National recovery plan for the red goshawk
Erythrotriorchis radiatus

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National recovery plan for the red goshawk *Erythrotriorchis radiatus*

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Cover photo: Red goshawk, Kakadu National Park, Northern Territory (photo: David Baker-Gabb)

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Distribution summary

The red goshawk is very sparsely dispersed across approximately 15 percent of primarily coastal and near-coastal Australia from the Kimberley in Western Australia to north-eastern New South Wales (Blakers et al. 1984, Aumann and Baker-Gabb 1991, Barrett et al. 2003). Very low numbers, perhaps transient birds, have also been recorded along major rivers in central Australia (Garnett and Crowley 2000, Aumann 2001). While this broad geographic distribution has changed little since European settlement, there have been some marked contractions in large parts of the bird's range.

Summary of threats to species survival

The main cause of the decline of the red goshawk in north-east New South Wales and eastern Queensland is reported as widespread clearance of native forests and woodlands for agriculture. Other threats to the species include fragmentation and degradation of habitat, direct disturbance and/or loss of nesting sites and changes in prey availability. These threats are addressed under Section 4 of this plan within Actions 1.1, 2.1, 2.2, 2.3, 2.4 and 4.1.

Recovery plan overall objective

Maintain populations of red goshawk across their range and implement measures to promote recovery of the species.

Summary of actions

The actions needed to recover this species include:

- Monitor red goshawk habitat and determine territory occupancy and productivity, and use DNA analyses of feathers to determine adult survival rates;
- Collate information on known nest sites from the past 25 years and produce descriptive maps of important habitat and ensure information is secure;
- Conduct searches to identify previously unknown pairs of red goshawks, nest sites, and habitats critical for red goshawk survival;
- Identify important populations and nest sites, and use the information to inform monitoring programs and state and federal government planning frameworks;
- Provide specific information and advice to assist with the identification, acquisition and management of important habitat for the red goshawk;
- Conduct research to understand the relationship between habitat fragmentation, prey density and population persistence to better inform management;
- Protect habitat through acquisition or voluntary conservation agreements;

- Reduce the effects of red goshawk habitat fragmentation and degradation by encouraging landholders to protect and manage threatened red goshawk territories;
- Train personnel from state and local government to identify and understand the threats to red goshawk habitat;
- Produce and distribute information on the conservation status and habitat requirements of the red goshawk;
- Provide feedback to the public and agency personnel on progress of red goshawk recovery; and
- Review the effectiveness of the community awareness program.

1. General information

Conservation status

The red goshawk is listed as 'Vulnerable' under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). It is listed as 'Critically Endangered' in New South Wales (*Threatened Species Conservation Act 1995*), 'Endangered' in Queensland (*Nature Conservation Act 1992*), 'Vulnerable' in the Northern Territory (*Territory Parks and Wildlife Conservation Act 2000*), and 'rare or likely to become extinct' in Western Australia (*Wildlife Conservation Act 1950*).

The most recent national assessment of the species' status (Garnett *et al*. 2011) concluded that the species no longer satisfied criteria for threatened species listing.

International obligations

The red goshawk is a non-migratory raptor and is listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Affected interests

Organisations that may be affected by the actions proposed in this Recovery Plan include:

- Australian Government
- Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC)
- Australian Government Department of Agriculture, Fisheries and Forestry (DAFF)
- State/Territory and Local Government
- Queensland Department of Environment and Resource Management (DERM)
- Queensland Department of Employment, Economic Development and Innovation (DEEDI)
- Western Australia Department of Environment and Conservation (DEC)
- Northern Territory Department of Natural Resources, Environment, The Arts and Sport (DNRETAS)
- New South Wales Office of Environment and Heritage (OEH)
- Relevant State and Territory Local Government Authorities
- Natural Resource Management Bodies
- Queensland regional natural resource management groups

- Northern Rivers Catchment Management Authority
- Border Rivers-Gwydir Catchment Management Authority
- Rangelands NRM Coordinating Group (Rangelands WA)
- Natural Resource Management Board (NT) Incorporated
- Industry Groups
- National Farmers' Federation (NFF)
- AgForce Queensland
- Non Government Conservation Organisations
- Landcare groups
- Australian Bush Heritage Fund
- Australian Wildlife Conservancy
- Birdlife Australia
- Greening Australia
- Indigenous Land Councils and the Traditional owner groups they represent
- Research institutions
- Private landholders
- Leaseholders
- Community bird clubs
- Field naturalists clubs

This is a list of principal stakeholders, but it should not be considered exhaustive. Other interest groups may also need to be considered prior to undertaking particular tasks.

Consultation with Indigenous Peoples

Due to the vast geographic range of the red goshawk and hence the number of Indigenous groups with an interest in this species or the lands it occupies, the consultation undertaken with Indigenous groups in relation to the development of this recovery plan has been of a preliminary nature to date.

An exception to this is the Tiwi Islands, where the Tiwi people have been extensively involved in the monitoring and management of the species.

Recovery actions include consultation with affected Indigenous groups during the planning and implementation of specific local actions identified within this plan.

Benefits to other flora or fauna species or communities

Red goshawks occur in areas of high biodiversity and have large territories (Debus and Czechura 1988b, Aumann and Baker-Gabb 1991, Czechura 1997, 2001). Areas red goshawks are known to frequent possess intact forest or woodland, permanent water, and areas where large and diverse bird populations occur (Aumann and Baker-Gabb 1991, Czechura 2001). Hence, the conservation of any area for red goshawk will have a substantial biodiversity benefit for a wide range of woodland and forest animals and plants.

