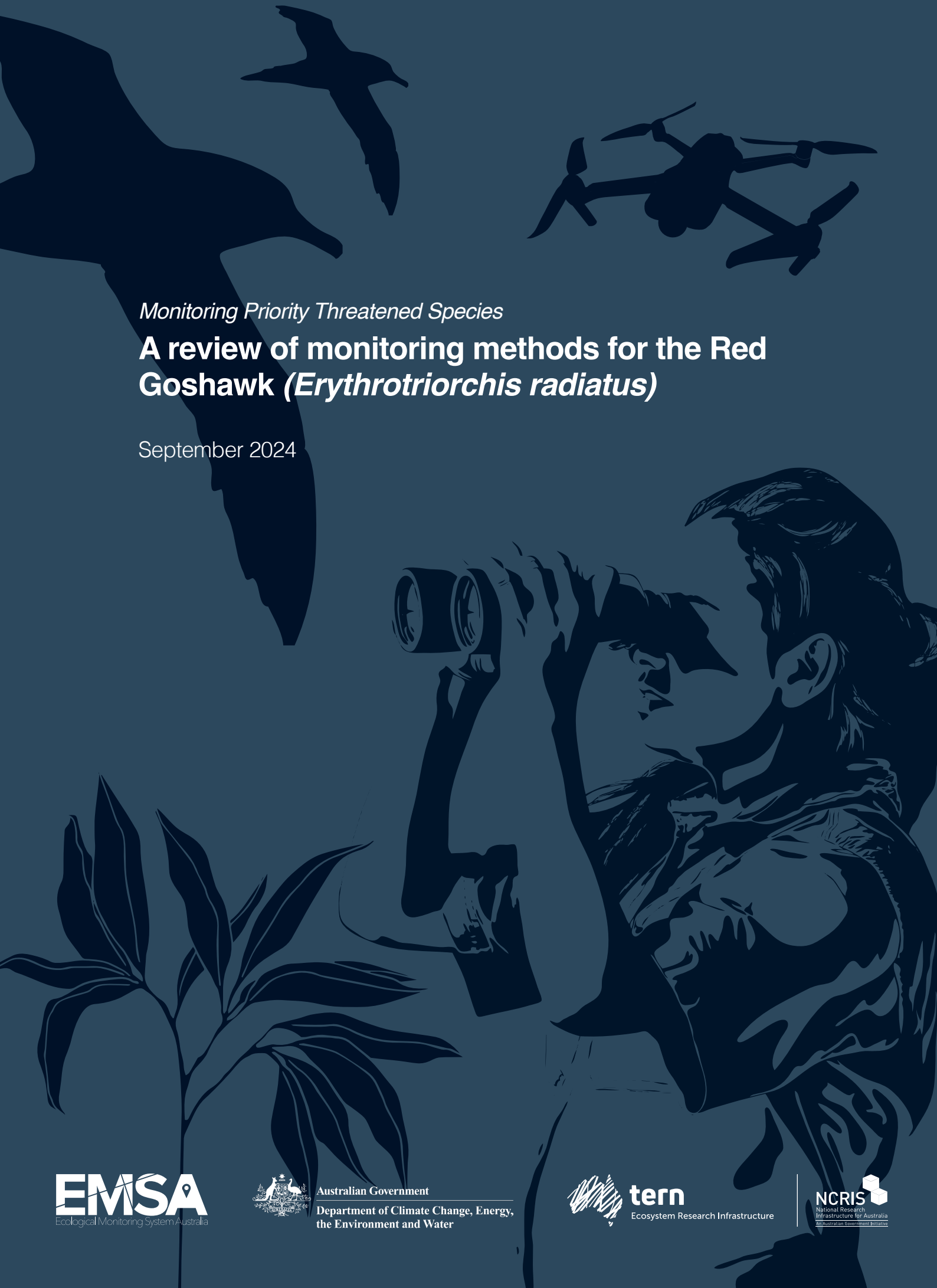

Monitoring Priority Threatened Species

A review of monitoring methods for the Red Goshawk *(Erythrotriorchis radiatus)*

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We acknowledge the Traditional Custodians of Australia and their continuing connection to land and sea, waters, environment and community. We pay our respects to the Traditional Custodians of the lands we live and work on, their culture, and their Elders past and present.

