Conservation Advice for *Calidris tenuirostris* (great knot)

In effect under the *Environment Protection and Biodiversity Conservation Act 1999* from 5 January 2024.

This document combines the approved conservation advice and listing assessment for the species. It provides a foundation for conservation actions and further planning.

Great knot, Crab Creek © Copyright,Chris Purnell

Conservation status

Calidris tenuirostris was assessed by the Threatened Species Scientific Committee to be eligible for transferring from the Critically Endangered category to the Vulnerable category under criterion 1. The Committee's assessment is at Attachment A. The Committee's assessment of the species' eligibility against each of the listing criteria is:

- Criterion 1: A2bce+3ce+4bce: Vulnerable
- Criterion 2: Ineligible
- Criterion 3: Ineligible
- Criterion 4: Ineligible
- Criterion 5: Insufficient data

The main factors that make the species eligible for listing in the Vulnerable category are based on changes in the estimated rate of population decline. Several studies have recorded variable trends of great knot with the following change over three generations: −45 percent (Clemens et al. 2016), −63 percent (Studds et al. 2017), −8 percent (waterbird meta-analysis; Clemens et al. 2019) and +140 percent (Clemens et al. 2019).

The most recent analysis by Rogers et al. (2023) estimated the mean annual change in population was −0.9% (95%CI: -3.8, 1.9) annually (1993 – 2021) for an estimated total percent change in abundance over three generations of -32.4% (95%CI: -69.2, 48.4). The mean annual change in the last 10 years (2012-2021) was -5.6% (95%CI: -14.6, 5.7), suggesting the decline is continuing (Rogers et al. 2023).

Despite large-scale coordinated counts across the country including strongholds of north-western and eastern Australia the five analyses show contrasting trends. Differing results may reflect non-linear changes over time, or different rates of decline in different parts of Australia (Clemens et al. 2021).

The species' listing of Vulnerable in 2010 (Garnett et al. 2011) was justified, as approximately 90,000 individuals disappeared and likely perished following the reclamation of tidal flats at Saemangeum, Republic of Korea in 2006 (Moores et al. 2008). The population now appears to have recovered from this event (Clemens et al. 2021).

The estimated population of great knot in the East Asian - Australasian Flyway in 2016 was 425,000 mature individuals, of which 381,900 were thought to occur in Australia (Hansen et al. 2016). The estimated Australian population in 2020 of 386,900 mature individuals is based on an extrapolation of the 2016 data using trends derived from Clemens et al. (2016, 2019) and Studds et al. (2017). The great knot's extent of occurrence (EOO) is estimated at 9,600,000 km^2 (range 9,100,000–10,100,000 km^2) and its area of occupancy (AOO) is estimated at 6,000 km^2 (range 6,000–9,000 km^2) (Clemens et al. 2021). The EOO and AOO of the species is thought to be stable.

The great knot is a listed migratory species under the EPBC Act. The species is listed on the Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA) and the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA). The great knot is also listed on Appendix I and II of the Convention on Migratory Species (CMS) as a member of the family Scolopacidae. These legally binding international agreements encourage relevant Contracting Parties to protect great knot, their habitats and to remove barriers to migration. While in Australia, great knot can be found at a number of Ramsar listed wetlands of international significance. Wetlands listed on the Ramsar Convention are listed as Matters of National Environmental Significance under the EPBC Act.

Species can also be listed as threatened under state and territory legislation. For information on the current listing status of this species under relevant state or territory legislation, see the Species Profile and Threats Database.

Species information

Taxonomy

Conventionally accepted as *Calidris tenuirostris* (Horsfield 1821), the great knot is a monotypic species. Other names for the species include the slender-billed knot; stripe-crowned knot; eastern knot; large sandpiper; and great sandpiper (Higgins & Davies 1996).

Description

Great knots are 26 – 28 cm long, have a wingspan of approximately 58 cm, and weigh around 155 g. They are a medium sized, bulky shorebird. Both sexes are similar in appearance, though females are slightly larger and tend to have less chestnut colouring in their scapulars whilst in breeding plumage. The species shows marked seasonal variation, and juveniles are distinguishable from adults.

Adult breeding

Great knot have a white chin and throat. The rest of the head is also white but is heavily streaked black and possesses an indistinct off-white supercilium. A diffuse, dusky patch is also present on the lores. The mantle, upper, and some of the scapular are black, broadly fringed white, pale grey, or occasionally rufous. The rest of the scapulars vary; most are black with broad grey tips, a narrow white fringe, and sometimes large chestnut spots. Others show a pattern which is an intermediate between the breeding and non-breeding plumages. These appear grey with black shafts and varying black centres, narrowly fringed white. The back and upper rump are dark grey, broadly streaked white. The innerwing coverts are dark brownish-grey with black shafts, narrowly fringed white. The underbody of the bird is primarily white, with heavy black streaking on the foreneck and upperbreast. Bold black spots and bars are present on the lower breast and upper belly. Large black spots run along the flanks and side of the belly. The rump and uppertail-coverts have a white patch but are also sparsely marked with black streaks and spots. These contrast greatly with the bird's plain dark-grey tail. The underwings are mostly white. The bill is black, tinged slightly green towards the base. The legs and feet are a dark slate-grey colour.

Adult non-breeding

The head and neck of non-breeding adults is brownish-grey streaked black. Their chin and throat are white. The bird has a grey face. The mantle, back, scapulars, and innerwing coverts are all brownish-grey and all feathers have diffuse, darker centres and narrow white fringes. This gives upperparts a streaked or variegated appearance. The underbody is primarily white, with faint grey suffusion on the breast and heavy grey streaking on the foreneck. This grades into spots on the breast. Additional spots run along the flanks to the undertail coverts. Upperparts become browner with wear.

Juvenile

Juveniles are somewhat similar to non-breeding adults but are typically darker and more boldly patterned. The head and neck are also coarsely streaked. The sides of the head and neck are paler and more finely streaked than the rest of the body, giving a caped appearance. The mantle and scapulars are black, grading to a dull grey on the bases of feathers. The tertials and

innerwing coverts are a paler brownish-grey, with clear blackish shaft-streaks. The underbody is white with a similar pattern of streaking and spotting as adult non-breeding plumage, though markings are larger, darker and more blackish-brown in colour. These markings often join to form a dark band on the breast, similar to that of breeding adults. With wear the mantle, back, and scapulars become more uniform in colour.