Social and economic impacts

Nearly all recent records of red goshawks are from public land such as national parks or state forests and are from eastern Australia, where most clearing of red goshawk habitat has occurred. Restrictions on logging within known red goshawk nesting areas is anticipated to have only minor economic impacts as red goshawks occur at very low densities, nesting at least 6.5 km apart, and most potential nest areas are near permanent water. Such sites are currently excluded from timber harvesting.

2. Biological information

Species description

The red goshawk is a large, swift and powerful rufous-brown hawk. It is one of the most sexually dimorphic raptors in the world (Baker-Gabb 1984), with females (1100 g) nearly twice as heavy as males (630 g). Adult male and juvenile red goshawks have rich rufous underparts, whereas adult females are much paler and heavily streaked below. Adults with their grey, darkly-streaked heads can be distinguished in the field from juveniles which have rufous heads.

The red goshawk is a solitary and secretive bird that is generally silent. Even when nesting, red goshawks are inconspicuous; they do not usually reveal themselves by flying off in alarm when approached (Aumann and Baker-Gabb 1991). Despite the differences between red goshawks and other raptors being well documented (e.g. Debus and Czechura 1988a), they are difficult to identify and many erroneous reports have to be discounted (Debus and Czechura 1988b, Debus 1993, Czechura 1996).

Taxonomy

Family name: Accipitridae

Scientific Name: *Erythrotriorchis radiatus*

Synonyms: *Accipiter radiatus*

Common Name: Red Goshawk

This bird has been placed in a monotypic genus (Christidis and Boles 1994), but an increasing body of opinion supports a broadening of *Erythrotriorchis* to include the chestnut-shouldered goshawk *E. buergersi* of New Guinea (Debus and Czechura 1988b, del Hoyo et al. 1994). Two races of red goshawk were once recognised: nominate race *radiatus* in eastern Australia, and race *rufotibia* of the Kimberley region, but Marchant and Higgins (1993) suggest that this is not justified.

Breeding

Red goshawks are probably monogamous and the same territories may be occupied year after year (Hollands 1984, Aumann and Baker-Gabb 1991). Breeding generally occurs in spring, with laying occurring from August to October in the south-east (Debus and Czechura 1988b), and May to October in the north (Aumann and Baker-Gabb 1991). Breeding activities are spread over many months, with courtship beginning in April and the young not leaving the natal territory until the end of the year (Aumann and Baker-Gabb 1991).

The red goshawk male does most of the nest building and food provisioning. The female lays one or two eggs, which she incubates for 39-43 days. The nestling period is 51-53+ days. Fledged young are totally dependent on their parents for food for 25-30 days and at least partially dependent for another 40-50 days (Aumann and Baker-Gabb 1991). During

1987-1990, 0.9 young were fledged per attended nest (n=26), and 1.3 young per successful nest (n=18) in northern Australia (Aumann and Baker-Gabb 1991).

Diet

Over 95 percent of the red goshawk's diet is birds (Marchant and Higgins 1993), especially those in the 100-250 g range (Aumann and Baker-Gabb 1991). Males mostly capture birds the size of the rainbow lorikeet *Trichoglossus haematodus* and bar-shouldered dove *Geopelia humeralis*, while females commonly kill birds the size of the red-tailed black-cockatoo *Calyptorhynchus banksii* and blue-winged kookaburra *Dacelo leachii* (Cupper and Cupper 1981, Aumann and Baker-Gabb 1991).

Movement and range

In northern Australia, adult red goshawks are year-round residents and population turnover is probably low (Aumann and Baker-Gabb 1991, Czechura 2001), whereas in the south-east of their range, some adults migrate down from the ranges to lowland winter territories (Czechura 1996, 1997). Juveniles may disperse widely and are probably responsible for the bulk of the sightings outside the core breeding areas (Debus and Czechura 1988b).

As is common among large bird-eating raptors (Newton 1979), red goshawks have large home ranges. Tracking of two adult red goshawks fitted with radio-transmitters established that the female flew 5-7 km from the nest and the male 7-10 km. The home range was determined to be 120 km² and 200 km² respectively (Aumann and Baker-Gabb 1991). Czechura (1996) recorded red goshawks flying 6-10 km to hunting areas. These observations suggest that home ranges are 2-4 times larger than nesting territories.

Distribution

The red goshawk is very sparsely dispersed across approximately 15 percent of primarily coastal and near-coastal Australia from the Kimberley in Western Australia to north-eastern New South Wales (Blakers et al. 1984, Aumann and Baker-Gabb 1991, Barrett et al. 2003). Very low numbers, perhaps transient birds, have also been recorded along major rivers in central Australia (Garnett and Crowley 2000, Aumann 2001). While this broad geographic distribution (Figure 1) has changed little since European settlement (Blakers et al. 1984, Barrett et al. 2003), there have been some marked contractions in large parts of the bird's range.

Red goshawks probably occurred throughout the coastal lowlands of eastern Queensland and this segment of the population has largely disappeared (Czechura and Hobson 2000). There has also been a northward contraction of about 500 km in New South Wales (Debus and Czechura 1988b). More recent records of pairs of red goshawks in New South Wales are confined to the north of the Clarence River and 29° 30'S (Debus 1993), with nearly half of recent sightings from state forests or reserves.

Czechura (1996) concluded that red goshawks occur across southern Queensland to at least the western slopes of the Great Dividing Range. Marchant and Higgins (1993) suggested that the population in south-east Queensland was possibly isolated, but this was repudiated by Czechura (1996). Red goshawks in the south are mostly in areas of rugged terrain, though some spend the winter in fragmented habitat on the coastal plains. Most of the more recent locality records for both southern and northern Queensland birds are in existing national parks or state forests. Debus et al. (1993) considered north-east Queensland (north of 20°S) and eastern Cape York Peninsula to be the strongholds for the species in eastern Australia, and this has been corroborated by extensive field surveys (Czechura and Hobson 2000, Czechura 2001).