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About

This literature review collates information on one of the 110 priority threatened species identified in the *Threatened Species Action Plan 2022-2032* and has been reviewed by invited practitioners experienced in monitoring the species.

The *Survey Guidelines for Monitoring Threatened Species* project, a collaboration of the Department of Climate Change, Energy, the Environment, and Water (DCCEEW) and the Terrestrial Ecosystem Research Network (TERN), aims to improve our knowledge of threatened species by enhancing accessibility and sharing of quality scientific threatened species data. By developing best practice field survey guidelines and recommendations, practitioners will be better equipped to conduct standardised, repeatable surveys.

By identifying the monitoring methods typically implemented by practitioners, documenting and assessing the techniques known to work, and identifying opportunities to standardise the methods, we can move towards ensuring all monitoring is species-appropriate, comparable between practitioners and populations, and repeatable over time. Further, together with consistent terminology, guidelines, instructions, and data collection, we can refine efforts and resources to measure and share information. Data collected using robust, standardised methods will improve our knowledge of threatened species and underpin threatened species recovery at scale. This project is essential to establishing monitoring protocols and data repositories to enhance the accessibility and sharing of threatened species data.

TERN has prepared the literature reviews for the Department of Climate Change, Energy, the Environment, and Water. For further information, please visit the EMSA Threatened Species Survey Guidelines website. Additional information, particularly monitoring methods and techniques not included that should be considered, can be brought to the author's attention by emailing tern@adelaide.edu.au for consideration for future updates.

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1 Background

1.1 Species name

The Red Goshawk (*Erythrotriorchis radiatus*) (Latham 1801) is colloquially referred to as Australia's rarest bird of prey since it is taxonomically distinct from other endemic raptors (MacColl et al. 2023). It Is also denoted as a 'flagship species' (Czechura et al. 2010) of high priority (Seaton 2014)

1.2 Conservation status

The Red Goshawk is listed as Endangered under the *Environmental Protection and Biodiversity Conservation Act 1999* (Cth) due to its low population estimate (1,340 individuals in the wild) with a declining trend (high reliability), with all individuals existing in one subpopulation spread over an extremely large area (MacColl et al. 2021). The species listing under state legislation varies from state to state. Table 1.

Table 1. National, international and state conservation status for the Red Goshawk

Listing type	Status	Legislation or listing
Commonwealth	Endangered	*Environment Protection and Biodiversity Conservation Act 1999*
New South Wales	Critically Endangered	*Biodiversity Conservation Act 2016 (NSW)*
Northern Territory	Vulnerable	*Territory Parks and Wildlife Conservation Act 1976 (NT)*
Queensland	Endangered	*Nature Conservation Act 1992 (QLD)*
Western Australia	Vulnerable	*Biodiversity Conservation Act 2016 (WA)*
IUCN	Endangered	IUCN Red List of Threatened Species

