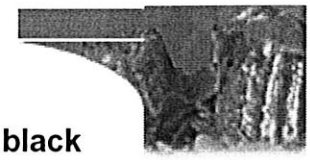


Scientific Articles of Interest

Karrak-watch: A summary of information about the Forest red-tailed black cockatoo (FRTBC) of south-west Western Australia

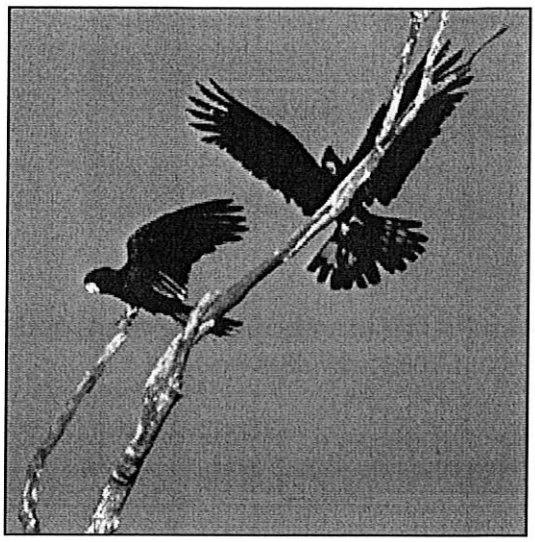
Scientific name: *Calyptorhynchus banksii* subspecies *naso.* First made known to science in 1836, when John Gould described it (as a full species) at a meeting of the Zoological Society in London. It is not known who collected the specimen.

Aboriginal (Noongar) name: Karrak (Emphasize the first syllable; pronounce *a* as in media, *rr* as in sporran).

Recognition: The FRTBC cannot be confused with any other bird species in south-west Western Australia. It is the only large black bird with scarlet/vermilion feathers on the tail. It also has a discordant but distinctive call resembling 'kar-rark' (evidently the basis of its Aboriginal name). At about 55 cm, its total length is similar to that of the Australian raven.

For a detailed description of plumage, see Johnstone & Storr (1998, p. 275) and Higgins (1999, p. 47).

Visit http://www.cockatoocare.com/ to hear the Forest Red-Tailed Black Cockatoo's call.



Original distribution: The FRTBC is one of 5 subspecies distributed as 8 populations over much of Australia (Higgins 1999). The most recent taxonomic revision (Ford 1980), based on size and shape of beak, body size, and coloration, found that differences between the FRTBC and the geographically nearest subspecies (*C. b. samueli* of the Pilbara and Mid-west) are slight. The FRTBC has a more robust bill and the female FRTBC has less yellow on the breast feathers.

Although it is generally thought that these 2 subspecies were well separated geographically before European settlement, historical information suggests that this perspective may be incorrect. The evidence for this is as follows:

1. J. S. Roe on 22 October 1836 recorded red-tailed black cockatoos visiting a spring for water, about 20 km west of Mt Moore (in the vicinity of Nungarin).

2. Daisy Bates recorded Aboriginal names for red-tailed black cockatoos from: Gingin; about 45 km NE of Mogumber; 'Dandaaragan'; Berkshire Valley; Carnamah; and 'Nyerrgoo'.

The original inland limit of distribution is now difficult to ascertain, as little baseline information is available. Johnstone & Storr (1998) regarded the original inland limits as north to Dandaragan and east to Toodyay, Wandering, Kojonup and upper King River [north of Albany]. However, Daisy Bates recorded Aboriginal names for red-tailed black cockatoos between Southern Cross and Mt Jackson, Coolgardie, Meckering, Wergejan near Beverley, east of Katanning, Korrlup (some 80 km NW of Jerramungup [i.e ?Nyabing], and Bremer Bay.

The naturalist Bruce Leake, however, did not report the FRTBC from near Kellerberrin during his long residence there, from the 1880s (Leake 1962). Crossman (1909) and Jenkins (1931) also did not list the species for Cumminin [south of Merredin] and Northam, respectively. Ford and Stone (1957) recorded a flock of 5 birds in December 1944 near Kokerbin Rock [between Kellerberrin and Kwolyin]. This record no doubt relates to birds wandering outside the normal breeding range.

Orton and Sandland (1913) noted that small flocks were often seen in areas with marri 'towards the coast [i.e. west of Moora] during summer, but go further north [to Dandaragan?] to breed'.

The FRTBC was observed at Wandering in 1898 and several large flocks were seen between Kojonup and Broomehill in June 1889 (E. Ashby in Mathews 1916-17, p. 110). Thomas Carter (1923, p. 141) stated that this species was not observed at Broomehill. To my knowledge, FRTBC have not been recorded at Dryandra. Job Haddleton, who lived near Katanning from the 1880s (Haddleton 1952), did not report FRTBC from there. Early visits to the Stirling Range by reliable observers did not result in any FRTBC records (Milligan 1903; Whitlock 1911, 1912). Ethel Hassell (1975) noted that FRTBC 'occasionally...would appear' near Jerramungup in the 1880s. E. A. Hassell (no date) noted that red-tailed black cockatoos occurred on the Salt [Pallinup] River and its tributaries, but were absent from the Fitzgerald and Gairdner Rivers. Thirteen FRTBC were seen in Albany in 1905 (Nicholls 1905). In summary, the normal inland limit of distribution in the SE part of the range of the FRTBC appears to have been approximated by a line joining Kojonup, Kendenup and Warriup.

Subsequent changes in distribution: By 1920, FRTBC no longer bred on the Swan Coastal Plain near Perth, being 'Only occasionally seen in the district' (Alexander 1921). By the 1930s, FRTBC no longer occurred near Dandaragan (Gordon Roberts, pers. comm.). By 1948, FRTBC were 'Never reported nowadays on the Swan coastal plain' (Serventy 1948, p. 34). No FRTBC were recorded in the 1920s/1930s near Mandurah, Bunbury or Rockingham (Serventy 1930, Whitlock 1939, Sedgwick 1940). Until 1950, FRTBC appeared each autumn in wandoo forest at Glen Avon [between Toodyay and Northam] and west of Clackline (Masters & Milhinch 1974).