Distribution

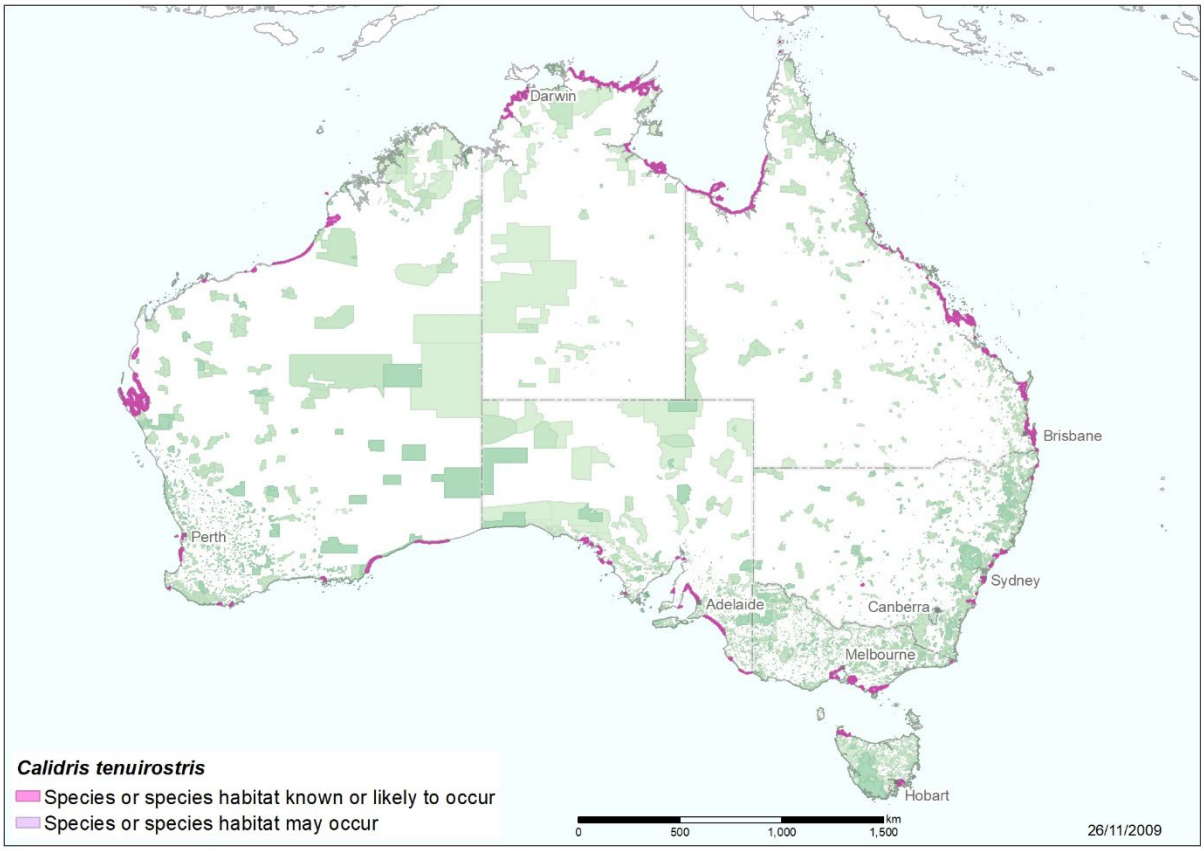
Global distribution

Great knots breed in north-east Siberia and winter along tropical coasts, largely in northern Australia but as far west as the Middle East (Weller et al. 2020). Tracking data has found they use a wide variety of stopover sites in south-east and eastern Asia, including the coasts of India, Bangladesh, and Pakistan (Chan et al. 2019; Birdlife International 2021). The Yellow Sea is also a particularly important stopover site on migration in both spring and autumn.

Australian distribution

The great knot has been recorded around the entirety of the Australian coast, with a few scattered records inland. The species is now absent from some sites along the south coast where it used to be a regular visitor (Garnett et al. 2011). The greatest numbers of individuals are found in northern Australia; where the species is common on the coasts of the Pilbara and Kimberley, and in the Northern Territory from Darwin to the south-east Gulf of Carpentaria. Other important sites include the Broad Sound-Shoalwater Bay area, the Mackay region, and Moreton Bay in Queensland. The species is much less common in south-west Australia, South Australia, Victoria, and Tasmania (Higgins & Davies 1996).

Map 1 Modelled distribution of great knot



Source: Base map Geoscience Australia; species distribution data Species of National Environmental Significance database.
Caveat: The information presented in this map has been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything contained herein.
Species distribution mapping: The species distribution mapping categories are indicative only and aim to capture (a) the habitat or geographic feature that represents to recent observed locations of the species (known to occur) or habitat occurring in close proximity to these locations (likely to occur); and (b) the broad environmental envelope or geographic region that encompasses all areas that could provide habitat for the species (may occur). These presence categories are created using an extensive database of species observations records, national and regional-scale environmental data, environmental modelling techniques and documented scientific research.

Cultural and community significance

Within Australia, the great knot occurs within the lands of numerous Traditional Owner groups. The cultural and community significance of the species is not known. Further research into the subject area may benefit the conservation of the species by providing insights about traditional land management.

This statement of significance is not intended to be comprehensive, applicable to, or speak for, all Indigenous Australians and it is acknowledged that Indigenous groups and individuals are the custodians of this knowledge.

Relevant biology and ecology

Habitat

Foraging habitat and diet

Great knots feed along the water's edge of intertidal mudflats. They feed by rapidly jabbing their bill into the mud, taking prey from the surface, or just below it (BirdLife Australia 2021). The species forages mainly on bivalves, gastropods, crustaceans, annelid worms and echinoderms (e.g., sea cucumbers) (del Hoyo et al. 1996). Small chicks feed exclusively on insects (e.g., larval Diptera and Coleoptera) and spiders (del Hoyo et al. 1996). The species' persistence at some stop-over sites despite the loss of their preferred prey suggests they are flexible in their diet (Zhang et al. 2018, 2019)

Roosting habitat

The species typically roosts along sheltered coastal habitats such as inlets, bays, harbours, estuaries, and lagoons. Selected areas tend to be associated with nearby large intertidal mud and sandflats which are utilised for feeding.