1.3 Summary of data held in the Threatened Species Index

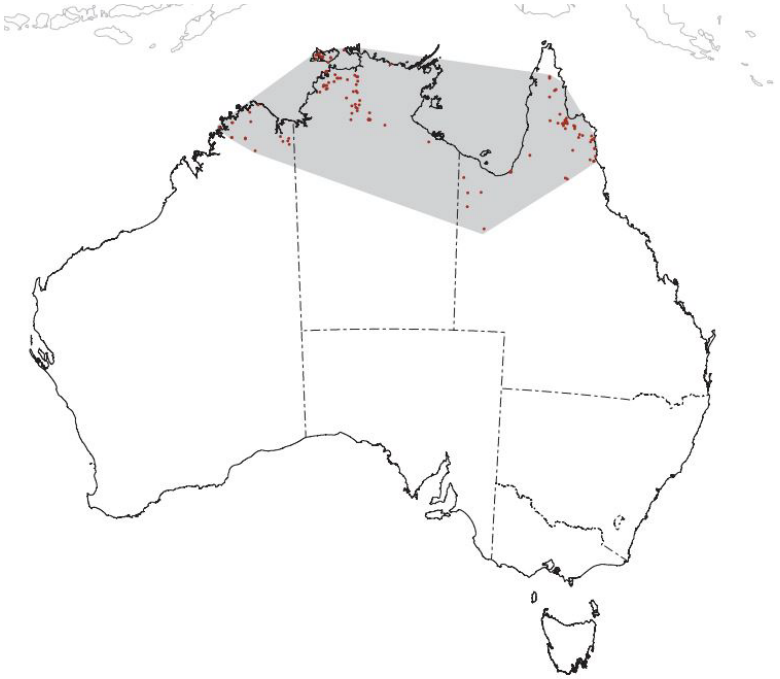
The Threatened Species Index (TSX) provides reliable and robust measures of change in the relative abundance of Australia's threatened and near-threatened species at national, state and regional levels. Understanding these changes in species populations is crucial for monitoring Australia's conservation progress and allows users to measure and report on the benefits of conservation investments, and to justify and design targeted management responses. Currently, the index is restricted to birds, plants and mammals, with new groups to be added in the near future.

The TSX does not hold data on the Red Goshawk. More information on the TSX, including how to contribute threatened species monitoring data to the index, can be found on the TSX website.

1.4 Distribution and abundance

Historically, the Red Goshawk was distributed across much of the New South Wales, Queensland and the Northern Territory coast lines, where it was densely populated (Czechura et al. 2010; MacColl et al. 2023; TSSC 2023). Its present distribution is scattered along the northern coastal regions of Western Australia, Queensland and the Northern Territory (Figure 1), from Broome to south-east Queensland (Baker-Gabb 2012; Woinarski 2006). Populations only remain dense in breeding areas such as the coastal lowlands along Cape York (Czechura et al. 2010). Birds stopped being observed in southern Queensland and New South Wales prior to the 2010s, mirroring the reduction in their breeding range, which is now restricted to east of the Kimberley, Cape York and the Tiwi Islands (Baker-Gabb 2012; MacColl et al. 2021). There have been sporadic sightings in central Australia, implying that the species may have a wider distribution (Baker-Gabb 2012; MacColl et al. 2023).

Figure 1. Distribution of the Red Goshawk



Source: (MacColl et al. 2021)

Australia's total Red Goshawk population is estimated to be around 250 to 2500 adults (MacColl et al. 2023). Outside of the Tiwi Islands, where nest occupancy is monitored annually and has been stable since 2001, there is very little consistent monitoring conducted for the species and population estimates are outdated but appear to be declining (Czechura et al. 2010; MacColl et al. 2021; Woinarski 2006). The abundance of the Red Goshawk has been found to resemble the abundance of its primary prey species (Aumann 2001), being present in particularly biodiverse areas (Baker-Gabb 2012; Seaton 2014).

1.5 Habitat requirements

Habitat availability is a determinant of distribution for the Red Goshawk, with optimal habitat for the species often also being favoured by agricultural ventures. This has led to a number of habitats becoming 'Of Concern' and 'Endangered' under the *Queensland Vegetation Management Act 1999* (Baker-Gabb 2012). The Red Goshawk requires a habitat mosaic to sustain its breeding, nesting, dispersal and hunting behaviours (Baker-Gabb 2012; Czechura et al. 2010). Nesting habitat overlaps with foraging habitat, as birds situate nests within productive, resource-rich areas that they can easily traverse with large sticks (Baker-Gabb 2012). Tall open forest or woodland habitat with high annual rainfall is optimal (Seaton 2014; Woinarski 2006). Habitat must be open to enable hunting and effective fast-paced movements (Baker-Gabb 2012; MacColl et al. 2023). Dense canopy is unsuitable for the large, long-winged birds (Czechura et al. 2009). Trees must be a minimum of 18 m in height for nesting purposes (Debus & Searle 2014) and ideally be taller than 30 m (Czechura et al. 2009). The species prefers a habitat dominated by eucalyptus. Darwin stringybark (*Eucalyptus tetradonta*), bloodwoods (*Corymbia spp.)* and paperbarks (*Melaleuca spp.)* are particularly favourable tree species (Czechura et al. 2009; Debus & Searle 2014). The species also shows an inclination for riparian habitats, and tree stands close to bodies of freshwater (Aumann 2001; Czechura et al. 2010; MacColl et al. 2023; Woinarski 2006). Major rivers offer sufficient habitat for Goshawk pairs (Baker-Gabb 2012). Although Red Goshawk predominantly occupies coastal forests (MacColl et al. 2023), it can be found in tropical savannas or bordering rainforest (MacColl et al. 2021). However, the species' habitat is geographically dependent to an extent.

