Post-fire Assessment Report— Natural Values:

2019 bushfire, Lamington National Park, South East Queensland Region

4 August 2020

Queensland Government

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Front cover

Western slopes of Laheys Tabletop, Lamington NP, 12 November 2019. The upper slopes of open forest were burnt with high intensity during the initial stages of the fire in early September 2019, with the lower slopes of Araucarian complex notophyll vine forest burning at much lower intensity, but with serious ecological outcomes, some two months later (Photo: H.B. Hines).

Contents

List of acronyms and abbreviations used in the text

BMAD	Bell Miner Associated Dieback (see Silver & Carnegie 2017).
BVG	Broad Vegetation Groups (BVGs) as described by Neldner *et al.* (2019).
dNBR	Normalised Burn Ratio difference product.
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.
FR	Forest Reserve.
IBISCA	The international research program: *Investigating the Biodiversity of Soil and Canopy Arthropods.*
LC	Least Concern.
NAFI	Northern Australia & Rangelands Fire Information.
NBR	Normalised Burn Ratio.
NCA	Queensland *Nature Conservation Act 1992.*
NKV	Natural Key Value.
NP	National Park.
NT	Near Threatened.
OUV	Outstanding Universal Value of a World Heritage Area.
QFES	Queensland Fire and Emergency Service.
QPWS	Queensland Parks and Wildlife Service.
QPWS estate	Conservation Parks, National 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 (2018), is a vegetation community in a bioregion that is consistently associated with a particular combination of geology, landform and soil (Neldner *et al.* 2020).
REDD	Regional Ecosystem Description Database, Version 10 (Queensland Herbarium 2018).
RR	Resources Reserve.
SF	State Forest.
V	Vulnerable.
VIIRS	Visible Infrared Imaging Radiometer Suite.
WHA	World Heritage Area.
XTC	Ex-Tropical Cyclone.

1 Executive summary

The Sarabah bushfire was the largest fire in Lamington National Park in the last hundred years, burning approximately 7% of the park estate, and destroying eight houses adjoining the park as well as Binna Burra Mountain Lodge.

The Sarabah 2019 bushfire event started on 1 September 2019, approximately 8-9km to the north of Lamington NP. On Friday 6 September 2019 strong and dry west to north-westerly winds caused it to move south and it crossed the northern boundary of Lamington NP in several places. By the morning of 8 September 2019, eight properties at Upper Beechmont and the Binna Burra Lodge were destroyed. The fire continued to burn within Lamington NP over the following months, moving south into moister vegetation types. A preliminary field assessment of fire severity and impacts was undertaken in November 2019. Significant rain in late December and January suppressed the fire. Further field assessments were undertaken during January-April 2020.

The total area burnt within QPWS estate (Lamington NP) was approximately 1 574ha, including 1 515ha burnt within the Lamington NP section of the Gondwana Rainforests World Heritage Area. A summary of the natural values impacted, and the degree of known or likely impact, is provided in Table 1. Relative fire severity varied considerably across the fire ground and included small areas of full canopy consumption including within rainforest. Substantial areas of rainforest, wet eucalypt open forests and rainforest/eucalypt forest ecotones were burnt. The potential ecological impact to burnt ecosystems was assessed as mostly moderate or high to catastrophic due to burning of fire sensitive vegetation communities, particularly rainforests.

This report identifies known and likely impacts of the bushfire event to the natural values on QPWS estate. It provides practical recommendations for mitigation, recovery and monitoring over the short- to long-term.

Table 1. The natural values known or likely to have been significantly impacted by the bushfire

Value ID	Value descriptor
NV_1	Rainforests – encompasses Natural Key Values (NKV) "Lowland subtropical rainforest" and "Dry vine forest". – ecosystems with a fire sensitive canopy and understorey.
NV_2	Wet eucalypt open forests and rainforest/eucalypt forest ecotones – partially encompasses NKV "Moist to dry open forest ecotones (eastern bristlebird and Hastings River mouse habitat)". – ecosystems and rainforest/eucalypt forest ecotones with a fire a tolerant canopy and a fire sensitive understorey.
NV_3	Dry eucalypt forests and woodlands – partially encompasses NKV "Moist to dry open forest ecotones (eastern bristlebird and Hastings River mouse habitat)". – ecosystems with a fire tolerant canopy and understorey.
NV_4	Montane heaths and shrublands – ecosystems with a fire tolerant canopy and understorey.
NV_5	Riparian corridors – encompasses NKV "Riparian corridors" – various ecosystems fringing streams and rivers with either a fire sensitive or fire tolerant canopy and a fire sensitive understorey.

An assessment of the impact to these natural values in Lamington NP is provided in section 6 and recovery actions are identified. There are likely to be indirect impacts from the fire due to erosion, landslips and additional tree falls due to wind throw and/or disease in compromised trees. Such events will exacerbate impacts (e.g. weed invasion) identified in this report and prolong ecosystem recovery.

Approximately 658ha of lowland subtropical and dry rainforests burnt, representing about 9% of these communities within the park. The moister, typically higher altitude rainforests, which are extensive within Lamington NP (6 961ha), were not burnt during this event. Within burnt rainforests approximately 30.6% burnt at low, 49.5% at moderate, 18.2% at high and 1.6% at extreme relative severity resulting in ecological impacts (refer section 5.1.1) ranging from moderate to high–catastrophic. Recovery of these ecosystems will take at least decades and will be dependent upon exclusion of further fires. Facilitating natural regeneration through the management of ecosystem-changing and or fire-promoting weeds is a key management recommendation.

About 221ha of wet eucalypt open forests burnt, representing less than 9% of this community within the park. Within burnt wet eucalypt open forests approximately 23.6% burnt at low, 53.1% at moderate, 22.2% at high and 1.1% at extreme relative severity, resulting in most areas with a moderate potential ecological impact and a relatively small area (48ha) with high to catastrophic potential ecological impact (refer section 5.1.1). An occasional high intensity fire is recognised as a natural part of the fire regime of these forests. Facilitating natural regeneration through strategic weed control is a key management recommendation.

About 641ha of dry eucalypt forests and woodlands, and 13ha of montane heath or shrublands burnt. These ecosystems are fire-adapted. Ecological impacts, however, are expected to be significant in areas of high to extreme fire severity in dry eucalypt forests and woodlands, because of the loss of critical habitat features such as hollow-bearing trees and large hollow logs. High intensity fire is typical in montane heaths and shrublands, but they require long inter-fire periods (in the order of 20-50 years; Qld Herbarium 2019). Ongoing management of fire in the dry eucalypt communities, and montane heaths and shrublands, is important for the health of these systems and also for minimising the risk of future fire incursions into fire sensitive ecosystems.

About 44ha of the mapped Natural Key Value riparian corridors burnt, which represents less than 4% of the value within Lamington NP. Within this area, approximately 45.3% burnt at low, 44.3% at moderate, 10.1% at high and 0.3% at extreme severity. Riparian corridors are a significant value of Lamington NP and Gondwana Rainforests WHA. They include a range of vegetation communities that have differing sensitivity to fire. Areas of high to extreme severity fire in these communities are likely to have serious ecological impacts in the medium to long term, regardless of the vegetation community. Areas of low to moderate severity in rainforested riparian areas are also likely to have serious ecological impacts in the medium to long term.

A large number of conservation significant flora and fauna species are known, or have potential habitat, within the burnt area (section 5.2). Impacts on these species will vary, but those in fire sensitive communities are likely to have been most highly affected. Only two species with more than 10% of their potential Queensland habitat falling within Lamington NP, had more than 10% of this habitat at Lamington NP burnt: Albert's lyrebird (Near Threatened) and the plant *Westringia rupicola* (Vulnerable). Both these species were likely significantly impacted by the fire. Albert's lyrebird is dependent upon fire sensitive rainforest as well as wet sclerophyll forest communities with a fire sensitive understorey. *Westringia rupicola* occurs on rock pavements and cliff lines which typically burn with high severity. Plants in these areas were likely highly drought stressed or perhaps even drought-killed at the time of the fire.

The following list summarises key management recommendations:

1. Prevent the establishment of high biomass grasses and lantana (*Lantana camara*) immediately adjacent to and within burnt rainforest, wet eucalypt open forest and ecotone communities.
2. Assess the establishment of vine and herbaceous weeds and undertake strategic control.
3. Assess the establishment of tree and shrub weeds and undertake strategic control.
4. Surveillance and strategic thinning, if justified, of native vine, shrub or tree species causing arrested rainforest or rainforest ecotone ecosystem recovery.
5. Undertake a control program for feral cats.
6. Reinstate damaged, or install new, strategic boundary fencing to prevent cattle entering regenerating areas.
7. Review weed and fire management planning in dry sclerophyll communities to reduce the risk of future fire encroachment into rainforests, and unplanned encroachment into wet eucalypt open forests and ecotones.
8. Undertake Health Checks to facilitate early detection of weeds and enable condition to be evaluated across the park.
9. Resurvey monitoring plots to quantify impacts.
10. Establish additional long-term vegetation monitoring plots in burnt communities.
11. Assess impacts from pathogens such as myrtle rust.
12. Investigate additional remote sensing methods to map more precisely the ecological impact in rainforests currently assessed as having low fire severity.
13. Protect regenerating rock pavement, cliff lines and montane heath and shrubland areas from visitation.

There are very limited opportunities to rehabilitate small areas via direct planting. Such actions should be confined to areas of land cleared prior to incorporation into Lamington NP (e.g. Rankins Paddock), where natural regeneration is slow or stalled due to dense weed infestations.

The fire provides research and monitoring opportunities that will help inform a) post-fire management actions for future fires impacting rainforest and wet eucalypt open forest communities in south-east Queensland, and b) ongoing fire management planning, planned burning and bushfire suppression.

2 Introduction and purpose of this report

This report is a rapid assessment of the known and likely impacts to the natural values of a protected area arising from a significant bushfire event. It is not intended to be a comprehensive report. It provides an overview of the fire and provides information to inform recovery planning for natural values, in particular Natural Key Values determined through the QPWS Values Based Management Framework (DES 2020).

The report succinctly documents the extent and ecological severity of the fire, prevailing weather conditions, and suppression methods. It describes the spatial data used in the evaluation and summarises areas and values within the burnt area (section 5). It provides QPWS with a snapshot of the priority impacts and associated risks to natural values following the bushfire, and provides 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 better supports 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 Sarabah bushfire within Lamington NP (Figs 1 and 5; section 4.1) in the Southeast Queensland Bioregion that burned over the period September-December 2019. Landscape features and place names used in this report as per 1:25 000 scale topographic mapping available online at QTopo: https://qtopo.information.qld.gov.au/.

3 Background

Lamington NP (21 258ha) is in the Scenic Rim west of the Gold Coast and south of Brisbane, at the southern extent of the South East Queensland Bioregion. The terrain is mountainous (up to nearly 1200m altitude) and supports a wide range of vegetation communities. It is an iconic national park widely known for the rainforests and landscapes it conserves. Most of the park is included within the Gondwana Rainforests WHA. It was one of the first national parks declared in Queensland (1915), so much of the park has a history of little or no timber harvesting. Further background information on Lamington NP is available at https://parks.des.qld.gov.au/parks/lamington. The bushfire assessed in this report burnt the north-eastern section of the park, where there is a history of timber harvesting and some grazing. Consequently, some areas affected by the bushfire included well established infestations of *Lantana camara* and other weeds and some small clearings.

3.1 Landscape overview of the fire and timeframe

3.1.1 Overview

The Sarabah 2019 bushfire event started about 1 September 2019, approximately 8-9km to the north of Lamington NP (Fig. 1). On Friday 6 September 2019 strong and dry west to north-westerly winds caused it to move south and it crossed the northern boundary of Lamington NP in several places. By the morning of 8 September 2019, a number of properties at Upper Beechmont and the Binna Burra Lodge were destroyed. The fire continued to burn within Lamington NP over the following weeks, moving south into moister vegetation types. This, in conjunction with milder weather conditions, including some rainfall in October 2019 (~30mm at Binna Burra), led to fire activity becoming undetectable.

A return to very dry and hot conditions in early November 2019 however, resulted in numerous re-ignitions within Lamington NP. During the latter half of November and through December 2019 fire slowly burnt through previously unburnt rainforest and wet sclerophyll forest communities. As an example, the upper slopes of Laheys Tabletop, dominated by open forest, were burnt at moderate to high intensity during the initial stages of the fire in early September, with the fire not penetrating the Araucarian complex notophyll vine forest on the mid to lower slopes. Some two months later, with ongoing leaf fall and further desiccation of the soil-leaf litter layer, the fire reignited and burnt downslope, at low intensity, to Canungra Creek (see cover photograph). In doing so, the fire burnt coarse woody debris and areas of deep leaf litter including at the base of large rainforest trees which ignited the trees, causing numerous tree falls, canopy gaps and loss of understorey vegetation. Furthermore, some areas of rainforests that burnt at very low intensity in September re-burnt in November–December due to leaf-fall and ongoing desiccation of the leaf litter and humus layer.

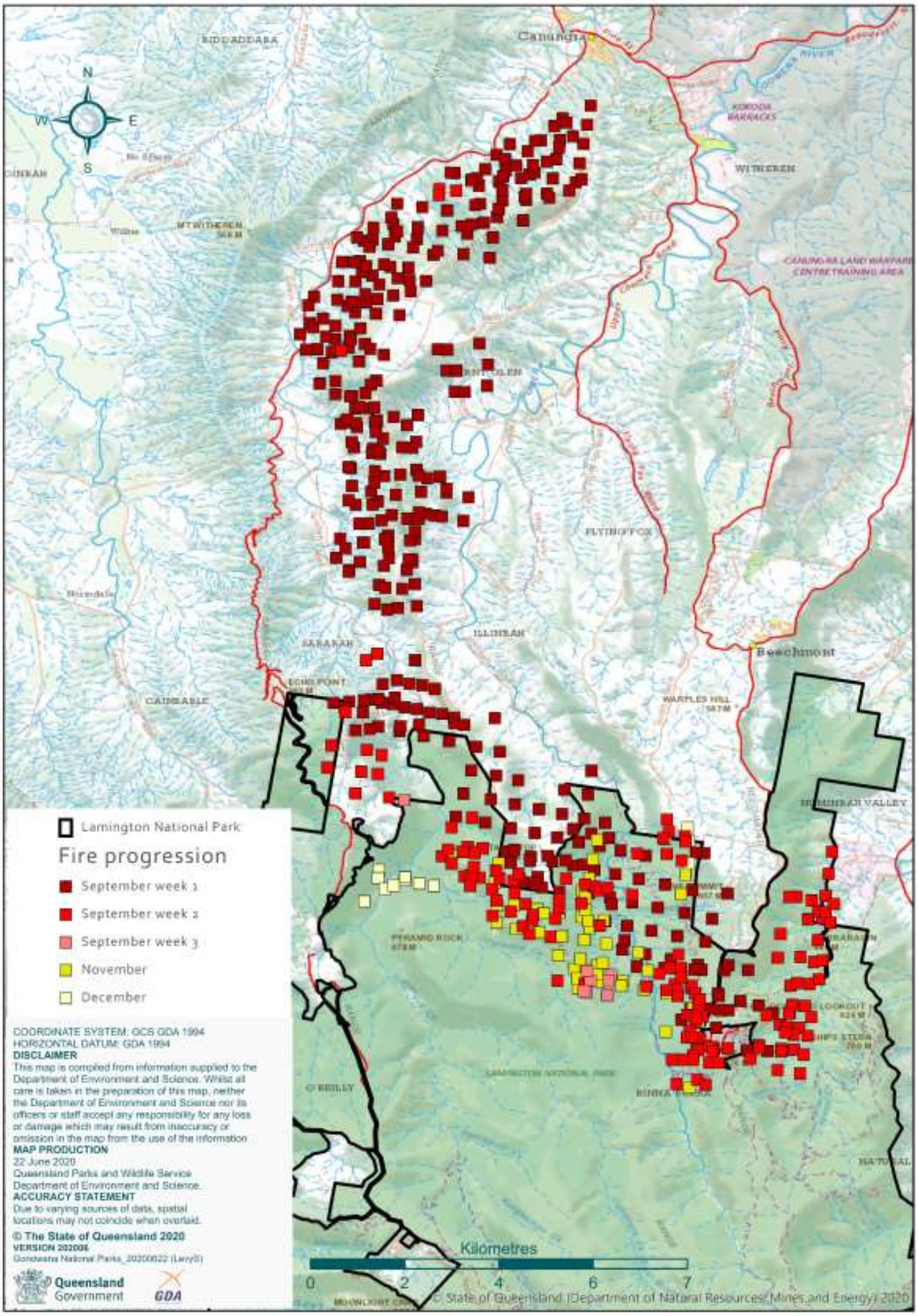

Figure 1. The progression of the Sarabah bushfire across the landscape from September to December 2019 based on VIIRS hotspots FIRMS (2020). The Lamington NP boundary is shown in black. The fire was not detectable on VIIRS from late September to early November 2019. Note VIIRS pixel size is 375m, and hotspots can be missed due to low intensity fire, cloud cover or incomplete satellite passes. This map therefore provides a coarse overview of the fire's progression.

3.1.2 Observations of fire behaviour by local QPWS staff

Overall observations

- The Sarabah bushfire started Sunday 1 September 2019 and continued for 24 weeks until a 200 mm+ rain event commencing on 15 January 2020 extinguished the fire.
- The 24-week fire period can be broken down to three distinct periods: initial bushfire, second burning of initial areas and third burning of new areas.

Initial bushfire period

- Followed the prolonged dry spell in 2019 where we had no real wet season, very dry January, a few light showers in February and a moist March (21 rainy days but no falls over 50mm).
- April and May were showery but there were only a couple of 50mm falls with most rainy days only resulting in <10mm, with no significant rain from June onwards.
- 2019 was the third rainfall deficit year in a row with the deluge in late March 2017 associated with XTC (ex-Tropical Cyclone) Debbie being the last major wet period.
- Many management agencies, including QPWS, continued their planned burning activities through August 2019 even though soil moisture was extremely low and weather patterns were abnormal with strong dry westerly winds being a feature early in the season. Planned burns proved hard to extinguish due to very low soil moisture and trees that continued to burn below ground.
- The fire commenced on Sunday 1 September 2019, on private property south-west of Canungra (Fig. 1) and spread north and south of the ignition point over the following days.
- The two days with significant loss of property (houses and associated structures) adjacent to Lamington NP (6-7 September) were marked by extremely low humidity (< 10%) and high winds (> 40km/hr) which produced extreme FDIs (145+), the highest on record for Binna Burra.
- The level of fire spotting because of ember attack from active fire fronts on these two days was unprecedented for the region, with fire spotting on the afternoon of 6 September being greater than 1km ahead of the main fire front.
- Apart from a narrow head fire which moved relatively quickly due to wind, slope and aspect, the rate of spread of the flanking fire fronts was consistently between 20 and 25m/hr for most of the fire event.
- Whilst flanking flame heights were mostly <2m, high fuel loads in some areas (30+tonnes/ha) and the low level of moisture retained in the vegetation and leaf litter layers resulted in the fire fronts having a long residence time which in places increased fire intensity and severity.
- Sclerophyll ecosystems (*Eucalyptus*, *Corymbia* or *Lophostemon* dominated) burnt in the initial stage of this fire, including extensive areas with a well-developed rainforest shrubby understorey (particularly above the Bellbird cliffs, the lower Bellbird and Illinbah walking track circuits).
- Previously storm-damaged areas were amongst the most severely burnt areas. XTC Debbie in 2017 and XTC Oswald in 2013 caused substantial canopy loss and increased coarse woody debris fuel load on the ground, which subsequently dried and increased fire intensity in these areas.
- Most of the fire fronts during the initial phase appear to have self-extinguished on the rainforest margins (i.e. where sclerophyll overstorey dropped out), with only minor penetration. Greater penetration into rainforests occurred where gaps from storm damage had resulted in a drier ground layer.
- Two drops of fire retardant by a large air tanker proved ineffective as the dense canopy layer prevented the retardant reaching the understorey and the fire fronts continued to burn through under the tree canopy.
- Where the bushfire entered areas burnt in planned burns within the previous two to five years, penetration into rainforest and riparian vegetation was minimal, with the bushfire stopping where the earlier planned burns had.
- The bushfire did not significantly penetrate into the two areas burnt in planned burns earlier in the year (i.e. January and August 2019).