The suggestion by Aumann and Baker-Gabb (1991) that a break in the red goshawk's breeding distribution exists across the Gulf of Carpentaria was questioned by Garnett and Crowley (2000). Czechura and Hobson (2000) concluded that the Gulf Plains do not appear to be suitable for the birds, but because of the presence of localised suitable habitat (the lower Leichhardt River), it is possible that a small number of red goshawks may be present there. A breeding record c.300 km inland near the upper reaches of the Leichhardt River (Barrett et al. 2003) supports this notion.

In the Northern Territory, the Tiwi Islands are the stronghold for the species supporting approximately 15% of the Australian population (Woinarski et al. 2000, Baker-Gabb 2009). On the mainland, pairs may also be found further inland along major rivers (Marchant and Higgins 1993, Garnett and Crowley 2000). The Victoria River district near the border with Western Australia and the Kimberley district (north of 17°S and east of 125°E) are important areas for red goshawks (Debus and Czechura 1988b, Aumann and Baker-Gabb 1991, Marchant and Higgins 1993).

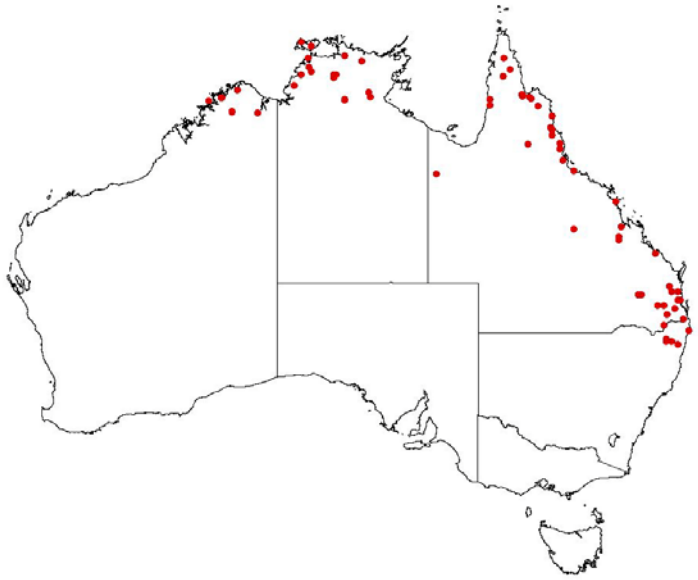

Figure 1: Red goshawk distribution. Data combined from Blakers et al. (1984), Barrett et al. (2003).

Habitat critical to the survival of the species

Habitat critical for red goshawk survival needs to contain all known sites for nesting, food resources, water, shelter, essential travel routes, dispersal, buffer areas, and sites needed for the future recovery as defined by the EPBC Act. Much of the remaining feeding and nesting habitat in eastern Queensland is on public reserves and state forests (Czechura 1996, Czechura and Hobson 2000), whereas in Cape York, the Top End and Kimberley the red goshawk's habitat is subject to a greater range of ownership and management practices, including public reserves, land under Indigenous ownership, and pastoral leases.

Foraging habitat

Resident pairs of red goshawks prefer intact, extensive woodlands and forests with a mosaic of vegetation types that are open enough for fast manoeuvring flight (Marchant and Higgins 1993). These favoured areas contain permanent water, are relatively fertile and biologically rich with large populations of birds. Such areas are also preferentially selected for agricultural development (Sattler and Williams 1999).

Red goshawks generally avoid very densely vegetated or very open habitats, but will hunt along ecotones between such habitats and woodlands or forests. In New South Wales, red goshawks frequent mixed subtropical rainforest, *Melaleuca* swamp forest and open eucalypt forest along coastal rivers (Debus 1993). In south-east Queensland, *Araucaria* vine forests and open forests are a significant component of the vegetation mosaics frequented by red goshawks (Czechura 1997). In northern Queensland, red goshawks are mainly associated with extensive, uncleared, mosaics of native vegetation, especially riparian vegetation, open forest and woodland (Czechura and Hobson 2000) that contain a mix of eucalypt, ironbark and bloodwood species. In southern and northern Queensland, red goshawks frequent a number of regional ecosystems that have been extensively cleared and are considered to be 'Of concern' or 'Endangered' under the Queensland *Vegetation Management Act 1999* (Czechura 1996, Czechura and Hobson 2000). This contrasts with Cape York Peninsula, where none of the regional ecosystems used by red goshawks is regarded as being at risk (Czechura 2001). On Cape York Peninsula, red goshawks are mainly found in vegetation types dominated by northern stringybark *Eucalyptus tetrodonta*, bloodwoods *Corymbia* spp. or paperbarks *Melaleuca* spp. (Czechura 2001). In the Top End, Tiwi Islands and Kimberley area, red goshawks are most often found in extensive open forest, open woodlands and riparian vegetation dominated by mature *E. tetrodonta*, woollybutt *E. miniata*, and Cadjeputs *Melaleuca leucadendron* (Aumann and Baker-Gabb 1991, Woinarski et al. 2000).