The species disappeared from the Moore River (Cowalla) area by 1900 (W. de Burgh, pers. comm.), from the Dandaragan area by the 1930s (G. Roberts pers. comm.), and from the Julimar area by 1950 (Abbott 1999).

Current distribution: In the period 1995-2000 CALM organized 3 surveys to ascertain the current distribution of FRTBC (Abbott 1998a, b). The first survey relied primarily on staff of CALM, Alcoa of Australia, and Worsley Alumina. Subsequent surveys actively sought records from the public. These records helped define more completely the current limits of distribution. Results are shown in Maps 1-4.

The second survey (1996-7) detected FRTBC near the Porongurup Range and Kalgan River, north and east of Albany respectively, as well as near Chidlow, NE of Perth. The third survey (1999-2000) resulted in many records from the Gidgegannup area, Kendenup area [NE of Mt Barker], several records well to the east of Albany, and records from the woolbelt (the area between Wandering, Boyup Brook, Mt Barker and Kojonup).

Based on the combined results of the 3 surveys, understanding of the current inland distributional limits of the FRTBC is now satisfactory. It appears that the FRTBC is expanding its geographical range. For example, Abbott (1995) studied the birds of the Porongurup Range from 1974 to 1991, and first recorded the FRTBC there in 1991; it is now widely reported in the area (See Maps 2, 3). In 1993 FRTBC were recorded without further details from a reserve of Banksia woodland at Inglewood, an inner suburb of Perth, as well as from 'local gardens' (Cooper 1995). I have also received several reports of FRTBC feeding on pine cones and gum nuts in suburban backyards in about 1996-7 in Dianella and Nollemara. Since 1993, FRTBC have frequently been recorded in John Forrest National Park (P. Sandilands, pers. comm.).

During the 3 surveys, a few outliers were recorded, at Williams, Narrogin, and near Boscabel. The record from the Stirling Range is of RTBC tail feathers next to a rubbish bin on a major tourist road. It is very likely that the feathers were picked up from somewhere else and discarded in the national park.

Original abundance: Gould (1865) noted, from observations recorded in the 1840s by his collector John Gilbert, that 'Except in the breeding-season, when it pairs, it may often be observed in companies of from six to fifteen in number'.

Subsequent changes in abundance: FRTBC were considered to be 'fairly common...soon after 1887' (Carter 1923, p. 141). Carter (in Mathews 1916-17, p. 109) thought that the FRTBC was 'rapidly diminishing in numbers'. By 1923, Carter stated that they were 'sadly diminished in numbers'. In the Bridgetown area in the 1920s the FRTBC was regarded as 'not at all numerous' (Whittell 1933). In the 1940s it seems to have occurred only sporadically on the Darling Plateau east of Perth, as Serventy (1948) recorded that 'at times it may be seen' there.

During the surveys, several participants offered anecdotal evidence of change in abundance. Near Donnybrook, one observer noted that 50 years ago small groups of FRTBC were seen at intervals of 2-3 years; now about 30 birds are seen daily. Another observer resident near Gidgegannup for 24 years thought that FRTBC were now more prolific and were in the district all year. In contrast, an observer who has lived near Collie for 10 years thought that flock size had decreased from 40-50 to 20 birds.

The data in Table 1 lend support to the idea that, by the 1950s, the FRTBC was scarce. Honorary rangers were asked to rate the abundance of the FRTBC in the local area in which they lived or travelled in regularly.

Table 1

Period **Abundance of FRTBC in south-west Western Australia 1955-58**

	None recorded	Few	Moderate	Plentiful	Increasing	Decreasing
Jan-Mar 1955	6	6				
Apr-Jun 1955	15	8				
Jul-Sep 1955	11	6				
Oct-Dec 1955	11	9		1		
Jan-Mar 1956	15	11	1			
Apr-Jun 1956	12	8	1		1	

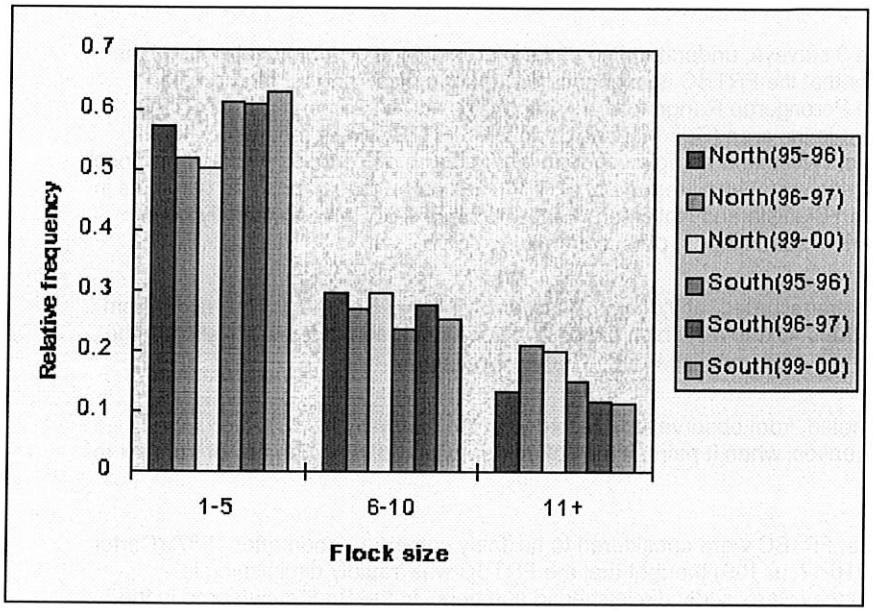
Source: Fisheries Department Bulletin for Honorary Rangers. Vol. 2 (2) 1955 to Vol. 5 (1) 1959.