Secondary burning

- Secondary burning occurred after the initial fire became undetectable. This was due in-part to the massive leaf drop, from canopy scorch and ongoing drought, ignited by smouldering, very large diameter, standing and fallen trees (particularly brush box *Lophostemon confertus*).
- The Darlington Range was the best example of this, with the fire relighting in late October - early November nearly two months after self-extinguishing on the rainforest margins (Fig. 1). It subsequently burnt back north towards Laheys Tabletop and back down the numerous sclerophyll dominated spurs on the sides of the range.

These fires, of low intensity, pushed further into the margins of the numerous dry rainforest gullies on either side of the Darlington Range due to the additional drying and low soil moisture within these ecosystems.

- Many large hoop pines (*Araucaria cunninghamii*) burnt during this period. Fire carried up the trunks following vines, epiphytes and leaf litter. It was a spectacular but disturbing sight as they went up in flames (up to 30m above the ground) like massive candles in the rainforest.

Third burning

- The third and final stage of the fire was from late November through December. The fire fronts of the secondary burning of the sclerophyll forests and dry rainforest gullies on the Darlington Range burnt down and through rainforests as a ground fire (flame height < 300mm and rate of spread ~100m/day) all the way to Canungra Creek and through the riparian rainforest along the creek (Fig. 1).
- A large area of dry rainforest on the western slopes of Laheys Tabletop burnt at this time. Other areas that burnt during this period included: the northern park boundary at Illinbah down to the Coomera River (previously unburnt dry rainforest, lowland subtropical rainforest and riparian forest), wet sclerophyll forest in the Chiminya and Nixons Creek area, and wet gullies and areas of lantana around the base of Kurraragin/Egg Rock and in the vicinity of the park boundary with the Numinbah Correctional Centre down to Nixons Creek.
- At peak intensity, the fire spotted across Canungra Creek in early-mid December and then moved slowly upslope towards Kamarun Lookout area and Blue Creek Falls. It also moved south across Pyramid Creek, burning to the base of Pyramid Rock.
- QPWS staff, with assistance of QFES Remote Area Firefighting Team on occasions, undertook a month of arduous remote area firefighting in Canungra-Pyramid Creek and Chiminya-Nixons Creek. This involved chipping containment lines, carrying portable pumps and hoses to extinguish fire, and burning out small areas in long-unburnt sclerophyll communities, to contain the fire.

3.2 Weather

The Bureau of Meteorology (2019) undertook detailed analyses of the fire weather affecting north-east New South Wales (NSW) and south-east Queensland (Qld) during early September 2019. Key climate and weather factors leading up to and during the fire event include:

- Rainfall prior to September 2019 had been below average on a range of timescales from months to years, leading to a prolonged and severe drought.
- Rainfall in the Gold Coast hinterland had been well below average, but generally not lowest on record for the year-to-date. Conditions were extremely dry at the start of the year, with rainfall in January and February below average to locally lowest on record for those months. Rainfall for March to June was generally close to average, with a return to drier than average conditions in July and August. August was very dry (less than 10 mm at most sites) but August is a seasonally dry month for the region.
- Year-to-date rainfall was generally about 50% below average at sites with at least 40 years of rainfall records such as Mount Tamborine, Wunburra, Springbrook, and the longest-running Gold Coast site (Miami). Those long-term sites all had one of their ten driest starts to the year: Wunburra (second-lowest); Springbrook (third-lowest); Miami (fourth-lowest); and Tamborine (eighth-lowest).
- From 6 September 2019 there were much warmer than average daytime temperatures, very low relative humidity (<15%), and gusty winds.

The McArthur Forest Fire Danger Index (FFDI) is commonly used in Australia to indicate the combined influence of various weather factors associated with dangerous bushfire conditions. It reflects longer-term rainfall and temperature patterns and shorter-term weather. A time series of the FFDI data (as described by Dowdy 2018) for the Gondwana forest areas of south-east Queensland is provided in Figures 2 and 3: annual averaged FFDI, and average number of Very High FFDI days per year (i.e. FFDI greater than 25), respectively. These figures show much higher than average FFDI for the region in 2019 and substantially higher number of days with Very High FFDI in 2019 compared to the historical data (data provided by A. Dowdy, Bureau of Meteorology, August 2020).

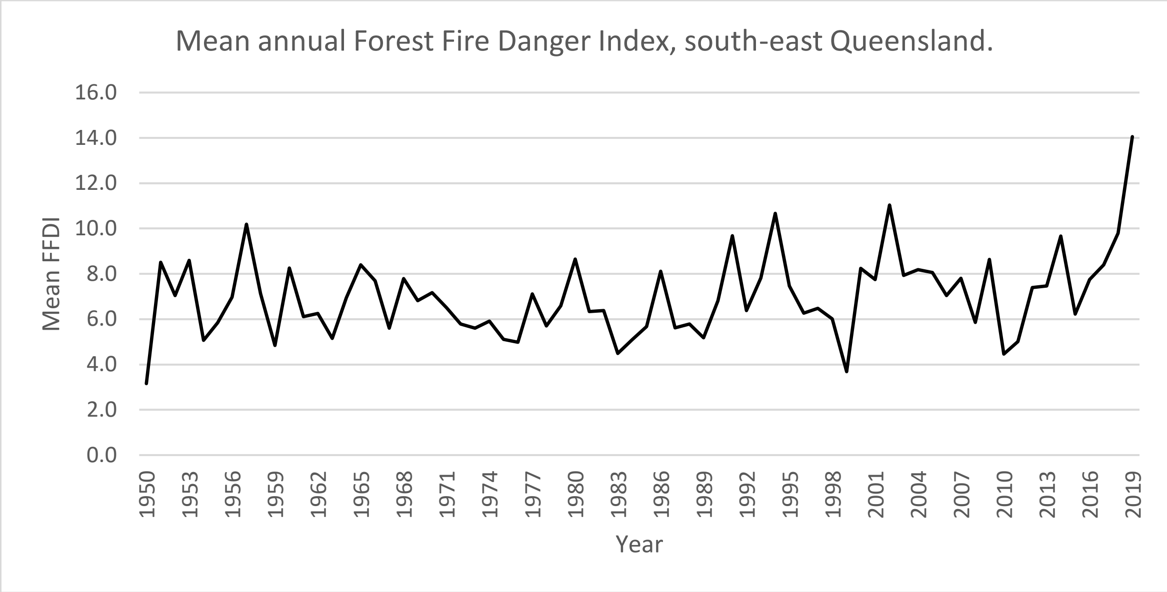

Figure 2. Time series of mean annual Forest Fire Danger Index (FFDI) for south-east Queensland (28-29S 152-153.5E).

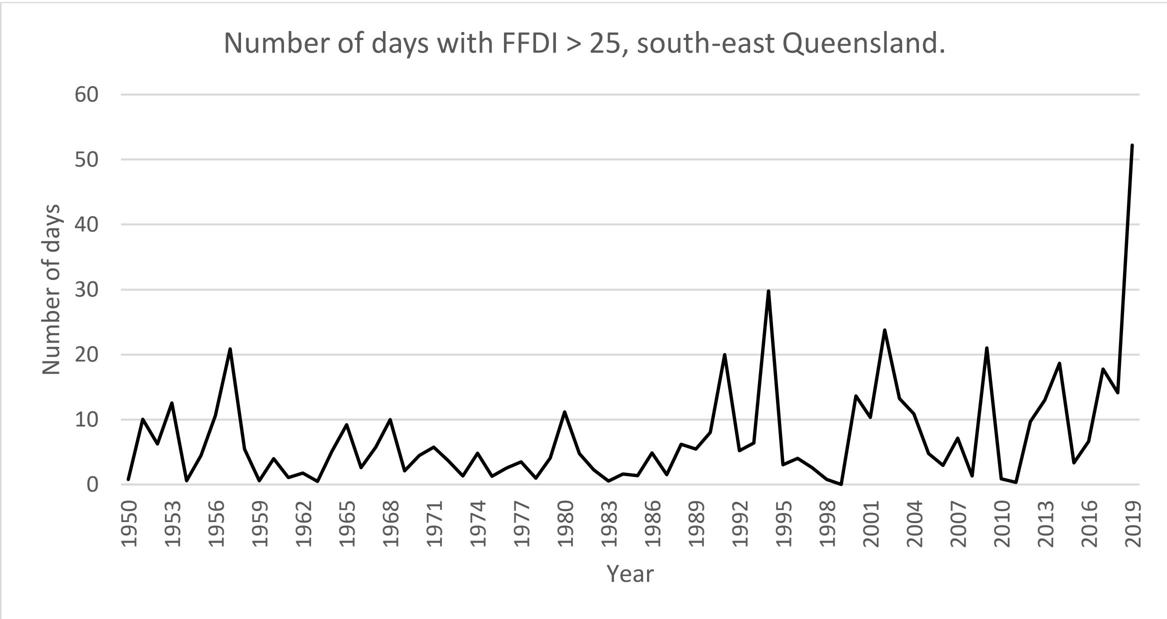

Figure 3. Time series of the number of severe Forest Fire Danger Index days (FFDI >25 = Very High) per year, for south-east Queensland (28-29S 152-153.5E).

Some rainfall was received on the fire ground during October 2019 (~30mm at Binna Burra) and during this period the fire smouldered undetected. A return to very low humidity and above average temperatures from early November saw numerous re-ignitions of the fire, with the fire moving slowly through parts of the lower Canungra and Coomera River valleys (Fig. 1). Approximately 60mm of rain was received on Christmas Eve, and with showers and rain through January (~200mm total, 100mm 18 January), the fire was extinguished.

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 fire lines, use of foams and retardants in sensitive ecosystems).

A range of suppression methods were used on QPWS estate during the event, including:

- Aerial water bombing support (direct attack):
  - a 737 large air tanker did two drops of retardant, coloured with red dye, one in the Piccabeen Creek area of the Illinbah Circuit and the other north of Nixons Creek parallel to Egg Rock Creek, with water sourced

from central NSW.
- smaller aircraft and helicopters with water sourced from Advancetown Lake and the Numinbah Correctional Centre waste water treatment ponds, with no added surfactants, gels, retardants or dyes. Areas particularly targeted included those adjacent to Binna Burra lodge complex, Nixons and Chiminya Creeks.
A few hundred water drops were used to slow the progression of the fire, protect life and property and target hot spots.

- No earthmoving machinery was used to widen or reopen fire-lines within Lamington NP.
- Back-burning was conducted along the northern side of Egg Rock Firetrail and around the Binna Burra QPWS office complex.
- Fortification of the Lower Bellbird Walking Track as a mineral earth break through raking of leaf litter and leaf-blowing.
- Various rakehoe/leaf blower lines (totalling hundreds of metres to kilometres) in remote areas to contain hotspots.
- Pumping of water from creeks in some remote areas.
- Mop up and patrol with QPWS fire units, rural and urban appliances and remote area firefighting teams, with Fire-Brake Class A foam (but not near any water ways).
- A large quantity of urban grade firefighting foam was used to defend the QPWS office complex at Binna Burra.

4 Assessment methods

4.1 Fire extent and severity mapping

Spatial data was supplied by Department of Environment and Science, QFES, and Department of Natural Resources Mines and Energy.

Fire progression was mapped daily at times using satellite imagery from Planet.com imagery, Sentinel-2 and linescan data. A shortwave infrared rendering was used to depict the fire front and burnt area in Sentinel-2 and false colour rendering was applied to the Planet.com imagery. Linescan data was provided by QFES. The final fire extent (Fig. 4) was derived from the above sources and refined using fire severity mapping described below and field assessments. Digitising was completed using ArcGIS Pro 2.4.2.

Fire severity mapping (Fig. 5), using 12 band Sentinel-2 L2A satellite imagery, formed the basis of the assessment for the bushfire. The fire severity classification was derived from pre- and post-fire imagery (24 August 2019 and 21 January 2020 respectively) covering the extent of the fire. 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 (b8) and 12 (b12) according to the following formula:

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

A 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. Appendix 1 contains photographs of burnt sites from within the assessment area.

Overall, the dNBR analysis created a consistent and generally reliable classified product reflecting relative damage to the forest canopy and subcanopy. The classification appeared to work best in the sclerophyll forests. Field assessments showed that some areas of rainforest mapped with low severity fire were unburnt and some areas mapped as unburnt experienced low severity fire. A more reliable assessment of the extent and severity within rainforest communities may be achieved using imagery captured a few months post-fire, when death of vines, shrubs and trees, caused by low intensity fire at their bases/root zone, becomes more detectable in the canopy. Extent and severity mapping for the bushfire was complicated in the Kurraragin/Egg Rock area by recent planned burns – one about a month prior to the bushfire and another earlier in 2019. Some of the areas shown in Fig. 5 as low severity to the southwest of Kurraragin/Egg Rock did not burn in the bushfire, whilst some of the areas to the north of Kurraragin/Egg Rock burnt in both the August 2019 planned burn and September 2019 bushfire (likely as a as a result of re-ignition during bushfire conditions).

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

Note that fire severity refers to an observable effect on vegetation (in our assessments through the use of satellite imagery, with some ground observation). It shouldn't 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. grasslands) 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).

Table 2. Relative fire severity classes, derived from the dNBR analysis.

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	Maximum dNBR value
Unburnt	Unburnt, canopy and subcanopy unchanged (within the mapped extent).	0.19
Low	Canopy and subcanopy unscorched, shrubs may be scorched, fire-sensitive low shrubs may be killed.	0.29
Moderate	Partial canopy scorch, subcanopy partially or completely scorched, and/or fire-sensitive tall shrub or small tree layer mostly killed.	0.47
High	Full canopy scorch to partial canopy consumption, subcanopy fully scorched or consumed.	0.72
Extreme	Full canopy, subcanopy and understorey consumption.	10.00

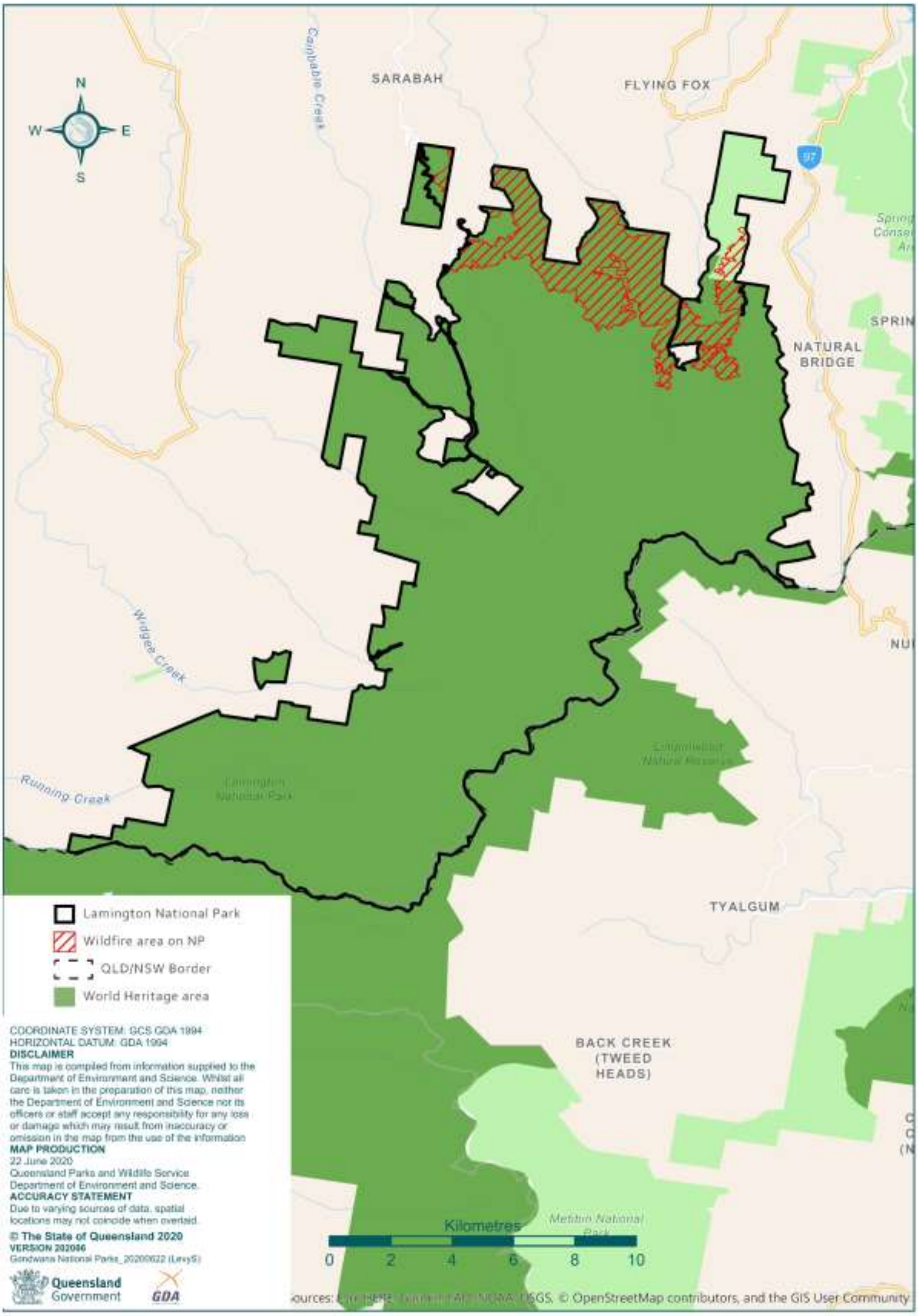

Figure 4. Extent of the Sarabah bushfire within Lamington NP, in relation to the Gondwana Rainforests WHA. Lamington NP boundary shown as black, Gondwana Rainforests WHA shaded dark green, protected areas outside shaded WHA light green and estimated fire extent within Lamington NP shown as red cross-hatch.

