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National Recovery Plan for the southern cassowary *Casuarius casuarius johnsonii*

Andrew Dennis and the Cassowary Recovery Team

Cataloguing data

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Acknowledgement of Country

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

Image credits

Cover page: Image © Liz Gallie

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Acronyms

Acronym	Name
ARC	Australian Research Council
C4CCC	Community for Coastal and Cassowary Conservation
CAFNEC	Cairns and Far Norther Environment Centre
CCRC	Cassowary Coast Regional Council
CKC	Cassowary Keystone Conservation
CRC	Cairns Regional Council
CRT	Cassowary Recovery Team
CSC	Cook Shire Council
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CYLC	Cape York Land Council
CYNRM	Cape York Natural Resource Management
DAF	[Queensland] Department of Agriculture and Fisheries
DAWE	[Australian] Department of Agriculture Water and Environment
DD	[Australian] Department of Defence
DERM	[Queensland] Department of Environment and Resource Management
DESI	Queensland Department of Environment, Science and Innovation
DESE	[Australian] Department of Education Skills and Employment
DISER	[Australian] Department of Industry, Science, Energy and Resources
DITRD&C	[Australian] Department of Transport, regional Development and Communications
DNRME	[Queensland] Department of Natural Resources Mines and Energy
DoR	Queensland Department of Resources
DRDMW	[Queensland Department of] Regional Development, Manufacturing and Water
DSC	Douglas Shire Council
DSDILGP	[Queensland] Department of State Development, Infrastructure, Local Government and Planning
DTIS	[Queensland] Department of Tourism, Innovation and Sport
EDO	Environmental Defenders Office
EPA	[Queensland] Environmental Protection Agency
FNQROC	Far North Queensland Regional Organisation of Councils
GBCRC	Garners Beach Cassowary Rehabilitation Centre
HSC	Hinchinbrook Shire Council
HVAS	Hope Vale Aboriginal Shire
ILUA	Indigenous Land Use Agreement
IPA	Indigenous Protected Area
IUCN	International Union for the Conservation of Nature
KC	Kuranda Conservation

Acronym	**Name**
KE	Kuranda Envirocare
LRAS	Lockhart River Aboriginal Shire
MSC	Mareeba Shire Council
NIAA	National Indigenous Australians Agency
NPARC	Northern Peninsula Area Regional Council
NQLC	North Queensland Land Council
QCC	Queensland Conservation Council
QFES	Queensland Fire and Emergency Services
QH	Queensland Herbarium
DESI-QPWS&P	Queensland Parks and Wildlife Service and Partnerships
R4F	Rainforest 4 Foundation
RNTBC	Registered Native Title Bodies Corporate
RR	Rainforest Rescue
RRA	Rainforest Reserves Australia
SDILGP	[Queensland Department of] State Development, Infrastructure, Local Government and Planning
TCS	Townsville City Shire Council
TerrainNRM	Terrain Natural resource Management
TMR	[Queensland Department of] Transport and Main Roads
TRC	Tablelands Regional Council
TSC	Torres Shire Council
TWS	The Wilderness Society
WIRES	Australian Wildlife Rescue Organisation
WPSQ	Wildlife Preservation Society of Queensland
WWF	World Wildlife Fund
YAS	Yarrabah Aboriginal Shire
ZAA	Zoo and Aquarium Association Australasia

Vision

A healthy population of the southern cassowary, *Casuarius casuarius johnsonii*, occupies its full potential range in connected landscapes of functional ecosystems on Cape York Peninsula and in the Wet Tropics region. Each population coexists with informed communities who adapt management actions to ensure the long-term sustainability of the southern cassowary's populations.

Painting print © Wendy Cooper on behalf of artist William T. Cooper

1 Summary

The purpose of this plan is to set out the management and research actions that are necessary to stabilise, better understand and recover the southern cassowary (*Casuarius casuarius johnsonii*) population over the next ten years (see Table 1).

1.1 Status

Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)	Endangered
Nature Conservation Act 1992 (Queensland) – Wet Tropics population	Endangered
Nature Conservation Act 1992 (Queensland) – Cape York population	Vulnerable
IUCN Red List of Threatened Species (2013)	Least concern

1.2 Description, habitat, and distribution

The southern cassowary is a large flightless bird standing up to 2 m in height and weighing 35 – 75 kg, with females larger than males. It is closely associated with rainforest but frequently visits and uses resources found across the entire landscape, including *Melaleuca*, palm and mangrove swamps, beaches, woodlands, tall eucalypt forests, agricultural landscapes, and suburban gardens. In Australia, it has three disjunct populations: on far northern Cape York Peninsula; the McIlwraith and Iron Ranges further south on Cape York Peninsula; and in the Wet Tropics of Far North Queensland (see Figure 1; Figure 2).

1.3 Threats

Ongoing threats to the southern cassowary include the following, in order of prominence:

- Climate Change
  - Habitat loss through inundation, cyclone damage, fire, drought and movement of human populations
  - Possible changes in plant phenology and effects on cassowary physiology
- Habitat fragmentation, degradation and loss
- Land manager inaction and lack of planning at scale
- Roads and traffic
- Invasive introduced species
- Human interaction
- Disease

1.4 Recovery plan objectives and strategies

Table 1 Objectives and strategies to recover the southern cassowary

Objective	Description	Strategy
1. Habitat extent and condition is improved	The habitat suitable for cassowaries (including primary, secondary and rehabilitating habitat) is protected by enforceable laws, increased in area, connected across the landscape, accessible to cassowaries and enhanced in quality and resilience.	Protect, restore and connect habitat
2. Population viability is improved	The population of cassowaries has been estimated with a high level of precision and it has remained stable in current primary habitat while the species has expanded its range to occupy all potential habitat resulting in an overall increase in population size. Recruitment and mortality remain in balance or recruitment is higher than mortality. Threatening processes that could lead to a decline in population, area of occupancy or extent of occurrence are actively monitored and managed with strategies in place to deal with threats across all land tenures and time frames.	Understand distribution, habitat use, population trends and reproductive biology Manage and monitor threats
3. Indigenous knowledge and lore help guide recovery	All decisions, strategies and actions are derived from the meaningful incorporation of Indigenous knowledge, lore and values with contemporary scientific method and understanding, and broad community knowledge and values.	Facilitate engagement with Traditional Owner groups
4. Partners are engaged and recovery is well governed	The Cassowary Recovery Team is supported and funded by a full range of partners to perform a coordinating role in information management and dissemination and governance of the recovery program. There is strong awareness and a sense of ownership and responsibility in all communities across the cassowary's range, who feel empowered and informed to take action to protect and conserve the species.	Educate and engage community as custodians Cassowary conservation is integrated into policy and land-use plans Strengthen governance and partnerships Deliver actions at multi-species and landscape scales

1.5 Criteria for success

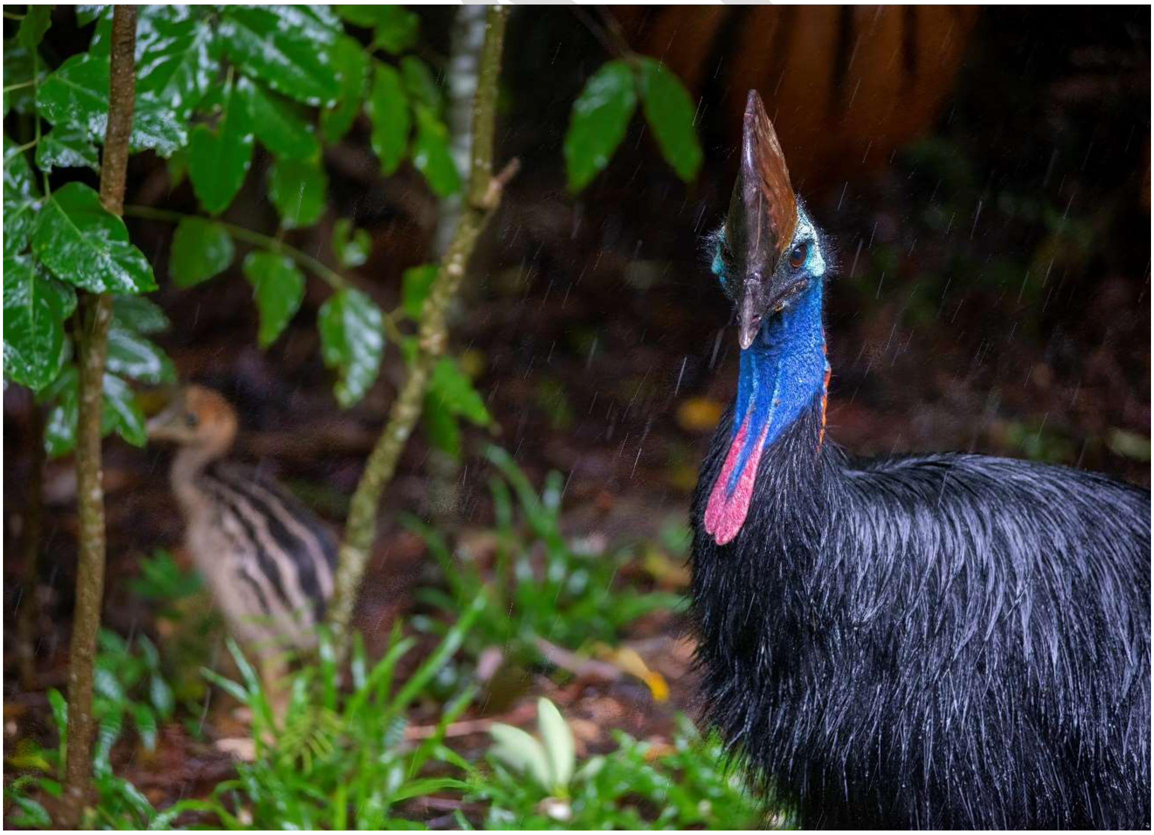
Criteria for success – within 5 years:

- A measure of habitat quality (e.g., Lawson *et al.* 2008) is applied to corridors, restoration and enhancement sites.
- Trends in threatening processes are measured, monitored and reviewed biennially by the Cassowary Recovery Team.
- Threats are known and their relative impacts clearly understood.
- All First Nations groups in cassowary country (~25) are offered membership of the recovery team and are supported to engage.
- There is communication and engagement, with opportunity for input, with 100% of First Nations groups in cassowary country.
- Aboriginal corporations that manage lands have access to information to support cassowary conservation in caring for country plans and actions.
- The recovery program is professionally managed, and governed by an updated framework of rules, relationships, systems, processes and accountability.
- Stakeholders are identified and engaged to an appropriate level with the recovery process.

Criteria for success – within 10 years:

- Landscape connectivity (see Keeley *et al.* 2021) at catchment scales is increased across 50% of catchments within the distribution of the cassowary.
- An additional 50% of existing unprotected cassowary habitat is protected using the full range of legislative and voluntary tools.
- A measurable increase in the area of habitat available to the cassowary under current and future climate scenarios.
- A repeatable population sampling method, that can be implemented by First Nations groups and citizen scientists, is developed and executed at least every 5 years to monitor population trends.
- Population trend remains stable or increases over at least two additional 5-year periods.
- Area of occupancy increases in accordance with improvements in habitat condition, area and connectivity using a 2023 baseline.
- The DESI-QPWS&P cassowary database demonstrates cassowaries are being sighted in new areas and/or cassowaries are re-occupying areas from which they have disappeared.
- Research on home ranges and movement patterns, reproductive biology and genetics to better understand population viability are completed.
- Mitigation strategies based on the best available evidence are developed and implemented for each threat as they are quantified.

- First Nations groups are leading or actively engaged in actions on country, such as population monitoring, collection of citizen science data, and restoration of habitat to full ecological function.
- Indigenous and non-Indigenous people collaborate in work on country where appropriate.
- Training and funding are provided for First Nations groups as needed.
- Community participation in management activities has increased.
- Councils, land managers and infrastructure managers have all adopted cassowary management practices that support the objectives of this plan.
- Voluntary habitat protection (e.g., Nature Refuges under the Nature Conservation Act (1992), Voluntary Declarations under the Vegetation Management Act (1999), Statutory Covenants under the Land Title Act 1994 (Qld) Indigenous Protected Areas (IPAs), Wildlife Land Trust) have increased against the 2022 baseline.
- Citizen science data collection, collation and analysis has increased against the 2022 baseline.
- Information is vetted and collated into an easily accessible form for land and infrastructure managers, the tourism industry and the public.
- A significant proportion of actions are conducted in collaboration with other recovery teams, i.e., the spectacled flying-fox and other threatened rainforest species.



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2 General information

2.1 Introduction

This document constitutes the National Recovery Plan for the southern cassowary *Casuarius casuarius johnsonii*, made under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The plan aims to halt the decline and support recovery of the cassowary in the wild. A concerted long-term vision, commitment, management and research effort, with adequate resourcing and policy settings, is necessary to protect this species into the future.

This plan outlines on-ground actions to enhance protection and improve or maintain quality, connectivity and extent of habitat, and to manage or mitigate the impacts of a range of threats (see section 4). These activities are planned to occur within a monitoring framework that measures the impact of management and considers climate change. The plan also sets out the research necessary to conserve the species and actions to guide the governance of the recovery process and engage communities in cassowary conservation.

2.2 Historical context

The southern cassowary was first listed as Endangered under the EPBC Act in July 2000 (DAWE 2022), having been transferred from the list of threatened species under prior national legislation. It was listed under the Queensland *Nature Conservation Act 1992* as Endangered in the Wet Tropics region and Vulnerable on Cape York Peninsula (see Table 2**.** Objectives and strategies to recover the southern cassowary). It was first recognised as declining as early as 1946 (White 1946). However, by 1987 up to 80% of its lowland and upland habitat had been clear felled for agriculture and other land uses (Winter *et al.* 1987). At the time of listing, habitat clearing and fragmentation were seen as major threats. Since the cessation of most clear felling of rainforest in the Wet Tropics with World Heritage Listing in 1988, habitat loss has declined in prominence, leaving climate change, habitat fragmentation and degradation, vehicle strike, catastrophic natural disasters, pigs, dogs, disease and consequences of interactions with humans as the main ongoing threats to the species.

This plan replaces the previous 'National recovery plan for the southern cassowary, *Casuarius casuarius johnsonii*' (Latch 2007). A review of the previous Recovery Plan (see section 2.5 and Appendix A. Review of actions in Latch (2007)) concluded that most recovery actions had been implemented to some extent. This plan builds upon the 2007 Recovery Plan and previous and current conservation measures being undertaken by the various partners involved in cassowary conservation. It also incorporates new research findings on this species and its habitat.

Conservation planning for the cassowary requires a long-term commitment. Existing management and protective mechanisms are not yet sufficient to fully recover the species. While it is anticipated that significant progress will be made, recovery of the cassowary is not envisaged within the scheduled five-year review window of the recovery plan. The National Recovery Plan for the southern cassowary *Casuarius casuarius johnsonii*, will therefore remain in place until it is replaced or the species no longer meets the criteria for listing as threatened under the EPBC Act.

2.3 Cultural significance

To most of the Traditional Owners of the Wet Tropics and Cape York Bioregions, the cassowary is a culturally significant species. Traditional Owners have song-line and storyline places and laws in place throughout the landscape. Each First Nations group has its own traditional stories and knowledge about the cassowary, they conduct ceremonies and dances for cassowary, and it is often represented in art. It is a totem for some. The cassowary was abundant before European colonisation and was an important food resource.

To Traditional Owners, the landscape is cultural and species such as the cassowary are part of that landscape. While continually moving through different areas, the cassowary and other species, over thousands of generations, have played an essential role in maintaining and sustaining different environments and habitats (Bradford *et al*. 2018; Bradford *et al.* 2020).

Cassowaries are also a significant species to the general community, appearing as symbols for regional councils, government agencies, in tourism, in planning at all levels, in education, stories and festivals, in print, as art and online. Numerous conservation and other community groups actively engage with cassowaries, their ecology and conservation and as an icon for the Wet Tropics. Their significance to modern communities is also seen through strong engagement with their care and recovery, and depictions in myriad artworks, advertising, logos, signage and products. Cassowaries have also been adopted as a symbol and name for the Cassowary Coast Regional Council and a key symbol for the Wet Tropics Management Authority.

2.4 Conservation status and international obligations

The southern cassowary is listed as Endangered nationally, while under Queensland state legislation the Wet Tropics population is listed as Endangered and the Cape York population, Vulnerable (see Table 2). The species is listed as Least Concern at a global scale because it is widespread on the island of New Guinea, where its extent of occurrence is about 15 times that in Australia, and much of that range is relatively isolated from severe disturbance by humans. Information and resource sharing with the Department of Environment and Conservation (Papua New Guinea) and the Ministry of Environment and Forestry (Indonesia), along with local and international conservation organisations working with the species outside Australia should be considered to conserve it across its entire distribution. It is also listed as Least Concern in the Action Plan for Australian Birds on the basis that there is no evidence of a decline in the last three generations and a majority of its habitat is now protected (Westcott *et al.* 2020).

Table 2 International, national, and state conservation status of the southern cassowary

Legislation	Conservation status
Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)	Endangered
Nature Conservation Act 1992 (Queensland) – Wet Tropics population	Endangered
Nature Conservation Act 1992 (Queensland) – Cape York population	Vulnerable
IUCN Red List of Threatened Species (2013)	Least concern

2.5 Review of previous recovery efforts

This recovery plan replaces the National Recovery Plan for the southern cassowary, *Casuarius casuarius johnsonii* (Latch 2007). A review of the previous plan was undertaken by the members of the Cassowary Recovery Team in April 2021, with this new plan being drafted at the same workshop. The new plan was revised in January 2022 and October 2022. The review of Latch (2007) was conducted by representatives from the Wet Tropics Management Authority, the Queensland Department of Environment and Science (Wildlife Operations and Queensland Parks and Wildlife Service and Partnerships), James Cook University, Commonwealth Scientific and Industrial Research Organisation, Queensland Transport and Main Roads, Cape York Natural Resource Management, Terrain Natural Resource Management, the Commonwealth Department of Agriculture, Water and Environment, the Commonwealth Department of Climate Change, Energy, Environment and Water, Kuranda Conservation, Abriculture, Jagun Aboriginal Corporation, Cairns and Far North Environment Centre, Girringun Aboriginal Corporation, Rainforest Rescue, the Zoo and Aquarium Association (Australia), Rainforest Reserves Australia, Mission Beach Cassowaries, Community for Coastal and Cassowary Conservation, Cassowary Keystone Species, Far North Queensland Regional Organisation of Councils, Brettacorp and Birdlife Australia. The review was facilitated by Drs Andrew Dennis (BazaCom) and Amanda Freeman (Nature North). Comments from the review, listed under each Specific Objective are outlined in Appendix A. Review of actions in Latch (2007), and are used to guide Objectives, Strategies and Actions of this Recovery Plan.

In summary, past recovery, threat management and research efforts for the southern cassowary, combined with other conservation measures to protect and restore tropical rainforests have set the recovery of cassowary populations on a positive trajectory in the Wet Tropics where the greatest decline was originally measured for the species (White 1946; Crome and Moore 1990; Garnett and Crowley 2000; Moore and Moore 2001). Several assessments now report that populations of the southern cassowary are stable or recovering (Westcott *et al.* 2014; NESP TSRH 2019; NESP TSRH 2020; Westcott *et al.* 2020). Recent surveys of populations on Cape York Peninsula indicate that cassowaries are still present in all areas from which they were previously known except for Lockerby Scrub (Bradford *et al.* 2018; Bradford *et al.* 2020; McLean 2020, 2022). These surveys have also helped identify ongoing and new threats to the species on Cape York Peninsula.