In the period 1960-80, the FRTBC appears to have become more common in some locations. For instance Kimber (1972) rated the species as 'common' within a radius of 15 miles [23 km] of Dwellingup, and Christensen *et al.* (1985) classified it as 'locally common' in the southern forests. This is in contrast to Ford

(1965), who stated that it was 'present in small numbers' in jarrah forest on the Darling Plateau between Armadale and Collie, and Dell (1983), who rated it as uncommon on the Darling Scarp, with fewer than 5 seen per day.

Current abundance: Most flocks of FRTBC consist of 1-5 birds (see Graph 1; note that 'North' and 'South' refer to an imaginary line running east/west through Donnybrook on the Preston River, the conventional boundary between the northern and southern jarrah forests). Johnstone & Storr (1998) mention that large flocks, up to 200 birds, are seldom met with. In 2000, reports of a flock of c. 150 birds on farmland near Collie were received.

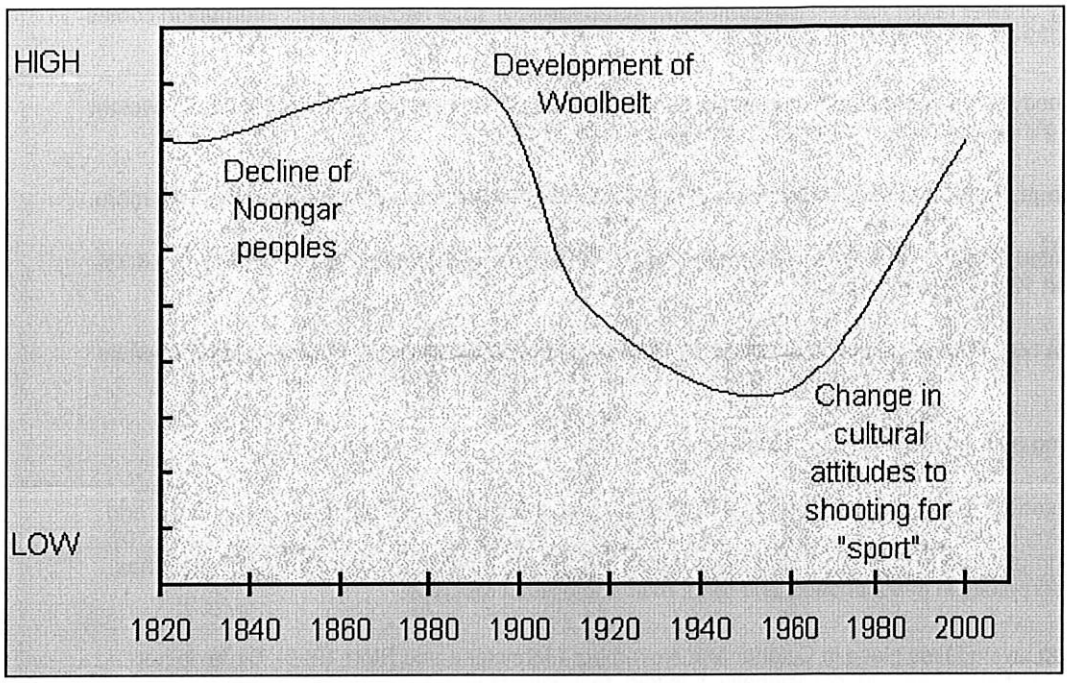
Graph 1



From Map 3, it is evident that flock sizes of 6-10, 11-20 and > 20 were noted throughout the current geographic range of the FRTBC.

A summary of changes - both observed and inferred - in abundance of FRTBC since the 1820s is shown diagrammatically in GRAPH 2. The main factors that are thought to have influenced the abundance of FRTBC are also shown.

Graph 2



Habitat: The currently occupied habitat differs from the original habitat in that much of the forest and woodland east of State Forest has been cleared for sheep farming. The FRTBC is now more dependent on the publicly-owned forests, particularly State Forest, as marked on Map 4. The FRTBC is essentially the cockatoo of the jarrah forests, in contrast to Baudin's cockatoo *C. baudinii*, which is the cockatoo of the karri forest, and Carnaby's cockatoo *C. carnabyi*, which is the cockatoo of the woodlands.

The only major difference found between north and south of the Preston River concerned the location of FRTBC records in the landscape. In the north, most sightings were in valleys (38%) and on ridges (26%), whereas in the south most records came from ridges (41%) and valleys (22%). This difference may reflect the variable niche of marri. In the north, marri reaches its optimum development below the level of the laterite-mantled upland, whereas in the south it tends to occur more upslope, being displaced by karri, yarri and flooded gum. Marri in the southern jarrah forest can contribute up to 33% of stand basal area, in contrast to a minimum of 16% in the northern jarrah forest. The proportion of FRTBC sightings midslope was similar (16% in north, 17% in south).

Food: The FRTBC eats seeds extracted from the woody fruits of eucalypts, mostly jarrah *Eucalyptus marginata* and marri *Corymbia calophylla*. Other species on which feeding has been recorded are yarri *E. patens*, Albany blackbutt *E. staeri*, karri *E. diversicolor*, sheoak *Allocasuarina fraseriana, Persoonia longifolia* and *Banksia grandis*. So far, the only introduced tree species on which feeding has been recorded are pine, Spotted gum *E. maculata* and Cape Lilac (White cedar) *Melia azederach* (Abbott 1998b, Johnstone & Kirkby 1999). Reports of FRTBC stripping foliage from the upper crowns of blue gum *E. globulus* have been received from near Collie and the Porongurup Range. There have also been reports from near Collie of feeding on the ground, apparently on Capeweed.

In the period November 2001 to January 2002, FRTBC have been reported eating Cape Lilac fruits and *Eucalyptus caesia* seeds in gardens to the west of Gosnells and Armadale railway stations (M. Bamess & R. Cockeram, pers. comm.). It appears that the FRTBC is beginning to broaden its diet.

