self-interest and economic progress with the rapid denudation of the original vegetation over millions of hectares in the 1950s and 1960s, resulting in extensive destruction of habitat for most species. It is therefore unlikely that many of the conspicuous species studied will regain their original local distribution and abundance.

The conceptual model developed includes all of the factors considered by previous investigators, but also highlights additional factors. It distinguishes for each species those factors of primary, secondary and lesser importance, and assesses their influence (beneficial or pernicious) in a historical perspective. A perceptive discernment and correct understanding of the sequence of operation of relevant human activities should avert misplaced emphasis on particular factors and lessen conceptual and analytical confusion.

The approach of this study, entailing retrieval of detailed and appropriate historical information, is considered to have yielded a comprehensive and coherent understanding of when, where, how and why the species studied have needed to respond to ecological upheavals.

ACKNOWLEDGEMENTS

For support and help I thank: L. Wright, B. Mahon and B. Mathiessen (for library services); M. Triffitt (for access to the libraries of the WA Museum and Royal Society of WA); G. Lindsay (for drafting Figures 47 and 50); H. Smith (for maps); A. Wills (for graphs); and all who readily and generously shared information (listed in Appendix 2), particularly the oldtimers for their willingness in making me in effect custodian of valuable information. K. Morris and D. Peacock reviewed and provided helpful advice on a near final draft of the manuscript. Two anonymous referees provided several suggestions that improved the paper, particularly in increasing its accessibility for readers unfamiliar with Western Australia.

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APPENDIX 1

Systematic Searches of Newspapers

Unless otherwise stated, all pages in the issues specified of the following newspapers were perused.

The Western Australian Chronicle and Perth Gazette February-April 1831.

The Fremantle Observer, Perth Gazette and Western Australian Journal April-June 1831.

The Western Australian October-December 1831.

The Western Australian Colonial News May 1832-January 1833.

The Perth Gazette January 1833-December 1843; October 1847; September 1848; March 1850; October-November 1850; July 1869; October 1872; May 1873; May-June 1874.

The Swan River Guardian October 1836-January 1837.

The Inquirer 12 August-28 October 1840; 25 August-20 October 1841; 8 March-5 April 1843; September 1844; October 1848; 4 September-13 November 1850; January-February 1851; January-February 1858; 31 March-28 July 1869; 14 May-11 June 1873; 2 October-13 November 1873; February 1877; 18 September-30 October 1878; February 1885; 1 December 1886-26 January 1887; December 1887; 3 April-22 May 1896; March 1897. A comprehensive card index in the library of the Royal Western Australian Historical Society, Nedlands covering issues published in the period 19 August 1840-29 December 1841, 10 January 1844-31 December 1845 and 13 January 1847-30 July 1851 was searched for relevant keywords.

The Swan River News and Western Australian Chronicle January 1844-July 1845.

The Western Australian Times May 1875; 28 April-16 May 1876.

The Eastern Districts Chronicle November 1877-May 1880; 5 January 1885-29 January 1887; 20 August 1892-2 March 1901; 1 April-30 December 1910; 8 January-30 April 1915.

The Victorian Express 18 September 1878-31 December 1879; 1 August 1883-25 December 1886; 3-31 December 1887.

The Albany Mail and King George's Sound Advertiser January-December 1883; February-April 1885.

The Morning Herald February 1885.

The West Australian February 1885; 1 December 1887-14 January 1888; 16 December 1895-6 January 1896; 1 December 1905-28 February 1906; May 1906.

The Western Mail December, March, June and September 1885, 1886, 1890, 1895, 1900 (April, not March); December 1904-January 1911 (first 20 pp.); January 1913-January 1914 (first 20 pp.); January-December 1919 (first 20 pp.); January 1926-December 1930.

The Australian Advertiser 2 May-11 June 1890.

The Geraldton-Murchison Telegraph 4-25 December 1894.

The Northam Advertiser 1 June-28 December 1895; 25 April-29 December 1900; 6 April-10 July 1929.

Esperance Chronicle and Dundas and Norseman Advertiser 8-19 October 1895; 3 January-16 September 1896.

The Geraldton Advertiser 4-29 July 1898.

The Eucla Recorder 15 October 1898-15 September 1900.

Great Southern Herald 4 January-27 June 1908.

The Northam Courier 4 March-1 April 1910.

