




Post-fire Assessment Report—Natural Values:

2020 Duling Bushfire, K'gari (Fraser Island), Great Sandy National Park, South East Queensland Bioregion

Queensland Government

Prepared by: Technical Services and Coastal and Islands Region of Queensland Parks and Wildlife and Partnerships, and the Queensland Herbarium and Wetlands Unit, Department of Environment and Science.

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Front cover: post-fire K'gari, (clockwise from top left): *Stylidium* sp. (R.Melzer), foredunes (A. Meiklejohn), *Eucalyptus racemosa/ Banksia aemula* open forest (AM), *Banksia aemula & Acacia* sp. seedlings (insert) (RM), *Euc. robusta* open forest on streamline with understorey of *Todea barbara* (RM), Wathumba wetland (RM).

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Contents

List of acronyms and abbreviations used in the text

BVG	Broad Vegetation Groups (BVGs) as described by Neldner *et al.* (2019b).
DES	Department of Environment and Science
dNBR	Normalised Burn Ratio difference product.
CIR	Coastal and Islands Region.
CP	Conservation Park
E	Endangered.
EPBC	Federal *Environment Protection and Biodiversity Conservation Act 1999.*
FIRMS	Fire Information for Resource Management System available online at https://firms.modaps.eosdis.nasa.gov/
FLAME	QPWS Fire Management System.
LC	Least Concern.
NBR	Normalised Burn Ratio.
NCA	Queensland *Nature Conservation Act 1992.*
NP	National Park.
NT	Near Threatened.
QFES	Queensland Fire and Emergency Services.
QPWS	Queensland Parks and Wildlife Service.
QPWS estate	National Parks, Conservation Parks, Resources Reserves, State Forests and Forest Reserves (in the context of the area encompassed by this report).
RE	Regional Ecosystem, as defined by Queensland Herbarium (2019), is a vegetation community in a bioregion that is consistently associated with a particular combination of geology, landform and soil (Neldner *et al.* 2019a, Neldner *et al*. 2020).
REDD	Regional Ecosystem Description Database, Version 11.1 (Queensland Herbarium 2019).
SF	State Forest.
V	Vulnerable.

1 Executive Summary

This report identifies known and likely impacts of the protracted bushfire event in spring-summer 2020, to the natural values on the K'gari (Fraser Island) section of the Great Sandy National Park World Heritage Area. It provides a rapid assessment of impacts, practical recommendations for threat mitigation, ecosystem recovery and monitoring over the short to long-term.

The bushfire impacted a total area of 75,110ha[1] (or 46%) of K'gari[2] section of Great Sandy National Park (the study area). A summary of the natural values impacted by the bushfire and the associated fire severity and Potential Ecological Impact, are provided in Table 1. A detailed assessment of the impact to each of the natural values, together with recommended actions is provided in Section 6. The recommendations are also provided below at the end of the Executive Summary.

The majority of the vegetation communities on K'gari are fire-adapted, requiring fire for rejuvenation, ecosystem health and the maintenance of species diversity. Their species have one or more mechanisms for surviving and/or recovering from fire. Vegetative and/or seedling regeneration was occurring across the fire affected areas at the time of inspection (i.e. within two to four months post-fire) including at sites where the fire severity was extreme – the latter being most common in those ecosystems that are highly resilient even to intense fire. The fire-adapted communities include the 'heathy' woodlands and open forests dominated by *Banksia aemula* (wallum banksia) and *Eucalyptus racemosa* (scribbly gum), the *Melaleuca quinquenervia* open forests, closed sedgelands and moist to wet, open to tall open eucalypt forests.

There was a mosaic of fire severity across the fire-adapted ecosystems, including significant unburnt patches within the broad extent of the fire. Nevertheless, for some fire-adapted ecosystems most of their distribution on K'gari is contained within the bushfire affected area, for example closed sedgeland in RE 12.2.15g (84%) and *Banksia aemula* low open woodland (82%). There were also extensive areas of high to extreme fire severity in some fire-adapted ecosystems. Management of these ecosystems on K'gari aims to minimise the risk of large scale bushfire and the extent of high to extreme fire severity, and to promote heterogeneity of fire age classes through space and time. The goal is to maintain healthy ecosystems and habitat for the diversity of species relying on it, including significant species (e.g. *Pezoporus wallicus wallicus* ground parrot).

K'gari also supports significant areas of fire-sensitive ecosystems and areas with a mosaic of fire-sensitive and fire-tolerant ecosystems (See table 1 - includes: foredune complex, beach ridge communities, rainforests, mangroves and saltmarsh). Long-term and extensive impacts are likely in the foredune complex, which includes communities that are highly fire-sensitive, in particular the *Casuarina equisetifolia* (coastal she-oak) woodlands-open woodlands. Approximately 8,265ha of foredune complex, representing 55% of this ecosystem on K'gari, was impacted by the bushfire. This included extensive areas of high to extreme fire severity. Full recovery is expected to be very slow and the risk of erosion is high. Previous bushfires have also impacted the foredune complex. The cumulative impact on the ecosystem is of concern and will likely affect its longer term resilience and recovery potential. The beach ridge communities are also of concern with approximately 464ha, representing 69% of the total area of this community on K'gari, impacted by the bushfire. Other fire-sensitive communities were largely unscathed (e.g. 4.3% of the total area of mangroves and saltmarsh and less than 1% of rainforest was impacted) and within the areas that were impacted severity was mostly low to moderate.

1. Note that this figure differs from the 83,390ha provided in some communications because it includes only national park estate and only areas mapped as burnt in the fire severity mapping process (described in Section 4.1). The figure of 83, 390ha includes all tenures and is the total area within the bushfire extent including some unburnt areas (large unburnt areas were removed). The term 'impacted' is used throughout the report to refer to areas that were identified in the fire severity mapping process as being burnt with low, moderate, high or extreme relative fire severity (refer Section 4.1).
2. Sandy Cape Conservation Park and Fraser Island State Forest are not included in the report. The former was not exposed to the fire. The latter is a total of 34.5ha and is predominately non-remnant. An area of 5.8ha of the SF was impacted by the bushfire.

Table 1. Summary of natural values and impacts of the fire.

For each natural value the:

- total impacted area (ha) and percentage impacted of the total extent in K'gari NP (% in parentheses);
- area impacted by fire within four relative fire severity classes (refer Section 4.1, Table 2) and percentage of the total area impacted in each class (% in parentheses) and;
- area represented in each of four Potential Ecological Impact classes (refer Section 5.1.1, Table 6) and percentage of the total area impacted in each class (% in parentheses).

Natural value	Total area impacted	Relative fire severity	Potential Ecological Impact
NV1: Foredune complex • BVG 28a – RE 12.2.14	8,265ha (55%)	Low: 2,791ha (34%) Mod: 2,604ha (31%) High: 1,996ha (24%) Extreme: 904ha (11%)	Limited or none: 0ha (0%) Mod: 2,791ha (34%) High: 2,604 (32%) Catastrophic: 2,870 (35%)
NV2: Beach ridge communities • BVG 9f – RE 12.2.11	464ha (69%)	Low: 180ha (39%) Mod: 161 (35%) High: 112ha (24%) Extreme: 11ha (2%)	Limited or none: 180ha (39%) Mod: 161ha (35%) High: 113ha (24%) Catastrophic: 11ha (2%)
NV3: *Banksia aemula* low open woodland on dunes and sand plains • BVG 29a – RE 12.2.9	38,975ha (82%)	Low: 7,496ha (19%) Mod: 12,171ha (31%) High: 14,923ha (38%) Extreme: 4,385ha (11%)	Limited or none: 34,590ha (89%) Mod: 4,385ha (11%) High: 0ha (0%) Catastrophic: 0ha (0%)
NV4: *Eucalyptus racemosa* open forest on dunes and sand plains • BVG 9g – RE 12.2.6	18,294ha (37%)	Low: 8,135ha (44%) Mod: 6,525ha (36%) High: 3,106ha (17%) Extreme: 528ha (3%)	Limited or none: 14,660ha (80%) Mod: 3,106ha (17%) High: 528ha (3%) Catastrophic: 0ha (0%)
NV5: *Melaleuca quinquenervia* open forest on sand plains • BVG 22a – RE 12.2.7	2,515ha (58%)	Low: 1,147ha (46%) Mod: 770ha (31%) High: 418ha (17%) Extreme: 180ha (7%)	Limited or none: 1,917ha (76%) Mod: 418ha (17%) High: 180ha (7%) Catastrophic: 0ha (0%)
NV6: Closed sedgelands • BVG 34c – RE 12.2.15, 12.2.15g (includes patterned fens).	5,119ha (49%)	Low: 1,037ha (20%) Mod: 1,229 (24%) High: 2,159ha (42%) Extreme: 695ha (14%)	Limited or none: 4,424ha (86%) Mod: 695ha (14%) High: 0ha (0%) Catastrophic: 0ha (0%)
NV7: Lakes – window and perched • BVG 34a – RE 12.2.15a, 12.2.15f	157ha (15%)	Low: 104ha (66%) Mod: 33ha (21%) High: 17ha (11%) Extreme: 3ha (2%)	Limited or none: 137ha (87%) Mod: 17ha (11%) High: 3ha (2%) Catastrophic: 0ha (0%)
NV8: Mangroves and saltmarsh • BVG 35a – RE 12.1.3 • BVG 35b – RE 12.1.2	122ha (4%)	Low: 100ha (85%) Mod: 21ha (17%) High: 0.8ha (0.6%) Extreme: 0 (0)	Limited or none: 69ha (57%) Mod: 44ha (36%) High: 8ha (7%) Catastrophic: 0.4ha (0.3%)
NV9: Moist to wet, open to tall open, eucalypt forests on parabolic high dunes • BVG 8a – RE 12.2.4 • BVG 8b – RE 12.2.8	1,110ha (5%)	Low: 636ha (57%) Mod: 341ha (31%) High: 104ha (9%) Extreme: 29ha (3%)	Limited or none: 977ha (88%) Mod: 104ha (9%) High: 29ha (3%) Catastrophic: 0ha (0%)
NV10: Rainforest on parabolic high dunes • BVG 3a – RE 12.2.3 • BVG 4a – RE 12.2.1	20ha (0.6%)	Low: 13ha (66%) Mod: 5ha (23%) High: 2ha (9%) Extreme: 0.4ha (2%)	Limited or none: 0ha (0%) Mod: 13ha (65%) High: 4ha (23%) Catastrophic: 2ha (11%)

A large number of conservation significant flora and fauna species are known, or have potential habitat, within the area affected by this bushfire (Section 5.2). Seven species with more than 10% of their potential Queensland habitat falling within the study area, had more than 10% of this habitat impacted by the bushfire: *Pezoporus wallicus wallicus* (ground parrot)[1], Vulnerable; *Crinia tinnula* (wallum froglet)[1], Vulnerable; *Litoria olongburensis* (wallum sedgefrog)[1], Vulnerable; *Esacus magnirostris* (beach stone-curlew)[1], Vulnerable; *Acacia baueri* subsp. *baueri* (tiny wattle)[1], Vulnerable; *Thelypteris confluens* (marsh fern), Vulnerable; *Phaius australis* (swamp orchid)[1], Endangered. An additional three threatened species, although not meeting the aforementioned criteria, had greater than 10,000ha of their potential habitat impacted by the bushfire. *Turnix melanogaster* (black-breasted button quail)[1], Vulnerable; *Acanthophis antarcticus* (common death adder)[1], and Vulnerable; *Rostratula australis* (Australian painted snipe). Further survey and monitoring of these species is warranted.

Recommended actions are summarised below and grouped by theme:

Pest management

1. Review the K'gari pest strategy and re-focus implementation to address risks, and opportunities, afforded by the bushfire event with consideration to the following recommendations. (Led by Coastal and Islands Region (CIR) in consultation with Butchulla Aboriginal Corporation and with support from the QPWS Pest and Fire Team, Ecological Assessment Unit and Threatened Species Operations).
2. Continue efforts to eradicate *Chrysanthemoides monilifera* subspecies *rotundata*, (bitou bush) from K'gari, with an increased focus on burnt foredune areas that are particularly prone to invasion.
3. Increase monitoring and act to prevent the establishment of ecosystem changing weeds, in particular high biomass grasses, in the bushfire area. Much of the island, particularly the interior, is blessed with low nutrient soils and associated low risk from weeds. However, some fire affected ecosystems are at greater risk, particularly foredune communities. The ash-bed effect may further increase the risk of establishment. There are numerous potential sources of ecosystem changing weeds, such as high biomass grasses that will require a proactive focus. Some are already established around the island's townships, along high-use visitor routes (e.g. Moon Point Road) and visitor nodes (e.g. Ocean Lake, Orange Creek). The risk of spread and new incursions is very high due to the large number of vehicles visiting the island and the widely distributed campsites along the eastern beaches. Regular surveillance is required for early detection of weed invasions, and early intervention is a high priority.
4. Undertake strategic management of other ecosystem changing weeds such as *Lantana camara* (lantana) and *Sphagneticola trilobata* (Singapore daisy), which have established in some foredune and adjacent communities on the east coast and have potential to increase in abundance or spread.
5. Continue the established program to mitigate the impact of the leaf hopper *Jamella australiae* on *Pandanus tectorius* populations.
6. Develop a plan to inform the presence and distribution of any remaining feral horses and plan to remove them from the island. Feral horses were last observed on trail cameras in August 2019 and the population is currently considered to be very low. An increase in abundance will cause significant degradation to the island's natural values and impact recovery from fire.
7. Build an improved understanding of abundance and distribution of cats, and their likely impact on significant species within post-fire landscapes, and determine appropriate actions for strategic control.
8. Monitor impacts of feral pigs and undertake strategic control. Feral pig density and ecological impact on the island remain low, presumably due to predation pressure from dingoes. Feral pigs have been recorded swimming to the island from the mainland. While eradication may not be feasible, monitoring for increased pig activity, particularly in ecologically sensitive areas such as wetlands, and targeted control are important management activities to assist bushfire recovery.
9. Continue to monitor for increased biosecurity risk from pathogens such as *Phytophthora* and myrtle rust; the latter favours new growth which is common post-fire. A collaborative project with Biosecurity Queensland and Butchulla Aboriginal Corporation is reviewing post-fire myrtle rust impacts.

1. Species has been recorded on K'gari.

Fire management

1. Review the K'gari fire strategy and refocus implementation with consideration to the Government response to the Inspector-General Emergency Management Report on the K'gari bushfires, and the recommendations arising from climate adaptation planning to be undertaken by the World Heritage Unit, QPWS, Butchulla and CSIRO. (Review to be led by CIR in consultation with Butchulla Aboriginal Corporation, the Area Fire Management Group led by QFES, and with support from the Pest and Fire Team, Ecological Assessment Unit and Threatened Species Operations). Aims include to minimise future widespread bushfire and impacts on life, property and world heritage values including fire-sensitive ecosystems, and re-establish a range of fire age classes appropriate to the fire-adapted ecosystems. The increased use of aerial burning is likely to be critical to achieving this goal given the large size of the island, access constraints, and importance of minimising on-ground disturbance and fragmentation of habitats.
2. Do not use firefighting agents within or adjacent closed waterbodies (e.g. perched lakes) and/or known or likely acid frog or acid fish habitat; otherwise avoid the use of firefighting agents within or adjacent to any wetland unless the risk to life, property, or environmental and cultural values of not using an agent far outweighs the benefits.
3. Do not use freshwater for fire suppression, within or adjacent to wetlands, that is likely to pose a biosecurity risk (e.g. introduction of aquatic weeds, spread of feral fish such as *Gambusia holbrooki* mosquitofish and cane toads) unless the risk to life, property, or environmental and cultural values of not using it far outweighs the benefits.
4. Do not use seawater for fire suppression within or adjacent freshwater systems, particularly closed waterbodies, unless the risk to life, property, or environmental and cultural values of not using it far outweighs the benefits. Its use would increase conductivity and potentially alter pH and so pose a significant risk to species that are adapted to living in very low conductivity (low salinity), acid environments (J.Marshall, pers. comm.).

Visitor management

1. Implement actions to avert recreational use/ access to recovering ecosystems, to minimise the risk of erosion and weed spread, particularly areas of burnt foredune complex.

Assessment, monitoring and research

1. Undertake Health Checks (Melzer *et al.* 2019). These facilitate early detection of weeds and assess impacts of recreation, feral horses and feral pigs. They enable the condition of key natural values to be evaluated across the park and through time to inform management.
2. Establish long-term vegetation and wetland condition monitoring (Wetland Condition Assessment Tool – WetCAT - due for release in 2021), to build more detailed (quantitative) understanding of the condition of ecosystems over time, and better understanding of trends and causal relationships, to inform management. Use historic monitoring sites where it is possible and appropriate to do so.
3. Encourage further research to build understanding of the impacts of fires on the wetland systems, including on water quality and species composition.
4. Monitor severely impacted sites that appear to have fundamentally changed as a consequence of cumulative impacts of a drying climate and bushfires (e.g. Yidney Lake and Yidney North Swamp), so as to build understanding of cause and effect and to guide their future management.
5. Investigate feasibility of using LiDAR technology to create fine scale mapping of bushfire affected areas of the foredune complex, to monitor recovery and ongoing impacts, and assess changes to the landscape from erosion (water, wind and recreational use) and the extent and geometry of sand blows.
6. Expand and/or implement survey and monitoring for key flora and fauna species occurring in fire prone/ fire-adapted ecosystems (e.g. *Acacia baueri* subsp. *baueri*, 'acid' frogs, fish and crayfish, ground parrot, black-breasted button quail) to better inform management of species and their habitat.
7. Undertake a survey of the lakes and wetlands through the centre of the island to determine where *Rhinella marina* (cane toad) successfully breed, to inform a strategic control program.
8. Undertake an ecological survey of the northern window lakes given limited pre-fire information and inaccessibility at the time of the post-fire assessment.

2 Introduction and purpose of this report

This is a report on a rapid assessment of the known and likely impacts to the natural values of QPWS estate in K'gari (Fraser Island) section of Great Sandy National Park arising from the 2020 bushfire event. Post-fire assessment was undertaken by the QPWS Ecological Assessment team, Coastal and Islands Region team, DES Wetland Unit and Butchulla Aboriginal Corporation representatives working collaboratively to assess the impacts of the bushfire on the natural and cultural values of K'gari. This report focusses on the natural values assessment component of the joint work.

While significant resources have been applied to the assessment and recovery efforts from the bushfire event, this report is not intended to be a comprehensive scientific report, rather it provides an expert summary of the bushfire event and information to inform planning for monitoring and recovery of natural values.

The report succinctly documents the extent and severity of the fires, prevailing weather conditions, and suppression methods used. It describes the spatial data used for impact evaluation and summarises areas and values within the bushfire affected area (Section 5). It provides a prioritised snapshot of the impacts and associated risks to natural values; and practical recommendations for mitigation, recovery and monitoring (Section 6).

Scoping the scale and nature of short to long-term recovery actions as soon as possible after a fire event enables land managers to manage immediate risks and plan for the future. It also assists in determining likely cost and resourcing implications.

This assessment is limited to the estimated extent of the bushfire that impacted national park tenure in K'gari (Fraser Island) section of Great Sandy National Park in the South East Queensland Bioregion from October to December 2020 (Figure 1).

Landscape features and place names used in this report are as per 1:25 000 scale topographic mapping available online at QTopo: https://qtopo.information.qld.gov.au/.

3 Background

K'gari (Fraser Island) is a World Heritage listed property located in the Wide Bay Burnett region at the northern extent of the South East Queensland Bioregion, approximately 250km north of Brisbane. The majority of the island is within Great Sandy National Park, with small amounts of other protected areas (Fraser Island State Forest and Sandy Cape Conservation Park), private land (including leases, resorts, private residences and holiday rentals), and unallocated state land making up the remainder. The largest sand island in the world, K'gari is composed of a series of dunes ranging in age from 700,000 years old in the west to 10,000 years old in the east (DES 2020).

Forest production and sand mining were previously undertaken on the island. These activities were phased out with a series of national park declarations over portions of the island from 1971; sand mining ended in 1976; and commercial forestry operations ceased in 1991 (DES 2020). K'gari (Fraser Island) was inscribed as a World Heritage Site in 1992 due to its outstanding universal values. The World Heritage Site includes portions of the internationally important Great Sandy Strait Ramsar site. The island has highly restricted ecosystems including: rainforests on parabolic dunes at elevations of up to 240 metres; patterned fens; and half of the perched, freshwater dune lakes in the world (UNESCO 2020).

The island is a popular destination for tourists with a range of tourism and recreational activities available, including: organised tours, resorts, camping, hiking, fishing, bird-watching and four-wheel-driving.

3.1 Landscape overview of the fire and timeframe

3.1.1 Overview

The Duling bushfire started from a failed attempt at extinguishing an illegal campfire near the southern edge of the Duling camping area, K'gari (Fraser Island) within Great Sandy NP, on 14 October 2020 and was contained on 13 December 2020 (but still active until at least 22 December 2020) after having impacted approximately 75,110ha (or 46%) of the K'gari (Fraser Island) section of Great Sandy National Park (Figure 1.).

K'gari (Sandy Cape Lighthouse Weather Station) had received above average rainfall in the 12 months prior to this event, but well below average rain in the months of October and November 2020. The above average rainfall in early 2020 may have contributed to above average ground cover (and therefore fuel load) observed on K'gari for October 2020. A combination of continuous dry fuel, high temperatures, erratic wind directions and inaccessible terrain hampered containment efforts until more favourable conditions occurred in mid-December.

The progression of the Duling fire is shown in Figure 2. NASA's Fire Information for Resource Management System (FIRMS), Visible Infrared Imaging Radiometer Suite (VIIRS), was used to track the progress of the fire with different coloured hotspots showing the progression across the landscape from October to December 2020. Some hotspots, however, may have been missed due to low intensity fire, cloud cover or incomplete passes (FIRMS 2020).

3.1.2 Observations of fire activity and behaviour

The K'gari fire was first reported on 14 October 2020 near Beach Camping Zone 8 (Duling, Ocean Lake), north of Orange Creek in the north east of K'gari (Fraser Island). Initial inspection by rangers suggested the ignition source was an abandoned, illegal campfire which was not extinguished properly. At this time the fire was considered not to be containable due to a combination of high fuel loads and a strong south-easterly wind driving the fire inland.

The fire progressed through inaccessible terrain in a north-easterly direction to Platypus Bay on the western side of K'gari before a change in wind direction turned the fire towards the south and southeast. Winds throughout the fire response varied from northerly aspects to southerly aspects, with variable wind speeds and gusts to 50km per hour plus with high day time temperatures and inaccessible terrain challenging fire planning and response efforts.

Backburning operations were undertaken on successive occasions with the primary objective to contain the fire to the remote north of the island. Containment attempts proved unsuccessful however, due to inaccessible terrain, erratic winds and highly flammable vegetation, with spotting occurring hundreds of metres beyond containment lines at times, resulting in the fire progressing further south and east while retaining an active northerly flank with alternate wind changes. At times the fire was being managed on four active fronts.

While high day time temperatures brought periods of high fire activity, particularly in more flammable vegetation types, other days saw mild fire conditions with a slow rate of spread and most evenings were generally cooler with higher relative humidities, contributing to the mosaic of burnt and unburnt country observed during aerial operations and reconfirmed in the fire assessments.

As the fire progressed, protection efforts including backburning and vegetation clearing were implemented around the east coast settlements of Orchid Beach, Cathedrals, Dundubara, Happy Valley, Poyungan and K'gari camp and Kingfisher Bay Resort and Village in the south western side of the island.

Aerial water bombing initially proved largely ineffective in stopping the progression of the fire in the conditions due to a number of factors including the dry sandy soils not retaining the water, complex vegetation structures and highly volatile vegetation communities, and the inability to access areas to provide follow up ground suppression.

Aerial assets did however play a major role in protecting communities, cultural assets and significant natural values like the Valley of the Giants. Over 13 million litres of water and retardants were dropped throughout the campaign. Retardants were only approved for use in line with QPWS policies which adopt a precautionary approach unless life and property or significant values are placed at risk. The use of retardants around water bodies was not endorsed, and the use of water from the island's fresh water lakes was heavily restricted due to potential biosecurity threats, safety and cultural considerations.

The fire was managed collaboratively by QPWS and Queensland Fire and Emergency Services, and Butchulla representatives were engaged at all times. At various stages control of the fire was exchanged between QPWS and QFES relative to their roles under the Queensland Bushfire Management Plan while the partner agency supported in a deputy role. Through the course of the fire several settlements self evacuated when risks to communities were heightened, and visitation was restricted to the island.

A significant rain event developed from 13 December onwards, bringing the fire largely under control. Despite rainfall of up to 50mm, small areas of active fire continued to be reported by aerial surveillance up until 22 December 2020.

Figure 1. Estimated extent of bushfire on K'gari, Great Sandy National Park, October to December 2020. Base map: QTopo.

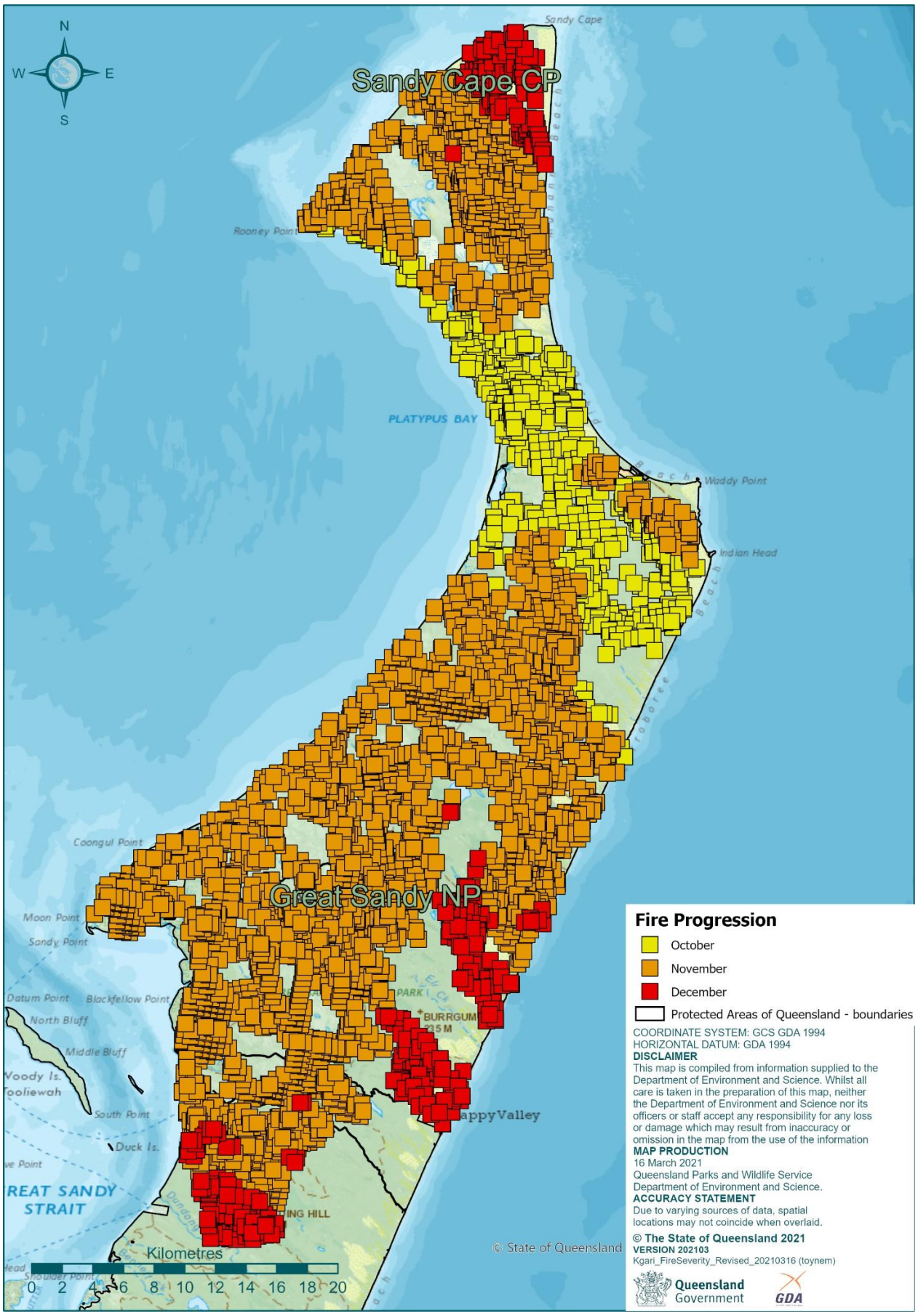

Figure 2. The progression of the Duling bushfire across the landscape October to December 2020, from VIIR hotspots FIRMS (2020).