This is a positive outlook that now needs consolidating with ongoing management of threats, restoration of habitat and enhancement of landscape connectivity to ensure the species' populations remain viable and past efforts are built upon. It is likely that these gains are, in part, due to actions from the previous plan being partially or fully completed. However, there are a few that were not attempted or remain incomplete. Some are still deemed relevant and are carried forward in updated forms into this plan.

2.6 Partners and affected interests

Cassowaries are distributed across most of the Wet Tropics bioregion and large areas of eastern Cape York Peninsula, as well as the island of New Guinea, and thus have a broad array of interest from international, national, state and local stakeholders. Within Australia, cassowaries occur on all types of tenures in both the Wet Tropics and Cape York regions. Land managers and threat management activities are therefore diverse and often involve multiple interests.

In addition, cassowaries are culturally significant to most Traditional Owner groups that overlap with their distribution (see section 2.3). All Traditional Owner groups who have contributed to discussions about this plan and other rainforest issues to date have expressed strong concerns for cassowaries and a strong desire to be engaged in management, scientific research and monitoring (M. Morta *pers. comm.* 2022). Combined, this results in a diverse group of partners that need to be engaged in cassowary recovery. Some of these are broadly outlined in Table 3**.** Engagement with Traditional Owners and respect for their cultural traditions is paramount across all actions. This is because a high proportion of lands in the Wet Tropics and Cape York Peninsula having Traditional Owner interests over them, such as Indigenous land use agreements (ILUAs), IPAs, Native Title Determinations and applications (e.g., 87.5% of the Wet Tropics World Heritage Area; WTMA 2022; National Native Title Tribunal 2021). In addition, cassowaries have high cultural significance to many Traditional Owners who have responsibility for lands on which they occur.

Table 3 Affected interests and their potential involvement in achieving outcomes for cassowary recovery

Category	Interested parties	Potential roles and responsibilities	Benefits and/or impacts
Australian government	DCCEEW	Making the plan under the EPBC Act. Provide funding and support where available. Regulatory decision making. Review of the plan.	Framework and support for recovery of the species.
Australian government	NIAA	Funding and support for Indigenous groups, particularly those implementing aspects of the plan.	Enhance ability of Indigenous groups to care for country and implement aspects of the plan.
Australian government	DESE	Funding to support research, monitoring and modelling.	Enhanced ability to manage and recover species.
Australian government	Commonwealth landholding agencies e.g., Department of Defence	Implement the plan to the extent to which it applies in Commonwealth areas	Action for recovery of the species.
Queensland government	DESI, DESI-QPWS&P, DoR	Assist in developing, provide updates and comply with plan. Ensure the plan is implemented in Queensland protected areas and threatened species programs. Ensure compliance is managed where appropriate. Provide funding and support.	Delivery of state conservation intent and obligations.

Category	Interested parties	Potential roles and responsibilities	Benefits and/or impacts
Queensland government	DAF, QFES, DRDMW, DTIS, TMR, SDILGP	Assist in developing, provide updates and comply with plan where appropriate. Ensure compliance with the plan and appropriate referrals are made as needed. Ensure departmental activities support and enhance the conservation outcomes required by the plan. Ensure the intent of the plan is reflected in and not compromised by the Far North Queensland and Cape York Regional Plans.	Delivery of state conservation intent and obligations.
Aboriginal Corporation Registered Native Title Bodies Corporate representing	Jabalbina Yalanji, Western Yalanji, Yirrganydji Gurabana, Dulabed and Malanbarra Yidinji, Gunggandji-Mandingalbay Yidinji Peoples, Mandingalbay Yidinji, Wadjanburra Tableland Yidinji, Wabubadda, Choorechillum (Ngadjon Jii PBC), Mamu, Girramay People, Djabugay Native Title, Gulngay Kinjufile, Wanyurr-Majay, Warrgamay Traditional Owners, Gurambilbarra Wulgurukaba, Gudang Yadhaykenu, Wuthathi, Kuuku-ya'u, Uutaalnganu, Kaantju, Umpila, Kuuku yani	Assist in developing, provide updates and comply with plan. Implement aspects of the plan on country. Engage with researchers and managers. Facilitate use of fire as a tool to maintain appropriate habitat mosaics across the landscape. Monitor compliance of dog control and habitat clearing where possible.	Enhanced connection between people and country and delivery of cultural obligations in custodial lands, joint management areas and other managed lands.
Indigenous Protected Area Organisations	Girringun, Eastern Kuku Yalanji, Kaanju Ngaachi Wenlock and Pascoe Rivers, Wuthathi	Delivery and implementation of IPA plans for the management of protected areas that contribute to biodiversity outcomes for the National Reserve System.	Partner on recovery actions for the southern cassowary within IPAs.
Land councils	NQLC, CYLC	Facilitate partner connections and implementing of on-ground actions and monitoring.	Connections and information flow across Indigenous groups. Enhanced opportunities for Healthy Country custodianship.
Natural resource management bodies	Terrain, North Queensland Dry Tropics, Cape York	Assist in developing, provide updates and comply with plan. Provide funding and support. Facilitate and implement on-ground actions and monitoring. Facilitate partner engagement and planning.	Increase knowledge and engagement for people and country. Better management and understanding of cassowaries in the landscape.

Category	Interested parties	Potential roles and responsibilities	Benefits and/or impacts
Local councils	Hinchinbrook Shire; Cassowary Coast; Yarrabah; Cairns; Tablelands; Mareeba; Douglas Wujal; Cook; Lockhart River; City of Townsville; Northern Peninsula Area	Assist in developing, provide updates and comply with plan. Implement aspects of the plan in local government areas as per the recommendations of Huddy and Reaston (2021).	Deliver on local conservation and management obligations and sustainable development. Human-cassowary interactions may increase with urban expansion., with more pressure on councils to manage problem birds. Increase local knowledge and engagement. Appropriate referrals to the EPBC Act.
Commercial operators	Current and future developers, tourism industry operators, consultants	Comply with the plan and ensure ecologically sustainable developments and activities.	Informed decision-making and developments designed to avoid significant impacts or enhance cassowary conservation
Private landholders	e.g., RR, South Endeavour Trust, Australian Wildlife Conservancy, Nature refuge landholders	Implement aspects of the plan on protected lands and provide updates to recovery team	Well managed secure habitat. Human-cassowary interactions may increase.
Researchers	Queensland Museum, Griffith University, The University of Queensland, James Cook University, CSIRO and others.	Assist in developing, provide updates and comply with plan. Address significant knowledge gaps. Report on progress.	Assist partners to meet obligations.
Community groups	TREAT, Birds Australia, Landcare groups within distribution, Natural history groups (Herpetological Society, NQ Naturalists Club)	Assist in developing, provide updates and comply with plan. Implement aspects of the plan, facilitate connections and information flow	Enhanced networking and plan delivery
Conservation organisations	CAFNEC, Kuranda Conservation, Kuranda Envirocare; R4F, Rainforest Rescue, C4, CKC, WWF, The Wilderness Society, WPSQ, QCC, Brettacorp, Mission Beach Cassowaries, ZAA	Assist in developing, provide updates and comply with plan. Implement aspects of the plan and provide updates and information to recovery team. Provide funding where possible. Facilitate partner connections and information exchange.	Enhanced delivery of plan
The public	People interacting with cassowaries and their habitat	Report sightings and incidents to 1300 130 372, comply with appropriate behaviour toward cassowaries, have regard to recovery plan.	Lower risks to cassowaries and humans, support conservation efforts. Human-cassowary interactions may increase, however with appropriate education, these can occur safely.

3 Ecology and biology

3.1 Taxonomy and description

In the previous recovery plan, the southern cassowary was treated as a subspecies within Australia (*Casuarius casuarius johnsonii*; Latch 2007). Current taxonomic understanding removes subspecific status and recognises a single species throughout its distribution, including Papua New Guinea, eastern Indonesia and north-eastern Australia (*Casuarius casuarius*; Dickinson and Remsen 2018; del Hoyo and Collar 2019; Clements *et al.* 2019; Gill *et al.* 2020). Its listing in the Queensland *Nature Conservation Act 1992* and the Commonwealth *Environment Protection and Biodiversity Act 1999* remains at subspecific level, referring only to Australian populations of this species. This recovery plan continues to refer to the Australian populations as *Casuarius casuarius johnsonii*, as it is currently listed under the EPBC Act.

The southern cassowary is a large flightless bird standing up to 2 m in height and weighing 35 – 75 kg, with females larger than males. In mature adults, a pale blue head is crowned by a brown casque, the featherless neck is blue on the sides and front and orange to purple on the back. Two bright red wattles of variable length hang from the lower, anterior part of the bare neck and the body is covered in glossy black feathers. Its thick legs appear scaly, and each of three toes has a strong nail, the inner being up to 12 cm long and dagger-like. Young chicks are striped longitudinal, dark brown and creamy white, while subadults are uniform brown.

3.2 Distribution and populations

The southern cassowary occurs throughout the southern half of Papua New Guinea, Papua, West Papua and the islands of Aru and Seram in Indonesia and in north-eastern Australia (see Figure 1). In Australia, it has three disjunct populations, across Gudang Yadhaykenu and Wuthathi countries including on the McHenry Uplands (and previously Lockerbie Scrub) on far northern Cape York Peninsula; Kuuku-ya'u, Uutaalnganu, Kaantju, Umpila, and Kuuku yani countries centred around the rainforests of the McIlwraith and Iron Ranges further south on Cape York Peninsula; and the Wet Tropics bioregion, encompassing Guugu-Yimidhirr, Kuku-yalanji, Djabuganjdji, Yidinjdji, Mbabaram, Djirbalngan, Ngadjon-ji, Yirranydji, Mamu, Djiru, Gulnay, Girramay, Bandjin, Warrgamay, Nywaigi, Wulgurukaba, Wargamaygan and Gugu-Badhun countries from Big Tableland near Cooktown to Paluma near Townsville (see Figure 2). In the Wet Tropics, the cassowary population is partially fragmented due to natural barriers, such as river gorges and habitat discontinuities, and habitat fragmentation caused by human disturbance. This plan deals with the species' Australian distribution, both the Cape York Peninsula and Wet Tropics populations. Due to significantly different conditions and threats between Cape York Peninsula populations and the Wet Tropics, actions in this plan will sometimes refer specifically to either the Wet Tropics or Cape York Peninsula populations. If an action does not refer to either location, then it is relevant to all.

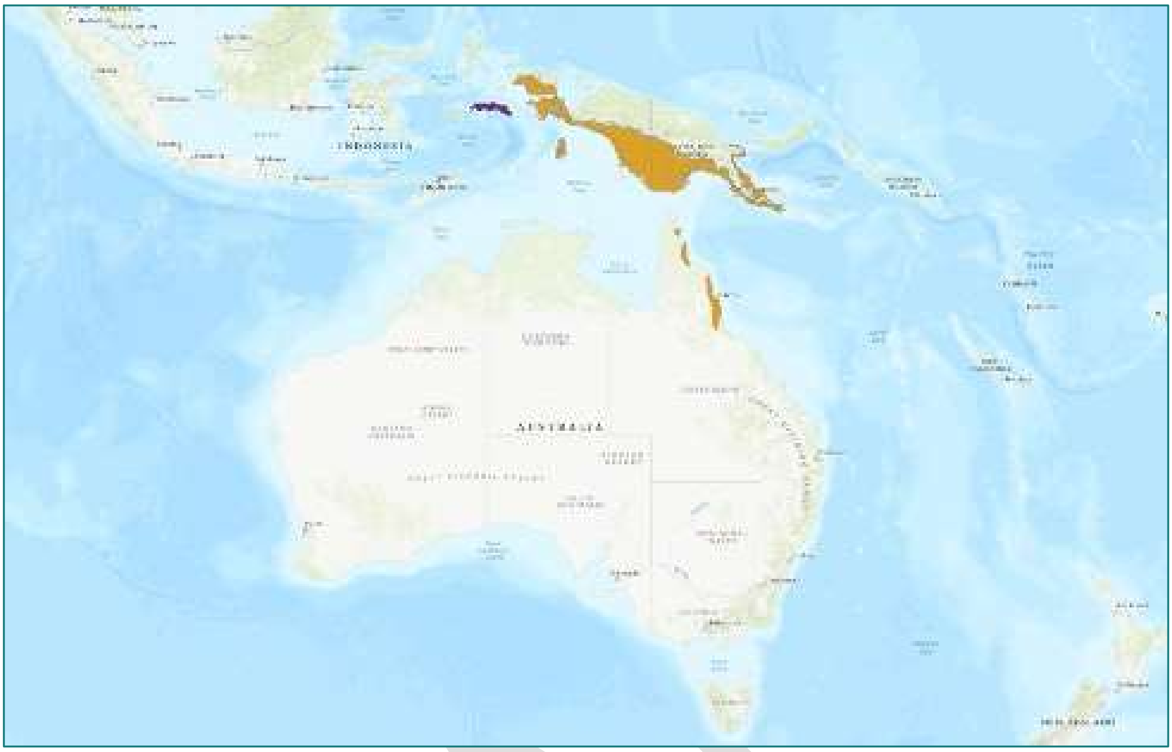

Figure 1 Global distribution of the southern cassowary *Casuarius casuarius johnsonii* (Birdlife International 2018)

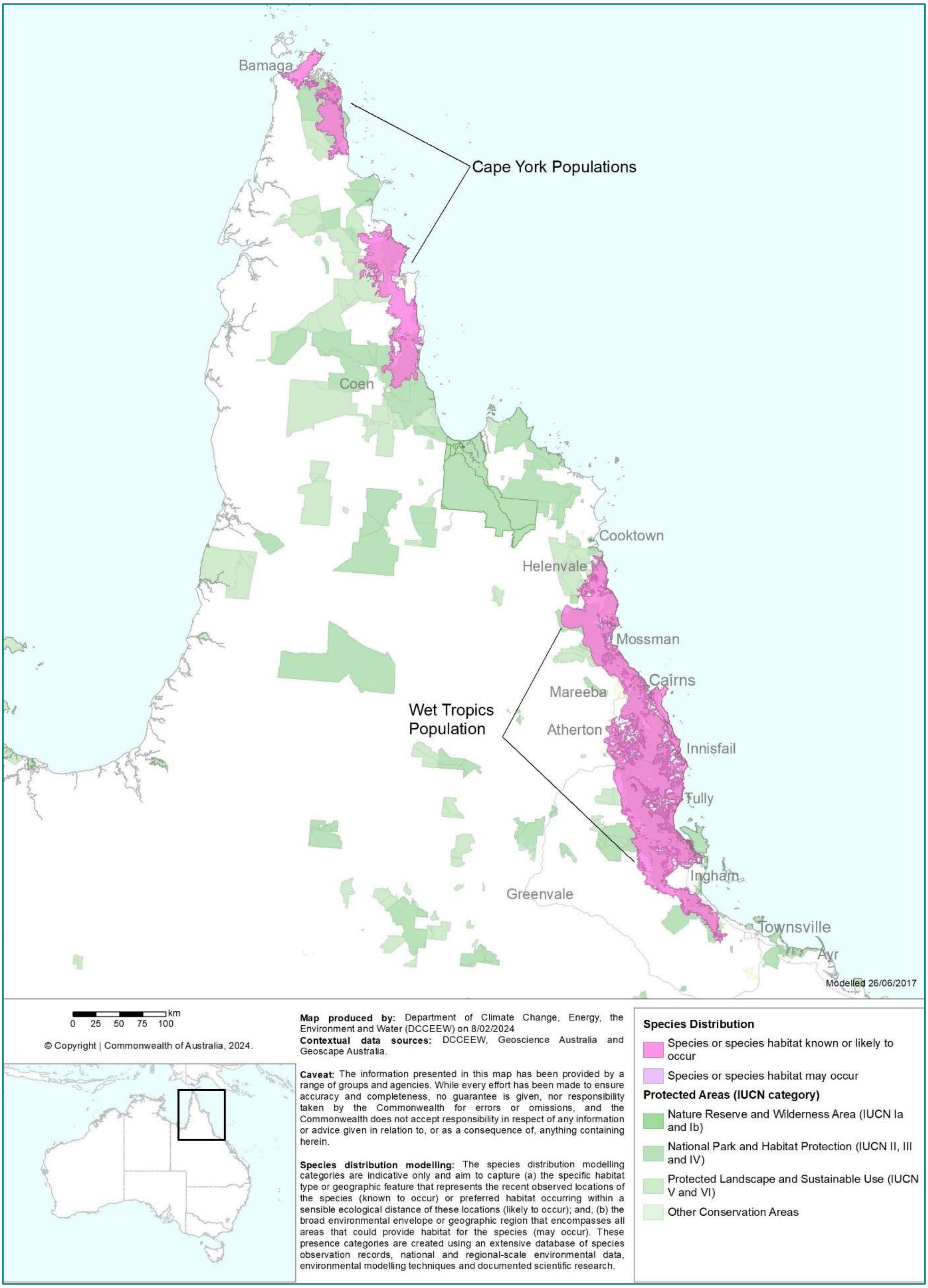

Figure 2 Australian indicative distribution of the southern cassowary *Casuarius casuarius johnsonii* (DCCEEW 2024)

3.3 Locations where the cassowary is under pressure

In the previous recovery plans (QPWS 2002; Latch 2007), eight areas within the Wet Tropics were identified as "populations" under greatest threat. These did not represent discrete or biological populations or sub-populations but instead, sets of locations where cassowaries were considered under the greatest threat from development pressures. In the period since the last plans were written, some threats and pressures have changed, as has our understanding of their ecology and movements.

Although there are no data on genetic structuring in cassowaries, it is very likely, given their longevity, the time between generations, and their ability to move over large distances (both as adults and while dispersing as subadults), that cassowaries in the Wet Tropics are a single population. In addition, given their use and historical transport by people, it is possible that they represent a single population across their entire range. However, if there is genetic structuring it is likely to occur between Australia's Wet Tropics, Cape York Peninsula and New Guinea, which may include genetic differences between separated locations on Cape York Peninsula and the islands off New Guinea.

Within the Wet Tropics there are locations where cassowaries are considered under greater pressure of survival than in other locations (see section 4). These include:

- Areas where there is a frequent interface between cassowaries and humans (such as Mission Beach, Innisfail and surrounds, Kuranda, the Daintree Rainforest and Cairns), exposing cassowaries to vehicle strike, dog attack and entrapment in fences
- Coastal areas that are likely to suffer littoral forest loss due to sea-level rise and intense cyclones, such as along the Malbon Thomson Range, Bramston Beach, Ella Bay, Cowley and Kurramine Beaches and between Hull Heads and Cardwell (Coastal Risk Australia 2021)
- Highly fragmented landscapes that impede movement (such as much of the coastal lowlands and the southern Atherton Tablelands).

It has long been thought by the general community that cassowaries are at their highest densities in the coastal sub-regions of the Wet Tropics. While it is demonstrated that cassowary densities in an area can change over time (Westcott *et al.* 2014), there are locations where cassowaries are consistently at their highest densities. These are likely to be forests that have higher productivity and diversity among plants, consequently producing a higher biomass of fruit, spread across more of the year than at other locations. Westcott *et al.* (2014), who included comparisons with Crome and Moore's (1990) work, found that areas where cassowaries reached their highest densities were in the central Wet Tropics between the Herbert River and Atherton Tablelands, encompassing low to mid elevations and generally areas of extensive habitat. These findings clearly demonstrate that while cassowaries may be abundant in the coastal sub-regions of the Wet Tropics, these are not necessarily the places where their densities are highest. However, it is in those coastal sub-regions that the cassowary faces the greatest number of threats. Climate change, which includes multiple impacts, is also likely to affect coastal communities more than the low to mid elevations in ranges. However, no areas will escape the severe impacts of an increase in frequency and severity of extreme events (see section 4) such as cyclones.