Breeding habitat

Great knots breed in montane tundra in the subarctic at heights of 300-1,600 m (del Hoyo et al. 1996; Birdlife International 2021). Nesting typically occurs in lichenous gravelly herbfields (Clemens et al. 2021), *Empetrum* spp., *Dryas* spp. and *Vaccinium* spp. (Johnsgard 1981), or alternatively on areas with a continuous layer of lichen and scattered stunted larch *Larix* spp. or dwarf pine *Pinus pumila* (del Hoyo et al. 1996).

Reproductive Ecology

Egg laying occurs from late May to late June. Clutch sizes of four eggs are typical, though sometimes only three are laid. Incubation takes around 21 days, and the female parent departs the breeding grounds after the eggs hatch, leaving the male to tend to the chicks (del Hoyo et al. 1996). The fledging period lasts for approximately 20–25 days. Young are independent for a few days after fledging.

Migration

The great knot is a migratory shorebird, moving south from Russia to non-breeding areas in Australia. It is thought that most adults congregate in the western and southern Sea of Okhotsk, then fly directly to northern Australia. Other groups may move south to the Korean Peninsula before flying directly to Australia (Higgins & Davies 1996; Antonov & Huettmann 2004). Individuals found on other Asian coasts are most likely juveniles. Birds show strong fidelity to non-breeding sites as well as breeding sites (Higgins & Davies 1996).

Departure from breeding grounds

Post-breeding migration starts in late June and seems to occur in three waves up to early September. Birds fly towards the northern Sea of Okhotsk, though individuals have been recorded in inland Ussuriland, Russia. Non-breeders, failed breeders and females migrate southward first, followed by males which have bred successfully. The final wave consists of young birds. The great knot passes through south-east Siberia, and along the coasts of the Sea of Okhotsk, southern Ussuriland (from early August to early September), Sea of Japan, the Republic of Korea (late August to mid-October), East China Sea (late July to late October, but mostly August to September), Taiwan (September-October) and Hong Kong (late August-November) (Higgins & Davies 1996; Tomkovich 1997; Barter 2002).

Other stopovers occur in Thailand, the Philippines, western Micronesia, Cambodia, Vietnam, Malaysia, Indonesia, Timor and Papua New Guinea (Higgins & Davies 1996).

Non-breeding season

In Australia, large numbers arrive in the north-west in late August-early September (Lane 1987), though juveniles and many males may not arrive till October-November (Barter 1986). Some move through the Torres Strait (Draffan et al. 1983). Most individuals stay in northern Australia (Lane 1987), though some move further south and birds occasionally reach New Zealand (Higgins & Davies 1996).

After arriving in Australia, most individuals probably remain at or close to their arrival destinations throughout the non-breeding season, and those few that move to southern Australia probably do so in a single flight from northern Australia. Some birds do move from north-west Australia by November with some arriving at the Gulf of Carpentaria in September-December and some arriving on the east coast in September-November. A few birds may move through inland Queensland, New South Wales, and Victoria from September-February (Higgins & Davies 1996). Usually, great knots arrive in South Australia, Victoria, and Tasmania from October-November (Lane 1987; Thomas 1970b). Some appear to move from north-west to south-west Australia along the western coast, sometimes moving into south-west Australia in October. At Eyre Bird Observatory, the great knot generally arrives late August-December.

Return to breeding grounds

Most birds leave Australia directly from the north coast in March-April (Lane 1987), with some moving through the Torres Strait (Draffan et al. 1983). However, most probably fly directly to the Yellow Sea region of China and Korea, with a few to Japan. Smaller numbers leave southern Australia from February and may move through South Australia and eastern Queensland (Higgins & Davies 1996). Thousands have been recorded in south-east Irian Jaya in February-April. The great knot is also recorded from Bali in March; Sumatra in March-April; and Olango Island, Philippines in February-May. High numbers of individuals move through the Kamchatka Peninsula, eastern Siberia, on the northern migration (Gerasimov & Gerasimov 2000). Some individuals also move through Vietnam, Hong Kong and Taiwan (Higgins & Davies 1996). Birds arrive in the breeding grounds from late May, with males arriving before females (Tomkovich 1996). First-year birds generally remain in the non-breeding range (Hayman et al. 1986) and have been recorded in Borneo, Java, Papua New Guinea, and in Australia (Higgins & Davies 1996). At the Gulf St Vincent, South Australia, there is sometimes an influx of individuals in March-April that remain for several months (Close & McCrie 1986).

Habitat critical to the survival

Habitat critical to the survival of the species refers to areas that are necessary:

- For activities such as foraging, breeding, roosting, or dispersal;
- For the long-term maintenance of the species (including the maintenance of species essential to the survival of the great knot, such as macrobenthos);
- To maintain genetic diversity and long-term evolutionary development; or
- For the re-introduction of populations or recovery of the species.

In Australia, a large network of sites are required during the non-breeding season for the species to cope with natural and human-driven environmental changes (Xu et al. 2019).

Habitat critical to the survival of great knot includes a mosaic of feeding and roosting habitat. The species may be highly selective about foraging environments due to its specialised feeding techniques. Feeding habitat includes exposed sandy or soft mud substrates on intertidal flats and beaches. In general, feeding takes place over the whole tidal range; however, like most migratory shorebird species, upper tidal flats may be especially important.

Roosting habitat consists primarily of large intertidal sandflats, spits, and banks. Less frequently, roosting occurs within mudflats, estuaries, coastal lagoons, and bays. In hot conditions, great knot may choose roost sites where a damp substrate lowers the local temperature. During periods of cyclonic activity, shorebirds tend to move to sheltered areas to avoid high winds and heavy rain (Jessop & Collins 2000).

No Critical Habitat as defined under section 207A of the EPBC Act has been identified or included in the Register of Critical Habitat.

International and nationally important habitat

Under the EPBC Act, 'important habitat' is a key concept for migratory species, as identified in EPBC Act Policy Statement 1.1 Significant Impact Guidelines - Matters of National Environmental Significance 2009. Defining this term for migratory shorebirds in Australia is important to ensure that habitat necessary for the ongoing survival of the 37 species is appropriately managed.

