Forestry Corporation

2019–20 Wildfires

Environmental impacts and implications for timber harvesting in NSW State forests

An assessment of the impact of the 2019-20 fire season on biodiversity, soil and water values and implications for managing ongoing timber harvesting operations in native State forests

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Executive summary

During 2019-20, widespread bushfires impacted many areas available for timber harvesting under the Coastal Integrated Forestry Operations Approval (CIFOA). Broadly, these forests have evolved with fire and can be generally characterised as resilient and likely to recover over time. However, due to the scale and severity of the fires in 2019-20, a review of the environmental impacts in relation to ongoing timber harvesting is appropriate.

This report examines the specific fire impacts on the forest landscape across the areas of native forest regulated by the CIFOA with some reference to forests on other land tenures. The assessments include consideration of impacts and management of soil and water, habitat and threatened species.

The report and its findings are preliminary in nature, and it will take time for full information on the fire impacts in NSW forests to be collected and understood. However, the report provides a framework for ensuring timber harvesting continues to be managed sustainably at this time, based on the best available information.

The report draws on data from fire severity mapping, habitat modelling, species records and post fire assessments and considers relevant literature on fire impacts in the forests of eastern Australia. This information has been synthesised by Forestry Corporation of NSW and supports the recommendation that a resumption of harvesting under the CIFOA, supplemented with the adoption of additional precautionary conditions in areas affected by the fires is sufficient to meet the precautionary principle as outlined in the NSW Regional Forest Agreements (RFAs). These supplementary conditions are summarised in the concluding section of the report.

Forestry Corporation will continue to gather and assess all relevant available information and review its practices to ensure that timber harvesting activities continue to meet the requirements of the RFA and NSW government policy.

Image at right – recovering forest landscape, Kiwarrak State Forest, Mid North Coast Region, June 2020
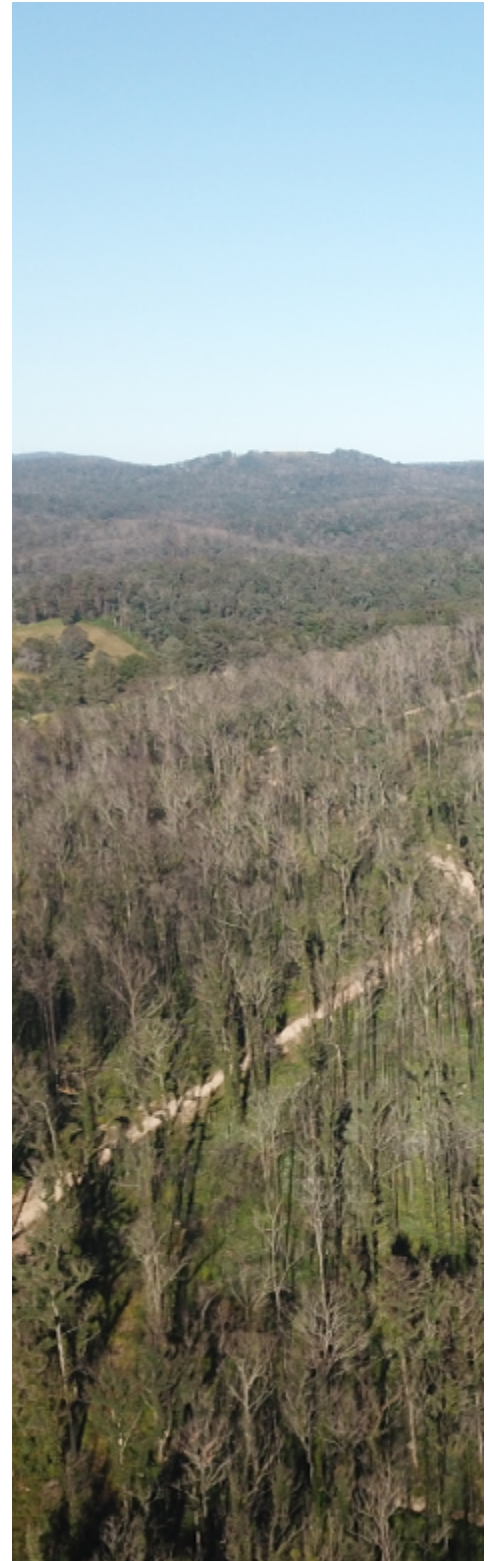
Objectives of this review

This review has been conducted by Forestry Corporation of New South Wales (Forestry Corporation) in response to the wildfire event that occurred in New South Wales from August 2019 through to February 2020. The fires were widespread across many areas of forest managed by Forestry Corporation to produce timber products under the terms of the Coastal Integrated Forestry Operations Approval (CIFOA). Significant areas impacted by fires were burnt at high intensity. As such, these fires warrant an assessment to determine how impacts should be taken into account in planning and carrying out future management activities within native State forests, particularly in relation to timber harvesting.

Forestry Corporation are aware that other reviews and inquiries into the fires and their effects are being carried out. However, it is imperative that Forestry Corporation conduct a review specifically relating to its operations in line with the principles of ecologically sustainable forest management (ESFM), including the precautionary principle.

The precautionary principle expressed in the NSW Regional Forest Agreements (RFAs) is defined as:

'where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by:
» *careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and*
» *an assessment of the risk-weighted consequences of various options.'*

It is acknowledged that this review is preliminary in nature and has been undertaken with access to a limited amount of field data that has been collected in the short period of time since the fires took place. However, the report does access the best available data and draws conclusions from analysis of this data, field surveys and assessments carried out both before and since the fires. The report draws on the significant ecological expertise within Forestry Corporation, which has a team of 15 ecologists based throughout the state as well as forest scientists and specialists with decades of forestry experience.

Better understanding the impacts of the fires on biodiversity will take many years and require ongoing data gathering and analysis through a long-term forest monitoring program. This work is underway, initiated by the introduction of the CIFOA in November 2018 and the development of the New South Wales Forest Monitoring and Improvement Program, led by the Natural Resources Commission. This monitoring work will clarify the baseline expectations for biodiversity, soil and water values across the forest estate and will also show trends over time in these values, as well as monitoring the impacts of timber harvesting. Existing programs with pre- and post-fire measurements will be important sources of information, such as the Department of Primary Industries (DPI) koala monitoring program that has conducted annual monitoring since 2015. In the interim, Forestry Corporation has undertaken an environmental values assessment, which is reported in this document. This assessment utilises a range of data and expert interpretation to determine if the CIFOA is appropriate to manage impacts on

environmental values, including threatened species, and where additional measures are required.

When applying the precautionary principle in relation to forest management, it is important to recognise that timber harvesting will only be applied in a cumulative total of approximately 10 per cent of the native State forest estate over the next five years, which equates to around one per cent of the broader forested area when public forest in national parks and reserves is considered (Slade and Law 2017). Assessment and management of the other approximately 99 per cent of public forests in the RFA areas that will not be subject to timber harvesting in this period will also be of very high importance in managing the multiple values in these forests. The environmental impacts that have occurred from these fires will be mitigated over time as the forests' natural recovery mechanisms occur. This can be rapid for some species and values and take considerable time for others (eg Kavanagh et al 2004; O'Loughlin et al 2020).

This report has considered the impacts on values at the scale of both the full public forest estate and within harvestable State forest areas. This provides context as to what practical precautionary measures can be applied in landscapes during timber harvesting operations, as well as other important management actions such as pest management and monitoring across the broader State forest estate in coming years.

It is recognised that climate change has played a role in the extent and severity of the 2019-2020 wildfires (CSIRO 2020) and that future climate projections indicate increased risk of drought and heatwave conditions (Commonwealth of Australia 2018). It is beyond the scope of this report to model the impacts of climate change on the recovery of the forest or the adequacy of the NSW Forest Management Framework to manage the impacts of climate change on biodiversity. Such an exercise has merit but is beyond the short term scope of this report.

Background

Megafires along the Great Dividing Range of New South Wales have occurred before (Pyne 1991), and Australian forests are very resilient to the impact of wildfires and have effective survival and regeneration strategies (Bradstock 2008). However, the 2019-20 fire season was the worst in living memory and a substantial area of the NSW State forest estate was impacted by bushfire. The scale and severity of these fires required a re-assessment of the State forest estate and the threatened species found throughout the affected forests. Assessment and monitoring of flora and fauna are core components of Forestry Corporation's fire recovery program, alongside seed collection and storage, expansion of our nurseries to grow seedlings and rebuilding forest infrastructure.

State forests are managed for multiple uses, including environmental conservation, community recreation and renewable timber production. Forestry Corporation carries out long-term monitoring programs to assess populations of threatened species across the landscape, as well as targeted surveys to ensure specific protection measures are in place in timber harvesting operations (Slade and Law 2017).

What we know about the extent and severity of the fires

Forestry Corporation, as one of NSW's four statutory firefighting authorities, was heavily involved in the management of the 2019-20 fires, under the leadership of the Rural Fire Service (RFS). More than 500 Forestry Corporation staff completed more than 16,500 shifts on fires from June 2019 until early February 2020. The fires affected more than five million hectares of public and private land across the coastal regions of NSW. The area impacted included around 830,000 hectares of native State forests and 62,000 hectares of State forest timber plantations, which equates to around half of the native forest area managed by Forestry Corporation and a quarter of the state-owned plantation estate. The impacts on forests are still being understood, however the extent and the severity of the fires varied substantially within and between regions. The short, medium and long-term impacts on forests vary between regions in terms of timber, biodiversity, forest recovery and socio-economic impacts.

Governments have commenced a range of assessments to begin to understand the potential impacts. In February, the NSW Department of Planning, Industry and Environment (DPIE) released their Wildlife and Conservation Bushfire Recovery Paper (DPIE 2020a), which included an initial analysis of threatened species across the landscape that was generated by overlaying records with fire extents. The Australian Government Department of Agriculture similarly undertook a national review, which was updated in March 2020 and listed species requiring urgent intervention (DAWR 2020). In May 2020, DPIE released its Fire Extent and Severity Mapping (FESM) which mapped the fire severity across NSW from the 2019-20 wildfires (DPIE 2020b). These published species lists, and fire severity mapping data have been drawn upon in this report, in conjunction with limited post-fire surveys and assessments and knowledge of species ecology, as a basis for assessing potential impacts of fires on biodiversity from the fires and potential mitigations.

What we don't know yet

Ecological research and monitoring are long-term processes. It is necessary to repeat surveys and studies over time to produce reliable results for any given population of forest dwelling species. This is particularly so for many threatened species for two main reasons, the first being the often low probability of detection from surveys (Garrard et al. 2013). The second reason is that many populations are highly dynamic, with changes related to factors such as drought,

climate variation and the habitat dynamics of forest succession from both natural disturbance like fire and human activities such as timber harvesting (eg Law et al. 2016, Law et al. 2018a). Consequently, a reliable picture of the long-term impacts will take time to establish.

Similarly, this report does not consider the potential future changes to forest ecosystem function and recovery based on climate change, as this is a matter beyond its scope. It is expected that climate change scenarios will be considered in the five-year review of the CIFOA and RFAs, as required in those instruments.

Fire severity

Fire severity on public land in each Regional Forest Agreement region

Fire extent and severity mapping (FESM) is a machine learning algorithm used to classify fire severity using a metric of biomass loss derived from Sentinel 2 satellite imagery (DPIE 2020b). DPIE published data showing the state-wide extent of the 2019-20 fires on the SEED portal, which is the NSW Government's central resource for Sharing and Enabling Environmental Data, in May 2020. The biodiversity and threatened species assessments summarised in this report rely on this FESM data. Additional severity mapping was also developed by Forestry Corporation's Forest Information and Planning team, who rapidly produced a Sentinel 2 derived model of burn severity using the burn severity index for the State forest estate in the GoogleEarth Engine platform.

State forests are managed in line with Regional Forest Agreements (RFAs). There are three separate RFAs in NSW, covering the Eden, North East, and Southern regions of NSW. The North East RFA includes the Upper North East and Lower North East forestry sub-regions while the Southern RFA includes the Tumut and South Coast sub-regions. Forestry Corporation has assessed fire severity on public land (excluding private property) across each of these RFA regions, or sub-regions in Southern, using four severity classes based on the FESM mapping for each IFOA forestry region. Maps 1-4 and Figure 1 show how the fire extent and severity on public land varied between the RFA regions.

Fire severity is considered important for determining the likely impact of fires on environmental values, with areas burnt at low severity expected to have less impact and quicker recovery than areas burnt at high severity (eg Bradstock et al 2012; Heath et al. 2016). The assessment of fire severity on species habitat models described in this section also considers areas that are permanently protected and managed as reserves, both within State forests and the conservation estate, and areas that are available for timber harvesting using two simplified categories. Areas that were unburnt have been categorised together with areas that burnt at low severity, while areas that burnt at moderate-high severity have been grouped in another category. These categories are anticipated to differentiate between both the initial impact and recovery trajectories in a generalised manner. Unburnt forest and areas burnt at low severity are expected to continue to largely support populations and enable quick habitat recovery, as canopies are largely unaffected, while stands that suffered a larger heat output and more substantial canopy impacts are more likely to suffer increased mortality and have slower recovery. In the North East RFA region, in the Tumut sub-region and in the Eden RFA region, around two thirds of public land was unburnt or burnt at low severity. In the Southern RFA region (excluding the Tumut sub-region), fires were more extensive, with only 30 per cent unburnt or burnt at low intensity and a high proportion burnt at high intensity.

For the purpose of simplifying the charts and data in this paper, the following classification of FESM was used for reporting:

Pixel Value	FESM severity	Proportion of foliage affected (%)	Severity class	Harvest status assessment by species
0	Unburnt	0% canopy and understorey burnt	Unburnt	Unburnt-Low
1* and 2	Non-FESM burnt and Low	> 10% Understorey Retains > 90% green canopy	Low Intensity	
3	Moderate	20-90% canopy scorch	Moderate	Moderate-High
4 and 5	High and Extreme	> 90% canopy scorch	High	