APPENDIX 2

Personal Communications

Oldtimers interviewed (with year of birth, and locality for which information was provided)

Adams, Colin 1922 Woogenilup (Kalgan R)
Anderson, Jim 1920 Wahkinup Bk, Qualeup, Wilga, Kojonup (to 1937)
Andrews, Daphne 1910 Norring Lake (1929-84)
Armstrong, Cedar 1924 near Margaret R (to 1991)
Ashcroft, Arthur 1921 Dwellingup, Ludlow, Margaret R, Wellington Mills
Ashton, Ted 1914 Margaret R
Avery, Lance 1906 Nannup (to 1913), Yoongarillup
Ball, Tom 1919 Sawyers Valley (1926-48), Mt Helena (1948-)
Bamess, Fred 1914 Channybearup area (Five Mile Bk)
Batt, Arthur 1917 Marradong district
Baxter, Ron 1931 Morawa
Beeck, Neville 1920 c. 16 km WNW of Katanning
Beggs, Bruce 1928 Grimwade (1935-39), Kirup (1939-40)
Bessell, Keith 1916 Osmington (1932-)
Bignell, George 1911 c. 12 km NE of Kojonup
Birmingham, Ted 1921 near Dwellingup
Blond, Philip 1916 Cowaramup (1923-9)
Blythe, David 1924 near Nannup
Boase, Fred 1921 midway between Goomalling and Dowerin
Boddington, Dot 1930 c. 10 km E of Yandanooka
Bradford, Bill 1918 near Minniging, 15 km NW of Narrogin (to 1946)
Bradford, Dawson 1915 near Minniging, 15 km NW of Narrogin
Breeden, Rob 1928 Busselton
Brenton, Dorothy 1921 Mt Shadforth area near Denmark (1928-45)
Brenton, George 1917 Mt Shadforth area near Denmark (1928-45)
Broad, Harvey 1929 Merkanooka
Brockman, Frank 1915 Dudinyillup (to 1936), Lake Jasper
Brockman, Fred 1925 Dudinyillup (to 1978), coastal areas south of Pemberton
Brockman, Rob 1917 Dudinyillup (to 1988)
Burrows, Myrtle 1921 Channybearup (Five Mile Bk) (to 1983)
Burton, Leonard 1919 Osmington (1927-32)
Busby, Tony 1922 Osmington, Cowaramup, Rosa Bk (1929-)
Butler, Bill 1924 c. 10 km N of Wickepin
Butler, Harry 1930 Mokine, between Spencers Bk and Clackline
Butterly, Laurie 1915 near Yallingup (1934-85)
Candy, Norm 1914 c. 6 km W of Cuballing
Carter, Frank 1924 Cunderdin
Carroll, Les 1926 Buckingham (early 1930s)
Charteris, Dick 1905 (immigrated 1925) Wilga, Capel, Boyup Brook
Chitty, Walter 1919 Warinegaring (NW of Bakers Hill)
Cluett, Les 1917 near Porongurup Range (area bounded by Spring, Mt Barker-Porongurup and Chester Pass Rds)
Cochrane, Laura 1924 Moodiarrup
Cochrane, Lowden 1924 south side of Towerrining Lake
Collins, Peter 1929 Gutha
Cook, Harry 1923 E of Julimar forest
Cook, Sam 1916 E of Julimar forest
Court, Les 1913 Five Mile Bk near Pemberton (1923-30s)
Cowcher, George 1929 Culbin
Croot, Nicol 1912 Watheroo (1929), Canna, Morawa (to 1974)
Croxford, Eileen 1912 Parryville, c. 18 km W of Denmark (1924-9)
Darnell, Barry 1935 Rosa Bk (to 1979), Forest Grove (1979-)
Darnell, Bill 1934 Rosa Bk
Dawson, Arthur 1921 near Northcliffe (to 1927), Manjimup (to 1934), Dwellingup (to 1985)
Dearle, Jack 1922 Greenbushes, Balingup, Grimwade (from 1946)
de Burgh, Bill 1912 Baramba (to 1977)
de Landgrafft, Fred 1930 Tonebridge
Dhu, Judy 1924 farm adjacent to northern boundary of Tutanning Nature Reserve (1946-69)
Douglas, Athol 1915 Tarin Rock and Kukerin (to 1934)
Doust, Stan 1922 c. 1 km N of Bridgetown
Drage, Claude 1925 Mt Barker, Forest Hill
Dunn, George 1914 Greenbushes (until 1928), Manjimup, Palgarrup, Nannup
Dunnett, Wally 1928 between Treen Bk and Fly Bk forest blocks (from 1931)
Edgcumbe, Frank 1908 Henley Bk, near corner of Gnangara and West Swan Rds (Upper Swan)
Elverd, George 1912 c. 5 km E of Forest Hill
Enright, Jerry 1923 Duck Rd, c. 5 km NE of Mt Barker (to 1947); Woogenilup
Farmer, Jim 1918 Boddington
Farmer, Vera 1925 Boddington (1932-)
Fawcett, Charles 1912 Mokine (between Marradong and Quindanning)
Ferry, Ted 1914 c. 6 km E of Woogenilup (to 1938); Woogenilup-Kendenup (to 1964)