Important habitats in Australia for migratory shorebirds under the EPBC Act include those recognised as nationally or internationally important. The widely accepted and applied approach to identifying internationally important shorebird habitat throughout the world has been through the use of criteria adopted under the Ramsar Convention.

According to this approach, wetland habitat should be considered internationally important if it regularly supports:

- 1 percent of the individuals in a population of one species or subspecies of waterbird or
- a total abundance of at least 20,000 waterbirds.

Nationally important habitat for migratory shorebirds can be defined using a similar approach to these international criteria, i.e., if it regularly supports:

- 0.1 percent of the flyway population of a single species of migratory shorebird or
- 2,000 migratory shorebirds or
- 15 migratory shorebird species.

The National Directory of Important Migratory Shorebird Habitat identifies all known feeding and roosting sites of great knot in Australia (Weller et al. 2020). These areas are identified as internationally or nationally important in accordance with the EPBC Act Policy Statement 3.21 - Industry guidelines for avoiding, assessing, and mitigating impacts on EPBC Act listed migratory shorebird species.

An Internationally Important site is determined for great knot if it regularly supports more than 1 percent of the species' total population (1 per cent flyway of the population = 4,250 individuals, Hanson et al 2016).

A Nationally Important site is determined for great knot if it regularly supports more than 0.1 percent of the bird's Flyway population (0.1 per cent of the flyway population = 425 individuals, Hanson et al. 2016).

All internationally or nationally important habitat that exceeds the above thresholds is considered habitat critical to the survival of the species. The degradation or loss of designated important habitat will have disproportionately detrimental impacts on the species' populations and must be avoided.

Habitat critical to the survival of the species should not be destroyed or modified. Actions that remove habitat critical to the survival would interfere with the recovery of great knot and reduce the area of occupancy of the species. It is important to retain as much foraging and roosting habitat as possible. Actions that have indirect impacts on habitat critical to the survival should also be minimised (i.e., human disturbance or light pollution impacting habitat). Actions that compromise survival, such as the introduction of new diseases, weeds, or predators, should also be avoided.

Threats

In Australia, major threats to the great knot are habitat loss, disturbance, and pollution. Elsewhere, the main threat to the species is changes to coastal staging locations, particularly along the coast of the Yellow Sea. The Yellow Sea is heavily affected by rapid development for aquaculture and industry, invasion by cordgrass (*Spartina alterniflora*), pollution from oil and pesticides, and hunting. The species' habitat area is also shrinking through a combination of restricted inflow of sediments from increasingly dammed rivers (Murray et al. 2014; Melville et al. 2016) and sea level rise (Iwamura et al. 2013), with sea walls at many sites preventing suitable inland habitat.

Table 1 Threats

Threats in Table 1 are noted in approximate order of highest to lowest impact, based on available evidence. Threats marked with an asterisk (*) are those that occur largely outside of Australia.

Threat	**Status** [a]	**Evidence**
Habitat loss, fragmentation, and degradation		
Habitat loss caused by residential and commercial development (In Australia and overseas*)	• Timing: current • Confidence: observed • Likelihood: almost certain • Consequence: major • Trend: increasing • Extent: across part of its range	Australia: Wetland loss and degradation in Australia has occurred mainly due to competing land uses and ignorance of the value of wetlands (Geoscience Australia 2021). Due to the distribution of the human population, estuaries and permanent wetlands of the coastal lowlands have experienced most

Threat	Status [a]	Evidence
		losses, especially in the southern parts of the continent (Lee et al. 2006). Shoreline development and changes in local hydrology are the biggest driver of wetland habitat loss. Specific threats include: Landfill or reclamation associated with industrial, housing, or port developments, road construction, marinas, canals and resorts. Additional actions include clearing areas of saltmarsh for solar salt production; damage of wetland areas by rubbish dumping and storm water draining; and, damage of wetlands from the run-off from urban areas which alters the natural salinity regime of wetland areas (Geoscience Australia 2021). <u>Overseas:</u> The increasing requirement for residential housing and urban and coastal infrastructure is driving the draining and filling of wetlands throughout the East Asian - Australasian Flyway. The threat is particularly severe in China, where coastal wetlands have declined in both size and quality over the last 50 years (Zhang et al. 2012; Murray et al. 2014; Sun et al. 2015). Since 1990, approximately 40 percent of naturally occurring coastal wetlands have been lost in China (Gong et al. 2010; Xia et al. 2017). The loss of stopping sites can have two consequences for migratory shorebird populations: 1) Birds may not be able to store sufficient energy reserves for the ongoing migratory flight, thus failing to arrive at their destination; or 2) birds may arrive at their destination but perform poorly because of the carry-over effects of inadequate refuelling during their migration, which could reduce reproductive success (Hua et al. 2015).
Habitat loss caused by industrial aquaculture (In Australia and overseas*)	• Timing: current • Confidence: observed • Likelihood: almost certain • Consequence: moderate • Trend: increasing • Extent: across part of its range	<u>Australia:</u> Australia's coastal environment has undergone rapid changes over the last three decades as the aquaculture industry expands and intensifies to meet the rising demand for seafood products (Ayyam et al. 2019; Ahmed & Thompson 2019; Commonwealth of Australia 2020). Direct and indirect effects of aquaculture may arise from activities including intertidal oyster farming, bait

Threat	Status [a]	Evidence
		harvesting, the compaction of sediments by vehicles, beach nourishment, nutrient enrichment, and the dumping of rubbish or debris (Fuller et al. 2019). Any structural modification of soft-sediment feeding habitat may considerably affect deep-probing shorebirds and may inhibit successful shorebird foraging (Fuller et al. 2019). <u>Overseas:</u> Aquaculture is increasing in scale and intensity throughout the East Asian - Australasian Flyway, particularly within the Yellow Sea where China is the world's leader in aquaculture production. Around the Yellow Sea, aquaculture is practised both in artificial ponds and within intertidal and subtidal zones (Melville et al. 2016). Development of artificial aquaculture ponds results in the loss of intertidal habitats. Thus, shorebirds are forced to feed or roost in artificial environments when tidal flats are submerged (Bai et al. 2018) and are often subject to high levels of disturbance (Melville et al. 2016). Artificial wetlands typically host fewer species and fewer individuals of shorebirds compared with natural ones (Bai et al 2018). Harvesting of edible organisms within natural intertidal areas also occurs throughout the EAAF, including from areas within designated nature reserves. It is not known whether the harvesting of intertidal benthos is significantly affecting shorebirds; however, the amount harvested is, in many cases, substantial and impacts on non-target species may be severe (Melville et al. 2016).
Invasion of mudflats and coastal saltmarshes by mangroves and cordgrass*	• Timing: current • Confidence: observed • Likelihood: almost certain • Consequence: moderate • Trend: increasing • Extent: across part of its range	A number of studies have revealed significant losses of saltmarsh to mangrove (McTainsh et al. 1988; Morton 1994; Duke 1995). Several factors may drive the incursion of mangroves into saltmarshes and mudflats. These include changing patterns of precipitation; altered tidal regime or sea-level; catchment modifications leading to altered sedimentation and nutrient levels; and land subsidence (Saintilan & Williams, 2001). Incursion by mangroves reduces feeding habitat availability for