Nesting sites: The FRTBC has been recorded nesting in jarrah, marri, karri and wandoo trees (Gould 1865, Abbott 1998b, Johnstone & Kirkby 1999). It needs hollows in standing trees to provide nesting sites. The nest site is usually a vertical hollow in the trunk and sometimes in a large branch. Nest hollows in marri range from 8-14 m above ground, with the entrance size 12-41 cm and depth of hollow 1-5 m (Johnstone & Storr 1998). Because FRTBC are large birds, the size of the nest hollow obviously needs to be correspondingly large. Detailed studies of the number and size of hollows in jarrah forest show that large hollows are the least common type of hollow available in jarrah forest.

Is logging a threat? Although concern about the current and long-term supply of large hollows is justified, available information (both factual and inferential) indicates that there is no shortage of suitable nest sites throughout jarrah forests.

1. Hollows used by FRTBC occur in trees with a diameter, measured 1.3 m above ground, of 60 cm or larger.

2. The density of trees larger than 60 cm diameter in jarrah forest is 13.3/ hectare. (This information comes from the 1989-91 jarrah forest inventory).

3. Based on body weight/home range equations derived from many bird species, the FRTBC (body weight about 600 g) has a predicted home range of about 116 to 187 ha.

4. A home range of this area should have some 1,543 to 2,487 trees present with diameter 60 cm or more.

5. Hollows suited for usage by FRTBC have been recorded in trees with diameter of 61 to 200 cm in 4.7% of marri and 12.2% of jarrah trees.

6. Therefore a home range should have 104 to 167 trees which have at least one hollow suited for use by FRTBC.

7. Each nesting pair requires only one hollow.

FRTBC are sometimes presumed to be threatened by the harvesting of marri in the southern jarrah forest and in karri woodchipping operations. However, marri was clearfelled only from karri forest, which is less than 10% of the current geographic range of the cockatoo. As a further safeguard, more than half of the karri forest has been reserved in perpetuity in national parks and road, river and stream reserves.

Reproduction: Egg laying takes place in October and November (Johnstone and Storr 1998). Birds do not breed until 4-5 years of age. One egg, occasionally 2, is laid. Incubation takes 1 month and the young bird fledges after a further 2 months. Only the female incubates and broods.

Some participants in the surveys reported breeding at other times of the year (March-May; September-November). However, some of these observations may be based on birds accessing hollows for drinking water. There have also been reports of 2 young leaving the nest hollow.

Nesting may not occur each year, and may be linked to those years when marri fruits prolifically (Johnstone & Kirkby 1999).

Longevity: Not known, possibly 60-80 years?

Current conservation status: Not threatened. Listed as near threatened by Garnett and Crowley (2000), based on a significant and continuing decline in abundance in over 50% of its former range of occupancy and/or extent of occurrence.

Association with oldgrowth forest: The FRTBC is not dependent on oldgrowth forest (Map 6). If it were, FRTBC should not occur in the northern jarrah forest because little oldgrowth forest remains there (41,190 ha). Its stronghold should be the southern forests, where 365,390 ha of oldgrowth forest remain. Map 4 clearly demonstrates thar FRTBC occur about equally in the northern and southern forests.

Analysis of the factors influencing distribution and abundance: There are many factors that can actually or potentially influence the total population size of a species in south-west Western Australia. It is useful to divide these factors into those that are natural processes, and those that have operated only after European settlement. *Positive* signifies that the factor is favourable to FRTBC ecology, whereas *negative* means that the factor should be detrimental.

Natural factors

- Extended drought. FRTBC require daily access to drinking water, which they obtain from hollows in trees, from streams, from pools, and since European settlement from stock water troughs on farms. Importance rating: Minor (negative).

- Severe storms. These may blow down large senescent trees, which are the trees most likely to have the large hollows needed for nesting. Storms of exceptional severity occurred, for example, on 20 April 1841, 17 June 1842, 11 April 1843, 28 February 1845, 17 March 1871, 10 March 1872, 22 July 1900, 26 March 1923, 6 April 1969, 20 March 1975 and 21 April 1991. Some storms may be quite local (Stewart nd:95). Importance rating: Minor (negative).

- Strong winds. These can cause large branches to break away, providing hollows of a size suitable for nest sites. Importance rating: Major (positive).

- High intensity wildfires. These are associated with periods of extended drought, and thus are expected to have occurred infrequently. These fires may burn down large, senescent trees. Importance rating: Minor (negative).

- High intensity wildfires. These can cause large branches to combust, burn away the crown, or initiate fire scars that allow entry of wood-decaying fungi. Over time these may develop into hollows. Importance rating: Major (positive).

- Aboriginal predation. Historical sources document that Aborigines hunted FRTBC. Moore (1884, p. 203) and Bunbury & Morrell (1930, p. 86) mention their tail feathers being used to adorn the hair. Dale (1834) shows a coloured picture of this. Other accounts are provided by Smyth (1878, p. 237), Bolton et al. (1991, p. 133), and McNair & Rumley (1981). Captured birds were probably eaten. Cockatoos were brought down with the *karli* [boomerang] or with sticks (Grey 1841, pp. 281-2; Browne 1856, p. 542; Roth 1902, p. 48). Grey also describes how a wounded cockatoo was fastened to a tree as a decoy. Because of the well-developed social behaviour of cockatoos, large numbers could then be killed. Importance rating: Major (negative).

  It seems that Aborigines seldom raided nest hollows, as John Gilbert noted in 1839 that their eggs are 'generally placed in trees so difficult of access that even the natives dislike to climb them' (Gould 1865).

- Aboriginal burning. Because most Aboriginal fires were lit in summer, with the same area being set alight every 3-4 years, it is likely that most fires were low intensity and patchy. Trees were not burnt down and there was little chance of damage to crowns and limbs. Importance rating: Major [negative, for hollow development); Minor (positive, few trees burnt down).