3.2 Weather

The closest BOM weather station is the Sandy Cape Lighthouse station (#039085) located at the northern extent of the island. Weather observations from Sandy Cape include:

- Above average rainfall in the early months of 2020 (841mm recorded across February and March 2020).
- Below average rainfall during the fire event in months of October and November (68mm combined total).
- Highly variable wind direction – ranging from south-easterly early in the fire to northerly then to westerly in late October; becoming north-easterly to north-westerly in November; and then ranging from south-westerly to north-westerly to easterly/south-easterly in early December.
- Wind speeds ranged from four to 33km per hour (average: 14km/h in October; 15km/h in November and 13km/h in December).
- Minimum temperatures ranged from 18.2 to 24.5^{o}C and maximums ranged from 24.7 to 31.2^{o}C.
- Relative humidity ranged from a low of 46% in October to a high of 96% in December.
- A total of 113.9mm of rain fell during December, helping control the fire.

It is important to note that weather observations at the fire front often varied significantly from those at Sandy Cape. Site specific weather forecasts and observations were used by the incident management teams through the event, particularly to inform predictive fire behaviour modelling. On ground conditions varied considerably with: erratic wind directions – as wind eddied through dune corridors; wind gusts to 40 to 50 km plus per hour and; daytime temperatures at times in excess of 30^{o}C.

3.3 Suppression methods used on estate

The aim of this section is to briefly describe fire suppression methods used within QPWS estate, particularly those that may have significant impacts on natural values (e.g. construction of new firelines, and use of foams and retardants in sensitive ecosystems).

A range of suppression methods were used on QPWS estate during the event. Brief details are provided here.

- Aerial water bombing support, using numerous rotary and fixed wing aircraft (including LATs) concentrated on defending life and property and enhancing containment lines. Aerial operations at K'gari involved 30 aircraft and over 13 million litres dropped (freshwater, saltwater and gel suppressants).
- QFES consulted with QPWS before the use of gel fire suppressants as part of aerial operations. Approval by QPWS was provided in line with the department's *Procedural guide QPWS air operations* under the section "Use of Class A Foams and Retardants", and the department's Procedural Guide Incident response: Use of bushfire firefighting agents.
- For aircraft able to source water 'on the fly', both saltwater from waters adjacent to K'gari and freshwater from nominated lakes on K'gari were used. Sourcing water from the freshwater lakes on K'gari was regulated: for visitor safety (in high use lakes); to minimise biosecurity threats to the World Heritage Values (from the potential introduction of pests and pathogens); to limit impacts on cultural values, and; to limit impacts from saltwater usage. Specific lakes were nominated by Butchulla Aboriginal Corporation to ensure sensitive cultural values of other lakes were protected. The amount of water taken from the nominated lakes was guided by input from BAC cultural advisors.
- Aircraft that needed to refill on ground were supplied with potable freshwater from local Government water supplies at airports.
- Backburning on-park was conducted around vulnerable settlements including Orchid Beach, Cathedrals, Happy Valley and K'gari Camp and along various firelines in a range of vegetation types. Backburning from firelines was undertaken along: Wathumba track, Awinya track, Moon Point Road, Bogimbah Road and Cornwell's Road and other minor tracks.
- Tractors/slashers/ground crews were used to widen current lines and push over hazardous trees. One small section of new track was created near K'gari camp.
- Firefighting foams (Class A – foam block) were used by ground crews consistent with QPWS policies, and not within sensitive wetlands.

3.4 Potential impacts of suppression methods

The Department of Environment and Science, *Procedural guide QPWS air operations* provides that QPWS does not support the use of retardants on QPWS managed areas. Retardant acts as a fertilizer, and the use of retardant is of environmental concern in low nutrient ecosystems as the retardant is likely to have more long-term environmental impact than the wildfire. Retardant should only be used in native forest areas on QPWS managed areas where the protection of high-risk assets (i.e. life and property in the Izone) is the immediate objective and bombing using water or foam is ineffective.

When decisions are made to use retardants, the *Procedural Guide: 2.20 – Use of bushfire firefighting agents* provides guidance on the issues to consider in bushfires for the use of firefighting agents (retardants, suppressants, foams) on QPWS estate. Its purpose is to pre-inform and facilitate decision-making on the use and response measures for firefighting agents. The Procedural Guide details the toxicity of various agents and their environmental fate. It demonstrates that the use of current firefighting agents, under normal application conditions of low concentrations spread along fire fronts, is unlikely to have any long-term adverse environmental effects with a very low probability of significant acute short-term effects on the areas of application. There are, however, a number of potential impacts relevant to the areas in question.

1. In wetlands where there is limited dilution or flushing (e.g. small, perched lakes) there is a potential for fish kills due to the rapid depletion of dissolved oxygen from increased biochemical oxygen demand (BOD).
2. Retardants have the potential to increase nutrients (Nitrogen and Phosphorus) as they break down. This could impact wetland systems, with limited dilution or flushing, that are adapted to nutrient poor environments (e.g. sedgelands, lakes). The Procedural Guide also recommends that releases of polyacrylamide suppressants and foams to waterways be avoided.
3. While not specifically addressed in the Procedural Guide, amphibians are known to be sensitive to surfactants (Mann and Bidwell 2001) such as those in some firefighting agents. There is, however, a lack of detailed information on the potential impacts of these products on the acid frog species known to inhabit the area. Given the significance of K'gari to the conservation of these frog species, the precautionary principle should apply, and firefighting agents should not be used within or near known or likely acid frog habitats.

Care must be taken when sourcing freshwater for fire suppression within or adjacent to wetlands so as to avoid biosecurity risks including the introduction of aquatic weeds, and the spread of cane toads and feral fish such as *Gambusia holbrooki* (mosquitofish).

4 Assessment methods

4.1 Fire extent and severity mapping

Spatial data was supplied by Department of Environment and Science, Queensland Fire and Emergency Services, and Department of Natural Resources Mines and Energy.

Fire severity mapping (Figure 3a), using 12 band Sentinel-2 L2A satellite imagery, formed the basis of the assessment. The fire severity classification was derived from pre- and post-fire imagery. Images had a resolution of approximately 10m. A Normalised Burn Ratio (NBR) classification was developed for both the pre-fire and post-fire images (Brewer *et al.* 2005, Miller and Thode 2007). Using Sentinel-2 bands 8 and 12 the formula used was:

$$NBR = (b8 - b12) / (b8 + b12)$$

An NBR difference product (dNBR = Pre fire NBR - Post fire NBR) was derived and divided into five relative fire severity classes (Extreme, High, Moderate, Low and Unburnt) (Table 2). These classes were based on visual interpretation of the imagery, informed by ground-based field assessment (Figure 3b).

The final fire extent (Figure 1) was digitised from the fire severity mapping. Digitising was completed using ArcGIS Pro 2.4.2. Fire progression was mapped using NASA's FIRMS, Visible Infrared Imaging Radiometer Suite (VIIRS), (FIRMS 2020). Linescan data was provided by Queensland Fire and Emergency Services.

Note that fire severity refers to an observable effect on vegetation. It should not be confused with fire intensity, which in its simplest definition is the energy output of a fire (which is influenced by a range of variables including amount of fuel, fuel configuration, fuel dryness, prevailing weather, slope, residence time). Thus, a low intensity fire in some vegetation communities (e.g. sedgelands) can result in high fire severity (complete removal of standing vegetation) but a fire of the same intensity in an open forest may result in low fire severity (complete removal of the grassy understorey, with no scorching or consumption of shrub or canopy layers).

Overall, the dNBR analysis created a consistent and generally reliable classified product reflecting relative damage to the forest canopy and subcanopy. Factors, such as vegetation structure and substrate type appear to affect the sensitivity of this product in different vegetation communities.

Sourcing appropriate satellite imagery that was cloud and smoke free proved to be difficult. Cloud-free imagery was available for 5 December 2020, which was used for most of the bushfire area. However, the fire continued to burn after this date. Additional satellite imagery was captured for the areas around Happy Valley and Sandy Cape. The paucity of suitable satellite imagery combined with the length of the fire event affected our ability to create a consistent severity map across the entire area. Some areas had more than a month prior to the imagery, and already started regenerating, whereas other areas had only been exposed to fire a few days prior to the imagery.

We compensated for this by splitting the main dNBR (5 Dec 2020 imagery) used in two, with lower classification breaks used for the northern area (north of Platypus Bay Road), which was exposed to fire earlier, than for the southern areas which were exposed later. The area covered, classification break points, resolution and start and end dates of each dNBR raster used to create the overall severity mapping are provided in Table 3 and Figure 4.

The dNBR method for producing fire severity mapping has some known limitations, particularly, when trying to map severity across different vegetation and substrate types. This method can miss areas of low severity fire in tall forests with a dense canopy and sub-canopy or midstrata. Conversely, areas of low canopy height, such as grasslands and sedgelands, will tend to show up as high to extreme severity, as most fires will result in complete removal of standing biomass (Collins *et al.* 2018).

Some areas of low severity fire in forests with tall, dense canopies were not detected by the dNBR, notably the area west of Happy Valley. This area of low severity burn was detected during ground truthing and has been included in the total fire extent despite not being detected via the dNBR process.

The relative fire severity classification must be treated as an approximation as the analysis was rapid in nature and verification limited, so users need to be aware of potential limitations. These limitations are, however, unlikely to significantly affect overall assessments of likely ecological impacts nor unduly influence management and recovery recommendations.

Table 2. Relative fire severity classes.

Note: Canopy here refers to the ecologically dominant layer – the layer that contributes most to the overall biomass of the vegetation community (Neldner *et al.* 2020).

Severity class	Relative fire severity class description
Unburnt	Unburnt, canopy and subcanopy unchanged (within the mapped extent).
Low	Canopy and subcanopy un-scorched, shrubs may be scorched, fire-sensitive low shrubs may be killed.
Moderate	Partial canopy scorch, subcanopy partially or completely scorched, and/or fire-sensitive tall shrub or small tree layer mostly killed.
High	Full canopy scorch to partial canopy consumption, subcanopy fully scorched or consumed.
Extreme	Full canopy, subcanopy and understorey consumption.

Table 3. Imagery dates used to calculate dNBR and image resolution.

Satellite imagery areas	Classification breaks	Start imagery date	End imagery date	Resolution
Sandy Cape	Unburnt < 0.21 Low < 0.55 Moderate < 0.74 High < 0.89 Extreme < 2	26/9/2020	14/1/2021	10m
Happy Valley	Unburnt < 0.1 Low < 0.38 Moderate < 0.6 High < 0.79 Extreme < 2	26/9/2020	10/12/2020	10m
North of Platypus Bay Road	Unburnt < 0.3 Low < 0.56 Moderate < 0.72 High < 0.92 Extreme < 2	26/9/2020	5/12/2020	10m
South of Platypus Bay Road	Unburnt < 0.18 Low < 0.38 Moderate < 0.58 High < 0.86 Extreme < 2	26/9/2020	5/12/2020	10m

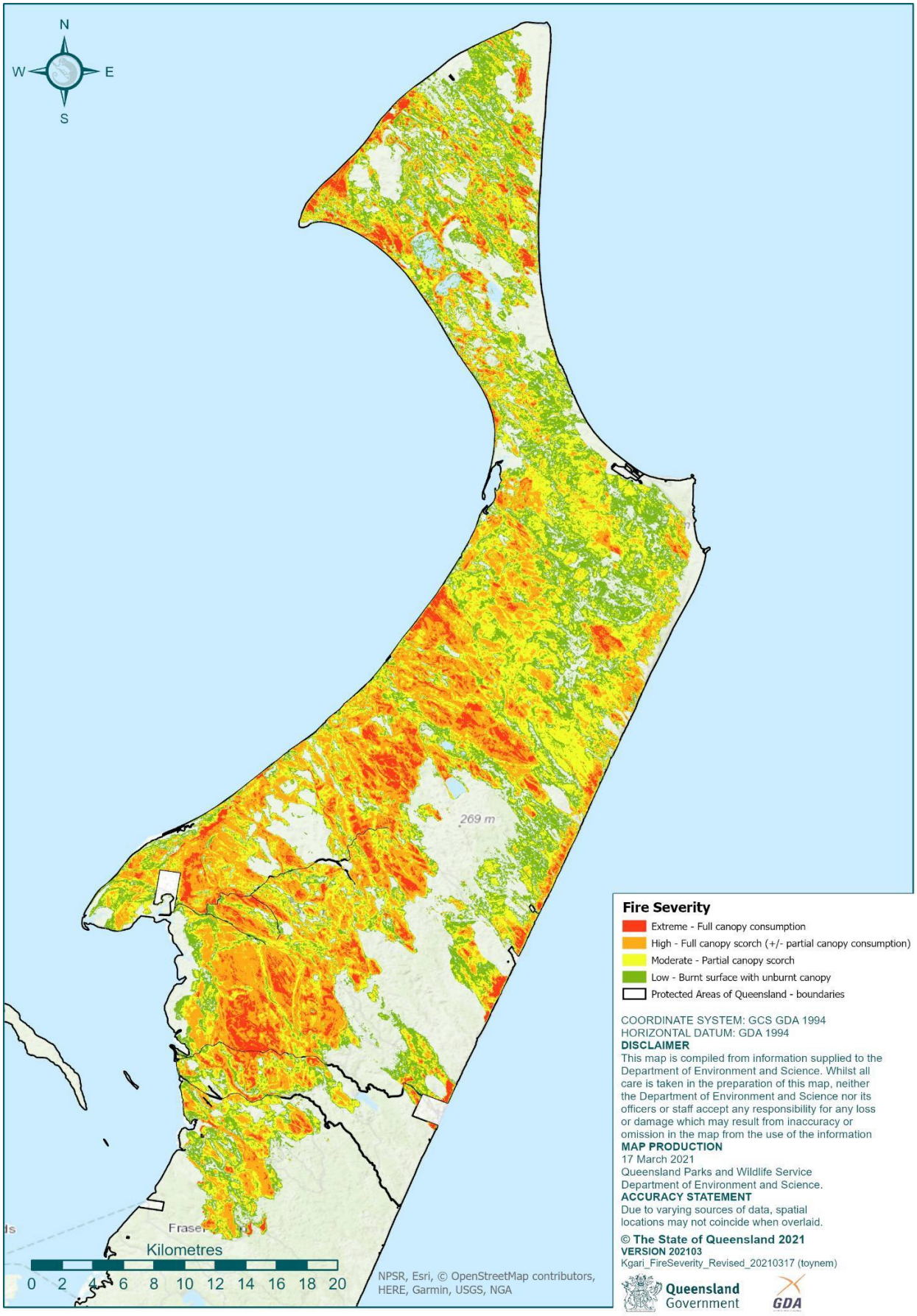

Figure 3a. Estimated severity of Duling bushfire, K'gari (Fraser Island), Great Sandy NP, October to December 2020.

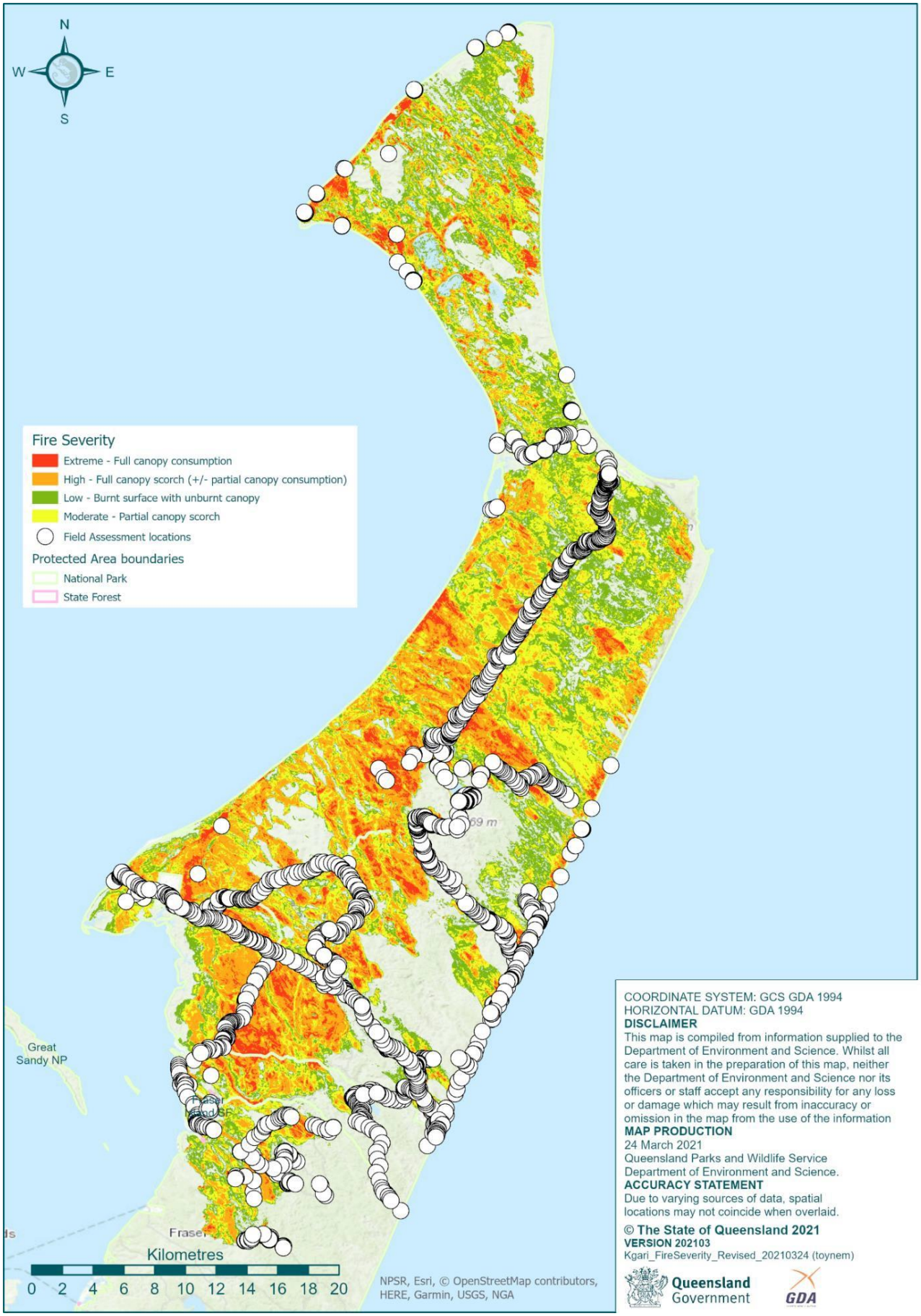

Figure 3b. Locations (white circles) of field assessment sites, 1-12 February, 2021.

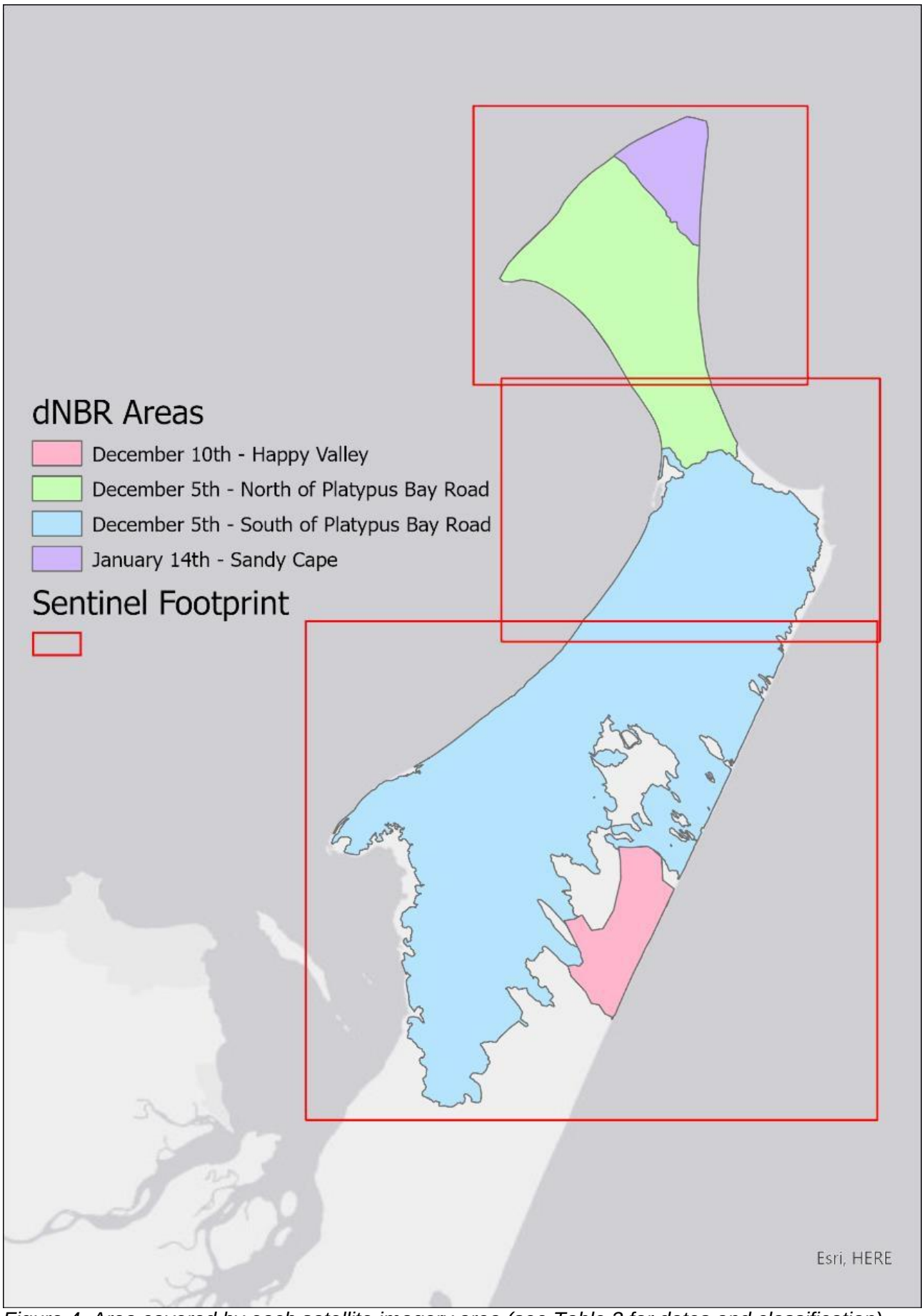

Figure 4. Area covered by each satellite imagery area (see Table 3 for dates and classification)

4.2 Vegetation

Regional Ecosystems (REs) are vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The Queensland Herbarium has mapped REs throughout Queensland. We used version 10.1 of the mapping for this assessment (Queensland Herbarium 2019). Many areas have a high spatial diversity of vegetation communities, so at 1:100 000 scale it is not always possible to spatially delineate each vegetation community into homogenous (pure) polygons. Consequently, mapped RE polygons are sometimes heterogeneous, such that a polygon may be attributed to more than one regional ecosystem code (e.g. 12.2.15/12.2.7), with the percentage of the area of the polygon occupied by each regional ecosystem or vegetation recorded (Neldner *et al.* 2020). For the purposes of this report the RE assessment utilises RE1 or the dominant RE for each mapped polygon and doesn't attempt to consider the percentage of it within the polygon. The resolution or scale of RE mapping delineates a minimum area for remnant vegetation of 1 ha and/or 35 m in width.

REs are grouped into higher-level vegetation communities referred to as Broad Vegetation Groups (BVGs) (Neldner *et al.* 2019b), and we provide summaries at the 1:2 000 000 and 1:5 000 000 scales.

4.3 Conservation species data sources

Information on conservation significant species (Threatened, Near Threatened, Special Least Concern or Endemic terrestrial or freshwater fauna and flora species) known, or likely, to occur in the fire extent, was principally derived from the state's wildlife information system WildNet (accessed 8/12/2020) which includes plant species locality information held by the Queensland Herbarium. WildNet was searched for records that fell within the latitudes of -24.6828 and -25.432 and longitudes of 152.974 and 153.375. This rectangle included an approximate 2km buffer on the northern, eastern, southern and western extent of the QPWS estate affected by the fire. Limited spatial validation of these records was undertaken, with some records rejected due to having: very poor spatial precision; erroneous georeferences; coordinates well outside of the fire extent; being vagrant species, or intertidal or marine dependent species, and/or migratory species unlikely to be impacted by the fire.

Spatial datasets on significant species are inherently limited and biased, so we also summarised the area of modelled potential habitat for selected conservation significant species within the bushfire area (DES 2019). Refer to Appendix 5 for a description of methods used. The lists generated by the models were scrutinised by experts and species deemed highly unlikely to occur on the park were removed.

We also referred to knowledge of local staff, published and unpublished information, as well as expert opinion to augment the spatial analyses and inform the impact assessment process.

Species nomenclature, taxonomy and status used in this report follow WildNet. In the body of the report we use common names for birds and mammals and scientific names for all other species.

4.4 Field assessment

Field assessment of ecological impacts and limited verification of fire extent and severity mapping was conducted by helicopter on 22 December 2020 and on foot and by vehicle over the period 1 to 12 February 2020. Observations regarding the vegetation, signs of fire severity and a series of photographs were recorded at various locations throughout the area impacted by fire (Figure 3b). Access to some of the fire affected areas was restricted I February due to closed tracks, inundation of the extensive wetland systems and tides.

4.5 Data and report availability

The fire severity mapping is available via the Queensland Government's Open Data Portal, through the Queensland Spatial Catalogue at http://qldspatial.information.qld.gov.au/catalogue/custom/index.page. Internally the mapping is available through the Spatial Information Resource (SIR) (administered by Department of Natural Resources and Mines).

This report is available in WildNet Multimedia, Media ID = 28604, and is searchable using the keywords: fire, severity, ecological, natural values, assessment, K'gari, Fraser, Great Sandy or via the link: http://wildnet/wildnet/bin/WNE0130$VMEDIAQRY.QueryView?P_MEDIA_ID=28604"

5 Summary of areas impacted by fire

Basic fire details and a summary of areas impacted by fire are provided in Table 4. Statistics were derived using ArcGIS and the sources identified in the table. A summary of the areas impacted by fire (ha) within QPWS managed estate, by relative fire severity class, is provided in Table 5 and shown on Figure 3a.

Table 4. Summary of impacted areas.

Description	Value and units	Source and notes
FLAME Fire ID(s) and Names	13318488	Great Sandy National Park/NP/W/2020/002
Fire start date:	14/10/2020	FLAME
Fire started on or off-estate	On	FLAME/ FIRMS hotspots
Date fire first recorded on estate	14/10/2020	FLAME
Date fire declared contained	25/09/2019	FLAME
Total area impacted by fire (on and off estate combined)	75,726ha	Fire severity analysis from EO Browser
Bioregion(s)	South East Queensland	
Estate name(s)	Great Sandy NP Fraser Island SF	FLAME Fire severity analysis from EO Browser
QPWS Region(s)	Coastal and Islands Region	
Area impacted by fire within QPWS estate	75,110ha	This report (Table 4, Appendix 2), based on relative fire severity mapping. See also Table 4.
Area impacted by fire within World Heritage Area	75,110ha	World Heritage, DES ENVBAT.QLD_WORLDHERTAREA
Area impacted by fire within Ramsar areas	225ha	WetlandInfo
Directory of Important Wetlands of Australia within burn extent	75,067ha	Directory of Important Wetlands in Australia (DIWA) (DEE 2019)
Area of fire impacted habitat of state Biodiversity Significance (BAMM)	75,110ha	This report - relative fire severity mapping. SIR dataset: ENVBAT.BPA_SEQ See also Table 5.

Table 5. Area impacted by severity class (refer Table 4) within estate as of 8 January 2020.

Severity class	Great Sandy NP	DIWA	BAMM State Biodiversity Significance
Low	21,686	21,666	21,686
Moderate	23,873	23,863	23,873
High	22,813	22,808	22,813
Extreme	6,738	6,730	6,738
Total	**75,110**	**75,067**	**75,110**

5.1 Vegetation impacted by fire

Summaries of the area of Regional Ecosystems and Broad Vegetation Groups impacted by fire and the fire severity are provided in Appendices 2 and 3, respectively.

5.1.1 Potential Ecological Impact

The ecological impact of any given fire event on a vegetation community depends upon the extent and severity of the fire and the tolerance or sensitivity of the community to fire, as well as the history of previous fires. Many ecosystems are adapted to a particular fire regime (intensity, frequency, season) and require appropriate fire to maintain ecosystem health. Other ecosystems are fire intolerant or fire-sensitive and if they burn, significant long-term ecological damage is likely.