Threat	Status [a]	Evidence
		great knot and may force the species away from traditional feeding sites. Invasive plant species can also cause major changes in the geomorphology of coastal systems (Kennedy et al. 2017). Along the coasts of the Yellow Sea, cordgrass (*Spartina alterniflora*) has spread rapidly throughout intertidal wetlands and now occupies half of all important coastal shorebird sites in mainland China (Hua et al. 2015; Jackson et al. 2021). The species has also become established in the southern hemisphere, especially Australia and New Zealand. It generally grows seaward from the edge of marshes, facilitating the accumulation of sediment, and eventually replacing open tidal flats with dense, elevated *S. alterniflora* marshes (Kennedy et al. 2017; Jackson et al. 2021). The prolific growth of *S. alterniflora* reduces the availability of foraging and roosting habitat for shorebirds and hinders their movement through the environment (Gan et al. 2009; Jackson et al. 2021).
Downstream effects of large dams*	• Timing: current • Confidence: observed • Likelihood: almost certain • Consequence: major • Trend: increasing • Extent: across part of its range	Many areas of great knot habitat are shrinking due to a combination of restricted inflow of sediments from increasingly dammed rivers (Murray et al. 2014; Melville et al. 2016), and sea level rise - with sea walls at many sites preventing suitable habitat migrating inland. Additionally, water regulation and diversion infrastructure along major tributaries has resulted in the reduction of water and sediment flows (Melville 1997; Barter et al. 1998; Barter 2002). Wetlands are particularly vulnerable to the presence of dams and river management activities as they are dependent on seasonal flooding to sustain ecosystem function (Sun et al. 2012; Junk et al. 2013). Damming reduces flooding to wetlands, causing them to shrink and become inhospitable for a range of aquatic biota, including wetland-dependent birds (Sun et al. 2012).
Anthropogenic disturbance		
Disturbance at feeding and roosting sites	• Timing: current • Confidence: observed • Likelihood: likely	Visitation to many great knot roosting sites such as sandflats, beaches, bays, and estuaries is increasing. The resultant increase

Threat	Status [a]	Evidence
(In Australia and overseas*)	• Consequence: moderate • Trend: increasing • Extent: across part of its range	in development and human recreation is likely to disturb shorebirds such as the great knot. Disturbance from human activities, including recreation, shellfish harvesting, fishing, and aquaculture is likely to increase significantly in the future (Barter et al. 2005; Davidson & Rothwell 1993), with disturbance from off-leash dogs being particularly problematic (Weston & Stankowich 2013). Anthropogenic disturbance at feeding and roosting sites causes birds to stop feeding and fly around. This may force birds away from traditional roosting and feeding sites (Lilleyman et al. 2014) and reduce fat/energy reserves. This can affect an individual's ability to complete the northward migration back to their breeding grounds and may negatively affect survival or reproductive success. Frequent disturbances may place additional and unsustainable pressures on populations already experiencing major declines (Lilleyman et al. 2014).
Climate change		
Sea level rise (In Australia and overseas*)	• Timing: current • Confidence: observed • Likelihood: almost certain • Consequence: major • Trend: increasing • Extent: across the entire range	Global sea level has risen by around 17 ± 5 cm during the 20th century (IPCC 2007; Watson 2011). Current projections predict an increased rate of sea level rise over the duration of the 21st century, with the upper bound global rise ranging from 1.3-1.6m (van de Wal et al. 2022). These increases in sea level are likely to submerge more than 20 percent of coastal wetlands worldwide (Rodriguez et al. 2017). The longest continuous Australasian records show a rise in mean sea level of approximately 12 cm between 1920 and 2000 (Watson 2011). Forecasts predict a further rise of 70 cm by the end of the century (McInnes et al. 2015; Zhang et al. 2017). Coastal wetlands in Australia may be particularly vulnerable to sea level rise, where a reduction in the area of land available for feeding and roosting is likely, and nutrient and sediment flows will likely be altered. The effect of these changes on great knot have not been quantified. Further research is required to understand how

Threat	Status [a]	Evidence
		further sea level rises will affect great knot populations.
Climate change in Arctic breeding areas*	• Timing: current • Confidence: observed • Likelihood: almost certain • Consequence: major • Trend: increasing • Extent: across part of its range	Climate change may influence the timing of significant temperature-related events, such as the emergence of key food resources and the thawing of important breeding and staging habitats, both of which are likely to influence the overall timing and success of migration for the species.
Exploitation		
Hunting*	• Timing: current • Confidence: observed • Likelihood: almost certain • Consequence: moderate • Trend: static • Extent: across part of its range	Hunting is a widespread and likely unsustainable threat to migratory waterbirds in the EAAF and has been linked to the decline of many threatened species in the Flyway. There are records of hunting from 14 of the 22 countries within the flyway - from the breeding grounds, through stopping sites, to the non-breeding grounds. It is of particular concern that records of hunting exist for 34 internationally important shorebird sites (Gallo-Cajaio et al. 2020). Countries with the most records of hunting are Russia, China, Thailand, and Myanmar (Gallo-Cajiao et al. 2020).
Pollution		
Chronic and acute pollution (In Australia and overseas*)	• Timing: current • Confidence: observed • Likelihood: almost certain • Consequence: minor • Trend: increasing • Extent: across the entire range	Shorebird habitats are threatened by the chronic accumulation and concentration of pollutants. Chronic pollution may arise from both local and widespread sources. Migratory shorebirds may be exposed to chronic pollution during their time in Australia and along their migration routes, although the extent and implications of this exposure remains largely unknown. In their feeding areas, shorebirds are most at risk from bioaccumulation of human-made chemicals such as organochlorines from herbicides and pesticides and industrial waste. Agricultural, residential and catchment run-off carries excess nutrients, heavy metals, sediments and other pollutants into waterways, and eventually wetlands. Wetlands and intertidal habitats are threatened by acute pollution caused by, for example, oil or chemical spillage. Acute pollution generally arises from accidents, such as chemical spills from shipping, road or industrial accidents. Generally, migratory

Threat	Status [a]	Evidence
		shorebirds are not directly affected by oil spills, but important habitat may be affected for many years through catastrophic loss of marine benthic food sources.