* This class is reserved for future research and development by DPIE. Includes areas mapped as unburnt by FESM but were inside burnt area maps provided by RFS and National Parks and Wildlife Service (NPWS). Adapted from the FESMv2.1 factsheet (DPIE 2020 b).
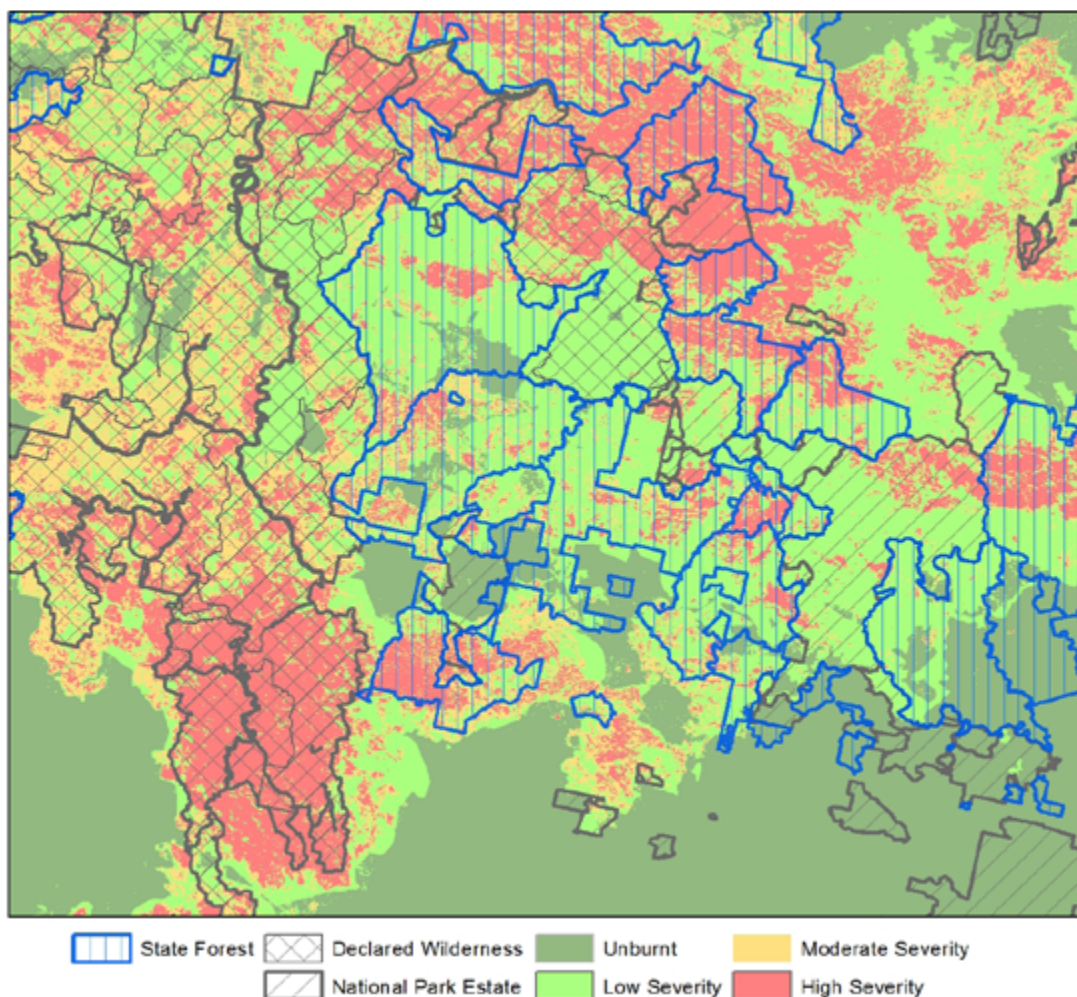
Figure 1 – Example of reclassified, FESM derived, fire severity map from west of Coffs Harbour in north-east NSW overlaying different public land tenures in hatches and private land without hatch. The map shows an example of typical high severity fire runs in red that occurred under severe weather conditions. The bright green and orange areas were burnt at low and moderate severity and dark green was unburnt. The following pie charts that show fire severity on public forests use this same green-red colour scheme. Private land was excluded from the analysis as private lands contain a mix of forest and unforested land as can be seen outside of the hatch areas in the map where the light and dark green represent unburnt forest and cleared land in private property.
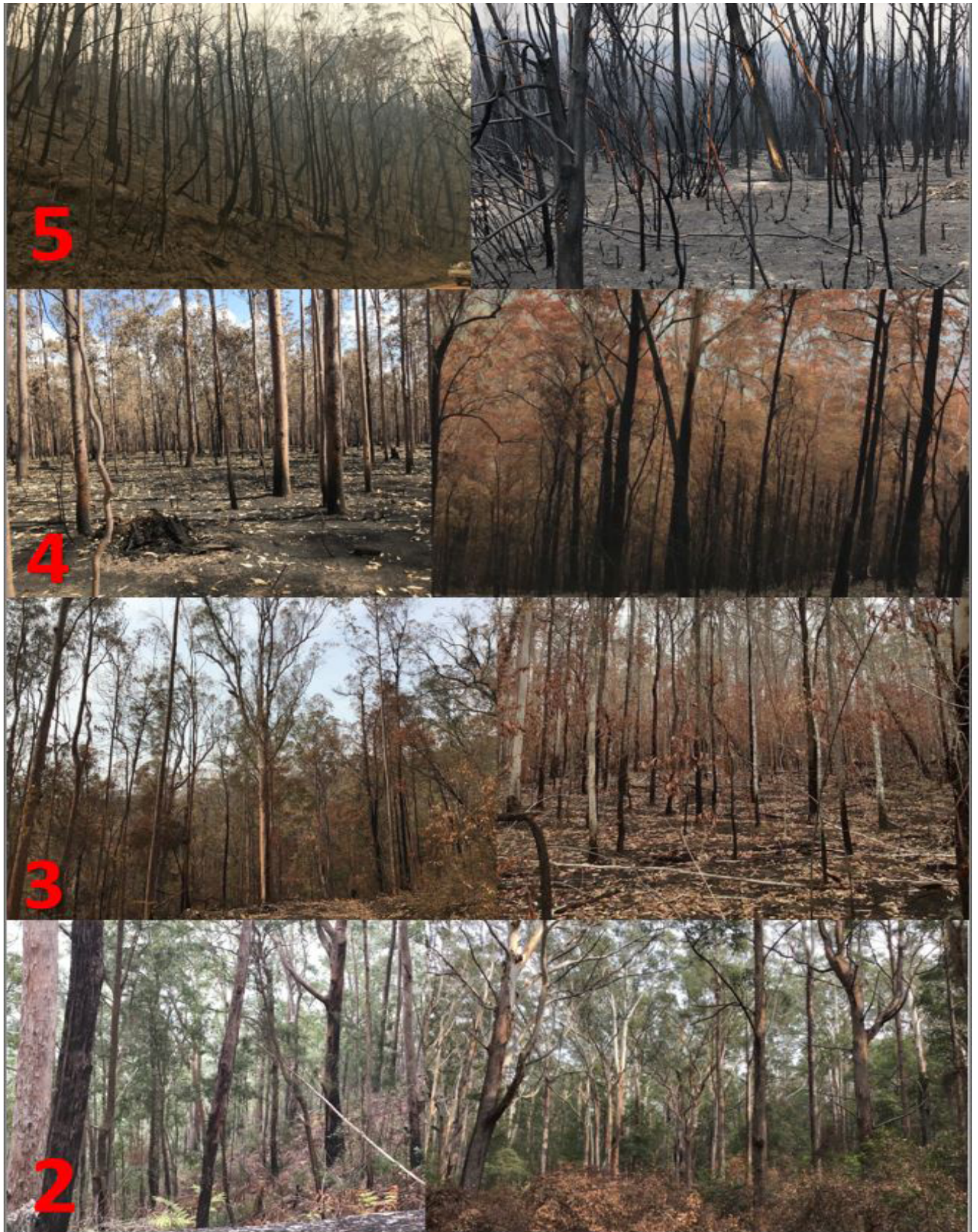
Figure 2: Examples of different fire severity categories. 4 and 5 = high severity fire (>90% canopy scorch, red in charts and maps); 3 = moderate severity fire (20-90% canopy scorch, orange) and 2 = low severity (Understorey impacted but >90% green canopy retained, light green).

Fire severity by Regional Forest Agreement region

North East

- Unburnt – 1,402,545
- Low – 720,402
- Moderate – 451,214
- High – 617,300

Tumut sub-region

- Unburnt – 543,228
- Low – 66,094
- Moderate – 72,881
- High – 234,505

Eden

- Unburnt – 307,558
- Low –99,274
- Moderate – 66,106
- High – 163,649

South Coast sub-region

- Unburnt – 120,587
- Low – 101,758
- Moderate – 128,961
- High – 364,049
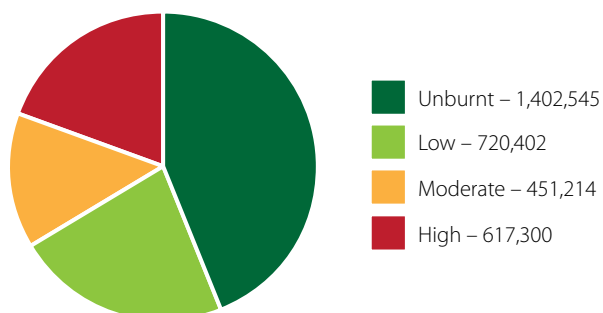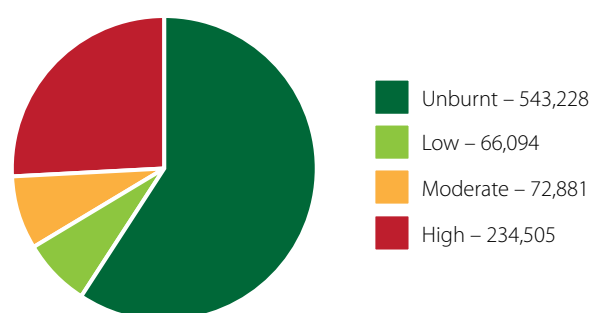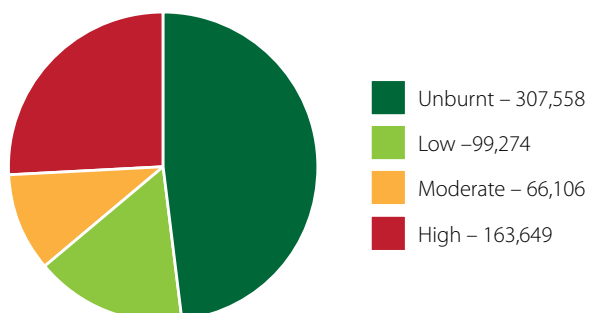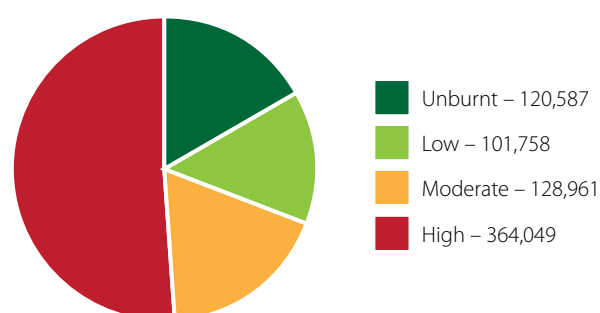
Figure 3: Fire Severity on public forests (private forests excluded) using simplified FESM classification.

The charts above illustrate that the fires were highly variable across the RFA regions. South Coast and Tumut sub-regions from the Southern RFA region were assessed separately as they have different forest types and fire extents. The South Coast sub-region had the largest proportion burnt as well as the highest proportion of severe fire. The extent of fire in every region is still very large and significant.

Table 1: Fire impacts on public forest by tenure

	Tenure type	Unburnt	Burnt	Total
All public forest tenure classifications within the RFA regions	National Park & nature reserve	1,439,634	2,048,959	3,488,593
	Native State Forest	423,482	774,350	1,197,832
	Softwood plantation	14,904	10,224	25,128
	Hardwood plantation	13,304	4,957	18,261
	Leasehold land	120,537	33,099	153,636
	Vacant Crown Land	143,690	58,220	201,910
	Other public forest types	94,423	117,824	212,247

The table above outlines the different tenure categories of public forest included in the fire severity assessment for each region. DPI conducted an analysis of fire severity by tenure, which is available on their website.

Fire severity in harvestable forest by region

On average, 43 per cent of the NSW State forest estate is managed solely for conservation and not available for timber harvesting (Slade and Law 2017). The other remaining areas are available to be harvested for timber production under the strict protection measures of the CIFOA, with a small proportion of that area harvested and regrown each year. The figures below quantify the area of fire severity classes in State forest that is zoned for harvesting and is available for timber production under the CIFOA.

North East Region - Harvestable State forest
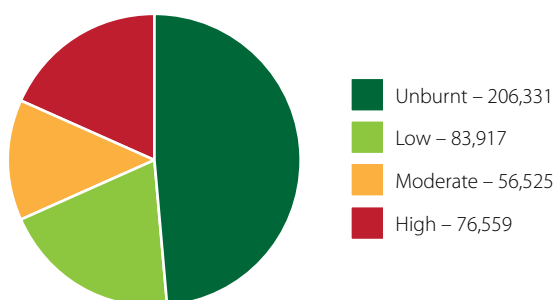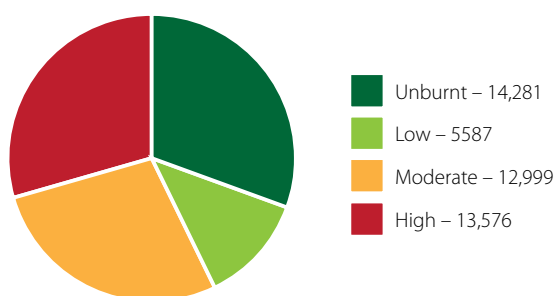
- Unburnt – 206,331
- Low – 83,917
- Moderate – 56,525
- High – 76,559

Tumut sub-region - Harvestable State forest

- Unburnt – 14,281
- Low – 5587
- Moderate – 12,999
- High – 13,576

Eden Region - Harvestable State forest

- Unburnt – 22,174
- Low –29,149
- Moderate – 20,722
- High – 40,868

South Coast sub-region - Harvestable State forest

- Unburnt – 7276
- Low – 20,754
- Moderate – 29,286
- High – 60,034
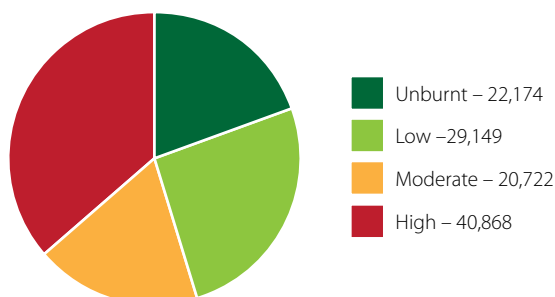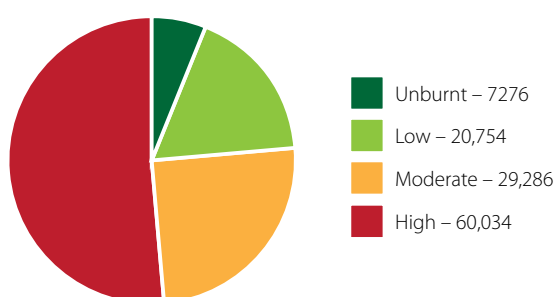
Figure 4 – charts showing the extent and severity of fire on areas of harvestable State forest (figures in hectares)

These show that in the North East, significant proportions of the area of forest available for timber harvesting were not burnt or burnt at low severity. Low severity fire may often have positive ecological outcomes in the forest landscape, akin to a hazard reduction burn or traditional landscape burning practices (eg Bowman 1998; Morgan et al. 2020 ; Penman et al. 2008a, Penman et al. 2008b; Law et al. 2019). The charts show that the harvestable areas in the southern regions were subject to a larger proportion of severe fire.

Soil and water impact and recovery

Bushfires can create conditions that lead to increased runoff and soil erosion, primarily due to the removal of groundcover and the organic layer on the forest floor and a reduction in evapotranspiration from vegetation, which leads to increased soil moisture storage and the recharge of groundwater systems (Talua and McInnes Clarke, 2015).   The most important factors that determine the occurrence and severity of runoff and soil erosion are the severity of the fire and the timing and intensity of rainfall that follows the fire. Additional disturbance from timber harvesting activities can have an aggravating effect on runoff and soil erosion in the absence of controls to account for the temporary loss of vegetation and ground cover.

Low intensity fire generally does not increase soil erosion as it has little effect on soil organic matter and is usually followed by a rapid recovery in groundcover (Wallbrink et al. 2004). Around 35 per cent of the native forest estate was subject to low intensity fire impacts during the fire season. These areas are unlikely to require any additional consideration given that the fire events ended in February and adequate time has elapsed to ensure that ground cover recovery will have occurred.

After the moderately intense fires that occurred in the coastal ranges surrounding the Sydney metropolitan area in January 1994, Prosser and Williams (1998) found that at the hillslope plot scale fire increased runoff through enhanced soil hydrophobicity and increased sediment transport through the reduction in ground cover, which lowered the threshold for initial sediment movement. They found, however, that both runoff and sediment transport were very localised, resulting in little runoff or sediment yield after the fire at the hillslope catchment scale and suggested that intensive rainfall events (greater than one-year recurrence interval) are required to generate substantial runoff and sediment yield after moderately intense fire.

High intensity fires on the other hand often result in complete crown and understorey loss, complete combustion of ground cover and the loss of soil organic matter, leaving areas prone to accelerated soil erosion. If high severity fire is followed by large storm events, then accelerated soil erosion and runoff is inevitable. Robichaud et al. (2009) found that high severity fires increased runoff and erosion rates by two or more orders of magnitude, while low and moderate severity fires had a much smaller effect on runoff and soil erosion. Erosion rates can take up to a decade or more to recover to pre-disturbance levels after high intensity fire particularly where tree and shrub canopies have been killed (Talua and McInnes Clarke, 2015).

In February 2020, heavy rainfall fell across much of the NSW coast and caused widespread damage to the forest road infrastructure. This has likely also resulted in the delivery of massive quantities of ash, charcoal, nutrients and sediment into the stream network. Nyman et at (2011) documented a number of high magnitude erosion events following the 2003 and 2009 bushfires in eastern Victoria while Talau et al. (2019) also reported a number of large erosion events in the Warrumbungle National Park following the January 2013 fires. Debris flows were triggered by intense rainfall creating large runoff events on severely burnt catchments.

In the eastern Victorian catchments, Nyman et al (2011) found that the runoff-generated debris flows only occurred in dry eucalypt forest where hillslopes were an important source of material for the flows. In the wet eucalypt forest, they found that runoff-generated debris flows did not occur despite the catchments receiving rainfall intensities at levels that triggered debris flows in the dry eucalypt forest. They attributed the different responses to the higher soil infiltration capacity of the better structured soils in the wet eucalypt forest and the rapid recovery in vegetation, which promoted higher effective infiltration rates at the hillslope scale, resulting in low connectivity between overland flow on hillslopes and the stream network.

The recorded debris flows in the dry eucalypt forest all occurred within 12 months of the fire, suggesting that susceptibility diminished quickly during recovery of the catchments. Nyman et al. (2011) attributed this to the combined effects of increased infiltration capacity of recovering hillslopes and the increased hydraulic roughness from regrowing vegetation. It is generally accepted that as catchment vegetation recovers over the year or two after fire, the amount of sediment washing into the streams will generally decrease and, depending on the severity of the fire, can return to pre-fire levels relatively quickly as ground cover is restored (Prosser and Williams 1998; Wallbrink et al. 2004; Lane et at 2006; Robichaud 2009).

The road and trail network is another important post-fire source of runoff and sediment to the stream network and can remain so long after the hillslopes have recovered. Sosa-Perez and MacDonald (2016) reported a large increase in road-stream connectivity after high and moderate severity fires due to increased amounts of runoff and sediment upslope of the road, the accumulation and discharge of this runoff at a single location along the road and the reduced infiltration and roughness of the burned hillslope below the road. They also found that a high post-fire rate of road-stream connectivity was due to the a large headward extension of the channel network, a process which has also been reported by Wohl (2013). Sosa-Perez and MacDonald (2016) concluded that, while the combined effects of fires and roads pose a very difficult challenge for land managers, any effort to reduce the adverse effects of roads after a fire will continue to be beneficial after the hillslopes recover.

Since March 2020, Forestry Corporation has embarked on a major infrastructure rebuild program in fire affected forests across the state which includes the replacement of a large number of burnt road crossings and road drainage structures, repairing unstable sections of the road and trail network and installing additional road and trail drainage to control the amount of runoff that discharges onto burnt hillslopes. This program has been supported by additional government recovery funding with over one thousand kilometres of roads and trails rehabilitated to date and the program ongoing.