3.4 Habitat

The cassowary is closely associated with rainforest, and the fleshy fruits produced by rainforest trees, shrubs, vines, and herbs form the mainstay of their diet. However, the cassowary is by no means restricted to rainforest, frequently visiting, and using resources found across its range, including *Melaleuca*, palm and mangrove swamps, beaches, woodlands, tall eucalypt forests, vine thickets, agricultural landscapes, and suburban gardens. In parts of its range, such as in Cape York Peninsula, the habitat mosaic it uses may be dominated by non-rainforest vegetation, especially at particular times of the year.

When defining cassowary habitat, the state of Queensland has considered the biological relationship of cassowaries to a vegetation association and whether the vegetation is remnant or non-remnant. They have defined Primary, Secondary, and Rehabilitating Habitat (see EPA 2004; DNRME 2004; WTMA 2004; EPA 2007; DERM 2009) based on Regional Ecosystem classifications, incorporating bioregion, land zone and plants (Sattler and Williams 1999).

Essential Habitat is also defined, being described as vegetation in which a species that is Endangered or Vulnerable under the Queensland *Nature Conservation Act 1992* has been known to occur and includes the area of vegetation shown on the essential habitat map (*Vegetation Management Act 1999*). For the cassowary, Essential Habitat is synonymous with Primary Habitat but also includes Secondary Habitat enclosed within blocks of Primary Habitat. The Commonwealth has adopted the same Essential Habitat data, adding cassowary corridors as Potential Cassowary Habitat (DEHWA 2009; DEHWA 2010). The mapping layer for these data is available through the Wet Tropics Plan DIY Biodiversity Mapping Tool. However, the State and Commonwealth habitat mappings for the cassowary do not completely align because they are based on different datasets, an issue that will be resolved to facilitate other actions (see Figure 3, Figure 4 and action 1.6). The Commonwealth and Queensland governments will continue working together to refine the mapping of the southern cassowary's habitat.

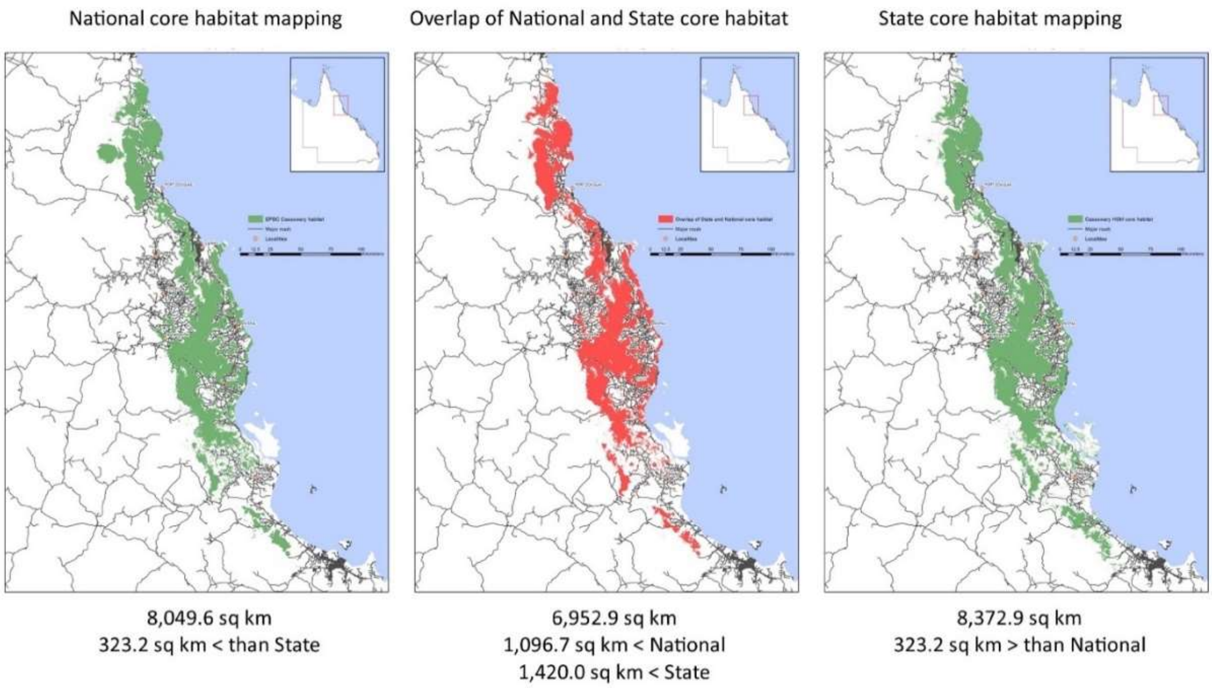

Figure 3 Overlap between State and Commonwealth mapping of core cassowary habitat (Primary or Essential) demonstrating significant differences and need for reconciling (Huddy and Reaston 2021)

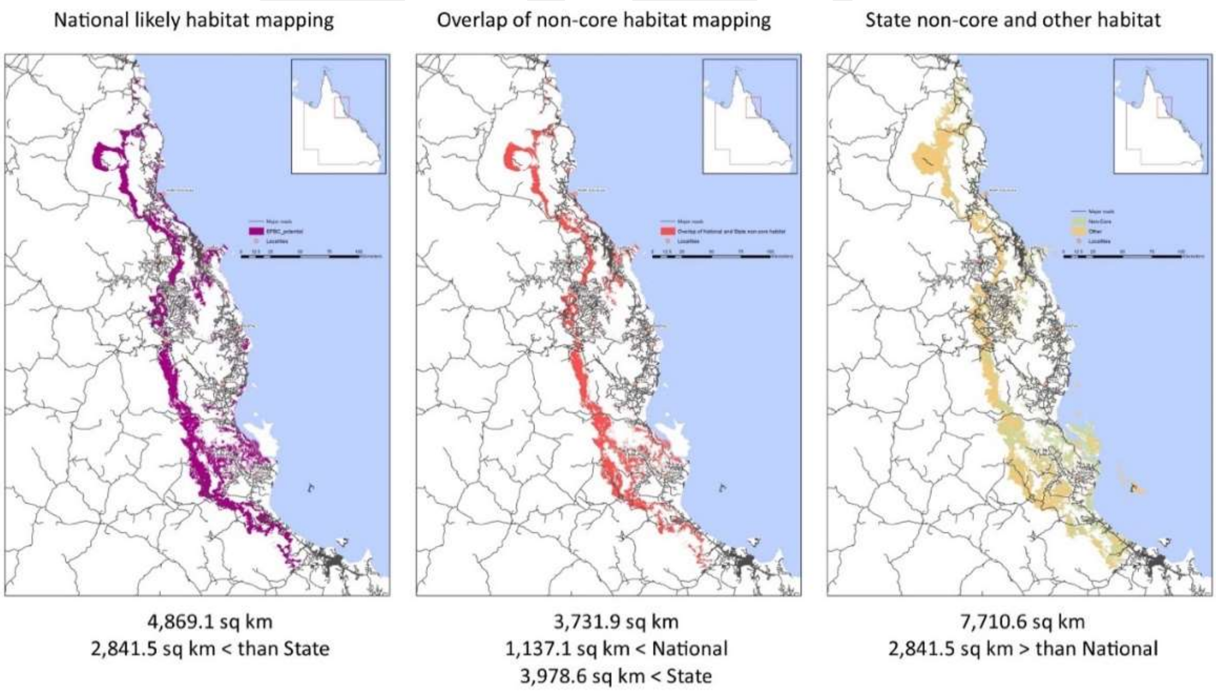

Figure 4 Overlap between State and Commonwealth mapping of potential and non-core cassowary habitat demonstrating significant differences and need for reconciling (Huddy and Reaston 2021)

3.4.1 Habitat critical to the survival of the species

Due to the level of threat faced by the southern cassowary, and its Endangered status under the EPBC Act, all available habitat should be considered critical to its survival. This includes 'Essential Habitat' as defined under the Queensland Vegetation Management Act (1999) and all other vegetation, both remnant and non-remnant, linking fragments of 'Essential Habitat'. Of particular importance are areas of Primary Habitat (Queensland Vegetation Management Act 1999), which are known or likely to be used by cassowaries for activities associated with breeding and raising young, contain food resources or may be used for some other aspect of its life history. Also, important are areas of Secondary Habitat that provide occasional or seasonal resources, access to water or linkages between areas of Primary Habitat. Rehabilitating habitat, which is dysfunctional but restorable, may also be critical when it provides shelter or supplementary food or forms part of a matrix allowing cassowaries to traverse between remnants of Primary Habitat, for example, when it forms a non-remnant corridor (Queensland Vegetation Management Act 1999).

All habitats are important in times of stress. The most common periods of stress are periods of food shortage following short term floods or cyclones (see Metcalfe *et al.* 2008), and while sub-adults are dispersing from their paternal range and being displaced by residents defending occupied territories. Because catastrophic events, such as cyclones, leave an extensive footprint of disturbance, connectivity across the landscape becomes critical so that individuals can access temporary resources outside their normal ranges. In addition, it is likely that prior to European settlement the Wet Tropics contained a single, well connected cassowary population but decades of clear felling and the expansion of human populations and infrastructure may have introduced barriers to movement and gene flow, potentially creating disjunct sub-populations within the Wet Tropics.

Therefore, habitat that is critical to the survival of the species includes:

- Primary Habitat – needed for breeding and raising young, food, water resources, and other aspects of cassowary life history (most remnant forest in the Wet Tropics)
- Secondary Habitat – that provide access to occasional or seasonal resources or facilitate movement between patches of Primary Habitat
- Rehabilitating Habitat – that forms part of a vegetation matrix that reduces resistance to movement and improves the permeability of human induced barriers, facilitating essential gene flow across the population.

Parts of the landscape, once cleared, have been abandoned and are in a process of natural regeneration. Cassowaries are among a suite of animals that can traverse most of the landscape and disperse seeds over large distances into these regenerating forests (see section 3.9), thereby increasing plant species diversity, resilience and functioning of the regenerating forests. Including Rehabilitating Habitat in identified cassowary corridors, alongside Primary and Secondary Habitat, is necessary to maintain gene flow, facilitate the ecological process of seed dispersal and ensure the long-term evolutionary development of the species.

Cleared and cultivated land are generally not considered Cassowary habitat and are not mapped as such despite cassowaries occasionally traversing them or seeking food or water in them. In addition, there are several remnant rainforest and other vegetation associations that have few or no sightings of cassowaries and are therefore excluded from existing habitat mapping by EPA (2004).

However, this mapping did include areas such as the Windsor Tableland and rainforest areas above 1000 m (DERM 2009). This assumption needs reviewing (see Action 1.2).

3.5 Population size and trend

The southern cassowary was considered abundant in the early 1900's in lowland and upland forests in the Wet Tropics region (White 1912). A major decline was inferred from the clearing of 80% of lowland and upland rainforest by the late 20th century (Winter *et al.* 1987), though the combination of traditional and non-traditional hunting also appeared to be a significant pressure in the early 1900s (White 1946). Since this time, two region-wide surveys (Crome and Moore 1990; Westcott *et al.* 2014) and several focal area surveys (Bentrupperbäumer 1998; Moore and Moore 1999 b, c, d, e, f; Moore and Moore 2001; Moore 2007) have provided estimates of numbers. The Crome and Moore (1990) and Westcott *et al.* (2014) estimates are the most comparable and suggest a stable or increasing population at the Wet Tropics regional scale. The estimate for 1988 was between 1500 to 4000 individuals (Crome and Moore 1990), while the best estimate for the period 2011 to 2014 was ~4000 to 4700 (Westcott *et al.* 2014). In between these region-wide surveys, Moore and Moore's (2001) work in focal areas estimated lower densities than earlier work at nearby sites (Bentrupperbäumer 1998). Although methods were not directly comparable, this reinforced concern among the community that cassowaries were continuing to decline, at least at these localised sites (Moore 2007).

Despite the variation in methods and estimates, and the difficulties in finding a reliable repeatable method to count cassowaries, consideration of all surveys over this period suggests a stable population at the scale of the Wet Tropics region (see Westcott *et al.* 2020). In addition, considerable anecdotal evidence is suggesting a recent re-expansion of area of occupancy and an increase in densities in some areas. For example, cassowaries have re-occupied Longlands Gap rainforests and adjacent tall eucalypt forest on the Evelyn Tableland (A.J. Dennis *pers. obs.* 2023) and are being reported in higher densities than previously at Cape Tribulation (Mason 2023). These studies all contribute valuable lessons for the development of a practical method for monitoring population trends at multiple scales in which robust survey data can be collected by First Nations groups and citizen scientists (see Action 2.1).

Population estimates for Cape York Peninsula are currently preliminary and there are no comparisons available across different times. However, work is underway to undertake limited, short-term surveys to monitor populations as part of Traditional Owner groups caring for country initiatives (Bradford et al. 2018, Bradford et al. 2020, McLean 2020, McLean 2022).

3.6 Reproduction

Females are known to mate with multiple males (polyandry) and lay three to five olive-green eggs in the nests of more than one male with which they associate in their home range. Males will mate with multiple females (polygyny), incubating the eggs and raising the young of more than one female (Crome & Moore 1988; Bentrupperbäumer 1998; Moore 2007). This generally occurs between June and October. Males incubate eggs for 50 days (47 – 56) and care for young for as little as eight (Liz Gallie *pers. comm.* 2023) but often 12 to 18 months (Bentrupperbäumer 1998; Biggs 2013). On rare occasions, females are known to temporarily associate with a male and chicks, assisting with care. On one occasion a female adopted a chick, raising it to independence after the male and its siblings were killed (Biggs 2013, Mission Beach Cassowaries 2011).

Females pay little attention to where they lay, though most nests are in relatively dense understorey patches or near a solid feature such as buttresses or the trunk (Bentrupperbäumer 1998; Biggs 2013). Nesting and the rearing of young occur throughout all habitats and throughout their distribution. Subadults, on reaching independence, are generally ejected from the paternal range and may travel large distances seeking a location where they can establish without being harassed by adults (Bentrupperbäumer 1998; Biggs 2013).

3.7 Diet and foraging

Cassowaries eat mostly fleshy fruit, including those with a fleshy aril or receptacle, though they also consume invertebrates, small vertebrates, flowers, fungi and carrion (Bentrupperbäumer 1998; Bradford *et al.* 2008). They are known to eat the fruit of more than 240 species of plants, including from trees, shrubs, vines, and herbs, with tree fruits from the families Elaeocarpaceae, Lauraceae, Myrtaceae and Rutaceae dominating in their droppings. They potentially consume fruit from more than 1,500 species of plants that have fleshy fruit suitable for consumption (Bradford *et al.* 2008). They take a wide range of sizes, from 3-4 mm diameter fruits to those over 60 mm in diameter, though they are more likely to select large-fruited (and seeded) species when they are available. There is no evidence of cassowaries selecting for colour of fruit (Bradford *et al.* 2008). While they take mostly fallen fruit, it is not uncommon to see them plucking fruit directly from a plant, occasionally leaping vertically to do so. In addition to wild fruits and other dietary items, it is not uncommon for a cassowary living alongside people to forage from picnic blankets, tables and baskets or backyard bird feeders and compost heaps, thereby consuming a wide range of non-natural foods.

3.8 Movement

Several studies have used a range of techniques to examine cassowary movements (Bentrupperbäumer 1998; Westcott *et al.* 2005; Dennis and Westcott 2007; Campbell *et al.* 2012; Campbell *et al.* 2014). Despite this, our understanding of how the movement patterns and home ranges of cassowaries differ with age class, habitat, seasons and locations is still incomplete. Adult cassowaries at Mission Beach maintained home ranges that varied in size and shape both seasonally and year to year, the size and shape depending on patterns of food abundance and environmental conditions (Bentrupperbäumer 1998). This suggests that we might expect the cassowary to be highly variable in its movement patterns depending on location and season. In addition, cassowaries have regular routes to and from feeding sites and are presumably contained within a home range, but they may also undertake regular movements outside of this core home range. Cassowaries may make repeated visits to a fruiting tree, which could be one of the reasons they frequently cross open areas and will preferentially use roads and tracks to reach remnant forest patches (Westcott *et al.* 2008). What is clear from these studies is that each individual can use a very large area and that large areas of habitat are required for the persistence of the species.

Studies tracking the movements of the cassowary over long periods are rare (Bentrupperbäumer 1998) and those using radio or satellite telemetry have been short lived (Westcott *et al.* 2005; Campbell *et al.* 2014). Surveys across the Wet Tropics demonstrate that cassowaries occur at a range of densities (Westcott *et al.* 2014) and some forests are more productive than others (Hopkins and Graham 1989; Moore 1991; Dennis 1997). Cassowaries in areas of low productivity are likely to move over much greater distances than those in highly productive forests to access sufficient resources.

It is likely that resources on Cape York Peninsula are more widely dispersed than in the Wet Tropics due to lower rainfall and generally poorer soils, making it likely that cassowaries on Cape York Peninsula are at lower densities and require larger home ranges.

Bentrupperbäumer's (1998) work, following focal individuals at Mission Beach, demonstrated that they travel distances >4km in 6 – 10 hours and commonly range from less than 1 to >4.5km in a day, with about 35% of each day spent travelling. Other studies have found similar results, with cassowaries averaging movements of about 4km over periods from half a day to a few days, with individuals moving up to 12.5km over a couple of days (Westcott *et al.* 2005). The five birds radio-tracked in Westcott *et al.*'s (2005) study ranged on average over 313ha (up to ~500ha) in periods between 11 and 112 days. Work to model seed dispersal demonstrates that they often move 1 – 1.5km over 2 to 30 hours, and that movement varies through the day with more travel occurring in the early morning and evening (Westcott *et al.* 2005).

One study examined the movement patterns of a small number of adults and sub-adults over a short time frame (several weeks – 3 months) using GPS technology (Campbell *et al.* 2012). Similar to Bentrupperbäumer (1998), this study found that females have larger home ranges than males which were overlapping between but not within the sexes (Campbell *et al.* 2012).

3.9 Seed dispersal

Cassowaries provide a significant seed dispersal service to a wide range of plants. There are several characteristics that combine to make them significant dispersers:

- Cassowaries have a wide gape and can swallow very large fruit with large seeds (Bradford *et al.* 2008)
- Seeds are treated gently through the gut and most germinate readily after gut passage (Bradford and Westcott 2010)
- Cassowaries are large bodied and can consume large quantities of fruit
- The time taken for a seed to pass through a cassowary gut is highly variable taking from just under one hour to up to 30 hours, with most passing within three hours (Dennis and Westcott 2007)
- Cassowaries can move over large distances in the time seeds remain within a gut but like gut passage rates, movement patterns are highly variable (Dennis and Westcott 2007).

These characteristics, combined with their abundance in some areas, mean that they can move large numbers of fruits over a wide range of distances and deposit viable seeds away from the parent plant. They are better able to move large seeds over large distances than other species. These characteristics are favourable to plants as they place seeds in many locations over space and time, improving the probability that some will survive to recruit a new plant.

The seed dispersal role played by cassowaries is complemented by 64 other vertebrate seed dispersers in the Wet Tropics, some of which also function as seed predators. Together with wind, water and gravity, this entire community of animals determines the final distribution, germination and survival of seeds from approximately 1,500 plant species. Several species, including the cassowary, provide dispersal to plant seeds not duplicated by other animals.