Post-European settlement factors

- Shooting for food. In the pioneering times of the 1830s and 1840s, the early settlers relied on many native species for food; 'all eatable species near settlement are persecuted or destroyed' (Bolton et al. 1991, p. 270). Cockatoo soup, stews or other dishes are mentioned frequently (Bassett 1954, Bolton et al. 1991, Bradshaw 1857, Breton 1834, Clark 1994, Facey 1981, Haebich 1988, Heal 1988, Johnston 1962, Landor 1847, Roberts 1834, Roe 1836, Shann 1926, Statham 1981, TWH 1833). Even in the early 1900s, Carter (1920, p. 711) recorded that FRTBC 'are easily obtained, but there is not much meat on them'. Importance rating: Major (negative) around settlement, possibly up to the 1920s.

- Shooting for sport. Part of the British heritage and masculine pioneer ethos was shooting animals for amusement, e.g. Roberts 1834, Bradshaw 1857. Any conspicuous species, including kangaroo, wallaby, possum, emu, parrots and quail, was considered fair game. Anon. (1861) in Victoria provides a great number of examples of widespread slaughter. This era was virtually finished by 1950, when the Wildlife Conservation Act was legislated and the Game Act of 1912 was repealed. Carter (in Mathews 1916-17, pp. 109-110) mentions FRTBC being shot 'to obtain the handsome tail-feathers...If one of a flock...is shot and falls wounded to the ground, the rest of the birds will hove close around it, and thus afford an easy target to the gunner, so long as he remains out of sight. I have known of six or eight birds having been shot at one time (not one shot), one after another, through this habit of theirs...'. Carter (1923) regarded shooting to obtain the tail feathers as the main reason for the decline of the species. Andrew Muir (b. 1917) has confirmed that birds were shot for their tail feathers. Rex Herbert (b. 1926) was paid 2/6 per tail in the 1930s. FRTBC in wandoo forest 40 km NE of Mundaring 'suddenly disappeared' in 1950 (Masters and Milhinch 1974). This may indicate illegal shooting of birds. Several participants in the surveys suggested that shooting was the reason FRTBC were rare in the 1950s. Importance rating: Major (negative) around settlements and accessible areas.

  In the 1999-2000 survey, evidence of some FRTBC having been illegally shot north of Albany was found. The birds had been snapping off the tops of bluegums.

  It appears that the main reason why Baudin's cockatoo is in decline and the FRTBC is not is that Baudin's cockatoo damages apples in orchards whereas the FRTBC does not. Orchardists in the past have shot hundreds of Baudin's cockatoo (Halse 1986). Regrettably, much illegal shooting by orchardists still takes place.

- Timber harvesting, 1870-1940. Commercial logging commenced in 1870 near Jarrahdale when a British consortium was granted a 250,000 acre timber concession. Sawmillers, in order to maximize their profits and minimize labour costs, preferentially took jarrah trees with long, sound boles. Trees with damaged stems were left; it is these specimens that are expected to have had large hollows. Marri trees were not felled, as kino veins permeated the bole, making the timber unmarketable. Following the proclamation of the Forests Act in 1919, the jarrah forests came under management by professionally-trained foresters. For many years there were insufficient personnel to regulate cutting. By 1928, a 'Foresters' Manual' was

published which, with a strong focus on timber, resulted in 'tidying up' of logged stands. Marri trees were ringbarked but not felled. This program expanded in the 1930s with the ready availability of cheap labour as a result of the Depression. Importance rating: Minor (negative).

- Wildfire. The great increase in wood debris on the forest floor after logging, together with the official anti-burning philosophy of the time, meant that summer and autumn wildfires increased in intensity and frequency. Although such fires may have caused some mortality of FRTBC, these fires had the beneficial result of increasing the rate of formation of large hollows. Importance rating: Major (positive).

- Timber harvesting, 1970 onwards. With the rise of a strong biodiversity conservation ethos in the 1970s, forest management has put in place several strategies to cater for the persistence of hollow-dependent species such as the FRTBC (CALM 1994). Importance rating: Minor (negative); Major (positive).

  For jarrah forest, these include:

  1. converting no more than *c.*1% of multiple purpose forest to the establishment phase each year;
  2. seeking a structural mix of 40: 40: 15: 4 (mature/senescent: immature: juvenile: establishment stage);
  3. not exceeding a gap size of 10 ha;
  4. retaining 4 *marked* habitat trees/ha in logged stands;
  5. seeking to retain 3 size classes in each coupe; and
  6. retaining strips of unlogged forest between gaps.

  In karri forest, current policy is:

  1. not exceeding 400 m between areas of mature forest where this is possible;
  2. not harvesting river and stream zones;
  3. varying rotation lengths to ensure a diversity of forest structures such that a minimum proportion of the area of karri forest dominated by mature and senescent stages of development is retained at approximately 40%. This is achieved by deferring from clearfelling a) more than 20% of pre-1940 regrowth, b) more than 30% of the total area of regrowth forest regenerated between 1940 and 1975, c) 10% of all stands regenerated each year between 1975 and 1990, and d) 50% of all stands regenerated after 1990.
  4. not logging oldgrowth forest;

- Dieback of trees from Phytophthora root rot. *Phytophthora cinnamomi* was probably introduced with European settlement. Tree mortality was first recorded in jarrah forest in the 1920s. Since then, dieback disease has spread extensively throughout the higher rainfall [western] sector. However, dieback has been a beneficial factor for the FRTBC, as it has increased the supply of large hollows. As trees have died back from their crowns, the larger branches have died and broken off. Marri trees are unaffected by dieback disease. Importance rating: Major (positive).

- Prescribed burning. Fires set under prescription, usually in spring, by forest managers have reduced the frequency and scale of occurrence of summer and autumn wildfires since the 1960s. From the perspective of the FRTBC, low intensity fires are a mixed blessing as they reduce the risk of trees being burnt down but minimize the damage to the upper bole and large branches necessary to promote the development of large hollows. Importance rating: Major [negative] (hollow development); Minor [positive] (tree burndown).

- Mining. Mining for alumina and gold in the jarrah forest both involve deforestation where economically viable deposits occur. Because the scale is relatively small, mining is considered to have had a minor impact on the FRTBC. Importance rating: Minor (negative).