Figure 5: Mid North Coast fire-affected landscape following heavy rains. In this image: sediment from erosion backed up in a blocked road drainage structure, demonstrating the potential for erosion in post-fire environment. Effects such as this will have been quite widespread across NSW fire-affected areas on both public and private land.

Mitigations for soil and water risk in timber harvesting

Existing conditions

The conditions and protocols in the CIFOA use best management practices (BMPs) for assessing and managing soil erosion risk associated with forestry activities. These are based on the results of 40 years of scientific research on the effects of timber harvesting in native forests on soil erosion and water quality (e.g., Croke et al. 1999a and 1999b; Cornish 2001; Wallbrink and Croke, 2002; Motha et al. 2003; Webb et al. 2012, Walsh et al. 2020). This research has consistently shown that if the BMPs are implemented, then the impact of forestry activities on soil erosion and sediment delivery to the stream network is minimal and usually within natural variability.

Post-fire considerations

Among other things, the literature highlights the importance of stable surfaces on the hillslopes in managing concentrated runoff from the outlets of road and track drainage structures. Forestry Corporation recognised that during the immediate post fire period, severely burnt areas were devoid of groundcover and stable surfaces and had the potential for accelerated runoff and soil erosion. In these instances, site-specific conditions were developed and introduced ahead of timber harvesting activities to manage this risk. These site-specific conditions included increased buffer strip widths along the stream network, slope restrictions and use of tree heads and branches to provide surface roughness and ground cover on the burnt hillslopes.

However, in most areas of State forest, groundcover has recovered to pre-fire levels in the months following the fires. In some areas, ground cover is now far greater than what would be required to provide stable ground surfaces capable of handling concentrated flow. Examples of the varying degrees of recovery in ground cover across the State forest estate are provided in the case studies below.

Recommendations

In order to satisfy the precautionary principle in assessing potential risk to soil and water associated with timber harvesting in areas burnt during the fire season, the following measures are recommended in addition to the existing risk mitigation measures in the CIFOA:

1. In those areas where ground cover has recovered to a level that provides stable surfaces capable of handling concentrated flow from road and track drainage structures, it is appropriate to undertake forestry activities using the existing best practice soil and water conditions and protocols as set out in the CIFOA (EPA 2018).

2. In those areas where ground cover has not recovered to provide stable surfaces capable of handling concentrated flow from road and track drainage structures;

   » Determine on a site by site basis (through site inspection by a suitably qualified expert) if mitigations can be put in place to reduce risk to an acceptable level, or

   » wait until ground cover has recovered and apply the CIFOA soil and water conditions and protocols.

3. The assessment of stability should apply at a range of scales as appropriate; the compartment scale (greater than 50 hectares) to determine if areas have recovered sufficiently to harvest; to the patch scale (less than 10 hectares) to identify if parts of a harvest area have not recovered as well as the general area and can be temporarily excluded or have additional mitigations; and the site-specific scale where BMPs are implemented, such as ensuring a stable surface is present at the location of a drainage structure or where one is proposed to be constructed. This is an important consideration particularly in those forests that were subject to moderate or severe burn intensities followed by significant rainfall events, as the post-fire road-stream connectivity is likely to have increased in these areas.

Case studies – Ground cover and soil stability recovery

A large range of field inspections have been carried out by Forestry Corporation. These are briefly outlined in the case studies below.

Casino Management Area

Forests inspected:
Doubleduke / Myrtle / Braemar State Forests

Initial fire severity:
Moderate to high

Environment:
Typically grassy forests with Spotted Gum and dry mixed hardwood forest types, significant areas of swamp and low lying topography.

Recovery conditions:
Fires impacted these forests in October and November 2019 and the forests were inspected in May-June 2020. There has been high rainfall in the six to nine months since fires passed.

Recovery assessment:
» Good to excellent ground cover across all inspected sites.
» No additional measures to the CIFOA are required to mitigate soil and water risk in these locations.

Good ground cover recovery. Doubleduke State Forest. Far North Coast east of Casino. June 2020

Good ground cover recovery. Myrtle State Forest. Far North Coast between Grafton and Casino. June 2020

Figure 6: Case study Casino Management Area

Good ground cover recovery. Myrtle State Forest. Far North Coast east of Casino. May 2020.

Good ground cover recovery. Braemar State Forest. Far North Coast between Grafton and Casino. May 2020

Figure 7: Case study Casino Management Area

Coffs Harbour and Dorrigo Management Area

Forests inspected:

Kangaroo River / Clouds Creek / Sheas Nob State Forests

Initial fire severity:

Moderate to high

Environment:

Typically grassy forests with Blackbutt and mixed hardwood forest types, undulating topography often with rainforest gullies.

Recovery conditions:

Fires impacted these forests in October - November 2019 and the forests were inspected in May-June 2020. There has been very high rainfall in the six to nine months since fires passed.

Recovery assessment:

» Good to excellent ground cover across all inspected sites.

» No additional measures to the CIFOA are required to mitigate soil and water risk in these locations.

Excellent ground cover recovery. Kangaroo River State Forest. Image 1: December 2019

Good ground cover recovery. Sheas Nob State Forest. North Coast west of Coffs Harbour

Image 2: June 2020

Figure 8: Case study: Coffs Harbour and Dorrigo Management Area

Wauchope and Taree Management Area

Forests inspected:
Bril Bril / Bellangry / Kiwarrak State Forests

Initial fire severity:
Moderate to high

Environment:
Typically grassy to shrubby forests with Blackbutt and mixed hardwood forest types, undulating topography.

Recovery conditions:
Fires impacted these forests in November 2019 and the forests were inspected in May-June 2020. There has been high to very high rainfall in the six to nine months since fires passed.

Recovery assessment:
» Good to excellent ground cover across all inspected sites.
» No additional measures to the CIFOA are required to mitigate soil and water risk in these locations.

Good ground cover recovery. Bril Bril State Forest. Mid North Coast near Wauchope

Good ground cover recovery. Bellangry State Forest. Mid North Coast near Wauchope

Figure 9: Wauchope and Taree Management Area

Batemans Bay Management Area

Forests inspected:

Benandarah / Shallow Crossing / Brooman State Forests

Initial fire severity:

Moderate to high

Environment:

Typically Spotted Gum forest types, undulating to steep topography.

Recovery conditions:

Fires impacted these forests in January 2020 and the forests were inspected in June 2020. There has been good rainfall in the six months since fires passed.

Recovery assessment:

» Fair to good ground cover across all inspected sites.

» Site by site assessments recommended to determine where additional measures to the CIFOA are required.

Benandarah State Forest
Understorey and ground cover have reached more than 70 per cent levels across most areas inspected. This image is from April, four months after the fire occurred in the area.

South Brooman State Forest
Understorey and ground cover have reached more than 70 per cent levels across most areas inspected. This image is from April, four months after the fire occurred in the area.

Figure 10: Batemans Bay Management Area

Narooma Foothills Management Area

Forests inspected:

Dampier State Forest

Initial fire severity:

High

Environment:

Typically steep, mixed hardwood forests. Generally shallow ground cover and poor soils.

Recovery conditions:

Fires impacted these forests in January 2020 and the forests were inspected in June 2020. There has been some rainfall in the six months since fires passed.

Recovery assessment:

» Poor to nil ground cover recovery across inspected areas.

» No harvesting should take place until at least January 2021 and only after a suitably qualified expert assessment indicates the landscape and soils are stable.

Dampier State Forest
Poor ground cover recovery Dampier State Forest.
South Coast west of Narooma

The area was inspected with drone due to ongoing safety concerns regarding walking in the area.

Figure 11: Narooma Foothills Management Area.

Eden Management Area

Forests inspected:

Yambulla / Nadgee State Forests

Initial fire severity:

Low - moderate - high

Environment:

Typically undulating Silvertop Ash forests. Generally low ground cover. Poor-moderate soils.

Recovery conditions:

Fires impacted these forests in January 2020 and the forests were inspected in May to June 2020. There has been some rainfall in the six months since fires passed.

Recovery assessment:

»   Fair to good ground cover across all inspected sites.

»   Site by site assessments recommended to determine where additional measures are required.

Yambulla State Forest
Ground cover includes grasses, leaf fall, and regenerating canopy and understorey species.

Nadgee State Forest
Ground cover still in early stages of recovery at May 2020 but reaching levels of more than 70 per cent in many places.

Figure 12: Eden Management Area

Biodiversity impacts and recovery

Fire has played an important role is shaping the ecology of Australia (eg Gill et al. 1981; Bradstock et al. 2012). Many Australian plants have functional traits to enable survival or recovery from fires such as thick bark, epicormic buds and woody capsules that enable resprouting or regeneration post fire (Bradstock 2008; Heath et al 2016; Keith 2012). Wildfire intensity, and the subsequent severity of the impacts on flora and fauna, can be highly variable in the landscape with fuel, weather and topography each playing an important role (Gill et al. 2012; Sullivan et al. 2012; Collins et al. 2019). Fire regimes, and in particular recurrence intervals of large fires, are also a significant factor on biodiversity impacts (Bradstock 2008; Morris and Watson 2020; O'Loughlin et al. 2020). Past or future wildfires could be expected to alter the impacts associated with this event. Most of the State forest affected in the 2019-20 fires were not impacted by the large fires in southern Australia from 2003-2009, unlike some areas in Victoria and the alpine areas in NSW. Consequently, the cumulative impact of repeat fires has not been considered in this assessment, but is certainly a significant issue that can affect recovery going forward.

Large-scale high-intensity fires can cause widespread habitat destruction and direct mortality of flora and fauna species (Lindenmayer et al. 2013; Mclean et al. 2018). Large fires do not burn homogenously, and many species are resilient due to in-situ survival or regeneration mechanisms (Bradstock 2008). Unburnt patches and areas burnt at low severity serve as habitat refuges after fires, offering habitat that allows for persistence and recolonisation of populations from these unburnt areas (Berry et al 2015; Wills et al 2020).

Survival and recolonisation of hollow dependant mammals during fires is related to both fire severity and availability of refuges (Lindenmayer et al. 2013; Mclean et al. 2018). Matthews et al. (2007) observed koalas in a remnant coastal forest following intense wildfire and found utilisation of burnt trees by individuals occurred within months following the fire. However, areas with a high wildfire frequency can have reduced koala occupancy (Law et al. 2017). Studies on birds, bats and reptiles after large wildfires have found varied species-level responses and note that rapid recovery of vegetation following fires can mediate impacts; that long unburnt habitat patches can be important for particular species; and that context (severity and patchiness at different scales) is relevant for some but not all species (Barton et al. 2014, Bradstock 2008; Dixon et al. 2018; Law et al. 2018b; Lindenmayer et al. 2008; Wills et al. 2020).

Forestry Corporation have assessed the potential impacts of the 2019-20 wildfires on key habitat features and individual threatened fauna by overlaying fire severity mapping with a range of key mapped communities, species habitat models (if available) and species records where models were not available, along with available post-fire field assessments and surveys to build an understanding of the relative impact on biodiversity values. The following analysis identifies that fire severity has been variable; for most species and in most regions less than a third of their habitat was burnt at high severity; limited post-fire surveys have already identified surviving or regenerating individuals for over 40 different threatened species; assessments show forest recovery is well underway, especially in areas burnt at low-moderate severity.

Mitigations for biodiversity in timber harvesting

Principles to mitigate impact of harvesting in burnt environments

The literature on the ecological impacts of salvage harvesting is largely drawn from studies in North America and the montane ash forests of Victoria (eg Lindenmayer and Ough 2006; Lindenmayer and Noss 2006). These are forests that are largely killed by intensive fires and historically salvage harvesting has included intensive harvesting such as clear-felling and replanting or sowing. Whilst this is not proposed in New South Wales State forests, the following principles identified in these papers to mitigate ecological impacts from salvage harvesting are appropriate to consider:

» exclude harvesting altogether from areas such as nature reserves and old growth forests

» vary harvest intensity (eg not all clearfall and sow)

» retain biological legacies such as large living and dead trees, large logs and unburnt understorey vegetation

» avoid or reduce disturbance to unburned and partially burned areas within the fire area

» consider natural recovery and avoid sowing or replanting in areas that will recover naturally

» ensure adequate riparian protection and retention of logs and slash on the ground, avoid steep slopes and areas of erodible soils to limit soil erosion and protect aquatic habitat.

Each of these elements has been considered for proposed harvesting operations in areas impacted by fire by looking at both the suitability of the existing conditions to mitigate impacts as well as what appropriate post-fire management actions might be applied. Tables 8 and 9 outline the proposed conditions to be applied in fire-affected forests.

Existing conditions

The conditions and protocols in the CIFOA use a multi-scale landscape approach (Lindenmayer and Franklin 2002) to forest management that is underpinned by retention forestry methods (Gustafsson et al. 2012) to protect biodiversity values in forestry operations. A recent meta-analysis identified retention forestry as the most effective management approach in timber production forests for minimising species loss (Fedrowitz et al. 2014). The CIFOA was remade after an extensive review that was undertaken by the NSW Government from 2013-2018 using a rigorous process of expert panels and independent advice (NRC 2016). This produced a modern forestry regulatory framework that was approved for implementation in November 2018 (EPA 2018). The conditions include harvesting and yield limits at a range of scales to limit activities in any one area; permanent retention of environmentally significant areas (ESAs) such as rainforest and old growth forests, wetlands and riparian exclusions, threatened ecological communities, ridge and headwater habitat and rocky outcrops. Further protection in the net harvest area (outside of retention zones) is established following targeted surveys and searches for threatened species and habitat features that generate protection of valuable habitat clumps, hollow-bearing trees, giant-trees and various nest, den, roost trees and feed trees. The whole management system is also underpinned by a monitoring and adaptive management approach (Slade and Law 2017).

Post-fire considerations

Harvesting limits: the CIFOA limits continue to ensure operations are dispersed across the landscape over time. This remains an important principle in reducing the cumulative impacts of fire and timber harvesting. However, as the effects of fires, particularly the distribution of fire of varying severity, were not uniform across the landscape it may be beneficial in some instances to focus harvesting on severely affected areas and to therefore minimise harvesting in less affected areas for biodiversity, recovery and forest regeneration outcomes while enabling timber production to continue. This would particularly be important in forest types that are killed or highly degraded in high severity fires. This impact largely occurs in Ash forest types that are susceptible to, have a history of, and regenerate prolifically from, high intensity fires. The harvestable Silvertop Ash forests in the State forests at Eden and Alpine Ash forest in the State forests at Tumut largely developed following earlier severe fires and follow-up harvesting and regeneration treatments. Both these forest types tend to support lower levels of biodiversity than other forest in the adjacent landscapes (Braithwaite et al. 1988; Kavanagh and Stanton 1998).

Landscape exclusions: whilst fire has affected many forests managed under the CIFOA, the underpinning landscape exclusions are still appropriate for long-term protection and retention. These exclusion zones will largely recover via natural regenerative processes. The identification and application of permanent wildlife habitat clumps and tree retention clumps from the net harvest area are new measures recently introduced under the CIFOA and it is appropriate for these to be prioritised to less severely burnt areas or areas that have retained or are recovering biodiversity values in the short term, especially in heavily burnt landscapes.

Species-specific considerations: the fire impacts of each fauna species have been considered as described below and reported in Appendix 1.

Recommendations

In order to satisfy the precautionary principle, the following measures are recommended to manage the risk to biodiversity values from timber harvesting in areas burnt during the fire season. The full range of considerations is detailed in the following sections and Appendix 1. In summary, the additional measures proposed are:

1. Apply additional habitat and tree retention clumps in burnt forests to protect multiple biodiversity values. The clump-based approach was recommended by the CIFOA fauna expert panel as an efficient and effective model to protect multiple biodiversity values. The logic can be similarly applied to prioritise and protect values in burnt landscapes whilst forest recovery occurs. Consequently, the protection of an additional five per cent of the harvest area at the local landscape scale in wildlife habitat clumps and an additional five per cent of the harvest area at the compartment scale in tree retention clumps in fire-affected areas is proposed. Clumps should be selected using the same principles identified in Protocol 22 of the CIFOA (EPA 2020). This effectively doubles the area of clumps suggested by the fauna expert panels and Natural Resources Commission in their final report (NRC 2016) as a means of ensuring that local biodiversity priorities are accounted for in planning timber harvesting operations in burnt landscapes.

2. Have regional ecologists undertake site-specific assessments and apply recommended actions for threatened flora on a case-by-case basis for planned harvesting operations as individual species responses are variable as is the site-specific context of operations.

3. Follow the species and regional approaches outlined in Appendix 1 for threatened fauna species, in particular in relation to how species habitat is prioritised into permanent and temporary habitat clumps.

4. Continue to implement surveys and monitoring post-fire to assess recovery and inform and adapt the management actions proposed in this document as required. The monitoring approaches to be applied include:

   » Individual species plans under the CIFOA for flora and fauna species (EPA 2018)

   » Fire recovery monitoring under development by Forestry Corporation using repeatable analysis of Sentinel 2 images supported by permanent photo points established soon after fires. These may be augmented or verified with images captured by drones.

   » Monitoring for target flora and fauna species under both the CIFOA and the New South Wales Forest Monitoring and Improvement Program (https://www.nrc. nsw.gov.au/forest-monitoring). These methods are under development and will extend existing monitoring by DPI undertaken since 2015 (https://www. dpi.nsw.gov.au/forestry/science/koala-research). Methods are likely to include fauna occupancy modelling for numerous micro-bat species, koalas, large forest owls, and Yellow-bellied Gliders using acoustic monitors and automated call recognisers as well as targeting small to medium size mammals using camera traps.