Historically the Red Goshawk also frequented rainforest, swamp and open eucalypt forest in Northern New South Wales, as well as vine forests and open forests in southern Queensland (Baker-Gabb 2012), however their population declined to extinction in these regions over the 1980, 1990s and 2000s (Cooper et al. 2014; MacColl et al. 2021; Seaton 2014).

1.6 Biology and ecology

The Red Goshawk is a robust raptor species (Baker-Gabb 2012) with an average wingspan of 100 to 135 cm and an average length of 45 to 60 cm(TSSC 2023). The species has one of the most significant displays of reverse-size sexual dimorphism of any raptor species (Czechura et al. 2009; Debus et al. 2015; MacColl et al. 2023). Females are larger than males, weighing 528 g more on average (MacColl et al. 2023). Aside from size, females can be visually differentiated according to their pale and streaked underbody, which shows some white(Baker-Gabb 2012; TSSC 2023). Juveniles can be distinguished by their rufous head feathers and rufous underbody (Baker-Gabb 2012; TSSC 2023).

A strictly carnivorous species, the Red Goshawk predominantly predates on other birds (MacColl et al. 2023). It prefers consuming medium-sized birds (MacColl et al. 2021; Woinarski 2006) between 100 g and 250 g (Baker-Gabb 2012). Specific bird families that have been observed as preferential and more commonly preyed upon include kookaburras (*Dacelo),* parrots (*Loriini) and* cockatoos (*Cacatuidae)* (Corbett et al. 2014; MacColl et al. 2023). The Red Goshawk has also been recorded consuming the Little Red Flying Fox (*Pteropus scapulatus)* (Corbett et al. 2014). It is a cryptic and secretive bird that makes little noise (Baker-Gabb 2012) and can be considered an aerial ambush predator (Czechura et al. 2009). Despite being difficult to observe while hunting, the Red Goshawk is most active when hunting and mirrors its prey species' activity pattern (Aumann 2001).

The migration pattern of the Red Goshawk is influenced by the seasons in its geographical location, being a permanent resident in northern Australia, while historic populations in eastern Australia would migrate south during winter (Baker-Gabb 2012; TSSC 2023). The species is capable of traversing significant distances (over 1000 km (MacColl et al. 2021)), generally resulting in large home ranges (Czechura et al. 2009) of up to 200 km^2 (MacColl et al. 2021; Woinarski 2006). A breeding pair generally share a home range, maintaining a nesting territory within the home range during the breeding season (TSSC 2023). Despite being monogamous (Baker-Gabb 2012), the species is rarely seen in pairs or family groups (TSSC 2023), and males do not participate in any parental care aside from sporadic nest visits (Debus et al. 2015). Instead, males contribute to the creation of the nest and provide food resources (Baker-Gabb 2012). Nests are usually "conspicuous basket-shaped stick nests that are placed in large trees near watercourses" (Woinarski 2006). Preference is given to trees taller than 20 m for nesting (MacColl et al. 2021).

In Queensland the Red Goshawk population begins its breeding season before the wet season, with egg-laying beginning before July. Eggs are incubated for between 35 and 40 days before hatching. Once hatched, juveniles will remain in their natal territory for around six months (Czechura et al. 2009).