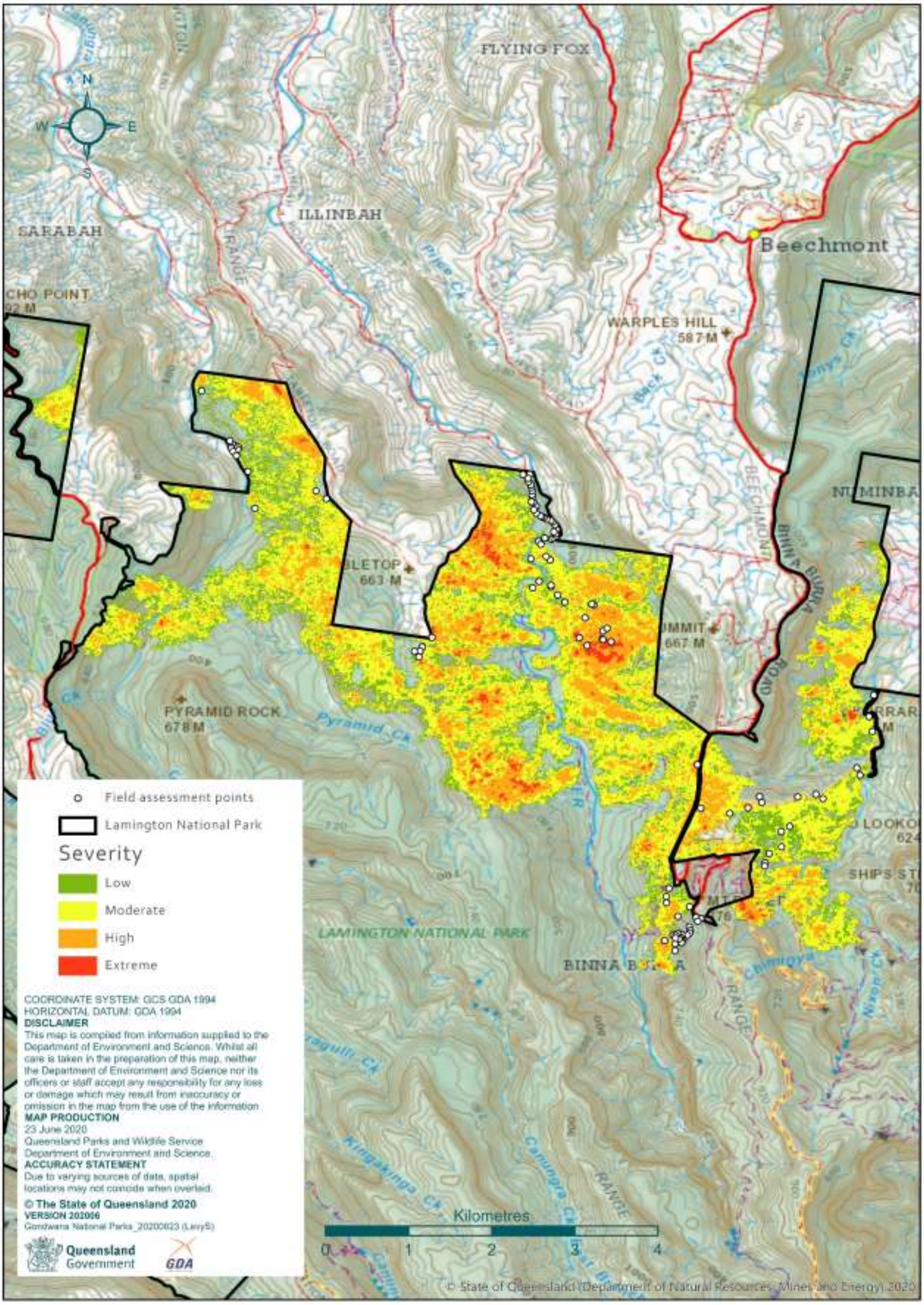

Figure 5. Relative fire severity of the Sarabah bushfire within Lamington NP. White circles show the location of verification sites. Base map: QTopo.

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 and version (10.1) was used for this assessment (Queensland Herbarium 2018). 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 often heterogeneous, such that a polygon is attributed to more than one regional ecosystem code (e.g. 11.3.2/11.3.25), 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 take into account the percentage of it within the polygon. The resolution or scale of RE mapping delineates a minimum area for remnant vegetation of 1ha and/or 35m in width.

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

4.3 Conservation significant species data sources

Information on conservation significant species (threatened, Near Threatened, Special Least Concern or endemic forest fauna and flora species) known, or likely, to occur in the burn area, was principally derived from the state's wildlife information system WildNet (accessed 28 November 2019), which includes plant species locality information held by the Queensland Herbarium. WildNet was searched for records with a locational precision of 2000m or better that fell within the latitudes of -28.115 and -28.219 and longitudes of 153.129 and 153.221 (Appendix 4). This rectangle included an approximate 2km buffer on the northern, eastern, southern and western extent of the QPWS estate affected by the fire event. Limited validation was undertaken, but some records or species were rejected due to likely spatial or taxonomic errors, or vagrants.

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 burn area. Refer to Appendix 5 for a description of methods used. The lists generated by the models were scrutinised by departmental experts and species deemed highly unlikely to occur on the park were removed.

Knowledge of local staff, published and unpublished information, as well as expert opinion, were used to augment the spatial analyses and inform the impact assessment process. To help identify those significant species most at risk from bushfire each was classified according to their known or likely fire sensitivity, or dependence upon fire sensitive ecosystems.

Species nomenclature, taxonomy and statuses 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 on foot and by vehicle over the period 11-13 November 2019 and 30-31 January, 18 February and 8 April 2020. Observations of impacts on and recovery of vegetation, fire severity and a series of photographs were recorded at various locations. Verification sites are shown as white circles on Fig. 5. During the initial assessment period, numerous re-ignitions of hotspots precluded safe access to many areas. Subsequent assessments included some areas that burnt in late November-December 2019. No aerial inspections were undertaken.

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 (Fire Extent and Severity 2019-2020 - South East Queensland dataset). 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 = 27820, and is searchable using the keywords: fire, severity, ecological, natural values, assessment, Lamington or via the link:
http://wildnet/wildnet/bin/WNE0130$VMEDIAQRY.QueryView?P_MEDIA_ID=27820

5 Summary of areas burnt

Basic fire details and a summary of areas burnt is provided in Table 3. Statistics were derived using ArcGIS and the sources identified in the table. A summary of the areas burnt (ha) by relative fire severity class is provided in Table 4. The map of relative fire severity is provided in Figure 5.

Table 3. Summary of burnt areas

Description	Value and units	Source and notes
FLAME Fire ID(s)	13268380	Flame Label: Lamington National Park/NP/W/2019/003
FLAME Fire name(s) (FLAME)	Binna Burra Bushfire	
QFES fire name(s)	Sarabah	
Fire start date	31/08//2019	FLAME
Fire started on or off-estate	Off estate	FLAME/ FIRMS hotspots (Fig. 1).
Date fire first recorded on estate	06/09/2000	FLAME
Date fire declared contained	14/01/2020	FLAME
Total area burnt (on and off estate)	4 997ha	FLAME extent mapping
Bioregion(s)	South East Queensland	
Estate name(s) burnt	Lamington NP	FLAME
QPWS Region(s)	South East Queensland	
Area burnt within QPWS estate	1 574ha	This report (Table 4, Appendix 3), based on relative fire severity mapping. See also Table 4.
Area burnt within World Heritage Area	1 515ha	This report, based on relative fire severity mapping. Name of WHA: Gondwana Rainforests World Heritage Area ENVBAT.QLD_WORLDHERTAREA See also Table 4.
Area burnt within Ramsar areas	0ha	Name of Ramsar area: N/A
Directory of Important Wetlands of Australia within burn extent	Upper Coomera River	Directory of Important Wetlands in Australia
Area burnt of habitat of state Biodiversity Significance (BAMM)	1 554ha	This report, based on relative fire severity mapping. SIR dataset: ENVBAT.BPA_SEQ See also Table 4.
Area of core Koala habitat (SEQ Koala Conservation Strategy 2019-2024) burnt	823ha	This report, based on relative fire severity mapping. SIR datasets: ENVBAT.HSM_SEQRP_KOALA ENVBAT.HSM_SEQRP_KOALA_LRKHA See also Table 4.

Table 4. Area burnt (ha) by relative fire severity class within Lamington National Park.

Severity class	Lamington NP	Gondwana Rainforests WHA	BAMM State Biodiversity Significance	Core Koala habitat
Low	370.71	357.64	363.93	149.51
Moderate	782.11	749.19	773.62	413.10
High	388.42	375.72	383.98	240.22
Extreme	32.90	32.51	32.55	19.79
Total	**1574.14**	**1515.07**	**1554.09**	**822.62**

5.1 Vegetation burnt

Summaries of the area of Regional Ecosystems and Broad Vegetation Groups within Lamington National Park and the area of each burnt, within each relative fire severity class 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 fire and require fire of an appropriate severity and interval to maintain ecosystem health. Other ecosystems are fire intolerant or fire sensitive and if they burn significant long-term ecological damage is likely.

For this assessment, REs were classified into three fire tolerance categories using fire management guidelines provided in the Regional Ecosystem Description Database (Qld Herbarium 2019) for RE1 and expert knowledge:

- *fire sensitive canopy and understorey,*
- *fire tolerant canopy/fire sensitive understorey,* or
- *fire tolerant canopy and understorey.*

The area, of each of the three fire tolerance categories, subjected to low, moderate, high or extreme fire severity, is shown in Table 5A. Burnt areas were assigned to three Potential Ecological Impact classes, based on the matrix (Table 5A) of fire severity and fire tolerance of the vegetation communities and the susceptibility of the ecosystem to threats, such as invasion by ecosystem-changing weeds, that could significantly impede or derail recovery. A summary of the Potential Ecological Impact is provided in Table 5B, is mapped in Figure 7, and discussed in section 6.

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

Table 5A. Area (ha) of burnt remnant vegetation classified by fire tolerance and relative fire severity class.

Fire severity		Fire tolerance of vegetation community (based on RE1)		
		Fire sensitive canopy and understorey	Fire tolerant canopy/fire sensitive understorey	Fire tolerant canopy and understorey
Low	Canopy and subcanopy unscorched, shrubs may be scorched, fire sensitive low shrubs may be killed.	**202**	**50**	**106**
Moderate	Partial canopy scorch, subcanopy partially or completely scorched, and/or fire sensitive tall shrub or small tree layer mostly killed.	**326**	**113**	**326**
High	Full canopy scorch to partial canopy consumption, subcanopy fully scorched or consumed.	**120**	**46**	**212**
Extreme	Full canopy, subcanopy and understorey consumption.	**10**	**2**	**19**

Table 5B. Potential ecological impact (ha) to burnt remnant vegetation based on fire tolerance and relative fire severity class, for RE1.

Note that the concept of potential ecological impact class also takes into account the susceptibility of the ecosystem (given the fire severity to which it has been subjected) to threats post-fire that could significantly impede recovery.

Potential ecological impact class	Fire tolerance of vegetation community (based on RE1)		
	Fire sensitive canopy and understorey	Fire tolerant canopy/fire sensitive understorey	Fire tolerant canopy and understorey
Limited or none		**50**	**432**
Moderate	**202**	**113**	**212**
High	**326**	**46**	**19**
Catastrophic	**130**	**2**	**0**

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 expected relative rapid regeneration by native, fire-adapted, understorey species, helping to minimise the risk of weed invasion by ecosystem-changing species (if they were not already established prior to the fire). There will be limited 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 reliant on the understorey.

Moderate potential ecological impact (yellow):

There may be localised decline in, or loss of, some understorey species, over the short-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.

High potential ecological impact (orange):

Rainforest recovery requires recovery of both structure and composition and is expected to be slow (decades to hundreds of years) given: the loss of some to many trees (either as a direct consequence of the fire or because of associated stressors such as fungal attack – there may be ongoing death of some tree species/individuals for several years after the fire); vegetative regeneration, where it occurs, is likely to be predominantly basal or from the rootstock; loss of the seedling bank and likely limited seed-bank means that the recovery of some species will be dependent on seed being transported into the site. The risk of invasion by ecosystem-changing weed species (e.g. *Lantana camara*) is likely to be high, and may be exacerbated by past disturbance regimes.

For the eucalypt-dominated communities this class 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, in the wet eucalypt open forests that have a rainforest understorey and the potential flow-on effects to faunal assemblages; loss of epiphytes and niches suitable for their re-establishment at least in the mid-term. It is recognised that occasional high intensity fire in wet eucalypt open forests is likely critical to the ecology of the ecosystem in terms of providing opportunity for eucalypt regeneration in sites where rainforest dominates the understorey and may assist, in conjunction with a planned burn program, in maintaining a grassy to mixed shrubby understorey in others. The risk of invasion by ecosystem-changing weeds is likely to be high, and may be exacerbated by past disturbance regimes.

Catastrophic potential ecological impact (red):

There is significant risk of an ecosystem not recovering as a consequence of the substantial changes in structure, composition and microclimate and associated likelihood of invasion by ecosystem-changing weeds or native species better adapted to the post-fire environment than the impacted ecosystem, and/or risk of future 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.

5.2 Significant species potentially impacted

The list of conservation significant forest 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 potential habitat for selected conservation significant species within each relative fire severity class. Potential impacts on threatened species are discussed in section 6.3.

A large number of conservation significant flora and fauna species are known, or have potential habitat, within the burnt area. Impacts on these species will vary, but those in fire sensitive communities are likely to have been most highly affected. Only two species with more than 10% of their potential Queensland habitat falling within Lamington NP, had more than 10% of this habitat at Lamington NP burnt: Albert's lyrebird (Near Threatened) and the plant *Westringia rupicola* (Vulnerable). Maps, showing potential ecological impact, overlain with potential habitat for these two species are presented in Appendix 8. Both these species were likely significantly impacted by the fire. Albert's lyrebird is dependent upon fire sensitive rainforest as well as wet sclerophyll forest communities with a fire sensitive understorey. *Westringia rupicola* occurs on rock pavements and cliff lines which typically burn with high severity. Plants in these areas were likely highly drought stressed or perhaps even drought-killed at the time of the fire.

5.3 Area of Natural Key Values burnt

Under the Values Based Management Framework, seven Natural Key Values (NKV) have been identified for Lamington NP. Fig. 6 shows the location of NKVs with respect to the extent of the 2019 bushfire. The area burnt for each NKV by relative severity class is summarised in Table 6. The Broad Vegetation Group (BVG) of each NKV is shown in Table 6 in parentheses.

Much of Lamington NP, including a majority of the burnt area, falls within the Gondwana Rainforests World Heritage Area, meeting various natural heritage criteria for Outstanding Universal Value. The Natural Key Values identified for Lamington NP incorporate these values. Further detail of the World Heritage Value of Lamington National Park is included in Appendix 7.

Table 6. Area of Natural Key Values (NKV) burnt (ha) at Lamington NP, by relative fire severity class.

BVG = Broad Vegetation Group at the 1:2 000 000 scale

Natural Key Value (corresponding BVG*)	Area of NKV within estate (ha)	Percentage NKV burnt	Relative fire severity (ha)			
			Low	Moderate	High	Extreme
Dave's Creek montane heath and Ships Stern shrubby woodland (BVG 9 and 29)	204.6	0.0%				
Dry vine forest (BVG 5)	140.8	21.5%	13.23	13.23	3.45	0.37
High altitude rainforests - cool temperate rainforest (BVG 6)	635.1	0.0%				
High altitude rainforests - warm temperate rainforest (BVG 6)	120.6	0.0%				
High altitude rainforests - upland subtropical rainforest (BVG 6)	5565.4	0.0%				
Lowland subtropical rainforest (BVG 2)	3471.1	15.4%	159.65	267.17	99.56	9.20
Moist to dry open forest ecotones (eastern bristlebird and Hastings River mouse habitat) (BVG 8 and 11)	1251.6	13.8%	42.64	94.84	34.52	0.32
Riparian corridors (various BVGs)	1130.9	3.9%	20.09	19.65	4.48	0.14
Total	**12520.1**	**6.3%**	**235.60**	**394.90**	**142.00**	**10.02**

*under the Values Based Management Framework, a NKV for a protected area may include all or part of a BVG mapped within that protected area. Refer to Appendix 3 for a description of the BVG and a summary of the area burnt within each relative severity class for Lamington NP.

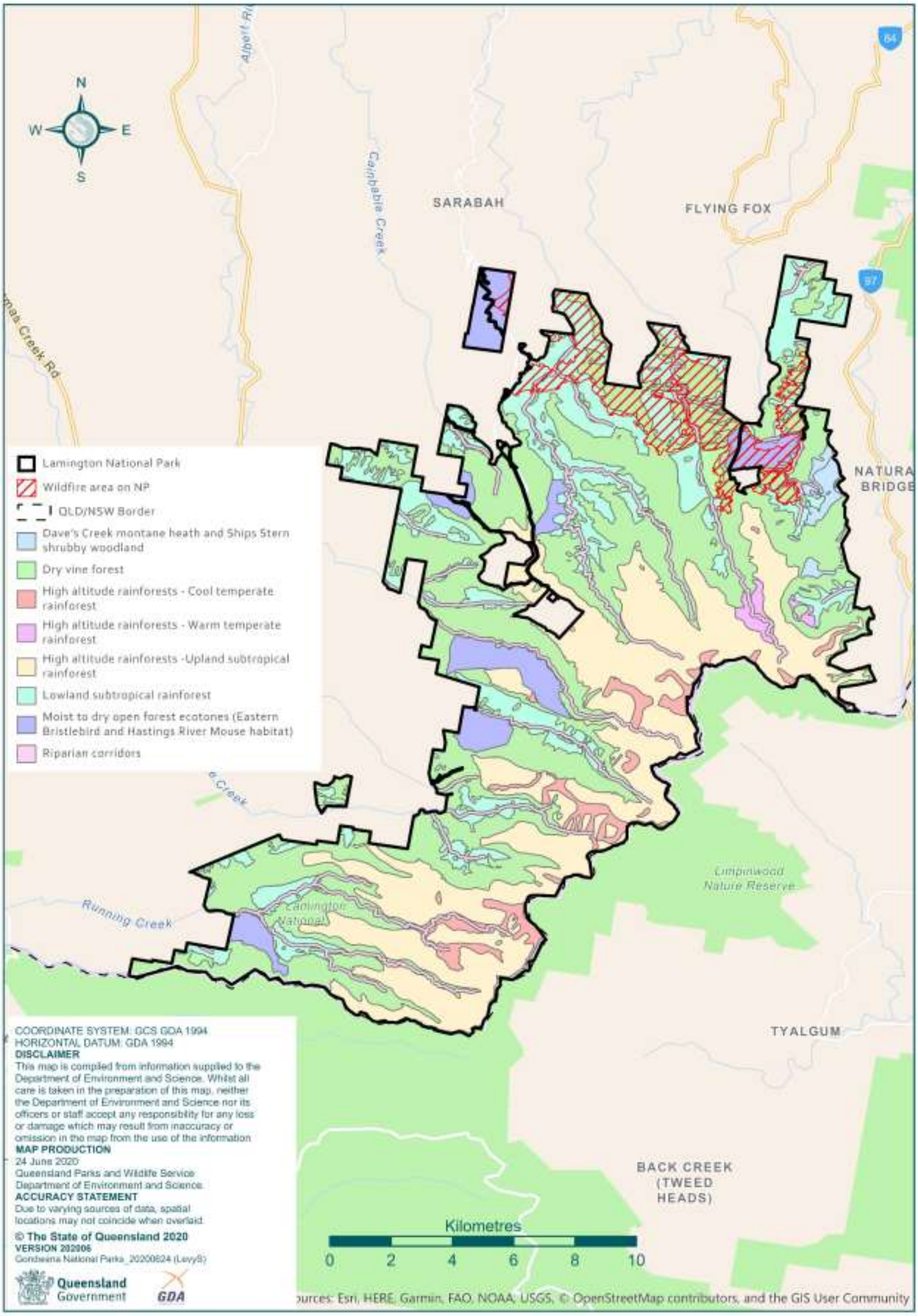

Figure 6. Estimated extent of the Sarabah bushfire within Natural Key Values of Lamington National Park.