Fire severity and observed habitat impacts

High severity fire: Impacts and recovery

Figure 13: Example of rapid recovery in a forest that burnt at high severity. Images were taken in December 2019 (left) and June 2020 (right) at Kangaroo River State Forest, Coffs Harbour Management Area and show full canopy burn and significant regeneration, with only some mature tree epicormic recovery.

Figure 14: Example of slow recovery in a forest that burnt at high severity. Images were taken in January 2019 (left) and June 2020 (right) in Dampier State Forest, South Coast Management Area and show full canopy burn and mature tree epicormic recovery in early stages.

General ecological impact characteristics of different high severity areas

» Significant mortality of fauna species, especially those without high mobility.

» Significant loss of current standing hollows bearing trees and coarse woody debris (CWD), especially dead stags, logs and trees with basal hollows. This may be partially offset by damage to canopy limbs in older trees that exposes new hollows or will speed up hollow development in regrowth trees and creation of new CWD via trees that fell during or following the fires.

» Often full regeneration / transition to new successional forest with alteration of forest age, structure and composition affecting distribution of feed tree / shelter and nesting habitat opportunities for medium to long-term.

Hollow-bearing tree impacts in areas burnt at high severity

Hollow-bearing trees provide important habitat for many species (Gibbons and Lindenmayer 2002). Many hollow-bearing trees have been affected by fires, but fire damage has and will create hollows in many additional trees to help recruitment and replacement of this habitat.

Figure 15: Image at left shows loss of hollow bearing tree, which was unfortunately common on many firegrounds. Image at right shows numerous trees with epicormic branches where original canopy branches have broken, and hollows have potential to form in coming decades.

Coarse Woody Debris impacts in areas burnt at high severity

Coarse woody debris (CWD) provides shelter habitat for many species. In heavily burnt areas the initial loss of CWD that burnt during the fires has often been offset by increased and continuing build-up of CWD following the initial fire impact, as burnt down trees and limbs fall and accumulate on the forest floor. In areas impacted by fires at moderate and high severity, the rate of CWD accumulating on the forest floor after the initial fire impact has been quite high. In areas impacted by low severity burns, CWD loss from the fires may not be offset by new inputs, as fewer trees were lost or damaged. In these instances, timber harvesting has the potential to rebuild CWD volumes and associated habitat opportunities in areas where CWD has been reduced (Stares et al. 2018; Threlfall et al. 2018).

Figure 16: Image at left: Braemar State Forest, November 2019, showing almost total loss of coarse woody debris. Image at right taken in Dampier State Forest in June 2020 showing significant CWD accumulation following fire.

Moderate severity fire impacts and recovery

Figure 17: An example of an area of forest burnt at moderate severity immediately post-fire and during recovery. Images taken in November 2019 and May 2020, Braemar State Forest Casino Management Area, North Coast Region

General ecological impact characteristics of different areas burnt at moderate severity

» Rapid recovery of scorched canopies from epicormic shoots

» Some loss of hollows, especially dead stags and new hollow formation likely accelerated in a proportion of mature canopy trees

» Reduction in CWD, partly offset via recruitment of CWD from tree fall.

Low severity fire impacts and recovery

Figure 18: Low severity fire impacts. Top image: Low severity fire, September 2019, Mount Belmore State Forest, Casino Management Area,. Some parts of this fire ground carried high severity, some such as the area pictured were burnt in backburning operations under mild conditions. Bottom images: Kangaroo River State Forest (December 2019). This forest was subject to high and moderate severity fire in some areas, but other areas were much less severe. In the less severe areas, the fire impact can be considered beneficial to long-term forest health. Fire of this nature would be desirable on a regular basis to maintain forest health and would be regularly introduced, such as through hazard reduction burning.

General ecological impact characteristics of areas impacted by low severity fires

» Negligible impact on forest canopies and lower impact on hollows

» Temporary alteration of understorey composition / maintenance of grassy forests

» Positive for forest health with reduction in dense understorey and leaf litter in some sites suffering from eucalypt decline, including bell-miner associated dieback.

Fire impacts on key mapped conservation areas on State forest

Around half of the State forest estate is already set aside as permanent mapped reserves. Assessments of the impact on fires on some of these key landscape exclusions are presented in this section. Their importance in delivering ecological outcomes has been documented (eg Munks et al. 2020; Slade and Law 2017).

Rainforest

The scale and intensity of the 2019-20 fires were notable for the impact observed on rainforest areas that typically are not disturbed by fire. Up to 36 per cent of rainforests within State forests in the Eden Region were impacted by moderate to high intensity fires (Table 2). There was a greater impact within the State forests in the South Coast region, with up to 67 per cent of the rainforest affected by moderate to high fire intensity. Fortunately, on the north east, a lower proportion (11 per cent) of the mapped rainforest areas were affected by moderate to high intensity fire. Rainforest on the South Coast tends to be distributed in narrow and sheltered riparian areas adjoining dry forest types, increasing the susceptibility of these areas to fire under the drought conditions experienced. Post-fire assessments have identified many rainforest trees and plants resprouting, indicating a level of resilience.

Figure 19: Sooty Owl nest tree in a small isolated rainforest patch in Eden impacted by fire.

Figure 20: Rainforest Gully in Kiwarrak State Forest on the Mid North Coast. This small pocket was subject to low-intensity fire and largely unaffected. The surrounding forest was subject to high severity fire (image from June 2020, approximately eight months after the fire).

Existing conditions

The CIFOA excludes forestry operations from mapped rainforests, providing them with permanent protection. There are also buffers on rainforest in Eden and most of the South Coast and warm temperate rainforest on the North Coast. These buffers ensure harvesting disturbance and edge effects to the rainforest margins are minimised.

Post-fire considerations

There is little that can be done to change the recovery trajectory of fire-affected rainforest other than to avoid further disturbance over time to impacted sites. In this context, the CIFOA identifies and provides an extremely high level of protection for all rainforest through detailed mapping.

Recommendations

As all rainforest is mapped and protected, the existing CIFOA protection measures should be adequate to retain the integrity of impacted rainforest where it persists and can regenerate. Future fuel management operations should be conducted to avoid further burning within rainforest communities and also reduce fuel loads in the landscape generally, and adjoining rainforest communities specifically, to reduce the risk of future wildfires having such a large impact on those communities.

Threatened Ecological Communities

Threatened Ecological Communities (TECs) are found throughout State forests and the impact on TECs across the landscape has been variable depending on each community's extent and where severe fires occurred (Table 2). Some TECs are recognised as being fire tolerant and to some extent periodic fire is a natural occurrence in these ecosystems. Grey Box-Grey Gum Wet Sclerophyll Forest in the NSW North Coast Bioregion has had approximately 55 per cent of its mapped extent affected by moderate-high intensity fire. Approximately 80 per cent of the potential White Gum Moist Forest distribution in the NSW North Coast Bioregion has been affected by moderate to high fire intensity. Fire affected the Subtropical Coastal Floodplain forest around Grafton and Casino far more than further south in its distribution. In the Upper North East region, 62 per cent of the mapped extent was affected by moderate to high intensity fire, compared to five per cent of the mapped extent in the Lower North East region. In the Southern NSW Tablelands, Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland and Lowland Grassy Woodland in the South East Corner Bioregion were most affected with 87 per cent and 92 per cent of the mapped extent impacted by moderate to high intensity fire respectively.

Existing conditions

TECs are identified as mapped exclusions within the CIFOA and are permanently set aside from timber harvesting and managed for conservation.

Post-fire considerations

Many TECs will be affected both in structure and species composition in the short term, however there is little that can be done to change the recovery trajectory of these ecosystems other than to continue to ensure that they are not disturbed as they recover. As the CIFOA already provides complete protection for TECs, there are no additional protection measures required.

Recommendations

The identified TEC mapped exclusion protection measures remain intact, but areas affected by fire should be assessed for recovery and weed control to enable appropriate regeneration of native species. Future fuel management practices should consider the appropriate fire regime for the community to support healthy communities.

Large forest owl exclusion zones

Large forest owls include the Sooty Owl, Masked Owl, Barking Owl and Powerful Owl. They are all hollow nesting species with variable home range sizes up to 1000 hectares. Large areas of suitable habitat are established and managed for their protection throughout the State forest estate (Table 2). Notably, habitat for these owl species is also well represented in the reserve system of national parks and conservation areas as well as in permanent State forest reserves.

Variable proportions of the exclusion zones within State forests burnt at high severity. Eden and the South Coast areas had 42 per cent and 46 per cent of the owl landscape areas within the management zones within State forests impacted by high intensity fire respectively. For the north east this figure was 11 per cent.

Existing conditions

The CIFOA identifies large landscape exclusion zones within State forests to ensure habitat protection for of the large forest owls. In addition to the permanently reserved landscape areas specifically set aside for large forest owls, the network of creek and river protection zones within State forests protect important roosting and nesting habitat, as do the measures that ensure the protection of trees with hollows throughout the State forest estate. Measures that move harvesting operations around in time and space to ensure habitat recovery occurs for prey species is likely an important component of maintaining owl populations in the landscape (Kavanagh and Bamkin 1995; Kavanagh et al. 1995).

Post-fire considerations

Importantly, harvestable State forests make up only a proportion of the foraging habitat for large forest owl species. As the species are predators with large home-ranges, protection and recovery of habitat for prey species at the landscape scale is important. The small proportion of the public forest landscape (approximately one per cent) that might be harvested over the next five years means that harvesting operations are unlikely to have additional impact on large forest owl recovery.

Recommendations

In addition to the robust CIFOA conditions, protection of temporary habitat clumps to support dietary prey species populations to re-colonise and recover may further mitigate impacts on large forest owls. Monitor owl populations by utilising existing DPI acoustic data collected since 2015 and continue acoustic surveys under the NRC monitoring program.

Legend

/// Fire Extent 2019-20

■ Timber Plantations

■ Mapped Conservation Areas on State Forest

■ State Forest - available for harvesting
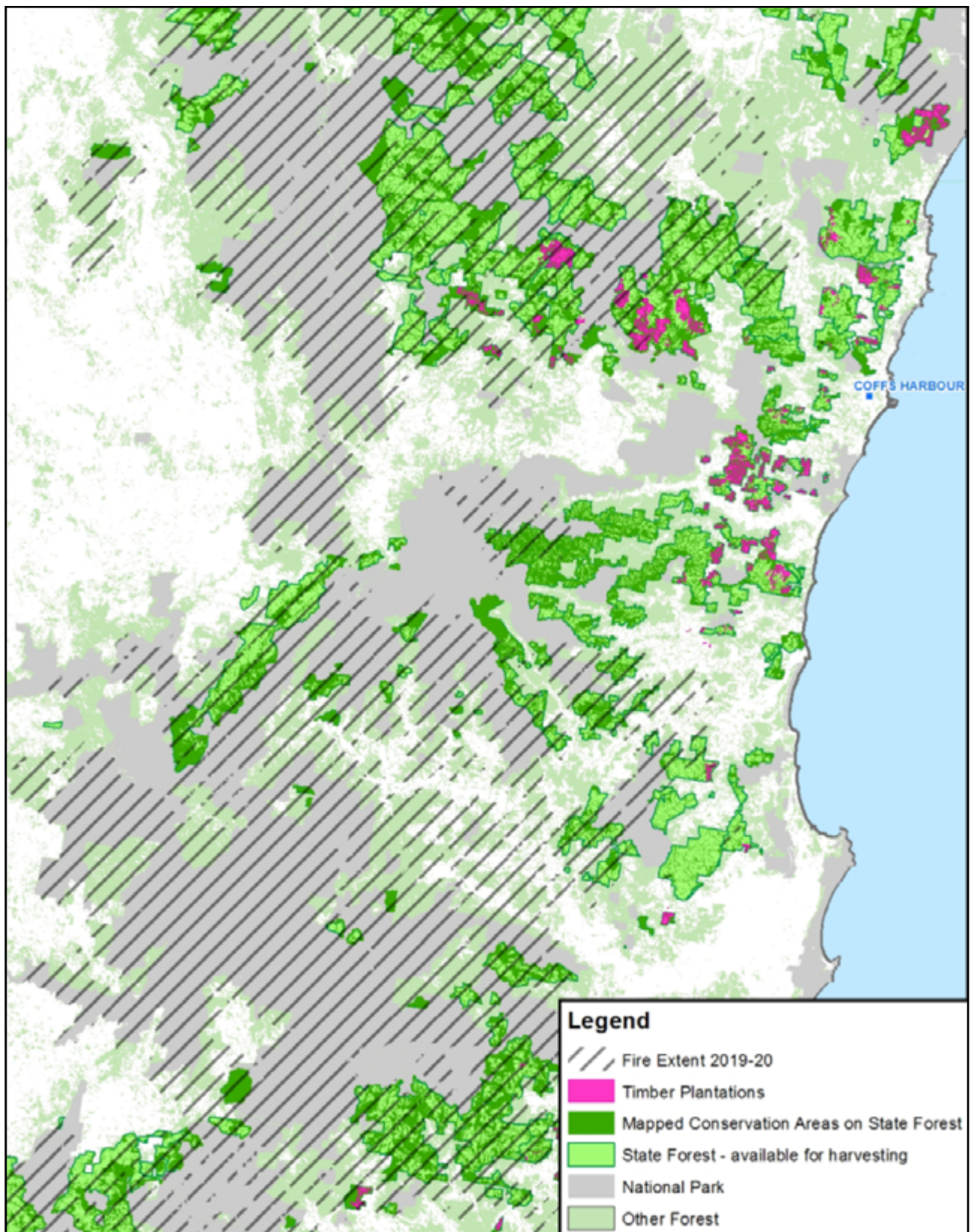
■ National Park

■ Other Forest

Figure 21: Map showing typical NSW forest landscape with a network of mapped conservation area both in State forest and national park estate, with significant areas of forest also on private property. Fire extent from the 2019-20 fires is overlaid in transparency.

Table 2: Impact of fires on areas set aside for conservation within State forests by exclusion type

State forest exclusion type	Unburnt	Low	Moderate	High	% Mod/High
Eden Region					
Owl landscape	2,592	3,891	2,499	6,003	57%
River-flat eucalypt forest	148	774	309	434	45%
IFOA rainforest	2,092	1,054	358	782	27%
Montane peatlands and swamps	262	13	9	75	24%
Swamp Oak Floodplain Forest	10	6	1	0	5%
Coastal saltmarsh	14	7	1	0	4%
Dry rainforests of the South East forests	1	-	-	-	0%
Indicative Lowland Grassy Woodland	0	0	-	-	0%
North East Region					
Indicative White Gum Moist Forest	639	1,397	4,055	4,112	80%
Subtropical Coastal Floodplain Forest	3,153	1,698	1,575	4,616	56%
Grey Box - Grey Gum Wet Sclerophyll Forest	1,075	233	789	835	55%
Swamp Sclerophyll Forest	488	68	144	407	50%
Owl landscape	36,506	18,223	9,436	8,988	25%
Montane peatlands and swamps	284	174	32	63	17%
River-flat eucalypt forest	141	27	22	6	14%
Lowland Rainforest TEC	7,440	4,079	1,011	655	13%
Rainforest	45,313	29,701	5,488	3,385	11%
Lowland Rainforest on Floodplain	598	61	12	4	2%
Swamp Oak Floodplain Forest	201	0	0	0	0%
Coastal saltmarsh	39	-	-	-	0%
Southern Region (South Coast and Tumut subregions)					
Montane peatlands and swamps	1	2	10	45	95%
Indicative Lowland Grassy Woodland	97	88	118	2,014	92%
Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland	76	22	94	576	87%
Swamp Sclerophyll Forest	4	2	13	14	84%
Owl landscape	5,307	3,805	5,244	12,580	66%
Rainforest	711	4,681	3,727	6,747	66%
Swamp Oak Floodplain Forest	6	12	15	20	65%
River-flat eucalypt forest	277	582	548	706	59%
Lowland Rainforest	-	435	290	101	47%
Coastal saltmarsh	3	19	12	6	44%
Montane peatlands and swamps	407	181	116	320	43%
Brogo Wet Vine Forest	16	1	-	-	0%
Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland	71	-	-	-	0%

Biodiversity survey results from burnt forests

Forestry Corporation staff have commenced targeted biodiversity surveys at a range of sites for a range of species. Whilst these are in early stages and are not yet comprehensive or systematic, it has been pleasing at least 41 different threatened species have been detected during these surveys. It is apparent that the diversity and number of species detected in heavily burnt landscapes is much lower than normal levels, however even in these landscapes some species have been detected. To date, the following species have been detected in post-fire assessments, noting that surveys have not been carried out in all State forests affected by fires.