Fletcher, Eric 1912 c. 20 km E of Broomehill
Foan, Alf 1929 Brookhampton
Forrest, Wes 1915 Yallingup (to 1932), Balingup (1932-33), Manjimup (1946-)
French, Bevan 1929 Gidgegannup
Gardner, George 1912 c. 18 km E of Pingelly (1912-32), Northcliffe (to 1935), Manjimup
Gardner, Gilbert 1918 c. 18 km E of Pingelly (to 1931, and 1942-)
Garstone, Ray 1931 Woodanilling
Garstone, Sid 1926 Margaret R (1928-)
Gath, Malcolm 1931 E Cuballing
Gee, Jim 1926 Osmington, Margaret R
Giblett, Ashley 1919 Bridgetown, Perup R (1939-63)
Granville, Ken 1925 Morawa
Gray, Rhys 1914 Mundaring (to 1935, 1941-92)
Green, Hilda 1901 Doust Rd, c. 19 km E of Bridgetown (to 1930), c. 12 km E of Bridgetown (1930-96)
Hall, Henry 1920 S Caroling
Hanekamp, Bessell 1920 Middlesex (from early 1930s), E side of Lake Muir (from 1948)
Harvey, George 1908 S of Moorine Rocks (1929-37), Mokine, Wooroloo
Hassell, Bill 1927 Warriup (to 1985)
Hawley, Bill 1924 Moodiarrup
Herbert, Rex 1926 Pallinup R near Gnowangerup (to 1934), Needilup (to 1940), Jeramungup (to 1953)
Higgins, George 1914 Camballup, Kent R
Holmes, Bob 1908 Mingenew (1927-84)
Hunt, Jim 1921 E Woogenilup (Kalgan R)
Hunter, Arthur 1920 Dryandra-Narrogin (W of Cuballing)
Jackson, Don 1932 McAlinden
Jones, Ken 1925 Pimelea, Shannon, Jarrahdale
Kern, Audie 1927 Pemberton (1946-), Dean Mill, Hakea, Banksiadale, Collie
King, Ray 1928 20 km NE of Goomalling
Knight, Brian 1927 Morawa
Korn, Dick 1910 near Dwalganup (from 1929)
Korn, Walter 1907 c. 24 km S of Boyup Brook (1938-97)
Lanagan, Frank 1912 Canna (1928-70s)
Lane, Dick 1930 c. 9 km ESE of Hyden
Livesey, Jim 1927 Napier (to 1946)
Lodge, Geoff 1933 Dale R, c. 36 km W of Beverley (to 1947), Bridgetown (to 1995)
Loney, Joyce 1928 Pumphrey's Bridge/Mooterdine
Main, Barbara 1929 Yorkrakine
Marden, Terry 1934 South Stirling area, between Branson Rd, Palmdale Rd, Manypeaks, Green Range and Kojaneerup Spring Rd (1960s-1980s)
Marsh, George 1922 Marsh Rd, c. 7 km N of Qualeup
Marsh, Mabel 1927 Kulikup (to 1946), Qualeup (to 1998)
Marshall, Alf 1911 36 km W of Pingelly (Noombling, 1938-)
Masters, Jim 1917 c. 8 km NW of Tammin
McEvoy, Aub 1915 Dwellingup and Harvey (from 1930)
McNeill, Marjory 1923 near Lake Ninan (to 1939)
McNeill, Milton 1923 c. 20 km NE of Dalwallinu
Mewett, Harry 1924 near Quindalup
Miles, Charlie 1932 Gidgegannup
Mills, Margaret 1916 c. 6 km NE of Merredin (to 1962)
Mills, Ted 1918 Bowelling (to 1942), Collie
Mitchell, Brian 1928 near Newlands, Donnybrook
Mitchell, Clem 1918 near Newlands
Mitchell, Frank 1925 Norring Rd, Wagin
Moir, Basil 1922 Glenelg Rd, c. 8 km N of Isongerup Peak (Amelup)
Moir, Doug 1920 'Salisbury' near Borden (Sandalwood, to 1927), c. 20 km S of Kojonup/14 km from Carlecatup
Moir, Doug 1931 Cape Riche
Morgan, D. 1934 Irishtown
Mottram, Cliff 1920 near Warren R, adjacent to Quininup forest block
Moyes, Harry 1921 Mokerdillup
Mouritz, Val 1930 E of Hyden
Muir, Andrew 1917 Deeside
Muir, Jim 1920 Deeside
Muir, Roland 1922 W side of Lake Muir (until 1944)
Newman, George 1925 Harvey and Dwellingup districts (1953-86)
Nilsson, Bill 1914 (immigrated 1922) near Bramley forest block, Margaret R
Nix, Keith 1930 c. 24 km S of Boyup Bk
Noakes, Cecil 1922 Rosa Glen (from 1951)
O'Brien, Jim 1927 c. 15 km SW of Mullewa
O'Halloran, Denis 1907 Cherry Tree Pool, NE of Kojonup
Outridge, Josie 1907 c. 3 km W of Boyup Bk (to 1929)
Padman, Gordon 1918 near Brookhampton (to 1978)
Paini, Luigi 1919 c. 15 km NW of Kojonup
Palmer, Jim 1919 24 km SE of Kojonup (except c. 1941-5)
Pearse, Cam 1932 Forest Hill
Perry, Dick 1902 near Gnangara, Mundaring, Hamel, Argyle, Margaret R E to Nannup, Pemberton to Walpole, Denmark
Pocock, Elinor 1920 Jacup (to 1942), Rabbit-proof fence near Needilup (to 1981)
Pugh, Bob 1922 Narrikup (to 1979)
Purse, Janet 1917 c. 8 km E of Boyup Bk, near Blackwood R
Rajander, Nils 1918 c. 10 km W Darkan (1926-75)
Rigby, Ray 1931 near Yealering
Roberts, Vic 1920 Darradup and Scott R areas
Rowe, Dave 1927 Margaret R
Sanderson, Hartley 1906 Kalannie
Sasse, Dick 1920 E Canna
Schinzig, John 1925 Moodiarrup