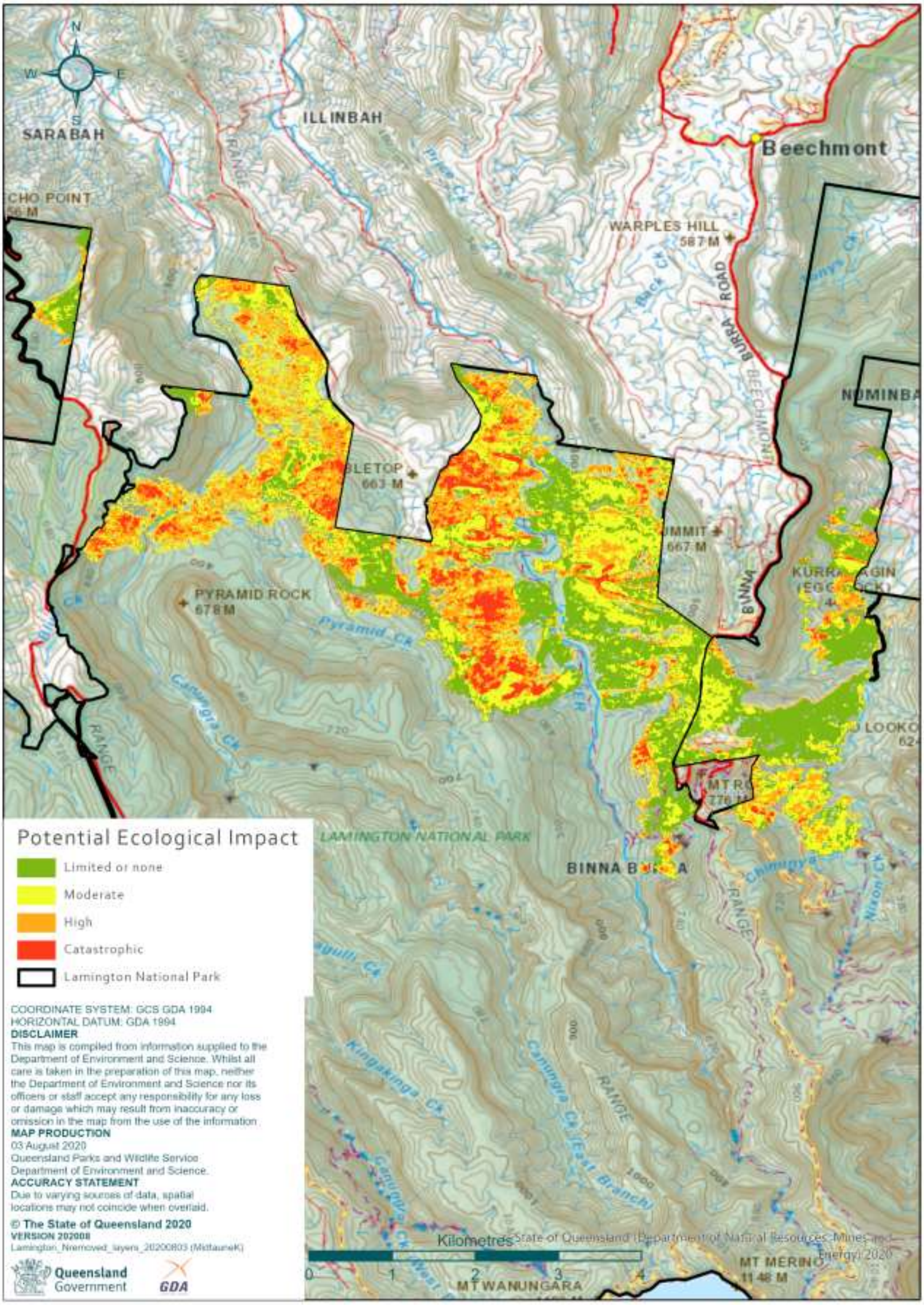

Figure 7. Map of potential ecological impact within Lamington National Park.

5.4 Ecological monitoring sites

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

Table 7. Existing ecological monitoring sites that are known to or are likely to have burnt during the event.

Dataset name	Type of monitoring	General location of monitoring site(s)	Custodian	Priority for resampling
IBISCA vegetation plots	Long term quantitative plots surveyed in 2006 and 2016	Canungra Ck	Melinda Laidlaw, Queensland Herbarium	High
Bell Miner Affected Dieback (BMAD) monitoring	Photo monitoring	Sarabah section	Wil Buch, QPWS	High
Threatened frogs monitoring	Stream transects	Nixons Ck and Coomera R	Harry Hines, QPWS	High

6 Significant impacts and recovery actions

6.1 Summary of priority impacts and recovery actions

Five natural values were assessed as being significantly impacted by the bushfire event. For the purposes of our assessment these are defined using Broad Vegetation Groups at the 1:2 000 000 scale (BVG 2M):

Value Id.	Value descriptor
NV 1	Rainforests – encompasses NKVs "Lowland subtropical rainforest" and "Dry vine forest". – Regional Ecosystems with a fire sensitive canopy and understorey. – BVGs 2, 4 and 5.
NV 2	Wet eucalypt open forests and rainforest/eucalypt forest ecotones – partially encompasses NKV "Moist to dry open forest ecotones (eastern bristlebird and Hastings River mouse habitat)". – Regional Ecosystems and rainforest/eucalypt forest ecotones with a fire tolerant canopy and a fire sensitive understorey. – BVG 8.
NV 3	Dry eucalypt forests and woodlands – partially encompasses NKV "Moist to dry open forest ecotones (eastern bristlebird and Hastings River mouse habitat)". – Regional Ecosystems with a fire tolerant canopy and understorey. – BVGs 9, 10, 11 and 28.
NV 4	Montane heaths and shrublands – Regional Ecosystems with a fire tolerant canopy and understorey. – BVGs 29.
NV 5	Riparian corridors – encompasses NKV "Riparian corridors" – Regional Ecosystems fringing streams and rivers with either a fire sensitive or fire tolerant canopy and a fire sensitive understorey. – various BVGs.

The highest priority impacts and actions for recovery are summarised below. 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.

- **Rainforest:** iconic, highly diverse, fire sensitive ecosystems. A large proportion of burnt areas have high to catastrophic potential ecological impact due to the sensitivity of the ecosystems to fire, the fire severity and its impact on the structure and composition, and the significant risk of invasion by ecosystem changing weeds. Recovery is likely to take decades (at least) and will require exclusion of fire and the prevention of invasion by weeds. Review of fire management planning for surrounding fire-adapted ecosystems – with the aim of minimising risk of fire incursion into recovering rainforest (and unburnt rainforest), and control of ecosystem-changing weeds are the highest priority actions.
- **Wet eucalypt open forests and rainforest/eucalypt forest ecotones:** diverse ecosystems, some with high temporal and spatial variability, with a range of fire sensitivities. Most burnt areas have moderate potential ecological impact with some areas high to catastrophic. The ecological requirement for occasional high intensity fires in some of these ecosystems is recognised. However, the risk of invasion by ecosystem-changing weeds that have the potential to derail recovery (directly through competition and indirectly through changed future fire regimes) is factored into the evaluation of potential ecological impact. The risk of weed invasion is exacerbated where fire has substantially impacted the canopy and subcanopy. The control of ecosystem-changing weeds, and the review of strategies for weed and fire management in adjacent drier sclerophyll communities, are the highest priority actions.
- **Dry eucalypt forests and woodlands:** diverse, fire dependent ecosystems with a range of ecological fire requirements. Potential ecological impact is predominantly moderate but with small areas of high impact. Whilst these ecosystems are fire-adapted the partial to full consumption of the canopy and subcanopy in some areas represents long-term impact with respect to faunal habitat values, some of which may take decades to hundreds of years to form (e.g. hollow-bearing trees). Opening up of the canopy and subcanopy also increases the risk of invasion by ecosystem-changing weeds. Preventing the invasion of ecosystem-changing weeds is the priority action.
- **Montane heaths and shrublands:** fragile, naturally fragmented communities, with a distinctive flora. They are fire adapted and high to extreme fire severity is likely to be within the ecological tolerance of the ecosystem. The risk of ecosystem-changing weed invasion is low. The potential ecological impact has been identified as moderate to high in recognition that physical disturbance from trampling by visitors could significantly impede recovery. Priority actions include excluding visitors from burnt sites and reviewing fire strategies to ensure the period until the next fire event, and fire frequency thereafter, is within the ecological tolerance of the ecosystem.
- **Riparian corridors –** the potential ecological impact ranges from moderate to high–catastrophic with these ecosystems being particularly susceptible to weed invasion and erosion. The control of ecosystem-changing weeds, and the review of strategies for weed and fire management in adjacent drier sclerophyll communities, are the highest priority actions.

It is not recommended that restoration plantings are undertaken within the World Heritage Area given the risk of introducing novel genetic material, invasive plants or fungi (e.g. orange pore fungus *Favolaschia calocera*) or pathogens (e.g. myrtle rust (*Austropuccinia psidii*). Soil compaction caused by repeated visitation to a site can also be detrimental and impede natural regeneration. Previously cleared areas may be an exception and are discussed in section 6.3.

6.2 Limitations

This report focuses on a single fire event and we recognise that the response or 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 some 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. some rainforest species), or above-ground parts of the plant are scorched and recovery is from epicormic resprouting (e.g. eucalypts). However, much regeneration (especially rainforest) will be from seed as the seedling bank has been killed. For those species dependent upon basal resprouting or seed, recovery may take decades, but in some cases species may, unfortunately, be locally lost. In our assessment of the potential ecological impact of the fire we assumed that impacts to ecosystems dominated by fire tolerant 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.

Regional Ecosystem mapping and Broad Vegetation Groups underpin our assessment. Many polygons mapped within Lamington NP are heterogeneous, meaning more than one vegetation or regional ecosystem occur within it, generally because the REs occur in a mosaic below the scale of mapping. Two local examples demonstrate this issue: 1) narrow rainforest-sclerophyll forest ecotones (e.g. brush box *Lophostemon confertus* open forest) are often included within rainforest polygons (rather than being mapped as RE 12.8.9), and 2) narrow or small patches of palm forest (*Archontophoenix cunninghamiana*) are often included in another rainforest RE (e.g. RE 12.3.1 or 12.11.1) rather than mapped separately. In both instances, these communities are mapped within vegetation communities that fall into a different Broad Vegetation Group and they may have different fire tolerances. Communities dominated by brush box in Lamington NP have a fire tolerant canopy and a fire sensitive understorey, whereas rainforest is entirely fire sensitive. Field observations showed that some areas mapped with moderate severity fire within rainforest polygons contained brush box, which germinated from fires likely to have occurred centuries ago. These issues of scale and heterogeneity within RE mapping complicate our assessment, however RE mapping provides the framework for quantitative analysis.

These limitations are unlikely to grossly 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.

6.3 Impact assessment and recovery actions

6.3.1 NV 1: Rainforests

Potential ecological impact: mostly high to catastrophic but with significant areas of moderate impact.

Recommended recovery actions

1. Prevent the establishment of high biomass grasses and *Lantana camara* immediately adjacent to and within the burnt rainforest communities, with regular herbicide treatment in the growing season. This requires an early and regular ongoing response.
2. Assess the establishment of vine and herbaceous weeds and undertake strategic control. This requires an early and regular ongoing response.
3. Assess the establishment of tree and shrub weeds and undertake 6-12 monthly, targeted control. Surveillance and strategic thinning of native vine, shrub or tree species that is causing arrested rainforest or rainforest ecotone ecosystem recovery over a broad area and over a long duration or is impacting a highly restricted significant natural value.
4. Undertake a control program for feral cats.
5. Reinstate damaged, or install new, strategic boundary fencing to prevent cattle entering regenerating rainforest areas. Priority areas include Laheys Tabletop, Canungra and Coomera valleys.
6. It is recommended that restoration plantings within the World Heritage Area be avoided wherever possible in order to avoid the unintended introduction of novel genetic material, invasive plants or fungi (e.g. orange pore fungus *Favolaschia calocera*) and pathogens including myrtle rust (*Austropuccinia psidii*). Soil compaction caused by repeated visitation to a site is also detrimental to rainforest soils and can impact natural regeneration.
7. Review strategies for weed and fire management in adjacent sclerophyll communities; aim to reduce the risk of future fire encroachments into rainforests.
8. Undertake Health Checks (Melzer *et al.* 2019) for the rainforest communities – these will facilitate early detection of weeds and enable condition to be evaluated across the park.
9. Resurvey IBISCA monitoring plots within three months of the fire to quantify impacts (Queensland Herbarium).
10. Establish additional long-term vegetation monitoring plots in burnt rainforest communities (e.g. Laheys Tabletop, Coomera valley including *Owenia cepiodora* population) to evaluate the rate and direction of recovery and to fill knowledge gaps with respect to the fire response of species (Queensland Herbarium and Ecological Assessment Unit with support from Regional Technical support and Management Unit).
11. Monitor for increased biosecurity risk from pathogens such as myrtle rust (which favours new growth, common post-fire).
12. Investigate additional remote sensing methods to map more precisely the ecological impact in rainforests currently assessed as having low fire severity.

Contracting of cat and weed control and boundary fencing may be necessary due to competing priorities (i.e. undertaking planned burning) in the growing season, the extent of the treatment area and access constraints. Where contractors be engaged, strong oversight is required to ensure works are undertaken appropriately (e.g. minimal clearing of fence lines, minimising non-target impacts during weed control).

Overview of value and impact

This value encompasses two Natural Key Values defined under the VBMF for Lamington NP: "Lowland subtropical rainforest" and "Dry vine forest" (Section 5.3). It includes Regional Ecosystems with a fire sensitive canopy and understorey within BVG 2M groups 2, 4 and 5 (Appendices 2 and 3). Fire severity and impact photographs are provided in Appendix 1, Figs A1.1-4.

Rainforests are a primary natural and aesthetic value of Lamington NP and Gondwana Rainforests WHA. They are fire sensitive communities and therefore park management aims to exclude fire from them. Higher intensity fires in these communities have high to catastrophic and long-lasting impacts. Drier rainforest communities may have more resilience to low intensity fire than moister rainforest communities, although response to such fire in these communities is not well understood.

About 658ha of lowland subtropical and dry rainforests burnt in Lamington NP (Appendix 3), which represents about 9% of BVG 2M groups 2, 4 and 5 within the park. The moister, typically higher altitude rainforests (BVG 2M group 6 *Notophyll vine forest and microphyll fern forest to thicket on high peaks and plateaus*, Appendix 3), that are extensive within Lamington NP (6 817ha), were not burnt.

Within affected rainforests approximately 30.6% burnt at low, 49.5% at moderate, and 18.2% at high and 1.6% at extreme relative severity (Appendix 2), with likely ecological impact ranging from moderate to high-catastrophic (section 5.1.1). During field assessments we observed that rainforests with low intensity fire had considerable variation in ecological impacts. Where fire appears to have burnt quickly, then extinguished, impacts were relatively minor, with loss of the upper most leaf litter layer and death of ground cover, seedlings and saplings, with no loss of sub-canopy and canopy trees (Fig. A1.3). However, in rainforest areas where low intensity fire persisted (often probably as smouldering fire with little or no flame), deeper leaf litter burnt. Where this occurred in accumulated litter around the base of larger trees this caused the roots and or base of trees to burn out with the tree subsequently dying, or toppling causing significant additional canopy damage (Figs. A1.2-4). In these areas, low intensity fire has caused significantly higher ecological impact. Remote sensing of canopy changes over longer time periods may be required to get a better understanding of the ecological impact of low intensity fire in these rainforests, and direct on-ground management actions.

The rainforests within the extent of the fire is known or likely habitat for a large number of threatened or other significant wildlife species (Appendices 4 and 5). Impacts on these species will vary but those that live in or depend upon the forest floor (e.g. rufous scrub-bird, black-breasted button-quail, long-nosed potoroo, *Coeranoscincus reticulatus*, *Adelotus brevis, Mixophyes fleayi*, *M. iteratus*, threatened rainforest plants with seedling banks) are likely to be most significantly impacted, together with plant species with no or limited capacity for resprouting.

A significant number of very large fig trees were lost (fire burning out the dead host trunk and causing the fig to collapse or die – Fig. A1.1). Figs are keystone species, providing a critical food source for many animals (e.g. Coxen's fig-parrot, fruit doves, fruit bats) as well as roosting habitat (e.g. micro bats, sooty owl) or sheltering/foraging habitat (e.g. snakes, *Saltuarius swaini*) as well as providing habitat for many epiphytic plants.

The seedling and sapling bank in rainforests is assembled over decades of recruitment and in fire-impacted areas is likely to have been greatly reduced or eliminated, removing the next generation of recruits. This will be a particularly significant issue where the mature individuals in a population have been killed. In areas where fire has also burnt the soils' organic horizon, it is likely that the seed bank has also been reduced or removed. Seed dispersal from surrounding areas of forest into the understorey of fire-impacted areas and the suppression of competition from weeds will be vital to recovery. A range of rainforest species have the capacity to resprout, predominantly from the base or rootstock, at least in some circumstances. For those species dependent upon basal resprouting and/or seed, recovery may take decades. Species reliant solely on regeneration from seed may be locally lost unless there is a nearby source and suitable vectors for dispersal.

The establishment or promotion of ecosystem-changing weeds (refer Appendix 6) or high biomass native grasses poses a serious risk to rainforest communities. High biomass exotic grasses (e.g. *Megathyrsus maximus, Melinis minutiflora*) and *Lantana camara* are common in disturbed areas of the park and adjoining lands. They greatly increase the risk of future fire incursion and higher intensity fire. The bare ground and loss of canopy cover resulting from the current fire provide an ideal environment for their germination and establishment adjacent to, and within, rainforest communities. Further fires in burnt rainforest are likely to eliminate any possibility of the recovery of these communities.