Table 3: Threatened species observed in burnt State forest inspections January – May 2020

Species	State forests located
Threatened fauna species	
Dusky Woodswallow	Kangaroo River, Nungatta, Yambulla
Eastern Bent-wing Bat	Mogo
Flame Robin	Bago, Yambulla
Gang-gang Cockatoo	Yambulla
Giant-barred Frog	Clouds Creek
Glossy Black-cockatoo	Bellangry, Collombatti, East Boyd, Nadgee, Timbillica, Yambulla
Greater Glider	Mogo, Clouds Creek, Enfield, Doyles River
Hastings River Mouse	Doyles River
Koala	Bril Bril, Kiwarrak, Bodalla
Little Lorikeet	Kangaroo River
Littlejohns Tree-frog	Yadboro, Nadgee
Long-nosed Potoroo	East Boyd
Masked Owl	Bodalla, Clouds Creek
Powerful Owl	Mogo
Scarlet Robin	Buckenbowra, Nadgee, Nungatta, Yambulla
Sooty Owl	East Boyd
Southern Brown Bandicoot	East Boyd, Nadgee, Yambulla
Sphagnum Frog	Kippara
Spotted-tailed Quoll	Doyles River, Buckenbowra
Square-tailed Kite	Wandera
Squirrel Glider	Shaes Nob
Stuttering Frog	Bulga, Clouds Creek
Varied Sittella	Nadgee, Timbillica
Yellow-bellied glider	Bril Bril, Bellangry, Shaes Nob, Clouds Creek, Enfield, Doyles River, Bago, Nadgee, Yambulla
Threatened Plant Species	
Acacia constablei	Nadgee
Astrotricha sp. Wallagaraugh	Yambulla
Boronia umbellata	Bagawa
Eucalyptus glaucina	Camira, Myrtle
Grevillia masonii	Whiporie
Hakea archeoides	Kippara
Hibbertia marginata	Gibberagee
Macrozamia johnsonii	Chaelundi
Melaleuca groveana	Kippara
Melaleuca irbyana	Whiporie
Mellichrus sp. Gibberagee	Gibberagee

Species	State forests located
Parsonia dorrigoensis	Collombatti, Ingalba
Paspalidium grandispiculatum	Doubleduke
Philotheca myopyroides	Kippara
Rhodamnia rupescens	Wild Cattle Creek
Solanum sulphureum	Kiwarrak , Yarrat
Typhonium sp. aff. browni	Wild Cattle Creek

Table 4: Non-threatened species detected (note this list is not comprehensive)

Frogs and reptiles	Birds	Birds	Mammals
Common eastern froglet	Australian king parrot	Red wattlebird	Agile antechinus
Eastern smooth frog	Australian owlet nightjar	Red-browed firetail	Brown antechinus
Striped marsh frog	Australian raven	Red-browed treecreeper	Bush rat
Southern brown tree frog	Bassian thrush	Restless flycatcher	Common brush-tailed possum
Broad-palmed frog	Beautiful firetail	Rufous whistler	Common ringtail possum
Lesueur's frog	Bell miners	Satin bowerbird	Common wombat
Wilcox's frog	Black-faced cuckoo-shrike	Southern boobook	Eastern grey kangaroo
Great barred frog	Brown quail	Spotted pardalote	Echidna
Red-backed toadlet	Brown thornbill	Spotted quail-thrush	Long-nosed bandicoot
Dendy's toadlet	Brown-headed honeyeater	Striated thornbill	Mountain brushtail possum
Diamond python	Crescent honeyeater	Superb fairy-wren	Red-necked wallaby
Eastern brown snake	Crested shrike-tit	Superb lyrebird	Sugar glider
Black rock skink	Crimson rosella	Tawny frogmouth	Swamp wallaby
Yellow-bellied water-skink	Eastern whipbird	Wedge-tailed eagle	White-striped freetail-bat
Lace monitor	Eastern yellow robin	White-bellied cuckoo-shrike	
Delicate skink	Fan-tailed cuckoo	White-browed scrubwren	
Pale-flecked garden skink	Golden whistler	White-naped honeyeater	
Red-bellied Black Snake	Grey fantail	White-throated needletail	
Small-eyed Snake	Grey shrike-thrush	White-throated nightjar	
	Laughing kookaburra	White-throated treecreeper	
	Lewin's honeyeater	White-winged chough	
	Mistletoe bird	Wonga pigeon	
	Musk lorikeet	Yellow-faced honeyeater	
	Noisy friarbird	Yellow-tailed black cockatoo	
	Pied currawong	Yellow-tufted honeyeater	
	Pilotbird		

Interim biodiversity assessment process

The assessment undertaken by Forestry Corporation specifically looks at the potential impacts of recent fires on threatened species and potential additional mitigations that could be applied if conducting timber harvesting operations in burnt forests or forests adjoining burnt areas. The assessment is interim in nature as there has not yet been adequate time to undertake landscape-wide flora and fauna surveys to provide a comprehensive picture of persistence across the landscape. Continuation of the DPI acoustic monitoring program and implementation of the proposed NRC forest monitoring projects will be crucial to assess impacts and recovery over numerous survey seasons in a truly comprehensive manner.

Timber harvesting operations within the fire assessment area must comply with comprehensive regulations to protect threatened species habitat, which are detailed in the CIFOA. This assessment considers these CIFOA measures and identifies potential additional measures that could be implemented in timber harvesting operations. The aim of these additional measures is to reduce the risk of significant impacts on the listed species from harvesting operations in forests burnt in the 2019-20 fires while also considering harvesting in unburnt landscapes adjacent to burnt areas. The assessment is intended to apply the precautionary principles to ensure that *serious or irreversible environmental damage* is prevented.

The species lists in Appendix 1 and fire severity mapping data detailed above, in conjunction with limited post-fire surveys, assessments and knowledge of species ecology were used as a basis for assessing potential impacts and potential mitigations. As the CIFOA operates in a broader landscape context, the assessment considered impacts both across the public forest estate (national parks, crown and leasehold land and state forest) as well as specifically within areas that are zoned for timber harvesting under the Forest Management Zoning (FMZ) system. Species that largely do not occupy commercial forests planned for harvesting in the coming two years were not considered. The following process was used:

1. Assess fire severity by region on threatened species habitat models or records to determine relative fire impact for at risk species.
2. Map the extent of reserves and harvest area (harvest status) by fire severity by species habitat models to determine relative importance of the harvestable area for species protection and recovery.
3. Consider ecological adaptations of species to survive low-moderate intensity fire.
4. Assess ongoing suitability of current CIFOA conditions to mitigate impacts on species in burnt landscapes.
5. Consider suitability of potential additional mitigations to reduce potential impacts from harvesting operations if required.
6. Consider other non-harvesting management practise that may be important to species recovery.

Individual species assessments

A list of threatened species that was identified as likely to occur in areas subject to harvesting in burnt forests over the next two years was compiled drawing on species record data, post-fire surveys and assessments, species ecology and habitat maps where they were available. For each of the identified species, an assessment was undertaken to identify basic ecological issues for the species around fire and how much of the

habitat was burnt at different intensities. This assessment overlayed modelled habitat areas over the land tenure, for example National Parks and nature reserves, State forest conservation areas or State forest harvest areas (FMZ 3-5), and harvest status.

Species with high proportions of habitat that had been burnt at higher intensities are likely to have experienced a greater initial impact from fires, particularly where they are small home range species with limited ability to move away from an approaching fire.

Species with high proportions of suitable habitat in harvestable State forest have more chance of having a population-level impact from subsequent harvesting operations than those where harvesting will only occur in a small proportion of suitable habitat.

From a review of this data an assessment was also made to determine whether the existing CIFOA survey and protection measures for the species are still adequate, or if additional measures would be appropriate. Several of the species assessed are detailed in case studies in this report. A full list of species considered, the source of models used and management actions proposed is included in Appendix 1 to this report.

Legend:

- Yellow-bellied Glider Model Habitat
- State Forest
- National Park Estate
- Unburnt Forest
- Low Severity
- Moderate Severity
- High Severity

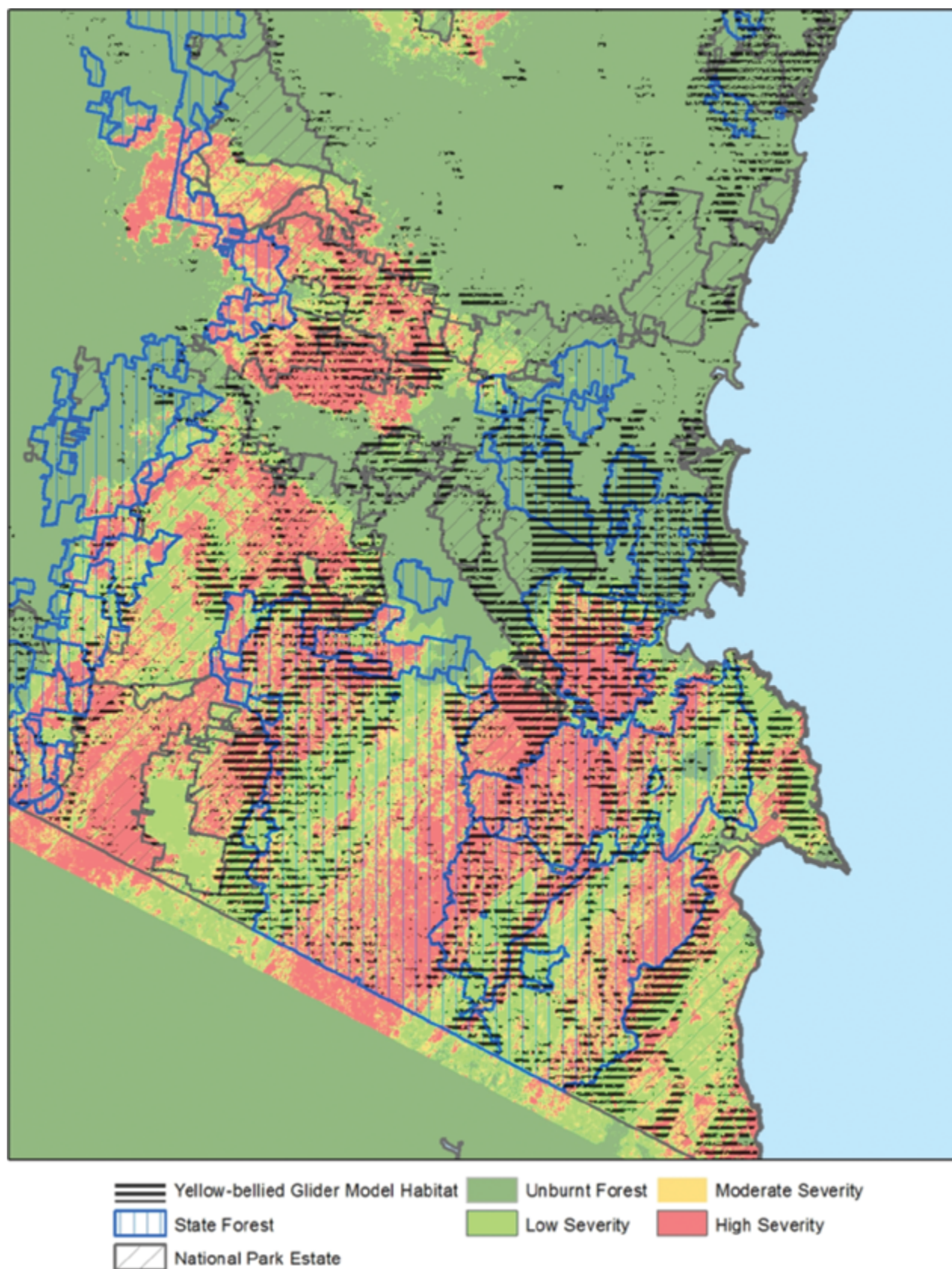Figure 22: Assessment 1 – Fire severity (four classes) on species model habitat in public forests. Fire severity (Green (low)-Red (high) stretch layer) were intersected with tenure and individual species habitat models (moderate-high quality class from Comprehensive Regional Assessment (CRA) models) for each region to assess the potential fire impact on the species. Table 5 shows the results of this assessment for each species.

Example Fire Severity/ Harvest Status and Model Habitat Clouds Creek SF

- Yellow-bellied Glider Model Habitat
- Harvestable: Mod-High Intensity
- Harvestable: Unburnt-Low Intensity
- Reserve: Mod-High Intensity
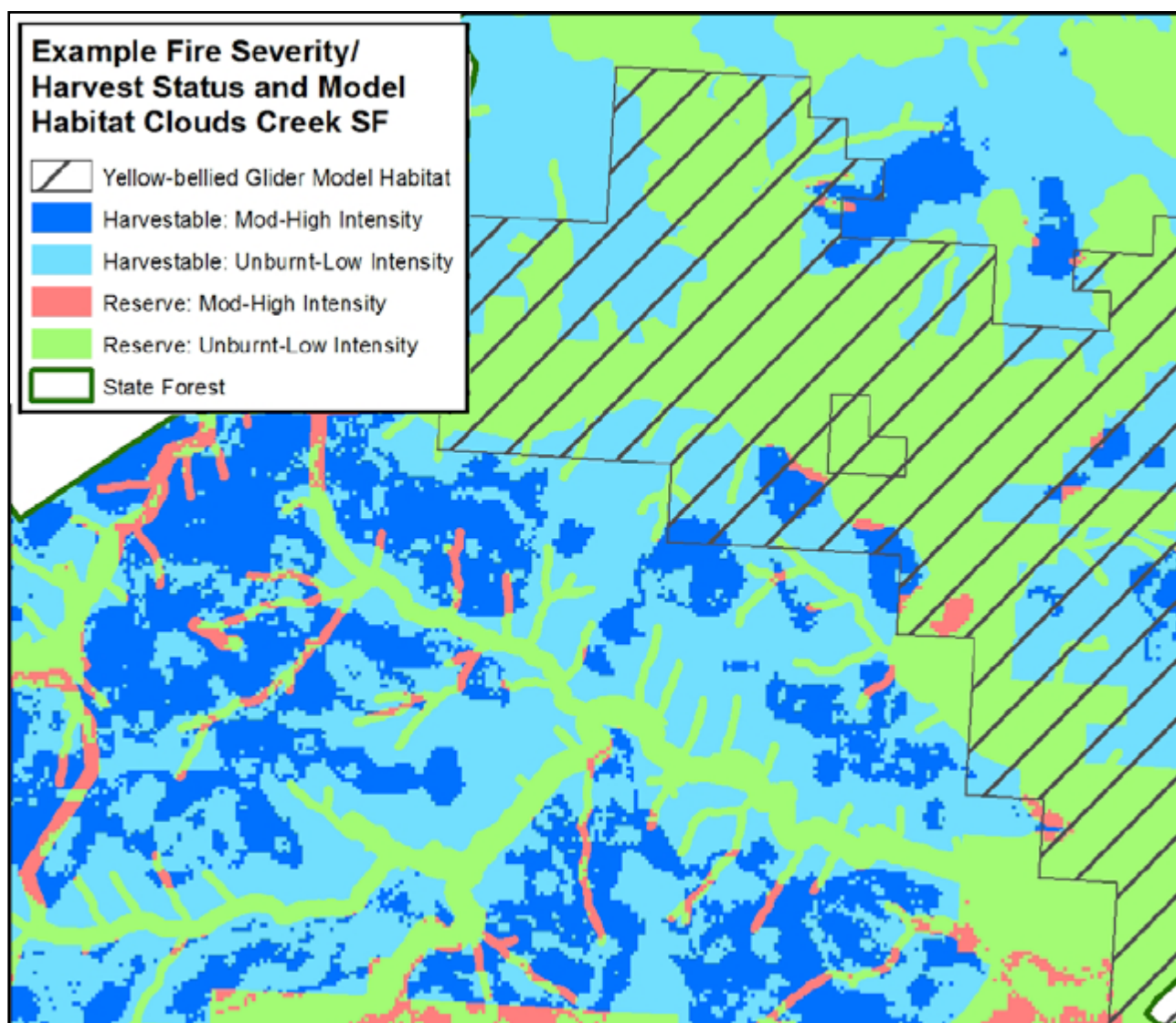- Reserve: Unburnt-Low Intensity
- State Forest

Figure 23: Assessment 2 – Fire severity (two classes) in model habitat based on harvest status (reserve/available). Example of how harvest status (harvest area and reserve) and fire severity were intersected with individual species habitat models in each region to assess the relative importance of harvestable area for impact on species. Table 7 shows the results for each species assessed. The more the species models (hatch) overlay reserves that were unburnt or burnt at low intensity (green) the lower the fire impact is likely to be on the species. The greater the habitat overlays intensively burnt reserves (red) or harvestable State forest (dark blue), the greater the potential impact and the more important the unburnt harvestable forests (light blue) might be in the short-medium term as refuge habitat as the broader landscape recovers.

Table 5: Assessment 1: Fire Severity in threatened species model habitat in public forests.