1.7 Threats

Raptor populations in general, are declining at greater rates than all other bird orders (MacColl et al. 2023). The Red Goshawk has seen reductions in population density across 29.7 % of its historic breeding range and no longer occurs at all in an additional 34 % of its historic breeding range (MacColl et al. 2023). Land clearing is the predominant threat to the persistence of the Red Goshawk (Baker-Gabb 2012; Czechura et al. 2010; Woinarski 2006) and is partly responsible for the species

decline in New South Wales and south-eastern Queensland. Forests and woodlands are continually being removed for agricultural purposes (Baker-Gabb 2012), an example being the extensive clearing for pulpwood plantations (Woinarski 2006). Removal of habitat increases habitat fragmentation, reduces the quality of available habitat, alters prey availability, benefits invasive species, causes the loss of nesting sites, and may directly disturb individuals or directly disrupt breeding patterns (Baker-Gabb 2012; Corbett et al. 2014; MacColl et al. 2021). The considerable impact of habitat degradation has led to its categorisation as a flagship species as the loss of the Red Goshawk in an area indicates a loss of overall biodiversity (Seaton 2014).

Aside from habitat loss, the Red Goshawk is at risk of being shot, having its eggs poached (Woinarski 2006), and population capacities are reduced by altered fire regimes that cause woodland thickening and impede hunting efficiency (DERM 2012), decreased abundance of prey species and overgrazing (TSSC 2023). Psittacine Beak and Feather Disease (PBFD) may be an additional threat, as it has been recorded in raptor species (MacColl et al. 2023).

2 Existing monitoring

2.1 Overview of monitoring methods

The Red Goshawk's extensive range and cryptic behaviour create difficulty in determining if it is present in an area without directly observing it either nesting or when it is in flight (Seaton 2014). Characteristic signs that may be used to indicate its presence in an area are "prey items, nests, feeding perches [or] remains" (Czechura et al. 2009). Although the species is highly secretive, its presence can be definitively determined by its conspicuous fledglings, which make obvious noises when hungry (Seaton 2014).

Key Red Goshawk population monitoring indices include:

- Prey density and abundance
- Habitat condition and extent
- Territory occupancy
- Extent of nest occurrence
- Adult survival rates
- Population density
- Breeding performance.

2.2 Monitoring resources

The Red Goshawk is a difficult species to monitor and identify (Baker-Gabb 2012). The species subsequently has the least number of sightings reported for a raptor species in Australia across all continental-scale population censuses (MacColl et al. 2023). Monitoring raptor species is made difficult by their preference for remote and inaccessible areas, their low population densities, their ability to travel large distances and their sizable home ranges (MacColl et al. 2023; MacColl et al. 2021). For the Red Goshawk in particular, this has resulted in a significant lack of information pertaining to abundance, demographics and distribution (Czechura et al. 2011; Seaton 2014). Only the population in the Tiwi Islands have been monitored consistently to date (MacColl et al. 2021). The lack of monitoring data for the species has been identified as an issue that has led to the development of methods for standardising historical data and identifying key populations for ongoing monitoring (MacColl et al. 2023; TSSC 2023).

Key resources with information for monitoring the Red Goshawk include:.