Tree and shrub weeds (e.g. *Cinnamomum camphora*, *Ligustrum lucidum*, *L. sinense, Solanum chrysotrichum, S. mauritianum*), various vines (e.g. *Araujia sericifera*, *Passiflora subpeltata*) and herbaceous weeds (e.g. *Ageratina adenophora, A. riparia*) are highly invasive in disturbed rainforests of the region. Conditions post-fire are ideal for their establishment or spread. While these weeds are unlikely to pose a significant future fire risk, they can seriously impede recovery of rainforests.

Some sites, particularly those closer to access tracks, had abundant weed species that will naturally decline through time as the ecosystem recovers. These include species such as *Phytolacca octandra* (inkweed) and *Solanum nodiflorum* (deadly nightshade). A proliferation of vines has occurred in many sites – these are however, dominated by native species. These are likely to be important in the immediate aftermath of the fire in binding soil and providing rapid cover. They will be suppressed as the ecosystem recovers

Burnt rainforest communities are however at risk of:
– arrested recovery, with communities dominated for years to decades by native rainforest pioneer species including *Acacia* or vine species,
– conversion to a more fire tolerant regional ecosystem facilitating further fires along rainforest ecotones or acting as a conduit for fire further into rainforests, or
– novel communities dominated by non-native species (e.g. *Lantana camara*).
Where native species are observed to be causing arrested recovery there are two situations where management intervention may be warranted. The first is where the issue is occurring over a large area and the impact is likely to be long-term (decades). The second is where a significant natural value with a highly restricted distribution (e.g. an important population of a threatened plant species) is being impacted. Management of this issue in rainforests is limited to manual thinning, which has been used successfully in restoration of disturbed tropical rainforests. Any removal of native species needs to be well justified and should be trialled at a small scale with monitoring to determine whether the desired result is achieved.

Burnt rainforest communities are at risk due to increased edge effects including weed and pest animal invasion.

Cats and cane toads are known to prefer open areas for foraging and movement, with cats known to target recently burnt areas for foraging (McGregor *et al.* 2014). Cane toads are toxic to predators and have likely been a significant contributor to the local decline of spotted-tail quolls. It is not anticipated that the cane toads will establish breeding populations within burnt rainforest, but the more open understorey in the short-term is likely to facilitate dispersal of adult animals in the park. During field assessments in January 2020 recently metamorphosed cane toads were encountered during daylight hours traversing burnt rainforests in the Canungra valley. Cats are a significant threat to a range of ground dwelling animals including several threatened species.

6.3.2 NV 2: Wet eucalypt open forests and rainforest/eucalypt forest ecotones

Potential ecological impact: mostly moderate, with some areas high to catastrophic.

Recommended recovery actions

1. Prevent the establishment of high biomass grasses and *Lantana camara* immediately adjacent to and within these communities, with regular herbicide treatment in the growing season. This requires an early and regular ongoing response.
2. Assess the establishment of vine and herbaceous weeds and undertake strategic control. This requires an early and regular ongoing response.
3. Assess the establishment of tree and shrub weeds and undertake 6-12 monthly, targeted control.
4. Surveillance and strategic thinning of native vine, shrub or tree species that is causing arrested rainforest or rainforest ecotone ecosystem recovery over a broad area <u>and</u> over a long duration or is impacting a highly restricted significant natural value.
5. Undertake a control program for feral cats.
6. Reinstate damaged, or install new, strategic boundary fencing to prevent cattle entering regenerating areas. Priority areas include Laheys Tabletop, Canungra and Coomera valleys.
7. It is recommended that restoration plantings within the World Heritage Area be avoided wherever possible in order to avoid the unintended introduction of novel genetic material, invasive plants or fungi (e.g. orange pore fungus *Favolaschia calocera*) and pathogens including myrtle rust (*Austropuccinia psidii*). Soil compaction caused by repeated visitation to a site is also detrimental to rainforest soils and can impact natural regeneration.
8. Review strategies for weed and fire management in adjacent drier sclerophyll communities so that recommended fire frequencies are achieved in wet eucalypt open forests and rainforest/eucalypt forest ecotones.
9. Undertake Health Checks (Melzer *et al.* 2019) to facilitate early detection of weeds and enable condition to be evaluated across the park.
10. Establish long-term vegetation monitoring plots in these communities to evaluate the rate and direction of recovery and to fill knowledge gaps with respect to the fire response of species (Queensland Herbarium and Ecological Assessment Unit with support from Regional Technical support and Management Unit and/or external researchers).
11. Monitor for increased biosecurity risk from pathogens such as myrtle rust (which favours new growth, common post-fire).

Contracting of cat and weed control and boundary fencing may be necessary due to competing priorities (i.e. undertaking planned burning) in the growing season, the extent of the treatment area and access constraints. Where contractors are engaged, strong oversight is required to ensure works are undertaken appropriately (e.g. minimal clearing of fence lines, minimising non-target impacts during weed control).

Overview of value and impact

This value encompasses part of the Natural Key Value defined under the VBMF for Lamington NP: "Moist to dry open forest ecotones (eastern bristlebird and Hastings River mouse habitat)" (Section 5.3). It includes Regional Ecosystems and rainforest/eucalypt forest ecotones with a fire a tolerant canopy and a fire sensitive understorey, including BVG 2M group 8 (Appendices 2 and 3). Note that ecotones may not be mapped as RE polygons as they are typically narrow and dynamic – refer section 6.1. Fire severity and impact photographs are provided in Appendix 1, Figs A1.5-7.

Wet eucalypt open forests and rainforest/eucalypt forest ecotones are a significant value of Lamington NP and Gondwana Rainforests WHA. They have a fire sensitive understorey and management aims for long intervals, 8-20+ years (shorter where there is a grassy understorey), between planned burns, with an occasional high intensity fire.

About 221ha of wet eucalypt open forests burnt in Lamington NP (Appendix 3), which represents 8.6% of BVG 2M group 8. Within burnt wet eucalypt open forests approximately 23.6% burnt at low, 53.1% at moderate, 22.2% at high and 1.1% at extreme relative severity (Appendix 2), resulting in significant areas of moderate, and some high to catastrophic, potential ecological impact.

During field assessments, we observed significant ecological impacts within these communities, even in some areas where fire severity was mapped as low. As we observed in rainforests, some low intensity fire (often probably as smouldering fire with little or no flame) burnt deep into leaf accumulated around the base of larger trees, causing the roots and or base of trees to burn out, with the tree toppling, causing significant additional canopy damage (Fig. A1.5). In these sclerophyll communities, this issue was probably exacerbated by the presence of basal hollows or scars from previous fire events.

Where these communities have a well-developed rainforest understorey, they provide known or likely habitat for the same suite of threatened or other significant wildlife species as rainforests, with similar potential impacts (refer NV_1). Where these communities have a dense native grass understorey, they provide potential habitat for threatened species such as Hastings River mouse and eastern bristlebird. As the overstorey is sclerophyll dominated, these communities provide habitat for greater glider and koala. Large old growth trees in wet eucalypt forests provide numerous hollows critical to the shelter and or breeding of many species (e.g. micro-bats, possums and gliders, owl nest sites).

The establishment or promotion of ecosystem-changing weeds (refer Appendix 6) or high biomass native grasses poses a serious risk to rainforest communities. High biomass exotic grasses (e.g. *Megathyrsus maximus, Melinis minutiflora*) and *Lantana camara* are common in disturbed areas of the park and adjoining lands. They greatly increase the risk and severity of future fire in these communities. The bare ground and loss of canopy cover resulting from the fire provide an ideal environment for their germination and establishment adjacent to, and within, rainforest communities. Likewise, an increased dominance of some native grasses (e.g. blady grass *Imperata cylindrica*) may also be undesirable due to their flammability.

Tree and shrub weeds (e.g. *Cinnamomum camphora*, *Ligustrum lucidum*, *L. sinense, Solanum chrysotrichum, S. mauritianum*), various vines (e.g. *Araujia sericifera*, *Passiflora subpeltata*) and herbaceous weeds (e.g. *Ageratina adenophora, A. riparia*) can be invasive in disturbed rainforest-wet eucalypt forest ecotones of the region. Conditions post-fire are ideal for their establishment or spread. While these weeds are unlikely to pose a significant future fire risk, they can seriously impede recovery of rainforest-wet eucalypt forest ecotones.

Burnt rainforest-wet sclerophyll forest ecotones are however at risk of:
– arrested recovery, with communities dominated for years to decades by native rainforest pioneer species including *Acacia* or vine species,
– conversion to a more fire tolerant regional ecosystem facilitating further fires along rainforest ecotones or acting as a conduit for fire further into rainforests, or
– novel communities dominated by non-native species (e.g*. Lantana camara*).
Where native species are observed to be causing arrested recovery in these ecotones there are two situations where management intervention may be warranted. The first is where the issue is occurring over a large area and the impact is likely to be long-term (decades). The second is where a significant natural value with a highly restricted distribution (e.g. an important population of a threatened plant species) is being impacted. Management of this issue in rainforests is limited to manual thinning, which has been used successfully in restoration of disturbed tropical rainforests. Any removal of native species needs to be well justified and should be trialled at a small scale with monitoring to determine whether the desired result is achieved.

Disturbed wet eucalypt open forests increase the risk of bell minor populations, leading to declines in passerine diversity and an increase in bell miner associated dieback (BMAD). BMAD is likely to be exacerbated where fire has impacted the canopy and or is likely to lead to increased understorey density (Silver & Carnegie 2017). Management of woody weeds (particularly lantana) and introduced vines is a priority in these areas.

Where these communities have lost their rainforest understorey, they are at risk due to increased edge effects including weed and pest animal invasion. Cats and cane toads are known to prefer open areas for foraging and movement, with cats known to target recently burnt areas for foraging (McGregor *et al.* 2014). Cane toads are toxic to predators and have likely been a significant contributor to the local decline of spotted-tail quolls. Cats are a significant threat to a range of ground dwelling animals including several threatened species.

6.3.3 NV 3: Dry eucalypt forests and woodlands

Potential ecological impact: predominantly limited or none but with significant areas of moderate and small areas of high**.**

Recommended recovery actions

1. Prevent the establishment of high biomass grasses and *Lantana camara*, especially in areas adjacent to fire sensitive communities such as rainforest. Use regular herbicide treatment in the growing season. This requires an early and regular ongoing response.
2. Assess the establishment of vine and herbaceous weeds and undertake strategic control. This requires an early and regular ongoing response.
3. Assess the establishment of tree and shrub weeds (e.g. Easter cassia *Senna pendula*) and undertake 6-12 monthly, targeted control.
4. Undertake a control program for feral cats.
5. Reinstate damaged, or install new, strategic boundary fencing to prevent cattle entering regenerating areas. Priority areas include Laheys Tabletop and Coomera valley.
6. It is recommended that restoration plantings within the World Heritage Area be avoided wherever possible in order to avoid the unintended introduction of novel genetic material, invasive plants or fungi.

7. Review strategies for weed and fire management in these communities; aim to reduce the risk of future fire encroachments into rainforests.
8. Undertake Health Checks (Melzer *et al.* 2019) – these will facilitate early detection of weeds and enable condition to be evaluated across the park.
9. Establish long-term vegetation monitoring plots in burnt dry eucalypt forest and woodland communities to evaluate the rate and direction of recovery and to fill knowledge gaps with respect to the fire response of species (Queensland Herbarium and Ecological Assessment Unit with support from Regional Technical support and Management Unit and/or external researchers).
10. Monitor for increased biosecurity risk from pathogens such as myrtle rust (which favours new growth, common post-fire).

Contracting of cat and weed control and boundary fencing may be necessary due to competing priorities (i.e. undertaking planned burning) in the growing season, the extent of the treatment area and access constraints. Where contractors be engaged, strong oversight is required to ensure works are undertaken appropriately (e.g. minimal clearing of fence lines, minimising non-target impacts during weed control).

Overview of value and impact

This value partially encompasses a Natural Key Value defined under the VBMF for Lamington NP: "Moist to dry open forest ecotones (eastern bristlebird and Hastings River mouse habitat)" (Section 5.3). It includes Regional Ecosystems with a fire tolerant canopy and understorey within BVG 2M groups 9, 11 and 28 (Appendices 2 and 3). Fire severity and impact photographs are provided in Appendix 1, Figs A1.8-9.

Dry eucalypt forests and woodlands are a significant value of Lamington NP and Gondwana Rainforests WHA. They are fire adapted communities and fire management is critical to their conservation. Management of these communities includes burning to maintain their health, with desired extent, frequency and intensity of burning guided by the ecology of these systems and the threats to them (e.g. weed invasion) (NPRSR 2013, Queensland Herbarium 2018). Extensive areas of high to extreme severity fire in these communities are likely to have serious ecological impacts in the short-medium term.

About 641ha of dry eucalypt forests and woodlands burnt in Lamington NP (Appendix 3), which represents less than 18% of BVG 2M groups 9, 11 and 28 within the park. Within burnt dry eucalypt forests and woodlands approximately 16.1% burnt at low severity, 49.4% at moderate severity, 31.7% at high and 2.8% at extreme severity (Appendix 2) with potential ecological impact mostly limited or none but with significant areas of moderate and small areas of high (section 5.1.1). During field assessments we observed some areas with: significant loss of canopy, although in places some of this appears to have been due to preceding drought; loss of large trees from basal fires; disproportionate loss of grey gums; complete loss of ground cover resulting in exposed mineral earth. We also observed widespread recovery of trees with post-fire coppicing and epicormic regrowth. However, there has been subsequent death of a significant number of reshooting trees in the period up to eight months post-fire, highlighting that impacts in fire adapted communities may continue for months to years following the fire.

Dry eucalypt forests and woodlands within the extent of the fire are known or likely habitat for a number of threatened or other significant wildlife species (Appendices 4 and 5). Impacts on these species will vary but those that live in or depend upon the forest floor (e.g. long-nosed potoroo, *Adelotus brevis*), depend upon foliage for food (e.g. koala, greater glider), or large hollow bearing trees (e.g. greater and yellow-bellied gliders, various micro bats and birds) are likely to be most significantly impacted. We observed that large grey gums (probably *Eucalyptus biturbinata*) in the Coomera valley were impacted by the drought/fire event more than other eucalypts, with numerous trees apparently killed, some from fire burning high up in the trunk, causing the head of the tree to collapse. Grey gums are particularly important food trees for koalas (foliage) and yellow-bellied gliders (sap) (Fig. A1.13), potentially exacerbating impacts of the current fire on these species.

The establishment or promotion of ecosystem-changing weeds (refer Appendix 6) poses a risk to dry eucalypt forests and woodlands communities. High biomass exotic grasses (e.g. *Megathyrsus maximus, Melinis minutiflora*) and *Lantana camara* are common in disturbed areas of the park and adjoining lands. They increase the risk of higher fire frequency and or severity. The bare ground and loss of canopy cover resulting from the fire provide an ideal environment for their germination and establishment, particularly in moister communities on higher fertility soils.

Burnt communities are at risk due to increased edge effects including weed and pest animal invasion. Cats and cane toads are known to prefer open areas for foraging and movement, with cats known to target recently burnt areas for foraging (McGregor *et al.* 2014). Cane toads are toxic to predators and have likely been a significant contributor to the local decline of spotted-tail quolls. The more open understorey in the short-term is likely to facilitate dispersal of cane toads in the park. Cats are a significant threat to a range of ground dwelling animals including several threatened species.

6.3.4 NV 4: Montane heaths and shrublands

Potential ecological impact: moderate to high, at least in the short-term.

Recommended recovery actions

1. Protect regenerating areas from visitation.
2. Undertake Health Checks (Melzer *et al.* 2019) – these will facilitate early detection of weeds and enable condition to be evaluated across the park.
3. Assess and prevent the establishment of weeds.
4. Establish long-term vegetation monitoring plots in montane heath and shrubland communities to evaluate the rate and direction of recovery and to fill knowledge gaps with respect to the fire response of species (Queensland Herbarium and Ecological Assessment Unit with support from Regional Technical support and Management Unit).
5. Monitor for increased biosecurity risk from pathogens such as myrtle rust. The latter favours new growth which is common post-disturbance.

Overview of value and impact

This value includes Regional Ecosystems with a fire tolerant canopy and understorey within BVG 2M group 29 (Appendices 2 and 3). Fire severity and impact photographs are provided in Appendix 1, Fig A1.10.

Montane heaths and shrublands are a significant value of Lamington NP and Gondwana Rainforests WHA. They are fire-adapted communities and fire management is critical to their conservation. Management of these communities includes burning to maintain their health, with desired extent, frequency and intensity of burning guided by the ecology of these systems and the threats to them (NPRSR 2013, Queensland Herbarium 2018). These communities are typically small and patchy in extent and generally burn at high intensity. Areas of high to extreme severity fire in these communities is likely to be within the ecological tolerance of the ecosystem, although likely to have significant ecological impacts in the short-medium term. Whether there are longer-term impacts will be dependent upon the period until the next fire event and fire frequency thereafter, and degree of physical disturbance from visitation.

About 13.1ha of montane heaths and shrublands burnt in Lamington NP (Appendix 3), which represents less than 4% of BVG 2M group 29 within the park. Within burnt montane heaths and shrublands approximately 8.5% burnt at low, 33.9% at moderate, 49.0% at high and 8.6% at extreme relative severity (Appendix 2) with potential ecological impact, likely to be mostly moderate to high (section 5.1.1). These communities were not visited during field assessments, however high to extreme fire severity was observed on Kurraragin/Egg Rock from a distance (Fig A1.10).

Montane heaths and shrublands are fragile, naturally fragmented communities, with a distinctive flora. Many areas are too small to be mapped as Regional Ecosystems, but we include all such vegetation communities as well as rock pavements and cliff lines within this value. Significant areas within this value include Kurraragin/Egg Rock, Poondarah cliffs, Whittenbah Waffers and the broken cliff line area between Binna Burra Road and Numinbah Correctional Centre. Within the mapped extent of fire within montane heaths and shrublands, there is known or likely habitat for a number of threatened or other significant wildlife species (Appendices 4 and 5). Impacts on these species will vary but most will be well-adapted to living in such fire-prone habitat, with some potentially dependent upon fire for regeneration (e.g. *Banksia conferta*). Some of the significant plant species grow on rock outcrops (cliffs, peaks or rock platforms) (e.g. *Westringia rupicola*) which can provide protection for some individuals from fire. These areas would have been badly drought affected prior to the fire and resulted in increased impacts from the fire, possibly causing significant ecological impact.

The montane heaths and shrublands of Lamington NP are not particularly prone to weeds due presumably to low fertility, shallow soils that in some areas become waterlogged for extended periods. However, monitoring for weeds is still recommended.