To put cassowary dispersal in the context of the wider community of seed dispersers, cassowaries consumed ~4% of quandong fruit (*Elaeocarpus grandis*) from 24 trees sampled in a study on seed dispersal (Dennis and Westcott 2007), the rest were consumed and dispersed by a wide range of other birds and several mammals, with only 2.8% remaining untouched. After modelling the likely deposition distances of the entire community of dispersers based on their behaviour, gut passage rate and movement data, dispersal by cassowaries overlapped with other species up to 1.3 km from the parent tree and most seeds were deposited within that distance. However, cassowaries were the only species carrying seeds beyond this, and they continued to deposit a few seeds up to 2.4 km from the parent plant in this model (Dennis and Westcott 2007).

Photograph © Liz Gallie, Wet Tropics Image

4 Threats

4.1 Historical causes of decline

The loss and fragmentation of 80% of lowland and upland cassowary habitat (Winter *et al.* 1987) is one of the most significant contributors to the historical decline of the cassowary (see section 2.2). Large scale clearing of rainforest largely ceased after the Wet Tropics of Queensland were listed on the World Heritage register in 1988. Since then, much cassowary habitat has been protected and some has been restored, with State Forests being converted to National Park and private lands being protected with covenants and agreements (see review of Specific Objective 1; Appendix A. Review of actions in Latch (2007); see also Fitzsimons 2015). In addition to the clearing of forest, hunting contributed to the historical decline of the cassowary (White 1946). This was a combination of traditional hunting by rainforest Aboriginal people, and non-traditional hunting by settlers seeking to supplement their diet with protein sources from bush foods. Combined, this hunting placed a significant pressure on cassowary populations in the early 1900s (White 1946). Neither of these pressures is as prominent as it once was. However, loss of habitat is still a significant pressure that requires remediation (see section 4.2.4) and the fragmentation of habitat caused by historical clearing is still having significant impacts.

4.2 Current threatening processes

In the past, as is the case now, loss of habitat was associated with expanding human populations. This also brought additional threats associated with higher densities of people and domestic animals, such as hunting in the past, then steadily building other threats, such as vehicle strike and dog attack (including by pig hunting dogs), the latter two gaining in prominence over time.

It is important to note that most of these threats do not act in isolation, rather, interacting with one another to amplify or mitigate each other's impacts. The threats are listed in rank order of severity as determined during a workshop with the recovery team (see section 2.5) and reinforced by a risk matrix evaluation (see Table 4) and an indicative summary of threat levels for Wet Tropics and Cape York Peninsula (see Table 5).

- Climate Change
  - Habitat loss through inundation, cyclone damage, fire and movement of human populations
  - Possible changes in plant phenology and effects on cassowary physiology
- Habitat fragmentation, degradation and loss
- Land manager inaction and lack of planning at scale
- Roads and traffic
- Invasive introduced species
- Human interaction
- Disease

Table 4 Risk matrix – Wet Tropics

Likelihood	**Consequences**				
	Not significant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain		**Human interaction-disturbances, disruptions, barriers, feeding, domestic dogs Roads and traffic Invasive introduced species – wild dogs (not dingoes), cattle and horses**	**Invasive introduced species – pigs (*Sus scrofa*) Habitat fragmentation, degradation and loss**	**Climate change-Habitat loss through inundation, changes to vegetation associations and refugia; movement of human populations Invasive introduced species – flammable and palatable weeds**	**Climate change-Habitat loss through increased temperature, storms, cyclones, fire and drought**
Likely			**Climate change-movement of human populations Habitat fragmentation**	**Land manager inaction and lack of planning at scale Climate change – changes in plant phenology**	
Possible					
Unlikely		**Climate change-effects on cassowary physiology**			
Unknown		**Climate change-changes in vegetation community distribution**		**Disease**	

Risk Matrix legend/Risk rating:

Low Risk	Moderate Risk	High Risk	Very High Risk

We define consequences as follows:

Not significant	– no measurable medium- to long-term effects
Minor	– population or subpopulation expected to easily recover
Moderate	– population or subpopulation reduces <30% or recovery stalls
Major	– population or subpopulation declines 30 to 70%
Catastrophic	– population or subpopulation declines >70% or extinction

We have considered the possible frequency, scope and duration of threats in the context of current land tenures and management, assuming those will remain stable. The ranking is by consensus with the cassowary recovery team and using available literature.

Table 5 Indicative summary of threat levels for Wet Tropics and Cape York Peninsula

Region	Risk level	Threats
Wet Tropics	Very High	Most climate change impacts, habitat degradation and loss, some invasive introduced species, land manager inaction and lack of planning
Wet Tropics	High	Habitat fragmentation, some climate change impacts, roads and traffic in some local areas
Wet Tropics	Moderate	Roads and Traffic, human interaction (including domestic/hunting dog attacks)
Wet Tropics	Low	Climate change effects on cassowary physiology and vegetation associations
Wet Tropics	Unknown	Disease
Cape York	Very High	Most climate change impacts, some invasive introduced species
Cape York	High	Some climate change impacts, habitat loss
Cape York	Moderate	Human interaction (including dog attacks)
Cape York	Low	Climate change effects on cassowary physiology and vegetation associations
Cape York	Unknown	Disease

4.2.1 Climate change

In this context, climate change is defined as the long-term global and regional changes in patterns and averages of temperature, humidity and rainfall over years or decades (Shaftel *et al.* 2021). Climate change impacts regional weather having the following actual and predicted effects in the Wet Tropics (see Queensland Future Climate Dashboard; Cobon *et al.* 2017):

- Rise in average, maximum and minimum temperature
- Increase in rainfall variability and decrease in rainfall overall
- Decrease in humidity
- Higher severity and duration of storms
- More intense droughts
- Sea level rise.

These changes are likely to impact cassowary populations through increased habitat loss and changes in plant phenology. Therefore, climate change is considered the highest priority threat and has the potential to amplify the impacts of other threats, requiring vigilance and adaptive approaches to dealing with novel climatic situations.

Increased habitat loss

The effects of climate change may increase habitat loss through several mechanisms including:

- The loss or transition of coastal forests through saltwater inundation caused by sea level rise and storm surges that penetrate further inland than previously – the area likely to be affected can be calculated based on current inundation predictions

- Regular incremental loss of rain forest through uncontrolled fire caused by longer dry periods (e.g., Smee 2019)
- Regular incremental loss of forest after more intense and more frequent cyclones
  - damaging larger areas more severely and resulting in “cyclone scrubs”, which persist for many decades (Metcalfe *et al.* 2008; Murphy 2008)
  - weed invasion after climate change induced disturbance, suppressing recovery (Murphy 2008)
  - increased fire intensity and frequency in rainforest after cyclone disturbance caused by dry fuel build up, flammable vines dominating cyclone scrubs, and increased burning in adjacent areas occupied by humans when conditions become dry after disturbance
  - increase in illegal and legal clearing by humans after cyclone damage.

On the other hand, increasing temperatures and CO_2 levels, combined with loss of appropriate fire regimes, increases the likelihood of rainforest communities establishing in some sclerophyll communities. This transition is evident throughout the Wet Tropics (e.g., Tng *et al.* 2011; Jackson and Diggins 2021). Inundation, cyclones and fire are more likely to remove climax forests that are more productive and more likely to support dense populations of cassowaries. However, gain of resources in sclerophyll forests recently colonised by rainforest communities will not offset these losses because larger mature trees are the most productive (Bradford and Murphy 2019; Minor and Kobe 2019).

Changes in plant phenology
The effects of climate change may significantly change the timing and abundance of leaf, flower and fruit production by rainforest plants. There is some evidence to indicate that this is already occurring in a range of ecosystems (e.g., Visser and Both 2005; Chambers 2009; Scranton and Amarasekare 2017; Deb *et al.* 2018) but it is still an unanswered question in Australia’s Wet Tropics and Cape York Peninsula cassowary habitats. Cassowaries may have some ability to adapt to changes in seasonality but their reproductive output or condition may be disrupted by such changes. Cassowary are more likely to suffer population decline if decreases in productivity result in fewer fruits or lean seasons become longer.

Impacts on cassowary physiology
There is no research regarding the effect of climate change on cassowary physiology. Cassowaries are distributed from the equator to 20 degrees latitude and from sea level to above 1000 m, suggesting they can tolerate a wide range of temperature and rainfall conditions. Several mammal species in the Wet Tropics have been shown to have physiological constraints that hinder their ability to adjust to increasing temperatures (Krockenberger *et al.* 2012; Meade *et al.* 2018). Several birds are predicted to shift in altitudinal range (Shoo *et al.* 2005; de la Fuente *et al.* 2022), and many have already done so (Hoffman *et al.* 2019; Williams and de la Fuente 2021), presumably as a result of their physiological intolerance to increasing temperatures. Diseases also demonstrate changes in virulence based on temperature (Berger *et al.* 1999). While cassowaries are less likely to be affected than the species examined to date, the issue cannot be dismissed out of hand, with possible effects of heatwaves on nesting success being postulated.

Changes in the distribution of vegetation associations and refugia
Several authors have modelled the likely changes in vegetation distribution in future climate scenarios (Hilbert *et al.* 2001). Combined with habitat loss and potential changes in seasonality and biomass of fruit production, changes in climate envelopes may cause a long-term change in the distribution of suitable forests and resources, possibly causing a contraction to refugia (Ostendorf *et al.* 2001; Williams *et al.* 2003; Hilbert *et al.* 2007).

Movement of human populations
The distribution and abundance of human populations in or near cassowary habitat is likely to change significantly over coming decades due to rapid population growth (e.g., Cummings Economics 2017) and changing distribution of the population in response to climate change. Regional Councils are beginning the process of identifying areas of inundation and developing plans on where and how to move populations (e.g., Cairns Regional Council 2021) resulting from sea-level rise caused by climate changes. The re-inundation of coastal lowland cropping areas that were once drained swamps may cause a shift in the distribution of farmlands, possibly necessitating the clearing of new areas for cropping. A combination of changing cassowary habitat distribution and increasing and shifting human populations are likely to increase a range of impacts including:

- vehicle strikes
- dog attacks
- other disturbance (e.g., noise, feeding, 'nuisance birds')
- incremental loss of habitat.

4.2.2 Habitat fragmentation
Habitat fragmentation is the isolation of patches of habitat that can support cassowaries within a matrix of habitat that is not suitable for cassowaries. Most often the unsuitable habitat matrix is in the form of agricultural, urban or suburban areas. In addition, habitat can be fragmented by rivers, roads and other linear infrastructure.

Habitat suitable to cassowaries was highly fragmented after European settlement (Winter *et al.* 1987). Their distribution has several naturally occurring habitat bottlenecks and discontinuities, and barriers to movement such as river gorges, some of which have been further narrowed by human disturbance. Although cassowaries are better able to cross intervening areas than many species affected by habitat fragmentation, they are still susceptible to many of its impacts (see section 4.2.6). Internal fragmentation, such as by linear infrastructure but also by fencing, has the greatest impact in natural and human-made bottlenecks.

A result of fragmentation is that the measurable area of habitat that appears to be available has a lower carrying capacity than the same area in continuous forest. This reduces the potential population size supported by the apparent area of habitat available (e.g., see Haddad *et al.* 2015). For example, Mt Whitfield in Cairns, had resident cassowaries in the 1970s. As the ~550 ha of habitat became progressively more isolated by urban development, the resident cassowaries were killed by dogs and cars and became "nuisance" birds due to habituation through hand feeding.

The species no longer occurs on Mt Whitfield and re-occupation of the 550 ha of habitat available – an area that could probably support 6 – 10 birds – would rely on revegetation of a corridor to connect other populations and mitigation of the threats that led to their extirpation.

4.2.3 Habitat degradation

Weed invasion and changed fire regimes have been noted as degrading habitat (Latch 2007; Westcott *et al.* 2007). Cyclone damage may facilitate weed invasion and the formation of cyclone scrubs, which both potentially degrade habitat (Metcalfe *et al.* 2008; Murphy 2008). A range of other factors are thought to degrade habitat for cassowaries but measures of impacts and evidence are currently lacking. These include pig damage and competition, flammable grasses and weeds, and the effects of human interactions, such as dog incursions and hunting, pollution, noise and lights. The previous plan expressed significant concern with the invasion of the introduced weed, pond apple, *Annona glabra* (Latch 2007). The effects of this weed still remain unmeasured and may be similar to a range of other transformer weeds that suppress succession and recovery after disturbance, such as the giant bramble, *Rubus alceiflora*, and lantana, *Lantana camara*.

4.2.4 Habitat loss

Numerous blocks of private land are cleared or partially cleared each year, some in areas that serve as movement corridors for cassowaries. This regular incremental loss, which also includes clearing for forestry plantings, roads, power, fence lines and other linear infrastructure, agriculture and fire breaks, is adding up to become a substantial loss of quality habitat and further fragmentation of the landscape rendering some patches of suitable habitat unusable due to their small size and lack of connection to other patches of habitat. Habitat loss can also occur through degradation and the occurrence of deterrents such as domestic dogs hunting in forests. The area cleared in the Wet Tropics bioregion has averaged over 1100 ha per year over 30 years between 1988 and 2019 (Statewide Landcover and Trees Study 2022). It increased ten-fold from a low of 284 ha in 2010 to 2294 ha in 2017. Clearing continues with crops, pasture and forestry being the dominant replacement land uses of woody vegetation (Statewide Landcover and Trees Study 2021; Statewide Landcover and Trees Study 2022). No data are available since 2019 but it is likely that >1,100 ha continues to be cleared each year.

Habitat loss is a continuing issue. Its impact is significant for the following reasons:

- loss is often in areas of high cassowary density
- continuing urban and rural residential expansion in many areas (notably Atherton Tablelands, Mission Beach, Kuranda) causes loss of habitat on private land
- Inappropriate fire regimes can reduce the size of rainforest patches where they occur in a sclerophyll dominated landscape (e.g., Cape York Peninsula; see also sections 4.2.1 and 4.2.8)
- incremental losses are cumulative, ongoing and many are irreversible
- habitat loss can also increase fragmentation of the landscape.

4.2.5 Land manager inaction and lack of planning at scale

Despite significant progress in this area (see review of Specific objective 2.1; Appendix A. Review of actions in Latch (2007)), there is still insufficient action and commitment by government at all levels, resulting in poor coordination and strategy, low prioritisation, and insufficient compliance monitoring and enforcement – leading to cumulative incremental loss and degradation of habitat and continuation of some threats. In addition, some threats are treated in isolation when they would be better dealt with in combination, and despite solid efforts in this area (see review of Specific objective 7; Appendix A. Review of actions in Latch (2007)), there is insufficient or inappropriate community education and engagement. Only a single Local Area Plan has been written since the last recovery plan (Hill *et al.* 2010; see also Terrain NRM 2012). This lack of action and coordination across planning instruments is likely to be having a detrimental impact on cassowary recovery and probably represents a significant loss of opportunity for better recovery outcomes. While it should be acknowledged that this inaction and lack of planning is not a direct threat on its own, it is a strong interactor with most other threats and is therefore included in the threats section of this plan.

4.2.6 Roads and traffic

Vehicle strikes continue to be the most frequent measurable cause of mortality for cassowaries in the Wet Tropics (see review of Specific Objective 3.1; Appendix A. Review of actions in Latch (2007)) and are also noted for Cape York Peninsula (Bradford *et al.* 2020). There is an increasing likelihood of encounters on roads with stable or increasing cassowary numbers (Westcott *et al.* 2014) and increasing human populations (Cummings Economics 2017) causing continuous suburban and agricultural expansion. Areas where both cassowary and human numbers are increasing are particularly susceptible. Therefore, it is critical that work in this area continues and that systems already developed, such as Cassowary Advanced Roadside Monitoring Alerting (CARMA) are implemented in other areas of high road mortality (see review of Specific Objective 3.1; Appendix A. Review of actions in Latch (2007); and Action 2.8). Overlapping with the lack of planning (see section 4.2.5), significant improvements could be made with the design and placement of roads if communication between relevant government departments, such as TMR, DESI, WTMA, SDILGP, regional councils, Traditional Owners and the general community is improved.

4.2.7 Human interaction

- Interactions with human communities in cassowary habitat is considered the source of numerous actual and potential impacts. These include:
- various disturbances and disruptions to habitat, including infrastructure and barriers to access and items listed in habitat degradation (1033660496.6784.2.3)
- inappropriate behaviours such as feeding, not controlling domestic dogs and driver behaviour – partially driven by lack of awareness and ignorance
- Domestic dogs accounted for 6 deaths in 2019/2020 and their impact is likely to be an increasing problem as human (and domestic dog) population density increases and more developments abut natural forests.

4.2.8 Invasive introduced species

Invasive species have a high potential to degrade cassowary habitat and threaten the species. Some have already been listed in sections on climate change (Section 1033660496.6784.2.1), habitat degradation (Section 1033660496.6784.2.3) and human interaction (Section 1033660496.6784.2.7).

However, some have such a high potential to transform or disrupt primary habitat or cassowary survival that strategies directed specifically at managing invasive species are warranted. Invasive introduced species that require attention include:

- Highly flammable weeds that grow beside or within rainforests or are capable of invading after disturbance (e.g., *Panicum maximum*, *Melinus minutiflora*, see Grice and Setter 2002; Gamba *Andropogon guyanus*, see Babawi *et al.* 2018)
- Weeds producing palatable fruit dispersed by cassowaries and other wildlife (e.g., pond apple *Annona glabra*, guava *Psidium guajava*, cherry guava *P. cattleyanum*; giant bramble *Rubus alceifolius*)
- Pigs *Sus scrofa*
- Dogs (not including dingoes) *Canis familiaris*
- Cattle *Bos taurus,* and
- Horses *Equus caballus.*

Managing flammable weeds in and around rainforest areas is becoming increasingly important as the incident and severity of cyclone disturbance increases and the duration of dry periods extends due to climate change. This is likely to be a severe problem on Cape York Peninsula where cassowary habitat is integrated in a tight mosaic with fire tolerant vegetation susceptible to highly flammable grass invasion and therefore hotter fires (e.g., see McLean 2022). Rainforest does not tolerate fire. Several weeds producing fleshy fruit have the potential to form dense monodominant stands that suppress the recruitment of native plants, particularly in areas recovering from disturbance.

There is a known overlap in the diets of pigs and cassowaries (Mitchell 2002) but the level of competition this might create remains unknown, although recent observations on Cape York Peninsula noted pigs removing all fallen fruit from a crop just prior to a cassowary arriving to feed at the same crop (McLean *pers. comm.* Oct 2022). Anecdotes of pigs destroying cassowary nests (Crome and Moore 1990) add to the perception that pigs are detrimental to cassowary populations. However, the relationship between the two and the potential threat caused by pigs remain unquantified. Pigs cause notable disturbance to soil in ecosystems in the McIlwraith range and likely destroy seedlings and suppress plant recruitment across wider Cape York Peninsula (Bradford *et al.* 2018; Bradford *et al.* 2020; McLean 2020) and in the Wet Tropics (Mitchell 2002). Further north on Cape York Peninsula, their numbers and impact seem lower (McLean 2022). There are currently numerous anecdotal accounts and observations by experienced observers suggesting that pig numbers, and their consequent impacts are increasing in both the Wet Tropics and on Cape York Peninsula. This may increase the level of competition for fallen fruit and of disturbance in ecosystems, altering plant recruitment patterns and is a potential threat that needs to be investigated.

Other introduced herbivores, such as cattle and horses, are also likely to disturb and disrupt rainforest ecosystems (particularly riparian zones), through erosion, trampling and compaction of soil, eating seedlings/ saplings, and by weed spread through dung (Bradford *et al.* 2018; Bradford *et al.* 2020).