To aid in evaluating the Potential Ecological Impact (PEI) the Regional Ecosystems were classified into four fire tolerance categories using fire management guidelines provided in the Regional Ecosystem Description Database (Qld Herbarium 2019) for RE1, QPWS planned burn guidelines (DNPRSR 2013) and other expert knowledge:

1. *Intolerant*: communities that are sensitive to fire; management aims to exclude fire.
2. *Low tolerance*: communities may have a mix of fire-sensitive and fire-tolerant/adapted species; management aims to burn at low intensity and with high patchiness under conditions where the impact on fire-sensitive species and habitat components is minimised.
3. *Moderate tolerance*: communities of fire-tolerant/adapted species where the aim is to burn at low to moderate intensity.
4. *High tolerance*: communities of fire-tolerant/adapted species where planned burns are typically of moderate to high intensity and/or where it is acknowledged that occasional high intensity fire is a natural part of the ecosystem's ecology and the ecosystem is known to recover.

The concept of PEI, which integrates fire severity mapping with knowledge of vegetation community fire tolerance and threats to post-fire recovery, helps identify areas likely to be most severely impacted that may require increased resources (e.g. pest management), or altered management approaches (e.g. modification to planned burn program) to enhance recovery. Conversely, areas may be identified as likely requiring little or no additional management intervention. The classes of PEI used for this assessment are further explained in Box 1.

For the purposes of this report the closed sedgelands and other peat forming systems have been classified as having a high fire tolerance as they are fire-adapted systems and can tolerate fires of high severity, as long as the peat layer is wet enough not to burn. In certain situations (i.e. lower water table during drought) peat deposits can become dry and, if ignited during bushfire, catastrophic ecological impact can occur (e.g. Corbett 2010). Small areas of peat were found to have burnt. Improving the ability of the severity mapping to detect areas of peat engagement would improve the ability to identify areas of potentially catastrophic impacts due to extensive peat fires.

The area, of each of the four fire tolerance categories, subjected to low, moderate, high or extreme fire severity, is shown in Table 6a. Burnt areas were assigned to four PEI classes, based on the matrix in Table 6a of fire severity and fire tolerance of the vegetation communities. A summary of the PEI is provided in Table 6b, is mapped in Figure 5, and discussed in Section 6.

Table 6. Fire tolerance and Potential Ecological Impact

Table 6a. Summary of burn severity (ha) of vegetation communities, classified by fire tolerance.

	Fire tolerance of vegetation community (based on RE1)			
Relative Fire Severity Class	**Intolerant**	**Low**	**Moderate**	**High**
Low - Canopy and subcanopy un-scorched, shrubs may be scorched, fire-sensitive low shrubs may be killed.	2,882.0	179.8	10,078.9	8,533.1
Moderate - Partial canopy scorch, subcanopy partially or completely scorched, and/or fire-sensitive tall shrub or small tree layer mostly killed.	2,626.3	161.0	7,682.0	13,399.7
High - Full canopy scorch to partial canopy consumption, subcanopy fully scorched or consumed.	1,970.4	112.7	3,645.1	17,082.1
Extreme - Full canopy, subcanopy and understorey consumption.	906.3	10.8	740.8	5,079.9
Total	8,385.0	464.3	22,146.8	44,094.7

Table 6b. Area (ha) of Potential Ecological Impact (within estate).

	Fire tolerance of vegetation community (based on RE1)			
Potential Ecological Impact	**Intolerant**	**Low**	**Moderate**	**High**
Limited or no ecological impact likely		179.8	17,761	39,015
Moderate ecological impact likely	2,882.0	161.0	3,645	5,080
High ecological impact likely	2,626.3	112.7	741	
Catastrophic ecological impact possible	2,876.7	10.8		

Box 1. Overview of the Potential Ecological Impact classes

Limited or no Potential Ecological Impact (green):

The consequence of the fire is likely to be short-term with persistent canopy and subcanopy cover and/or species, and expected relatively rapid regeneration by native, fire-adapted, species, helping to minimise the risk of invasion by ecosystem-changing plant species. There will be limited, short-term, or no impact on fauna species reliant on the canopy species for food and/or shelter (e.g. hollows) and likely relatively short-term impacts on species generally.

Moderate Potential Ecological Impact (yellow):

There may be localised decline in, or loss of, some species, over the short to mid-term as a direct consequence of the fire and associated poor regenerative capacity or specialised requirements of some species for successful regeneration, and/or as a consequence of a reduction in resources or specialised niches. Ecosystems in this impact class are expected to recover over the short to mid-term.

High Potential Ecological Impact (orange):

There is expected to be localised decline in, or loss of, some species and regeneration of these areas is expected to take time, depending on structure and species composition. The rating of High PEI reflects: the immediate to short or mid-term impacts on food resources for fauna; loss of critical structural elements and faunal habitat features such as large hollow bearing trees which take decades to hundreds of years to replace; likely changes in understorey species composition, in the short to mid-term at least. The risk of invasion by ecosystem-changing weeds is likely to be high, may be exacerbated by past disturbance regimes and may further exacerbate future bushfire events.

Catastrophic Potential Ecological Impact (red):

There is significant risk of an ecosystem not recovering as a consequence of the substantial changes in: vegetation structure and composition; soil structure, composition and chemistry (e.g. consumption of peat, altered nutrient availability or increased susceptibility to erosion); and microclimate. These changes can increase likelihood of erosion, and invasion by ecosystem-changing plant species (weeds or native) better adapted to the post-fire environment than the impacted ecosystem, potentially increasing fuel loads further exacerbating the risk of future high severity fire. Some, possibly many, flora and fauna species can be expected to be permanently lost from the location. The risk of permanent change is greater where surrounding ecosystems are also significantly impacted by the bushfire or other disturbances and/or there are no sources of propagules nearby.

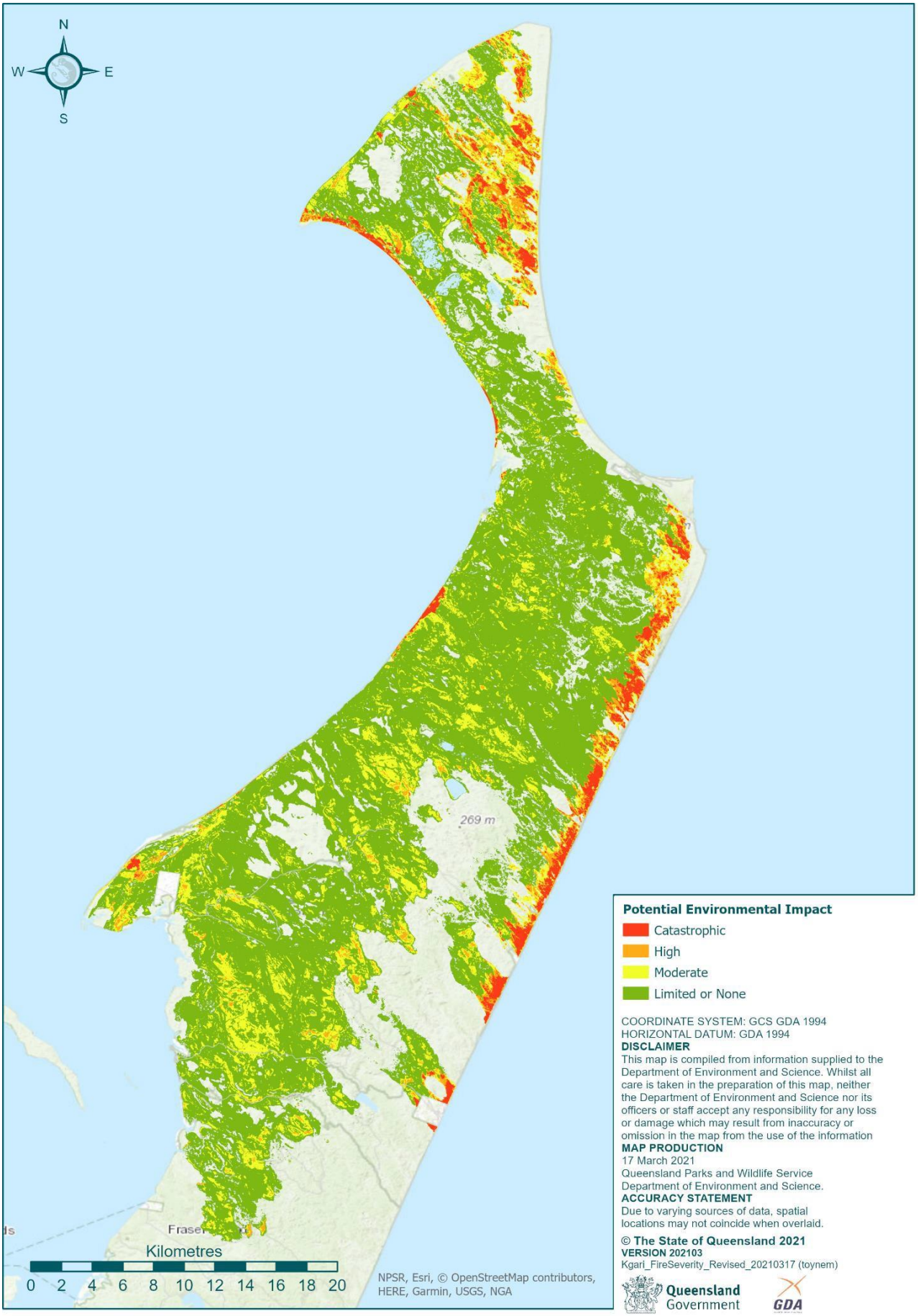

Figure 5. Potential Ecological Impact – K'gari (Fraser Island), Great Sandy NP.

5.2 Significant species potentially impacted

The list of significant fauna and flora species recorded from within a buffered, bounding rectangle of the fire extent is provided in Appendix 4. Appendix 5 summarises the area of modelled potential habitat for selected threatened species within the extent of the fire.

There are eight threatened species (four fauna, four flora) for which a substantial proportion (≥10%) of their modelled potential habitat occurs in the study area (refer Appendix 5). Of these species, seven had a substantial proportion (≥10%) of their modelled habitat in the study area impacted in the bushfire event. An additional three fauna species, although not meeting the aforementioned criteria, had greater than 10,000ha of their modelled potential habitat impacted by the fire. Summary details are provided for these ten species in Table 7. Maps of their modelled potential habitat are provided at the end of Appendix 5 except for species deemed by the Department to be confidential.

The dingo (*Canis familiaris* (dingo)), locally known as Wongari, is not a threatened species but has significant conservation value on K'gari because of its: cultural significance to the Butchulla people; importance ecologically as a top order predator and because K'gari animals rarely interbreed with domestic or feral dogs, and; iconic status. Dingo management on K'gari is guided by a conservation and risk management strategy (DEHP 2013). Dingoes are highly mobile. They are also extremely opportunistic and adaptable (Behrendorff *et al*. 2016, Behrendorff 2017, Behrendorff *et al*. 2018) and well able to take advantage of resources made available by fires. Experienced, long-term QPWS staff on K'gari report that there is no evidence of negative impacts from the recent fire on the dingo population other than possible increased movement to the coast.

Table 7. Threatened species with a substantial portion of modelled potential habitat (PH) impacted by fire.

Scientific name	Common name	Status		Potential Habitat (PH)				
		NCA	EPBC	PH in study area (ha)	% Qld PH in study area	Total PH impacted (ha)	% study area PH impacted	% Qld PH impacted
Fauna								
*Pezoporus wallicus wallicus**	ground parrot	V		12 505	22	6 254	50	11
*Crinia tinnula**	wallum froglet	V		42 362	16	18 752	44	7
*Litoria olongburensis**	wallum sedgefrog	V	V	15 596	11	4 641	30	3
*Esacus magnirostris**	beach stone-curlew	V		78 155	11	29 728	38	4
*Turnix melanogaster**	black-breasted button-quail	V	V	57 325	6	16 543	29	2
*Acanthophis antarcticus**	common death adder	V		159 585	5	74 440	47	2
Rostratula australis	Australian painted snipe	E	E	75 591	2	46 309	61	1
Flora								
Acacia baueri subsp. *baueri**	tiny wattle	V		36 889	37	27 003	73	27
Thelypteris confluens		V		13 361	23	68 78	51	12
*Phaius australis**		E	E	74 787	20	22 670	30	6

*Record in WildNet or Herbrecs for K'gari section of Great Sandy NP

5.3 Wetland Values

K'gari contains extensive and diverse wetlands. The *Aquatic Conservation Assessment (ACA) for the riverine and non-riverine wetlands of Southeast Queensland catchments* (DEHP 2015) was used to identify the relative conservation value of wetlands based on their 'AquaScore'. A wetlands 'AquaScore' is determined based on a combination of scores for a range of criteria, with 'Very High' value wetlands being: *These wetlands have very high values across all criteria (aquatic naturalness, catchment naturalness, diversity and richness, threatened species, special features and representativeness), or they have very high representativeness values in combination with very high aquatic naturalness, catchment naturalness or threatened species values. They may also be wetlands nominated as a special feature by an expert panel for their very high flora, fauna and/or ecological values, regardless of values across other criteria* (DEHP 2015: p36*).*

The extent of wetlands impacted by fire is shown in figure 6. The extent impacted at each relative fire severity class is provided in Table 8.

The wetlands are discussed in detail in Section 6. A factor requiring special consideration was the degree to which peat deposits burnt during the bushfire. Peat fires have the potential to result in catastrophic impacts to wetland systems (e.g. Corbett 2010). Assessment of the impacted area and the healthy post-fire regrowth in these systems indicate that peat burning was limited.

One of the limitations of the severity mapping using satellite imagery, was the ability to differentiate severity classes, in communities with low, dense canopies, such as heath-, shrub-, sedge- and grass-land communities. With improvement it may be possible to refine this methodology to better identify those areas of peat burning, and perhaps redefine the *Extreme* fire severity category, for wet heaths and sedgelands, to include only those areas where peat engagement occurred.

Table 8. Area (ha) of non-riverine wetlands impacted per AquaScore - Aquatic Conservation Assessment: Non-Riverine wetlands of SEQ.

	Wetland AquaScore (area in Ha)		
Relative fire Severity	Very High	High	Medium
Low - Canopy and subcanopy un-scorched, shrubs may be scorched, fire-sensitive low shrubs may be killed.	555.2	63.6	1.7
Moderate - Partial canopy scorch, subcanopy partially or completely scorched, and/or fire-sensitive tall shrub or small tree layer mostly killed.	987.7	46.9	2.1
High - Full canopy scorch to partial canopy consumption, subcanopy fully scorched or consumed.	1,762.5	14.9	1.9
Extreme - Full canopy, subcanopy and understorey consumption.	2,693.7	27.2	4.4

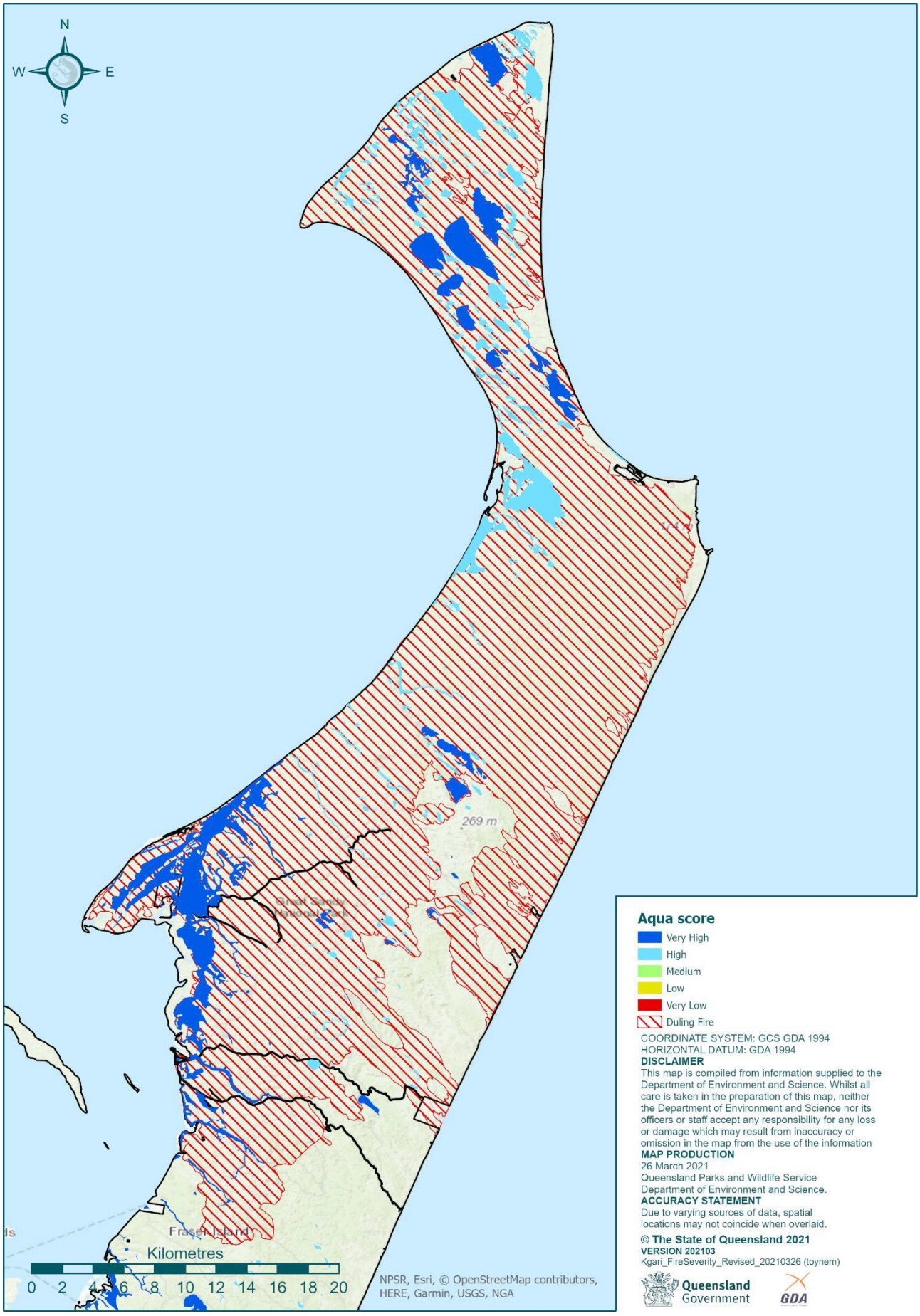

Figure 6. K'gari (Fraser Island), Great Sandy NP - Wetland AquaScore and fire extent on reserve.

5.4 Ecological monitoring sites

Existing ecological monitoring sites that are known to, or are likely to, have been impacted by the fire are listed in Table 9 (and shown in Figure 7) together with basic details and the priority (high to low or not a priority) for re-sampling the sites/plots to better inform an assessment of the impact of fire on natural values and subsequent recovery.

Table 9. Existing long-term ecological monitoring sites.

Dataset name	Type of monitoring	General location of monitoring site(s)	Custodian	Priority for resampling
Corveg sites	Long term quantitative flora sites	Rainforest communities	Queensland Herbarium, DES	Med
Hockings and Hobson	Long term quantitative sites (flora and fauna)	Spectrum of vegetation types	QPWS, DES	High
Montreal Process*	Long term quantitative flora sites	Moist to wet, open to tall open forest	Queensland Herbarium DES	High

*These sites were originally established, in 1998, by the then Department of Natural Resources as detailed Forest Monitoring Sites.

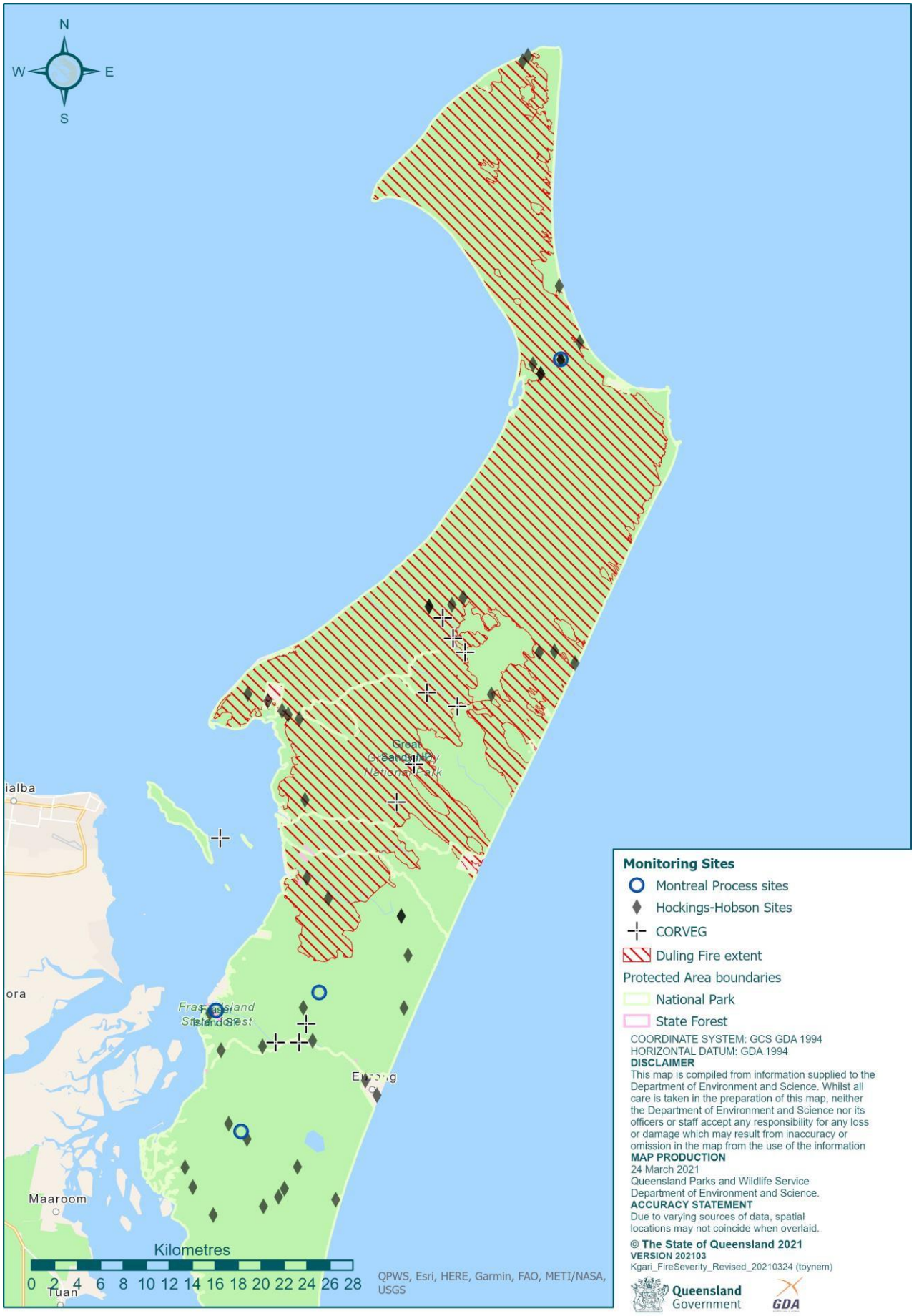

Figure 7. Map of long-term ecological monitoring sites on K'gari (Fraser Island), Great Sandy NP.

6 Significant impacts and recovery actions

6.1 Introduction

Ten ecosystem groups are discussed in Section 6. They are listed in Table 10 together with the associated Regional Ecosystems and Broad Vegetation Groups (BVG 1M). A detailed assessment of each significant known or likely impact to natural values and a full list of recommended recovery actions are provided in Section 6.3. A summary of impacts and actions for recovery is provided below. A list of pest plants and animals, that are likely to adversely affect recovery of burnt habitat or impact significant species, is provided in Appendix 6.

Table 10. Natural values known, or likely, to be impacted.

Value ID	Value descriptor	Associated Broad Vegetation Groups and Regional Ecosystems
NV1	Foredune complex	BVG 28a – RE 12.2.14
NV2	Beach ridge communities	BVG 9f – RE 12.2.11
NV3	*Banksia aemula* low open woodland on dunes and sand plains	BVG 29a – RE 12.2.9
NV4	*Eucalyptus racemosa* open forest on dunes and sand plains	BVG 9g – RE 12.2.6
NV5	*Melaleuca quinquenervia* open forest on sand plains	BVG 22a – RE 12.2.7
NV6	Closed sedgelands-wet heath (including patterned fens)	BVG 34c – RE 12.2.15, 12.2.15g
NV7	Lakes – window and perched	BVG 34a – RE 12.2.15a, 12.2.15f
NV8	Mangroves and saltmarsh	BVG 35a – RE 12.1.3 BVG 35b – RE 12.1.2
NV9	Moist to wet, open to tall open, eucalypt forests on parabolic high dunes	BVG 8a – 12.2.4 BVG 8b – 12.2.8
NV10	Rainforests on parabolic high dunes	BVG 3 – RE 12.2.3 BVG 4 – RE 12.2.1

The majority of the vegetation communities on K'gari are fire-adapted requiring fire for rejuvenation, ecosystem health and the maintenance of species diversity. Their species have one or more mechanisms for surviving and/or recovering from fire. Regeneration was occurring across the burnt area at the time of inspections (i.e. within one to four months post-fire) including at sites where the fire severity was extreme – the latter being most common in those ecosystems that are highly resilient even to intense fire. For example, epicormic regrowth and seedlings of the canopy species, in 'heathy' woodlands and open forests dominated by *Banksia aemula* (wallum banksia) and *Eucalyptus racemosa* (scribbly gum), were common to abundant. Similarly, regeneration in the *Melaleuca* open forests and in the fens and other peat-based swamps was advanced in most cases with dominant woody species (e.g. *Melaleuca quinquenervia*; *Banksia robur* swamp banksia, *Leptospermum liversidgei* swamp may) resprouting epicormically and/or from the base and herbaceous species such as sedges, rushes and forbs resprouting from underground organs such as rhizomes and bulbs. Flowering was well underway in the swamps (e.g. *Drosera binata* forked sundew*, Hibbertia salicifolia, Stylidium* spp. trigger plants, *Burmannia disticha*). The near-threatened *Litoria cooloolensis* (Cooloola sedgefrog) and Vulnerable frog species *Crinia tinnula* (wallum froglet), *Litoria olongburensis* (wallum sedgefrog) and *Litoria freycineti* (wallum rocketfrog) were recorded within regenerating wetlands. Resprouting was also common and widespread in the moist to wet, open to tall open forests and seedlings of canopy species, such as *Eucalyptus pilularis* (blackbutt), *Euc. resinifera* (red mahogany) and *Lophostemon confertus* (brush box), were common in the open ground created by the fire.

There was a mosaic of fire severity across the fire-adapted ecosystems, including significant unburnt patches within the broad extent of the fire. For some fire-adapted ecosystems however (e.g. patterned fens, *Banksia aemula* low open woodland), a large proportion of their distribution on K'gari was impacted by fire. There were also extensive areas of high to extreme fire severity in some fire-adapted ecosystems. Management of these ecosystems on K'gari aims to minimise the risk of large scale bushfire and the extent of high to extreme fire severity and to promote heterogeneity of fire age classes through space and time. In some cases fire management of these ecosystems takes into consideration particular requirements of significant species (e.g. *Pezoporus wallicus wallicus* ground parrot).

K'gari also supports significant areas of fire-sensitive ecosystems and areas with a mosaic of fire-sensitive and fire-tolerant ecosystems (e.g. foredune complex, beach ridge communities, rainforests, mangroves and saltmarsh). Long-term and extensive impacts are likely in the foredune complex, which includes communities that are highly fire-sensitive, in particular the *Casuarina equisetifolia* (coastal she-oak) woodlands-open woodlands. Approximately 8,265ha of foredune complex, representing 55% of the ecosystem on K'gari, was impacted by fire. This included extensive areas of high to extreme fire severity. Full recovery is expected to be very slow and the risk of erosion is high. Previous bushfires have also impacted the foredune complex. The cumulative impact on the ecosystem is of concern and will likely affect its longer term resilience and recovery potential. The beach ridge communities were also significantly impacted with approximately 464ha, representing 69% of the total area of this community on K'gari, burnt. Other fire-sensitive communities were largely unscathed (e.g. 4.3% of the total area of mangroves and saltmarsh and less than 0.6% of rainforest was impacted) and within the areas that were impacted severity was mostly low to moderate.