Species	Unburnt	Low	Moderate	High	Model Area (ha)
Eden Region					
Spotted-tailed Quoll	33%	20%	13%	34%	119,938
Glossy Black-cockatoo	24%	21%	15%	40%	273,014
Yellow-bellied Glider	27%	24%	15%	35%	116,779
Powerful Owl	29%	23%	16%	32%	204,371
Masked Owl	41%	21%	16%	23%	43,866
Long-nosed Potoroo	31%	25%	15%	30%	106,808
Greater Glider	50%	15%	9%	25%	65,537

Species	Unburnt	Low	Moderate	High	Model Area (ha)
North East Region					
Yellow-bellied Glider	33%	25%	18%	24%	1,181,540
Greater Glider	41%	26%	15%	19%	1,398,270
Barking Owl	44%	21%	15%	20%	193,320
Glossy Black-cockatoo	37%	25%	16%	22%	1,143,041
Hastings River Mouse	24%	38%	17%	21%	493,724
Powerful Owl	42%	25%	14%	19%	2,253,063
Koala	55%	20%	11%	15%	832,633
Masked Owl	42%	24%	15%	20%	1,107,230
Parma Wallaby	37%	35%	13%	16%	890,485
Spotted-tailed Quoll	48%	26%	11%	14%	891,917
Philoria pughi	14%	62%	14%	10%	7,639
Stuttering Frog	45%	34%	11%	10%	515,650
Rufous Scrub-bird	47%	32%	11%	10%	107,405
Philoria richmondensis	39%	42%	9%	10%	83,405
Long-nosed Potoroo	54%	25%	10%	10%	326,727
Philoria sphagnicolus	43%	38%	10%	9%	80,733
Giant Barred Frog	59%	25%	7%	8%	232,565
Pouched Frog	69%	23%	5%	3%	75,901
Philoria loveridgei	96%	4%	<1%	<1%	9,936
South Coast sub-region					
Glossy Black-cockatoo	10%	15%	21%	54%	420,446
Yellow-bellied Glider	11%	16%	21%	53%	366,939
Masked Owl	25%	13%	16%	46%	866,518
Spotted-tailed Quoll	19%	15%	18%	48%	443,762
Greater Glider	18%	16%	19%	47%	556,105
Powerful Owl	35%	12%	14%	39%	1,436,730
Long-nosed Potoroo	24%	12%	15%	49%	180,363
Red-browed Treecreeper	35%	16%	16%	33%	1,079,307
Tumut sub-Region					
Greater Glider	55%	7%	9%	29%	239,488
Yellow-bellied Glider	45%	11%	18%	26%	163,174
Spotted-tailed Quoll	67%	8%	8%	17%	418,831

Table 6: Record analysis – based on records on public forest for species without a model

Species	Unburnt	Low	Moderate	High	Number of records
Brush-tailed Phascogale	62%	9%	17%	12%	359
Eastern False Pipistrelle	41%	19%	17%	23%	1,194
Gang-gang Cockatoo	48%	12%	12%	28%	2,793
Giant Burrowing Frog	83%	4%	3%	9%	501
Golden-tipped Bat	77%	11%	5%	7%	206
Rufous Bettong	73%	9%	5%	13%	778
Sooty Owl	52%	22%	12%	14%	1,429

Table 7: Assessment 2: Fire severity in species model habitat in public forests by harvest status. Harvest status is reserve or available for harvest. Severity is in two classes, Unburnt and Low, or Moderate and High. The table is sorted by the proportion of modelled habitat in reserves burnt at moderate-high severity and colour coded. Yellow-orange indicates more than 20 per cent of the area burnt at higher severity and greens represent less than 20 per cent burnt at higher severity.

Species	Reserves -Unburnt /Low	Reserves - Mod-High	Harvest Area - Unburnt /Low	Harvest Area - Mod-High
Eden Region				
Spotted-tailed Quoll	44%	40%	9%	7%
Glossy Black-cockatoo	33%	39%	12%	17%
Yellow-bellied Glider	38%	37%	12%	13%
Powerful Owl	41%	34%	12%	14%
Masked Owl	45%	33%	17%	5%
Long-nosed Potoroo	47%	32%	9%	12%
Greater Glider	59%	29%	8%	5%
North Coast Region				
Yellow-bellied Glider	48%	38%	10%	4%
Greater Glider	45%	33%	13%	9%
Barking Owl	58%	32%	7%	4%
Glossy Black-cockatoo	48%	32%	14%	6%
Hastings River Mouse	49%	28%	13%	10%
Powerful Owl	54%	27%	13%	6%
Koala	58%	26%	11%	5%
Masked Owl	48%	26%	17%	9%
Parma Wallaby	60%	23%	11%	6%
Spotted-tailed Quoll	61%	21%	13%	5%
Philoria pughi	68%	21%	8%	3%
Stuttering Frog	70%	18%	9%	3%
Rufous Scrub-bird	75%	17%	4%	4%
Philoria richmondensis	77%	17%	4%	2%
Long-nosed Potoroo	66%	16%	13%	5%
Philoria sphagnicola	72%	13%	9%	6%
Giant Barred Frog	60%	11%	24%	5%
Pouched Frog	80%	5%	11%	3%
Philoria loveridgei	98%	2%	0%	0%
South Coast Region				
Glossy Black Cockatoo	20%	54%	6%	20%
Yellow-bellied Glider	20%	52%	7%	22%
Masked Owl	33%	51%	5%	11%
Spotted-tailed Quoll	27%	51%	6%	15%
Greater Glider	27%	48%	7%	18%
Powerful Owl	43%	45%	4%	8%
Long-nosed Potoroo	29%	41%	7%	23%
Red-browed Treecreeper	43%	35%	8%	14%
Tumut Sub-Region				
Greater Glider	56%	30%	8%	6%
Yellow-bellied Glider	45%	29%	12%	15%
Spotted-tailed Quoll	73%	21%	3%	4%

Assessing potential for post-fire timber harvesting to impact on biodiversity or threatened species

Table 7 identifies that the potentially harvestable areas within State forests do not contain significant proportions of low or unburnt habitat for most of the assessed species and that much larger extents occur within reserves or non-harvestable forest on public land.   The South Coast sub-region had the most widespread high-intensity fires and the impacts on reserved habitat are most substantial for Glossy Black-cockatoo and Yellow-bellied Gliders (highlighted in blue in the table above). Around 75 per cent of modelled habitat is in reserves and 25 per cent in harvestable areas for these two species. Approximately 20 per cent of the modelled habitat in the region was unburnt or burnt at low intensity in reserves, whilst six to seven per cent remained unburnt or burnt at low intensity in potential harvest areas on State forest. For this reason additional landscape assessment to identify priority suitable habitat areas for Gliders in the South Coast Region is proposed (Table 9).

Timber harvesting across the NSW coastal State forests only impacts a small proportion of State forest area each year.   The reserve design that underpinned the RFAs when they were first established in the 1990s prioritised inclusion of high-quality species habitat in the reserve system, as can be seen by the high portions of species habitat in reserves in Table 7. Over the next five years of proposed harvesting, 99 percent of the public forest would not be subject to harvesting and approximately one per cent might be harvested. Considering the fire impacts on Glossy Black-cockatoo in the South Coast, the species with the highest proportion of high severity habitat burnt, the proposed harvesting program within unburnt habitat would represent a maximum of 0.6 per cent of the species habitat across the region.

In determining what this means for each species it is important to also consider the basic ecology and habitat need of each species. The following case studies outline the assessment process for those species and the same consideration was applied to all species listed in Appendix 1.

The potential for significant impact on any of species over the next five years from timber harvesting operations assessed is low as most preferred habitat is not available for harvest, and only a small proportion of that available will be harvested in the coming five years and robust protections, including additional clumps, will be in place to mitigate impacts.

The CIFOA contains a robust multi-scale protection approach that provides a retention forestry approach to areas planned for harvesting (Munks et al. 2020; Slade and Law 2017). In particular, the targeted and broad area search surveys seek to identify both individual plants and animals and also protect the best available habitat within the harvestable area in wildlife habitat clumps and tree retention clumps. The outcomes of this approach will be monitored as part of the NSW forest monitoring program.

This report identifies for the species of concern listed by the NSW Government (2020 a) to identify if there is a case for additional protection measures to ensure that the precautionary principle is applied in any planned harvesting events. A summary of the assessment that has been carried out for each individual species is contained in Appendix 1.

Fauna assessment case studies

Case studies are presented for a range of different species and species groups. These demonstrate the assessment methodology used to undertake the interim classification of species impact that has been carried out for all the species summarised in Appendix 1.

The species chosen for these case studies represent a cross section of fauna from across the State forests regulated by the CIFOA. They include some of the species most at risk and others that illustrate lower or no concern.

These case studies also provide insight into the suggested CIFOA adequacy assessment and additional measures proposed to support the precautionary principle in relation to each species or species group.

Case Study 1: Rufous Scrub-bird

North Coast habitat specialist

Ecology summary:

The species is a habitat specialist occupying very dense groundcover and understorey in rainforest and wet sclerophyll forests on the margins of rainforest. It has poor capacity to disperse or avoid high intensity fires as it is almost flightless. The species is known to be associated with three to 10-year-old post-disturbance (harvesting or hot fire) regrowth and has good capacity to repopulate areas after disturbance events if refuge habitat is available at the time of the disturbance (Ferrier 1985).

Habitat impact:

In wet sclerophyll forests, the preferred dense low habitat for the species can be replaced by taller shrubs. Peak habitat occurs three to 10 years after disturbance. Habitat will develop rapidly in favourable circumstances and recruitment of a population into regenerating habitat will follow successful breeding seasons. The species is well reserved, with 92 per cent of modelled habitat in public forests reserved. Most of this was unburnt or burnt at low intensity during the 2019-20 fires, suggesting the species will have good capacity to survive in or reoccupy that habitat. Only four per cent of the modelled habitat was burnt at moderate to high severity and occurs within harvestable State forest, so it is unlikely harvesting operations contribute a significant additional threat.

Photo: Example of Rufous Scrub-bird habitat showing preferred dense understorey. Photo was taken around six years after moderate intensity fire in Werrikimbe National Park.

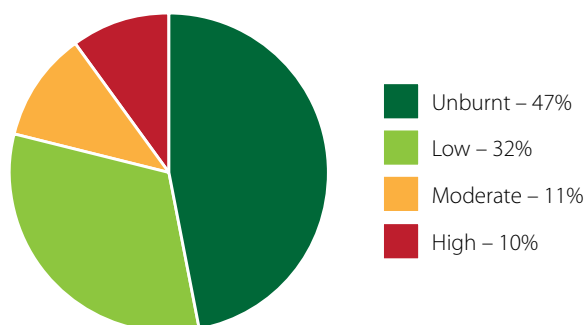## Fire severity on Rufous Scrub-bird modelled habitat in public forests

Legend:
- Unburnt – 47%
- Low – 32%
- Moderate – 11%
- High – 10%

Figure 24: Fire severity on modelled Rufous Scrub-bird modelled habitat in all public forests.

Fire severity on Rufous Scrub-bird modelled by harvest status

Legend:
- Reserves/other public forest (low intensity) – 75%
- Reserves/other public forest (high intensity) – 17%
- Harvestable State forest (low intensity) – 4%
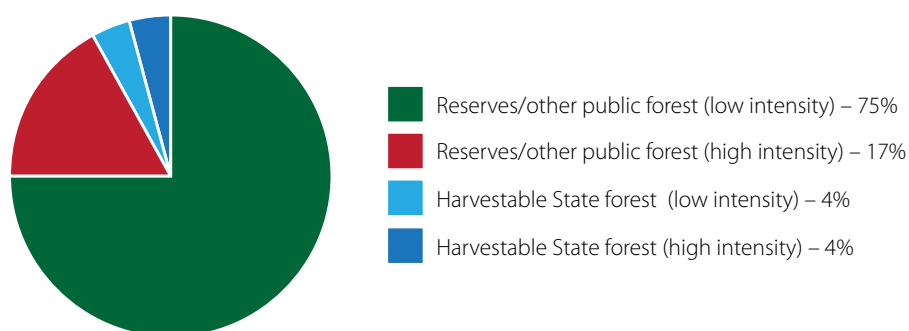- Harvestable State forest (high intensity) – 4%

Figure 25: Fire severity by harvest status (note unburnt and low intensity classes grouped and moderate and high intensity classes grouped).

Management response:

Existing conditions:

The existing CIFOA conditions require that potential habitat is surveyed, and suitable habitat is identified and retained within 300 metres of records.

Post-fire considerations:

The existing conditions within the CIFOA remain appropriate for management of the species in post-fire environments.

Recommendation:

Design of exclusion zones around pre-fire records should consider and allow for habitat recovery by incorporating areas with current suitable habitat where this is available, along with areas with potential to recover into suitable habitat into the species-specific exclusion zones.

Case study 2: Greater Glider

Widespread, hollow-dependant species with small home range and slow recovery potential
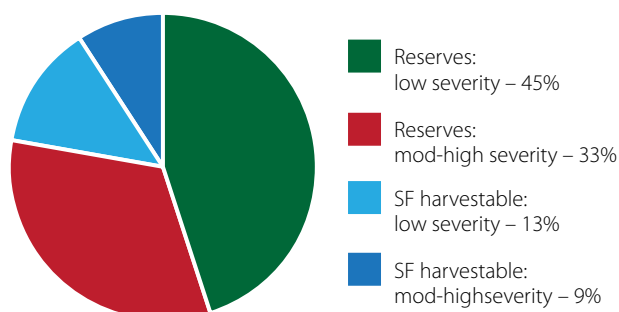
Ecology summary:

Greater Gliders are an obligate tree-hollow dweller that forages solely on leaf, with small home-range size. The species is listed federally as a vulnerable species with several threatened populations in NSW, including Eurobodalla Local Government Area (LGA) on the South Coast. Individuals are likely to survive low intensity fire, however mortality is likely to increase in high severity fires (Lindenmayer et al 2013; McLean et al. 2018). The species decline in Victoria is linked to wildfire severity and extent since 2003 (DELWP 2019). The combination of timber harvesting and fire is implicated in glider decline (McLean et al 2018). The small home range makes it suited to surviving and occupying areas refuge habitat. Low reproductive rate means re-occupation of severely burnt habitat can be slow.
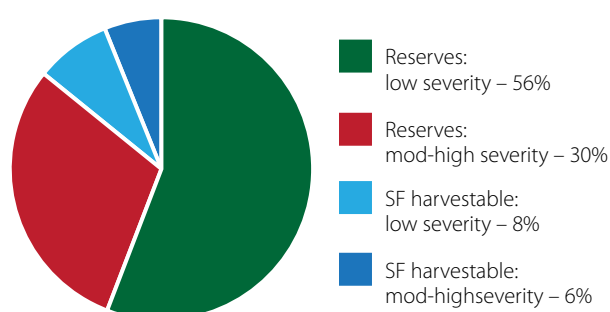
Habitat impact:

Figure 26 shows the fire severity in Greater Glider habitat across the four regions. Overall 34 per cent of Greater Glider habitat was burnt at moderate to high severity, although this varied considerably between regions.
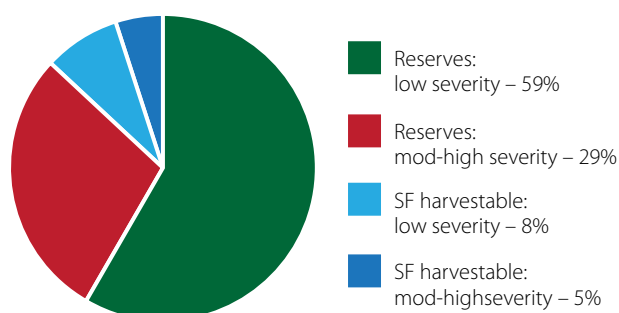
North Coast

Reserves:
low severity – 45%

Reserves:
mod-high severity – 33%

SF harvestable:
low severity – 13%

SF harvestable:
mod-highseverity – 9%

Tumut

Reserves:
low severity – 56%

Reserves:
mod-high severity – 30%

SF harvestable:
low severity – 8%

SF harvestable:
mod-highseverity – 6%

Eden

Reserves:
low severity – 59%

Reserves:
mod-high severity – 29%

SF harvestable:
low severity – 8%

SF harvestable:
mod-highseverity – 5%

South Coast

Reserves:
low severity – 27%

Reserves:
mod-high severity – 48%

SF harvestable:
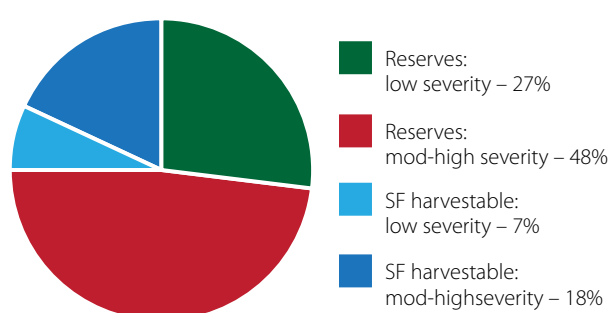low severity – 7%

SF harvestable:
mod-highseverity – 18%

Figure 26: Fire severity in modelled Greater Glider habitat on public forests for each CIFOA region by harvest status for each region.

In Eden, Tumut and the North Coast 45-59 per cent of Greater Glider habitat is set aside in reserves that remained unburnt or burnt at low severity. Another eight to 13 per cent of habitat found within harvestable areas of State forest were also unburnt or burnt at low severity. Glider populations in these regions have suffered a lesser impact and will have larger source populations to support recovery and recolonisation of burnt areas.