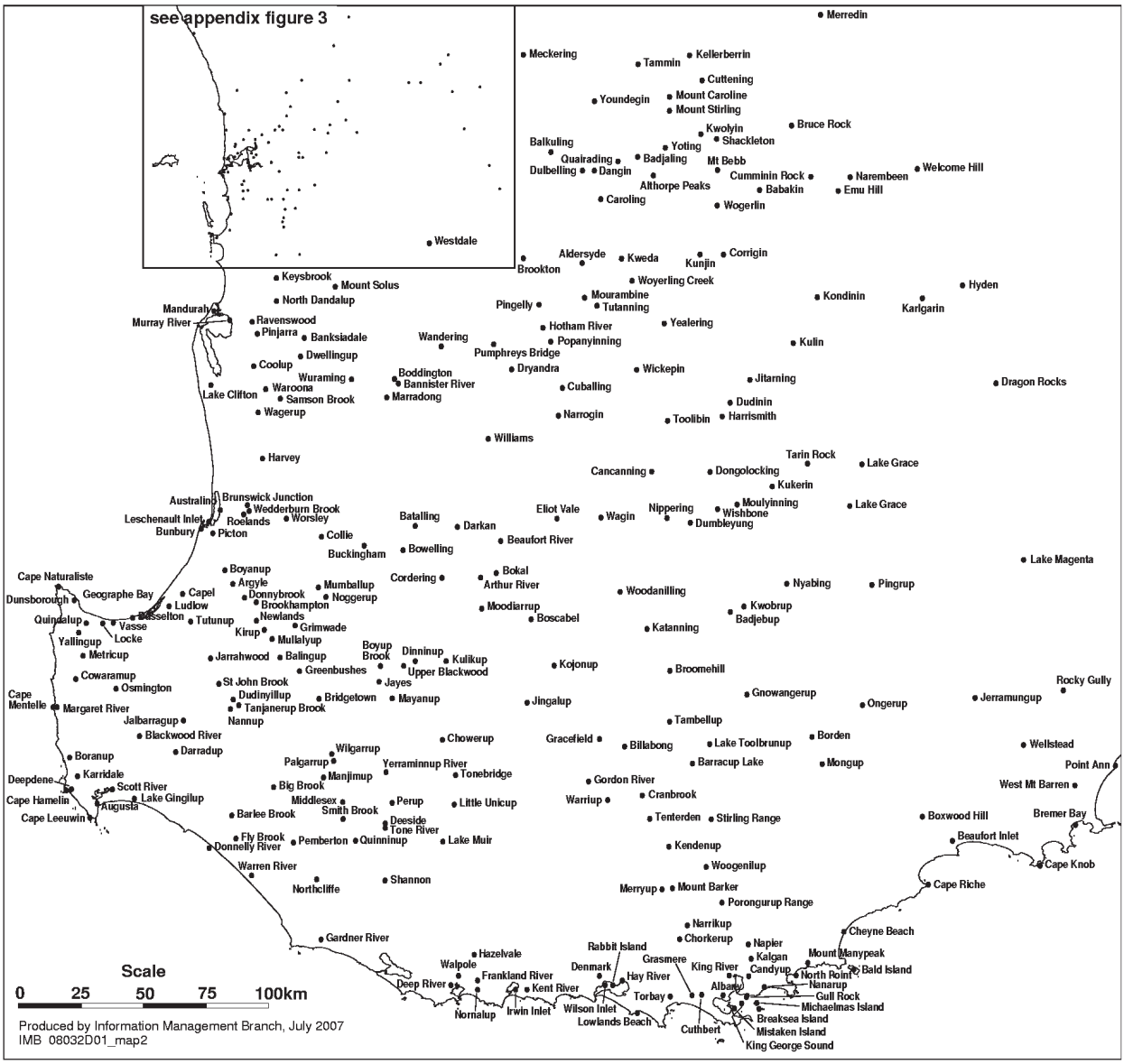
Schinzig, Rudolf 1910 Hillman R
Scott, Allie 1902 Abba R (from 1938)
Scott, Bill 1904 Capercup (from 1920s)
Scott, Lew 1920 near Storry and Strickland forest blocks; near mouth of Donnelly R (to 1985)
Scott, Lionel 1922 near Storry and Strickland forest blocks; near mouth of Donnelly R
Scott, Vern 1918 Tanjanerup
Shanhun, Eddie 1921 Yellanup, S of Porongurup Range (1930-51)
Shanhun, Jimmy 1926 Woodburn area, SE of Porongurup Range (to 1951)
Simmonds, Alf 1916 Collie
Simmonds, Roy 1919 Collie
Smith, Dick 1917 Grimwade (1919-34)
Smith, Frank 1910 Bruce Rock (to 1947), c. 19 km W of Cranbrook (from 1947)
Smith, Ian 1929 Piawaning (to 1979)
Smith, Ken 1912 Kingston area, SE of Bridgetown (to 1976)
Sobott, Jack 1912 Boyup Brook, Greenbushes, Ellis Ck, Lewana, Nannup (to 1934)
Sounness, Frank 1922 Merryup, c. 5 km W of Mt Barker
Stewart, Dave 1921 Walpole (from 1929)
Stokes, Betty 1926 Corrigin (1927-37), Cunderdin (1937-)
Stokes, James 1920 Cunderdin
Stokes, Jim 1924 Merkanooka
Stone, Phil 1932 c. 10 km N of Kwolyin
Studsor, Jack 1925 Collie (early 1930s)
Talbot, Len 1926 Carlotta, near Nannup (to 1946), Margaret R
Tame, Bill 1924 near Nannup (from 1940)
Taylor, Allan 1916 Grasmere (1919-37, 1951-)
Thorne, Ken 1927 Osmington (to 1954)
Tichbon, Neville 1928 between Gwindinup and Argyle
Tilley, Ken 1924 Morawa