[a]Timing—identifies the temporal nature of the threat
Confidence—identifies the nature of the evidence about the impact of the threat on the species
Likelihood—identifies the likelihood of the threat impacting on the whole population or extent of the species
Consequence—identifies the severity of the threat
Trend—identifies the extent to which it will continue to operate on the species
Extent—identifies its spatial context in terms of the range of the species

Categories for likelihood are defined as follows:
Almost certain – expected to occur every year
Likely – expected to occur at least once every five years
Possible – might occur at some time
Unlikely –known to have occurred only a few times
Unknown – currently unknown how often the threat will occur
Categories for consequences are defined as follows:
Not significant – no long-term effect on individuals or populations
Minor – individuals are adversely affected but no effect at population level
Moderate – population recovery stable or declining
Major – population decline is ongoing
Catastrophic – population trajectory close to extinction

Each threat has been described in Table 1 in terms of the extent that it is operating on the species. The risk matrix (Table 2) provides a visual depiction of the level of risk being imposed by a threat and supports the prioritisation of subsequent management and conservation actions. In preparing a risk matrix, several factors have been taken into consideration, they are: the life stage they affect; the duration of the impact; the spatial extent, and the efficacy of current management regimes, assuming that management will continue to be applied appropriately. The risk matrix and ranking of threats has been developed in consultation with experts and using available literature.

Table 2 Risk Matrix (* threat occurs mostly outside Australia)

Likelihood	Consequences				
	Not significant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain		Chronic and acute pollution	Habitat loss caused by industrial aquaculture* Invasion of mudflats and coastal saltmarshes by mangroves and cordgrass* Hunting*	Habitat loss caused by residential and commercial development Sea level rise Climate change in Arctic breeding areas* Downstream effects of large dams*	
Likely			Disturbance at feeding sites		
Possible					
Unlikely					
Unknown					

Risk Matrix legend/Risk rating:

Low Risk	Moderate Risk	High Risk	Very High Risk

Priority actions have then been developed to manage the threats, particularly where the risk was deemed to be 'very high' (red shading) or 'high' (orange shading). For those threats with an unknown or low risk (blue and green shading respectively) research and monitoring actions have been developed to understand and evaluate the impact of the threats, where appropriate.

Conservation and recovery actions

Primary conservation objective

- Minimise further loss of habitat critical to the survival of great knot throughout Australia (including habitat predicted to become habitat critical in the future because of climate change).
- Prevent further declines in great knot populations within the Australian jurisdiction by working with relevant Range States to address threats in the East Asian-Australasian Flyway.

Conservation and management priorities

Habitat loss, disturbance and modifications impacts

- Strengthen international cooperation for great knot conservation through the full participation and engagement of all Range States in relevant multilateral frameworks (CMS, Ramsar and the World Heritage Convention).

- Continue to identify important habitat for great knot in Australia and improve site protection and management using international, national, and state mechanisms (i.e. new national parks, conservation reserves, Ramsar sites and biodiversity stewardship payments).
- Unify existing management plans for important shorebird areas into a guided and standardised document. Subsequentially, develop management plans for each recognised important shorebird area which specifically considers migratory shorebirds.
- Update existing site management plans to ensure they correctly take account of the species' local-scale movement patterns and incorporate all important habitats utilised during their non-breeding period.
- Ensure that future development projects avoid any activities that disproportionately affect the upper tidal flats and/or areas providing major foraging opportunities as identified by species experts, local studies, and site managers.
- Ensure that functional connectivity of sites is maintained throughout the species' migration network.
- Develop and implement guidelines for coastal wetland rehabilitation and the creation of artificial wetlands to support populations of migratory shorebirds, including great knot.
- Develop and, where necessary, implement floating roost sites that can support great knot roosting in areas severely affected by human development.

Climate change and severe weather impacts

- Develop and implement a climate change adaptation plan for the species.
- Quantify and predict changes to important habitat because of climate change and identify potential shifts in the breeding and non-breeding distribution of the species.
- Quantify the significance of sea level rise on great knot's feeding and roosting habitat within Australia.

Hunting

- Identify key areas where the legal and illegal take of great knot occurs.
- Work within CMS and the East Asian-Australasian Flyway Partnership to develop a comprehensive program of work to address the illegal hunting, take and trade of migratory waterbirds in the EAAF.
- Publish an updated field guide of shorebirds within the East Asian – Australasian Flyway and develop a series of educational materials showing common and protected species, and their distribution throughout the Flyway in order to improve knowledge within hunting and fishing communities about which species cannot legally be taken, injured, or traded.
- Promote the strengthening of legal mechanisms to reduce illegal hunting of migratory shorebirds and encourage stronger enforcement of these mechanisms.

Disturbance at feeding and roosting sites

- Install shorebird identification signs and warning signs around areas of important habitat to help educate the public about migratory shorebirds, their roosting locations, the impacts of disturbance, and how to avoid disturbing feeding / roosting birds.
- Develop guidelines or local government regulations to reduce beach driving and off-leash dog walking in areas of important habitat for great knot.

Stakeholder engagement/community engagement

- Promote exchange of shorebird conservation information between governments, NGOs, Traditional Owners and communities through use of networks, publications and web sites.
- Develop and implement a community education and awareness program to reduce the effects of recreational disturbance on migratory shorebirds.
- Train a greater number of volunteers, in particular Traditional Owners, to survey migratory shorebirds and improve involvement in monitoring activities.