The sections below outline a range of recommended actions for each natural value, which are summarised below and grouped by theme:

Recommended actions are summarised below and grouped by theme:

Pest management

1. Review the K'gari pest strategy and re-focus implementation to address risks, and opportunities, afforded by the bushfire event with consideration to the following recommendations. (Led by the CIR in consultation with Butchulla Aboriginal Corporation and with support from the Pest and Fire Team, Ecological Assessment Unit and Threatened Species Operations).
2. Continue efforts to eradicate *Chrysanthemoides monilifera* subspecies *rotundata*, (bitou bush) from K'gari, with an increased focus on burnt foredune areas that are particularly prone to invasion.
3. Increase monitoring and act to prevent the establishment of ecosystem changing weeds, in particular high biomass grasses, in the bushfire area. Much of the island, particularly the interior, is blessed with low nutrient soils and associated low risk from weeds. However, some fire affected ecosystems are at greater risk, particularly foredune communities. The ash-bed effect may further increase the risk of establishment. There are numerous potential sources of ecosystem changing weeds, such as high biomass grasses that will require a proactive focus. Some are already established around the island's townships, along high-use visitor routes (e.g. Moon Point Road) and visitor nodes (e.g. Ocean Lake, Orange Creek). The risk of spread and new incursions is very high due to the large number of vehicles visiting the island and the widely distributed campsites along the eastern beaches. Regular surveillance is required for early detection of weed invasions, and early intervention is a high priority.
4. Undertake strategic management of other ecosystem changing weeds such as *Lantana camara* (lantana) and *Sphagneticola trilobata* (Singapore daisy), which have established in some foredune and adjacent communities on the east coast and have the potential to increase in abundance or spread.
5. Continue the established program to mitigate the impact of the leaf hopper *Jamella australiae* on *Pandanus tectorius* populations.
6. Develop a plan to inform the presence and distribution of any remaining feral horses and plan to remove them from the island. Feral horses were last observed on trail cameras in August 2019 and the population is currently considered to be very low. An increase in abundance will cause significant degradation to the island's natural values and impact recovery from fire.
7. Build an improved understanding of the abundance and distribution of cats, and their likely impact on significant species within post-fire landscapes, and determine appropriate actions for strategic control.
8. Monitor impacts of feral pigs and undertake strategic control. Feral pig density and ecological impact on the island remain low, presumably due to predation pressure from dingoes. Feral pigs have been recorded swimming to the island from the mainland. While eradication may not be feasible, monitoring for increased pig activity, particularly in ecologically sensitive areas such as wetlands, and targeted control are important management activities to assist bushfire recovery.
9. Continue to monitor for increased biosecurity risk from pathogens such as *Phytophthora* and myrtle rust; the latter favours new growth which is common post-fire. A collaborative project with Biosecurity Queensland and Butchulla Aboriginal Corporation is reviewing post-fire myrtle rust impacts.

Fire management

1. Review the K'gari fire strategy and re-focus implementation with consideration to the Government response to the Inspector-General Emergency Management Report on the K'gari bushfires, and the recommendations arising from climate adaptation planning to be undertaken by the World Heritage Unit, QPWS, Butchulla and CSIRO. (Review to be led by CIR in consultation with Butchulla Aboriginal Corporation, the Area Fire Management Group led by QFES, and with support from the Pest and Fire Team, Ecological Assessment Unit and Threatened Species Operations). Aims include to minimise future widespread bushfire and impacts on life, property and world heritage values including fire-sensitive ecosystems, and re-establish a range of fire age classes appropriate to the fire-adapted ecosystems. The increased use of aerial burning is likely to be critical to achieving this goal given the large size of the island, access constraints, and importance of minimising on-ground disturbance and fragmentation of habitats.
2. Do not use firefighting agents within or adjacent closed waterbodies (e.g. perched lakes) and/or known or likely acid frog or acid fish habitat; otherwise avoid the use of firefighting agents within or adjacent to any wetland unless the risk to life, property, or environmental and cultural values of not using an agent far outweighs the benefits.
3. Do not use freshwater for fire suppression, within or adjacent to wetlands, that is likely to pose a biosecurity risk (e.g. introduction of aquatic weeds, spread of feral fish such as *Gambusia holbrooki* mosquitofish and cane toads), unless the risk to life, property, or environmental and cultural values of not using it far outweighs the benefits.
4. Do not use seawater for fire suppression within or adjacent freshwater systems, particularly closed waterbodies, unless the risk to life, property, or environmental and cultural values of not using it far outweighs the benefits. Its use would increase conductivity and potentially alter pH and so pose a significant risk to species that are adapted to living in very low conductivity (low salinity), acid environments.

Visitor management

1. Implement actions to avert recreational use/ access to recovering ecosystems, to minimise the risk of erosion and weed spread, particularly areas of burnt foredune complex.

Assessment, monitoring and research

1. Undertake Health Checks (Melzer *et al.* 2019). These facilitate early detection of weeds and assess impacts of recreation, feral horses and feral pigs. They enable the condition of key natural values to be evaluated across the park and through time to inform management.
2. Establish long-term vegetation and wetland condition monitoring (Wetland Condition Assessment Tool – WetCAT - due for release in 2021), to build more detailed (quantitative) understanding of the condition of ecosystems over time, and better understanding of trends and causal relationships, to inform management. Use historic monitoring sites where it is possible and appropriate to do so.
3. Encourage further research to build understanding of the impacts of fires on the wetland systems, including on water quality and species composition.
4. Monitor severely impacted sites that appear to have fundamentally changed as a consequence of cumulative impacts of a drying climate and bushfires (e.g. Yidney Lake and Yidney North Swamp), so as to build understanding of cause and effect and to guide their future management.
5. Investigate feasibility of using LiDAR technology to create fine scale mapping of bushfire affected areas of the foredune complex, to monitor recovery and ongoing impacts, and assess changes to the landscape from erosion (water, wind and recreational use) and the extent and geometry of sand blows.
6. Expand and/or implement survey and monitoring for key flora and fauna species occurring in fire prone/ fire-adapted ecosystems (e.g. *Acacia baueri* subsp. *baueri*, 'acid' frogs, fish and crayfish, ground parrot, black-breasted button quail) to better inform management of species and their habitat.
7. Undertake a survey of the lakes and wetlands through the centre of the island to determine where *Rhinella marina* (cane toad) successfully breed, to inform a strategic control program.
8. Undertake an ecological survey of the northern window lakes given limited pre-fire information and inaccessibility at the time of the post-fire assessment.

6.1 Limitations

This report focuses on a single fire event and we recognise that the response/recovery of ecosystems and species will vary depending on fire history and future fire and climate. For many species, information on their fire ecology is lacking or poorly known. The direct impact from fire, post-fire response and recovery potential will vary widely among sites and species. For example, for many plant species the above-ground part of the plant is killed by the

fire but may recover by resprouting from the base or rootstock (e.g. many sedges and shrubs), or above-ground parts of the plant are scorched, and recovery is from epicormic (i.e. along the trunk and branches) resprouting (e.g. eucalypts). However, much regeneration will be from seed. For those species dependent upon basal resprouting or seed, recovery may take several years in fire-adapted communities to decades in fire-sensitive communities. In our assessment of the potential ecological impact of the fire we assumed that impacts to ecosystems dominated by fire-adapted vegetation types were likely to be relatively lower and of shorter duration than impacts to fire-sensitive communities, based on known and assumed species and ecosystem fire response. The effects of fire on many faunal species are not known or poorly understood.

While our field evaluation had good geographic coverage of the impacted area, it occurred within a few months post-fire, it's focus was on reviewing the extent and severity mapping of the fire and was limited to qualitative visual assessments of severity and impact. Some areas of interest were not assessed due to access constraints (e.g. remote areas of rainforest mapped as fire impacted, window lakes).

Mapping of Regional Ecosystems, Broad Vegetation Groups and fire severity underpin our assessment. All mapping has limitations of scale, resolution and accuracy. Limitations of the fire severity mapping are described in section 4.1 but the most significant issues potentially affecting our assessment was a) the time between pre- and post-fire satellite imagery, b) the presence of clouds on images and c) difficulties in detecting low intensity fire in communities with a tall and dense canopy/subcanopy. Fire severity refers to an observable effect on vegetation irrespective of fire intensity (the energy output of a fire) and in our mapping is a measure of the change in canopy and or subcanopy. Thus, a low intensity fire in some vegetation communities (e.g. sedgelands) can result in high fire severity (complete removal of standing vegetation) but a fire of the same intensity in an open forest can result in low fire severity (complete removal of the grassy understorey, with no scorching or consumption of shrub or canopy layers). In herbaceous or other communities with a low canopy height, the fire severity mapping won't effectively distinguish areas of differing fire intensities, with a tendency to classify a greater proportion of areas to high or extreme severity. Our mapping of Potential Ecological Impact integrates Regional Ecosystem and fire severity mapping and is based on our interpretation of the relative fire sensitivity or tolerance of vegetation communities with consideration of the differences in fire severity mapping between wooded and herbaceous communities (or other communities with a low canopy height).

The limitations outlined here are unlikely to affect recommended post-fire management actions. Local-scale knowledge of park managers during implementation of on-ground recovery programs will help ensure effective conservation outcomes.

6.2 Impact assessment and recovery actions

Refer to Appendices 2 and 3 for details of the area impacted within each fire severity class by Regional Ecosystem and Broad Vegetation Group, respectively.

Note that streamlines have been mapped, and are included below, as part of the regional ecosystem in which they occur.

6.2.1 NV1: Foredune Complex

Potential Ecological Impact: mostly catastrophic, high and moderate impact.

Fire severity and impact photographs are provided in Appendix 1, Plates 1-1 to 1-13.

Recommended recovery actions:

1. Review the K'gari fire strategy to minimise the risk of fire impact, and in particular incursion by unplanned fires.
2. Continue efforts to eradicate *Chrysanthemoides monilifera* subspecies *rotundata*, (bitou bush) from K'gari, with an increased focus on burnt foredune areas that are particularly prone to invasion.
3. Increase monitoring and act to prevent the establishment of ecosystem changing weeds. The burnt areas of this natural value are particularly at risk. There are numerous potential sources of ecosystem changing weeds, such as high biomass grasses, that will require a proactive focus. Some are already established around the island's townships and along high-use visitor routes. The risk of spread and new incursions along the eastern beaches is very high due to the large number of visiting vehicles and the widely distributed campsites. Regular surveillance is required for early detection and early intervention is a high priority.
4. Implement strategic management of other ecosystem changing weeds such as *Lantana camara* (lantana) and *Sphagneticola trilobata* (Singapore daisy), which have established in some foredune and adjacent communities on the east coast and have the potential to increase in abundance or spread.
5. Continue to manage the impact of the leaf hopper *Jamella australiae* on *Pandanus tectorius* populations.
6. Prevent inappropriate recreational use in the burnt foredunes, to minimise the risk of erosion and weed spread.
7. Undertake Health Checks – these will facilitate early detection of weeds and enable the condition of key natural values to be evaluated across the park.
8. Establish long-term vegetation monitoring across the foredune complex to build understanding of the rate and direction of recovery. Use historic monitoring sites where it is possible and appropriate to do so.
9. Consider using LiDAR technology to create fine scale mapping of burnt areas of the foredune complex, to monitor recovery and ongoing impacts, and assess changes to the landscape from erosion (water, wind and recreational use) and the extent and geometry of sand blows.
10. Undertake survey and monitoring for the Vulnerable black-breasted button quail.

Overview of value and impact

This value is primarily comprised of BVG 28a – RE 12.2.14 (Biodiversity status – no concern at present): *Spinifex sericeus* (beach spinifex) grasslands on strand, *Casuarina equisetifolia* (coastal casuarina) low woodland to open forest on foredunes together with a complex patchwork of *Banksia integrifolia, Acacia* spp., *Pandanus tectorius, Corymbia tessellaris* (Moreton Bay ash) and vineforest species such as *Cyclophyllum coprosmoides* (coast canthium) and *Acronychia imperforata* (beach acronychia). The community also occurs on exposed parts of dunes extending inland. Patches of *Casuarina glauca* are present in places on low frontal dunes on the west coast. Sand blows (BVG 28d – RE 12.2.16; Biodiversity status – Of concern), which are largely devoid of vegetation, are a feature on the east coast.

About 8,265ha or 55% of the total extent of foredune complex within protected areas on K'gari was impacted. Of the impacted areas of this community approximately 34% (2 791ha) experienced low, 32% (2,604ha) moderate, 24% (1,996ha) high, and 11% (904ha) extreme, fire severity. (Appendix 2)

Of the natural values of K'gari, the foredune complex has the greatest Potential Ecological Impact from the fire, due to the proportion of this community on the island that burnt, fire sensitivity of some components of this community, the extent of moderate to extreme fire severity, and threats to its recovery. Nearly 5 500ha of this community have PEI of high to catastrophic.

While there are fire-adapted species within these communities there are some dominant species and communities that are highly fire-sensitive – in particular the *Casuarina equisetifolia* woodlands/open forests for which the aim is to always exclude fire. *Casuarina equisetifolia* is typically killed even by low intensity fire. It does not recover from canopy or soil-stored seed – seedlings are absent or rare after fire – and none were observed in impacted areas

during the assessment. Fire killed *Casuarina glauca* were common in some areas of the west coast, but in contrast, abundant seedling germination was present in some, but not all, sites. *Pandanus tectorius*, a feature in the foredune complex is also highly fire sensitive.

Even fire-adapted species were significantly impacted across areas burnt with extreme and high fire severity. For example, patches of *Corymbia tessellaris* woodland were found where almost all the trees appeared to be dead (Plate 1-7a) with but a few resprouting from the base. In contrast, in the same small patch of woodland, there were *Lophostemon suaveolens* (swamp box) which were resprouting epicormically and from the base, with some basal shoots flowering (Plates 1-7b & c). *Banksia integrifolia*, which unlike *B. aemula*, does not have canopy stored seed was showing some recovery via basal resprouts in highly impacted areas. Resprouting from rootstock and the base was common to abundant in the case of some *Acacia* spp., together with seedlings. Some vineforest species such as *Cyclophyllum coprosmoides* and *Acronychia imperforata*, were resprouting from the base and/or epicormic shoots. Resprouting from rootstock was prolific in the case of *Austromyrtus dulcis* (midgen berry) (Plate 1-8c). Resprouting from rootstock and the base of trees and shrubs will play a significant role in soil stabilisation in the immediate post-fire environment in many sites. Herbaceous species, that recover from rhizomes or bulbs, such as *Pteridium esculentum* (bracken fern), *Dianella caerulea* (blue flax-lily) and *Zoysia macrantha* (prickly couch) were common to abundant in places and will also be important in soil stabilisation.

This complex of communities plays a vital role in stabilising dunes. Sand slips were occurring on some steep frontal dunes prior to the fire, presumably due to the prolonged dry. Erosion is likely to be exacerbated by the fire.

The community is susceptible to invasion from the ecosystem changing weed *Chrysanthemoides monilifera* subspecies *rotundata* (bitou bush), which is the subject of an ongoing eradication program (Behrendorff *et al.* 2019). Other ecosystem changing weeds such as *Sphagneticola trilobata* (Singapore daisy) and *Lantana camara* (lantana) are already established in parts of this community and may increase in abundance or spread due to the fire. Invasion by additional ecosystem changing weeds such as high biomass grasses, is a significant risk, as some are already established around the island's townships and along high-use visitor routes (e.g. Moon Point Road). The risk of new incursions is exacerbated in this community due to the large number of vehicles visiting along the foreshores and the widely distributed campsites along the eastern beaches. Regular surveillance is required for early detection of weed incursions, and early intervention is a high priority.

Extensive areas of foredune complex along the eastern beach north of Happy Valley, had been significantly impacted by fire in 2013. Parts of that area that did not burn during the current fire event provide valuable insights into the post-fire recovery of this community. Seven years post-fire significant areas show little sign of recovering (Plates 1-9, 1-10).

This community is known or likely habitat for the following significant species: *Esacus magnirostris* (beach stone-curlew), *Calyptorhynchus lathami lathami* (glossy black cockatoo), *Pandion cristatus* (eastern osprey – nesting habitat), *Turnix melanogaster* (black-breasted button-quail), *Potorous tridactylus tridactylus* (long-nosed potoroo), *Acanthophis antarcticus* (common death adder), *Anilios silvia* (striped blind snake) and the four acid or wallum frogs.

6.2.2 NV2: Beach ridge communities

Potential Ecological Impact: mostly none to limited and moderate.

Recommended recovery actions:

1. Review the K'gari fire strategy and re-focus implementation to minimise the risk of fire impact, and in particular incursion by unplanned fires.
2. Increase monitoring and act to prevent the establishment of ecosystem changing weeds in the bushfire area, in particular high biomass grasses.
3. Undertake strategic management of *Lantana camara* (lantana).

Overview of value and impact

The value is comprised of BVG 9f – RE 12.2.11 (Biodiversity status – no concern at present): *Corymbia tessellaris* ± *Eucalyptus tereticornis, C. intermedia* and *Livistona* decora woodland on beach ridges.

In general the recommendation is to avoid burning the community and to burn surrounding ecosystems under conditions that minimise fire penetrating it. This is because environmental conditions and triggers other than fire are thought to maintain a healthy ecosystem, including the balance of fire-adapted and non fire-adapted species and because fire, in some circumstances, increases the risk of invasion by *Lantana camara* and high biomass grasses such as *Megathyrsus maximus* var. *pubiglumis* (green panic) and *Megathyrsus maximus* var. *maximus* (Guinea grass). It is recognised that judicious planned burning may be appropriate in some situations depending on the local topographic context and species composition. For example, the community may provide habitat for the Vulnerable *Acacia baueri* subsp. *baueri,* thought to be an obligate seeder (Benwell 1998, Halford 1998) and likely to benefit for relatively frequent fire (Conroy 2012).

About 464ha or 69% of the total extent of beach ridge communities within protected areas on K'gari were impacted by the fire. Of the impacted areas of this community approximately 39% (180ha) experienced low, 35% (161ha) moderate, 24% (112ha) high, and 2% (11ha) extreme, fire severity. More than a quarter of the area impacted has a PEI of high to catastrophic.

6.2.3 NV3: *Banksia aemula* low open woodland on dunes and sand plains

Potential Ecological Impact: None or limited to moderate impact.

Fire severity and impact photographs are provided in Appendix 1, Plates 3-1 to 3-5.

Recommended recovery actions

1. Review K'gari fire strategy with a view to limiting the extent being burned during any one fire event (i.e. improving heterogeneity of age classes).
2. Increase monitoring and act to prevent the establishment of ecosystem changing weeds such as *Andropogon virginicus* (whiskey grass).
3. Surveillance for, and early redress of, inappropriate vehicular access.

Overview of value and impact

The *Banksia aemula* 'heathlands' (BVG 29a – RE 12.2.9; Biodiversity status – no concern at present) cover the greatest area of any of the regional ecosystems within the fire extent and represent the greatest area impacted by the fire (38,975ha, or 82% of the extent of the community within the protected areas of K'gari). Of the impacted areas of this community approximately 19% (7,496ha) experienced low, 31% (12,171ha) moderate, 38% (14,923ha) high, and 11% (4,385ha) extreme, fire severity. Given the fire-promoting characteristics of this community (e.g. continuous and elevated fine fuels, prevalence of species with volatile oils), the substantial areas of moderate to extreme fire severity is not unusual. Nevertheless, it is undesirable for such a large area of the community to be exposed to fire in a single event.

This community is highly adapted to fire with an array of mechanisms for rapid recovery and as such the Potential Ecological Impact is expected to be none or limited for 89% of the area burnt and moderate for the remainder. Regeneration (reshooting from epicormic and basal buds, rootstock and underground organs such as bulbs, germination) was underway throughout the impacted areas at the time of the assessment and full recovery is expected as there are few existing threats, apart from future fires.

Weed invasion is a minor risk in the community given the nutrient poor soils. Whiskey grass (*Andropogon virginicus*) is an exception and has been recorded on the island. Regular inspections to detect infestations early will facilitate rapid and more cost effective control.

The general opening up of the area by the fire, with a short-term reduction in vegetation cover and density could

lead to increased recreational misuse (e.g. vehicle access) and subsequent increase of erosion. Signs of inappropriate access and the creation of new tracks should be addressed early.

This community is known or likely habitat for the following significant species: *Pezoporus wallicus wallicus* (ground parrot), *Pteropus poliocephalus* (grey-headed flying-fox), *Acanthophis antarcticus* (common death adder) and the Vulnerable *Acacia baueri* subsp. *baueri.* The latter is thought to be an obligate seeder (Benwell 1998, Halford 1998) and likely to benefit for relatively frequent fire (Conroy 2012).

6.2.4 NV4: *Eucalyptus racemosa* open forest on dunes and sand plains

Potential Ecological Impact: Mostly none or limited but with areas of moderate to high.

Fire severity and impact photographs are provided in Appendix 1, Plates 4-1 to 4-5.

Recommended recovery actions

1. Review K'gari fire strategy with a view to limiting the extent being burned during any one fire event (i.e. improving heterogeneity of age classes).
2. Increase monitoring and act to prevent the establishment of ecosystem changing weeds such as *Andropogon virginicus* (whiskey grass*).*
3. Surveillance for, and early redress of, inappropriate vehicular access.

Overview of value and impact

The *Eucalyptus racemosa* (scribbly gum) open forests (BVG 9g – RE 12.2.6; Biodiversity status – no concern at present) are a prominent ecosystem in the K'gari landscape. The understorey is often shrubby, with a species composition similar to the *Banksia aemula* woodlands but herbaceous species such as *Pteridium esculentum* (bracken fern), grasses and sedges, may also be prevalent. It is habitat for the Near Threatened *Boronia rivularis* – a relatively long-lived low shrub that only regenerates post-fire from seed.

The scribbly gum open forests represent the second largest area within the fire extent and the second greatest area impacted (18,295ha, or 37% of its extent within protected areas of the island). Of the impacted areas of this community approximately 44% (8,135ha) experienced low, 36% (6,525ha) moderate, 17% (3,106ha) high, and 3% (528ha) extreme, fire severity.

The community is well adapted to fire with regeneration underway throughout the burnt areas at the time of the assessment. *Eucalyptus racemosa* seedlings were frequently encountered in burnt areas. Full recovery is expected as there are few existing threats, apart from future fires. As such, 80% of the impacted area has a Potential Ecological Impact of none or limited with 17% and 3% experiencing moderate or high PEI, respectively.

Weed invasion is a minor risk in the community given the nutrient poor soils. Whiskey grass (*Andropogon virginicus*) is an exception and has been recorded on the island. Regular inspections to detect infestations early will facilitate rapid and more cost effective control.

The general opening up of the area by the fire, with a short-term reduction in vegetation cover and density could lead to increased recreational misuse (e.g. vehicle access) and subsequent increase of erosion. Signs of inappropriate access and the creation of new tracks should be addressed early.

This community is known or likely habitat for the following significant species: *Pezoporus wallicus wallicus* (ground parrot), *Pteropus poliocephalus* (grey-headed flying-fox), *Acanthophis antarcticus* (common death adder), the Vulnerable *Acacia baueri* subsp. *baueri* (tiny wattle) and the Endangered *Macrozamia pauli-guilielmi.* The latter has not been recorded in the impacted area but does occur on K'gari. Adults of *Macrozamia pauli-guilielmi* have an underground stem from which they resprout after fire. Tiny wattle is thought to be an obligate seeder (Benwell 1998, Halford 1998) and likely to benefit for relatively frequent fire (Conroy 2012).

6.2.5 NV5: *Melaleuca quinquenervia* open forest on sand plains

Potential Ecological Impact: mostly none or limited but with some areas of moderate and high.

Fire severity and impact photographs are provided in Appendix 1, Plates 5-1 to 5-4.

Recommended recovery actions

1. Increase monitoring and act to prevent the establishment of high biomass grasses adjacent to and within the community.
2. Avoid the use of firefighting agents within or adjacent to wetlands.
3. Avoid the use of freshwater for fire suppression, within or adjacent to wetlands, that is likely to pose a biosecurity risk (e.g. introduction of aquatic weeds, spread of feral fish such as *Gambusia holbrooki* mosquitofish and cane toads).
4. Avoid the use of seawater for fire suppression within or adjacent to wetlands.

The value is comprised of BVG 22a – RE 12.2.7, *Melaleuca quinquenervia,* or rarely *M. dealbata,* open forest on sand plains (Biodiversity status - no concern at present).

Approximately 2,515ha was impacted, representing 58% of the area on estate. Of the impacted areas of this community approximately 46% (1,147ha) experienced low, 31% (770ha) moderate, 17% (418ha) high, and 7% (180ha) extreme, fire severity. Abundant regeneration of herbaceous native species was present at sites visited.

The community is well adapted to fire with the dominant species regenerating vegetatively and via seedlings. Approximately 76% of the impacted area has a Potential Ecological Impact of none or limited with 17% and 7% experiencing moderate and high PEI, respectively.

The only site of concern from the assessment is Orange Creek (Plate 5-4). Here, there was substantial death of *Melaleuca quinquenervia* that appeared to be caused by a combination of waterlogging, increased salinity and fire. Weeds, including *Megathyrsus maximus* var. *pubiglumis* (green panic) were common in the area.

These wetlands are potential habitat for the Endangered *Phaius australis* (swamp orchid) – a perennial orchid that resprouts after fire and Near Threatened *Boronia rivularis* (Wide Bay boronia)*.* The latter is a relative long-lived species and an obligate seed regenerator. Fire is considered important for its regeneration, but frequent fire would prevent plants reaching maturity and setting seed for the next generation (Wang 1997).

6.2.6 NV6: Closed sedgelands

Potential Ecological Impact: mostly none or limited but with substantial area of moderate.

Fire severity and impact photographs are provided in Appendix 1, Plates 6-1 to 6-8.

Recommended recovery actions

1. Review the K'gari fire strategy with a view to limiting the extent of this community being burned during any one fire event (i.e. improving heterogeneity of age classes) and to minimise the risk of fire encroachment when peat is dry.
2. Improve the process for fire severity mapping to better detect areas that experience peat engagement.
3. Undertake Health Checks and wetland condition monitoring – these will facilitate early detection of a decline in condition and early response.
4. Establish long-term vegetation monitoring plots, including burnt and comparative unburnt sites.
5. Undertake surveys and monitoring of key significant species (e.g. fish and crayfish surveys, acoustic monitoring of threatened frogs and ground parrot) to assess effects of the fire and inform future management.
6. Undertake a survey of these wetlands to determine if and where *Rhinella marina* (cane toad) successfully breed, to inform a strategic control program.
7. Build an improved understanding of the abundance and distribution of cats, and their likely impact on significant species (e.g. *Pezoporus wallicus wallicus* ground parrot, *Potorous tridactylus tridactylus* long-nosed potoroo) during the period these ecosystems take to recover their vegetation cover, and determine appropriate action for strategic control.
8. Do not use firefighting agents within or adjacent to these wetlands unless the risk to life, property, or environmental and cultural values of not using it far outweighs the benefits..
9. Do not use freshwater for fire suppression, within or adjacent to these wetlands, that is likely to pose a biosecurity risk (e.g. introduction of aquatic weeds, spread of feral fish such as *Gambusia holbrooki* mosquitofish and cane toads) unless the risk to life, property, or environmental and cultural values of not using it far outweighs the benefits.
10. Do not use seawater for fire suppression within or adjacent to these wetlands unless the risk to life, property, or environmental and cultural values of not using it far outweighs the benefits. Its use would increase conductivity and potentially alter pH and so pose a significant risk to species that are adapted to living in very low conductivity (low salinity), acid environments.

This value consists of BVG 34c – RE 12.2.15 and 12.2.15g (Biodiversity status – no concern at present), swamps variously dominated by sedges and rushes including *Gahnia sieberiana* (sword sedge), *Empodisma minus* (spreading rope rush), *Machaerina* spp. (previously *Baumea* spp.) and *Lepironia articulata* – the latter usually being in standing water. Shrubs including *Banksia robur* (swamp banksia) and *Leptospermum liversidgei* (swamp may) are common to abundant in some parts of this regional ecosystem and sub-RE; such areas are often referred to as 'wet heaths'. Ferns such as *Blechnum indicum* (swamp water fern) and *Gleichenia dicarpa* (pouched coral fern) are abundant in areas, particularly on the margins. Freshwater streams run through some of the wetlands and are included in this value.

For RE 12.2.15, 4,490ha or 46% of its extent on K'gari was impacted. Of the impacted areas of this community approximately 22% (1 012ha) experienced low, 25% (1,103ha) moderate, 38% (1,732ha) high, and 14% (643ha) extreme, fire severity.