- Agriculture. Clearing of forest for cattle grazing, sheep grazing, orchards, vegetable-growing, vineyards etc. has had a substantial impact on the FRTBC, as only some 40% of the original jarrah and wandoo

forest remains. Carter (1923, p. 141) considered clearing as the second main factor in the decline of the FRTBC. Importance rating: Major (negative)

- Feral honeybees. These occur throughout the jarrah forest, and occupy large hollows. They thus prevent FRTBC from using such hollows. Importance rating: Major (negative).

Other factors that are known to be influential in the persistence of other native species are considered to be either irrelevant, or of little importance, to the FRTBC. These factors include:

1. Establishment of the red fox, an introduced predator, in south-west Western Australia. The FRTBC spends little time on the ground and is diurnal.
2. Establishment of the rabbit in south-west Western Australia. The diets of the FRTBC and the rabbit do not overlap.
3. Establishment of the cat in south-west Western Australia. Feral cats are uncommon in jarrah forest, evidenced by their lack of success in preventing recovery of a suite of previously threatened mammal species such as the quenda, woylie and tammar.
4. Damming of rivers in south-west Western Australia. The area of forest destroyed by this process is too small to have impacted on the FRTBC.
5. Establishment of pine plantations in south-west Western Australia. FRTBC have rarely been reported eating seed of pines, unlike Carnaby's cockatoo. At about 80,000 ha, the extent of pine forest is relatively small.
6. Establishment of the kookaburra in south-west Western Australia. There have been no reports of kookaburras predating the eggs or young of the FRTBC.
7. Colonization of south-west WA by the galah *C. roseicapilla* since the 1920s. Galahs do not occur in forests, except on farms or in towns.
8. Salination of streams. No streams which are sourced from publicly-owned forest are saline.

Table 2 summarizes these risks and their assessment.

Table 2

Risk factor	Likelihood of risk to cockatoos (C) or their hollows (H)	Consequences of risk	Management of risk
Natural factors			
Extended drought	Low (C)	Low	Not manageable
Severe storm	Low (H)	Low	Not manageable
Strong wind	Low (H)	Low: Breakage of crowns and limbs initiates development of hollows	Not manageable
High intensity wildfire	Low (H)	Low: Large senescent trees burnt down	Prescribed low-intensity burning
	Low (H)	Low: Fire scars initiate development of hollows	-
Aboriginal predation	**High** (C)	**High**: Decreased population size	No longer relevant
Aboriginal burning	Low (H)	Low: Burning down of senescent trees	No longer relevant
		High: Retards development of hollows	No longer relevant

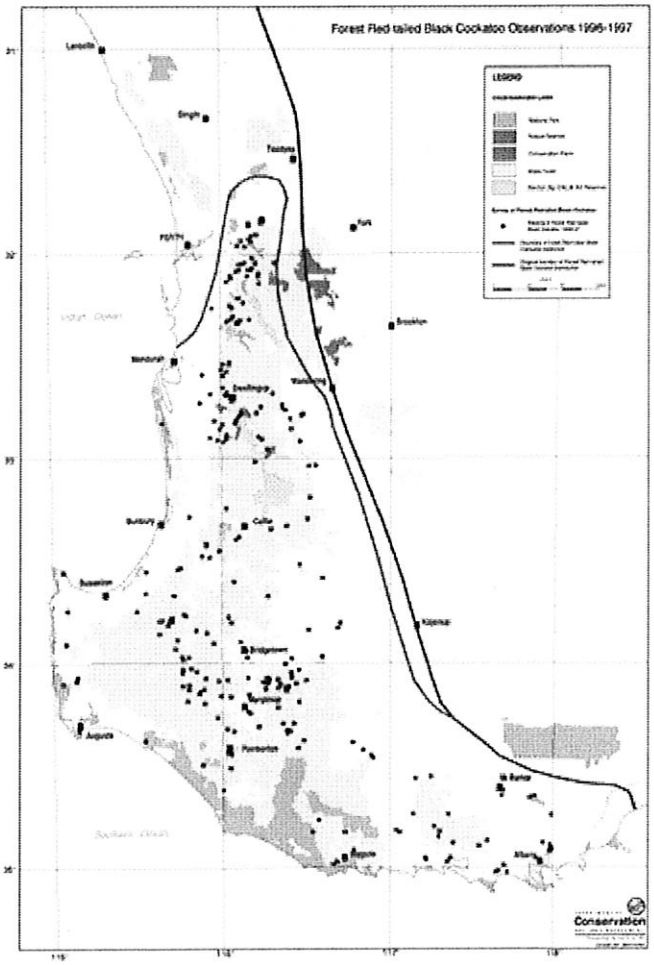
Post-European settlement factors			
Shooting for food	**High** (C)	**High**: Decreased population size	No longer relevant
Shooting for sport	**High** (C)	**High**: Decreased population size	No longer relevant
Timber harvesting in jarrah forest			
1870-1940	Low (C)	Low	Large fire-scarred jarrah trees not logged; no marri logged
	Low (H)	Low	Spatial & temporal scale of logging; high standard required of logged trees
1970 onwards			
	Low (H)	Low	Spatial & temporal scale of logging; unmarked and marked habitat trees retained on gaps; increased area of unlogged or unloggable reserves
	Low (C)	Low	Spatial scale of logging; breeding season = only 3 months of the year
Timber harvesting in karri forest (clearfelling)	Low (H)	Low	Spatial dispersion of coupes
	Low (C)	Low: FRTBC is casual in karri forest	-
Wildfire	**High** (H)	Low: Large senescent trees burnt down	Prescribed low-intensity burning
		Low: Fire scars initiate development of hollows	-
	High (C)	Low: Decreased population size	Prescribed low-intensity burning
Dieback of trees	Low (H)	Low: Crown decline initiates development of hollows in jarrah trees; marri trees unaffected	-
Prescribed low-intensity burning	Low (H)	Low: Burning down of senescent trees	-
		High: Retards development of hollows	Set fires so that some scarring of limbs occurs
Mining	Low (H)	Low	Area affected is relatively small
Agriculture	**High** (C)	**High**: Food trees removed over a large area	Not manageable
	High (H)	**High**: Insufficient large trees retained	Not manageable
Feral honeybees	**High** (H)	**High**: Competition for nesting hollows	Not manageable with the financial resources available
Fox	Nil (C)	Nil	-
Rabbit	Nil (C)	Nil	-
Cat	Low (C)	Low	-
Damming of rivers	Low (H)	Low	Area affected is relatively small