Tindale, Alf 1919 Kentdale Rd, Kent R (from 1928)
Torrent, Andrew 1903 Yoongarillup, c. 12 km E of Busselton (1907-23)
Torrent, Louis 1915 Yoongarillup, c. 12 km E of Busselton (to 1939)
Torrie, Jim 1921 c. 8 km N of Kulikup (1920-34)
Tozer, Charlie 1913 East Bk near Pemberton
Treloar, George 1917 c. 5 km SW of Boyup Bk
Trigwell, Brenda 1914 c. 5 km E of Bridgetown (to 1939), c. 20 km N of Dinninup
Trigwell, Richard 1912 c. 1.5 km NW of Trigwell Bridge
Turner, Len 1917 c. 4 km E of Kent R, near South Coast Hwy (1924-)
Vickers, Dos 1919 c. 10 km SW of Highbury (to 1950); Darlington
Warner, Les 1922 Busselton/Ludlow
Warren, Gwen 1917 c. 4 km NE of Highbury (Narrogin Valley)
Warren, Tom 1927 Dwellingup
Wellstead, Keith 1922 Nalyerup
West, Ernest 1916 West Rd, Bramley (1922-)
West, Keith 1925 Bussel Hwy, Bramley (to 1972)
Whistler, Harold 1907 Brancaster, c. 10 km S of Dinninup (to 1975)
White, John 1923 Morawa
White, Joyce 1927 Morawa
White, Kate 1912 Norrine Hill (between Wandering and Hotham R)
Whyte, JS 1927 between Bramley and Treeton forest blocks, near Margaret R
Wilding, Tom 1919 Mokine, between Spencers Bk and Clackline
Williams, Jack 1911 Bridgetown
Yewers, Patricia 1916 Merkanooka
Young, Bill 1915 Wilgarup R, near Quillben (Mt Royal), Lake Muir
Young, Ernie 1925 Mt Royal, near Kin Kin forest block (early 1930s to 1946)