On the South Coast, only 27 per cent of Greater Glider habitat remains unburnt and seven per cent of this occurs within harvestable areas of State forest. Unfortunately, this means that 64 per cent of the habitat in the region burnt at moderate to high intensity. In this region, greater fire impacts on Glider populations can be expected. Figure 27 shows the fire severity across Greater Glider modelled habitat in part of the South Coast region.
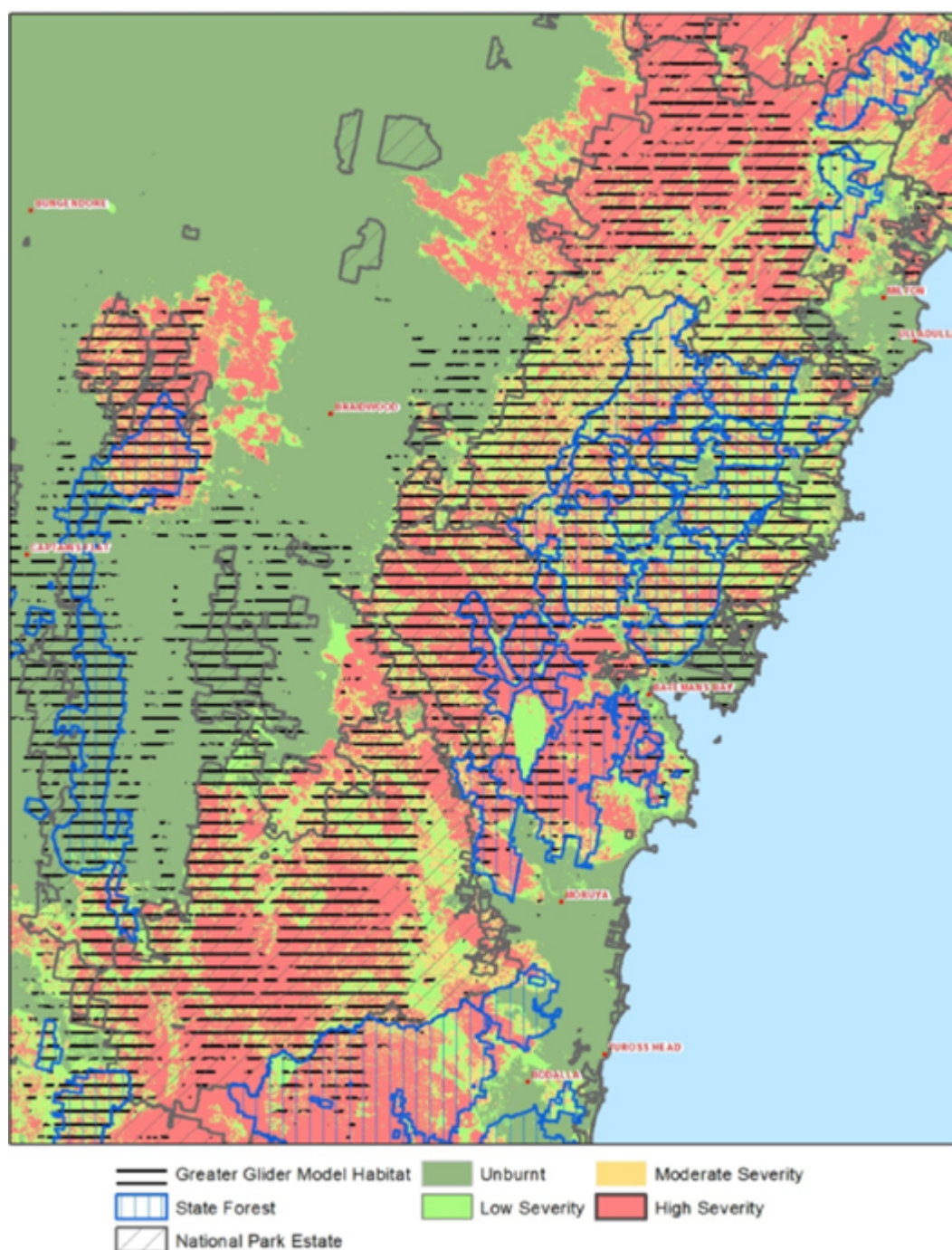

Figure 27: Fire severity map and Greater Glider modelled habitat in part of the South Coast region

Management response:

Existing conditions:

Greater Gliders are a species known to be at risk from forestry operations if high levels of basal area removal occur and hollow-bearing tree numbers are significantly reduced (Kavanagh 2000 ; McLean et al 2018). The CIFOA manages these harvesting risks by requiring at least eight hollow-bearing trees to be protected per hectare where they occur and placing harvesting limits to retain basal area across most of the Greater Glider habitat. Wildlife and tree retention clump provisions target retention of habitat patches within mature forests containing hollow-bearing trees, as these are likely to be valuable for Greater Gliders (Kavanagh and Wheeler 2004).

Post-fire considerations:

The species' small home range makes it suitable for a site-based protection approach to retaining patches of unburnt and partially burnt habitat near records or in high quality habitat in either permanent CIFOA tree retention clumps or temporary habitat clumps on a site-specific basis.

Recommendations:

Retention of additional, temporary tree retention clumps and wildlife habitat clumps is proposed (Table 9) which, along with the permanent clumps, will see 20 per cent of the net harvest area in burnt forests protected as refuge habitat. These clumps prioritise protection of preferred glider habitat.

A survey program in the South Coast region of potential habitat to determine occupancy of areas burnt at different severity and to identify where to implement additional habitat protection measures is proposed. Occupied habitat within harvestable areas identified in the South Coast region will be prioritised for inclusion into wildlife habitat clumps and tree retention clumps.

Case Study 3: Hastings River Mouse

Restricted distribution, small home range mid-successional habitat species

Ecology summary:

A small native rodent. Recent research found the species prefers mid-successional habitat in grassy tablelands forests of Northern New South Wales with abundant grass, fern, edge and rush (Law et al. 2016). Fox and cat predation are risks. The species declines in preferred habitat following drought or in competition with Bush rats. The species use coarse woody debris (logs), basal hollows, crevices and rocky areas as shelter habitat (Pyke and Read 2002).

Habitat impact:

A well reserved species with 77 percent of the species' modelled habitat on public forests occurring in reserves. Overall 35 percent of Hastings River Mouse habitat was burnt at high intensity within its range. Ten percent of the species habitat occurs within harvestable State forest that burnt at moderate to high severity. Annual monitoring conducted in burnt forests at six sites (21 grids) in autumn 2020 captured a lactating female who was sheltering in an underground crevice. Individuals are likely to survive immediate fire impacts when an area has burnt at low severity and utilise refuge habitat and recolonise after high severity fires. Surveys indicate rapid habitat recovery in sites burnt at low-moderate intensities and some high severity sites. Rapid reproductive rate means likely to quickly reoccupy habitat where populations remain in refuge areas (Lindenmayer et al 2010).
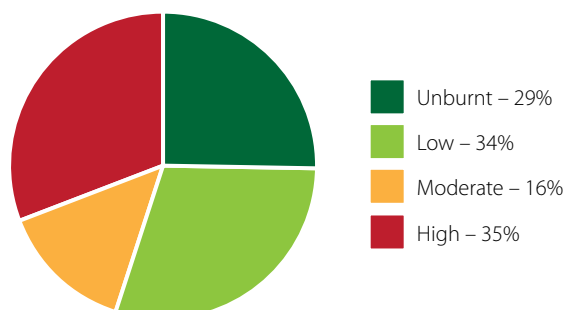
Figure 28: Lactating female Hastings River Mouse captured at Doyles River State Forest following Stockyard fire. Mid North Coast Region.

Figure 29: Recovering habitat at the Doyles River site. Hastings River Mouse prefer grass, sedge, rush and fern understorey often associated with post-fire environments and regularly burnt tablelands forests.

Fire severity on Hastings River Mouse modelled habitat in public forests

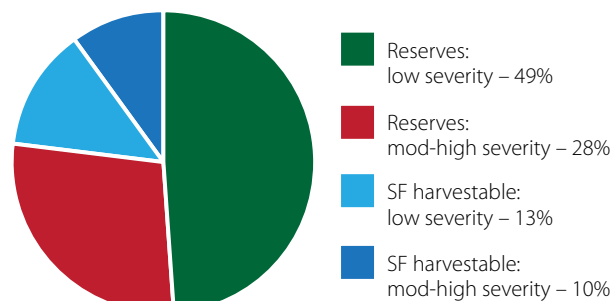Fire severity on Hastings River Mouse modelled habitat (DPI) by harvest status

- Unburnt – 29%
- Low – 34%
- Moderate – 16%
- High – 35%

- Reserves: low severity – 49%
- Reserves: mod-high severity – 28%
- SF harvestable: low severity – 13%
- SF harvestable: mod-high severity – 10%

Figure 30: Fire severity on modelled Hastings River Mouse modelled habitat in all public forests (on left) and by harvestable status (on right).

Management response:

Existing conditions:

The CIFOA includes requirements for site-specific surveys and protections around records.

Post-fire considerations:

Small home range makes the species suitable for a site-based protection approach to protect occupied sites.

Recommendations:

It remains appropriate to continue to use modelled habitat, surveys and site-based protections required under the CIFOA in fire-affected forests. As the species utilises mid-successional habitat, inclusion of suitable or recovering habitat in temporary habitat clumps is an appropriate strategy to manage impacts in fire-affected forests. Harvesting nearby and unoccupied sites where coarse woody debris has been lost or reduced by fires can help re-establish shelter habitat in affected sites (Meek et al 2006; Threlfall 2018). Encourage predator control in areas where there have been significant impacts on shelter habitat and continue annual monitoring to assess population recovery after fires.

Case Study 4: North Coast koalas

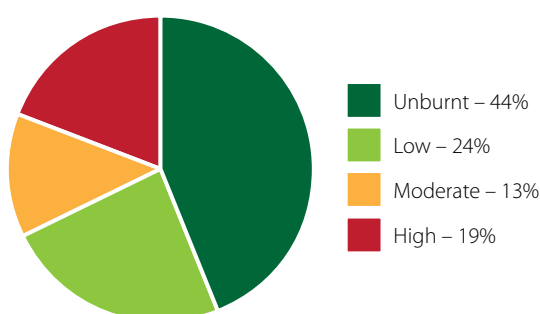Widespread species on North Coast with medium home range size

Ecology summary:

An iconic five to 10 kilogram arboreal marsupial with reasonably well-known Eucalypt feed tree species preferences. Recent work has produced a reliable and field validated habitat model and identified high occupancy levels on the North Coast (Law et al 2017) and resilience to harvesting activities at the local landscape scale (Law et al 2018). Mortality likely to be high in areas burnt at high intensity. Rapid habitat recovery likely in all but severely-affected sites with a large fire extent, with epicormic resprouting shown to be a suitable food resource (Matthews et al 2007) and recolonisation of burnt sites can occur quickly (Matthews et al 2016). Current GPS tracking by DPI, Forestry Corporation and Port Macquarie Koala Hospital is finding frequent use of young trees regenerating after harvesting and nearby exclusion areas by both males and breeding females (B. Law pers comm).

Habitat impact:

A well reserved species, with 84 percent of the public forest habitat on the North Coast reserved. The modelled habitat for this species is also widespread across private land and around 25 per cent of the total high-quality habitat across the North Coast occurs within reserves. Thirty-two percent of koala habitat in public forests across national parks and State forests was burnt at moderate to high severity on the North Coast, with initial surveys and rescue response suggesting significant impacts within areas burnt at high severity. Current DPI Forest Science monitoring at Bril Bril and Bellangry State forests has found koala persistence in low fire severity areas but little activity where fire severity was high (B. Law pers comm). Forty-four percent of preferred koala habitat is unburnt and another 24 percent burnt at low intensity, where high survival can be expected. Five percent of the species' habitat occurs within harvestable State forest that burnt at moderate to high severity, whilst 11 percent was unburnt or burnt at low severity. Surveys conducted in fire-affected forests have identified koalas in a number of forests burnt at low-moderate severity including Bril Bril and Kiwarrak State forests. Surveys indicate rapid habitat recovery in most sites, although a proportion of severely burnt areas remain slow to recover or have had high adult tree mortality. Koalas' low reproductive rate means populations are likely to recover slowly where source populations were reduced to a small size.

Fire severity on koala modelled habitat (DPI) in North Coast public forests

- Unburnt – 44%
- Low – 24%
- Moderate – 13%
- High – 19%

Fire severity on koala modelled habitat (DPI) on North Coast by harvest status

- Reserves: low severity – 58%
- Reserves: mod-high severity – 26%
- Harvestable State forest: low severity – 11%
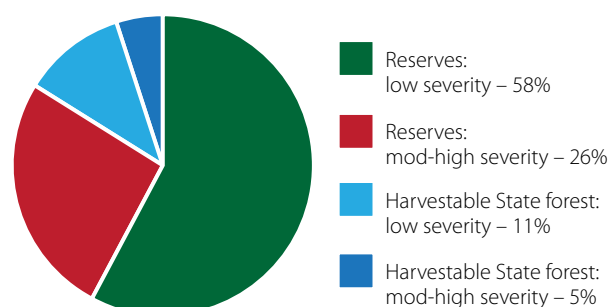- Harvestable State forest: mod-high severity – 5%

Figure 31: Fire severity in modelled koala habitat on (a) State Forests and (b) by harvest status.

Ongoing research

Forestry Corporation continues to support a number of research projects on koalas on the North Coast, including a radio-tracking study looking at habitat use in recently harvested forests and three projects led by the Natural Resources Commission https://www.nrc.nsw.gov.au/koala-research investigating nutritional value of koala habitat, diet and habitat quality and population dynamics using acoustic sensors. Three acoustic grid sites were affected by fire, which will allow detailed estimates of the effect of fire in these locations on koala density.

Forestry Corporation have maintained a relationship with the Department of Primary Industries forest science group and the current status of that research program and the ongoing occupancy monitoring is available at https://www.dpi.nsw.gov.au/forestry/science/koala-research.

The monitoring and research work, both recently completed and underway, provide the best possible foundation for understanding the impacts of the recent fires on koala populations, risks within the harvested forest estate, and to identify, monitor and manage the recovery trajectory in the coming years.

Management response:

Existing conditions:

The CIFOA includes site-specific feed tree retention of preferred browse species based on modelled habitat classes and contemporary records in addition to the large network of protected habitat within State forests.

Post-fire considerations:

Moderate home range size (typically 10-100 hectares) and known browse preferences makes the species suitable for habitat-based protection via both the permanent clump requirements of the CIFOA and proposed temporary clumps.

Recommendations:

An additional 10 per cent of the net harvest area is proposed for temporary protection in fire-affected forests in wildlife habitat and tree retention clumps in burnt forests (Table 9). These add to the permanent clump network, which protects 10 per cent of the harvest area. Preferred koala habitat should be prioritised for inclusion in both permanent and temporary clumps, selected from unburnt and low severity areas, where available, and better recovering areas where these remnants patches are not available. In landscapes that are largely unburnt or burnt at low intensities, normal CIFOA protections are expected to continue to support koala populations. Continuation of acoustic monitoring that commenced in 2015 is proposed, with sites to sample a mixture of fire severity classes to identify the fire impact on koala occupancy and how that recovers over time.

Fire Severity in DPI Modelled Koala Habitat

High Severity Fire in Koala Model Habitat

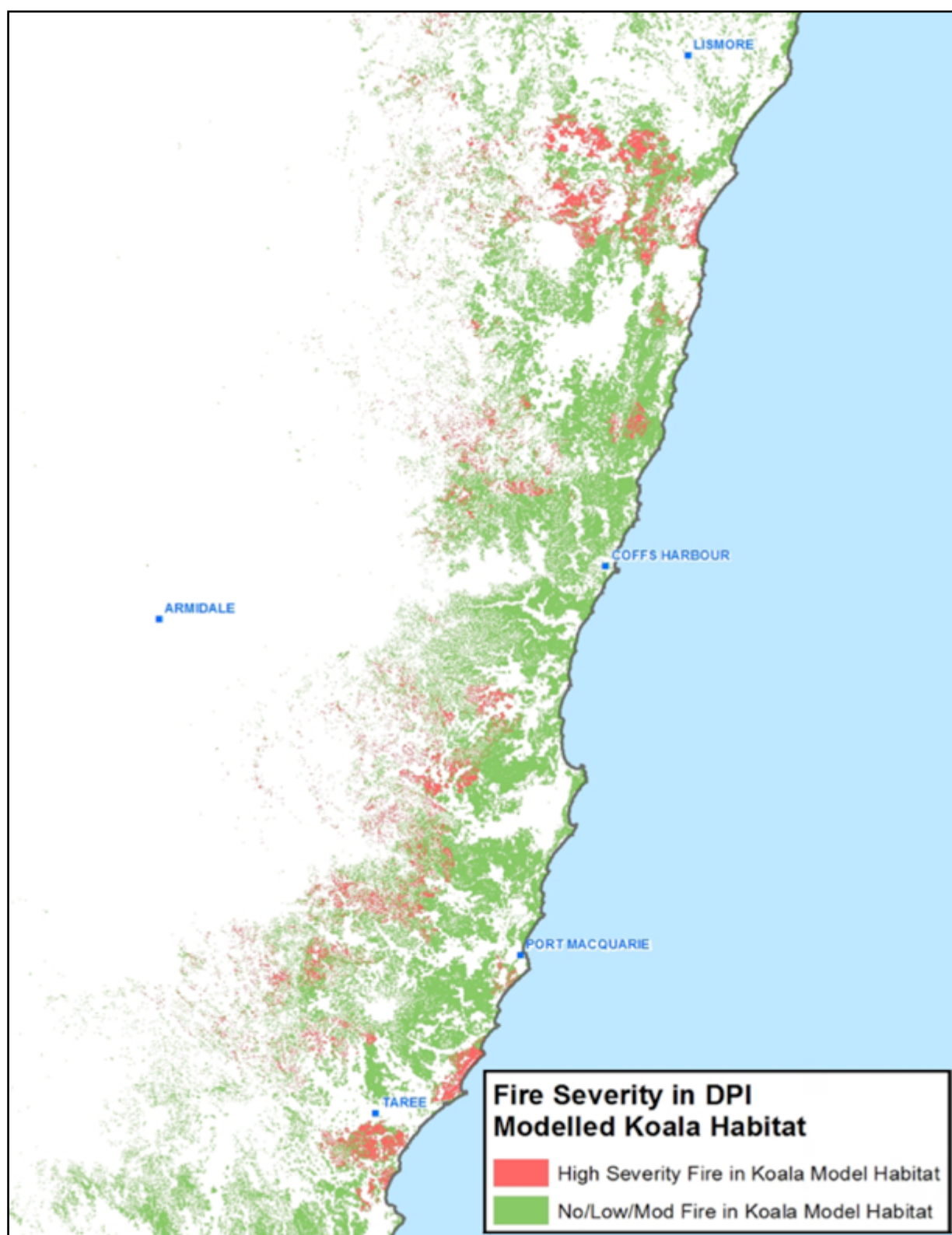No/Low/Mod Fire in Koala Model Habitat

Figure 32: High severity fire and high-quality koala habitat model on the North Coast.