Survey and monitoring priorities

- Continue to survey and expand coverage of northern Australia and identify important habitats.
- Continue to monitor the number of birds at staging and non-breeding sites trends using existing programs (i.e., BirdLife Australia and QWSG) and undertake analysis of data to improve the accuracy of global population estimates, monitor population trends, and assess the effectiveness of management interventions.
- Consolidate monitoring databases and raw data collected by relevant stakeholders.
- Regularly monitor water quality and the level of chemical contamination within areas of important habitat for red knot and determine the impact of this pollution on the health of great knot.
- Monitor the spread of cordgrass throughout Australia and, if necessary, develop guidelines for wetland rehabilitation which explicitly outline methods to restore wetland habitat degraded by cordgrass (e.g., develop methods to eradicate and prevent the further spread of cordgrass).

Information and research priorities

- Identify through satellite tracking the migratory routes and non-breeding distributions of great knot from different breeding populations.
- Investigate the significance of cumulative impacts of development on great knot habitat and populations in Australia.
- Investigate the impacts of hunting and shorebird prey harvesting on great knot populations throughout the East Asian - Australasian Flyway.
- Quantify the effects of disturbance on great knot in Australia.

- Quantify the effects of chronic and acute pollution on great knot population health, and where necessary implement and amend strict guidelines which restrict the use of pesticides and herbicides around areas of important habitat for migratory shorebirds.

Links to relevant implementation documents

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The Threatened Species Scientific Committee finalised this assessment on 7 June 2023.

Attachment A: Listing Assessment for *Calidris tenuirostris*

Reason for assessment

This assessment follows evaluation by experts of the conservation status of the species in accordance with the Action Plan for Australian Birds 2020 (Garnett and Baker 2021).

Assessment of eligibility for listing

This assessment uses the criteria set out in the EPBC Regulations. The thresholds used correspond with those in the IUCN Red List criteria except where noted in criterion 4, sub-criterion D2. The IUCN criteria are used by Australian jurisdictions to achieve consistent listing assessments through the Common Assessment Method (CAM).

Key assessment parameters

Table 3 includes the key assessment parameters used in the assessment of eligibility for listing against the criteria. The definition of each of the parameters follows the Guidelines for Using the IUCN Red List Categories and Criteria.

Table 3 Key assessment parameters

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Number of mature individuals	386,900	330,400	502,700	The estimated population of great knot in the East Asian - Australasian Flyway in 2016 was 425,000 birds, of which 381,900 were thought to come to Australia (Hansen et al. 2016). The estimated Australian population in 2020 of 386,900 mature individuals is based on an extrapolation of the 2016 data using trends derived from Clemens et al. (2016, 2019) and Studds et al. (2017). The figure is very similar to the 380,000 individuals estimated 15 years ago (Wetlands International 2006).
Trend	declining			Clemens et al. (2021); Rogers et al. 2023)
Generation time (years)	6.4	5.8	7.0	Bird et al. (2020)
Extent of occurrence	9,600,000 km^2	9,100,000 km^2	10,100,000 km^2	The species occurs at coastal sites around Australia (Clemens et al. 2021)
Trend	stable			Clemens et al. (2021)
Area of Occupancy	6,000 km^2	6,000 km^2	9,000 km^2	Clemens et al. (2021)

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
AOO is a standardised spatial measure of the risk of extinction, that represents the area of suitable habitat known, inferred or projected to be currently occupied by the taxon. It is estimated using a 2 x 2 km grid to enable comparison with the criteria thresholds. The resolution (grid size) that maximizes the correlation between AOO and extinction risk is determined more by the spatial scale of threats than by the spatial scale at which AOO is estimated or shape of the taxon's distribution. It is not a fine-scale estimate of the actual area occupied. In some cases, AOO is the smallest area essential at any stage to the survival of existing populations of a taxon (e.g. breeding sites for migratory species).				
Trend	stable			Clemens et al. (2021)
Number of subpopulations	1	1	1	Clemens et al. (2021)
Trend	stable			Clemens et al. (2021)
Basis of assessment of subpopulation number	No genetic evidence but birds are assumed to mix freely across the breeding sites.			
No. locations	>10			Clemens et al. (2021)
Trend	Not calculated			Clemens et al. (2021)
Basis of assessment of location number	The spatial nature of the threats are such that there are > 10 geographically or ecologically distinct areas in Australia where a single threatening event could affect all individuals of the species present within a period of one generation.			
Fragmentation	Not severely fragmented.			
Fluctuations	Not subject to extreme fluctuations in EOO, AOO, number of subpopulations, locations or mature individuals.			

Criterion 1 Population size reduction

Reduction in total numbers (measured over the longer of 10 years or 3 generations) based on any of A1 to A4			
	Critically Endangered **Very severe reduction**	**Endangered** **Severe reduction**	**Vulnerable** **Substantial reduction**
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3, A4	≥ 80%	≥ 50%	≥ 30%

A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.

A2 Population reduction observed, estimated, inferred or suspected in the past where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible.

A3 Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [(*a) cannot be used for A3*]

A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

Based on any of the following

(a) direct observation [except A3]
(b) an index of abundance appropriate to the taxon
(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
(d) actual or potential levels of exploitation
(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites

Criterion 1 evidence

Eligible under Criterion 1 A2bce+3ce+4bce for listing as Vulnerable

Several studies have recorded variable trends of great knot with the following change over three generations: −45 percent (Clemens et al. 2016), −63 percent (Studds et al. 2017), −8 percent (waterbird meta-analysis; Clemens et al. 2019) and +140 percent (Clemens et al. 2019).

The most recent analysis by Rogers et al. (2023) estimated the mean annual change in population was −0.9% (95%CI: -3.8, 1.9) annually (1993 – 2021) for an estimated total percent change in abundance over three generations of -32.4% (95%CI: -69.2, 48.4). The mean annual change in the last 10 years (2012-2021) was -5.6% (95%CI: -14.6, 5.7), suggesting the decline is continuing (Rogers et al. 2023).

Despite large-scale coordinated counts across the country including strongholds of north-western and eastern Australia the five analyses show contrasting trends. Differing results may reflect non-linear changes over time, or different rates of decline in different parts of Australia (Clemens et al. 2021).