Others (with affiliation if relevant)

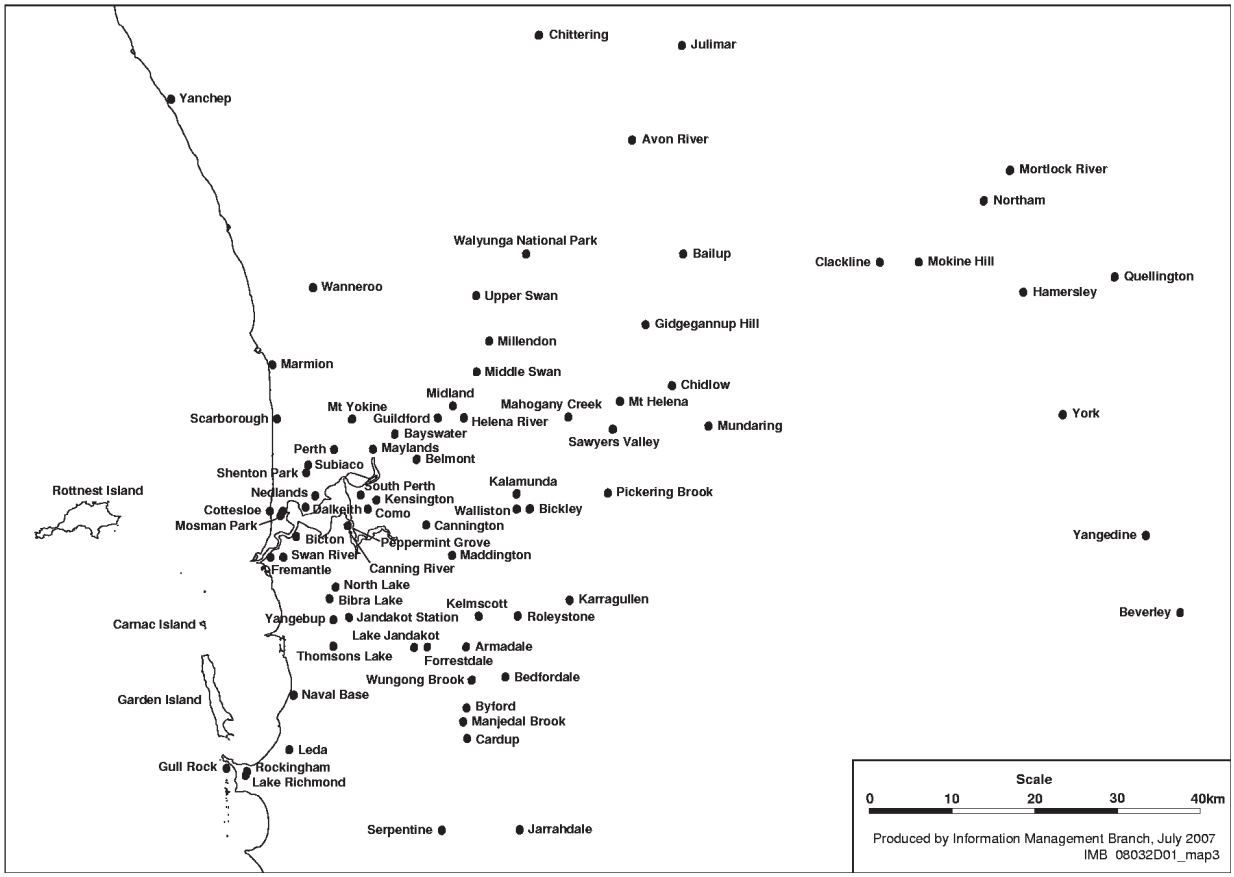
M Bignell, Kojonup
D. Breen, Shenton Park
P. Bridge, Hesperian Press
T. Broun, Beverley
A Burbidge, Floreat
H. Burne, Alcoa World Alumina Australia, Huntly
P. Christensen, formerly Department of Conservation and Land Management
N. Cooper, Western Australian Museum
R. Crosby, Rocky Gully, Frankland R
G. Crowe, Collie
M. Cusack, Moodiarrup
P. de Tores, Department of Environment and Conservation
A. Errington, formerly Department of Conservation and Land Management
B. Fletcher, c. 4 km SW of Mt Saddleback
G. Friend, formerly Department of Conservation and Land Management
M. Grant, Department of Environment and Conservation
T. Grant, University of New South Wales
G. Harnett, Department of Environment and Conservation
M Hercock, Burswood
G. Hoare, Department of Environment and Conservation
L. Hassan, Roleystone
J. Havel, formerly Department of Conservation and Land Management
M. Letch, Mokine (near Clackline)
G. Liddelow, Department of Environment and Conservation
C. Lloyd, Manjimup