One of the main threats to these communities is impacts from visitation (walking, unauthorised rock climbing and abseiling) and such impacts will be exacerbated during recovery post-fire. Kurraragin is a restricted access area (significant Aboriginal area under the *Aboriginal Cultural Heritage Act 2003*) so any permits to access the area should take into account the increased ecological fragility of the vegetation communities there post-fire. Some areas are particularly dangerous post-fire as the substrate is loose under foot, so visitation may also need to be restricted for public safety reasons.

6.3.5 NV 5: Riparian corridors

Potential ecological impact: moderate to high–catastrophic

Recommended recovery actions

1. Prevent the establishment of high biomass grasses and *Lantana camara* immediately adjacent to and within the burnt rainforest communities, with regular herbicide treatment in the growing season. This requires an early and regular ongoing response.
2. Assess the establishment of vine and herbaceous weeds and undertake strategic control. This requires an early and regular ongoing response.
3. Assess the establishment of tree and shrub weeds and undertake 6-12 monthly, targeted control.
4. Undertake a control program for feral cats.
5. Reinstate damaged or install strategic boundary fencing to prevent cattle entering regenerating rainforest areas. Priority areas include Laheys Tabletop, Canungra and Coomera valleys.
6. It is recommended that restoration plantings within the World Heritage Area be avoided wherever possible in order to avoid the unintended introduction of novel genetic material, invasive plants or fungi (e.g. orange pore fungus *Favolaschia calocera*) and pathogens including myrtle rust (*Austropuccinia psidii*). Soil compaction caused by repeated visitation to a site is also detrimental to rainforest soils and can impact natural regeneration.
7. Review weed and fire management planning in adjacent sclerophyll communities to reduce the risk of future fire encroachments into riparian areas.
8. Undertake Health Checks (Melzer *et al.* 2019) for riparian communities – these will facilitate early detection of weeds and enable condition to be evaluated across the park.
9. Establish long-term vegetation monitoring plots in burnt riparian areas (e.g. Coomera valley) to evaluate the rate and direction of recovery and to fill knowledge gaps with respect to the fire response of species (Queensland Herbarium and Ecological Assessment Unit with support from Regional Technical support and Management Unit and/or external researchers).
10. Monitor for increased biosecurity risk from pathogens such as myrtle rust. The latter favours new growth which is common post-disturbance.
11. Investigate additional remote sensing methods to map more precisely the ecological impact in riparian rainforests currently assessed as having low fire severity.

Contracting of cat and weed control and boundary fencing may be necessary due to competing priorities (i.e. undertaking planned burning) in the growing season, the extent of the treatment area and access constraints. Where contractors be engaged, strong oversight is required to ensure works are undertaken appropriately (e.g. minimal clearing of fence lines, minimising non-target impacts during weed control).

Overview of value and impact

This value encompasses the Natural Key Values defined under the VBMF for Lamington NP: "Riparian corridors" (Section 5.3). Regional Ecosystems fringing streams and rivers have either a fire sensitive or fire tolerant canopy and a fire sensitive understorey. Fire severity and impact photographs are provided in Appendix 1, Figs A1.11-12.

Riparian corridors are a significant value of Lamington NP and Gondwana Rainforests WHA. They include a range of vegetation communities that have differing sensitivity to fire. Areas of high to extreme severity fire in these communities are likely to have serious ecological impacts in the medium to long term, regardless of the vegetation community. Areas of low to moderate severity in rainforested riparian areas are also likely to have serious ecological impacts in the medium to long term.

About 44ha of the mapped NKV riparian corridors burnt in Lamington NP, which represents less than 4% of the NKV within the park. Within burnt NKV riparian corridors approximately 45.3% burnt at low, 44.3% at moderate, 10.1% at high and 0.3% at extreme severity.

Riparian corridors within the mapped extent of the fire are known or likely habitat for many threatened or other significant wildlife species (Appendices 4 and 5), including many of those from rainforests, wet eucalypt forests and ecotones. Potential impacts on those species will be similar to those identified for NV_1 and NV_2.

Significant portions of Nixon's and Pyramid Creek catchments were burnt, and while only a small proportion of the catchment areas of Canungra Creek and Coomera River were impacted, the fire burnt the riparian zone over many kilometres. Catchments heavily impacted by fire may have altered hydrology, water chemistry, sediment and charcoal load, although this depends on timing, duration and intensity of rainfall events post-fire. The affected riparian corridors at Lamington NP are known to provide core breeding habitat for the threatened frogs *Adelotus brevis*, *Litoria pearsoniana, Mixophyes fleayi* and *M. iteratus* (Appendix 4).

The establishment or promotion of ecosystem-changing weeds (refer Appendix 6) poses a risk to riparian corridors. High biomass exotic grasses (e.g. *Megathyrsus maximus, Melinis minutiflora*) and *Lantana camara* are common in disturbed areas of the park and adjoining lands. They increase the risk of higher fire frequency and or severity. The bare ground and loss of canopy cover resulting from the fire provide an ideal environment for their germination and establishment, particularly in these moister higher fertility areas. Riparian corridors are naturally disturbed areas, susceptible to weeds with weeds already well established in some areas. Fire provides an opportunity for further incursion of these weeds along the riparian zone and into adjoining communities.

Burnt communities are at risk due to increased edge effects including weed and pest animal invasion. Cats and cane toads are known to prefer open areas for foraging and movement, with cats known to target recently burnt areas for foraging (McGregor *et al.* 2014). Cane toads are toxic to predators and have likely been a significant contributor to the local decline of spotted-tail quolls. The more open understorey in the short-term is likely to facilitate dispersal of cane toads in the park. Cats are a significant threat to a range of ground dwelling animals including several threatened species.

6.4 Rehabilitation of previously cleared areas

Several areas within Lamington NP that were cleared prior to gazettal burnt during the current bushfire event. Some of these areas were heavily weed infested and impacts from the fire on regeneration of native species is high. The fire provides an opportunity to access these areas and undertake active rehabilitation. Such areas potentially allow for community groups/members to become involved in direct bushfire recovery, through tree plantings, weeding and other maintenance. Plantings could also be targeted to provide known high quality food resources for threatened species such as koala, greater glider or glossy black-cockatoo. Such rehabilitation is expensive and time-consuming (Peeters, Butler and Laidlaw 2014) and the concerns raised in previous sections means that it is only appropriate for these highly degraded areas. Areas where this could potentially occur within the burnt area at Lamington include Illinbah clearing, Rankins Paddock and cleared areas of the recently acquired area adjacent to Numinbah Correctional Centre. An assessment of the success of previous plantings in Rankins Paddock should be undertaken first to identify the most suitable species and rehabilitation methods.

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Appendix 1. Fire severity and impact photographs

Figure A1.1. Loss of figs, *Ficus* species, during the fire.

Top left: private property adjacent to Lamington NP. Top right: Illinbah, Lamington NP. (H. Hines 18 Feb 2020). Lower: Canungra Ck, Lamington NP. (W. Buch 30 January 2020).

Figure A1.2. Impacts of the fire on Araucarian complex notophyll vine forest on the lower slopes adjacent to Canungra Ck, Lamington NP.

Top left: Low intensity fire, showing loss of seedling bank. Top right: Moderate intensity fire, with subsequent toppling of trees. Lower: Rocky substrates often protect drier rainforests from fire, but here the fire has removed accumulated leaf litter and lithophytic bryophyte and lichen communities and split rocks. (H. Hines 30 January 2020).

Figure A1.3. Impacts of the fire on Araucarian complex notophyll vine forest on the lower slopes adjacent to Canungra Ck, Lamington NP.

Top left: Unburnt area, showing density of seedling bank. Top right: Very low intensity fire showing some loss of seedling bank. Lower: Loss of coarse woody debris and exposure of soil during the fire and creation of large canopy gap due to toppling of large trees. (H. Hines 31 January 2020).

Figure A1.4. Impacts of the fire on Araucarian complex notophyll vine forest on Laheys Tabletop, Lamington NP. All photos within a few hundred metres of each other, area burning 12 November 2019.

Top left: Unburnt area, showing density of seedling bank and lushness of vegetation at time of second burning. Top right: low intensity second burning, large canopy gap due to toppling of large trees, loss of seedling bank from first burning. Lower: very low intensity second fire – leaf-fall following first fire has just burnt, basal fire smouldering in large rainforest tree and loss of seedling bank from initial fire in early September 2019. (H. Hines).

Figure A1.5. Impacts of the fire on wet eucalypt open forests and rainforest/eucalypt forest ecotones.

Top: low to moderate intensity fire in brush box dominated ecotonal forest, showing loss of very large brush box trees due to long residence time of fire within the duff layer, causing toppling of large trees, creation of large canopy gaps and loss of rainforest understorey, Caves Circuit. Lower: low intensity fire has killed the rainforest shrubby understorey of this wet eucalypt forest beside Nixons Creek. (H. Hines November 2019)

Figure A1.6. Impacts of the fire on wet eucalypt open forests and rainforest/eucalypt forest ecotones.

Top: low to moderate intensity fire in eucalypt-rainforest ecotonal forest in the Bellbird area, showing loss of loss of rainforest understorey and exposed soil surface (H. Hines November 2019). Lower: low to moderate intensity fire has killed the rainforest shrubby understorey of this wet eucalypt forest beside Coomera River. This photograph also shows the slow rate of recovery, taken some 7 months post-fire (A. Meiklejohn April 2020).

Figure A1.7. Impacts of the fire on wet eucalypt open forests and rainforest/eucalypt forest ecotones.

Landscape view of the eastern slopes of Darlington Range from Caves Circuit, Binna Burra, showing the extent of the fire (brown canopies). The fire at this stage had mostly burnt within sclerophyll communities, which in this area included extensive brush box (*Lophostemon confertus*) with a vine forest understorey (H.B. Hines 12 November 2019). During November and December 2019, the fire reignited (see small smoke plume centre right) and reburnt some previously burnt areas and penetrated further into wet eucalypt and rainforest communities.

Figure A1.8. Impacts of the fire on dry eucalypt forests and woodlands.

Top left: loss of grey gums (probably *Eucalyptus biturbinata*) due to fire burning high in the trunk causing the crown to collapse. Top right: soil erosion and silt deposition in an area with high fire severity. Lower: canopy recovery five months post- high to extreme fire severity (lower Coomera River valley, H.B. Hines 18 Feb 2020).

Figure A1.9. Impacts of the fire on dry eucalypt forests and woodlands.

Top left: moderate severity fire, note post-fire leaf-fall. Top right: seedling bank of Eucalyptus species, in ash bed created through the burning of coarse woody debris, moderate severity fire. (lower Coomera River valley, H.B. Hines 12 November 2019). Lower: landscape view of the lower Coomera River valley, showing the extent of moderate to extreme fire severity within dry eucalypt communities on Laheys Tabletop (top left) and western aspects of the lower slopes of the valley (centre) (H.B. Hines 12 November 2019).

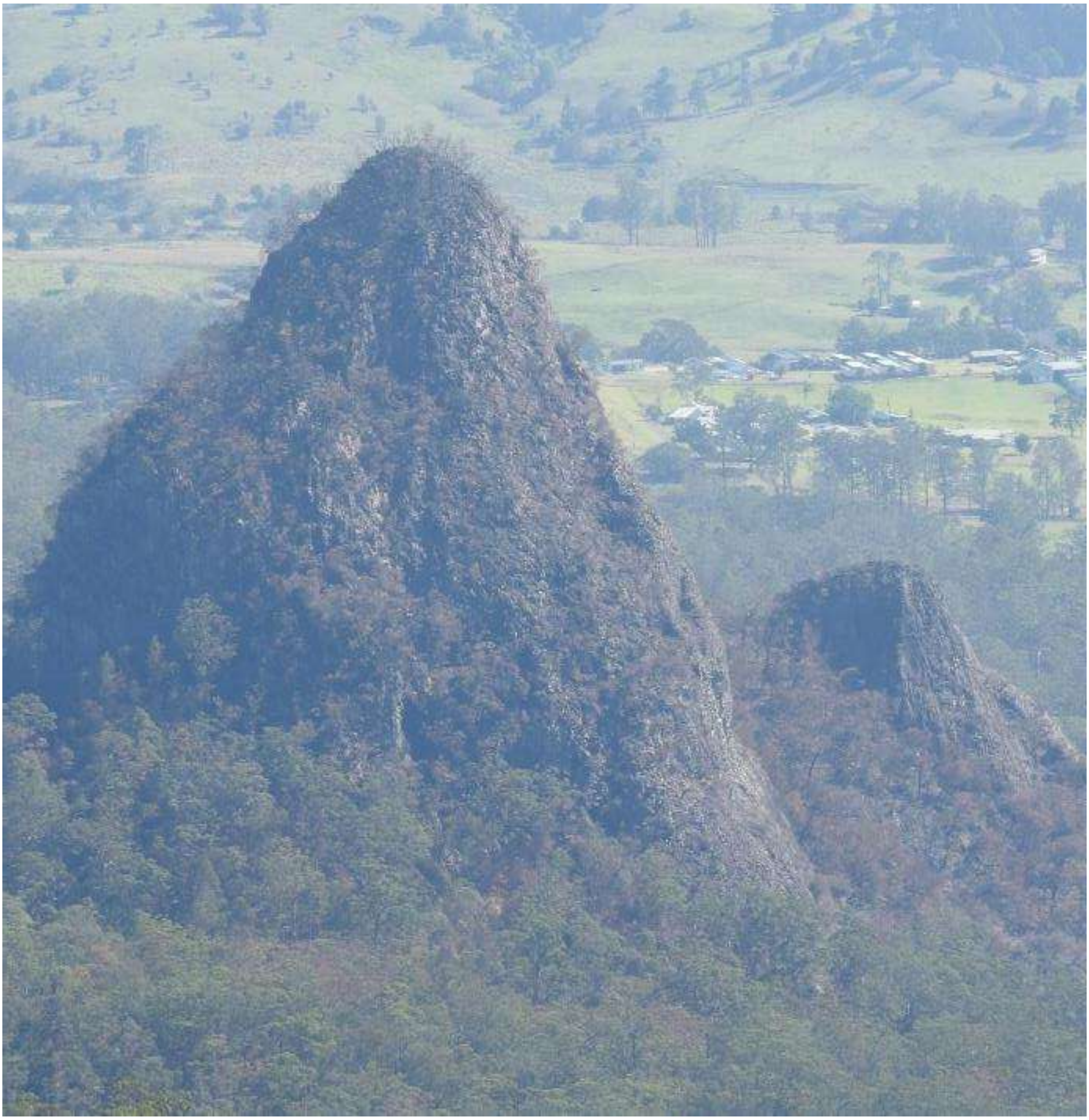

Figure A1.10. Impacts of the fire on montane heaths and shrublands.

Locally high to extreme fire severity on the steep and exposed slopes of Kurraragin (Egg Rock). (H.B. Hines 12 November 2019).

Figure A1.11. Impacts of the fire on riparian areas, Lamington NP.

Upper: fire burnt downslope at low intensity to the edge of Canungra Creek (November 2019). Lower: fire burnt at moderate intensity through palm groves at Piccabeen Creek, a significant stream in the Illinbah section of the Coomera River catchment. (W. Buch).

Figure A1.12. Impacts of the fire on riparian areas, Lamington NP.

Top: a minor tributary of the Coomera River in the Illinbah area, showing large amounts of debris and timber fallen into the stream bed following the fire. Whilst water was clear there was evidence of increased sediment in the stream bed. (H. Hines 18 Feb 2020). Lower: riparian rainforest burnt at low intensity, on the banks of Coomera River, known habitat for three species of threatened frogs, including one of the few remaining populations of the endangered giant barred frog *Mixophyes iteratus* in the Scenic Rim (A. Meiklejohn April 2020).

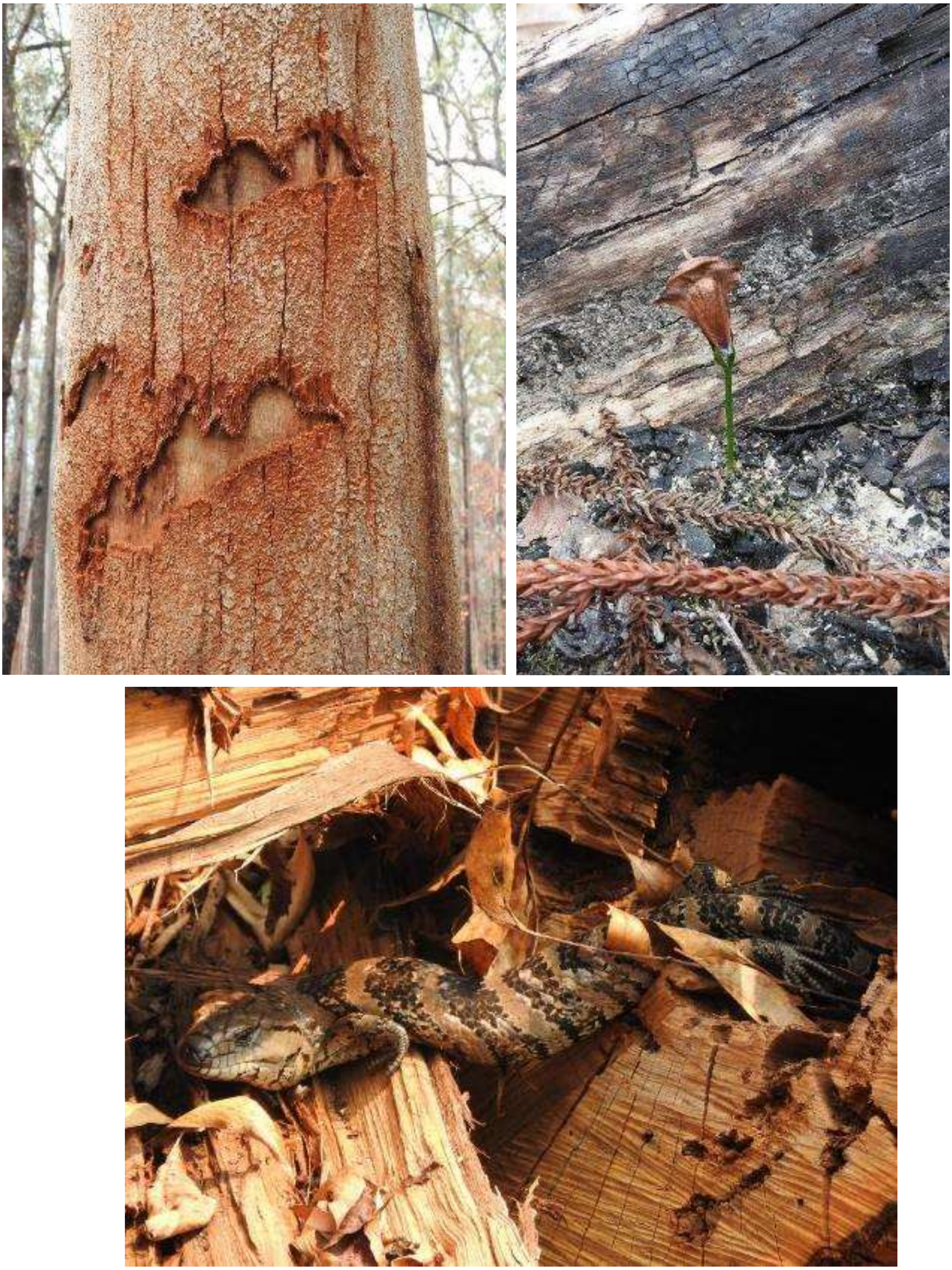

Figure A1.13. Incidental observations of wildlife within the burnt area.