In northern New South Wales and southern and northern Queensland, red goshawks are mainly found in rugged terrain (Debus 1993, Czechura 1996, Czechura and Hobson 2000), as the more suitable lowland forest has been cleared or modified. In the Kimberley, Top End and Cape York Peninsula, red goshawks commonly hunt and breed in both lowland sites and rugged terrain (Aumann and Baker-Gabb 1991, Czechura 2001). Apart from birds over-wintering in fragmented forests and woodlands near heavily timbered country in coastal south-east Queensland (Hughes and Hughes 1988, Czechura 1996), red goshawks are rarely seen away from large areas of intact native vegetation (Aumann and Baker-Gabb 1991, Czechura 2001), and there are no breeding records from areas where vegetation is extensively fragmented. Forest fragmentation on the Tiwi Islands that removed >25% of hunting habitat within 4 km of nests had a significant impact on nesting success by reducing the output of fledged young, even though it had little impact on the occupation of territories (Baker-Gabb 2009). During 2001-08, only four of 12 (33%) nests fledged young once their territories had >25% of their forests and woodlands cleared during forestry operations, whereas 23 of 30 (77%) nests fledged young from territories where <25% of the forest was cleared (Baker-Gabb 2009).

Nesting habitat

Nesting habitat is a subset of foraging habitat, with a tall stand of trees invariably selected as the nest location (Aumann and Baker-Gabb 1991). All identified nest trees have been within 1 km of permanent water, often adjacent to rivers or clearings, and usually the tallest (mean height = 31 m) and most massive trees (Aumann and Baker-Gabb 1991, Czechura 2001). Such situations provide mature trees for both the substantial nests the birds construct and foraging advantages where prey is concentrated. In flat to rolling country where there may be few breaks in the tree canopy, nest trees are sometimes selected alongside roadways or other clearings, but still within 1 km of permanent water (Aumann and Baker-Gabb 1991, Czechura 2001). Such positions allow ready access to the nest site, an advantage for large, long-winged birds, and are useful for male red goshawks carrying sticks up to 2 m long onto the nest platform (Aumann and Baker-Gabb 1991).

Debus and Czechura (1988b) and Aumann and Baker-Gabb (1991) found that 30 nests were built at an average height of 20 m. Nests are large (c. 1.0 x 0.7 m), rather flat and

untidy structures that are sufficiently different from those of most other raptors to be obvious to survey teams. They are most like those of the square-tailed kite *Lophoictinia isura*, being placed close to the top of a tall tree on a substantial, horizontally-inclined fork.

Important populations

The issue of delineating important populations for the red goshawk is complicated both by the ecology of the species, whereby breeding pairs occupy extensive home ranges, and by the definition of 'population' adopted. Red goshawks from Top End, Tiwi Islands, Cape York, central coastal Queensland and southern coastal Queensland/northern New South Wales are morphologically indistinguishable (Marchant and Higgins 1993) suggesting that there is either limited genetic interchange between the groups of red goshawks or that fragmentation of the red goshawk population is only a recent phenomenon.

Whilst the persistence of genetic interchange between red goshawks in these areas might imply the existence of a single continental population, it is important from a management perspective to differentiate the population at a regional scale. Information derived from implementation of the recovery plan will refine our understanding of red goshawk populations. Action 4.1 of this plan will identify important populations of red goshawk using a set of criteria developed by species experts. The information will be collected on populations and nest sites and will be analysed to determine if distinct populations exist. The following summarises current knowledge of red goshawk populations across their range.

Using BIOCLIM[1] predictions, and approximate densities of one breeding pair per 20 km of creek or river in core areas, and half that density in range areas, Aumann and Baker-Gabb (1991) estimated that there were formerly about 60 pairs of red goshawks in Western Australia, 200 in the Northern Territory and 180 in Queensland. This gives an estimated total of 440 pairs at the time of European settlement. They considered that only 350 pairs of red goshawk may remain in Australia. However, Garnett and Crowley (2000) suggested that there might still be 500 pairs, with 100 pairs on the Tiwi Islands (Baker-Gabb 2009).

Czechura *et al* (2011) found that following field surveys, it was estimated that there were 10-30 pairs of red goshawks in southern Queensland (Czechura 1996, Stewart and Hobson 2002), 35-40 pairs in northern Queensland (Czechura and Hobson 2000), and 60-70 pairs for Cape York Peninsula (Czechura 2001) and possibly five pairs in the Mt Isa Inlier Bioregion. This estimate suggests that up to 135 – 140 breeding pairs remain in Queensland. This estimate is slightly lower than the estimate of 180 breeding pairs historically in Queensland (Aumann and Baker-Gabb1991). Comparison of these figures suggests that a population decline (>20%) is likely to have occurred in recent times. However, further survey effort is required in parts of the red goshawk's historical range to confirm this.

Data on recorded distances between breeding pairs' nests suggest that it is reasonable to predict densities of about one breeding pair per 10 km of creek or river in core areas, and half that density in range areas. This is double the density used by Aumann and Baker-Gabb (1991), Czechura (2001), and Garnett *et al* (2011) in their calculations and could indicate a current number of breeding pairs of around 700.

1 *BIOCLIM is a computer generated bioclimatic prediction system that uses bioclimatic parameters derived from monthly mean climate estimates to approximate energy and water balances at a given location.*

3. Management practices.

Management practices necessary to protect the red goshawk are primarily those related to surveys, monitoring and habitat protection. They also include vegetation management (forestry and land clearing), fire management, and implementing appropriate grazing regimes.

Documentation

Documentation that sets out research and past management actions to support the recovery of the red goshawk in Australia includes:

- A species recovery outline for the red goshawk in *The Action Plan for Australian Birds 2000* (Garnett and Crowley 2000)
- *Recovery Plan for the Red Goshawk* (*Erythrotriorchis radiatus*) (New South Wales National Parks and Wildlife Service 2002)

Habitat protection

Several significant areas within the species' distribution in eastern and northern Australia are protected in conservation reserves or state forests. These include the following major reserves:

- New South Wales – Border Ranges National Park, Yuraygir National Park,
- Queensland – Lamington National Park, Conondale National Park, Blackdown Tableland National Park, Eungella National Park, Mungkan Kandju National Park, Lakefield National Park,
- Northern Territory – Kakadu National Park, Nitmiluk National Park, Litchfield National Park, and
- Western Australia – Drysdale River National Park, Mitchell River National Park, Mt Hart National Park.