For RE 12.2.15g, 629ha or 85% of its extent on K'gari was impacted. Of the impacted areas of this community approximately 4% (25ha) experienced low, 20% (125ha) moderate, 68% (426ha) high, and 8% (52ha) extreme, fire severity.

Sub-RE 12.2.15g includes the 'patterned fens' – the patterning due to pools or channels of water contained within ridges of peat and living vegetation. Twenty fen complexes, covering about 521 ha have been identified across the Great Sandy area (i.e. K'gari and the adjacent Cooloola area), with the Moon Point fens among the largest of them and those at Wathumba being the northernmost (Moss *et al*. 2013). The patterned fens in the Great Sandy area are unique outside the northern hemisphere. Detailed accounts of the wetlands, and patterned fens specifically, are available (e.g. Fairfax *et al.* 2011, Moss *et al*. 2012 and 2013).

The sedgelands are highly adapted to fire. Charcoal analysis of sediment cores from the fens indicate that they have remained stable in the face of significant changes in fire regimes over thousands of years (Moss *et al.* 2012 and 2013). *Empodisma minus* – the primary species responsible for the development of the peat, being the biggest contributor in terms of biomass – plays a critical role in the protection of the fens from fire damage with its living rhizomes covering the surface, helping to protect the base of the fen and facilitate regeneration (Moss *et al*. 2013).

Fire is critical to the ecology of the sedgelands, providing opportunity for less dominant species to persist, promoting flowering in some species, maintaining open pools and channels, and likely helping to maintain the extent of the sedgelands by minimising establishment of species from adjacent woodlands (Stewart *et al*. 2020).

So although a substantial proportion of the impacted areas experienced moderate, high and extreme fire severity, the Potential Ecological Impact is expected to be limited or none (86%) to moderate (14%); except where peat fires have occurred (discussed below and in Box 2). At the time of the assessment there was substantial vegetative and seedling regeneration (Plate 6-8c & d) in many sites including a return of 100% cover of sedges and rushes in some (Plates 6-4, 6-7), and flowering in a range of species including *Drosera binata* (forked sundew)*, Hibbertia salicifolia, Stylidium* spp. (trigger plants) and *Burmannia disticha* (Plates 6-2, 6-4). Weed invasion is a low risk in these ecosystems due to their low nutrient status and highly acidic soil and water.

The Endangered *Blandfordia grandiflora* Christmas bells has been recorded in wetlands on K'gari. It resprouts from corms and has a pulse of flowering and recruitment in the first one to two years after fire (Sandecoe 1991, Conroy 2012) with flowering declining significantly by four to five years after fire (Ramsey and Vaughton 1998). The sedgelands are also potential habitat for the Endangered *Phaius australis* (swamp orchid) – a perennial orchid that resprouts after fire and *Boronia rivularis* (Wide Bay boronia). The latter is a relative long-lived species and an obligate seed regenerator. Fire is considered important for its regeneration, but frequent fire would prevent plants reaching maturity and setting seed for the next generation (Wang 1997). The Vulnerable *Acacia baueri* subsp. *baueri* (tiny wattle) can also occur in closed sedgelands/wet heaths Tiny wattle is thought to be an obligate seeder (Benwell 1998, Halford 1998) and likely to benefit for relatively frequent fire (Conroy 2012).

These sedgelands are also critical habitat for a range of significant fauna species, including some endemic to the wallum of south-east Queensland and north-east New South Wales, including the 'acid frogs', 'acid fish' and the 'acid crayfish' *Cherax robustus*. All four of the acid frog species – the near-threatened *Litoria cooloolensis* (Cooloola sedgefrog) and Vulnerable *Crinia tinnula* (wallum froglet), *Litoria olongburensis* (wallum sedgefrog) and *Litoria freycineti* (wallum rocketfrog), occur in these ecosystems on K'gari. Limited research supports the hypothesis that these species are well adapted to fire (Lowe *et al.* 2013) and all were recorded opportunistically within regenerating wetlands during our field assessments. Several significant fish species occur in these wetlands on K'gari including the threatened (listed as Vulnerable) 'acid fish' *Nannoperca oxleyana* (Oxleyan pygmy perch) and *Pseudomugil mellis* (honey blue eye). Juvenile crayfish (*Cherax* sp.) were found in pools in a burnt fen (Plate 6-6a) and the fresh remains (i.e. post-fire) of adults were found at a number of the impacted wetlands visited during the assessment. Some of these had clearly been predated or scavenged. Within the impacted landscapes visited during the field assessment, water quality appeared to be high (not turbid, but very darkly tannin stained as is typical of these systems) and of low pH (e.g. 4.12 in the fens near Moon Point). Impacts on water quality or chemistry from the fire is likely to be transient, and so is not expected to impact aquatic biota in the long-term.

The wet heaths also provide critical habitat for the Vulnerable ground parrot (*Pezoporus wallicus wallicus*). In studies of Queensland populations abundance of this species peaks at five to eight years post-fire (McFarland 1991). The species is potentially vulnerable to predation by feral cats within early stage regeneration post-fire. There has been extensive fire within the core habitat of this species in south-east Queensland during the 2019 and 2020 fire seasons (e.g. Noosa, southern Cooloola, southern K'gari, and the current K'gari fire), heightening concerns for this species in the short-term. Protection of unburnt wet and dry heath patches on K'gari and northern Cooloola from fire for the next few years, to allow habitat and populations to recover, may be warranted.

While the outlook for the sedgelands is generally positive there were some areas of burnt peat. These were too small to distinguish using satellite imagery. They were mostly on the higher margins of the swamps or in parts of small swamps that had likely been very dry (based on unburnt but dry, hayed-off, sedges within the same swamp) at the time of the fire. Here, recovery will be delayed as root systems have been killed or significantly damaged, including of dominant species such as *Banksia robur* and *Gahnia sieberiana,* and the soil seed-bank destroyed (Plates 6-3, 6-8b). Many species of small vertebrates (e.g. acid frogs) and invertebrates probably seek shelter during the fire or live within burrows in peat (e.g. crayfish and *Petalura* litorea coastal petaltail, a rare dragonfly which has very long-lived terrestrial larvae), so peat fires may cause significant mortality for those species and long-term loss of habitat.

With climate change and expected drier conditions it is possible, particularly where fires result in the loss of peat and associated wetland species, that the environment on the margins of these sites may become more suitable for surrounding woodland ecosystems than for sedgeland. The most significant areas of peat fire observed during the field assessment were at Yidney Lake and a nearby wetland and are discussed in Box 2.

The fire severity and Potential Ecological Impact on the closed sedgelands raises few concerns, however, the extent that has been impacted in the fire event is of concern, particularly for species, such as the ground parrot. Establishing a diversity of age classes within the wet heaths and surrounding ecosystems may reduce the risk of future extensive, high severity fires. It is likely that an increased use of aerial ignition will be required to achieve this given on-ground access constraints.

The closed sedgelands are adapted to nutrient poor conditions and low pH, and as noted above, are habitat for a number of significant amphibian and fish species. Firefighting foams, gels and retardants should not be used in or near these communities. Likewise the use of foreign freshwater (e.g. sourced from dams on the mainland) should be avoided in these wetlands and adjacent areas due to biosecurity concerns (e.g. introduction of aquatic weeds, spread of feral fish such as *Gambusia holbrooki* mosquitofish).

Cane toads (*Rhinella marina*) are unlikely to establish in these communities due to the dense vegetation and low pH. However, immediate post-fire conditions on the margins of these wetlands may suit toads.

Box 2. Peat fire in Yidney Lake and nearby wetland

Plates 6-9 to 6-11

Despite the name, Yidney Lake together with the nearby unnamed wetland (referred to here as Yidney North Swamp), is a palustrine (i.e. swamp - RE 12.2.15) rather than lacustrine (i.e. lake) wetland. Both wetlands incurred significant impacts from the fire. It was not possible, for the current assessment, to explore likely impacts of previous fires on these two wetlands and hence possible cumulative impacts through time.

It is evident from the on-ground inspection both wetlands have been sufficiently dry for sufficiently long periods to allow the establishment of saplings in Yidney Lake, and small trees in Yidney North Swamp. These appear to be predominantly *Eucalyptus tereticornis* and *Lophostemon suaveolens* in the latter but include *Melaleuca* (presumably *M. quinquenervia*) in the case of Yidney Lake. Based on the stem density in Yidney North Swamp, the vegetation prior to the fire could reasonably have been classified as eucalypt open forest.

There has been sufficient moisture to allow the persistence of rushes and sedges including *Gahnia sieberiana* in Yidney Lake, however there was no evidence of *Empodisma minus* (the main peat-generating species in these systems). Rushes and sedges were also present in the Yidney North Swamp, however there was no evidence of *G. sieberiana* or *E. minus*. The 'Wetlands Insight Tool' (https://wetlandinfo.des.qld.bov.au/wetlands/facts-maps/wetland-background/insight.html), which summaries the amount of water, green vegetation, dry vegetation and bare soil over time in individual wetlands, shows that Yidney Lake has not had a significant body of open water since 1992 (77.5%) and September 2000 (49.6%). Since September 2000 open water was detected twice – December 2004 (6.8%) and August 2016 (0.8%). Adventitious roots (Plate 6-9b) on small *Melaleuca* in Yidney Lake are likely to date back to at least the wet event reflected in the September 2000 record. No open water has been detected in Yidney North Swamp since January 1992 (80.5%) and October 1992 (48.1%).

Both wetlands were sufficiently dry to incur peat burning during the 2020 fire with significant impact on the soil composition and structure, and associated significant impact on the canopy and understorey species. Many small trees have toppled over in the Yidney North Swamp, not due to an intense above ground fire (char heights were typically very low), but due to the roots being burnt or killed. Toppling probably mostly occurred well after the fire as fallen trunks mostly lacked char.

It seems unlikely that these wetlands will return to sedgeland-dominated systems, particularly given the pattern of observed flooding in recent times, predicted climate change and the lack of peat-generating plants, although some sedges and rushes were resprouting. *Eucalyptus tereticornis* seedlings have germinated en masse (a count in a 50x50cm quadrat yielded approximately 100) on the margins of Yidney Lake (Plate 6-10a) and were common in the lakebed at the time of the assessment (Plate 6-10b). Seedlings of other woody species, including *Acacia* sp., were also present in the lakebed (Plate 6-10c). There was some limited basal resprouting in *Lophostemon suaveolens* and *Euc. tereticornis* in Yidney North Swamp and seedlings of the latter were common to abundant; *Acacia* seedlings were occasional to common.

6.2.7 NV7: Lakes – window and perched

Potential Ecological Impact: majority none or limited impact; small areas of moderate to high.

Fire severity and impact photographs are provided in Appendix 1, Plates 7-1 to 7-3.

Recommended recovery actions

1. Control ecosystem changing pest plants, in particular high biomass grasses, where they occur (visitor nodes).
2. Establish ongoing monitoring of the condition of the lakes to provide a baseline against which to monitor impacts from fire in adjacent ecosystems.
3. Undertake Health Checks and wetland condition assessments – these will facilitate early detection of weeds and impacts from visitation and feral animals and enable condition to be evaluated across the park. Window lakes in the northern extent of the fire were not visited during our field work so assessment of these is a priority.
4. Undertake a survey of lakes to determine if and where *Rhinella marina* (cane toad) successfully breed, to inform a strategic control program.
5. Do not use firefighting agents within or adjacent to these wetlands.
6. Do not use freshwater for fire suppression, within or adjacent to wetlands, that is likely to pose a biosecurity risk (e.g. introduction of aquatic weeds, spread of feral fish such as *Gambusia holbrooki* mosquitofish and cane toads).
7. Do not use seawater for fire suppression within or adjacent to these wetlands.
8. Undertake and ecological survey of the northern window lakes given limited pre-fire information and inaccessibility at the time of the post-fire assessment.

This value includes permanent and semi-permanent window (RE 12.2.15a) and perched (RE 12.2.15f) lakes and their associated fringing vegetation, in BVG 34a. The Biodiversity Status is no concern at present.

Most lakes within the extent of the fire were either not impacted or had patches of fringing vegetation impacted by the fire. A total of 157ha or 14% of its extent on K'gari was impacted. Of these impacted areas, 66% (104ha), 21% (33ha), 11% (17ha) and 2% (3.4ha) experienced low, moderate, high and extreme fire severity, respectively. Vegetation in the impacted areas was recovering well at the time of the assessment. The Potential Ecological Impact is expected to be none or limited for 87% of the impacted area and moderate or high for the remaining 11% and 2%, respectively. There is a small risk of weed spread and establishment into burnt areas of fringing vegetation at high visitation nodes such as Ocean Lake.

Some catchments of perched lakes were extensively impacted by fire and with significant areas of high to extreme severity. The low nutrient status of the sands of these catchments and the fact that most water flowing into these lakes is via shallow aquifers rather than overland flow, probably protects these lakes from significant changes in water quality and chemistry.

Various fish, frog, turtle, bird and invertebrate species depend on the lakes of K'gari including the Vulnerable *Pseudomugil mellis* (honey blue eye) and Near Threatened or Vulnerable acid frogs. Long-term impacts from the fire to populations of these species in the lakes is unlikely.

Cane toads (*Rhinella marina*) are known to breed in some lakes on K'gari, and during field assessments we recorded recently metamorphosed toads at Ocean Lake and Lake Bowarrady (and previously at Basin Lake). The fire may make conditions more suitable for toads to breed in these lakes in the short-term, through opening up vegetation around the margins and possibly through short-term changes in water chemistry (e.g. slight increases in pH). Toads don't appear to have established widely in the central areas of K'gari so there may be opportunities to strategically control this species at readily accessible lakes. However, surveys are required to inform this.

6.2.8 NV8: Mangroves and saltmarsh

Potential Ecological Impact: mostly none or limited impact; small areas of moderate; very small areas of high and catastrophic.

Recommended recovery actions

1. Review strategies for fire management in adjacent fire-adapted communities; aim to reduce the risk of future fire impacts.
2. Establish monitoring plots in burnt sites to examine the rate and direction of recovery.

The value includes BVG 35a – RE12.1.3: mangrove shrubland to low closed forest on marine clay plains and estuaries (Biodiversity status – no concern at present) and; BVG 35b – RE12.1.2: saltpan vegetation including grassland, herbland and sedgeland on marine clay plains (Biodiversity status – no concern at present).

Approximately 122ha, 4.3% of mangroves and saltmarsh within protected areas of K'gari were impacted by the fire, with 82% (100ha) experiencing low severity fire and 17% (21ha) and 0.6% (0.8ha) experiencing moderate or high fire severity, respectively. The Potential Ecological Impact is expected to be none or limited for 57% (69ha), moderate for 36% (44ha), high for 7% (8ha) and catastrophic for 0.3% (0.4ha) – the latter being restricted to mangroves.

Mangroves are not fire tolerant. Saltmarsh vegetation is typically not targeted for burning and is often too sparse to carry fire. An exception is some *Sporobolus virginicus* grasslands. The latter are occasionally burnt in grazing lands to promote new growth and they generally recover well providing they are not grazed by stock too early in the recovery phase or when too wet. Impacts from fire in these grasslands on K'gari are probably therefore minor.

Mangroves and saltmarshes are core habitat for the Vulnerable *Xeromys myoides* (water mouse). Given the relatively small area of mangroves and saltmarshes impacted, and the extensive mangrove and saltmarsh communities on K'gari, it is unlikely that the water mouse will be significantly affected.

Mangroves also provide feeding and roosting habitat for several listed migratory waders and resident shorebirds. The Great Sandy Strait is listed as a wetland of international importance under the Ramsar Convention, the Japan–Australia Migratory Bird Agreement (JAMBA) and the China–Australia Migratory Bird Agreement (CAMBA). Shorebirds feed at low tide and roost at high tide on small patches of adjoining land, claypans, saltmarshes or sandspits, as well as sometimes in mangroves. It is unlikely that shorebirds will be significantly affected given the small area of mangroves and saltmarshes impacted, relative to the extent of these communities on K'gari, and that the burnt areas were likely mostly along the landward margin and shorebirds tend to use the seaward margin.

6.2.9 NV9: Moist to wet, open to tall open, eucalypt forests

Potential Ecological Impact: majority none or limited impact; small area of moderate and very small area of high.

Fire severity and impact photographs are provided in Appendix 1, Plates 9-1 to 9-8.

Recommended recovery actions

1. Control ecosystem changing pest plants, in particular high biomass grasses and lantana, where they occur (visitor nodes, roads such as Happy Valley to Moon Point) and increase surveillance to ensure early detection of new infestations.
2. Undertake Health Checks – these will facilitate early detection of weeds and enable condition to be evaluated across the park.
3. Re-establish long-term vegetation monitoring using, as far as possible, historic monitoring sites.
4. Build an improved understanding of cat distribution and abundance, and likely impact on fauna.

The value is comprised of:

- BVG 8a – RE 12.2.4: *Syncarpia hillii, Lophostemon confertus* tall open to closed forest on parabolic high dunes (Biodiversity status – of concern);
- BVG 8b – RE 12.2.8: *Eucalyptus pilularis* open forest on parabolic high dunes (Biodiversity status – no concern at present).

Approximately 1,110ha or 5% of this value in K'gari was impacted by the fire. Of the area impacted 57% (636ha) experienced low severity, 31% (341ha) moderate severity, 9% (104ha) high severity and 3% (29ha) extreme fire severity. There was limited impact on The Valley of the Giants.

The canopy species in these communities are fire-adapted whereas the understorey is often mixed – including rainforest species. The recommended fire regime includes fire intensities ranging from low to high with an occasional high intensity fire recognised as likely being integral to the long-term maintenance of the fire-adapted myrtaceous overstorey. The Potential Ecological Impact is therefore expected to be none or limited for 88% (979ha), moderate for 9% (104ha) and high for 3% (29ha).

Burnt out and fallen trees were encountered at some sites. Seedlings of canopy species were common to abundant where the understorey had been substantially removed, including of *Lophostemon confertus*, *Eucalyptus pilularis* and *Euc. resinifera*. Epicormic resprouting was generally abundant on canopy species in areas burnt with higher intensities. Various rainforest species were found resprouting from the base including, but not limited to, *Cryptocarya glaucescens* and *C. macdonaldii, Endiandra discolor, Neolitsea dealbata* and *Backhousia myrtifolia.* The latter had seedlings in burnt and unburnt sites – in the case of unburnt sites they were present where there was a gap in the litter layer (W.J. McDonald pers. comm.). *Macrozamia douglasi* was commonly encountered resprouting in burnt sites.

The Near Threatened plant species *Tecomanthe hillii* (Fraser Island creeper) may occur in burnt wet eucalypt forests. Its fire response is unknown, but it tends to prefer locations close to water so is less likely to have been impacted. The Vulnerable *Archidendron lovelliae* (bacon wood) also occurs in this community (during the field assessment a significant population was observed in unburnt areas near Lake Garawongera). It is a species that may require localised disturbance for germination and establishment (W.J. McDonald pers. comm.), so the fire may be beneficial.

These communities are also core habitat of the K'gari endemic *Coggeria naufragus* (satinay sand skink) (Least Concern). It appears to be a burrowing species, so may have been protected during the fire. It and/or its prey may be dependent upon leaf litter for foraging.
These ecosystems are largely free of significant weeds, although some isolated *Lantana camara* (lantana) plants were observed.

6.2.10 NV10: Rainforest

Potential Ecological Impact: Approximately 21ha was impacted by the fire, the majority is expected to experience moderate impact.

Recommended recovery actions

1. Review fire management strategies to minimise the risk of future fire incursion into rainforest, particularly given climate change.
2. Control ecosystem changing pest plants, in particular high biomass grasses and lantana, where they occur (visitor nodes, roads such as Happy Valley to Moon Point) and increase surveillance to ensure early detection of new infestations.
3. Undertake Health Checks – these will facilitate early detection and control of weeds and enable condition to be evaluated across the park.
4. Re-establish long-term vegetation monitoring using, as far as possible, historic monitoring sites.

The value includes BVG 3a – RE 12.2.3: Araucarian vine forest on parabolic high dunes (Biodiversity status – of concern) and; BVG 4a – RE 12.2.1: notophyll vine forest on parabolic high dunes (Biodiversity status – of concern).

A total of 20ha or 0.6% of the total area of this value in K'gari was impacted by the fire. Of the impacted area, approximately 65% (13ha) experienced low severity fire, 25% (5ha) moderate, 5% (1ha) high and 2% (0.4ha) extreme fire severity. Rainforests are highly fire-sensitive and the management intent is to exclude fire from them. The Potential Ecological Impact is therefore moderate for 65% (13ha), high for 25% (5ha) and catastrophic for 10% (2ha). However, the small size of the areas involved is likely to ameliorate the impact and facilitate recovery, given close proximity to sources of propagules. It is possible that additional areas of rainforest and wet sclerophyll forest have burnt at low severity, as mapping such fire where there is a tall and dense canopy unaffected by fire, is difficult.

The Vulnerable *Archidendron lovelliae* (bacon wood) and Near Threatened *Tecomanthe hillii* (Fraser Island creeper) occur in rainforest ecosystems on the island. It is unlikely that populations of threatened species have been significantly impacted given the small area of rainforest impacted.

Rainforests are typically self-protecting from fire and can usually be relied upon to stop fires; this may not be the case as climate change progresses. Considerable effort, including aerial water bombing, was expended to minimise the risk of rainforest being impacted in the current event. During our field assessment we did not locate any areas of impacted rainforest. We did observe some areas of *Syncarpia hillii* and *Eucalyptus resinifera* with a very well developed rainforest understorey that did burn at low severity, which likely provides insights into the impact of fire on rainforest. Here fire seems to have burnt at low severity and for a short duration, leaving large woody debris largely intact and not burning deep into accumulated litter. This contrasts with the 2019 fires in wet sclerophyll and rainforest communities in the Queensland sections of the Gondwana Rainforests of Australian World Heritage Area (i.e. Lamington, Main Range and Mount Barney National Parks) where low intensity fires had a long residence time, burning deep into accumulated litter and coarse woody debris, often burning out the base of large trees and causing them to die or topple.

Given the small area of rainforest burnt, the low severity experienced, the relatively small impacts observed in

adjacent wet sclerophyll forest and the lack of ecosystem changing weeds, impacts to rainforests are likely to be minor. Rainforest in the vicinity of the Valley of the Giants was not impacted.

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Appendix 1. Fire severity and impact photographs

Plate 1-1. RE 12.2.14, Platypus Bay, north of Wathumba Creek (24.942058°S 153.234384°E). Fire severity: extreme. (A. Meiklejohn 3 Feb 2021)

Plate 1-2. RE 12.2.14, foredune complex north of Rooney Point (24.808528°S 153.121638°E). Fire severity: high. (A. Meiklejohn 2 Feb 2021)

Plate 1-3 (a-d). RE 12.2.4 foredune complex, Platypus Bay, WNW of Station Hill (24.847861°S 153.184924°E). Fire severity: extreme. (A. Meiklejohn 2 Feb 2021). a-d taken N, E, S, W.

Plate 1-4. Eastern beach (in the vicinity of the Maheno): high to extreme fire severity in foredune complex. (A. Meiklejohn, Feb 2021)

Plate 1-5. Eastern beach (25.233804°S 153.252278°E): unburnt through to extreme fire severity in foredune complex. (R. Melzer, Feb 2021)

Plates 1-6 (a-c): Panaroma, looking south (from 25.257083ºS 153.241877ºE) to the wreck of the Maheno, showing patches of unburnt through to extreme fire severity within the foredune complex (R. Melzer, 9 Feb 2021) .



Plates 1–7 (a-c): *Corymbia tessellaris* and *Lophostemon suaveolens* woodland in foredune complex off eastern beach; extreme fire severity. (R. Melzer 9 Feb 2021)

a. *Corymbia tessellaris* – most appear to be dead; few resprouting from the base. Plate 1i (next page) shows *Pteridium esculentum* (bracken fern) regeneration downslope.

b. *Lophostemon suaveolens* resprouting epicormically and from the base.

c. Basal shoots on *Lophostemon suaveolens* in flower.

Plate 1-8 (a-e): Foredune complex, eastern beach, burnt with high to extreme fire severity. (R. Melzer Feb 2021)
a (above left): *Corymbia tessellaris* (most appear dead) with abundant regeneration of Pteridium esculentum (bracken fern).
b (below left): *Acacia* sp. resprouting from rootstock.
c (mid): *Austromyrtus dulcis* (midgen berry) resprouting from rootstock.
e (below right): 25.223843oS 153.257133oE

Plate 1-9. RE 12.2.14, foredune just south of South Ngkala Rocks (24.903661ºS 153.274609ºE). Fire severity: unburnt; previously burnt in 2013 and showing minimal recovery. (A. Meiklejohn 3 Feb 2021)

Plate 1-10: Frontal dune community (25.301025ºS 153.220850ºE) burnt in a previous bushfire (2013) but not burnt in the current fire. (R. Melzer, 9 Feb 2021)

Plate 1-11: Unburnt wind-sheared closed low shrubland on steep frontal dune south of The Pinnacles. (R. Melzer, 9 Feb 2021)

Plate 1-12: Unburnt strand, *Casuarina equisetifolia* and *Pandanus tectorius* on foredunes and wind-sheared closed shrubland on steep frontal dune in the background, south of Happy Valley. (R. Melzer 12 Feb 2021)

Plate 1-13. Unburnt RE 12.2.14, foredune complex, between Sandy Cape and Rooney Point (24.711733ºS 153.221318ºE). (A. Meiklejohn 2 Feb 2021)

Plate 3-1 (a, b). Background: RE 12.2.9 *Banksia aemula* low open woodland on dunes. Fire severity: extreme.
(a. R. Melzer 6 Feb 2021; b. WJ. McDonald 6 Feb 2021)

Plate 3-2. RE 12.2.9 *Banksia aemula* low open woodland on dunes between Rooney Point and Sandy Cape (24.797656ºS 153.128712ºE). Fire severity: extreme. (A. Meiklejohn 2 Feb 2021)

Plate 3-3. RE 12.2.9, *Banksia aemula* low open woodland on sand plain (25.209753oS 153.090657oE). Fire severity: high. (A. Meiklejohn 1 Feb 2021)

Plate 3-4 (a-c) *Banksia aemula* community near Moon Point. Fire severity: extreme. Epicormic resprouting is abundant on the wallum banksia; a range of woody and herbaceous species are resprouting from rootstock and underground organs such as tubers and rhizomes; seedlings present. (R. Melzer 8 Feb 2021)

3-4a Photo includes seedings of *Banksia aemula, Acacia* sp., *Ricinocarpos pinifolius* (wedding bush) and *Austromyrtus dulcis* (midgen berry) resprouting from rootstock.

3-4b Close-up of seedlings of *Acacia* sp. and *Banksia aemula*.

Plates 3-5 (a & b). Opposite sides of a track through *Banksia aemula, Corymbia intermedia* woodland. a) unburnt and b) burnt with low to moderate fire severity. (R. Melzer 8 Feb 2021).

Plate 4-1. RE 12.2.6 *Eucalyptus racemosa* open forest on dunes (25.123689oS 153.201930oE). Fire severity: moderate. (R. Melzer 11 Feb 2021)

Plate 4-2. RE 12.2.6 *Eucalyptus racemosa* low woodland, Cornwall's Road (25.406034^{o}S 153.097376^{o}E). Fire severity: moderate to high. (R. Melzer 6 Feb 2021)

Plate 4-3. RE 12.2.6 *Eucalyptus racemosa* woodland (fire severity: high to extreme). Epicormic regrowth on woody species including scribbly gum; abundant regeneration in the ground stratum including woody species, *Pteridium esculentum* (bracken fern), *Dianella* sp. (blue flax lily) and sedges. (J. Augusteyn Feb 2021)

Plate 4-4. RE 12.2.6 *Eucalyptus racemosa* open forest, Wathumba Road (24.987555°S 153.295573°E). Fire severity: extreme. (A. Meiklejohn Feb 2021)

Plate 4-5. RE 12.2.6 *Eucalyptus racemosa* open forest (24.981498°S 153.292571°E). Fire severity: high to extreme. (G. Murrell 1 Feb 2021)

Plate 5-1. RE 12.2.7 *Melaleuca quinquenervia* open forest on sand plains west of Sandy Cape (24.703045°S 153.240463°E). Fire severity: extreme. (A. Meiklejohn 2 Feb 2021)

Plate 5-2. RE 12.2.7 *Melaleuca quinquenervia, Casuarina glauca* open forest (25.197194ºS 153.014008ºE) near Moon Point. Fire severity: moderate. (R. Melzer 8 Feb 2021)

Plate 5-3. RE 12.2.7 *Melaleuca quinquenervia* open forest, Moon Point Road (25.21513ºS 153.04897ºE). Fire severity: moderate. (R. Melzer 10 Feb 2021)

Plate 5-4 (a-d). RE 12.2.7 *Melaleuca quinquenervia* open forest, Orange Creek (24.91579ºS 153.2776ºE). (R. Melzer 11 Feb 2021)

Plate 6-1 (a-c) RE 12.2.15g closed sedgelands (fen), Bullock Road (25.214066°S 153.066878°E). Fire severity: high to extreme (R. Melzer 8 Feb 2021)

Plate 6-2 (a-d) RE 12.2.15g closed sedgelands (fen), Bullock Road (25.214066°S 153.066878°E). Fire severity: high to extreme (R. Melzer 8 Feb 2021)

6-2a & b Various regenerating herbs/ sub shrubs including *Empodisma minus* (spreading rope rush), *Gleichenia dicarpa* (pouched coral fern), *Hibbertia salicifolia, Drosera binata* (forked sundew).