Top left: recent sap-feeding scars of yellow-bellied glider *Petaurus australis* on a grey gum in the Nixons Creek area (11 November 2019). Top right: a hoop pine *Araucaria cunninghamii* germinating from an ash bed in burnt rainforest in the lower Canungra valley (30 January 2020). Lower: a pink-tongued lizard *Cyclodomorphus gerrardii* utilising a hollow in a tree felled by the fire, and crosscut when the Caves Circuit track was reopened (11 November 2019). (H.B. Hines)

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.* (2019 & 2020). All areas are in hectares, for RE1 (see Section 4.2). Estate refers to the QPWS estate(s) affected by the fire event (see Table 3). Column headings are: RE1 – Regional Ecosystem identifier for RE1; Short Description – brief description of RE1; Status – Biodiversity Status; BVG 2M – Broad Vegetation Group at the 1:2 000 000 scale; Estate – area of RE1 within QPWS estate; Low, Moderate, High, Extreme – area of RE1 burnt at each fire severity class.

#Areas of RE 12.3.1a, 12.8.3 and 12.8.4 below 300m in altitude (i.e. along the lower reaches of Canungra Creek and Coomera River) form part of the ecological community Lowland Rainforest of Subtropical Australia, listed as critically endangered under the federal *Environment Protection and Biodiversity Conservation Act 1999*.

RE1	Short description	Status	BVG2M	Estate	Burnt	Low	Moderate	High	Extreme
	Not vegetated			84.98	0.00				
non-rem	Non remnant			181.88	40.76	12.66	17.52	9.86	0.72
12.8.3#	Complex notophyll vine forest on Cainozoic igneous rocks. Altitude <600m	No concern at present	2	5023.57	16.74	5.96	7.31	3.14	0.33
12.8.4#	Complex notophyll vine forest with Araucaria spp. on Cainozoic igneous rocks	No concern at present	2	2488.64	610.91	182.46	305.19	113.45	9.80
12.3.1a#	Gallery rainforest (notophyll vine forest) on alluvial plains	Endangered	4	1.91	0.52	0.24	0.18	0.10	
12.9-10.16	Araucarian microphyll to notophyll vine forest on Cainozoic and Mesozoic sediments	Of concern	5	143.98	30.48	13.19	13.42	3.50	0.36
12.8.5	Complex notophyll vine forest on Cainozoic igneous rocks. Altitude usually >600m	No concern at present	6	6107.51	0.00				
12.8.6	Simple microphyll fern forest with Nothofagus moorei on Cainozoic igneous rocks	Of concern	6	569.10	0.00				
12.8.18	Simple notophyll vine forest with Ceratopetalum apetalum on Cainozoic igneous rocks	Of concern	6	140.95	0.00				
12.3.2	Eucalyptus grandis tall open forest on alluvial plains	Of concern	8	34.14	0.00				
12.8.8	Eucalyptus saligna subsp. saligna or E. grandis tall open forest on Cainozoic igneous rocks	Of concern	8	227.75	52.93	10.09	28.55	14.06	0.22
12.8.9	Lophostemon confertus open forest on Cainozoic igneous rocks	No concern at present	8	1601.44	158.21	39.76	84.14	32.30	2.00

RE1	Short description	Status	BVG2M	Estate	Burnt	Low	Moderate	High	Extreme
12.9-10.14a	Eucalyptus pilularis tall open forest on sedimentary rocks	No concern at present	8	6.08	3.65	1.91	1.50	0.25	
12.8.1	Eucalyptus campanulata tall open forest on Cainozoic igneous rocks	No concern at present	8	714.49	6.16	0.28	3.22	2.51	0.16
12.8.8a	Eucalyptus saligna subsp. saligna or E. grandis tall open forest on Cainozoic igneous rocks	Of concern	9	0.24	0.00				
12.8.20	Shrubby woodland with Eucalyptus racemosa subsp. racemosa or E. dura on Cainozoic igneous rocks	Of concern	9	116.37	0.00				
12.9-10.5d	Woodland complex often with Corymbia trachyphloia subsp. trachyphloia, C. citriodora subsp. variegata, Eucalyptus crebra, E. fibrosa subsp. fibrosa on quartzose sandstone	No concern at present	9	287.71	106.34	11.67	54.42	37.56	2.70
12.9-10.19a	Eucalyptus fibrosa subsp. fibrosa woodland on sedimentary rocks	No concern at present	10	5.28	0.00				
12.8.14	Eucalyptus eugenioides, E. biturbinata, E. melliodora +/- E. tereticornis, Corymbia intermedia open forest on Cainozoic igneous rocks	No concern at present	11	2316.66	448.60	78.13	226.55	132.95	10.97
12.8.16	Eucalyptus crebra +/- E. melliodora, E. tereticornis woodland on Cainozoic igneous rocks	Of concern	11	771.19	46.83	3.57	13.92	25.04	4.30
12.9-10.7	Eucalyptus crebra +/- E. tereticornis, Corymbia tessellaris, Angophora spp., E. melanophloia woodland on sedimentary rocks	Of concern	13	31.92	0.00				
12.9-10.17a	Eucalyptus acmenoides, E. major, E. siderophloia +/- Corymbia citriodora subsp. variegata open forest on sedimentary rocks	No concern at present	28	77.47	38.94	9.66	21.75	7.29	0.24
12.8.19	Heath and rock pavement with scattered shrubs or open woodland on Cainozoic igneous hills and mountains	Of concern	29	333.48	13.07	1.12	4.43	6.41	1.12

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.* (2019), 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 3).

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, Percentage – the percentage of BVG 2M within QPWS estate burnt (see section 4); Low, Moderate, High, Extreme – area of BVG 2M burnt at each relative fire severity class.

BVG 5M	BVG 2M	Estate	Burnt	Percentage	Low	Moderate	High	Extreme
	Non remnant or not vegetated.	266.86	40.76	15.3%	12.66	17.52	9.86	0.72
1. Rainforests, scrubs.	2. Complex to simple, semi-deciduous mesophyll to notophyll vine forest, sometimes with Araucaria cunninghamii (hoop pine).	7512.21	627.65	8.4%	188.43	312.50	116.59	10.12
	4. Notophyll and mesophyll vine forest with feather or fan palms on alluvia, along streamlines and in swamps on ranges or within coastal sandmasses.	1.91	0.52	27.4%	0.24	0.18	0.10	0.00
	5. Notophyll to microphyll vine forests, frequently with Araucaria spp. or Agathis spp. (kauri pines).	143.98	30.48	21.2%	13.19	13.42	3.50	0.36
	6. Notophyll vine forest and microphyll fern forest to thicket on high peaks and plateaus.	6817.56	0.00	0.0%				
2. Wet eucalypt open forests.	8. Wet eucalypt tall open forest on uplands and alluvia.	2583.91	220.95	8.6%	52.04	117.42	49.12	2.37
3. Eastern eucalypt woodlands to open forests.	9. Moist to dry eucalypt open forests to woodlands usually on coastal lowlands and ranges.	404.33	106.34	26.3%	11.67	54.42	37.56	2.70
	10. Corymbia citriodora (spotted gum) dominated open forests to woodlands on undulating to hilly terrain.	5.28	0.00	0.0%				
	11. Moist to dry eucalypt open forests to woodlands mainly on basalt areas (land zone 8).	3087.85	495.43	16.0%	81.70	240.47	157.99	15.27
	13. Dry to moist eucalypt woodlands and open forests, mainly on undulating to hilly terrain of mainly metamorphic and acid igneous rocks (land zones 11 and 12).	31.92	0.00	0.0%				
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. (she-oak), Acacia spp., Lophostemon suaveolens (swamp box), Asteromyrtus spp., Neofabricia myrtifolia.	77.47	38.94	50.3%	9.66	21.75	7.29	0.24
	29. Heathlands and associated scrubs and shrublands on coastal dunefields and inland/ montane locations.	333.48	13.07	3.9%	1.12	4.43	6.41	1.12
Total		**21266.76**	**1574.14**	**7.4%**	**370.71**	**782.11**	**388.42**	**32.90**

Appendix 4. Conservation significant forest fauna and flora species recorded from 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. **Rf** = rainforests, **Sclero** = *Lophostemon*, *Eucalyptus* and or *Corymbia* woodlands and forests; with X = the habitat is important for the species in the focal region. *The blue spiny crayfish is listed as V on the IUCN Red List.

Group	Common name	Scientific name	NCA	EPBC	Rf	Sclero
Animals						
amphibians	cascade treefrog	*Litoria pearsoniana*	V		X	X
amphibians	tusked frog	*Adelotus brevis*	V		X	X
amphibians	Fleay's barred frog	*Mixophyes fleayi*	E	E	X	X
amphibians	giant barred frog	*Mixophyes iteratus*	E	E	X	X
birds	rufous scrub-bird	*Atrichornis rufescens*	V	E	X	
birds	glossy black-cockatoo (eastern)	*Calyptorhynchus lathami lathami*	V			X
birds	eastern bristlebird	*Dasyornis brachypterus*	E	E		X
birds	Albert's lyrebird	*Menura alberti*	NT		X	X
birds	black-faced monarch	*Monarcha melanopsis*	SL		X	X
birds	satin flycatcher	*Myiagra cyanoleuca*	SL		X	X
birds	spectacled monarch	*Symposiachrus trivirgatus*	SL		X	X
birds	plumed frogmouth	*Podargus ocellatus plumiferus*	V		X	X
birds	Coxen's fig-parrot	*Cyclopsitta diophthalma coxeni*	E	E	X	
birds	rufous fantail	*Rhipidura rufifrons*	SL		X	
birds	black-breasted button-quail	*Turnix melanogaster*	V	V		
insects	Richmond birdwing	*Ornithoptera richmondia*	V		X	X
malacostracans	*blue spiny crayfish	*Euastacus sulcatus*			X	
mammals	black-tailed antechinus	*Antechinus arktos*	E	E	X	X
mammals	spotted-tailed quoll (southern subspecies)	*Dasyurus maculatus maculatus*	V	E	X	X
mammals	Hastings River mouse	*Pseudomys oralis*	V	E		X
mammals	platypus	*Ornithorhynchus anatinus*	SL		X	X
mammals	koala	*Phascolarctos cinereus*	V	V		X
mammals	long-nosed potoroo	*Potorous tridactylus tridactylus*	V	V	X	X
mammals	southern greater glider	*Petauroides volans volans*	V	V		X
mammals	grey-headed flying-fox	*Pteropus poliocephalus*	C	V	X	X
mammals	short-beaked echidna	*Tachyglossus aculeatus*	SL		X	X
reptiles	common death adder	*Acanthophis antarcticus*	V			X
reptiles	three-toed snake-tooth skink	*Coeranoscincus reticulatus*	C	V	X	X

Group	Common name	Scientific name	NCA	EPBC	Rf	Sclero
Plants						
Apocynaceae		*Marsdenia longiloba*	V	V		X
Apocynaceae	slender silkpod	*Parsonsia tenuis*	V		X	
Asteraceae	nightcap daisy bush	*Olearia heterocarpa*	NT			X
Asteraceae	mountain podolepis	*Podolepis monticola*	V		X	
Lamiaceae		*Westringia rupicola*	V	V		X
Lauraceae	rusty rose walnut	*Endiandra hayesii*	V	V	X	X
Meliaceae	onion cedar	*Owenia cepiodora*	V	V	X	
Myrtaceae		*Lenwebbia prominens*	NT		X	X
Myrtaceae		*Rhodamnia rubescens*	E		X	X
Orchidaceae		*Corunastylis sigmoidea*	NT			X
Proteaceae		*Alloxylon pinnatum*	NT		X	X
Proteaceae		*Banksia conferta*	V			X
Proteaceae	ball nut	*Floydia praealta*	V		X	
Proteaceae	rusty oak	*Helicia ferruginea*	V		X	
Proteaceae	macadamia nut	*Macadamia integrifolia*	V		X	
Proteaceae		*Macadamia tetraphylla*	V	V	X	
Ranunculaceae		*Clematis fawcettii*	V	V	X	X
Rutaceae		*Zieria adenodonta*	NT			X
Sapindaceae	long-leaved tuckeroo	*Cupaniopsis newmanii*	NT		X	X

Appendix 5. Potential habitat for selected conservation significant species within the burnt 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;
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.* 2020) and broad vegetation group is a high-level classification of vegetation composition at the 1:1M scale (Neldner *et al. 2019*).

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 in order 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 as a result 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.

Potential habitat for species lacking sufficient presence records to allow Maxent modelling have been incorporated into this analysis through the application of a 1km buffer to location records.

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Area burnt of potential habitat for selected conservation significant, (a) fauna, and (b) flora species, within affected QPWS estate.

Affected QPWS estate = Lamington National Park, 2019 bushfire.
Column headings: **Status** – **NCA** (*Nature Conservation Act* 1992) and **EPBC** (*Environment Protection and Biodiversity Conservation Act* 1999) statuses are: CE = critically endangered, E = endangered, V = vulnerable. **Habitat type** – **Rf** = rainforests, **Sclero** = *Lophostemon*, *Eucalyptus* and or *Corymbia* woodlands and forests; with X = the habitat is important for the species in the focal region. **Potential habitat** – **Qld area** = total area of potential habitat within Queensland (ha), **Estate area** = total area of potential habitat within affected QPWS estate (ha), **% in estate** = area of potential habitat within affected QPWS estate as a percentage of the area of potential habitat in Queensland, **Estate habitat burnt** = area of potential habitat burnt within affected QPWS estate (ha), **% estate habitat burnt** = area of potential habitat burnt as a percentage of the total potential habitat within affected QPWS estate. **Fire severity (ha)** = the area burnt within each relative fire severity class (low, moderate, high or extreme) (ha).
*Recorded from the area (refer Appendix 4). †Potential habitat defined by buffered points. ‡Core Koala habitat (SEQ Koala Conservation Strategy 2019-2024).

a) Fauna			Status		Habitat type		Potential habitat (ha or %)					Fire severity (ha)			
Group	**Scientific name**	**Common name**	**NCA**	**EPBC**	**Rf**	**Sclero**	**Qld area**	**Estate area**	**% in estate**	**Estate habitat burnt**	**% estate habitat burnt**	**Low**	**Mod**	**High**	**Ext**
birds	*Atrichornis rufescens**	rufous scrub-bird	V	E	X		14448	7906	54.7%	175	2.2%	45	81	47	3
birds	*Calyptorhynchus lathami**	glossy black-cockatoo	V			X	527111	2062	0.4%	265	12.8%	45	140	75	4
birds	*Cyclopsitta diophthalma coxeni**	Coxen's fig-parrot	E	E	X		173270	20614	11.9%	1453	7.0%	353	721	350	30
birds	*Dasyornis brachypterus**	eastern bristlebird	E	E		X	26765	4612	17.2%	120	2.6%	18	63	37	2
birds	*Lathamus discolor*	swift parrot	E	CE		X	970350	7518	0.8%	157	2.1%	44	86	27	1
birds	*Menura alberti*†*	Albert's lyrebird	NT		X	X	55117	8925	16.2%	1065	11.9%	260	536	252	17
birds	*Ninox strenua*	powerful owl	V			X	2239060	14623	0.7%	922	6.3%	208	448	248	19
birds	*Podargus ocellatus plumiferus**	plumed frogmouth	V		X		180202	7770	4.3%	667	8.6%	169	339	147	12
birds	*Stipiturus malachurus*	southern emu-wren	V			X	31182	299	1.0%	102	34.1%	12	51	36	3
birds	*Turnix melanogaster**	black-breasted button-quail	V	V	X		1013079	6643	0.7%	742	11.2%	215	371	145	12
mammals	*Chalinolobus dwyeri*	large-eared pied bat	V	V	X	X	1060419	20087	1.9%	1336	6.7%	279	662	363	32
mammals	*Dasyurus maculatus maculatus**	spotted-tailed quoll (southern subspecies)	V	E	X	X	396753	15385	3.9%	619	4.0%	144	314	153	7
mammals	*Petauroides volans**	greater glider	V	V		X	4275994	17291	0.4%	811	4.7%	169	408	219	15
mammals	*Phascolarctos cinereus*‡*	koala	V			X	629597	4045	0.6%	823	20.3%	150	413	240	20
mammals	*Potorous tridactylus tridactylus**	long-nosed potoroo	V	V	X	X	190173	18667	9.8%	1133	6.1%	225	553	326	29

a) Fauna			Status		Habitat type		Potential habitat (ha or %)					Fire severity (ha)			
Group	**Scientific name**	**Common name**	**NCA**	**EPBC**	**Rf**	**Sclero**	**Qld area**	**Estate area**	**% in estate**	**Estate habitat burnt**	**% estate habitat burnt**	**Low**	**Mod**	**High**	**Ext**
mammals	*Pseudomys novaehollandiae*	New Holland mouse	V	V		X	60485	1697	2.8%	268	15.8%	49	142	72	4
mammals	*Pseudomys oralis**	Hastings River mouse	V	E		X	25349	6522	25.7%	201	3.1%	39	104	55	3
amphibians	*Adelotus brevis**	tusked frog	V		X	X	985730	12283	1.2%	1394	11.3%	338	692	333	30
amphibians	*Litoria pearsoniana**	cascade treefrog	V		X	X	193704	17832	9.2%	1347	7.6%	314	662	340	31
amphibians	*Mixophyes fleayi**	Fleay's barred frog	E	E	X	X	48380	13342	27.6%	599	4.5%	141	306	142	10
amphibians	*Mixophyes iteratus**	giant barred frog	E	E	X		95357	923	1.0%	343	37.2%	81	169	85	8
reptiles	*Acanthophis antarcticus**	common death adder	V			X	3452148	14041	0.4%	1568	11.2%	371	781	385	32
invertebrates	*Ornithoptera richmondia**	Richmond birdwing	V		X		236182	12433	5.3%	1086	8.7%	225	533	301	27