As part of the Comprehensive Regional Assessment (CRA) of public forests in north-east New South Wales, approximately 65,000 ha of habitat potentially suitable for red goshawks was identified in the formal reserve system. This represents about 22 percent of the total area of predicted suitable habitat of approximately 296,000 ha in New South Wales.

The *Vegetation Management Act 1999* and the *Native Vegetation Conservation Act 1997* provides additional protection of red goshawk habitat within Queensland and New South Wales respectively.

Management guidelines

The New South Wales Office of Environment and Heritage administer a Forest Agreement for the Upper North East and Lower North East Regions under the *Forestry and National Parks Estate Act 1998*. Integrated Forestry Operations Approvals (IFOA) also apply and include specific reference to the *Threatened Species Conservation Act 1995.* Areas proposed to be logged that have a red goshawk record within 5 km, are required to be surveyed by State Forests New South Wales and any raptor nests located must be protected with a 400 m exclusion zone until the identity of the nest is determined. Where a red goshawk is recorded during these surveys within 5 km of the area to be logged, all operations are ceased until such time that a management prescription for that forestry compartment is developed.

The Queensland Department of Environment and Resource Management has developed a 'Conservation Management Profile' for the red goshawk. The profile provides management

guidance on minimising identified threats in relation to land clearing and vegetation management; using buffers to protect nest sites; managing nest disturbance; and managing fire and grazing.

The Queensland Department of Environment and Resource Management has also produced Back on Track Actions for Biodiversity documents for each of the 14 Natural Resource Management (NRM) regions across Queensland. These documents provide a framework to help direct management and research, as well as a strategic approach to the recovery of threatened species, including the red goshawk. The documents are based on the results of workshops that were held at the regional level, with consultation obtained from a range of potential contributors.

On the Tiwi Islands, annual searches for red goshawk nest sites are undertaken by trained staff. When a nest is located, a 300 m nest buffer and 600 m wide corridor to the nearest watercourse is applied. The nest site is monitored weekly and nesting success is recorded. Trends in nesting and nesting success have guided management practices over time (Baker-Gabb 2009).

Community education and information

As part of a community education and awareness program, a red goshawk information pamphlet and nest identification guide have been produced and distributed in New South Wales and Queensland by the relevant state agencies.

On the Tiwi Islands, plantation owners and the Tiwi Land Council have developed and implemented a community awareness program that includes public information sessions, school talks, community participation in monitoring activities and published material such as identification photos, and stories in local newspapers.

4. Threats to species' survival

Habitat loss

The main cause of the decline of the red goshawk in north-east New South Wales and eastern Queensland has been widespread clearance of native forests and woodlands for agriculture.(Hollands 1984, Debus and Czechura 1988b, Aumann and Baker-Gabb 1991, Debus 1993, Czechura 1996, Czechura and Hobson 2000). However, much of the existing remnant habitat is protected due to regulations under the *Vegetation Management Act, 1992*. This Act regulates clearing of remnant vegetation on freehold and indigenous land and state tenures. On some other state tenures native woody regrowth may also be protected.

Fragmentation

Red goshawks have been recorded over-wintering in areas of fragmented vegetation (Hughes and Hughes 1988), but they have only been recorded breeding in large areas of intact native forest and woodland (Aumann and Baker-Gabb 1991, Czechura 2001). Red goshawks on the Tiwi Islands had significantly reduced breeding success once >25% of forest and woodland was cleared within 4 km of their nest site (Baker-Gabb 2009), and this information should influence management prescriptions for logging operations in state forests and applications for land clearing.

For a widespread but sparse species such as the red goshawk, most developments are only likely to affect one or two pairs. However, the cumulative threat of many small developments and their associated impact on vegetation fragmentation is much harder to quantify and accommodate within recovery planning and impact assessment for this species.

Threats to nest sites

While disturbance to nesting birds is unlikely to be a problem because red goshawks are very tolerant of moderate numbers of people visiting their nest sites (Aumann and Baker-Gabb 1991), nests are much sought by egg-collectors (Debus and Czechura 1988b, Aumann and Baker-Gabb 1991, Czechura 1996). In addition, clearing of mature trees, even up to a kilometre from watercourses, has the potential to eliminate suitable nest sites.

Extensive, hot fires late in the dry season have caused nesting failures (Aumann and Baker-Gabb 1991, Baker-Gabb 2007), and fires may destroy nest trees (Czechura 2001). After Cyclone Ingrid blew down many trees, including red goshawk nest trees on Melville Island in 2005, subsequent fires were unusually hot and numerous ancient trees that survived the cyclone were burnt down, including two nest trees (Baker-Gabb 2007).

Threats to the prey base

Given that the presence of permanent fresh water is an essential component of red goshawk habitat, the degradation of rivers and wetlands utilised by potential prey species of the red goshawk may reduce prey availability (Czechura 1996, Czechura and Hobson 2000). Burning and heavy grazing may have altered the prey base and prey availability (Aumann and Baker-Gabb 1991), but these impacts are difficult to identify and harder to quantify. In tropical northern Australia, Franklin et al. (2005) found that grazing intensity was the greatest single human-induced cause of declines in the distribution and abundance of granivorous birds. However, it is not possible to determine whether the impacts on the bird fauna were a direct effect of grazing on seed abundance or due to indirect impacts of pastoral settlement, including alterations to fire regimes.