The species' listing of Vulnerable in 2010 (Garnett et al. 2011) was justified, as approximately 90,000 individuals disappeared and likely perished following the reclamation of tidal flats at Saemangeum, Republic of Korea in 2006 (Moores et al. 2008). The population now appears to have recovered from this event (Clemens et al. 2021).

Noting the variable trends observed in Australia overtime and ongoing threats in the East Asian – Australasian Flyway, the Committee considers that the species has undergone a substantial

reduction in numbers over three generations, and the cause has not ceased. Therefore, the species has met the relevant elements of Criterion 1 to make it eligible for listing as Vulnerable.

Criterion 2 Geographic distribution as indicators for either extent of occurrence AND/OR area of occupancy

		Critically Endangered Very restricted	Endangered Restricted	Vulnerable Limited
B1.	Extent of occurrence (EOO)	**< 100 km²**	**< 5,000 km²**	**< 20,000 km²**
B2.	Area of occupancy (AOO)	**< 10 km²**	**< 500 km²**	**< 2,000 km²**
AND at least 2 of the following 3 conditions:				
(a)	Severely fragmented OR Number of locations	**= 1**	**≤ 5**	**≤ 10**
(b)	Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals			
(c)	Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals			

Criterion 2 evidence

Not eligible

The great knot's extent of occurrence (EOO) is estimated at 9,600,000 km² (range 9,100,000–10,100,000 km²) and its area of occupancy (AOO) is estimated at 6,000 km² (range 6,000–9,000 km²) (Clemens et al. 2021). The estimated and minimum AOO is based on the number of 2x2 km squares encompassing all records since 1990; the highest assumes true AOO ≥50 percent higher (Clemens et al. 2021). The EOO and AOO of the species is thought to be stable. The species is not severely fragmented and is not subject to extreme fluctuations in EOO, AOO, number of subpopulations, locations, or mature individuals (Clemens et al. 2021). Therefore, the species has not met all the requirements of this criterion.

Criterion 3 Population size and decline

		Critically Endangered Very low	Endangered Low	Vulnerable Limited
Estimated number of mature individuals		**< 250**	**< 2,500**	**< 10,000**
AND either (C1) or (C2) is true				
C1. An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future)		**Very high rate 25% in 3 years or 1 generation (whichever is longer)**	**High rate 20% in 5 years or 2 generation (whichever is longer)**	**Substantial rate 10% in 10 years or 3 generations (whichever is longer)**
C2. An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions:				
(a)	(i) Number of mature individuals in each subpopulation	**≤ 50**	**≤ 250**	**≤ 1,000**
	(ii) % of mature individuals in one subpopulation =	**90 – 100%**	**95 – 100%**	**100%**
(b) Extreme fluctuations in the number of mature individuals				

Criterion 3 evidence

Not eligible

The number of mature individuals is estimated to be 386,900 (range 330,400–502,700). The species is assumed to mix freely within its breeding grounds, amounting to a single subpopulation. Therefore, the species has not met all the requirements of this criterion.

Criterion 4 Number of mature individuals

	Critically Endangered Extremely low	Endangered Very Low	Vulnerable Low
D. Number of mature individuals	< 50	< 250	< 1,000
D2.[1] *Only applies to the Vulnerable category* Restricted area of occupancy or number of locations with a plausible future threat that could drive the species to critically endangered or Extinct in a very short time			D2. Typically: area of occupancy < 20 km² or number of locations ≤ 5

[1] The IUCN Red List Criterion D allows for species to be listed as Vulnerable under Criterion D2. The corresponding Criterion 4 in the EPBC Regulations does not currently include the provision for listing a species under D2. As such, a species cannot currently be listed under the EPBC Act under Criterion D2 only. However, assessments may include information relevant to D2. This information will not be considered by the Committee in making its recommendation of the species' eligibility for listing under the EPBC Act, but may assist other jurisdictions to adopt the assessment outcome under the *common assessment method*.

Criterion 4 evidence

Not eligible

The total number of mature individuals is estimated to be 386,900 (range 330,400–502,700). The estimated Australian population of great knot is based on an extrapolation of the 2016 data using trends derived from Clemens et al. (2016, 2019) and Studds et al (2017). Therefore, the species has not met all the requirements of this criterion.

Criterion 5 Quantitative analysis

	Critically Endangered Immediate future	Endangered Near future	Vulnerable Medium-term future
Indicating the probability of extinction in the wild to be:	≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)	≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)	≥ 10% in 100 years

Criterion 5 evidence

Insufficient data to determine eligibility

Population viability analysis has not been undertaken. Therefore, there is insufficient information to determine the eligibility of the species for listing in any category under this criterion.

Adequacy of survey

The survey effort has been considered adequate and there is sufficient scientific evidence to support the assessment.

Public consultation

Notice of the proposed amendment and a consultation document was made available for public comment for 30 business days between 30 March 2023 and 15 May 2023. Any comments received that were relevant to the survival of the species were considered by the Committee as part of the assessment process and provided to the Minister for the Environment with the Committee's advice.

Listing and Recovery Plan Recommendations

The Threatened Species Scientific Committee recommends:

i) that the list referred to in section 178 of the EPBC Act be amended by **transferring** *Calidris tenuirostris* from the Critically Endangered category to the Vulnerable category.

ii) that there not be a Recovery Plan for this species in accordance with the provisions of the EPBC Act and the Committee's conservation planning principles as follows:

- An approved conservation advice is an effective, efficient and responsive document to guide the implementation of priority management actions, mitigate key threats and support the recovery for this species.
- An approved conservation advice would support the species recovery by identifying priority actions, stakeholders for engagement, and the survey and research priorities to facilitate a better understanding of key threats as well as biological and ecological knowledge gaps.
- The threats facing the entity, and the recovery actions needed can most effectively be guided via an approved conservation advice.
- The threats facing the entity, and the recovery actions needed can most effectively be guided via an approved conservation advice.

iii) Having regard to the above factors, a recovery plan is not required as it would not provide a significant conservation planning benefit above existing mechanisms.

Cataloguing data

This publication (and any material sourced from it) should be attributed as: Department of Climate Change, Energy, the Environment and Water 2024, *Conservation Advice for Calidris tenuirostris*, Canberra. 

This publication is available at the SPRAT profile for *Calidris tenuirostris* (great knot).

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