Domestic dogs are known to kill cassowaries of all ages and are a constant source of mortality around suburban areas in the Wet Tropics (DESI-QPWS&P data) and Indigenous communities on Cape York Peninsula (Bradford *et al.* 2020).

An increase in pig hunting with dogs facilitated by the development of roads and an increase in motor vehicle ownership in the 1980s is thought to explain the localised extinction of the cassowary in the Lockerbie scrub (Gudang Yadhaykeny Traditional Owners pers. comm. 2022).

4.2.9 Disease

In the previous plan (Latch 2007), Action 6.4 was to investigate the prevalence of disease. This work has progressed *ad hoc* through autopsies on deceased birds. Apart from these birds frequently showing signs of disease, there is no evidence to suggest that disease is a significant factor currently threatening the species. Current border control measures should be sufficient to minimise the introduction of novel diseases, such as through interactions with livestock or the pet bird trade, which could easily enter the wild cassowary population through their interface with suburbia. However, it is still important to understand the prevalence and epidemiology of diseases, such as aspergillosis and avian tuberculosis, in cassowary populations and this should continue to be assessed during autopsies on deceased birds.

Perhaps of more concern is the spread of myrtle rust *Austropuccinia psidii* (see State of Queensland 2019; Makinson *et al.* 2020), which may change the distribution and abundance of plants in the Myrtaceae family, many of which are cassowary food. Infected trees may have lower fruit production. In some forests species of Myrtaceae make up a high proportion of the species present and their loss may reduce carrying capacity or degrade habitat quality. Genera affected include *Syzygium*, *Acmena*, *Waterhousea*, *Lenwebbia*, *Rhodamnia*, *Rhodomyrtus*, *Austromyrtus* (State of Queensland 2019), representing a significant number of cassowary food species (Bradford *et al.* 2008).

5 Recovery objectives, performance criteria and actions

Objective 1: Habitat extent and condition is improved

The habitat suitable to cassowaries (including primary, secondary and rehabilitating habitat), both now and in future climate change scenarios, is protected by enforceable laws, increased in area, is connected across the landscape and is accessible to cassowaries and enhanced in quality and resilience (see Table 6).

Criteria for success – within 5 years:

- A measure of habitat quality (e.g., Lawson et al. 2008) is applied to corridors, restoration and enhancement sites.
- Criteria for success – within 10 years:
- Landscape connectivity (see Keeley et al. 2021) at catchment scales is increased across 50% of catchments
- An additional 50% of existing unprotected habitat is protected using the full range of legislative and voluntary tools
- A measurable increase in the area of habitat of the cassowary in current and future climate scenarios.

Strategy 1 – Protect, restore and connect habitat

Table 6 Actions to protect, restore and connect habitat

Action	Description	Details
1.1	Continue conversion of available lands to secure protected tenure	There are significant tracts of State Forest and other reserves, unallocated state land and leases within the Wet Tropics region that have been identified by the state government as suitable for conversion to National Park and contain primary cassowary habitat. The Queensland Government is maximising opportunities to transfer suitable State lands to the public protected estate and working with interested and eligible private landholders to declare private protected areas. These conversions will secure important areas for cassowary conservation. This should include consideration of Traditional Owner cultural aspirations and spiritual connections to the locations.
1.2	Identify and map new priority areas for protection and keep maps up to date and accessible	No region-wide prioritisation of land suitable or available for protection has been completed. This is a gap in efforts for cassowary recovery, though local area action groups continue to identify and seek funding to secure land as opportunities arise. A distribution wide approach considering all tenures would facilitate protecting the highest value parcels first. Prioritisation of land parcels should include Traditional Owner aspirations and knowledge as well as the likely impacts of future climate changes that might support or degrade cassowary habitat.

Action	Description	Details
1.3	Review definitions of primary, secondary, and rehabilitating habitat to develop measurable characteristics of quality in each category	Degradation of habitat is a significant threat. To manage and monitor this threat, a clear measure of habitat quality is essential (e.g., see Lawson *et al.* 2008). It requires parameters to determine if habitat is degraded, degrading or improving in quality. Measures may incorporate specific parameters such as invasion by pond apple or the occurrence of myrtle rust (see action 2.1) and more general measures such as canopy cover and structural and floristic diversity and should take note of existing toolkits (e.g., Kanowski *et al.* 2010). This measure can then be applied to assess whether efforts to mitigate habitat degradation are successful (but see section 3.4) and consider whether climate change is degrading or altering habitat quality.
1.4	Identify, resolve and monitor issues with habitat quality in areas of concern and areas being rehabilitated	The condition score, developed in Action 1.3, should then be applied where funding has been allocated to address issues that degrade habitat quality. Issues addressed might include weed and feral animal control, replanting and rehabilitation projects, and corridor creation and enhancements. As part of these projects, the initial measurement, then follow up monitoring of habitat quality parameters, should be costed and built into the works. These works could be joint management arrangements with traditional owner groups and should incorporate consideration of future climates.
1.5	Collaborate with other stakeholders to develop and offer incentives for voluntary habitat protection	As human populations increase and the urban footprints expand, conservation of forests on private lands will continue to increase in importance as a significant component of the protected area estate (see Fitzsimons 2015; Queensland Government 2022). To encourage more landholders to protect their land and to feel that the community values their commitment, ongoing structured support programs should be developed. These may include such instruments as ongoing rate relief, support for developing management plans, weed management and rehabilitation works or income generated through biodiversity credit systems. 'Other stakeholders' may include governments at all levels, corporate investors, NRM bodies and conservation organisations among others.
1.6	Measure and monitor habitat loss and gain	Ongoing habitat loss continues to be recognised as a significant threat to the recovery of the cassowary (see section 4.2.4). To ensure that habitat area and quality do not continue to decline unnoticed and unmeasured, it is essential that a suitable tool for monitoring habitat changes be developed (e.g., see State of Queensland 2017). This should start with reconciling habitat definitions and mapping (see section 3.4).
1.7	Review and update priority landscape connectivity requirements with emphasis on adaptation to climate change.	Regional populations continue to grow (Australian Bureau of Statistics 2022) and settlements expand. Native vegetation eligible for clearing is known (VMA 1999), inundation mapping is available (Coastal Risk Australia 2021), and modelling of climate refugia are known and mapped for the Wet Tropics (e.g., Hilbert *et al.* 2007; Murphy *et al.* 2012; Das *et al.* 2019). High priority corridors are already identified and mapped (Wet Tropics Management Authority 2012). The Queensland Government's "A Biodiversity Planning Assessment for the Wet Tropics Bioregion" provides expert advice on landscape in the Wet Tropics. Terrain NRM's Rainforest Decision Support Tool provides insights into landscape connectivity investment planning. All of these data can be synthesised to update priority areas for enhancing landscape connectivity in the Wet Tropics. This process should also be developed for Cape York Peninsula, where protecting corridors across a complex landscape dominated by fire may be more critical than in the Wet Tropics. Both should engage stakeholders in the updating process for maximum effect.
1.8	Identify connectivity issues on Cape York Peninsula	The process outlined in 1.7 should also be developed for Cape York Peninsula, where protecting connections and habitat fragments across a complex landscape dominated by fire may be more critical than in the Wet Tropics.

Action	Description	Details
1.9	Support collaborations to increase habitat connectivity and quality	Increase collaboration and information flow between all parties involved in habitat restoration and landscape connectivity and consider provenance, resistance to disease and other genetic factors when selecting trees for revegetation. Consideration of cultural interests, such as song-lines, storylines and bush tucker calendars (among others) should be incorporated in choosing sites.
1.10	Remove or ameliorate barriers	Methods to remove or ameliorate barriers, such as replacing 5 strand barbed wire or tall wire mesh with wildlife friendly fencing designs, installing road bridges or underpasses of at least 5 m in height and/or wildlife overpasses can facilitate the ability of the species to freely use the entire landscape matrix (see also Action 2.8).
1.11	Develop incentives to protect and increase connectivity	Use analysis from 1.7 and develop incentives for landholders and managers to protect existing corridors, manage their condition (e.g., weed removal) and continue replanting corridors and reconnecting fragments and therefore increase viable cassowary habitat; regularly review and update; initiate targeted restorations.
1.12	Restore degraded areas	Identify degraded areas to rehabilitate into better quality habitat and buffer areas to secure primary habitat.

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Objective 2: Population viability is improved

The population of cassowaries has been estimated with known precision, it has remained stable in current primary habitat and the species has expanded to occupy all potential habitat resulting in an overall increase in population size and area of occupancy within 10 years (see Table 7). Threatening processes that could lead to a population decline or change in area of occupancy or extent of occurrence are actively monitored and managed with strategies in place to deal with chronic and emerging threats across all land tenures and time frames (see Table 8). Recruitment and mortality remain in balance or recruitment is higher than mortality within 10 years.

Criteria for success – within 5 years:

- Trends in threatening processes are measured, monitored and reviewed biennially by the Cassowary Recovery Team
- Threats are known and their relative impacts clearly understood.

Criteria for success – within 10 years:

- A repeatable population sampling method that can be implemented by first nations groups and citizen scientists is developed and executed at least every 5-years to monitor population trends
- Population trend remains stable or increases over at least two additional 5-year periods
- Area of occupancy increases in accordance with improvements in habitat condition, area and connectivity
- The DESI-QPWS&P cassowary database demonstrates cassowaries are being sighted in new areas and/or cassowaries are re-occupying areas from which they have disappeared
- Research on home ranges and movement patterns, reproductive biology and genetics to better understand population viability are completed
- Mitigation strategies based on the best available evidence are developed and implemented for each threat as they are quantified.

Strategy 2 – Understand distribution, habitat use, population trends and reproductive biology

Table 7 Actions to understand distribution, habitat use, populations trends and reproduction

Action	Description	Details
2.1	Refine standard survey technique for monitoring trends in cassowary population	Drawing on existing work (Crome and Moore 1990; Westcott *et al.* 2014; Bradford *et al.* 2020; McLean et al. 2017; and Department of Defence), design a sampling protocol and strategy that can be carried out by citizen scientists, under the supervision of Traditional Owners when on country, with oversight by the WTMA scientific committee and the CRT. As part of this action, it is essential to establish appropriate protocols for governance, ownership and access to data, identifying the data owners and custodians and how the data are analysed, presented and accessed.

Action	Description	Details
2.2	Implement long term, funded program to monitor population trend	Using the sampling protocol and strategy from Action 2.1, complete a distribution wide survey at least every 5 years thereafter. Investigate opportunities to embed population monitoring in traditional owner ranger programs and need for more frequent surveys at local scales where impacts are high. Review and update survey methods for low density populations, such as on Cape York Peninsula, and by monitoring developments in genetic and statistical techniques.
2.3	Measure area of occupancy and extent of occurrence	The Cassowary Database (managed by DESI-QPWS&P Wildlife Rangers) is an important tool for assessing increases in the extent of occurrence and area of occupancy sought in this plan. Reports received may record initial sightings in new or previously occupied areas. An appropriate survey method can then be used to assess the likely number of cassowaries using a new area based on the monitoring protocols designed in Action 2.1. The method can also be used in restored habitats to periodically assess use. Indigenous rangers and community groups can employ survey methods in areas that are not part of the Wet Tropics wide monitoring to periodically check use of lesser-known areas.
2.4	Re-assess use of population viability analyses	As more demographic, movement and dispersal data become available, population viability analyses may be developed with lower error and higher confidence. Assessment of the value of undertaking population viability analyses at local and regional scales should be undertaken as new data become available. Genetic factors should be included in this modelling, where available, and consideration of the effects of climate change on viability incorporated, if possible.
2.5	Understand population genetics of the southern cassowary	As methods for extracting and analysing genetic samples from dung develop, employ them to understand the genetic structuring of all cassowary populations and estimate movement rates and gene flow across their distribution. Genetic diversity can have a significant effect on long term persistence of populations with inbreeding depression commonly recognised as a significant threat to a species persistence (see Hoffmann *et al.* 2021). It is important to have a clear baseline understanding of population genetic health and structuring to inform future management actions, such as genetic translocations should they be required.
2.6	Understand reproductive biology of the southern cassowary	There is consensus from stakeholders that captive breeding for release, adjunct to *in situ* cassowary conservation measures is unnecessary at this stage. However, there is a need to further develop the means to consistently and predictably reproduce the southern cassowary in an *ex situ* context, document the technical methods and tools, and document the outcomes of such endeavours (Biggs 2013). These efforts will be critical, should wild populations continue to fall victim to further human error, and stochastic events, including environmental, demographic and genetic.
2.7	Determine movement patterns and home range	Understanding home range size, overlap, variations in different habitats and location and between age classes is essential for managing a range of threats, understanding population viability, and how best to connect habitat patches across the landscape.

Strategy 3 – Manage and monitor threats

Table 8 Actions to reduce, manage and monitor threats

Action	Description	Details
2.8	Monitor, reduce and manage vehicle strike	Vehicle strike is the largest measured source of avoidable mortality. Previous work has made significant inroads into mitigating this threat but it continues to require ongoing management. Use existing data (Cassowary Database and Transport and Main Roads traffic monitoring data) to identify new areas for community education, including road signage, installing Cassowary Advanced Roadside Monitoring Alerting (see review of Specific Objective 3.1, Appendix A) and direct community education programs. Identified locations, particularly in areas of high density, where critical connectivity is fragmented by a road, and where traffic speeds are above 80km/hr, should have detailed and costed infrastructure plans developed, examining the feasibility of high bridges with verges that allow movements along the watercourse below the bridge or wildlife overpasses such as is currently under construction at Smith's Gap. Once implemented, any such installations should be carefully monitored for a minimum of five years to measure efficacy.
2.9	Continue to develop baseline data on epidemiology of the southern cassowary	While diseases in cassowaries do not appear to be a current threat, it is useful to understand underlying disease occurrence to monitor for future threat of an emerging disease or changes in the patterns of disease caused by environmental stressors such as climate change. Currently, many injured birds are euthanised and dead birds are autopsied by vets with data being submitted to DESI and stored in Tropical Vet Services database. This action should review sample collection protocols for collecting and storing data from post-mortems, incorporate the needs of captive breeding and research facilities where possible, and support the training of vets in these protocols and data management.
2.10	Incorporate measuring and mitigating biosecurity threats into the southern cassowary's recovery actions	This action should incorporate current and emerging biosecurity threats. A current example is myrtle rust, *Austropuccinia psidii*, which affects fruit production, plant survival and possibly future vegetation community structure. It is possible that significant seasonal resources may be diminished by this invasive disease and therefore it is critical to understand its current impacts and their possible long-term trends. Monitoring for and controlling the disease in re-plantings and corridors should be a part of measuring habitat quality. Current measures promoting the planting of genetically resistant stock into revegetation initiatives should be sought out and supported.
2.11	Support education, monitoring and compliance measures for domestic dog control	Domestic dogs are the second biggest cause of mortality recorded in the Cassowary Database. Most recorded deaths are caused by domestic dogs, which are already regulated by regional councils and state departments. Because domestic dogs should be under the control of their owners, strategies for managing and educating people are essential and collaboration between authorities are required to achieve this. Current data on dog attacks should be interrogated to determine if there are hotspots of dog attacks and education campaigns should be targeted there first.

Action	Description	Details
2.12	Measure and manage the impacts of dogs on Cape York Peninsula	Bradford *et al.* (2020) report that elders in the Iron Range area consider dog attacks to be one of the most significant threats to cassowaries. Traditional Owners in the northern Cape York Peninsula areas also have concerns about dogs (McLean 2020; 2022). Domesticated dogs are being lost or abandoned by local and tourist pig hunters. In addition, two domestic hunting dogs were recorded on the camera traps set out to detect cassowaries. It is necessary to measure the extent of the problem to understand the resources required and where they need to be targeted to address the threat. Therefore, develop a protocol for measuring and recording the occurrence of uncontrolled domestic hunting dogs in cassowary country on Cape York Peninsula. This could be managed locally by Indigenous ranger groups and combined with the DESI Cassowary Database. It could also be rolled out with Land and Sea Ranger groups in the Wet Tropics. Providing dog desexing services within Cape York communities will help prevent unwanted litters and reduce uncontrolled dogs hunting.
2.13	Measure and manage the impacts of pigs in the Wet Tropics and pigs and feral stock (cattle and horses) on Cape York Peninsula	Feral pigs disturb habitat through their regular and extensive, digging and churning of soil. They also consume some of the same fruit eaten by cassowaries (Bradford *et al.* 2018; Mitchell 2002). There impacts are extensive throughout the Wet Tropics and on Cape York Peninsula, though less so in the far northern Cape (McLean 2022). To ameliorate impacts, feral pigs should be controlled in all cassowary habitat that is affected. On Cape York Peninsula, this action should first measure the extent of the impact of pigs and feral stock in cassowary country to identify appropriate locations and what resources might be required to manage it.
2.14	Measure and manage the impacts of fire on the southern cassowary's habitat on Cape York Peninsula	Fire is a powerful land management tool and can affect huge expanses of the landscape at one time. Traditionally, fire was used to protect rainforest pockets. Changes in the land tenure and use on Cape York Peninsula have disrupted traditional burning practices, which has affected some landscapes significantly. Inappropriate fire (too frequent or hot) can have devastating effects on rainforest (Bradford *et al.* 2018). It is critical to develop a way to measure and monitor the impacts of fire on cassowary habitat on Cape York Peninsula. Local ranger groups and Indigenous organisations are best placed to measure the impacts, redevelop appropriate burning strategies and implement appropriate burning techniques. Continual monitoring and modification of these burning techniques will also be required as factors like climate change, invasive weeds and cyclones will affect the way fire interacts with, and alters, the landscape. Many local ranger groups and Traditional Owners across Cape York Peninsula are already practicing traditional methods of fire management or are enthusiastic to relearn the techniques. Supporting these organisations by assisting with training, materials and equipment to implement appropriate fire, fire monitoring and reporting will assist cassowary recovery and persistence.
2.15	Assess whether low genetic diversity is a threat on Cape York Peninsula	Cassowary populations on Cape York Peninsula are low density and dispersed in a naturally fragmented landscape, often with narrow, linear habitat features (Bradford *et al.* 2018; 2020). Sub-populations may be separated by marginal or hostile vegetation types, and other barriers to dispersal, potentially making them more susceptible to inbreeding depression than those in the Wet Tropics. These populations are also quite separated from the Wet Tropics populations. Therefore, understanding the genetics of cassowaries on Cape York Peninsula, and parameters associated with low genetic diversity, including inbreeding depression, are critical. Should Cape York populations of cassowaries need genetic rescue, a complete understanding of the issues in all populations, including the Wet Tropics, is essential to appropriately ameliorate any problems. Data from Action 2.5 should be applied to this investigation.

Action	Description	Details
2.16	Assess and model indirect impacts of climate change	Flowering and fruiting phenology and habitat extent and distribution could both be altered by climate change. These in turn may impact cassowary movement patterns, area of occupancy and possibly reproduction. Modelling where habitat may be lost or gained, including under extreme events, may inform adaptive management and facilitate decisions on connectivity. Monitoring fruiting phenology and comparing it to the extensive baseline data available (e.g., see Westcott *et al.* 2005) will inform management.

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Objective 3: Indigenous knowledge and lore help guide recovery

All decisions, strategies and actions meaningfully incorporate Indigenous knowledge, lore and values with contemporary scientific method and understanding, and broad community knowledge and values (see Table 9).