Threats to prey availability

On the Tiwi Islands where there are no pastoral enterprises, indigenous burning practices help to maintain an open understorey below a canopy of large, widely-spaced trees. This vegetation structure provides ideal hunting habitat for red goshawks. By contrast, on mainland northern Australia, inappropriate fire regimes and cattle grazing are recognised threats to biodiversity (Sattler and Williams 1999, Garnett and Crowley 2000) that can result in substantial increases in sapling growth below the canopy that prevent red goshawks from hunting there. Vegetation thickening is likely to have reduced prey availability and hence red goshawk densities over large areas of mainland northern Australia.

Information gaps

Although a significant body of research and assessment of the red goshawk has been completed during the past 20 years, there remain several key information gaps relevant to the management and conservation of the species. The most important of these gaps relate to our knowledge of the factors influencing territory occupancy, breeding success and adult survival in northern Australia (Garnett and Crowley 2000, Hamel *et al.* 2007). Hamel *et al.* (2007) undertook a preliminary population analysis (PVA) of data from the Tiwi Islands' red goshawks (Baker-Gabb 2007) and concluded that the parameter needing greatest attention was information on the survival of adult goshawks. The standard way to collect these data is to capture, individually mark and recapture/re-sight several birds so that more accurate survival and recruitment rates can be calculated. However, red goshawks are unusually difficult to trap (Baker-Gabb 2009) and so DNA analyses of moulted feathers collected from under nest sites (Hogan *et al.* 2008) should be a more effective way of collecting data on adult survival and recruitment rates. The significant disparity found between years for breeding success in northern Australia was highlighted by Aumann and Baker-Gabb (1991) and led to the recommendation that all of the territories they had located should be checked for a further two breeding seasons to ascertain territory occupancy and productivity, and to identify reasons for breeding failure or breeding

success. Queensland agencies have gone a long way towards determining the status and distribution of the red goshawk in their state (Czechura 1996, 1997, 2001, Czechura and Hobson 2000, Stewart and Hobson 2002), as have Great Southern and the Tiwi Land Council on the Tiwi Islands (Baker-Gabb 2009).

Communication gaps

While the bird watching community is generally well aware of the red goshawk's status and notoriously elusive habits (Debus and Czechura 1988b, Czechura and Hobson 2000), the wider community, particularly landholders and Indigenous Peoples in remote northern Australia (with the exception of the Tiwi Islands), have generally not been engaged in 'formal' red goshawk conservation in the past. However, Indigenous groups, through applying their Traditional Knowledge and continuing their land management practices/custodial responsibilities, may well have contributed to red goshawk conservation. In contrast, Tiwi people and foresters are developing and implementing red goshawk monitoring and conservation programs on the Tiwi Islands to meet the specific environmental conditions set by the Australian Government under the EPBC Act.

Current management practices

These activities may hamper the viability and recovery of red goshawk populations:

- Removal of >25% of forest and woodland within 4 km of a red goshawk's nest site, or the centre of its territory if a nest cannot be found
- Removal of actual or potential red goshawk nest trees
- Insufficient buffer zones of at least 300m from nests with 600 m wide forested corridors to intact forest
- Land-use changes that limit future options for revegetation of key areas
- Actions that suppress regeneration of habitat trees within priority areas
- Fire and grazing regimes that increase the density of sapling regrowth under canopy trees (vegetation thickening)
- Grazing or fire regimes that convert forest and woodland to grassland or reduce the abundance of prey species.

Any proposals for such activities should be assessed for possible impacts on this species and/or 'referred' for assessment of a significant impact under the provisions of the EPBC Act.

5. Recovery objectives, performance criteria and actions

Overall objective

Maintain populations of red goshawk across their range and implement measures to promote recovery of the species.

Specific objective 1: Identify and map important red goshawk habitat.

Performance criteria: *Important habitat identified and mapped within the first year*

Action 1.1 Collate information on known nest sites from the past 25 years

Action 1.2 Produce descriptive maps of important habitat for the red goshawk

Action 1.3 Conduct searches to identify previously unknown pairs of red goshawks, nest sites, and habitats critical for red goshawk survival

Justification: Addressing the main threats – habitat loss and fragmentation – will be dependent on understanding the status and dynamics of the red goshawk population at a national scale. Information on changes in territory occupancy for known nest sites from the past 25 years will assist in identifying important populations and habitats critical to the survival of the species. This information can then inform and prioritise implementation of other components of the recovery plan.

Methods: Data will be sourced from a range of existing government and non-government databases to enable information on recent nest localities to be collated and reviewed on a national scale. This information may then be used to assist targeted field survey work.

Potential contributors: BirdLife Australia, QLD DERM, NSW OEH, NT DNRETAS, WA DEC, research institutions.

Specific objective 2: Protect and appropriately manage important habitat areas to ensure long-term survival of the red goshawk.

Performance criteria: Important habitat areas are protected and managed appropriately within four years

Action 2.1 Provide specific information and advice to government agencies and non-government organisations to assist with the identification, acquisition and management of important red goshawk habitat.

Action 2.2 Reduce the effects of habitat fragmentation and habitat degradation by encouraging land owners to enter into voluntary conservation covenants/agreements in areas were red goshawks are located to protect both the birds and their habitat.

Justification: Due to the broad distribution and large foraging ranges of red goshawks, it will be important to protect large areas of suitable habitat to secure viable populations and reduce the effects of habitat fragmentation and disturbance. Areas of private land will be a key component in any strategy to protect red goshawk habitat. Once areas of habitat critical to the survival of the species are secured they must be appropriately managed to ensure key attributes are maintained. Fire regimes that protect both nesting habitat and promote widely spaced mature trees with an open understorey for hunting would be critical components of the ongoing management of these areas.