Pine plantations	Low (H)	Low	Area affected is relatively small
Kookaburra	Low (C)	Low	-
Galah	Low (H)	**High**: Competition for nesting hollows	The Galah colonizes urban forests and farms, but has not established in logged forests
Secondary salination	Low (H)	Low	-

Aboriginal legend. Noongars believed that the FRTBC acquired its red markings on the tail from black cockatoos with white markings on their tails (WTBC). These WTBC were attempting to defend a dingo which was attacking a willy wagtail. A swamp hen was feeding at the time on a sedge, the roots of which exude a red sap. The swamp hen cut a reed and struck the WTBC across their backs. When the WTBC spread their tails to defend their backs, the swamphen threw lumps of red sap at their tails. The WTBC became so hoarse from screaming that they could only vocalize karrark instead of wolah. (Paraphrased from Hassell 1975, pp. 226-227).

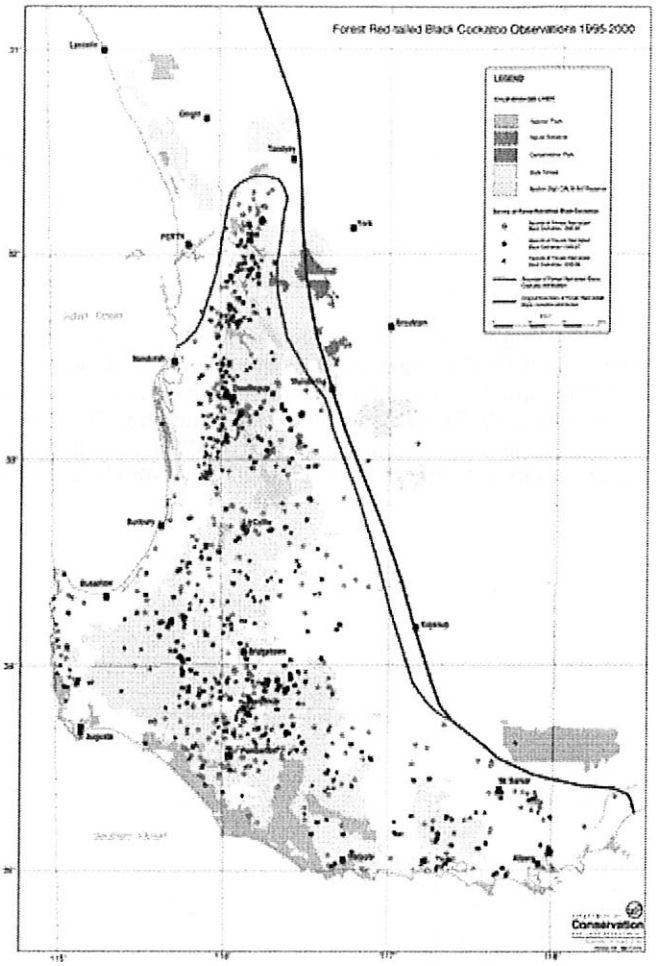
Map 1

(Click to enlarge)



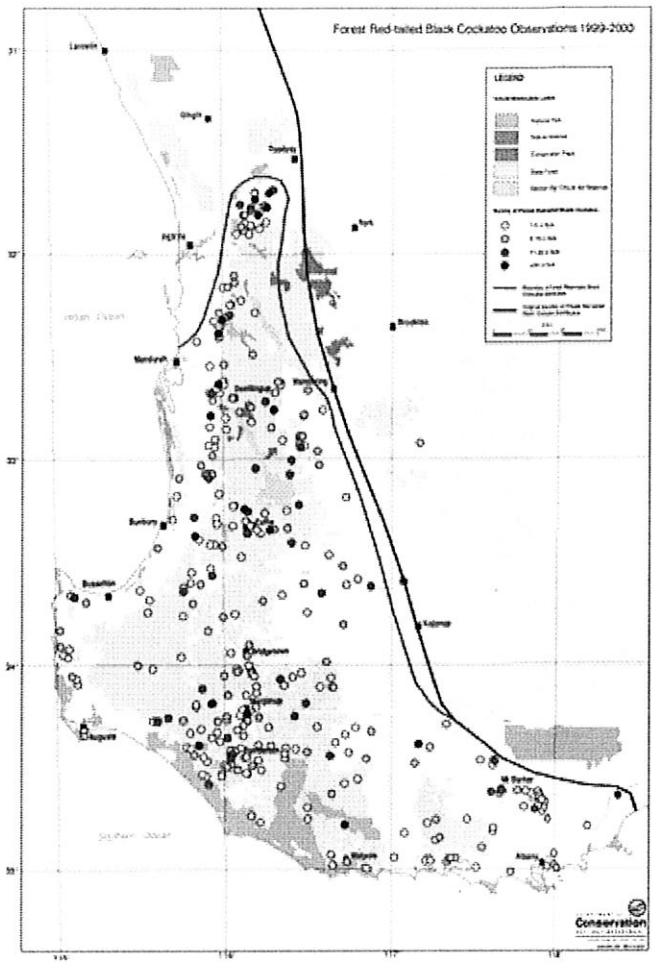
Map 2

(Click to enlarge)