Criteria for success – within 5 years:

- All First Nations groups (~25) are offered membership of the recovery team and are supported to engage with the team
- There is communication and engagement with opportunity for input with all First Nations groups in cassowary country
- Aboriginal corporations have access to information to support cassowary conservation in caring for country plans and actions.
- Criteria for success – within 10 years:
- First Nations groups are leading or actively engaged in actions on country, such as population monitoring, collection of citizen science data, and restoration of habitat to full ecological function
- Indigenous and non-Indigenous people collaborate in work on country where appropriate
- Training and funding are provided for First Nations groups as needed.

Strategy 4 – Facilitate engagement with Traditional Owner groups

Table 9 Actions to facilitate engagement with Traditional Owner groups

Action	Description	Details
3.1	Develop methods to ensure contemporary, citizen and Indigenous science are integrated in conservation actions and research.	Drawing on existing resources (e.g., NESP 2015; 2020; 2021; Hill *et al.* 2017), establish a protocol in consultation with Traditional Owners to guide the integration of Indigenous knowledge and lore into research, monitoring and on-ground actions associated with cassowary recovery. Guiding strong integration of all forms of knowledge and enquiry will be of particular benefit to a range of questions.
3.2	Continue to develop respectful, transparent, and honest relationships with First Nations groups in the southern cassowary's country	Establish a culture within the Cassowary Recovery Team that seeks to examine how Indigenous lore, knowledge, guidance and/or leadership can integrate into every aspect of the Cassowary Recovery Plan actions (see NESP 2015; 2019; 2021; Terrain NRM 2016; 2017), including seeking free, prior and informed consent for planning and actions on country.
3.3	Establish a directory to guide engagement with First Nations groups on the southern cassowary's country	Refine and extend existing directories (e.g., Terrain 2017) and incorporating more information than is currently easily available. Traditional Owner groups should have the opportunity to guide protocols for engagement that can be used by community groups and researchers seeking to undertake actions on country. This could include the following components: Groups willing (contact details included) or not willing to be contacted by Cassowary Recovery Team, its individual members or other non-member groups; Outline of current capabilities and capacity (e.g., number of individuals engaged); Groups seeking opportunities to build capabilities and capacity; Appropriate/agreed engagement process for each group; Yearly review.

Action	**Description**	**Details**
3.4	Continue to incorporate Traditional Owner knowledge and values into reviews of the recovery plan	Not all Traditional Owner groups have been consulted and not all groups have had sufficient time and resources to have strong and meaningful input into the recovery plan's development. Therefore, it is important to continue this aspect of the recovery planning process and seek new input from Traditional Owner groups and incorporate it into future revisions of the plan. DESI-QPWS&P joint management processes would offer a good avenue for engagement with Cape York First Nations groups. Once new input is received, operational changes to existing actions can be agreed to and recorded in the minutes of Cassowary Recovery Team meetings.
3.5	Seek opportunities to facilitate Traditional Owner groups to educate and advocate to the broader community	The Cassowary Recovery Team can enable opportunities for Traditional Owners to communicate their values and the work they do on country with the broader community. As part of testing how land management can incorporate Traditional Owner cultural values and Lore, or is led by Traditional Owners where appropriate, it is important that the broader community have knowledge of what these groups are already doing where this is culturally appropriate.
3.6	Develop and implement strategies for Traditional Owners to participate in actions from the Cassowary Recovery Plan	Most Traditional Owner groups have expressed a strong desire to engage in management, scientific research and monitoring (M. Morta *pers. comm.* 2022). In addition, a high proportion of lands where cassowaries are distributed have some form of formal Traditional Owner interest, such as Native Title Determinations, ILUAs, IPAs and joint management areas on National Parks. (WTMA 2022; National Native Title Tribunal 2021). It is, therefore, essential that traditional owners are able to participate at all levels in recovery actions. Examples might include the funding of ranger groups to implement monitoring programs on country to estimate cassowary population size, manage feral pigs and weeds and conduct revegetation programs to connect corridors.

Objective 4: Partners are engaged and recovery is well governed

The cassowary recovery team is supported and funded by a full range of partners to perform a coordinating role in information management and dissemination, and governance of the recovery program. There is strong awareness, a sense of ownership and responsibility in all communities in cassowary country, who feel empowered and informed to take action to protect and conserve the species (see Tables 10 – 13).

Criteria for success – within 5 years:

- Recovery program is professionally managed, and governed by an updated framework of rules, relationships, systems, processes and accountability
- Stakeholders are identified and engaged to an appropriate level with the recovery process
- Criteria for success – within 10 years:
- Community participation in management activities has increased
- Councils, land managers and infrastructure managers have all adopted cassowary management practices that support the objectives of this plan
- Voluntary habitat protection (e.g., Nature Refuges under the *Nature Conservation Act 1992*, Voluntary Declarations under the *Vegetation Management Act 1999*, Statutory Covenants under the *Land Title Act 1994* (Qld), IPAs, Wildlife Land Trust) have increased against the 2022 baseline
- Citizen science data collection, collation and analysis has increased against the 2022 baseline
- Information is vetted and collated into an easily accessible form for land and infrastructure managers, tourism industry and the public
- A significant proportion of actions are conducted in collaboration with other recovery teams, i.e., the spectacled flying-fox and other threatened rainforest species.

Strategy 5 – Educate and engage community as custodians

Table 10 Actions to educate and engage community as custodians

Action	Description	Details
4.1	Develop and implement a comprehensive communication strategy for the cassowary recovery plan's implementation.	Many aspects of cassowary recovery require engagement and communication with various sectors of the community, private and government organisations. A structured communication plan for use as a reference document could make this process more efficient and effective. The plan should include objectives and performance criteria and identification of strategic sectors, communities and partners. It should support and empower NGOs, government and agencies to align efforts with recovery plan priorities, consistent techniques and approaches, and data sharing. It should include a short, easily read executive summary of this plan, strategies and materials to engage with schools and seek to advertise laws, rules and procedures that support cassowary recovery and promote enforcement. The plan could also include a directory of community groups mapped to location or area of influence and identify where there are gaps in engagement. The plan could include area specific priorities, information on 'how you can help', 'who to get in touch with' and a section educating newcomers to cassowary country. The communication plan would require an ongoing coordinator to keep it up to date and would require monitoring and review (see action 4.).
4.2	Implement community engagement programs in priority areas where negative impacts on the southern cassowary are high.	In some areas, human cassowary interactions constitute the most significant immediate threats to the species. In these areas, it is important to engage the community, understand their values and attitudes towards cassowaries and implement education and awareness raising programs using appropriate tools. Considerable education and awareness raising has been conducted by a range of partners about responsible dog ownership, vehicle road strike and feeding of cassowaries. However, these issues remain relevant and unresolved. For example, analysis of the DESI cassowary incident database has further identified characteristics of hotspots for cassowary road strike (Bradford *et al.* 2021) and may also be interrogated to identify dog attack hotspots and areas of high human cassowary interaction where hand feeding is likely to be an issue. Dogs on communities on Cape York Peninsula are likely to be a problem that community engagement and education programs may be a helpful tool to mitigate. Online tools and citizen science projects may encourage people to document sightings of birds and other fauna, facilitating engagement with the natural world.
4.3	Support the southern cassowary's care and rehabilitation	Cassowaries continue to require rescue and rehabilitation. The existing program involving a wide range of partners but lead by DESI Wildlife Officers, local vets (e.g., Tropical Vets) and two main care facilities (Garners Beach Cassowary Rehabilitation Centre and the Tablelands Cassowary Rehabilitation Facility) is quite successful and requires ongoing support to further develop skills and facilities, continue data collection through autopsies, and improve post release monitoring of animals returned to the wild. This also includes post-disaster emergency feeding programs and protocols which require regular review. This process and these facilities should engage strongly with Indigenous ranger groups on the areas they service and where cassowaries are collected and released.

Strategy 6 – Cassowary conservation is integrated into policy and land-use plans

Table 11 Actions to integrate cassowary conservation into policy and land-use plans

Action	Description	Details
4.4	Review and update EPBC Act referral guidelines for the southern cassowary	The Significant Impact Guidelines for the Endangered southern cassowary (*Casuarius casuarius johnsonii*; DEWHA 2010) are now over 12 years old and require review and updating and incorporation of guidelines for Cape York Peninsula.
4.5	Work with strategic land use planners to recognise, protect and restore the southern cassowary's habitat and corridors.	Negotiate to integrate cassowary conservation into place based planning initiatives. Proactively engage with government planners and the development industry as they prepare and review their plans. This would be an iterative and collaborative process, ensuring all stakeholders represented on the Cassowary Recovery Team have the opportunity for input and possibly including membership of planners' on the Cassowary Recovery Team. Relevant plans include Australian Government Bioregional Plans, Queensland Government Regional Plans and local government planning schemes, including corporate plans and operational plans. In areas of habitat and corridors with significant development pressure, local area plans may be required to ensure protection and restoration of an ecologically functional habitat network and to avoid vehicle strike, domestic dog incidents and feeding. Local area plans would be informed by fine scale mapping.

Strategy 7 – Strengthen governance and partnerships

Table 12 Actions to strengthen governance and partnerships

Action	Description	Details
4.6	Engage a coordinator to advance the work of the recovery team	This action will follow from 4.4 and involve writing a specific role description and annual action plan to be overseen by an employer in association with the recovery team. The coordinator's roles might include to facilitate population monitoring data collection, recording and analysis; interrogating the Cassowary Database; facilitating the implementation of the communication strategy; monitoring governance of work performance in contracts or overseen by Cassowary Recovery Team; facilitate lobbying of appropriate level of government to manage threats to habitat quality and extent; developing the fundraising strategy; increasing activities and understanding of threats in Cape York, and liaising with researchers to ensure new information is brought to the attention of the team as it becomes available. In the absence of this coordinator position, these roles will fall back to volunteer members of the recovery team or will need to be contracted out.
4.7	Engage an Indigenous-identified person as a liaison officer	Develop a specific role description and annual action plan for coordinating and facilitating engagement between Indigenous and non-Indigenous partners involved in cassowary recovery. This role could sit within an existing organisation to focus 1 day per week on cassowary work. Indigenous partners will have substantial input to the recruitment/selection process.

Action	Description	Details
4.8	Establish an information management system	Significant amounts of information have been generated regarding cassowary recovery over several decades. Some of this information has been collated into readily accessible resources (e.g., Cassowary Recovery Team 2022; Terrain Rainforest Decision Support Tool 2020). However, much information and data are scattered in different places with different custodians. Establishing a primary point of reference to access available data and information and establish a set of shared “truths” to outlast individual members of recovery team would facilitate making informed decisions and efficient actions.

Strategy 8 - Deliver actions at multi-species and landscape scales

Table 13 Actions to deliver at multi-species and landscape scales

Action	Description	Details
4.9	Promote climate resilience and the recovery of other threatened species and ecosystems at landscape scales	Many of the threats faced by cassowaries, including climate change, operate at landscape scales. Numerous species across the distribution of cassowaries are facing similar threats and requiring similar recovery strategies. Actions designed for the recovery of cassowaries are likely to intersect with benefits or disbenefits to other threatened species and communities. Therefore, it is important to engage with other active recovery groups and stakeholders to facilitate taking advantage of synergies between recovery actions and consolidating place-based planning and management efforts and improving resilience to climate change. Creating connected landscapes where wildlife can move from fragment to fragment, from coast to ranges or across latitudes and altitudes requires ensuring that actions implemented at a local scale consider the context of the larger landscape and other species that may be affected.

6 Recovery plan implementation

6.1 Implementation schedule, costs and governance

Implementing this recovery plan will require commitment by, and collaboration between, stakeholders and partners. The Cassowary Recovery Team will be the key governance body to coordinate recovery effort, provide advice, facilitate and report on progress, share and review information, and identify funding opportunities. The recovery team will be guided by the Australian Government Recovery team governance – Best practice guidelines (Commonwealth of Australia 2017).

Potential partners and indicative costs are identified for implementing each action (see Table 14). Significant investment in actions is required for ongoing conservation effort and work undertaken in the first few years of this plan will provide indications of ongoing costs, which will be estimated at the 5-year review. Implementing this recovery plan is subject to resource opportunities and constraints affecting the key partners. The cost of implementing actions in this plan should be incorporated into the core business expenditure of the affected organisations where it is appropriate and possible. Additional funds should also be sought to implement actions in this recovery plan, particularly for organisations that do not have core funding for such actions.

Responsibilities and arrangements involving potential partners will be subject to negotiation once the recovery plan is in place. A detailed implementation plan could be developed by partners, through which agreement is reached on contributions to actions. Annual budgets should be identified and secured by the partners, with timing and reporting processes consistent with the proposed timeframes and priorities. This implementation plan will identify and commit responsible partners to agreed actions and be facilitated by the recovery team.

All actions are considered important steps towards ensuring the long-term survival of the cassowary. However, priorities are assigned to actions to assist timing of implementation, decision making and investment (see Table 14).

Priority 1 – Prompt action is critical to mitigate key threats and stabilise cassowary populations.

Priority 2 – Action will inform the management and recovery of the Cassowary.

Priority 3 – Action is desirable, enhances broader engagement and will contribute to long-term recovery.

Table 14 Indicative time frames, priorities and estimated costs of recovery actions over 5 years

			Indicative costs ($'000) and timing				
Actions	**Priority**	**Potential implementation partners**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
1.1 Continue conversion of available lands to secure protected tenure	1	DESI, DESI-QPWS&P, DoR, WTMA, Landholders	100	100	–	–	–
1.2 Identify and map new priority areas for protection and keep maps up to date and accessible	1	DESI, DESI-QPWS&P, DoR, WTMA, Landholders, Aboriginal groups and corporations, NGOs – e.g., C4, CAFNEC, KC, KE QCC RR TWS WPSQ, WWF	25	5	5	5	5
1.3 Review definitions of primary, secondary, and rehabilitating habitat to develop measurable characteristics of quality in each category	2	QH, JCU, WTMA, DESI, DESI-QPWS&P	30	–	–	–	–
1.4 Identify, resolve and monitor issues with habitat quality in areas of concern and areas being rehabilitated	2	DESI, DESI-QPWS&P, DoR, WTMA, Aboriginal ranger groups, TerrainNRM, CYNRM	500	500	300	300	200
1.5 Collaborate with other stakeholders to develop and offer incentives for voluntary habitat protection	3	DESI, DCCEEW, CCRC, CYNRM, TerrainNRM, CCRC, FNQROC, MSC, DSC, CSC, TCS, HSC, CRC, TRC, YAS, HVAS, corporates	Inestimable	–	–	–	–
1.6 Measure and monitor habitat loss and gain	2	DESI, DoR, QH	50	20	20	20	20
1.7 Review and update priority landscape connectivity requirements with emphasis on adaptation to climate change	1	JCU, WTMA, DESI, DCCEEW, CCRC, CYNRM, TerrainNRM, CCRC, FNQROC, MSC, DSC, CSC, TCS, HSC, CRC, TRC, YAS, HVAS, NGOs	60	60	–	–	–
1.8 Identify connectivity issues on Cape York Peninsula	1	JCU, CYNRM, Aboriginal groups and corporations, DESI, DESI-QPWS&P, DoR	60	60	–	–	–
1.9 Support collaborations to increase habitat connectivity and quality	1	WTMA, TerrainNRM, NGOs, Aboriginal groups and corporations	50	50	30	30	20
1.10 Remove or ameliorate barriers	1	CYNRM, TerrainNRM, CCRC, FNQROC, MSC, DSC, CSC, TCS, HSC, CRC, TRC, YAS, HVAS, NGOs	Inestimable	–	–	–	–

Actions	Priority	Potential implementation partners	Indicative costs ($'000) and timing Year 1	Year 2	Year 3	Year 4	Year 5
1.11 Develop incentives to protect and increase connectivity	3	WTMA, TerrainNRM, NGOs, Aboriginal groups and corporations, CCRC, MSC, DSC, CSC, TCS, HSC, CRC, TRC, YAS, HVAS	Inestimable	–	–	–	–
1.12 Restore degraded areas	1	WTMA, TerrainNRM, CYNRM, NGOs, Aboriginal groups and corporations, CCRC, MSC, DSC, CSC, TCS, HSC, CRC, TRC, YAS, HVAS, Landholders	100	100	100	100	100
2.1 Refine standard survey technique for monitoring trends in cassowary population	2	JCU, WTMA, CSIRO, TerrainNRM, CYNRM, DESI-QPWS&P	30	–	–	–	–
2.2 Implement long term, funded program to monitor population trend	2	DESI-QPWS&P, DESI, WTMA, TerrainNRM, CYNRM, Aboriginal groups and corporations, NGOs	100	30	30	–	30
2.3 Measure area of occupancy and extent of occurrence	2	DESI-QPWS&P	50	20	20	20	20
2.4 Re-assess use of population viability analyses	3	Research Institute e.g., JCU, CSIRO	–	–	–	–	30
2.5 Understand population genetics of the southern cassowary	3	DESI-QPWS&P, Research Institute e.g., JCU, CSIRO	–	100	100	100	–
2.6 Understand reproductive biology of the southern cassowary	2	Research Institute e.g., JCU, CSIRO, ZAA	50	50	50	–	–
2.7 Determine movement patterns and home range	2	Research Institute e.g., JCU, CSIRO	–	100	100	100	–
2.8 Monitor, reduce and manage vehicle strike	1	TMR, DESI-QPWS&P	Inestimable	–	–	–	–
2.9 Continue to develop baseline data on epidemiology of the southern cassowary	3	DESI-QPWS&P supported by local Vets	20	20	20	20	20
2.10 Incorporate measuring and mitigating biosecurity threats into the southern cassowary's recovery actions	1	DAF, DESI, CRT and all organisations involved in recovery actions	Inestimable	–	–	–	–
2.11 Support education, monitoring and compliance measures for domestic dog control	2	CCRC, FNQROC, MSC, DSC, CSC, TCS, HSC, CRC, TRC, YAS, HVAS, WTMA, DESI-QPWS&P	40	40	40	40	40
2.12 Measure and manage the impacts of dogs on Cape York Peninsula	1	FNQROC, CSC, HVAS, LRAS, TSC, DESI-QPWS&P, CYNRM	80	60	20	20	20

Actions	Priority	Potential implementation partners	Indicative costs ($'000) and timing				
			Year 1	Year 2	Year 3	Year 4	Year 5
2.13 Measure and manage the impacts of pigs in the Wet Tropics and pigs and feral stock (cattle and horses) on Cape York Peninsula	3	WTMA, FNQROC, Terrain, CSC, HVAS, LRAS, TSC, DESI-QPWS&P, CYNRM, Landholders, Aboriginal groups and corporations	500	500	500	200	200
2.14 Measure and manage the impacts of fire on the southern cassowary's habitat on Cape York Peninsula	1	QFES, CYNRM, DESI-QPWS&P, Landholders, Aboriginal groups and corporations, CSC, HVAS, LRAS, TSC	150	150	150	–	–
2.15 Assess whether low genetic diversity is a threat on Cape York Peninsula	3	DESI-QPWS&P, Research Institute e.g., JCU, CSIRO, ZAA	–	–	–	100	–
2.16 Assess and model indirect impacts of climate change	2	Research Institute e.g., NESP, JCU, CSIRO	–	50	50		
3.1 Develop methods to ensure contemporary, citizen and Indigenous science are integrated in conservation actions and research	2	Aboriginal groups and corporations, WTMA, TerrainNRM, CYNRM, Research Institute e.g., JCU, CSIRO, ZAA	100	–	–	–	–
3.2 Continue to develop respectful, transparent, and honest relationships with First Nations groups in the southern cassowary's country	2	CRT and all organisations involved in recovery actions	10	10	10	10	10
3.3 Establish a directory to guide engagement with First Nations groups on the southern cassowary's country	3	Aboriginal groups and corporations, WTMA, TerrainNRM, CYNRM, Research Institute e.g., JCU, CSIRO, ZAA	60	–	–	–	–
3.4 Continue to incorporate Traditional Owner knowledge and values into reviews of the recovery plan	2	Aboriginal groups and corporations, DESI-QPWS&P, WTMA, TerrainNRM, CYNRM, CRT	See 4.7	–	–	–	–
3.5 Seek opportunities to facilitate Traditional Owner groups to educate and advocate to the broader community	3	WTMA, NGOs, TerrainNRM, CYNRM	See 4.7	–	–	–	–
3.6 Develop and implement strategies for Traditional Owners to participate in actions from the Cassowary Recovery Plan	1	DESI-QPWS&P, DESI, WTMA, TerrainNRM, CYNRM, Aboriginal groups and corporations, NGOs	See 4.7	–	–	–	–