b) Flora			Status		Habitat type		Potential habitat (ha or %)					Fire severity (ha)			
Family	**Scientific name**	**Common name**	**NCA**	**EPBC**	**Rf**	**Sclero**	**Qld area**	**Estate area**	**% in estate**	**Estate habitat burnt**	**% estate habitat burnt**	**Low**	**Mod**	**High**	**Ext**
Apocynaceae	*Marsdenia coronata*	slender milkvine	V			X	321605	712	0.2%	125	17.5%	15	62	44	4
Apocynaceae	*Marsdenia longiloba**		V	V		X	67681	15315	22.6%	827	5.4%	168	415	227	17
Casuarinaceae	*Allocasuarina filidens*	Mt. Beerwah she-oak	V			X	1698	144	8.5%	2	1.3%	0	1	1	0
Corynocarpaceae	*Corynocarpus rupestris* subsp. *arborescens*	southern corynocarpus	V		X		396187	5359	1.4%	771	14.4%	218	386	155	12
Cyperaceae	*Cyperus semifertilis*		V	V	X		18241	5765	31.6%	1	0.0%	1	0	0	0
Ericaceae	*Leucopogon recurvisepalus*		E			X	17252	377	2.2%	109	28.9%	13	54	39	4
Euphorbiaceae	*Baloghia marmorata*	jointed baloghia	V	V	X		27772	2108	7.6%	374	17.7%	82	182	101	9
Euphorbiaceae	*Ricinocarpos speciosus*		V			X	187298	16551	8.8%	693	4.2%	136	349	195	13
Fabaceae	*Sophora fraseri*	brush sophora	V	V		X	379715	3499	0.9%	495	14.2%	135	244	107	9
Haloragaceae	*Gonocarpus effusus*		V	V		X	8456	480	5.7%	46	9.5%	6	22	16	2
Haloragaceae	*Haloragis exalata* subsp. *velutina*		V	V		X	765276	18613	2.4%	1211	6.5%	298	589	297	27
Lamiaceae	*Coleus nitidus*		E	E	X		118005	11651	9.9%	622	5.3%	129	312	168	13

b) Flora			Status		Habitat type		Potential habitat (ha or %)					Fire severity (ha)			
Family	**Scientific name**	**Common name**	**NCA**	**EPBC**	**Rf**	**Sclero**	**Qld area**	**Estate area**	**% in estate**	**Estate habitat burnt**	**% estate habitat burnt**	**Low**	**Mod**	**High**	**Ext**
Lamiaceae	*Westringia rupicola**		V	V		X	5525	2889	52.3%	341	11.8%	89	176	71	4
Lauraceae	*Cryptocarya foetida*	stinking cryptocarya	V	V	X		46704	72	0.2%	7	9.5%	1	3	3	1
Lauraceae	*Endiandra hayesii**	rusty rose walnut	V	V	X		21433	10564	49.3%	99	0.9%	22	51	24	2
Myrtaceae	*Eucalyptus taurina*	Helidon ironbark	V			X	147575	42	0.0%	22	53.1%	2	14	6	0
Myrtaceae	*Leptospermum luehmannii*		V			X	3565	6	0.2%	3	47.5%	0	1	1	1
Myrtaceae	*Leptospermum oreophilum*		V			X	15809	2139	13.5%	109	5.1%	13	49	42	5
Myrtaceae	*Rhodamnia rubescens**		E		X		290240	14915	5.1%	898	6.0%	187	443	246	22
Myrtaceae	*Rhodomyrtus psidioides*	native guava	E		X		294703	10288	3.5%	671	6.5%	141	344	174	12
Myrtaceae	*Syzygium hodgkinsoniae*	red lilly pilly	V	V	X		63911	8604	13.5%	239	2.8%	61	116	56	6
Myrtaceae	*Xanthostemon oppositifolius*	southern penda	V	V	X		65980	37	0.1%	3	7.1%	1	2	0	0
Oleaceae	*Jasminum jenniae*		E		X		77817	4774	6.1%	282	5.9%	67	145	65	5
Orchidaceae	*Corunastylis sigmoidea*†*		NT		X		704	703	99.9%	18	2.6%	3	8	6	1
Poaceae	*Arthraxon hispidus*		V	V			1094540	1303	0.1%	2	0.2%	0	1	1	0
Proteaceae	*Floydia praealta**	ball nut	V	V	X		319846	19920	6.2%	1297	6.5%	296	642	331	29
Proteaceae	*Helicia ferruginea**	rusty oak	V		X		22845	7634	33.4%	101	1.3%	27	53	20	1
Proteaceae	*Banksia conferta**		V			X	3152	1147	36.4%	30	2.6%	9	15	5	1
Proteaceae	*Grevillea linsmithii*		E			X	4397	175	4.0%	7	3.9%	1	3	3	1
Proteaceae	*Macadamia ternifolia*	bopple nut	V	V	X		88597	126	0.1%	27	21.4%	9	12	5	1
Proteaceae	*Macadamia tetraphylla**		V	V	X		61761	2441	4.0%	440	18.0%	97	211	119	14
Ranunculaceae	*Clematis fawcettii**		V	V	X		112227	16143	14.4%	679	4.2%	161	338	167	13
Rhamnaceae	*Pomaderris crassifolia*		V			X	121170	13285	11.0%	798	6.0%	162	399	220	18
Rutaceae	*Zieria adenodonta*†*		NT			X	1417	1386	97.8%	94	6.8%	26	53	14	1
Santalaceae	*Thesium australe*	toadflax	V	V		X	1105581	4288	0.4%	253	5.9%	38	108	97	10
Sapindaceae	*Cupaniopsis newmanii*†*	long-leaved tuckeroo	NT		X		47860	1013	2.1%	154	15.2%	36	75	41	3
Sapindaceae	*Cupaniopsis shirleyana*	wedge-leaf tuckeroo	V	V	X		600543	429	0.1%	61	14.2%	24	30	8	0
Sapindaceae	*Diploglottis campbellii*	small-leaved tamarind	E	E	X		200536	9876	4.9%	75	0.8%	18	39	17	1
Sapindaceae	*Lepiderema pulchella*	fine-leaved tuckeroo	V		X		41199	1421	3.4%	54	3.8%	14	28	11	1

b) Flora			Status		Habitat type		Potential habitat (ha or %)					Fire severity (ha)			
Family	Scientific name	Common name	NCA	EPBC	Rf	Sclero	Qld area	Estate area	% in estate	Estate habitat burnt	% estate habitat burnt	Low	Mod	High	Ext
Sapotaceae	*Planchonella eerwah*		E	E	X		229834	7003	3.0%	673	9.6%	191	333	139	11

Appendix 6. Pest plant and animals likely to impact significant species or affect recovery of habitat.

More pest species have been recorded in Lamington National Park than those listed below. Only those that are currently known to occur on the park and have the potential to significantly impact on recovering ecosystems or threatened species, and/or impact on their future protection have been included here. For example, species such as *Phytolacca octandra* (inkweed), which is prolific in some burned areas but will 'disappear' as the ecosystem recovers, are not included.

Group	Common name	Scientific name
Animals		
amphibians	cane toad	*Rhinella marina*
mammals	cat	*Felis catus*
Plants		
Apocynaceae	white moth vine	*Araujia sericifera*
Asteraceae	Crofton weed	*Ageratina adenophora*
Asteraceae	mistflower	*Ageratina riparia*
Asteraceae	groundsel bush	*Baccharis halimifolia*
Basellaceae	Madeira vine	*Anredera cordifolia*
Caesalpiniaceae	Easter cassia	*Senna pendula*
Lauraceae	camphor laurel	*Cinnamomum camphora*
Oleaceae	large-leaved privet	*Ligustrum lucidum*
Oleaceae	small-leaved privet	*Ligustrum sinense*
Passifloraceae	white passion flower	*Passiflora subpeltata*
Poaceae	green panic and Guinea grass	*Megathyrsus maximus*
Poaceae	molasses grass	*Melinis minutiflora*
Solanaceae	giant devil's fig	*Solanum chrysotrichum*
Solanaceae	wild tobacco	*Solanum mauritianum*
Verbenaceae	lantana	*Lantana camara*

Appendix 7. Summary of Outstanding Universal Value of Gondwana Rainforests WHA.

The United Nations Educational, Scientific and Cultural Organization (UNESCO) seeks to encourage the identification, protection and preservation of cultural and natural heritage around the world considered to be of outstanding value to humanity under an international treaty called the *Convention Concerning the Protection of the World Cultural and Natural Heritage* (World Heritage Convention).

Outstanding Universal Value (OUV) is the fundamental central concept of the World Heritage and forms the basis for World Heritage listing and reporting.

To be considered of Outstanding Universal Value, a property needs to meet one or more of ten criteria, as well as conditions of integrity and management. The Gondwana Rainforests WHA satisfies three natural heritage criteria (viii, ix and x):

viii. Outstanding examples representing major stages of Earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features.
ix. Outstanding examples representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals.
x. Contains the most important and significant habitats for in-situ conservation of biological diversity, including those containing threatened species of Outstanding Universal Value from the point of view of science or conservation.

The Statement of Outstanding Universal Value (SOUV) for the Gondwana Rainforests WHA outlines how the values of the area meet these three criteria (UNESCO 2019) and for criteria ix and x are summarised in the table below (IUCN 2017). Note these attributes apply to the entire Gondwana Rainforests WHA, of which Lamington NP forms a significant component towards the northern extent of the WHA.

UNESCO World Heritage Convention criteria	OUV Attribute	World Heritage values
*Criterion ix: Outstanding examples representing significant **ongoing ecological and biological processes in the evolution** and development of terrestrial, fresh water, coastal and marine **ecosystems and communities** of **plants and animals**.*		
The Gondwana Rainforests WHA contains outstanding examples of major stages in the Earth's evolutionary history as well as ongoing evolutionary processes. Major stages represented include the 'Age of the Pteridophytes' from the Carboniferous Period with some of the oldest elements of the world's ferns (1) represented, and the 'Age of Conifers' in the Jurassic Period with one of the most significant centres of survival for Araucarians (2) (the most ancient and phylogenetically primitive of the world's conifers). Likewise the property provides an outstanding record of the 'Age of the Angiosperms'. This includes a secondary centre of endemism for primitive flowering plants originating in the Early Cretaceous (3), the most diverse assemblage of relict angiosperm taxa representing the primary radiation of dicotyledons in the mid-Late Cretaceous (4), a unique record of the evolutionary history of Australian rainforests representing the 'golden age' of the Early Tertiary (5) , and a unique record of Miocene vegetation that was the antecedent of modern temperate rainforests in Australia (6). The property also contains an outstanding number of songbird species (7) including lyrebirds (Menuridae), scrub-	Outstanding record of the 'Age of the Pteridophytes' from the Carboniferous Period with some of the oldest elements of the world's ferns (1). Outstanding record of the 'Age of Conifers' in the Jurassic Period with one of the most significant centres of survival for Araucarians (2). Outstanding record of the 'Age of the Angiosperms' (divided into 4 phases): • a secondary centre of endemism for primitive flowering plants originating in the Early Cretaceous (3), • the most diverse assemblage of relict angiosperm taxa representing the primary radiation of dicotyledons in the mid-Late Cretaceous (4), • a unique record of the evolutionary history of	Significant Species • Relict, endemic, disjunct and primitive plant species (1-5). • Relict, endemic, disjunct and primitive animal species (vertebrate and invertebrate) (7 & 8). • Cold-adapted/dry species (6).

birds (Atrichornithidae), treecreepers (Climacteridae) and bowerbirds and catbirds (Ptilonorhynchidae), belonging to some of the oldest lineages of passerines (7) that evolved in the Late Cretaceous. Outstanding examples of other relict vertebrate and invertebrate fauna (8) from ancient lineages linked to the break-up of Gondwana also occur in the property. The flora and fauna of the Gondwana Rainforests WHA provides outstanding examples of ongoing evolution including plant and animal taxa, which show evidence of relatively recent evolution (9). The rainforests have been described as 'an archipelago of refugia, a series of distinctive habitats that characterise a temporary endpoint in climatic and geomorphological evolution'. The distances between these 'islands' of rainforest represent barriers to the flow of genetic material for those taxa which have low dispersal ability, and this pressure has created the potential for continued speciation.	Australian rainforests representing the 'golden age' of the Early Tertiary (5), • and a unique record of Miocene vegetation that was the antecedent of modern temperate rainforests in Australia (6). Outstanding number of songbird species (7) belonging to some of the oldest lineages of passerines (7) that evolved in the Late Cretaceous. Outstanding examples of other relict vertebrate and invertebrate fauna (8) from ancient lineages linked to the break-up of Gondwana. outstanding examples of ongoing evolution including plant and animal taxa which show evidence of relatively recent evolution (9).	
*Criterion x: Contains the most important and significant habitats for **in-situ conservation of biological diversity,** including those containing threatened species of Outstanding Universal Value from the point of view of science or conservation.*		
The ecosystems of the Gondwana Rainforests WHA contain significant and important natural habitats for species of conservation significance, particularly those associated with the rainforests which once covered much of the continent of Australia and are now restricted to archipelagos of small areas of rainforest isolated by sclerophyll vegetation and cleared land. The Gondwana Rainforests WHA provides the principal habitat for many species of plants and animals of outstanding universal value, including more than 270 threatened species (1) as well as relict and primitive taxa (2). Rainforests covered most of Australia for much of the 40 million years after its separation from Gondwana. However, these rainforests contracted as climatic conditions changed and the continent drifted northwards. By the time of European settlement rainforests covered only 1% of the landmass and were restricted to refugia with suitable climatic conditions and protection from fire. Following European settlement, clearing for agriculture saw further loss of rainforests and only a quarter of the rainforest present in Australia at the time of European settlement remains. The Gondwana Rainforests WHA protects the largest and best stands of rainforest habitat (3) remaining in this region. Many of the rare and threatened flora and fauna species are rainforest specialists (1), and their vulnerability to extinction is due to a variety of factors including the rarity of their rainforest habitat. The Gondwana Rainforests WHA also protects large areas of other vegetation	Principal habitat for many threatened species (1). Principal habitat for many relict and primitive taxa (2). The largest and best stands of rainforest habitat (3) remaining in this region. Large areas of other vegetation including a diverse range of heaths, rocky outcrop communities, forests and woodlands (4).	Significant Species • Relict, endemic, disjunct and primitive plant species (2). • Relict, endemic, disjunct and primitive animal species (vertebrate and invertebrate) (2). • Rare and Threatened Plants (1). • Rare and Threatened mammals (1). • Rare and Threatened birds (1). • Rare and Threatened frogs (1). • Rare and Threatened reptiles (1).

including a diverse range of heaths, rocky outcrop communities, forests and woodlands (4). These communities have a high diversity of plants and animals that add greatly to the value of the Gondwana Rainforests as habitat for rare, threatened and endemic species (1 & 2). The complex dynamics between rainforests and tall open forest particularly demonstrates the close evolutionary and ecological links between these communities. Species continue to be discovered in the property including the re-discovery of two mammal species previously thought to have been extinct: the Hastings River Mouse (*Pseudomys oralis*) and Parma Wallaby (*Macropus parma*).		

References

IUCN (2017) World Heritage Outlook Report for Gondwana Rainforests of Australia, https://www.worldheritageoutlook.iucn.org/explore-sites/wdpaid/12202

UNESCO (2019) Gondwana Rainforests of Australia, https://whc.unesco.org/en/list/368/

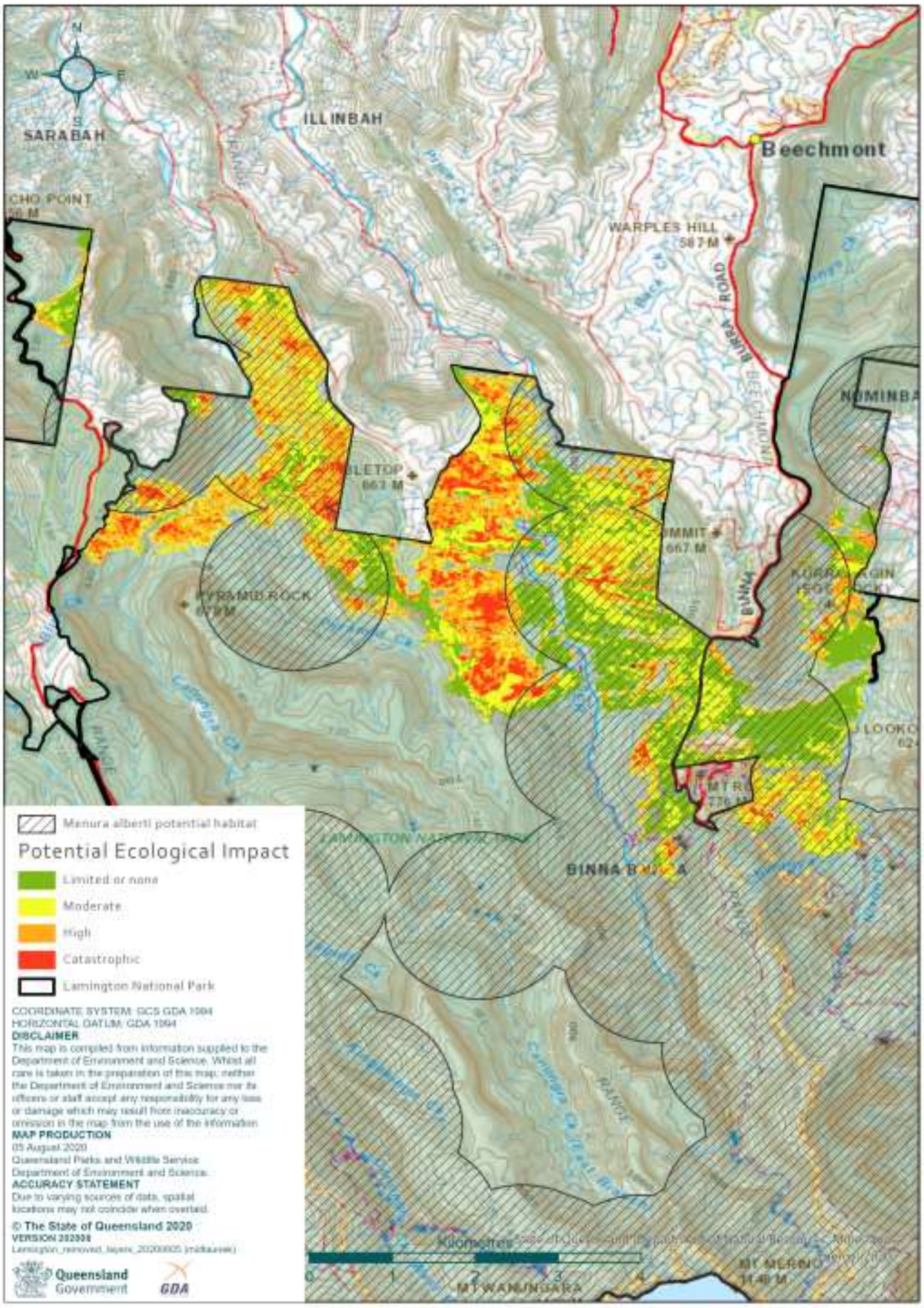
Appendix 8. Maps of significant species potential habitat and potential ecological impact

Maps, showing potential ecological impact, overlain with potential habitat for conservation significant species that met both the following criteria (refer Appendix 5):

- a significant proportion (>10%) of their potential Queensland habitat occurs in Lamington NP, and
- a significant proportion (≥10%) of their potential habitat within Lamington NP was burnt in the bushfire.

The species are: Albert's lyrebird (Near Threatened) and the plant *Westringia rupicola* (Vulnerable)

a) Albert's lyrebird



b) *Westringia rupicola*