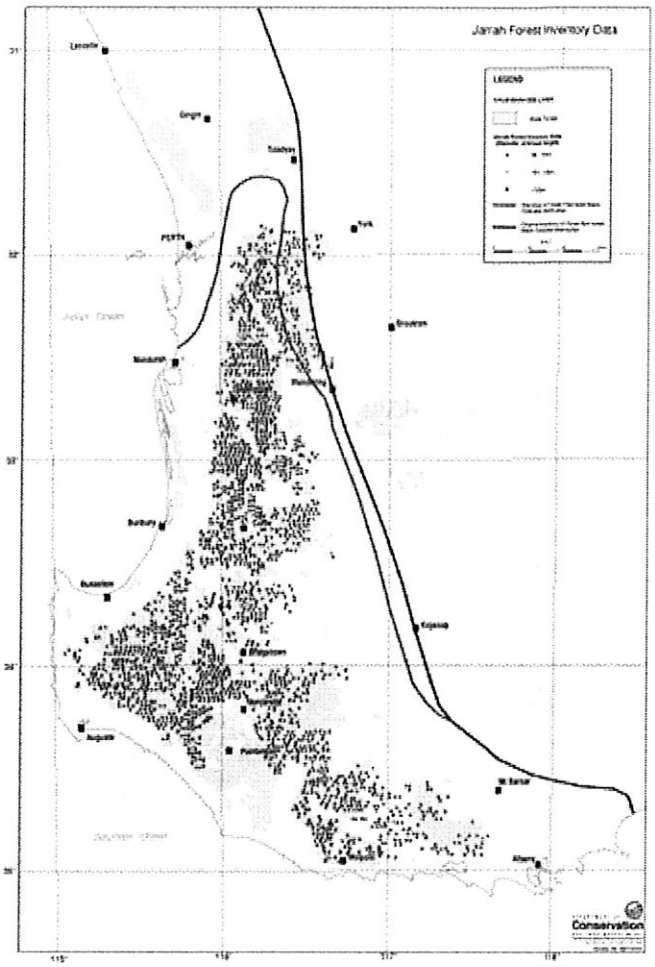
Map 3

(Click to enlarge)



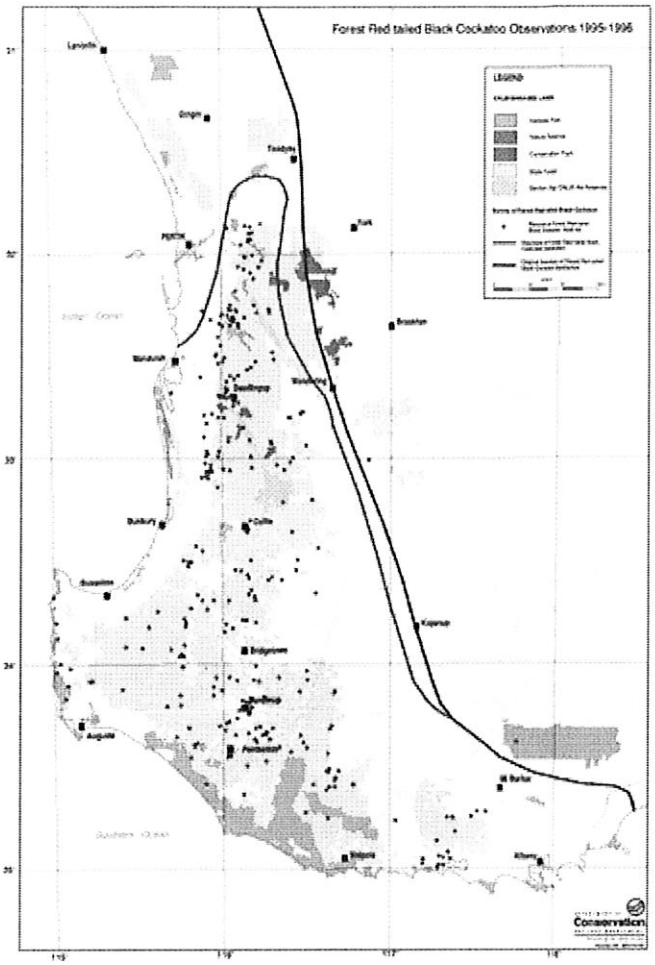
Map 4

(Click to enlarge)



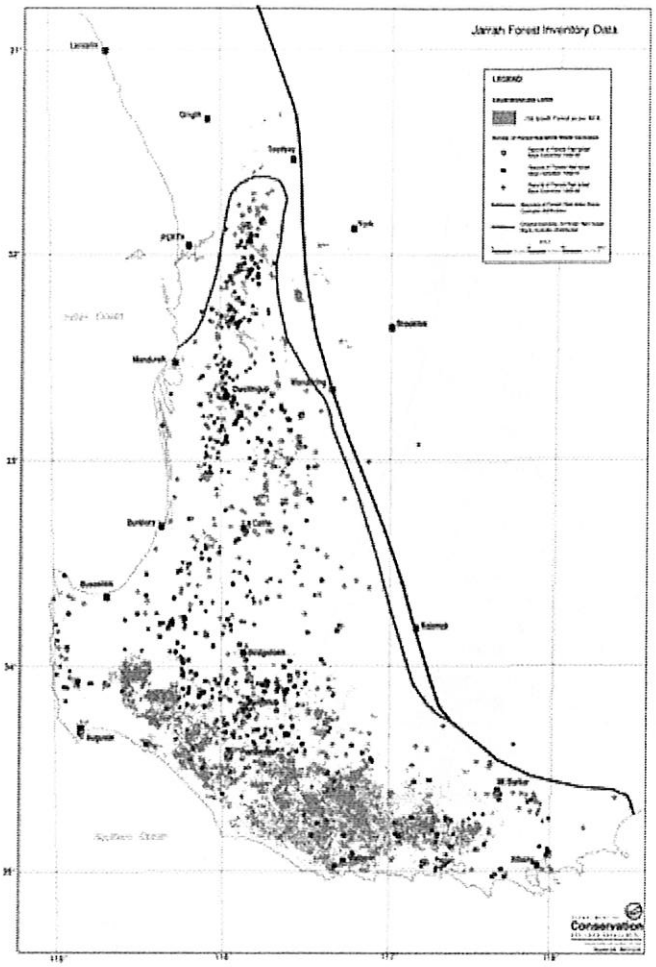
Map 5

(Click to enlarge)



Map 6

(Click to enlarge)



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