- *Rapid and recent range collapse of Australia's Red Goshawk Erythrotriorchis radiatus* (MacColl et al. 2023)
  - The population is well-monitored in the Tiwi Islands where field surveys have been conducted since 1978.
- *Threatened Species Scientific Committee Conservation Advice for Erythrotriorchis radiatus* (TSSC 2023).
  - Recommends: community education to engage citizen scientists to report Red Goshawk and nest observations to relevant government agencies.
  - Compile map locations of nests and bird observations. Protect this location data to avoid poaching of eggs.
  - Analyse Red Goshawk occurrence records over time to determine population trends and geographic range shifts at regional, state, and national scales.
  - Determine the species' spatial ecology including its habitat selections and environmental requirements
  - Quantify productivity/breeding rates at red goshawk nests across northern Australia over multiple seasons so that threats to population recruitment can be assessed now and in the future.
  - Monitor nest success and productivity at nest sites within disturbance landscapes to determine tolerance thresholds and associated land-use planning design (e.g. protection buffer sizes, connected corridors, habitat availability, etc).
- *The Action Plan for Australian Birds 2020* (MacColl et al. 2021)
  - Established monitoring program on the Tiwi Islands records nest occupancy
  - 2 to 4 people are used per nest survey.
- *Survey for the Red Goshawk (Erythrotriorichis radiatus) in south east Queensland* (Seaton 2014).
  - Areas of known breeding habitat should be used as a focal point for surveys.
  - Survey intensity/survey effort greater than or equal to 470 hours of active searching
  - 60 day survey period between December and May.
- *National recovery plan for the red Goshawk Erythrotriorchis radiatus* (DERM 2012)
- *Survey guidelines for Australia's threatened birds* DEWHA (2010)
- *Distribution, status and habitat of the Red Goshawk Erythrotriorchis radiatus in Queensland* (Czechura et al. 2010)
- *Observations on the Biology of the Red Goshawk Erythrotrirchis radiatus in Queensland* (Czechura et al. 2009)
  - Nest surveys should be conducted when egg-laying occurs, on the Cape York Peninsula this is from July to September before fledging occurs in November and December.
- WildNet for historical records
- eBird for opportunistic observations.

2.3 Survey methods

Monitoring of the Red Goshawk is predominantly done through direct observation of individual birds or occupied nests. Radio-tracking has also been used for monitoring the species, although it is less prolific. More information pertaining to these survey methods includes:

2.3.1 Ground counts

A ground count involves surveying an area from the ground and counting the number of individuals of the target-species encountered during the survey. Methods of conducting ground counts for raptors include vantage point counts, counts along transects and opportunistic observations.

The detectability of raptors is highly dependent on the ability of the observer to access the primary habitat (Corbett et al. 2014). To maximise the detectability of observing the Red Goshawk, the timing of surveys should correspond to the period post-completion of the breeding season (between December and May), as this is when individuals are most active because fledglings begin to leave the nest (Seaton 2014). Further, detectability is increased at first light and sunset (Debus et al. 2015; Debus & Searle 2014). Research by Debus and Searle (2014) found an association between Red Goshawk detection and the height of riparian trees, with detection increasing where trees were greater than 18 m in height. Probability of detection of individuals is also heavily influenced by observer accessibility (Corbett et al. 2014).

Vantage point

A vantage point count is a form of direct observation whereby an observer remains at a particular point to count the number of individuals. Vantage points can be used to obtain an index of abundance for the species being surveyed. The point should either be where there is a break in vegetation (e.g. creek or wetland margin) to ensure there is a view of the sky (Debus & Searle 2014) or alternatively the point should be elevated (Czechura et al. 2010; Czechura et al. 2009). A vantage point count can be undertaken alongside distance sampling which involves recording the distance from the observation point to the individual observed. Vantage points are preferred to transect counts for the Red Goshawk because visibility is greater from an elevated vantage point than from the ground (Seaton 2014). Likewise, the species does not respond to flushing and will remain still within the forest canopy to evade detection (Baker-Gabb 2012; Debus & Searle 2014).

Transect

Direct counts of Red Goshawk along transects can be undertaken on foot or from a vehicle and involve recording the number of individuals observed, the distance travelled and the length of time survey completion took (Debus & Searle 2014).

Opportunistic observation

Raptor species are often able to be opportunistically observed by tourists, bird watchers and while conducting unrelated field work where data can be uploaded to online platforms such as eBird (MacColl et al. 2023; Table 2; Noske 2021).