6-2c Tricoryne sp. in flower (yellow).

6-2d *Stylidium* sp. in flower (pink)

Plate 6-3 (a & b) RE 12.2.15g closed sedgelands (fen), Bullock Road (25.214066°S 153.066878°E). Fire severity: high to extreme. Some peat loss is evident on the higher margins of the swamp. (R. Melzer 8 Feb 2021)

Plate 6-4 (a-e) RE 12.2.15, unnamed closed sedgeland west of Lake Allom (25.193313°S 153.199862°E). Fire severity: moderate. (R. Melzer 7 Feb 2021)
Top right: *Hibbertia salicifolia* in flower. Below left: *Drosera binata.* Below mid: *Burmannia disticha.* Below right (f): *D. binata* flowering en masse (W.J. McDonald 6 Feb)

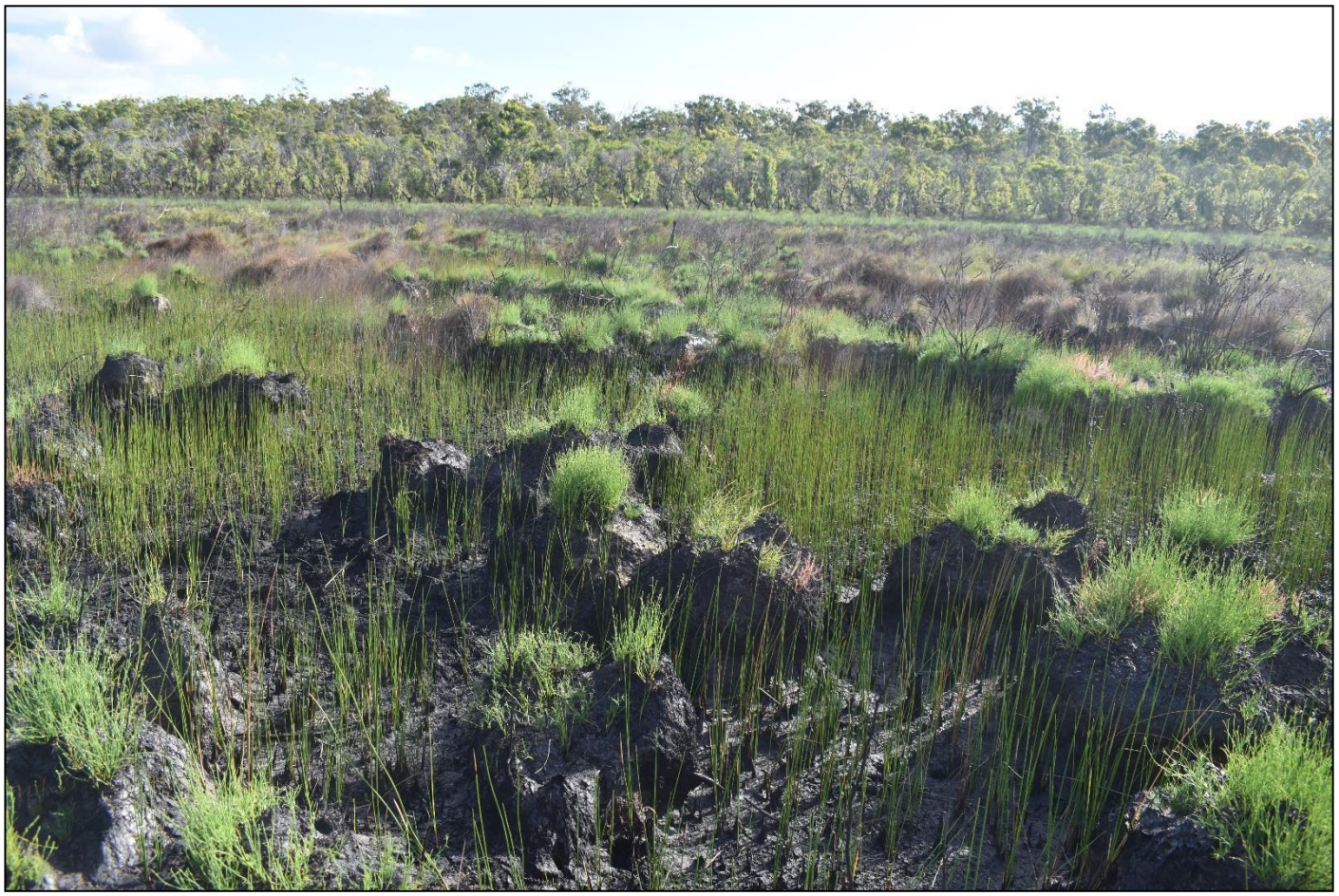

Plate 6-5 (a-c). RE 12.2.15g closed sedgelands, Bogimbah Airstrip (25.33384ºS 153.06659ºE). Fire severity: high to extreme but with scattered unburnt patches (below left). Sedges and rushes including *Empodisma minus* regenerating well from rootstock; *Drosera binata* abundant throughout (below right).

Plate 6-6 (a-d). Fauna observed in Bogimbah Airstrip sedgeland within 1-3 months post-fire.

a. Juvenile crayfish, approximately three months post-fire. (R. Melzer 10 Feb 2021)
b. *Litoria freycineti* (wallum rocketfrog), approximately one month post-fire. (A. Meiklejohn 22 Dec 2020)
c. Adult crayfish pincers unburnt, approximately three months post-fire. (R. Melzer 10 Feb 2021)
d. *Crinia tinnula* (wallum froglet). (R. Melzer 10 Feb 2021)

Plate 6-7 (a-e) RE 12.2.15 Closed sedgelands. Views across Wathumba wetland (ca. 24.942681^{o}S 153.243649^{o}E). Fire severity across the wetland was high to extreme. (R. Melzer 11 Feb 2021)

Plate 6-8 (a-d) RE 12.2.15g Closed sedgeland, Urang fen (25.29939°S 153.06049°E). Fire severity: high to extreme. (R. Melzer 11 Feb 2021)

Plate 6-8 (b) Some loss of peat on the higher margins.

Plates 6-8 (c & d) En masse seedling germination; (c – below left) is a close-up of (d – below right).

Plate 6-9 (a & b) Yidney Lake (25.320576ºS 153.186901ºE). Fire severity: extreme (moderate to high on margins). (R. Melzer 12 Feb 2021)

Plate 6-10 (a-c) Yidney Lake (25.320576ºS 153.186901ºE). Fire severity: extreme (moderate to high on margins). (R. Melzer 12 Feb 2021)

Plate 6-10 (a) Top: Yidney Lake in background. Dense *Eucalyptus tereticornis* seedlings at the inflow and around the margins and were common across the Lake.

Plate 6-10 (b) Below left: *Euc. tereticornis* seedlings in the interior of the Lake.

Plate 6-10 (c) Below right: Acacia sp. seedlings in the interior of the Lake.

Plate 6-11 (a & b) Unnamed wetland near Yidney Lake (25.314334ºS 153.188455ºE) (referred to in this report as Yidney North Swamp). Peat fire has killed and caused toppling of *Eucalyptus tereticornis* (R. Melzer 12 Feb 2021).

Plate 7-1 RE 12.2.15f perched lake, Boomerang Lake (25.227701oS 153.135673oE); fire of moderate severity in some fringing vegetation. (R. Melzer 10 Feb 2021)

Plate 7-2 Fire penetrated some of fringing vegetation (RE12.2.15) at Lake Bowarrady (RE 12.2.15f) (ca. 25.152004ºS 153.212203ºE). (R. Melzer 7 Feb 2021)

Plate 7-3 Fire (moderate severity) penetrated fringing vegetation near the day-use area at Ocean Lake (RE 12.2.15f) (24.924837°S 153.277687°E). (R. Melzer 11 Feb 2021)

Plate 9-1(left). RE 12.2.8/12.2.4 *Eucalyptus pilularis, Syncarpia hillii, Lophostemon suaveolens* tall open forest, (25.362786ºS 153.114666ºE) on Valley of the Giants Circuit track. Fire severity: low. (R. Melzer 6 Feb 2021)

Plate 9-2 (right). RE 12.2.8 *Eucalyptus pilularis* open forest near Lake Bowarrady (25.149844ºS 153.214716ºE). Fire severity: moderate. (R. Melzer 7 Feb 2021)

Plate 9-3. RE 12.2.8 *Eucalyptus pilularis* tall open forest (25.408127ºS 153.101540ºE). Fire severity: moderate. (H. Hines 6 Feb 2021)

Plate 9-4 (a & b). RE 12.2.4 *Eucalyptus pilularis, Syncarpia hillii* tall open forest, near Lake Bowarrady (25.152500°S 153.212799°E). Fire severity: moderate. (H. Hines 7 Feb 2021)

Plate 9-5. RE 12.2.4/12.2.8 *Eucalyptus pilularis, Syncarpia hillii, Lophostemon confertus* tall open forest with an understorey dominated by *Backhousia myrtifolia*, west of Lake Garawongera (25.326889°S 153.150283°E) fire severity: moderate. (H. Hines 9 Feb 2021)

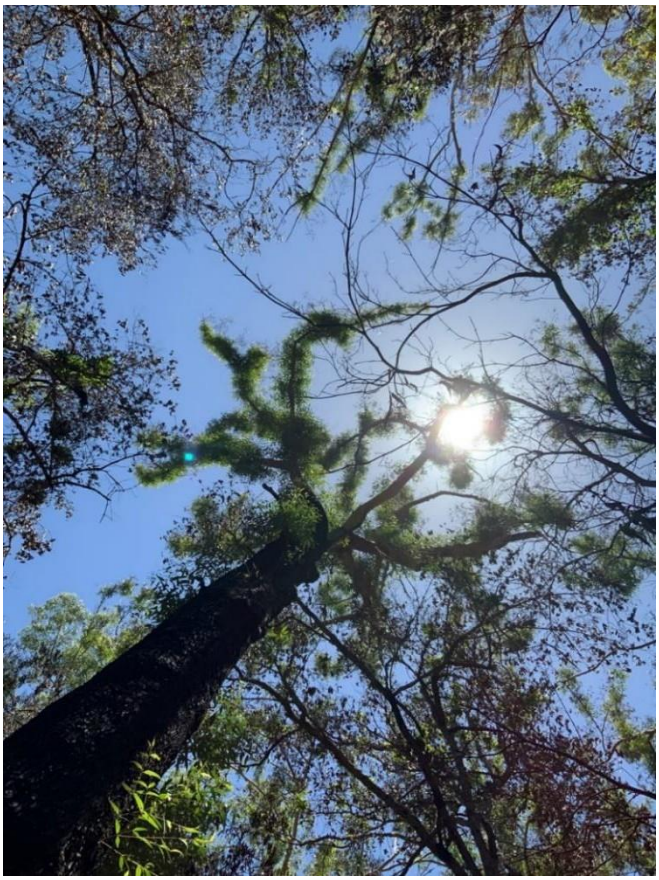

Plate 9-6 (a & b). RE 12.2.4/ 12.2.8 *Eucalyptus pilulari*
Syncarpia hilli tall open forest with upper midstratum of *Allocasuarina torulosa* (25.168175°S 153.187826°E). Fire severity: high. (R. Melzer Feb 2021)

Plate 9-7 (a & b). RE 12.2.8 *Eucalyptus pilularis* tall open forest (25.408542°S 153.090489°E). Fire severity: high. (R. Melzer Feb 2021)

Plate 9-8 (a & b). *Eucalyptus robusta* open forest on streamline within RE 12.2.4 (25.367199ºS 153.102899ºE), ground stratum dominated by *Todea barbara* with fertile, new growth post-fire. Fire severity: moderate (R. Melzer 6 Feb 2021).

Plate 10-1 (a & b). RE 12.2.3 Araucarian vine forest on parabolic high dunes, Cornwall's Road (25.408729ºS 153.101630ºE); fire penetrated the edge of the vineforest only. Fire severity: moderate. (H. Hines 6 Feb 2021)

Appendix 2. Area burnt within each fire severity class, by Regional Ecosystem, within QPWS estate.

Regional Ecosystem (RE) mapping and Broad Vegetation Groups (BVGs) as described by Neldner *et al.* (2020 & 2019b). All areas are in hectares, for RE1 (see section 4.2). Column headings are: RE1 – Regional Ecosystem identifier for RE1; RE description – brief description of RE1; Status – Biodiversity Status; BVG 2M – Broad Vegetation Group at the 1:2 000 000 scale; Tolerance – ability of community to tolerate fire (used in calculating PEI); Estate - area of RE1 within K'gari section of Great Sandy NP, Total – area of RE1 burnt within K'gari section of Great Sandy NP; Low, Moderate, High, Extreme – area of RE1 burnt at each fire severity class.

RE1	RE description	Status	Tolerance	BVG2M	Estate	Burnt	Low	Moderate	High	Extreme
12.2.3	Araucarian vine forest on parabolic high dunes	Of concern	Intolerant	3	2,297	9	6	3	0	0
12.2.1	Notophyll vine forest on parabolic high dunes	Of concern	Intolerant	4	994	11	7	2	1	0
12.2.4	Syncarpia hillii, Lophostemon confertus tall open to closed forest on parabolic high dunes	Of concern	Moderate	8	9,210	67	50	13	3	1
12.2.8	Eucalyptus pilularis open forest on parabolic high dunes	No concern at present	Moderate	8	13,961	1,042	585	327	101	29
12.2.11	Corymbia tessellaris +/- Eucalyptus tereticornis, C. intermedia and Livistona decora woodland on beach ridges in northern half of bioregion	No concern at present	Low	9	671	464	180	161	113	11
12.2.6	Eucalyptus racemosa subsp. racemosa open forest on dunes and sand plains. Usually deeply leached soils	No concern at present	Moderate	9	49,688	18,295	8,135	6,525	3,106	528
12.2.7	Melaleuca quinquenervia or rarely M. dealbata open forest on sand plains	No concern at present	Moderate	22	4,326	2,515	1,147	770	418	180
12.2.14	Foredune complex	No concern at present	Intolerant	28	15,083	8,265	2,791	2,604	1,966	904

RE1	RE description	Status	Tolerance	BVG2M	Estate	Burnt	Low	Moderate	High	Extreme
12.2.16	Sand blows largely devoid of vegetation	Of concern	Intolerant	28	4,001	50	35	10	2	2
12.2.9	Banksia aemula low open woodland on dunes and sand plains. Usually deeply leached soils	No concern at present	High	29	47,586	38,975	7,496	12,171	14,923	4,385
12.2.15	Gahnia sieberiana, Empodisma minus, Gleichenia spp. closed sedgeland in coastal swamps	No concern at present	High	34	9,656	4,490	1,012	1,103	1,732	643
12.2.15a	Permanent and semi-permanent window lakes	No concern at present	Moderate	34	340	67	52	10	4	1
12.2.15f	Permanent and semi-permanent perched lakes	No concern at present	Moderate	34	745	90	52	23	13	3
12.2.15g	Swamps dominated by Empodisma minus, Gahnia sieberiana, other sedges and forbs and shrubs such as Leptospermum liversidgei	No concern at present	High	34	744	629	25	125	426	52
12.1.2	Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains	No concern at present	Moderate	35	456	70	57	13	0	0
12.1.3	Mangrove shrubland to low closed forest on marine clay plains and estuaries	No concern at present	Intolerant	35	2,414	52	43	9	0	0
Total					**162,172**	**75,091***	**21,674**	**23,869**	**22,810**	**6,738**

* Note total excludes areas not mapped as Remnant Regional Ecosystem, hence difference from total area burnt within Great Sandy NP.

Appendix 3. Area burnt within each fire severity class, by Broad Vegetation Group, within QPWS estate.

Broad Vegetation Groups (BVGs) as described by Neldner *et al.* (2019b), derived from Regional Ecosystem mapping (using RE1). All areas are in hectares. Estate refers to the QPWS estate(s) affected by the fire event (see Table 2). Column headings are: BVG 5M & BVG 2M – BVG number and short description at the 1:5 000 000 and 1:2 000 000 scales; Estate – area of BVG 2M within QPWS estate, Burnt – area of BVG 2M burnt on QPWS estate, Percent – the percentage of BVG 2M within QPWS burnt; Low, Moderate, High, Extreme – area of BVG burnt at each fire severity class (see **Section 4**).

BVG 5M	BVG 2M	Estate	Burnt	Percent	Low	Moderate	High	Extreme
1. Rainforests, scrubs.	3. Notophyll vine forest/ thicket (sometimes with sclerophyll and/or Araucarian emergents) on coastal dunes and sandmasses.	2296.7	9.3	0.40%	6.3	2.5	0.5	0.0
	4. Notophyll and mesophyll vine forest with feather or fan palms on alluvia, along streamlines and in swamps on ranges or within coastal sandmasses.	994.0	11.1	1.11%	7.1	2.2	1.4	0.4
2. Wet eucalypt open forests.	8. Wet eucalypt tall open forest on uplands and alluvia.	23173.1	1110.4	4.79%	636.1	341.3	103.6	29.3
3. Eastern eucalypt woodlands to open forests.	9. Moist to dry eucalypt open forests to woodlands usually on coastal lowlands and ranges.	50359.2	18758.9	37.25%	8314.8	6685.9	3219.2	539.0
8. Melaleuca open woodlands on depositional plains.	22. Melaleuca spp. on seasonally inundated open forests and woodlands of lowland coastal swamps and fringing lines. (palustrine wetlands).	4326.2	2514.8	58.13%	1146.8	770.3	417.9	179.8
12. Other coastal communities or heaths.	28. Open forests to open woodlands in coastal locations. Dominant species such as Casuarina spp., Corymbia spp., Allocasuarina spp., Acacia spp., Lophostemon suaveolens, Asteromyrtus spp., Neofabricia myrtifolia.	19081.9	8312.4	43.56%	2825.3	2613.0	1968.2	905.9
	29. Heathlands and associated scrubs and shrublands on coastal dunefields and inland/ montane locations.	47586.0	38975.5	81.91%	7495.8	12171.2	14923.4	4385.0
15. Wetlands (swamps and lakes).	34. Wetlands associated with permanent lakes and swamps, as well as ephemeral lakes, claypans and swamps. Includes fringing woodlands and shrublands.	11485.3	5276.5	45.94%	1141.4	1261.5	2175.2	698.3
16. Mangroves and tidal saltmarshes.	35. Mangroves and tidal saltmarshes.	2869.5	122.1	4.25%	100.2	21.1	0.8	0.0
Total		**162171.8**	**75090.9**	**46.30%**	**21673.8**	**23869.1**	**22810.2**	**6737.8**

Appendix 4. Conservation significant fauna and flora species of the area.

Column headings: **NCA** (*Nature Conservation Act* 1992) and **EPBC** (*Environment Protection and Biodiversity Conservation Act* 1999) statuses are: EX = extinct, E = endangered, V = vulnerable, NT = near threatened, LC = least concern, SL = special least concern.

Habitat type – **SW***: *Saline Wetlands* (NV8 Mangroves and saltmarshes); **FW**: *Freshwater Wetlands* (NV5 Melaleuca open forest, NV6 Closed sedgelands, NV7 Lakes and any freshwater wetlands within any of the other mapped values), **DFWH**: *Dry Forests, Woodlands and Heathlands* (fire tolerant components of NV1 Foredune complex, NV2 Beach ridge complex, NV3 *Banksia aemula* low open woodland, NV4 *Eucalyptus racemosa* open forests, and components of NV9 with grassy or heathy understorey); **WF**: *Wet Forests*; NV10 Rainforests, components of NV9 with a well-developed rainforest understorey, and fire sensitive components of NV1 Foredune complex.

* note that numerous conservation significant aerial birds, shorebirds, seabirds and pelagic species have been recorded from K'gari. Only those species that are likely to regularly utilise habitats that were burnt on K'gari have been included.
# the satinay sand skink is endemic to K'gari and appears to be mostly restricted to wet forests.

a) Fauna

Group	Scientific name	Common name	Habitat type					
			NCA	EPBC	SW	FW	DFWH	WF
amphibians	*Crinia tinnula*	wallum froglet	V			X		
amphibians	*Litoria cooloolensis*	Cooloola sedgefrog	NT			X		
amphibians	*Litoria freycineti*	wallum rocketfrog	V			X		
amphibians	*Litoria olongburensis*	wallum sedgefrog	V	V		X		
birds	*Botaurus poiciloptilus*	Australasian bittern	E	E		X		
birds	*Calyptorhynchus lathami*	glossy black-cockatoo	V				X	X
birds	*Erythrotriorchis radiatus*	red goshawk	E	V	X	X	X	X
birds	*Esacus magnirostris*	beach stone-curlew	V		X			
birds	*Gallinago hardwickii*	Latham's snipe	SL			X		
birds	*Monarcha melanopsis*	black-faced monarch	SL				X	X
birds	*Myiagra cyanoleuca*	satin flycatcher	SL				X	X
birds	*Ninox strenua*	powerful owl	V				X	X
birds	*Pandion cristatus*	eastern osprey	SL		X		X	X
birds	*Pezoporus wallicus wallicus*	ground parrot	V			X	X	
birds	*Rhipidura rufifrons*	rufous fantail	SL					X
birds	*Symposiachrus trivirgatus*	spectacled monarch	SL					X
birds	*Tringa glareola*	wood sandpiper	SL			X		
birds	*Tringa stagnatilis*	marsh sandpiper	SL			X		
birds	*Turnix melanogaster*	black-breasted button-quail	V	V				X
insects	*Acrodipsas illidgei*	Illidge's ant-blue	V		X			

Group	Scientific name	Common name	Habitat type					
			NCA	EPBC	SW	FW	DFWH	WF
mammals	*Potorous tridactylus tridactylus*	long-nosed potoroo	V	V		X		X
mammals	*Pteropus poliocephalus*	grey-headed flying-fox	C	V		X	X	X
mammals	*Tachyglossus aculeatus*	short-beaked echidna	SL			X	X	X
mammals	*Xeromys myoides*	water mouse	V	V	X	X		
ray-finned fishes	*Nannoperca oxleyana*	Oxleyan pygmy perch	V	E		X		
ray-finned fishes	*Pseudomugil mellis*	honey blue eye	V	V		X		
reptiles	*Acanthophis antarcticus*	common death adder	V				X	X
reptiles	*Anilios silvia*	striped blind snake	NT				X	X
reptiles	*Coeranoscincus reticulatus*	three-toed snake-tooth skink	C	V				X
reptiles	*Coggeria naufragus*	satinay sand skink[#]	C					X

b) Flora

Family	Scientific name	Common name	Habitat type					
			NCA	EPBC	SW	FW	DFWH	WF
Bignoniaceae	*Tecomanthe hillii*	Fraser Island creeper	NT			X		X
Blandfordiaceae	*Blandfordia grandiflora*	Christmas bells	E			X		
Mimosaceae	*Acacia baueri* subsp. *baueri*	tiny wattle	V			X	X	
Mimosaceae	*Archidendron lovelliae*	bacon wood	V	V				X
Orchidaceae	*Diteilis simmondsii*		NT					X
Orchidaceae	*Phaius australis*		E	E		X		
Orchidaceae	*Pterostylis nigricans*		NT				X	
Proteaceae	*Persoonia prostrata*		PE	EX			X	
Rutaceae	*Boronia rivularis*	Wide Bay boronia	NT			X	X	

Appendix 5. Modelled potential habitat for selected conservation significant species within the impacted area.

The Queensland Herbarium's potential habitat models were created using Maxent (v 3.4.1) (Phillips *et al.* 2006), a proven species distribution modelling tool well suited to the development of models based on records of species presence (Elith & Leathwick 2009). The models utilise vetted records of fauna species occurrence compiled for the purpose of Biodiversity Assessments by the Queensland Department of Environment and Science and additional records held in WildNet. Flora records were compiled from the Queensland Herbarium's Herbrecs specimen database. All records had location precision of better than +/- 2000m, and all fauna records had a collection date post-1975. Records were screened for taxonomic and georeferencing accuracy. As records of species occurrence are heavily biased toward accessible parts of the landscape, a mask of Queensland's road network was used to down-weight species records collected along roads to have half the value of records collected away from roads. Models were constrained within an occurrence mask for each species, defined by a buffer of 200km around a convex hull encompassing all records of that species. These masks are used in Maxent to restrict the selection of background points (pseudo-absences) to the region of species presence and have important implications for model performance (Van Der Waal *et al.* 2007).

Models were based on seven environmental variables:
1. Annual mean temperature;
2. Temperature seasonality (coefficient of variation);
3. Annual precipitation;
4. Mean moisture index of the lowest quarter moisture index;
5. Broad vegetation group (BVG 1:1M);
6. Land zone; and
7. Terrain ruggedness index (after Riley *et al.* 1999)

The four climate variables were modelled from Australian monthly mean climate values nominally centred on 1990 (1976-2005) using Anuclim Version 6.1 software (Xu and Hutchinson 2011) applied to a SRTM-derived 3 Second Digital Elevation Model (DEM) (Geoscience Australia 2019). A terrain ruggedness index was also derived from the DEM using the methodology of Riley *et al.* (1999) and indicates the change in elevation between adjacent cells across Queensland. The two categorical variables, land zone and pre-clearing broad vegetation group, were derived from the pre-clearing Regional Ecosystem mapping. Land zone provides a high-level classification of substrate and geomorphology into twelve groups ranging from marine sediments through to ancient igneous substrates (Neldner *et al*. 2019a) and broad vegetation group is a high-level classification of vegetation composition at the 1:1M scale (Neldner *et al.* 2020).

Model performance was assessed by comparing the area under the ROC curve (AUC) with the 95th percentile AUC from 1000 null models for each species created by randomly selecting locations from under the species' mask (Raes and ter Steege 2007). Maxent produces a grid of continuous values, analogous to probabilities of habitat suitability, ranging from zero to one. We applied a 50% threshold to each model to convert this grid output into a binary prediction of high probability potential habitat. The use of conservative thresholds increases the risk of omission but reduces commission error. Any location records that were excluded because of this threshold were added back into the output following the application of a 1km radius buffer. The resulting output was clipped to the species' mask and simplified using a majority filter algorithm to remove outlying 'orphan' cells in the model output.

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Table 2: Modelled potential habitat impacted – Fauna

WF: *Wet Forests* may include NV10 Rainforests, components of NV9 with a well-developed rainforest understorey, and fire sensitive components of NV1 Foredune complex.