Methods: Information and education materials will be developed and provided to government and non-government agencies to promote the importance of protecting areas of habitat critical to the survival of the red goshawk in land acquisition and management schemes. Negotiations with landholders of important habitat, including Indigenous groups, will be conducted to encourage protection of suitable land.

Potential contributors: Australian Bush Heritage Fund, Australian Wildlife Conservancy, Agforce Qld, BirdLife Australia, Greening Australia, Indigenous groups, National Farmers Federation, QLD DERM, WA DEC, NSW OEH, NT DNRETAS, regional natural resource management groups and other partner organisations

Action 2.3 Conduct research to understand the relationship between fragmentation, prey density and population persistence to better inform management.

Action 2.4 Monitor red goshawk habitat.

Justification: Habitat loss is a major threat to the conservation and recovery of the species as the red goshawk is a highly mobile species that requires significant areas of intact habitat to support viable populations. It is necessary to understand the relationship between habitat fragmentation and species decline to inform management. Documenting habitat loss and monitoring offset works will provide a measurable basis to both evaluate the success of the recovery program and monitor the degree to which habitat loss remains a threat to the species.

Methods: All state jurisdictions have established remote systems for monitoring vegetation change and/or habitat loss at the landscape scale. Annual *State of the Environment* reporting also incorporates this information.

Potential contributors: DEWHA, QLD DERM, NSW OEH, NT DNRETAS, WA DEC and other partner organisations, research institutions.

Specific objective 3: Increase knowledge about the red goshawk's productive success and its survival.

Performance criteria: *Survival rates and turnover at territories are known by year four.*

Action 3.1 Monitor at least 20 nest sites each year to determine territory occupancy and productivity, and use DNA analyses of feathers to determine adult survival rates.

Justification: Monitoring will be important for understanding population dynamics and helping to identify threats. Monitoring will also serve to measure the effectiveness of any management regimes implemented to protect nest sites. Data on adult survival rates and turnover at territories are keys to developing an improved understanding of population viability (Hamel *et al.* 2007), and this information gap can be filled by undertaking DNA analyses.

Methods: Standard methods for monitoring will be agreed across jurisdictions. It is likely that this will entail some modification of the current approach adopted in the BirdLife Australia *Nest Record Scheme.* Information on adult survival and population turnover can be derived by undertaking DNA analyses of red goshawk feathers collected from below nests (Hogan *et al* 2008) and then revising the population viability model. The assistance of birdwatchers and other naturalists is likely to be required.

Potential contributors: BirdLife Australia, QLD DERM, NSW OEH, NT DNRETAS, WA DEC and community groups.

Action 3.2 Train personnel from state and local government to identify and understand the threats to red goshawk habitat.

Justification: State agencies and local governments have legislative responsibility for the identification, protection and management of biodiversity within their respective jurisdictions. Training of personnel within these organisations would enhance their capacity to integrate available knowledge of the red goshawk into planning and management decisions.

Methods: The habitat descriptions and maps developed under Actions 1.2 and 1.3 will form the base resource for this training. A training program will be designed, produced and delivered to relevant state and local government personnel. This could be offered to other resource management stakeholders where required.

Potential contributors: QLD DERM, local government, NSW OEH, NT DNRETAS, WA DEC and other partner organisations.

Specific objective 4: Identify important populations of red goshawks.

Performance criteria: *Important populations of red goshawks are identified within four years*

Action 4.1 Identify important populations and nest sites of red goshawks and use the information to inform monitoring programs and state and federal government planning frameworks.

Action 4.2 Ensure location information about red goshawk nest sites is secure.

Justification: Identifying important populations and nest sites of red goshawks will assist with implementation of threat-based actions. Due to the conservation status and elusive nature of the red goshawk, nest sites could be subject to disturbances by amateur enthusiasts and nest robbing by illegal egg-collectors. Limiting access to detailed information on nest site locations will reduce the potential for such activities.

Methods: The identification of important populations will be established using criteria to be developed by experts on the species. Information will be collected on populations and nest sites, including all new sightings and nest locations. The information will be analysed to determine if distinct populations exist. Populations will be prioritised into level of importance. This work will link with the results of Action 1.3. To ensure the security of nesting data, agencies and organisations will act as custodians for information on red goshawk populations and nest sites.

Potential contributors: DEWHA, QLD DERM, WA DEC, NT DNRETAS, NSW OEH, BirdLife Australia and other partner organisations.

Specific objective 5: Increase community awareness about the red goshawk and the conservation of the species.

Performance criteria: *Community awareness about the red goshawk and the species' conservation requirements is raised by year four.*

Action 5.1 Produce and distribute information / educational materials on the conservation status and habitat requirements of the red goshawk.

Justification: A number of different educational materials, including posters and brochures, that have been used to assist in informing the broader community on how to identify and protect red goshawk nesting habitat already exist. In order to capture a broader target audience, these materials need to be reviewed and updated and new materials/approaches developed.

Methods: Coordinate the development of high quality educational materials to build community awareness and capacity to support the recovery effort. It is important to identify the appropriate target audience and ensure that the materials cater for this audience.

Potential contributors: QLD DERM, WA DEC, NT DNRETAS, NSW OEH, BirdLife Australia and other partner organisations.

Action 5.2 Provide feedback to the public and agency personnel on progress of red goshawk recovery.

Action 5.3 Review the effectiveness of the community awareness program.

Justification: Regular feedback and evaluation is critical to maintaining an ongoing level of awareness and stakeholder and community involvement and support for the program.