Actions	**Priority**	**Potential implementation partners**	**Indicative costs ($'000) and timing** Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
4.1 Develop and implement a comprehensive communication strategy for the cassowary recovery plan's implementation	3	WTMA, CRT	See 4.7	–	–	–	–
4.2 Implement community engagement programs in priority areas where negative impacts on the southern cassowary are high	1	DESI-QPWS&P, DESI, WTMA, TerrainNRM, CYNRM, Aboriginal groups and corporations, NGOs	See 4.7	–	–	–	–
4.3 Support the southern cassowary's care and rehabilitation	3	DESI-QPWS&P, WIRES, GBCRC, RRA	15	15	15	15	15
4.4 Review and update EPBC Act referral guidelines for the southern cassowary	1	DCCEEW	60	–	–	–	–
4.5 Work with strategic land use planners to recognise, protect and restore the southern cassowary's habitat and corridors	1	CCRC, FNQROC, MSC, DSC, CSC, TCS, HSC, CRC, TRC, YAS, HVAS, LRAS, TSC, DESI, DSDILGP, DCCEEW	30	30	–	–	–
4.6 Engage a coordinator to advance the work of the recovery team	1	Options include WTMA, TerrainNRM, CYNRM, DESI-QPWS&P, Aboriginal groups and corporations	70	70	70	70	70
4.7 Engage an Indigenous-identified person as a liaison officer	2	Options include WTMA, TerrainNRM, CYNRM, DESI-QPWS&P, Aboriginal groups and corporations	30	30	30	30	30
4.8 Establish an information management system	1	DESI, CRT and all organisations involved in recovery actions	20	–	–	–	–
4.9 Promote climate resilience and the recovery of other threatened species and ecosystems at landscape scales	1	WTMA, TerrainNRM, CYNRM, CRT, Research Institute e.g., JCU, CSIRO, DESI-QPWS&P	See 4.7	–	–	–	–

6.2 Monitoring, evaluation, reporting and review

The implementation and success of the actions in this plan will be measured and reported by the recovery team consistent with the Australian Government Recovery team governance – Best practice guidelines (Commonwealth of Australia 2017). This plan will be reviewed 5 years from when it is "made". The Cassowary Recovery Team will coordinate the review in consultation with partners and stakeholders. The review will update and adapt the plan based on any unexpected impediments, responding to any unpredictable or new threats and re-assessing priorities on the basis of new knowledge and changes brought about by management actions. This review will also focus on ensuring Traditional Owner input is updated and incorporated where it was missing in the current plan. An updated plan may be deemed unnecessary if the species' listing status under legislation is reviewed and it is no longer threatened or if the current plan is suitable to continue unchanged.

6.3 Potential benefits and impacts associated with implementation

6.3.1 Broad biodiversity benefits

Many of the actions in this plan are far reaching and need to be implemented at landscape scales. For example, the cassowary is wide ranging and although requiring access to rainforest, it uses many different vegetation associations. Because of this, protecting and enhancing cassowary habitat and its connectivity across the landscape will benefit the very large number of other species that intersect with its distribution and face similar threats. A co-benefit could be convincingly argued for all terrestrial and volant species within the distribution of the cassowary, especially if the threats outlined in Section 4 are adequately managed by the Actions in Section 5. In addition, because some of the work to enhance connectivity will protect, rehabilitate and restore riparian forests, as will fire management to protect rainforests on Cape York Peninsula, it is likely that some freshwater ecosystems and threatened species may also benefit.

The Wet Tropics of northeastern Australia are hyper-diverse. Ensuring the long-term persistence of the cassowary will protect a significant proportion of that biodiversity. The cassowary is also a critical player involved in one of the key processes that drives and maintains diversity in tropical rainforest plants – seed dispersal. Seed dispersal is one of the key processes that determine rainforest community structure and contributes significantly to its resilience. In many systems around the world, it has been demonstrated that diversity of interactions in these systems tends to create stability and resilience (Elmqvist *et al.* 2003). It has also been demonstrated that some species are strong interactors and account for a large proportion of links and interactions in an ecological network. Cassowaries are one of these strong interactors and their loss from the system would alter the trajectory of community structure, diminish resilience of the entire system and ultimately result in a decline in plant diversity. The persistence of the cassowary, and its re-expansion into areas from which it has disappeared, will also benefit various threatened ecological communities, including Mabi forest, littoral rainforest, coastal vine thickets and lowland tropical rainforest.

In addition, the cassowary has evolutionary significance in its own right as it is the only member of its genus in Australia. It shares its family, Casuariidae, with the emu, *Dromaius novaehollandiae* and there are two other species of cassowary in New Guinea and neighbouring islands.

They are in the paleotropical order Struthioniformes, better known as ratites, along with ostriches (Africa), rheas and tinamous (South America) and kiwis (New Zealand), suggesting Gondwanan origins (del Hoyo 2020).

6.3.2 Social and economic considerations

The implementation of this recovery plan should not cause adverse impacts, instead, it should have positive social and economic outcomes. The cassowary is undoubtably one of the most iconic species in Queensland. Their cultural significance is deep and long lasting, from millennia in the past to the present day and across many Indigenous and non-Indigenous cultures wherever they occur (see section 2.3).

Cassowaries are a significant tourist icon and attraction with numerous businesses and organisations using cassowaries as a promotional symbol or selling objects such as toys, photos and other souvenirs. They have international renown, and their loss would result in significant reputational damage to Australia, Queensland and the local area, given how embedded they are in much symbolism for the Wet Tropics. In addition, many actions in this recovery plan are intended to create opportunities for Traditional Owner groups to lead, manage or otherwise be involved with caring for country and its associated skills development in Indigenous ranger programs.

In a review of the world heritage values of the spectacled flying-fox, Westcott *et al.* (2001) concluded that the species represented a significant component of World Heritage values in its own right and also contributed to two ecological processes that are important to the maintenance of other World Heritage values and the ongoing evolution of the Wet Tropics World Heritage Area. While no such review has been conducted for the cassowary, a similar or greater relevance to World Heritage values and their maintenance would be expected.

6.3.3 Potential for recovery

Cassowaries have already demonstrated resilience in the face of significant disturbance and threats. Since the delivery of actions from the previous plan, the population trend for the cassowary in the Wet Tropics is estimated to be stable or increasing (Westcott *et al.* 2014; Westcott *et al.* 2021), much of their habitat is now in protected areas, and chicks and subadults are recruited into the population. However, there are significant remaining threats, some of which are escalating, while others are patchily distributed and intense in some locations, increasing the risk that past successes will not be sustained. In addition, there is significant community concern and action to support continuing recovery efforts and strong Traditional Owner engagement. This support and the current population trend suggest a high potential for recovery, despite significant ongoing and emerging threats such as climate change impacts, myrtle rust and others.

Many of the threats are understood and there is a good understanding of the work required and some basic techniques to ameliorate them. For example, climate change and its associated effects are occurring at a landscape scale requiring the cassowary (and many other species) to be able to cross through the landscape matrix to access resources. Landscapes do not yet have suitable connections between habitat fragments for wildlife to move through as needed. We have restoration techniques and a basic understanding of where connections need to be placed in the landscape but the finer scale decisions still need to be made and the work funded and undertaken.

Further investment in cassowary recovery is likely to see a significant improvement in the long term persistence of the species and the realization of the strong co-benefits for many other species and ecological processes.

6.4 Interaction with existing plans, policies and programs

This recovery plan can interact with a range of other strategies and plans. The actions in this plan may integrate with aspects of other plans by identifying issues, approaches or considerations pertinent to the conservation and management of the Cassowary. Hill *et al.* (2010), identify a range of planning mechanisms that regulate development and outline how a lack of implementation has resulted in poor outcomes. One set of planning tools that have been recognised as being of particular importance are those associated with local government (e.g., Local Planning Scheme, Council Corporate Plan), covering such things as regional development, vegetation and pest management and biosecurity (see section 4.2.5; Huddy and Reaston 2021). Several plans include consideration of cassowary conservation and can guide action and planning at appropriate scales and link to this recovery plan. Of particular importance for the cassowary is the report by Huddy and Reaston (2021): "The role of local government in the preservation and recovery of threatened species and ecological communities". Other documents operating at a local or regional scale include (but are not limited to):

FNQ Regional Plan 2009 – 2031

- Guide to Cassowaries in Planning Schemes (Terrain 2012)
- Cassowary Conservation Management Plan (TMR 2020)
- Mission Beach Habitat Network Action Plan (Hill *et al.* 2010)
- Climate Adaptation Plan for the Wet Tropics 2020 – 2030
- Wet Tropics Strategic Plan 2020-2030
- Terrain NRM Strategic Plan 2021 – 2026
- Coastal Hazard Adaptation Plans and Strategies
- Indigenous Protected Areas, including Girringun, Eastern Kuku Yalanji, Kaanju Ngaachi Wenlock and Pascoe Rivers and Wuthathi, plans of management
- Regional Agreement for the involvement of Rainforest Aboriginal Peoples in the Management of the Wet Tropics of Queensland World Heritage Area
- Wet Tropics Plan for People and Country
- Far North Queensland, Local Government, Regional Pest Management Strategy, 2010–2015 (2010)
- Healthy Country Plans.

Numerous species across the distribution of cassowaries are facing similar threats and requiring recovery strategies and actions that may complement or oppose actions in this plan. Therefore, it is important to engage with other active recovery groups and stakeholders to facilitate taking advantage of synergies between recovery actions and consolidating place-based planning and management efforts.

This will also facilitate streamlining the work of Traditional Owner ranger groups so that actions for multiple species and communities can be integrated into single strategies for an area and competing or complimentary outcomes can be reconciled.

Examples of other threatened species and communities with action groups within the distribution of cassowaries include (but are not limited to):

- Spectacled Flying Fox Recovery Team
- Mabi Forest Action Group
- Littoral Rainforest Working Group
- Rainforest Recovery Network
- Mahogany Glider Recovery Team
- Northern Bettong Recovery Team
- Northern Yellow-bellied Glider working group
- Kuranda Tree-frog group

Recovery plans and threat abatement plans for species that do not have active working groups to connect with should also be considered in the context of actions undertaken for cassowary recovery, for example:

- Recovery plan for cave-dwelling bats, *Rhinolophus philippinensis*, *Hipposideros semoni* and *Taphozous troughtoni* 2001-2005
- Recovery plan for the stream-dwelling rainforest frogs of the Wet Tropics biogeographic region of north-east Queensland 2000-2004
- National Recovery Plan for the Spotted-tailed Quoll *Dasyurus* maculatus
- Listing advice for the Broad leaf tea-tree (*Melaleuca viridiflora*) woodlands in high rainfall coastal north Queensland
- National recovery plan for the bare-rumped sheathtail bat *Saccolaimus saccolaimus nudicluniatus* (2007)
- Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* (2014)
- Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*) (2017).

In addition, resources and abatement plans for listed threatening processes under the EPBC Act should also be considered as actions are implemented. Relevant examples include:

- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis
- Invasion of northern Australia by Gamba Grass and other introduced grasses
- Land clearance
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases
- Novel biota and their impact on biodiversity
- Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs
- Fire regimes that cause declines in biodiversity.

6.5 Guidance for decision makers

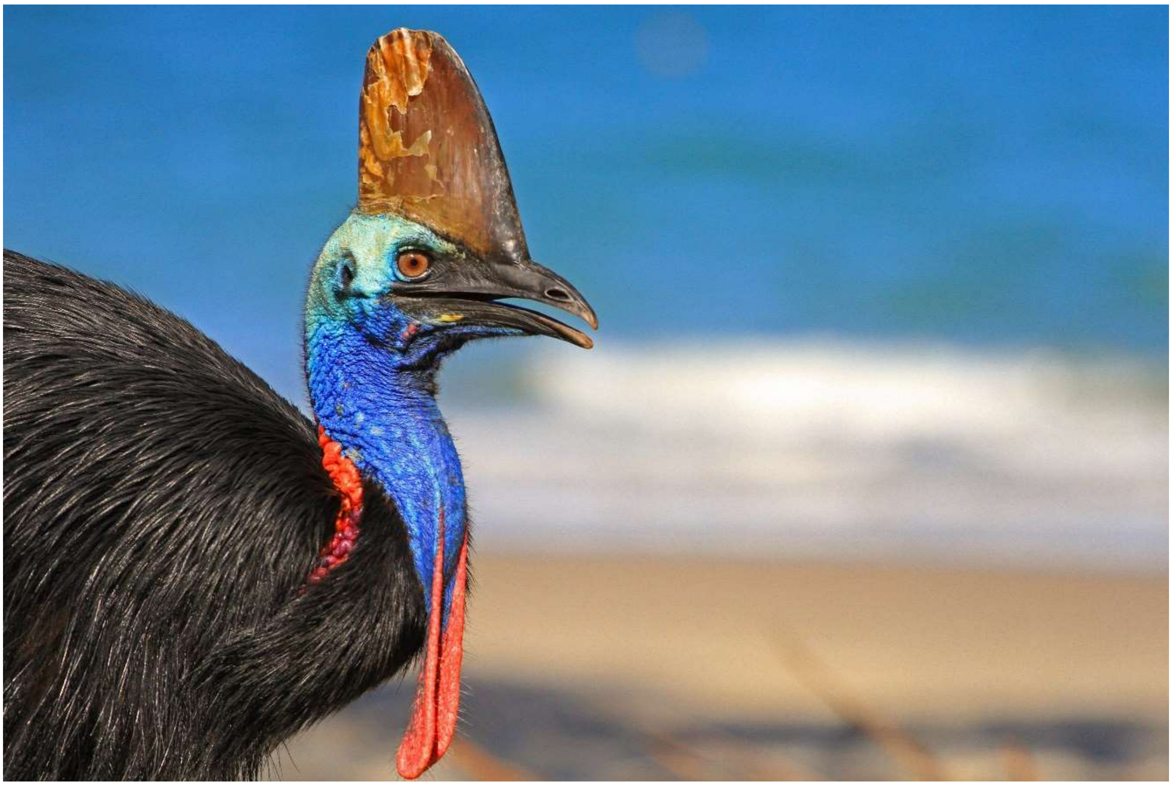
Under the EPBC Act an action will require approval from the Minister for the Environment if the action has, will have, or is likely to have a 'significant impact' on a matter of national environmental significance, such as a listed threatened species. The EPBC Act Significant Impact Guidelines 1.1 – Matters of National Environmental Significance (Department of the Environment, 2013) sets out criteria under which an action may have a significant impact on an endangered species, such as the cassowary. To further support decision making, the 'Significant impact guidelines for the endangered southern cassowary (*Casuarius casuarius johnsonii*) Wet Tropics population (EPBC Act policy statement 3.15; Commonwealth of Australia 2010) have been developed to support stakeholders including decision makers, developers, and assessors, to determine whether a proposed action is likely to have a significant impact on the Cassowary across its Wet Tropics range.

As outlined in Action 4.4, the Significant Impact Guidelines for the endangered southern cassowary (*Casuarius johnsonii*) Wet Tropics population require updating. However, as they currently stand, an action is likely to have a significant impact where it may adversely affect the long-term recovery of the Cassowary. Therefore, actions that may require approval under the EPBC Act include actions that result in the loss or reduction of the Cassowary population, further clearance, fragmentation or degradation of habitat critical to the survival of the species. Actions likely to have a significant impact could include but are not limited to:

- Habitat removal of greater than 1500m^2
- Removal of cassowary food trees
- Clearing that reduces corridor width
- Habitat degradation caused by exotic plants or animals, increased accessibility, fire behaviour change, microclimate change, reduces water quality or cassowary movement
- Fragmentation and isolation of habitats and populations caused by roads, fencing, drainage channels, powerlines, service infrastructure, subdivision of land

- Roads and traffic changes that increase conflict points, traffic volume or speed (>60km/hr), intersect movement corridors or traverse National Parks or Conservation Areas.

Before approval of a significant impact is granted, it should be clear that the mitigation hierarchy has been strenuously applied, and impacts are avoided, and then minimised, to the extent possible. If there are residual impacts, then an offset proposal consistent with the EPBC Offsets Policy (DSEWPAC 2012) must be prepared.



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Appendix A. Review of actions in Latch (2007)

Specific Objective 1: Protect essential cassowary habitat and landscape corridors

1.1 Complete mapping of essential cassowary habitat

Cassowary habitat mapping has been completed and 'Essential' habitat is recognised by Queensland legislation (DERM 2009a; Vegetation Management Act 1999; Essential Habitat Map version 9.13, updated 3rd June 2021). Cassowary habitat mapping is available to the recovery team (or on application) through the rainforest decision support tool (Terrain NRM 2019). There are areas where the mapping needs ground truthing and review, particularly on the western margins of the Wet Tropics and where further clearing has occurred since the maps were produced (see action 7.2). In addition, mapping is completed for Cape York Peninsula using RE v 11, which also needs further ground truthing but does show core habitat extending along riparian vegetation to western Cape York Peninsula.

1.2 Identify and prioritise areas of essential habitat for protection and management

Terrain NRM has developed a simple framework that can be used in conjunction with their Rainforest Decision Support Tool (Terrain NRM 2019) to identify priority habitat for protection and management. This framework includes movement corridors as a high priority so this has some overlap with Action 1.3. Several organisations and individuals have been funded to undertake weed management, revegetation and habitat protection on high priority locations based on this framework. Other cassowary habitat has been protected and managed on an *ad hoc* basis as opportunities have arisen. This has included protection and acquisition of private land (see1.4 Investigate strategies to conserve cassowary habitat on private lands), tenure conversions (e.g., State Forests to National Park), Native Title determinations (e.g., Unallocated State Land to Aboriginal Land Act freehold, some with IPA management plans). No region wide prioritisation of land available for protection has been completed. This is a considerable gap in efforts for cassowary recovery and is a high priority action for this plan to resolve (see action 1.1 and 1.2). There remain many opportunities to protect and manage significant tracts of land for the long-term sustainability of cassowary populations, the vegetation associations they occur in, and the other wildlife associated with those habitats.

1.3 Identify and prioritise habitat corridors for protection, restoration and management

General and priority corridors have been identified throughout the Wet Tropics and maps are available to the recovery team (or on application) through the rainforest decision support tool (Terrain NRM 2019). Four priority corridors were added to the Australian Governments Threatened Species Prospectus by the Threatened Species Commissioner in 2014 (Smiths Gap, Crater Lakes, Eubenangee Swamp and Kurrimine/Bingil Bay).

Many habitat patches and corridors throughout the Wet Tropics, have been protected and/or restored and are well on their way to becoming ecologically viable. Many more are being added, enhanced and extended. One local area habitat network action plan has been developed for Mission Beach to add detail to priorities for protection and restoration (Hill *et al.* 2010). More of these plans could be developed for other priority areas (see action 3.5).