			Status		Habitat type		Potential habitat (ha or %)					Relative fire severity class (ha)			
Group	Scientific name	Common name	NCA status	EPBC	WF	Other	Qld area	Estate area	% in estate	Estate habitat burnt	% estate habitat burnt	Low	Mod	High	Ext
Birds	*Botaurus poiciloptilus**	Australasian bittern	E	E		X	840577	26157	3.1	8704	33.3	2623	2670	2732	679
Birds	*Calyptorhynchus lathami**	glossy black-cockatoo	V		X	X	527111	15672	3.0	685	4.4	293	198	154	39
Birds	*Esacus magnirostris**	beach stone-curlew	V			X	698461	78155	11.2	29728	38.0	12332	10110	5627	1658
Birds	*Ninox strenua**	powerful owl	V		X	X	2239060	38952	1.7	2899	7.4	1147	940	679	134
Birds	*Pezoporus wallicus wallicus**	ground parrot	V			X	56693	12505	22.1	6254	50.0	1564	1766	2329	595
Birds	*Rostratula australis*	Australian painted snipe	E	E		X	4438067	75591	1.7	46309	61.3	15153	15296	12008	3852
Birds	*Turnix melanogaster**	black-breasted button-quail	V	V	X	X	1013079	57325	5.7	16543	28.9	4649	5006	5066	1822
Frogs	*Crinia tinnula**	wallum froglet	V			X	270543	42362	15.7	18752	44.3	3070	5108	8015	2559
Frogs	*Litoria freycineti**	wallum rocketfrog	V			X	116901	9518	8.1	2152	22.6	566	685	719	181
Frogs	*Litoria olongburensis**	wallum sedgefrog	V	V		X	138919	15596	11.2	4641	29.8	1668	1489	1221	263
Invert.	*Acrodipsas illidgei**	Illidge's ant-blue	V			X	70551	3962	5.6	614	15.5	285	192	122	15
Mammals	*Potorous tridactylus tridactylus**	long-nosed potoroo	V	V	X	X	190173	1352	0.7	24	1.8	4	6	11	3
Mammals	*Xeromys myoides**	water mouse	V	V		X	133086	5549	4.2	778	14.0	397	242	109	30
Reptiles	*Acanthophis antarcticus**	common death adder	V		X	X	3452148	159585	4.6	74440	46.6	21412	23704	22678	6646

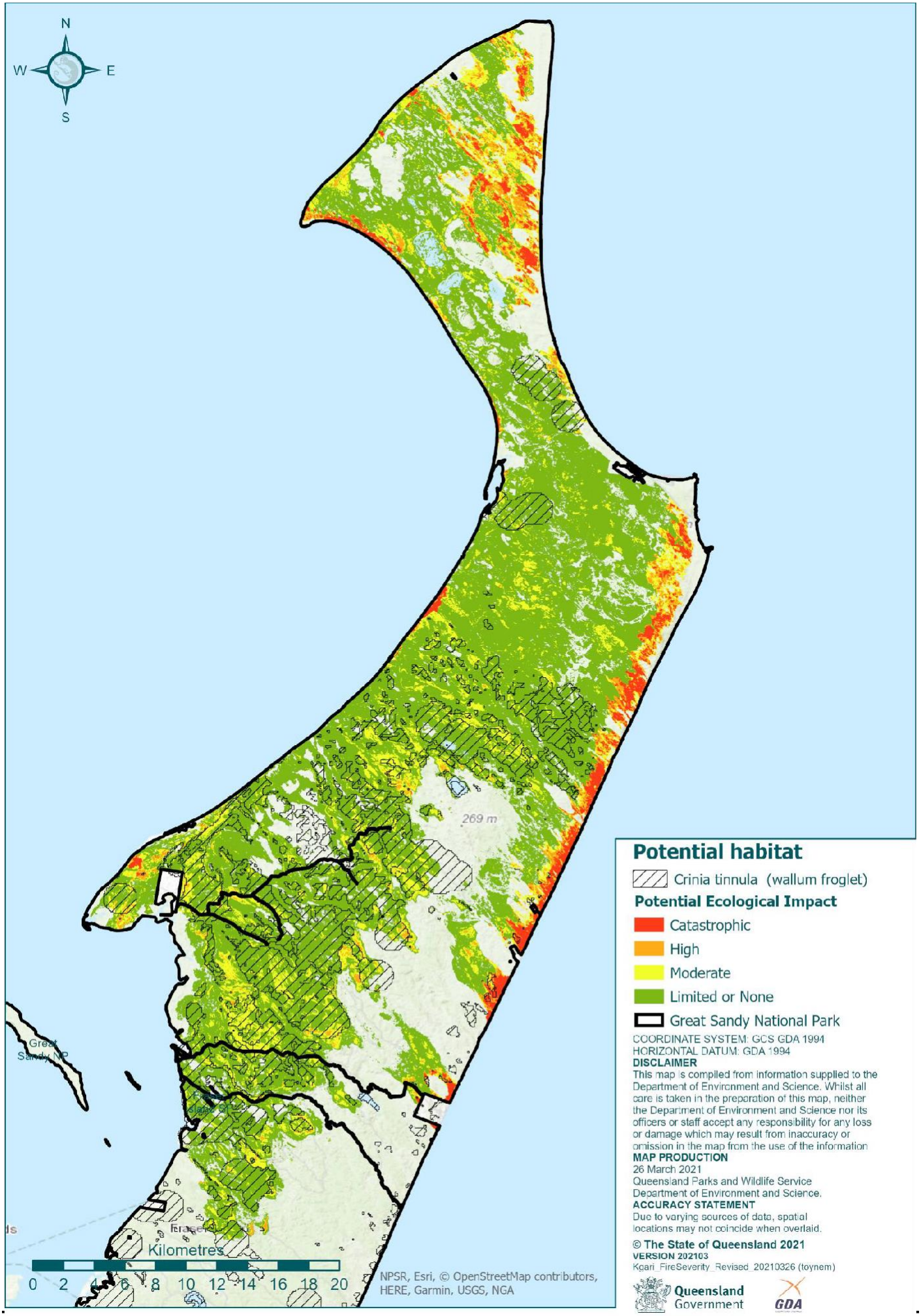
*Record in WildNet for K'gari section of Great Sandy NP

Table 3: Modelled potential habitat impacted – Flora

WF: *Wet Forests* may include NV10 Rainforests, components of NV9 with a well-developed rainforest understorey, and fire sensitive components of NV1 Foredune complex.

			Status		Habitat type		Potential habitat (ha or %)						Fire severity class (ha)			
Family	Scientific name	Common name	NCA status	EPBC	WF	Other	Qld area	Estate area	% in estate	Estate habitat burnt	% estate habitat burnt	% total habitat burnt	Low	Mod	High	Ext
Blandfordiaceae	*Blandfordia grandiflora**	Christmas bells	E			X	59330	2620	4.4	1134	43	1.9	295	408	356	75
Corynocarpaceae	*Corynocarpus rupestris* subsp. *arborescens*	southern corynocarpus	V		X		396187	4082	1.0	26	1	0.0	19	5	2	1
Lauraceae	*Cryptocarya foetida*	stinking cryptocarya	V	V	X		46704	2362	5.1	12	1	0.0	5	1	4	1
Mimosaceae	*Acacia baueri* subsp. *baueri**	tiny wattle	V			X	99577	36889	37.0	27003	73	27.1	2974	7381	12867	3781
Mimosaceae	*Archidendron lovelliae**	bacon wood	V	V	X		43073	10377	24.1	68	1	0.2	50	13	4	2
Oleaceae	*Jasminum jenniae*		E		X		77817	3011	3.9	37	1	0.0	28	7	1	0
Orchidaceae	*Phaius australis**		E	E		X	380295	74787	19.7	22670	30	6.0	8764	7728	4861	1317
Proteaceae	*Floydia praealta*	ball nut	V	V	X		319846	9998	3.1	67	1	0.0	50	12	3	2
Sapindaceae	*Cupaniopsis shirleyana*	wedge-leaf tuckeroo	V	V	X		600543	9221	1.5	7532	82	1.3	3399	2761	1196	177
Sapotaceae	*Planchonella eerwah*		E	E	X		229834	2536	1.1	676	27	0.3	241	230	162	43
Simaroubaceae	*Samadera bidwillii*		V	V	X	X	625134	19152	3.1	2522	13	0.4	956	792	620	154
Thelypteridaceae	*Thelypteris confluens*		V			X	57954	13361	23.1	6878	51	11.9	1976	1811	2331	760
Zamiaceae	*Macrozamia pauli-guilielmi**		E	E		X	190975	17122	9.0	526	3	0.3	191	153	153	28

*Record in WildNet and Herbrecs for K'gari section of Great Sandy NP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Potential habitat
Crinia tinnula (wallum froglet)
Potential Ecological Impact
Catastrophic
High
Moderate
Limited or None
Great Sandy National Park
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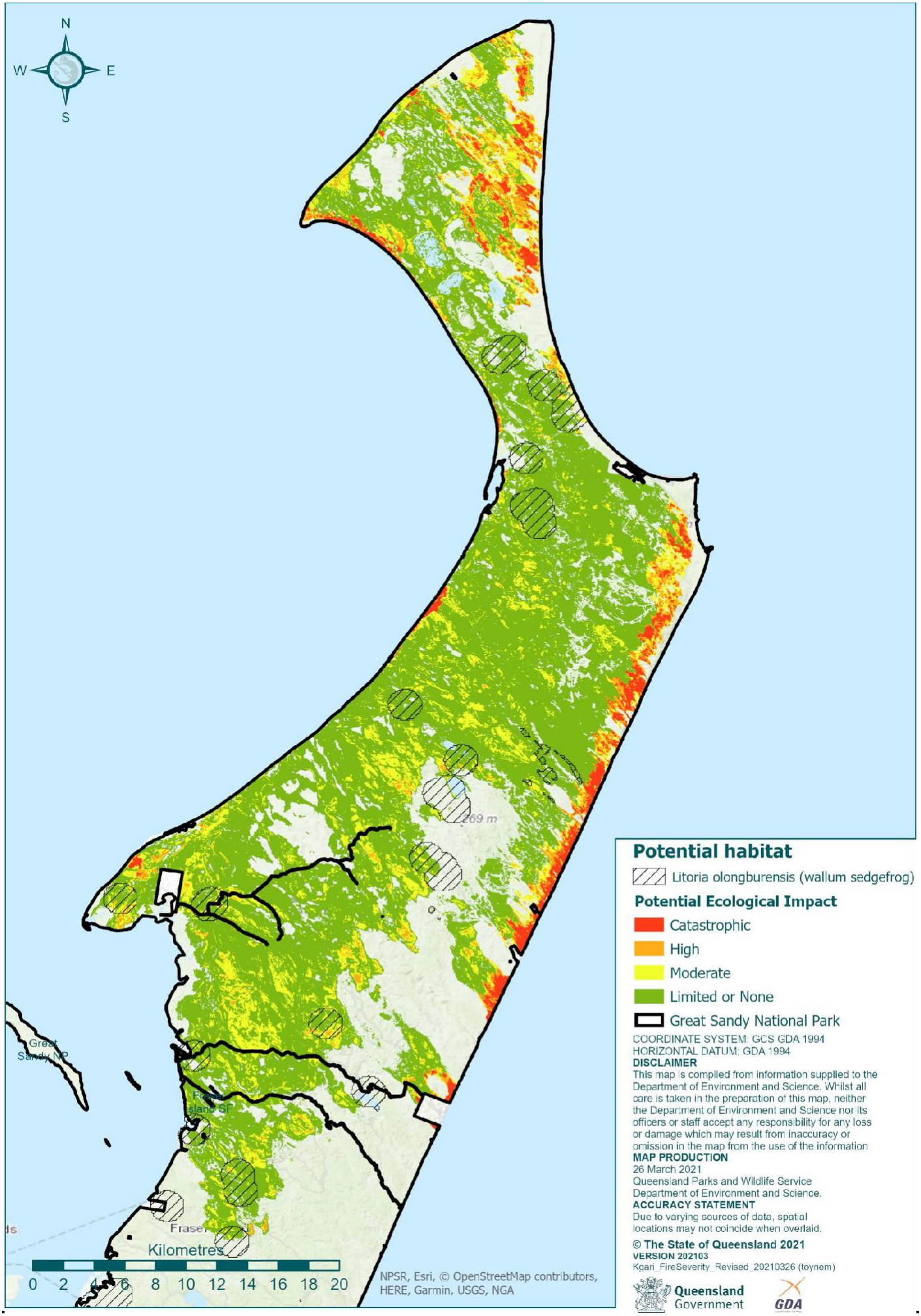
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Litoria olongburensis (wallum sedgefrog)
Potential Ecological Impact
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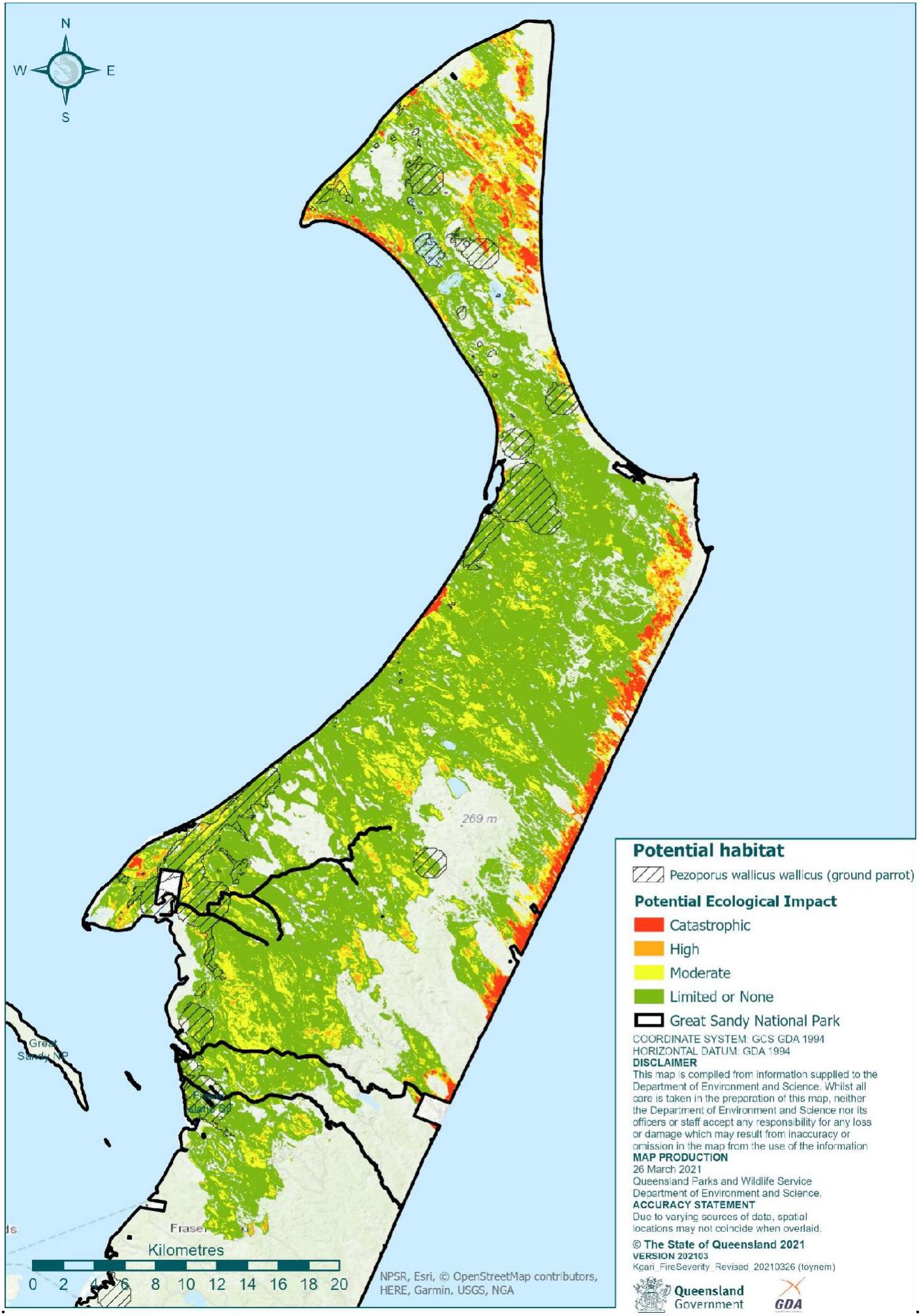
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Potential habitat
Pezoporus wallicus wallicus (ground parrot)
Potential Ecological Impact
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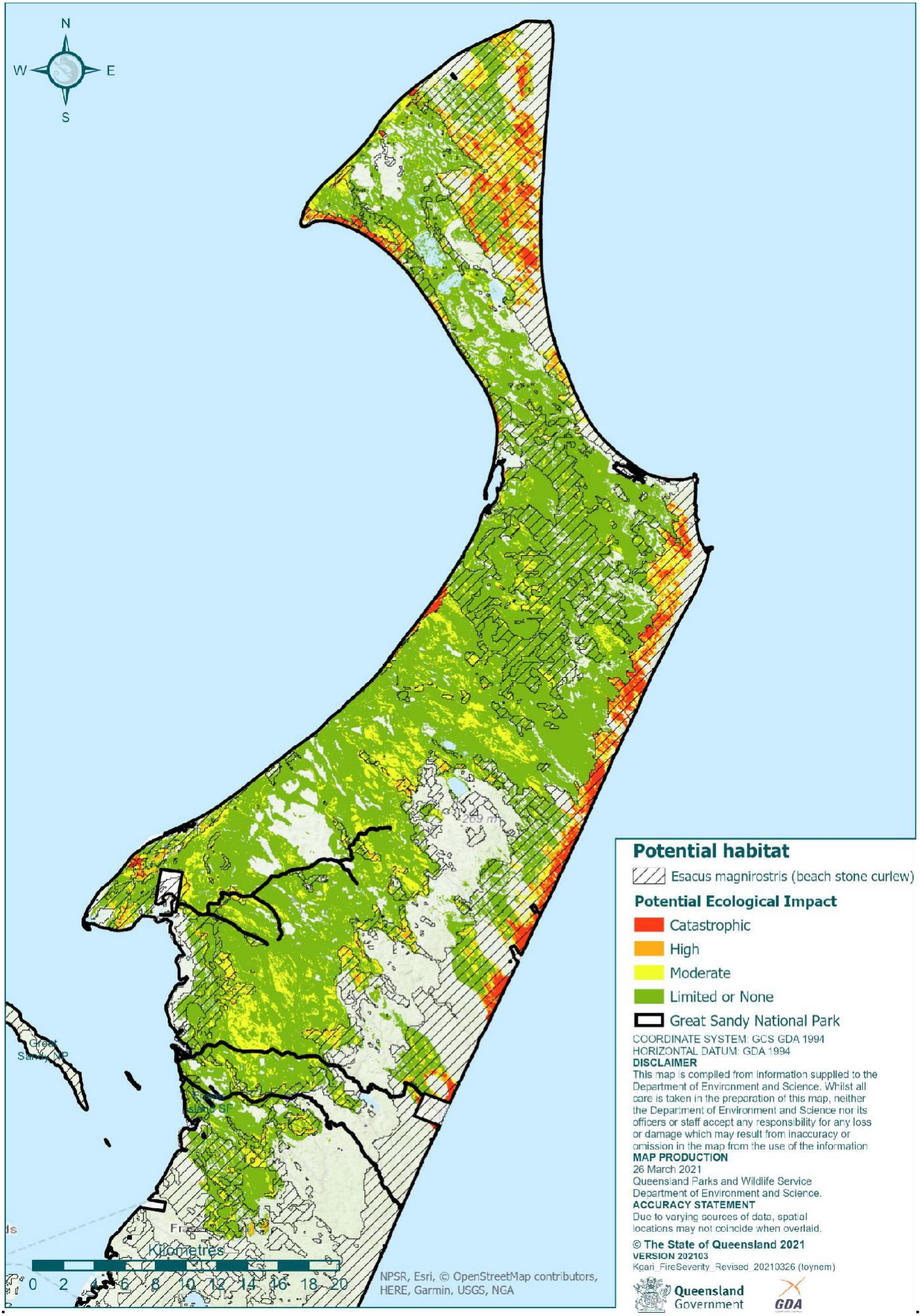
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Potential habitat
Esacus magnirostris (beach stone curlew)
Potential Ecological Impact
Catastrophic
High
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Limited or None
Great Sandy National Park
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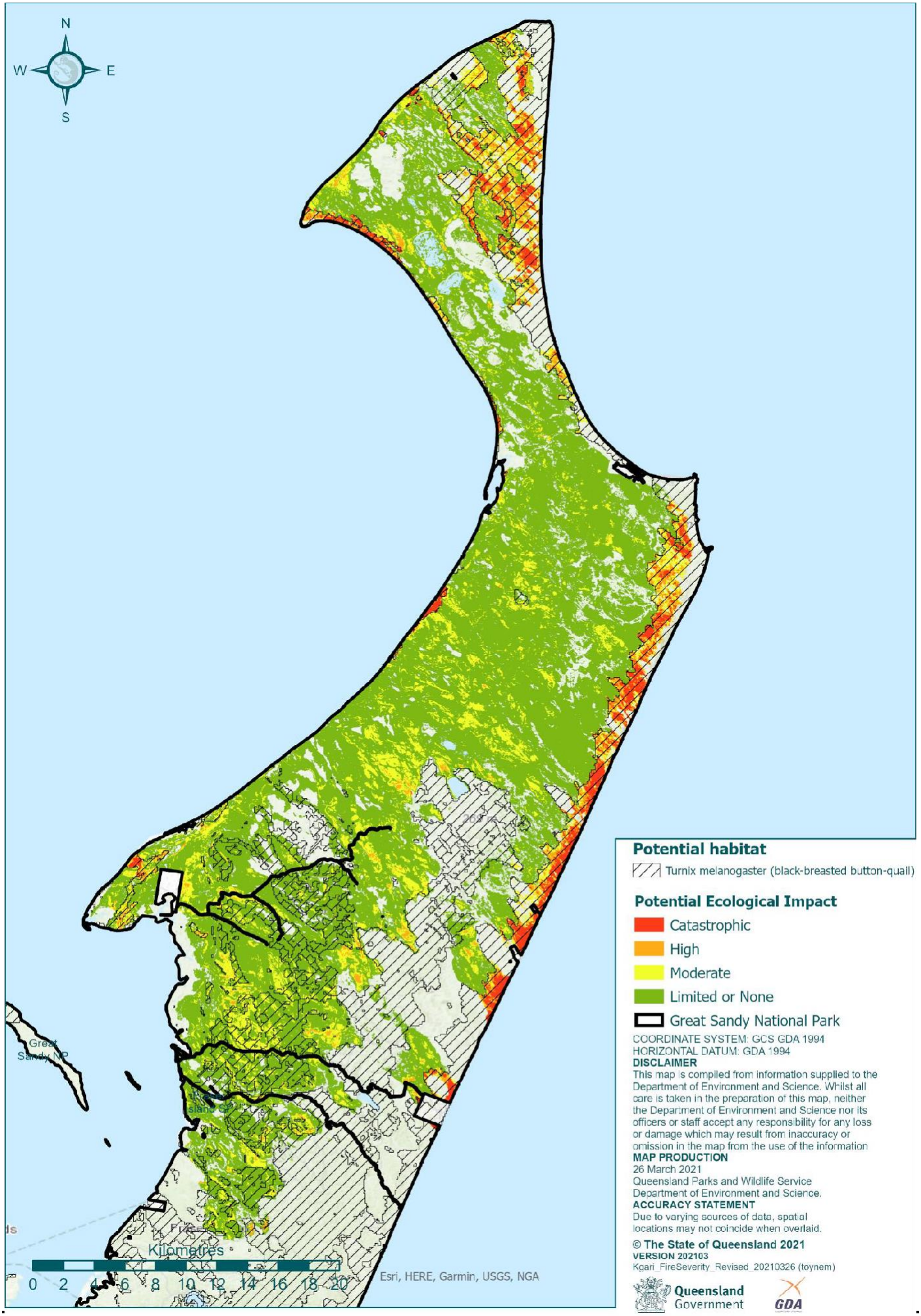
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Potential habitat
Turnix melanogaster (black-breasted button-quail)
Potential Ecological Impact
Catastrophic
High
Moderate
Limited or None
Great Sandy National Park
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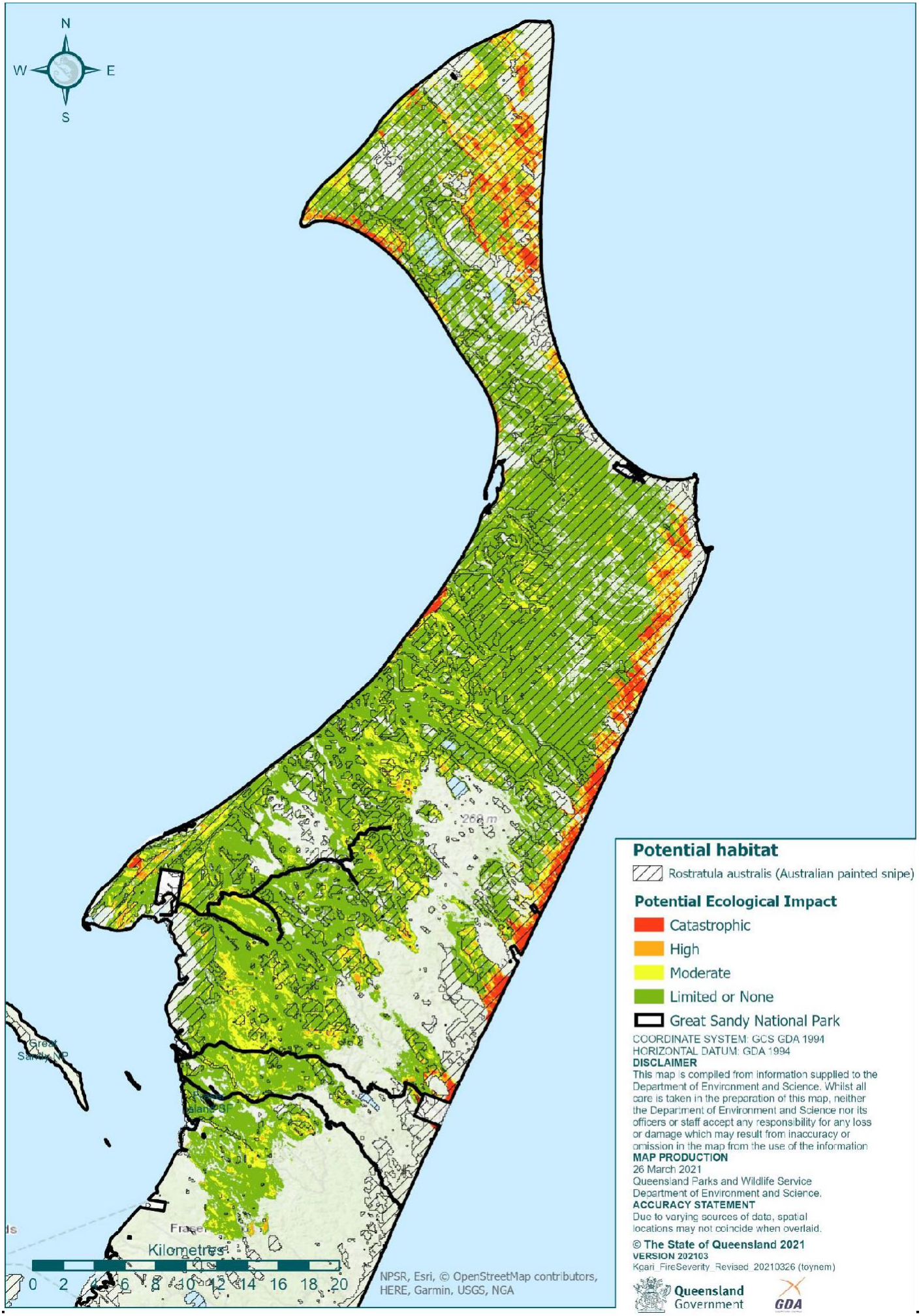
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Rostratula australis (Australian painted snipe)
Potential Ecological Impact
Catastrophic
High
Moderate
Limited or None
Great Sandy National Park
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Queensland Government
GDA
Kilometres
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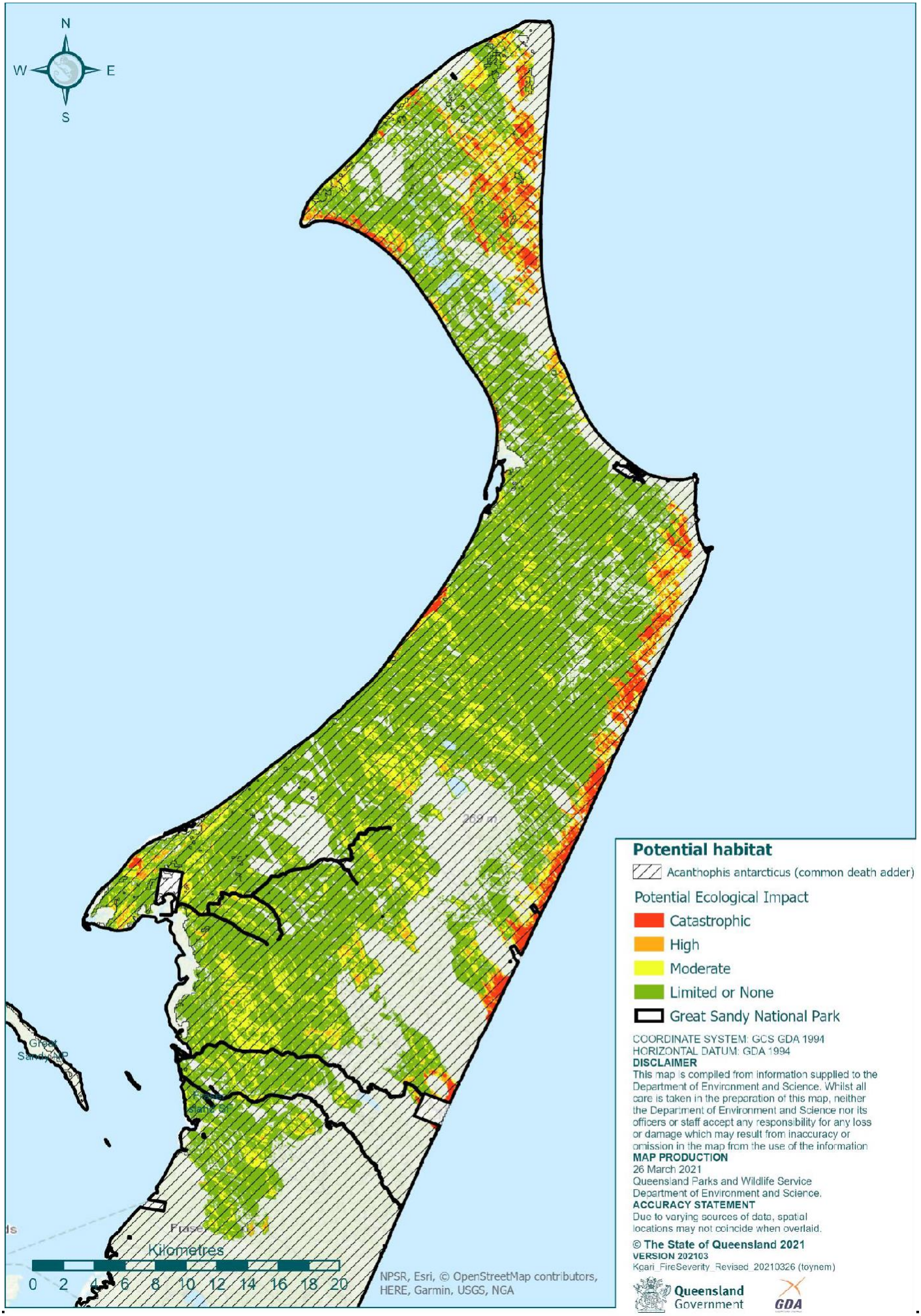
N
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Potential habitat
Acanthophis antarcticus (common death adder)
Potential Ecological Impact
Catastrophic
High
Moderate
Limited or None
Great Sandy National Park
COORDINATE SYSTEM: GCS GDA 1994
HORIZONTAL DATUM: GDA 1994
DISCLAIMER
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VERSION 202103
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Queensland Government
GDA
Kilometres
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NPSR, Esri, © OpenStreetMap contributors, HERE, Garmin, USGS, NGA
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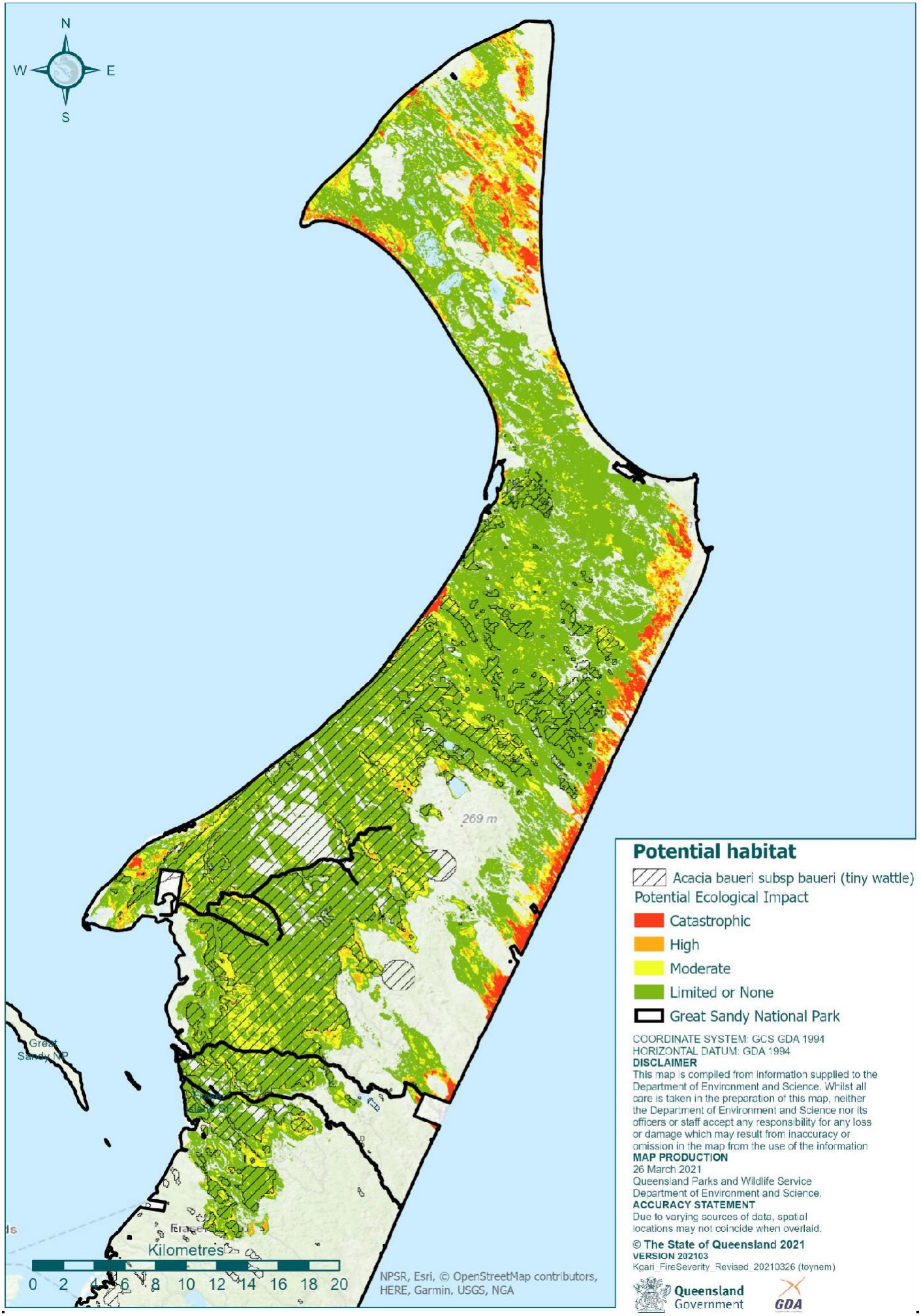
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269 m
Great Sandy NP
Fraser
Kilometres
0 2 4 6 8 10 12 14 16 18 20
NPSR, Esri, © OpenStreetMap contributors, HERE, Garmin, USGS, NGA
Potential habitat
Acacia baueri subsp baueri (tiny wattle)
Potential Ecological Impact
Catastrophic
High
Moderate
Limited or None
Great Sandy National Park
COORDINATE SYSTEM: GCS GDA 1994
HORIZONTAL DATUM: GDA 1994
DISCLAIMER
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Appendix 6. Significant pest plants and animals likely to adversely affect recovery of burnt habitat or impact significant species.