Methods: A communication strategy will be developed that identifies the most effective means of providing useful feedback to stakeholders involved with red goshawk recovery.

This could include the production and distribution of an annual report and/or newsletter, in either hard copy or electronic form. A review of the program and strategy could identify areas of improvement.

Potential contributors: QLD DERM, NSW OEH, NT DNRETAS, WA DEC, Birdlife Australia and other partner organisations.

Summary table
Priorities: 1 = High; 2 = Medium; 3 = Low

Objective	Performance criteria	Action	Priority
Identify and map important red goshawk habitat	Important habitat identified and mapped within the first year	1.1: Collate information on known nest sites from the past 25 years	1
		1.2: Produce descriptive maps of important habitat for the red goshawk	2
		1.3: Conduct searches to identify previously unknown pairs of red goshawks, nest sites, and habitats critical for red goshawk survival	1
Protect and appropriately manage important habitat areas to ensure long-term survival of the red goshawk	Important habitat areas are protected and managed appropriately within four years	2.1: Provide specific information and advice to government agencies and non-government organisations to assist with the identification, acquisition and management of important red goshawk habitat	2
		2.2: Reduce the effects of habitat fragmentation and habitat degradation by encouraging land owners to enter into voluntary conservation covenants / agreements in areas were red goshawks are located to protect both the birds and their habitat	2
		2.3: Conduct research to understand the relationship between habitat fragmentation, prey density and population persistence to better inform red goshawk management.	1
		2.4: Monitor red goshawk habitat	3
Increase knowledge about the red goshawk's productive success and its survival	Survival rates and turnover at territories are known by year four	3.1: Monitor at least 20 nest sites each year to determine territory occupancy and productivity, and use DNA analyses of feathers to determine adult survival rates	1
		3.2: Train personnel from state and local government to identify and understand the threats to red goshawk habitat	2
Identify important populations of red goshawks	Important populations of red goshawks are identified within four years	4.1: Identify important populations and nest sites of red goshawks and use the information to inform monitoring programs and state and federal government planning frameworks	1

Objective	Performance criteria	Action	Priority
		4.2: Ensure location information about red goshawk nest sites is secure	2
Increase community awareness about the red goshawk and the conservation of the species	Community awareness about the red goshawk and the species' conservation requirements is raised by year four	5.1: Produce and distribute information / educational materials on the conservation status and habitat requirements of the red goshawk	2
		5.2: Provide feedback to the public and agency personnel on progress of red goshawk recovery	2
		5.3: Review the effectiveness of the community awareness program	3

6. Evaluation of the recovery plan

An annual assessment will be conducted to assess progress towards recovery. This will include an evaluation of the overall progress as well as progress made on individual actions. A review of the recovery plan will be undertaken five years from its adoption and in accordance with the Australian Government Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) guidelines.

Completion of actions within this plan may require reporting by contributors to DSEWPaC. Reporting will also be available through DERM's Recovery Actions Database (an interactive web-based information system) which is currently in development.

7. Estimated costs of recovery

Action	Year 1 $	Year 2 $	Year 3 $	Year 4 $	Year 5 $	Total $
1.1: Collate information on known nest sites from the past 25 years	15 000	15 000	0	0	0	30 000 contract
1.2: Produce descriptive maps of important habitat for the red goshawk	5 000	5 000	5 000	5 000	5 000	25 000 'in kind'
1.3: Conduct searches to identify previously unknown pairs of red goshawks, nest sites and habitats critical for red goshawk survival	20 000	10 000	0	0	0	30 000 contract
2.1: Provide specific information and advice to government agencies and non-government organisations to assist with the identification, acquisition and management of important red goshawk habitat	2 000	2 000	2 000	2 000	2 000	10 000 'in kind'
2.2: Reduce the effects of habitat fragmentation and habitat degradation by encouraging land owners to enter into voluntary conservation covenants / agreements in areas were red goshawks are located to protect both the birds and their habitat	2 000	2 000	2 000	2 000	2 000	10 000 'in kind'
2.3: Conduct research to understand the relationship between habitat fragmentation, prey density and population persistence to better inform red goshawk management	15 000	15 000	15 000	0	0	45 000 contract
2.4: Monitor red goshawk habitat	2 000	2 000	2 000	2 000	2 000	10 000 'in kind'
3.1: Monitor at least 20 nest sites each year to determine territory occupancy and, productivity and use DNA analyses of feathers to determine adult survival rates	25 000	25 000	25 000	25 000	25 000	125 000 contract

Action	Year 1 $	Year 2 $	Year 3 $	Year 4 $	Year 5 $	Total $
3.2: Train personnel from state and local government to identify and understand the threats to red goshawk habitat	2 000	2 000	2 000	2 000	2 000	10 000 'in kind'
4.1: Identify important populations red goshawks and use the information to inform monitoring programs and state and federal government planning frameworks	1 000	1 000	1 000	1 000	1 000	5 000 'in kind'
4.2: Ensure location information about red goshawk nest sites is secure	4 000	4 000	4 000	4 000	4 000	20 000 'in kind'
5.1: Produce and distribute information / educational materials on the conservation status and habitat requirements of the red goshawk	10 000	2 000	2 000	2 000	1 000	17 000 contract
5.2: Provide feedback to the public and agency personnel on progress of red goshawk recovery	2 000	2 000	2 000	2 000	2 000	10 000 'in kind'
5.3: Review the effectiveness of the community awareness program	0	2 500	0	2 500	0	5 000 'in kind'
Totals	105 000	89 500	3 062 000	49 500	46 000	352 000
Total 'in kind' contributions from agencies						105 000
Total contract funds						247 000

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