1.4 Investigate strategies to conserve cassowary habitat on private lands

The Environmental Defenders Office (EDO) has produced four fact sheets on voluntary conservation on private land (EDO 2020). Strategies that have been successfully employed to conserve cassowary habitat on private land have included Nature Refuges under the Nature Conservation Act (1992), Voluntary Declarations under the Vegetation Management Act (1999), Statutory Covenants under the Land Title Act 1994 (Qld) IPAs, acquisitions by private sector in Daintree, Mission Beach, Kuranda, Carbine Tableland and Atherton Tableland and tenure conversions to National Park within the WTWHA. Other voluntary programs such as Wildlife Land Trust, and in the past, Land for Wildlife also encourage conservation and custodianship. Some of these tools and strategies could be put to further use once Action 1.2 in this plan is completed.

Specific Objective 2: Institute a more coordinated and stronger planning response to development issues in cassowary habitat

2.1 Strengthen linkages with other planning mechanisms to ensure an integrated and more consistent approach to cassowary conservation

Throughout the FNQ Regional Plan 2009 – 2031 there are reference to the Southern Cassowary, its associated habitats and movement corridors, and some threats. Consequently, ensuring an intent in all associated planning processes that cassowaries (among other threatened species and ecosystems) are considered. Terrain NRM provided the Cassowary Recovery Team with a Guide to Cassowaries in Planning Schemes (Terrain 2012), which outlines all the mapping resources available to planners that link to codes applying to mapped cassowary habitat. Transport and Main Roads now have a Cassowary Conservation Management Plan (TMR 2020), updated every three years, which outlines a project management framework to improve cassowary conservation. Hill *et al.* (2010), identify a range of planning mechanisms that regulate development that should include up to date information required to make informed decisions that include consideration of cassowary recovery.

2.2 Develop and implement Local Area Cassowary Conservation Plans

The Mission Beach Habitat Network Action Plan (Hill *et al.* 2010) is the only local area plan developed so far. It provides detailed background, advice, a strategy and an action plan. Terrain NRM was identified as its custodian and has partnered with members of the action plan committee to complete aspects of the plan. While some of the objectives of the plan remain unmet and actions yet to be undertaken, many have progressed significantly and the plan is seen as a useful tool to clarify an overall strategy and identify partners to engage in the work (see action 3.5). Kuranda Conservation is in the process of developing a local area plan suggesting this process may continue in other areas.

2.3 Investigate development of other statutory planning instruments to minimise impacts of development on cassowaries

The Far North Queensland Regional Organisation of Councils (FNQROC) has investigated the role of local government in the preservation and recovery of threatened species and ecological communities and have been presented with a range of strategies (Huddy and Reaston 2021). The recovery team has recommended that Healthy Country Planning for IPAs incorporate cassowary conservation measures. Cassowary habitat mapping is recognised in Queensland State Planning Policy.

Specific Objective 3: Implement strategies to protect cassowary populations by minimising the adverse impacts of roads, dogs, pigs and cyclone events

3.1 Minimise cassowary road mortality and injury

Numerous measures have been put in place by community groups, local councils, WTMA, DESI-QPWS&P and Transport and Main Roads to educate people about driving safely and being aware in cassowary country. Strategies include permanent and moveable signage, the Cass-O-Wary campaign, public fora and festivals. Reports on road management strategies for cassowaries were produced for the Mission Beach area (Goosem *et al.* 2011). Numerous strategies have been implemented to make road crossings safer for cassowaries including, traffic calming devices and/or exclusion fencing in high-risk areas in the Daintree, Kuranda and Mission beach. Transport and Main Roads have developed a design manual for fauna sensitive sections on main roads, improved road design for cassowaries in the Mission Beach area, undertaken a study led by CSIRO with support from DESI-QPWS&P and Terrain using AI video cameras to detect cassowaries about to cross a road in real time and light an automatic warning sign for drivers (Cassowary Advanced Roadside Monitoring Alerting – CARMA). Transport and Main Roads are establishing a cassowary land bridge (a world first) at Smith's Gap, a critical ecological linkage from coast to ranges. DESI-QPWS&P officers record reports of cassowaries including deaths. Fifty-five road deaths were reported between June 2017 and December 2020, consisting of 21 adults, 31 chicks and 3 subadults. There were an additional 17 vehicle strikes recorded where the fate of the bird remained unknown. From January to April 2021 a further five deaths from vehicle strikes have been recorded. Several studies have analysed the data collected by DESI-QPWS&P and local community group C4, to identify road strike 'hot spots' within the Wet Tropics and identify the ecological, physical and anthropogenic correlates of strike at both the landscape and location specific scales (Dwyer at al. 2016; Bradford *et al.* 2021). Road strikes were highest in areas of high cassowary density (Dwyer *et al.* 2016), and along straight sections of major roads with high canopy cover where the proportion of cassowary habitat was >50% (Bradford *et al.* 2021).

3.2 Implement appropriate dog control to minimise dog attacks on cassowaries

Unrestrained domestic and farm dogs and "wild dogs" (which includes dingoes and dingo crosses) in the Wet Tropics, and unrestrained community dogs and escaped pig-hunting dogs on Cape York Peninsula, are all recorded and perceived to hunt and injure or kill cassowaries (Bradford *et al.* 2018; Morrant 2015; QPWS incident database 2021).

For example, six deaths caused by dogs were recorded for 2019/2020 (QPWS incident database 2021). To help mitigate these effects, all regional councils have local laws supported by responsible dog ownership programs that require dogs to be kept behind fences or restrained so that they do not roam and cause problems. For example, in 2020/21, the 12 member councils of Far North Queensland Regional Organisation of Councils were responsible for managing nearly 60,000 transactions relating to domestic animals. This included nearly 35,000 dogs being registered, 2,778 responses to wandering dogs and dog attacks, and a total of >13,000 responses to animal management enquiries (T. Sydes *pers. comm.* 2022). Some have promoted responsible dog ownership specifically in relation to threats to cassowaries (e.g., Roberts 2018; Douglas Shire Council 2017; see also DAWE 2004), as have many community groups (e.g., Rainforest Information Centre; Rainforest Rescue). Cassowary Keystone Conservation, and other community groups, have lobbied all levels of government, raising awareness of the threats posed by roaming dogs, and, along with other stakeholders, contributed to improvements in dog control policy and enforcement. FNQROC has developed an Animal Management and Wildlife Stewardship policy (Version 1.2, 2017). The WTMA "Be Cass-O-Wary" program encourages responsible dog management and dogs are banned from most of the protected area estate. Both councils and protected area estate managers continue to issue Infringement Notices and penalties for breaches of these regulations (Travis Sydes *pers. comm.* 2021; DESI *pers. comm.* 2021). Management of "wild dogs" is covered in the Biosecurity Act 2014 and the Nature Conservation Act 1992 and the Queensland Wild Dog Management Strategy (State of Queensland 2021a). Morrant (2015), demonstrates that wild dog populations (consisting of dingoes and dingo x dog) living in the peri-urban and rural landscapes of the Wet Tropics feed primarily on common prey species such as agile wallabies, bandicoots and rodents. Despite a perception among the community that these dogs may impact threatened wildlife, this appears not to be the case or is so rare, the impacts should be considered negligible (Morrant 2015). However, despite considerable efforts and measures taken, detrimental interactions, up to and including deaths, between cassowaries and domestic dogs continue to be recorded on occasion (see actions 2.11 and 2.12).

3.3 Assess the potential impacts of pigs on cassowaries

No further targeted assessment of the impacts of feral pigs on cassowaries has been undertaken since that reported in the last recovery plan (Latch 2007). Field surveys and discussions with Traditional owners on the McIlwraith range revealed feral pigs are perceived to be a threat to cassowaries and cassowary habitat on Cape York. For example, feral pig diggings are abundant throughout rainforests, more so in lowland gallery forest, where large expanses of soil have been disturbed regularly and severely, negatively impacting seedling establishment (Bradford *et al.* 2018; Bradford *et al.* 2020). Pigs are assumed to predate directly on Cassowary eggs but no evidence is available to support this assumption. Pigs may compete for the same fleshy fruits that cassowaries eat as fleshy fruits are known in the diets of both animals but the significance of this possible competition is unknown (Mitchell 2002; Bradford *et al.* 2018; Bradford *et al.* 2020).

In addition, cassowaries continue to be trapped in pig traps and occasionally seriously injured, only rarely to the point of requiring euthanasia (G. Lauridson *pers. comm.* 2022). For example, of 19 cassowaries recorded by DESI-QPWS&P officers as trapped between June 2017 and September 2020, 11 were in pig traps, the rest in 'yards' of various types. None of these were recorded as killed.

The Department of Agriculture and Fisheries have released a general guide on pig control (State of Queensland 2008) and one specific to the Cassowary Coast (State of Queensland 2016), both of which discuss methods to avoid non-target species, including cassowaries. In summary, the impacts of feral pigs on cassowaries remains unmeasured but is likely to be primarily through indirect impacts on the shared environment rather than pigs being a direct threat.

3.4 Support existing planning and management strategies that target pigs and weeds in cassowary habitat

Regional Councils are required to have a biosecurity plan that covers invasive species in their area. Feral Pigs are listed as a restricted invasive animal. Regional councils, sometimes in partnership with DESI-QPWS, have programs working with farmers to trap and dispose of feral pigs. Several organisations and individuals have been funded to undertake weed management in cassowary habitat by Terrain NRM. These were prioritised and funds directed on the basis of the rainforest decision support tool (see action 1.2). In addition, many landholders, traditional owner groups, local governments and community groups manage the impacts of feral pigs and weeds in cassowary habitat as part of their biosecurity obligations. Others do similar work to contribute to conservation outcomes. Much of this work is funded by state and federal government programs relating to biosecurity, Landcare, and natural resource management and investment programs. Cape York NRM has plans to fund some pig and other feral animal management programs in cassowary habitat on Cape York for 2022/2023.

3.5 Manage threats arising from human-cassowary interactions

The two most destructive interactions between humans and cassowaries are deaths and injuries after vehicle strikes, and dog attacks due to people leaving dogs unrestrained. Supplementary feeding, where humans are present and visible to cassowaries, is a significant and detrimental human-cassowary interaction. This tends to habituate cassowaries to humans in a way where they seek human contact, sometimes in what appears an aggressive way. This is thought to bring them into more frequent conflict with threats associated with road traffic, domestic dogs and entrapment in pens and yards. To counter these threats, significant effort has been put into education programs aimed at reducing human cassowary interactions. These have included programs on vehicle strike, dog control and hand feeding using newsletters, various print, radio, television and online media, at public presentations and festivals and with signage. These education programs have been driven by numerous local community groups and conservation organisations, government agencies and natural resource management bodies.

3.6 Develop and implement, if required, a post-cyclone cassowary response strategy

The recovery team has recognised a range of post cyclone issues that impact on cassowary recovery. They include:

- Short- and mid-term famine, for which a post disaster feeding protocol has been established with feeding programs administered by DESI-QPWS&P as needed and according to internal strategies developed and reviewed from time to time
- Post cyclone weed spread, for which the FNQROC has developed a regional code of practice for disaster management weed spread prevention (FNQROC 2007)

- Increased threats from fire if there is a dry period after a cyclone, for which no response strategy has been developed
- Increased habitat clearing, for which no response strategy has been developed.

Specific Objective 4: Progress an effective cassowary rescue, rehabilitation and release programme

4.1 Continue to implement the cassowary rescue programme

A cassowary rescue program is active in the region. Generally, the public notify DESI-QPWS&P through the cassowary emergency hotline 1300 130 372. Then the appropriate Officer from Wildlife Operations Northern Region DESI-QPWS&P responds to the callout to rescue sick, orphaned or injured cassowaries. DESI-QPWS&P staff are in contact with the appropriate veterinarians that have experience with cassowaries. Once assessed, animals are treated accordingly. Some of these are sent to either the Garners Beach or Tablelands Cassowary Rehabilitation Centres as required. While this system is currently functioning well, partnership and funding arrangements may benefit from being formalised and a strategy introduced to ensure continuous network and facility development in other local areas, upskilling of additional veterinarians and wildlife rangers, Traditional Custodians and other succession planning measures.

4.2 Implement a translocation strategy

Methods for immobilization, tagging, transport and release of wild cassowaries have been described by Campbell *et al.* (2014). Captive husbandry has been outlined in detail by Biggs (2013). In December 2015, the cassowary recovery team asked representatives from the Department of Environment and Heritage Protection to provide information regarding policies on cassowary translocation to be reported at the February 2016 meeting. A formal strategy for the translocation of cassowaries in Australia has not yet been published. However, DESI-QPWS&P has internal protocols for translocations. The appropriate Traditional Custodians should be consulted (where practical) before cassowaries are translocated.

Specific Objective 5: Cassowary populations are monitored to assess population size, trends and status

5.1 Develop and implement a population survey methodology based on faecal DNA

Westcott *et al.* (2014) developed a population survey methodology based on faecal DNA. Although it was not able to be applied as originally envisaged, the use of DNA extraction and amplification from dung samples to recognise individuals and hence use in a mark-recapture style statistic to estimate population size can be considered successful. Unfortunately, dung encounter rates were not sufficient to use DNA sampling at a Wet Tropics wide scale. However, the researchers were able to apply the techniques at more intensively sampled sites and verify a strong statistical relationship between dung encounter rates and the number of individual cassowaries using an area. This equation can now be used to estimate cassowary populations at larger scales. To date, it has been used to compare historical and current estimates of population size based on the same basic data collection.

Although it is possible to continue to use this technique to monitor population trends there are three ways that the method can be refined and become more accurate:

- Continue to search for more variable DNA markers able to be extracted from dung samples to make individual recognition cheaper and more reliable
- Continue to sample cassowary movements in more locations, elevations and over longer timeframes to provide a more accurate and nuanced understanding of home range size for estimating density
- Examine alternative statistical techniques for mark recapture and transect based sampling designs.

5.2 Establish and implement a monitoring protocol in key habitat areas

Because of the strong relationship between dung encounter rates and population size estimates based on the recognition of individuals from faecal DNA, a technique for a monitoring protocol has now been successfully developed. While this had been implemented once as part of its development, a region-wide protocol for implementation by traditional owner and community citizen scientists has not been completed. There are several other considerations that need addressing before this can be successfully completed:

- Combine the Department of Defence monitoring data (including camera, trapping, sign encounter transects and radio tagging) to further refine a protocol suitable for broad implementation
- Serious consideration needs to be given to who will carry responsibility for the coordination, implementation and governance of any monitoring programs
- This appears to be a good opportunity for traditional owner groups to take carriage of caring for country and partner with community organisations to carry out the work.

5.3 Assess size of Wet Tropics and Cape York populations and develop population viability models

The Wet Tropics population has been assessed (Westcott *et al.* 2014) and is estimated to be in the order of 4,400 birds, suggesting a stable or increasing population when compared to previous population estimates. The populations of cassowaries on Cape York Peninsula have been examined in recent years (Bradford *et al.* 2018; Bradford *et al.* 2020; McLean 2020) in preparation for developing skills and techniques for estimating overall population size. Work on Cape York Peninsula continues. Cape York NRM has established a sightings database for cassowaries on Cape York Peninsula as a citizen science program. However, COVID19 has impeded its uptake to date, with few tourists travelling on Cape York Peninsula. Verified records will be provided to Wildnet and the DESI-QPWS&P Cassowary Incident Database.

The data required for developing a fully informed population viability model has not been available (see Moore 2003, 2007). No further population viability model has been attempted since Moore's (2003 and 2007) investigations for the Mission Beach and Ella Bay populations. Moore identifies a range of parameters that remain unknown.

While some of these are now reported on in captive studies, such as age of first reproduction and of reproductive senescence (Biggs 2013), there remain others that require further work to quantify, such as age specific mortality and immigration. Some of these data may be able to be gleaned from the cassowary database (see 5.5). Another attempt at a population viability model may soon be feasible if all available data from disparate sources can be collated to provide the required data for the model parameters.

5.4 Monitor and assess the effectiveness of corridors in facilitating cassowary movement

This has not been completed. It is potentially a simple project using camera traps or could be more sophisticated, such as using technology developed for monitoring road crossings.

5.5 Maintain a cassowary database

A cassowary database was established and is managed by Wildlife Officers from DESI-QPWS. All calls to the sighting and incident hotline (1300 130 372), which is advertised widely, are faithfully recorded, along with a range of associated observations, location data and follow up responses. The data need regular collating, cleaning and checking so they can be used to inform management. These data have been used to assess incident hotspots and crossing points to inform management (Bradford *et al.* 2021). Location data are also required to be uploaded into Wildnet. Significant Cassowary Incident Mapping (SCIM) has been established but the data are not yet vetted so numerous errors are obvious and require correcting. There are also a range of other databases that contain cassowary sighting data including Birdata, eBird, iNaturalist and the Atlas of Living Australia. However, Wildnet is the only database with a rigorous vetting process and is linked to state and federal legislation, therefore triggering a response if a development occurs near cassowary sighting records.

Specific objective 6: Improve understanding of cassowary ecology and threats to its survival to better inform cassowary recovery

6.1 Undertake a population study of cassowaries at Mission Beach, Daintree and Kuranda.

This action has not been progressed.

6.2 Determine the population genetic structure of cassowaries

This action has not been progressed.

6.3 Determine the survival rate and cause of mortality of subadults in different habitats

This action has not been progressed.

6.4 Investigate the prevalence of disease in cassowaries and factors affecting its epidemiology

This action has progressed steadily through the diligent recording of treatment and autopsy data by veterinarians dealing with sick, injured, orphaned and autopsying dead cassowaries.

These data are submitted to, and managed by, DESI-QPWS. To date no collation or analysis of these data is available. However, records continue to be collected and will form a good basis for understanding diseases of cassowaries and their prevalence in animals that come into care.

Specific objective 7: Engage the community in cassowary conservation and education

7.1 Involve the community in cassowary conservation

Community is deeply involved in cassowary conservation. The species is one of the most publicised threatened species in the Wet Tropics with a very strong implementation of symbols, educational material, stories, festivals and celebrations, websites and opportunities for community to engage in on ground actions. In addition, eight community groups are represented on the recovery team and significant funding directed at cassowary recovery has been directed through community groups over many years. Active community groups exist throughout the Wet Tropics but there is a notable gap on Cape York Peninsula. However, a program has also been funded on Cape York Peninsula to engage the community in cassowary conservation and awareness, record sightings, train for undertaking cassowary surveys and delivering on-ground habitat rehabilitation measures where required.

7.2 Promote and publicise the recovery plan

The Cassowary Recovery Plan is easily accessible and actively promoted by the recovery team, community groups and state and federal government agencies.

7.3 Ensure Aboriginal communities participate in all aspects of the recovery process

There is significant representation of Aboriginal communities on the Cassowary Recovery Team, many opportunities for engagement, and a strong desire from recovery team members, and state and federal government agencies to support new opportunities for Aboriginal communities to engage with cassowary recovery. Representatives of five Wet Tropics indigenous corporations frequently attend Recovery Team meetings. The cassowary recovery plan renewal process is attempting to engage all Traditional Owner groups throughout the cassowary's range.

7.4 Document traditional cultural knowledge of cassowaries

The WTMA, Terrain and Rainforest Rescue have collated a small amount of information on traditional owner knowledge and aspirations but no project designed specifically to document traditional knowledge has been undertaken, nor has consent been formally sought to do so.

Specific objective 8: Manage the recovery program

8.1 Ensure recovery plan implementation is coordinated effectively

Implementation of the recovery plan has been effectively coordinated by the Wet Tropics Management Authority with considerable support from the recovery team members (see https://cassowaryrecoveryteam.org/).

8.2 Review the recovery plan

Recovery plan review delayed but now complete.