B MacMahon, Department of Environment and Conservation
B. Maryan, WA Museum
J. McKenzie, Department of Environment and Conservation
J. Meachem, formerly Forests Department
T. Middleton, Department of Environment and Conservation
D Mitchell, Department of Environment and Conservation
K. Morris, Department of Environment and Conservation
S. Norrington, Macleay Museum, University of Sydney
J. Nunn, Dongara
M. O'Connor, formerly Curtin University
P. Orell, Department of Environment and Conservation
D. Peacock, Department of Water, Land and Biodiversity Conservation, Adelaide
D. Pearson, Department of Environment and Conservation
A. Pollard, Bannister
S. Quain, formerly Forests Department
E. Riley, Collie
R. Roe, Kensington (Gingin)
G. Styles, formerly Department of Conservation and Land Management
A. Thomson, Murdoch University
M. Tichbon, Gwindinup
K Tiedemann, Department of Environment and Conservation
R. Underwood, formerly Department of Conservation and Land Management
A. Wayne, Department of Environment and Conservation
I. Wheeler, Department of Environment and Conservation
B. Whittred, Department of Environment and Conservation
M. Williams, Department of Environment and Conservation
A. Wills, Department of Environment and Conservation
I. Wilson, Department of Environment and Conservation
A. Wood, Collie

Appendix Fig. 1 Toponyms in and near the northern sector of south-west WA, and referred to in the text. Youlanging Spring is not mapped, as its exact location is unknown. Note that official modern orthography is used.



Appendix Fig. 2 Toponyms in the southern sector of south-west WA, and referred to in the text. Lockeville and Querekin are not mapped, as their exact locations are unknown. Note that official modern orthography is used.



Appendix Fig. 3 Toponyms in the metropolitan and adjacent sector of south-west WA, and referred to in the text. Note that official modern orthography is used.

Appendix Fig. 4 Toponyms in and near the south-eastern sector of south-west WA, and referred to in the text. Note that official modern orthography is used.