Table 2. Overview of suitable methods for monitoring the Red Goshawk

Survey type	Study design	Survey effort	Location	Reference
Opportunistic observation	▪ All chance raptor sightings made while driving, walking or at observation points within the study area recorded.	▪ 2750 fieldwork hours from 1995 to 1997	Papunya, NT	(Aumann 2001)
Dietary remains	▪ Birds and nest sightings recorded from 1980 to 1994 by CSIRO and research visitors. ▪ Prey abundance also surveyed during this study. ▪ Predators and prey remains also collected at roosts, nests and feeding sites.	▪ 3537 records of differing raptor species ▪	Kakadu National Park, NT	(Corbett et al. 2014)
Vantage point and transects	▪ Searches were ▪ conducted from suitable elevated viewing points, on foot, by driving along road networks, and by combination of these. Binoculars were either 10 x 40 or 10 x 42 with a 25 x or 20-60 x zoom telescope.	▪ August to December 1999 and September 2000 to January 2001	Coen, Burketown and Lawn Hill National Park, QLD	(Czechura et al. 2009) and (Czechura et al. 2010)
Walked transects, driven transects and vantage point	▪ Transects were tracks within mature forest and along the boundary between revegetated areas and mature forest. Walked transects were also done through forest but in trackless areas or along creeks and wetland margins. Stationary observations were conducted at vantage points such as creek or wetland margins where there was a view of the sky.	▪ 20-70 km per driven trips in 2013 then 50 hours of walking, watching or slow driving	Weipa Plateau Province, QLD	(Debus & Searle 2014)
Nest observation	▪ Breeding behaviour of two active nest was studied for all or part of their breeding cycle from courtship and nest building to post-fledgling. ▪ Observations were made in timed observation periods. ▪ Observations made from an unconcealed position outside the Goshawks' alert distance, using binoculars	▪ April – October 1987-1989	Kakadu National Park, NT	(Debus et al. 2015)
Opportunistic observation and active search	▪ Tours as part of bird week conducted by boat where all sightings recorded. This was combined with 20 min censuses of 20, 2 ha sites on 6 occasions from 2008 to 2010.	▪ Annual 5-7 days tours between July and August from 2008-2015	Arnhem Land, NT	(Noske 2021)
Transect and vantage point counts	▪ Survey areas was focused on large emergent trees near roadsides. 10 x binoculars, 30-60 x telescope used and camera with 600 mm zoom telephoto lens. All raptors observed were recorded. Vantage point sites were used for multiple consecutive days.	▪ 60 days total between December 2013 and May 2014. ▪ 472 active search hours for hawks and nests.	Conondale National Park, D'Aguilar National Park, Lockyer State Forest, Main Range National Park and Lamington National Park, QLD	(Seaton 2014)

2.3.2 Other methods

Other monitoring methods that have been used but have not been widely implemented include:

- Sign-based observation (Corbett et al. 2014)
- Radio-tracking (Baker-Gabb 2012; MacColl et al. 2021)
- Aerial surveys
- Active searches for nests

Additional methods that may have future application include:

- DNA sampling
- eDNA sampling
- Aerial surveys
- Satellite telemetry
- Call surveys
- Capture-mark-recapture.

3 Key agencies and organisations involved in the species research and recovery

Key agencies, organisations or individuals identified as having been previous, or currently actively involved in monitoring the Red Goshawk include:

- Noosa and District Landcare Group
- Condamine Alliance
- Southern Gulf NRM
- Reef Catchments Ltd.
- David Baker-Gabb, Elanus Pty Ltd
- Tiwi Land Council
- Queensland Department of Environment and Science.
- Research and Recovery of Endangered Species (RARES) group
- Chris MacColl – University of Queensland

4 Key survey guideline recommendations gathered from the literature

This literature review of monitoring methods for the Red Goshawk has identified some key points that must be addressed when developing species-specific guidelines. These include:

- Searches for the species' characteristic nests, within the species known distribution and preferred habitats are the best methods for detecting Red Goshawk presence. Once potential nests are located, vantage point surveys can be employed to monitor the nests to confirm presence and nest occupation.
- Direct observation via ground surveys (walked or driven transects, and vantage points) are additional methods that should be employed.
- Surveys should be conducted at the completion of the breeding season, at both first light, and dusk. However if surveys are done during the breeding season, call playback may prove beneficial to confirm presence.
- Surveys should focus on known occupied sites of the primary preferred habitats, such as riparian areas with trees taller than 18 m.

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