More pest species have been recorded in the burnt estates than those listed below. Only those that are currently known to occur on the estates and have the potential to significantly impact on recovering ecosystems or threatened species, and/or impact on their future protection have been included here.

	Group	Common name	Scientific name
Animals	amphibians	cane toad	*Rhinella marina*
	mammals	pig	*Sus scrofa*
	mammals	horse	*Equus caballus*
	mammals	cat	*Felis catus*
Plants	Asparagaceae	climbing asparagus fern	*Asparagus plumosus*
	Asparagaceae	basket asparagus fern	*Asparagus aethiopicus* “Sprengeri”
	Asteraceae	groundsel	*Baccharis halimifolia*
	Asteraceae	bitou bush	*Chrysanthemoides monilifera* subsp. *rotundata*
	Caesalpiniaceae	Easter cassia	*Senna pendula* var. *glabrata*
	Poaceae	whiskey grass	*Andropogon virginicus*
	Poaceae	green panic and Guinea grass	*Megathyrsus maximus*
	Poaceae	rats tail grasses	*Sporobolus* spp. (exotic species only)
	Poaceae	pigeon grass	*Setaria sphacelata*
	Asteraceae	Singapore daisy	*Sphagneticola trilobata*
	Poaceae	broad-leaved paspalum	*Paspalum mandiocanum*
	Verbenaceae	lantana	*Lantana camara*

Addendum

Addentum to: Meiklejohn *et al.* (2021) Post-fire Assessment Report – Natural Values: 2020 Duling Bushfire, K'gari (Fraser Island), Great Sandy National Park, South East Queensland Bioregion.

Background

The regional ecosystem (RE) mapping for K'gari was refined by the Ecosystem Survey and Mapping Unit, Department of Environment and Science, in late 2022.

The Potential Ecological Impact (PEI) map, and associated data, in Meiklejohn *et al.* (2021) was produced using the RE mapping. The extensive revision of the RE mapping necessitated revision of the data underpinning the evaluation of PEI and the PEI map to more accurately reflect the impact of the 2020 Duling Bushfire. Note that there is no change to the total area impacted by the fire.

The following key summary data have been updated to reflect the new regional ecosystem mapping and are provided in this addendum:

- Table 1. Summary of natural values and impacts of the fire.
- Table 6a. Summary of burn severity (ha) of vegetation communities, classified by fire tolerance.
- Table 6b. Area (ha) of Potential Ecological Impact (within estate).
- Figure 5. Potential Ecological Impact map.
- Appendix 2. Area burnt within each fire severity class, by Regional Ecosystem, within QPWS estate.
- Appendix 3. Area burnt within each fire severity class, by Broad Vegetation Group, within QPWS estate.

Table and figure numbering aligns with the original report for ease of reference.

Summary of key changes

- Decrease in the mapped area of RE 12.2.14 (foredune complex) from 15,083ha to 10,838ha and therefore a reduction in the area impacted by fire from 8,265ha to 4,822ha and percent burnt from 55% to 44%. However, given the extreme fire sensitivity of some vegetation communities in the foredune complex, the high proportion of area impacted by the fire event remains a concern.
- Addition of RE12.2.12 - closed heath on seasonally waterlogged sand plains – 70ha on park (not previously mapped) of which 67ha (96%) was impacted. The Potential Ecological Impact is limited or none to moderate for the area burnt.
- Decrease in the mapped area of RE12.2.15 (9,656ha to 7,886ha) due to finer scale attribution to sub-REs and an associated increase in 12.2.15a (window lakes) (340ha to 1,964ha); reflected in increased area of window lakes impacted by fire from 67ha to 593ha. The Potential Ecological Impact remains as limited or none for most of the area impacted.
- Decrease in the mapped area of RE12.2.15g (patterned fens) (744ha to 666ha). There was no change to the area mapped as impacted by fire, resulting in an increase from 85% to 96% impacted. The Potential Ecological Impact remains limited or none to moderate for the area burnt.
- Decrease in the mapped area of RE12.2.*7* (*Melaleuca* open forest on sand plains) (4,326ha to 3,501ha) and reduction in the area impacted by fire (2,515ha to 1,839ha) and percent impacted (58% to 53%).

Table 1: Revised summary of natural values and impacts of the fire.

For each natural value the:

- total impacted area (ha) and percentage impacted of the total extent in K'gari NP (% in parentheses);
- area impacted by fire within four relative fire severity classes (refer Section 4.1, Table 2) and percentage of the total area impacted in each class (% in parentheses) and;
- area represented in each of four Potential Ecological Impact classes (refer Section 5.1.1, Table 6) and percentage of the total area impacted in each class (% in parentheses).

NB: The figures provided in the original report for total area and percent area impacted, are included here in [ ] for reference.

Natural value	Total area impacted	Relative fire severity	Potential Ecological Impact
NV1: Foredune complex • BVG 28a – RE 12.2.14	4,822ha (44%) [8,265ha (55%)]	Low: 1,442ha (30%) Mod: 1477 ha (31%) High: 1,372ha (28%) Extreme: 531ha (11%)	Limited or none: 0ha (0%) Mod: 1,442ha (30%) High: 1,477 (31%) Catastrophic: 1,903ha (39%)
NV2: Beach ridge communities • BVG 9f – RE 12.2.11 • BVG 28 – RE12.2.16	512 (11%) [464ha (69%)]	Low: 214ha (42%) Mod: 171ha (33%) High: 115ha (22%) Extreme: 13ha (3%)	Limited or none: 180ha (35%) Mod: 195ha (38%) High: 122ha (24%) Catastrophic: 15ha (3%)
NV3: *Banksia aemula* low open woodland on dunes and sand plains • BVG 29a – RE 12.2.9, 12.2.12	42,187 (82%) [38,975ha (82%)]	Low: 8,800ha (21%) Mod: 13,186ha (31%) High: 15,444ha (37%) Extreme: 4,757ha (11%)	Limited or none: 37,430ha (89%) Mod: 4,757ha (11%) High: 0ha (0%) Catastrophic: 0ha (0%)
NV4: *Eucalyptus racemosa* open forest on dunes and sand plains • BVG 9g – RE 12.2.6	19,358 (38%) [18,294ha (37%)]	Low: 8,607ha (44%) Mod: 6,876ha (36%) High: 3,283ha (17%) Extreme: 591ha (3%)	Limited or none: 18,767ha (97%) Mod: 0ha (0%) High: 591ha (3%) Catastrophic: 0ha (0%)
NV5: *Melaleuca quinquenervia* open forest on sand plains • BVG 22a – RE 12.2.7	1,839 (53%) [2,515ha (58%)]	Low: 764ha (42%) Mod: 586ha (32%) High: 346ha (19%) Extreme: 142ha (8%)	Limited or none: 1,697ha (92%) Mod: 0ha (0%) High: 142ha (8%) Catastrophic: 0ha (0%)
NV6: Closed Wet sedgelands • BVG 34c – RE 12.2.15, 12.2.15g (includes patterned fens).	4,442 (52%) [5,119ha (49%)]	Low: 596ha (13%) Mod: 1,095ha (25%) High: 2,096ha (47%) Extreme: 655ha (15%)	Limited or none: 3,787ha (85%) Mod: 655ha (15%) High: 0ha (0%) Catastrophic: 0ha (0%)
NV7: Lakes – window and perched • BVG 34a – RE 12.2.15a, 12.2.15f	680 (25%) [157ha (15%)]	Low: 503ha (74%) Mod: 112ha (16%) High: 47ha (7%) Extreme: 18ha (3%)	Limited or none: 662ha (97%) Mod: 0ha (0%) High: 18ha (3%) Catastrophic: 0ha (0%)
NV8: Mangroves and saltmarsh • BVG 35a – RE 12.1.3 • BVG 35b – RE 12.1.2	122ha (4%) [122ha (4%)]	Low: 100ha (82%) Mod: 21ha (17%) High: 1ha (1%) Extreme: 0 (0)	Limited or none: 70ha (57%) Mod: 43ha (36%) High: 9ha (7%) Catastrophic: 0ha (0%)
NV9: Moist to wet, open to tall open, eucalypt forests on parabolic high dunes • BVG 8a – RE 12.2.4 • BVG 8b – RE 12.2.8	1,108ha (5%) [1,110ha (5%)]	Low: 635ha (57%) Mod: 340ha (31%) High: 103ha (9%) Extreme: 29ha (3%)	Limited or none: 1,078ha (97%) Mod: 0ha (0%) High: 29ha (3%) Catastrophic: 0ha (0%)
NV10: Rainforest on parabolic high dunes • BVG 3a – RE 12.2.3 • BVG 4a – RE 12.2.1	20ha (0.6%) [20ha (0.6%)]	Low: 13ha (65%) Mod: 5ha (24%) High: 2ha (9%) Extreme: 0.4ha (2%)	Limited or none: 0ha (0%) Mod: 13ha (65%) High: 5ha (24%) Catastrophic: 2ha (11%)

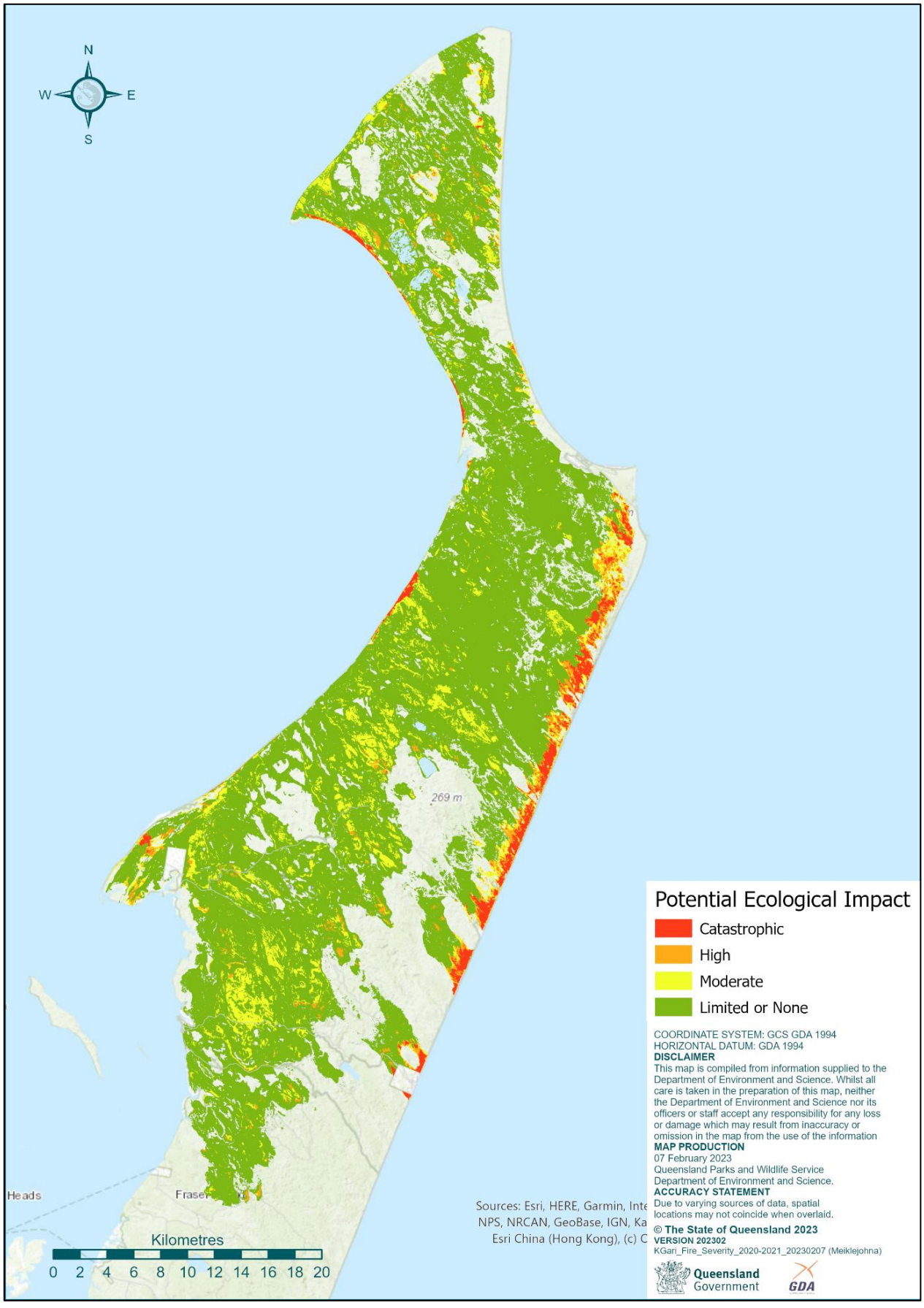

Figure 1: Revised Potential Impact mapping - Duling Fire 2020

Table 6. Fire tolerance and Potential Ecological Impact

Table 6a. Summary of burn severity (ha) of vegetation communities, classified by fire tolerance.

	Fire tolerance of vegetation community (based on RE1)			
Relative Fire Severity Class	**Intolerant**	**Low**	**Moderate**	**High**
Low - Canopy and subcanopy un-scorched, shrubs may be scorched, fire-sensitive low shrubs may be killed.	1,532.6	179.8	10,565.8	9,395.7
Moderate - Partial canopy scorch, subcanopy partially or completely scorched, and/or fire-sensitive tall shrub or small tree layer mostly killed.	1,500.0	161.0	7,927.2	14,280.8
High - Full canopy scorch to partial canopy consumption, subcanopy fully scorched or consumed.	1,376.6	112.7	3,780.7	17,540.2
Extreme - Full canopy, subcanopy and understorey consumption.	533.5	10.8	781.0	5,412.5
Total	**4,942.7**	**464.3**	**23,054.7**	**46,629.2**

Table 6b. Area (ha) of Potential Ecological Impact (within estate).

	Fire tolerance of vegetation community (based on RE1)			
Potential Ecological Impact	**Intolerant**	**Low**	**Moderate**	**High**
Limited or no ecological impact likely		179.8	18,493.0	41,216.7
Moderate ecological impact likely	1,532.6	161.0	3,780.7	5,412.5
High ecological impact likely	1,500.0	112.7	781.0	
Catastrophic ecological impact possible	1,910.2	10.8		

Appendix 2. Area burnt within each fire severity class, by Regional Ecosystem, within QPWS estate.

Regional Ecosystem (RE) mapping and Broad Vegetation Groups (BVGs) as described by Neldner *et al.* (2020 & 2019b). All areas are in hectares, for RE1 (see section 4.2). Column headings are: RE1 – Regional Ecosystem identifier for RE1; RE description – brief description of RE1; Status – Biodiversity Status; BVG 2M – Broad Vegetation Group at the 1:2 000 000 scale; Tolerance – ability of community to tolerate fire (used in calculating PEI); Estate - area of RE1 within K'gari section of Great Sandy NP, Total – area of RE1 burnt within K'gari section of Great Sandy NP; Low, Moderate, High, Extreme – area of RE1 burnt at each fire severity class.

RE1	Description	Status	Tolerance	BVG2M	Estate	Burnt	Low	Moderate	High	Extreme
12.1.2	Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains	No concern at present	Moderate	35	469	69.7	56.8	12.5	0.4	
12.1.3	Mangrove shrubland to low closed forest on marine clay plains and estuaries	No concern at present	Intolerant	35	2,700	52.4	43.4	8.5	0.4	0
12.2.1	Notophyll vine forest on parabolic high dunes	Of concern	Intolerant	4	994	11	7	2.2	1.4	0.4
12.2.11	Corymbia tessellaris +/- Eucalyptus tereticornis, C. intermedia and Livistona decora woodland on beach ridges in northern half of bioregion	No concern at present	Low	9	672	464.3	179.8	161	112.7	10.8
12.2.12	Closed heath on seasonally waterlogged sand plains	No concern at present	Moderate	29	70	67.1	5.6	13.6	22.2	25.7
12.2.14	Foredune complex	No concern at present	Intolerant	28	10,838	4,822.20	1,442.00	1,477.10	1,372.10	531
12.2.15	Gahnia sieberiana, Empodisma minus, Gleichenia spp. closed sedgeland in coastal swamps	No concern at present	High	34	7,886	3,805.10	570.8	969.2	1,662.20	602.9
12.2.15a	Permanent and semi-permanent window lakes. (This will be the veg on the margins)	No concern at present	Moderate	34	1,964	592.8	451.4	90.2	35.6	15.7
12.2.15f	Permanent and semi-permanent perched lakes. (This will be the veg on the margins)	No concern at present	Moderate	34	742	87.6	51.4	22	11.9	2.3
12.2.15g	Swamps dominated by Empodisma minus, Gahnia sieberiana, other sedges	No concern at present	High	34	666	636.7	25.1	125.5	433.8	52.3

	and forbs and shrubs - i.e. patterned fens									
12.2.16	Sand blows largely devoid of vegetation (This will be the veg on the margins)	Of concern	Intolerant	28	4,002	48.2	34.1	9.6	2.3	2.1
12.2.3	Araucarian vine forest on parabolic high dunes	Of concern	Intolerant	3	2,296	9	6.1	2.5	0.5	0
12.2.4	Syncarpia hillii, Lophostemon confertus tall open to closed forest on parabolic high dunes	Of concern	Moderate	8	9,214	65.8	49.5	13.1	2.6	0.7
12.2.6	Eucalyptus racemosa subsp. racemosa open forest on dunes and sand plains. Usually deeply leached soils	No concern at present	Moderate	9	51,083	19,357.80	8,607.30	6,876.10	3,283.20	591.2
12.2.7	Melaleuca quinquenervia or rarely M. dealbata open forest on sand plains	No concern at present	Moderate	22	3,501	1,839.20	764	586.4	346.3	142.5
12.2.8	Eucalyptus pilularis open forest on parabolic high dunes	No concern at present	Moderate	8	13,959	1,041.70	585.4	326.9	100.7	28.7
12.2.9	Banksia aemula low open woodland on dunes and sand plains. Usually deeply leached soils	No concern at present	High	29	51,422	42,120.30	8,794.10	13,172.60	15,421.90	4,731.70
Total					**162,478**	**75,090.9**	**21,673.8**	**23,869.0**	**22,810.2**	**6,738.0**

* Approximately 20ha of non-remnant was impacted by the fire and accounts for the difference in the total area provided here (total remnant regional ecosystem impacted) and the total area of K'gari section of Great Sandy National Park impacted by the fire (75,110ha) which includes both remnant regional ecosystems and non-remnant.

Appendix 3. Area burnt within each fire severity class, by Broad Vegetation Group, within QPWS estate.

Broad Vegetation Groups (BVGs) as described by Neldner *et al.* (2019b), derived from Regional Ecosystem mapping (using RE1). All areas are in hectares. Estate refers to the QPWS estate(s) affected by the fire event (see Table 2). Column headings are: BVG 5M & BVG 2M – BVG number and short description at the 1:5 000 000 and 1:2 000 000 scales; Estate – area of BVG 2M within QPWS estate, Burnt – area of BVG 2M burnt on QPWS estate, Percent – the percentage of BVG 2M within QPWS burnt; Low, Moderate, High, Extreme – area of BVG burnt at each fire severity class (see **Section 4**).

BVG 5M	BVG 2M	Estate	Burnt	Percent	Low	Moderate	High	Extreme
1. Rainforests, scrubs.	3. Notophyll vine forest/ thicket (sometimes with sclerophyll and/or Araucarian emergents) on coastal dunes and sandmasses.	2,296	9.0	0.4%	6.1	2.5	0.5	0.0
	4. Notophyll and mesophyll vine forest with feather or fan palms on alluvia, along streamlines and in swamps on ranges or within coastal sandmasses.	994	11.0	1.1%	7.0	2.2	1.4	0.4
2. Wet eucalypt open forests.	8. Wet eucalypt tall open forest on uplands and alluvia.	23,173	1,107.5	4.8%	634.9	340.0	103.3	29.4
3. Eastern eucalypt woodlands to open forests.	9. Moist to dry eucalypt open forests to woodlands usually on coastal lowlands and ranges.	51,755	19,822.1	38.3%	8,787.1	7,037.1	3,395.9	602.0
8. Melaleuca open woodlands on depositional plains.	22. Melaleuca spp. on seasonally inundated open forests and woodlands of lowland coastal swamps and fringing lines. (palustrine wetlands).	3,501	1,839.2	52.5%	764.0	586.4	346.3	142.5
12. Other coastal communities or heaths.	28. Open forests to open woodlands in coastal locations. Dominant species such as Casuarina spp., Corymbia spp., Allocasuarina spp., Acacia spp., Lophostemon suaveolens, Asteromyrtus spp., Neofabricia myrtifolia.	14,840	4,870.4	32.8%	1,476.1	1,486.7	1,374.4	533.1
	29. Heathlands and associated scrubs and shrublands on coastal dunefields and inland/ montane locations.	51,492	42,187.4	81.9%	8,799.7	13,186.2	15,444.1	4,757.4
15. Wetlands (swamps and lakes).	34. Wetlands associated with permanent lakes and swamps, as well as ephemeral lakes, claypans and swamps. Includes fringing woodlands and shrublands.	11,258	5,122.2	45.5%	1,098.7	1,206.9	2,143.5	673.2
16. Mangroves and tidal saltmarshes.	35. Mangroves and tidal saltmarshes.	3,169	122.1	3.9%	100.2	21.0	0.8	0.0
Total		**162,478**	**75,090.9**	**46.2%**	**21,673.8**	**23,869.0**	**22,810.2**	**6,738.0**