Figure 32 identifies the co-occurrence of high severity fires and high to moderate koala habitat across the majority of the fire affected areas of the North Coast. Green areas are nil-low-moderate burnt areas, while red are high severity burnt areas for those better koala habitat areas.
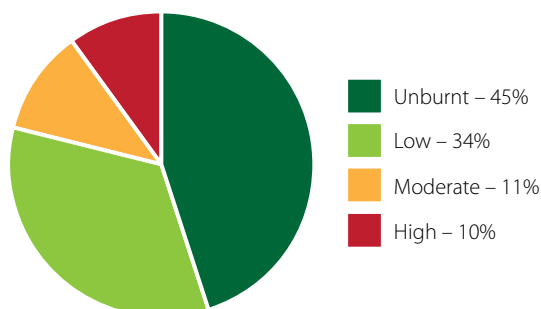
Case Study 5: Barred River Frogs

Ecology summary:

Three threatened species of barred-river frogs occupy medium to large streams across much of the North Coast. They breed in permanent streams and adults typically utilise leafy riparian habitats within 30 metres of the edge of streams (Lemckert 1999; Lemckert and Brassil 2000).

Habitat impact:

All species are well reserved (see Assessment Table 2) with 88 per cent of the Stuttering frog's habitat on public forest occurring within reserves. The species had relatively small proportions (21 per cent) of modelled habitat burnt at moderate to high severity. Harvestable State forests make up a very small proportion of their habitat and most of this was unburnt or burnt at low severity. Recent surveys have detected Stuttering and Giant Barred Frogs at several sites burnt at moderate to high severity.
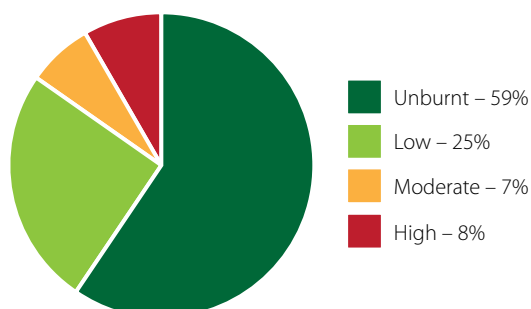
Fire severity on Stuttering Frog modelled habitat in public forests

Unburnt – 45%
Low – 34%
Moderate – 11%
High – 10%

Fire severity on Stuttering Frog modelled habitat by harvest status

Reserves: low severity – 70%
Reserves: mod-high severity – 18%
Harvestable State forest: low severity – 9%
Harvestable State forest: mod-high severity – 3%

Fire severity on Giant Barred Frog modelled habitat in public forests

Unburnt – 59%
Low – 25%
Moderate – 7%
High – 8%

Fire severity on Giant Barred Frog modelled habitat by harvest status

Reserves: low severity – 60%
Reserves: mod-high severity – 11%
Harvestable State forest: low severity – 24%
Harvestable State forest: mod-high severity – 5%
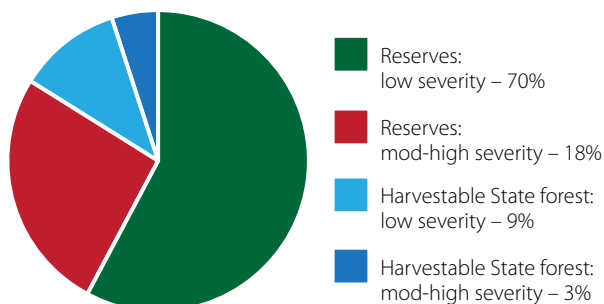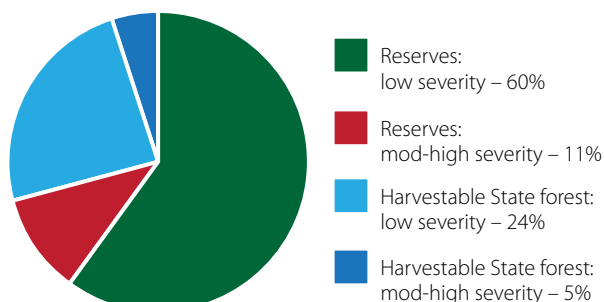
Figure 33: Fire severity in modelled Stuttering Frog and Giant Barred Frog habitat on (a) all public forests and (b) by harvest status.

Monitoring surveys – Bulga State Forest

Bulga State Forest is on the Mid North Coast of NSW and contains many areas of regrowth forest that have been harvested for timber and regrown. Forestry Corporation had carried out surveys for Stuttering Frogs at four sites within the forest ahead of timber harvesting in 2007, which were repeated post-harvesting in 2013. Immediately following the fires, the surveys were repeated at each of the four sites, including areas where fires impacted

right up to the creek beds. The surveys carried out post-fire showed a sustained population of Stuttering Frogs in the forest, with surveys repeated at four call playback sites in Bulga State Forest between 2007 and 2020 showing consistent and slightly increased numbers of Stuttering Frogs overall.

Stuttering Frog surveys repeated at four call playback sites in Bulga State Forest between 2007 and 2020.

Year	Number of records
2020 (post fire)	21
2013	13
2007	13

Figure 34: Bulga State Forest – Stuttering Frog monitoring survey site following 2019/2020 wildfire

Management Response

Existing conditions:
The CIFOA identifies these species as adequately protected by riparian exclusion zones and rainforest that protect the species, key habitat (Lemckert and Brassil 2000).

Post-fire considerations and recommendation
The preferred habitat of the species remains protected by the general CIFOA conditions that protect riparian systems and additional measures are unlikely to be necessary. Undertake further monitoring to confirm species persistence.

Case Study 6: Southern Brown Bandicoot

Ecology summary:

The Southern Brown Bandicoot has a patchy distribution in NSW, with known populations in the Sydney sandstone area and Eden. Its habitat consists of heath or open forest with heath understorey on friable or sandy soils. The species has the shortest known gestation of a marsupial of 11-12 days and can produce two or three litters of two to four young annually (NSW DEC 2006) and recover relatively quickly from wildfire (Arthur et al. 2012).

Habitat impact:

Heath and heathy forests are correlated but not limited to Yertchuk (*Eucalyptus consideniana*) forest types in the Eden area. This habitat is well reserved for this species under a Species Management Plan (SMP) approach under the Coastal IFOA. Heath communities are known to burn under low intensity conditions but regenerate quickly following fire. A large proportion of the habitat was burnt under varying intensity in the Eden area, with only approximately one per cent left unburnt and 70 per cent burnt at moderate to high intensity. The habitat is expected to regenerate quickly, and population recovery has the potential to be rapid with high fecundity known for this and other bandicoot species.

Fire severity: Southern Brown Bandicoot habitat (Yertchuk Forest) State forests, Eden

Unburnt – 1%
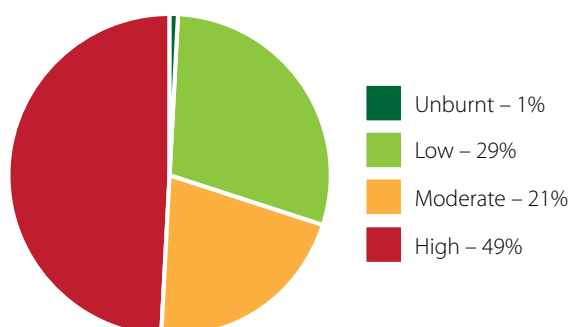Low – 29%
Moderate – 21%
High – 49%

Figure 35: Fire severity in modelled Southern Brown Bandicoot habitat on all State forests in Eden.

Survey results

Initial indications from camera monitoring sites conducted under the SMP have located Southern Brown Bandicoots at several sites in East Boyd, Nadgee and Yambulla State forests, providing hope for the species' recovery in the region. Long-nosed Potoroos have also been detected in East Boyd State Forest.

Management response:

Existing conditions:

The CIFOA identifies the SMP and habitat exclusions as measures to protect this species. Monitoring results generated over the last 12 years indicating that introduced predator control is a major issue for this and other critical weight species (Long-nosed Bandicoot, Long-nosed Potoroo) in the region.

Post-fire considerations:

Pest animal control programs will play a major role in the recovery of the Southern Brown Bandicoot along with the continuation of the current monitoring programs.

Recommendations:

Re-instigate and collaborate with other agencies on pest animal control programs. Small home range makes the species suitable for a site-based protection approach to protect occupied sites and unburnt habitat patches. Harvest nearby and unoccupied sites if groundcover (logs) have been consumed, especially in low to moderate burn intensity sites where logs were consumed but tree fall from fire damage has been low. Continue long-term monitoring program for the species to document recovery after fire.

Flora Case Studies

The CIFOA specifies several protection mechanisms for flora species including 20 metre exclusions, protection of mature individuals, Species Management Plans (SMP), Flora road management plans (FRMP), reflecting reproductive and disturbance recovery mechanisms, and development of site-specific conditions. SMPs have been developed for Rusty Plum *(Niemeyera whitei)* and Milky Silkpod *(Parsonsia dorrigoensis)*. These plans have established monitoring plots to assess ongoing occupancy and include fire measures to assess response and recovery to wildfires.

Targeted surveys at known threatened plant populations have been undertaken following the fires, with 17 species so far identified as surviving, resprouting or commencing germination events following the fires.

Figure 36: Resprouting flora. Top left *Hakea archaeoides;* Top right *Melaleuca groveana* resprouting in Kippara State Forest; Bottom left *Hibbertia marginata* resprouting in Gibberagee State Forest.

Management response:

Existing conditions:

Many threatened flora species occupy specialist habitats that largely fall outside the production forest area and are excluded from timber harvesting. Many species continue to have either CIFOA site specific survey and protection requirements or are managed under species-specific plans.

Post-fire considerations:

As threatened flora species mechanisms and response to fire vary, a species and site-specific consideration is appropriate for individual operational areas.

Recommendations:

Where harvesting or roading operations occur in burnt forests, each flora species will be considered for whether additional measures are required by the local ecologists. Where these plans apply, a review of the fire impact on the species has, or will be, undertaken prior to operations occurring for consideration and approval by the Environment Protection Authority (EPA).

Implications for forest management and timber harvesting

The impacts of the 2019–20 wildfires have been significant across the NSW forest estate. The analysis presented here begins to describe that impact in a manner that allows for reasonable management decisions to be made in relation to timber harvesting.

The impact of the fires has been highly variable across the forest landscape and any management interventions need to reflect that variability.

It is important when assessing management implications to determine what level of protection is offered by the CIFOA, then to consider what additional measures might be necessary when applying the precautionary principle.

Coastal Integrated Forestry Operations Approval environmental protection measures

The CIFOA is a complex and robust regulatory tool that contains requirements to manage environmental values at a range of spatial and temporal scales in the landscape including:

» Limits on annual harvesting extent in each management zone to ensure operations occur across the landscape

» Permanent retention of significant areas such as old growth, rainforest, wetlands, stream network and habitat corridors, which total nearly half of the State forest estate

» Limits on harvest intensity at the local landscape scale

» Targeted survey requirements for some species

» Broad area search requirements for general habitat identification and to determine species presence and protections

» Soil and water protection measures to maintain stability, minimise erosion and protect water quality

» Selective harvesting applied at most sites with strict basal area retention limits on harvesting at the site scale

» Protection of 10 per cent of the net harvest area in wildlife habitat and tree retention clumps focused on the best available habitat in each area

» Individual tree protections for various categories of trees with habitat value.

These measures are still fit for purpose in the post-fire environment and can provide adequate risk management for a large number of the forest values considered in this assessment. The CIFOA operates within a broader landscape and is intended to support the effectiveness of the much larger reserve network both on state forest and other public land tenures. The CIFOA itself is designed to ensure that timber harvesting operations in NSW State forests are planned and managed in a manner that does not lead to significant increased threats to biodiversity values under normal conditions.

In the immediate post-fire period the conditions of the CIFOA could not be implemented adequately for two main reasons. The first issue related to the loss of vegetation or ground cover which combusted during the fires. With good rainfall across most coastal districts following the fires, the forests are now recovering, with ground cover returning and trees

re-sprouting. Ground cover and soil stability have generally recovered rapidly across the estate, allowing for normal ground operations. Secondly, the significantly increased safety risk associated with the risk of overhead falling-tree hazards and unstable ground conditions have reduced substantially, allowing normal mark-up and targeted surveys. As a result, Forestry Corporation are now able to undertake operations in full compliance with the CIFOA.

Determination regarding additional precautionary measures

Forestry Corporation has identified a number of measures that are recommended to be adopted above the normal CIFOA conditions based on the findings of this review. These could be implemented as voluntarily measures to ensure that the precautionary principle is met.

The following tables provide a summary of the recommendations for ongoing timber harvesting in areas affected by the wildfires.

Table 8 sets out the key environmental risks and protections that the CIFOA covers as well as the additional measures Forestry Corporation has recommended for adoption to ensure that the precautionary principle is applied to harvesting in the short term in areas affected by fires.

Table 9 briefly summarises the regional priorities for managing timber harvesting in relation to the fire impacts and mitigations for managing local biodiversity priorities.

Table 10 outlines the key long-term management actions that will ensure that the CIFOA framework continues to be robust and meet the principles of ESFM, including the precautionary principle as set out in the Regional Forest Agreements.

Forestry Corporation recommends that these conditions remain in place while further assessments of forest recovery are undertaken. The continuation, alteration or removal of these measures should be considered at a later date, based on the best information available at the time.

Table 8: Key environmental risks, protections and additional measures

Environmental risk	Protection measure	Normal protections that continue to apply	Additional protections required?
Landscape level impacts on general high conservation value habitat	Landscape exclusion zones. These represent approximately 40 per cent of the coastal State forest estate. Measures apply to the whole Coastal IFOA region	Mapped exclusions » Old growth » Rainforest » Threatened Ecological Communities » Wetlands » Riparian exclusions » Ridge and headwater habitat » Large owl landscapes » Forest Management Exclusion Zones.	No These exclusions all continue to apply. Harvesting is not proposed in exclusion zones. Any fire-affected timber in these zones will not be recovered. Natural recovery and regeneration processes will be allowed to occur.
Timber removal exceeds sustainable levels and impacts on forest productivity and biodiversity	IFOA Sub-Region Scale harvesting limits These are Upper North East, Lower North East, Eden, South Coast, Tumut.	Limits on annual timber volume sales Annual area limit on intensive harvesting	Yes Reduce supply to minimum WSA level for 2019-20 and 2020-21 in affected areas. Reduced native forest yields and increased plantation yields in 2019-20 and 2020-21 to reduce harvesting to the minimum level needed to maintain industry operation.
Timber harvesting operations are concentrated, and regional landscapes are impacted	Management Zone harvesting limits These are grouped local State forests up to 50,000 ha in size)	No more than 10 per cent of a management zone can be harvested in a year. No more than 5 per cent intensive harvesting in a year in the specified intensive harvesting zone.	Yes Selective harvesting to be the only silvicultural method used on the North Coast in 2020, no intensive harvesting.
Local landscape biodiversity values not adequately assessed / protected	Local Landscape Area retention forestry practices and harvesting intensity limits Note: These are grouped compartments up to 1,500 ha in size.	Five per cent of the harvest area is set aside in permanent exclusions as wildlife habitat clumps. These are in addition to mapped landscape retention areas. Limit intensive harvesting to 33 per cent of the area within a 10- year period.	Yes Additional five per cent of the landscape set aside as temporary habitat clumps in each local landscape area. Selective harvesting to be the only silvicultural method used on the North Coast in 2020, no intensive harvesting.

Environmental risk	Protection measure	Normal protections that continue to apply	Additional protections required?
Local area biodiversity values not adequately assessed / protected	Compartment/ Coupe scale retention forestry practices and harvest intensity limits Note: These are the compartments harvesting operations are conducted in, generally 45-250 hectares in size.	Intensive harvesting limited to 45 hectare coupes. Selective harvesting limits (minimum basal area retention) in most areas. Five to eight per cent of the harvest area in each compartment set aside as permanent tree retention clumps. These are in addition to mapped landscape retention areas. Retained trees in every patch – hollow-bearing trees, giant trees, feed trees. Target pre-harvest surveys & habitat searches in every patch that trigger site-based protections.	Yes Additional five per cent of the harvest area are set aside as temporary clumps in each compartment Selective harvesting to be the only silvicultural method used on the North Coast in 2020, no intensive harvesting. Additional species specific survey and monitoring considerations by regional ecologists as outlined in Table 9 and Appendix 1 and for threatened flora on a site-by-site basis.
Soil erosion and water pollution	Site-scale soil and water protections applied to mitigate any stability issues at landscape and site scale	Riparian / drainage line buffers and exclusion zones to protect stream sides and filter sediment before entering streams. Operational conditions to ensure roads and tracks do not accelerate run-off / erosion. Maximum slope limits to avoid harvesting in high hazard areas Mass movement risk assessment Dispersible soils risk assessment Soil regolith risk assessment	Yes Site-scale risk assessment for ground cover recovery In patches (less than 10 hectares) that do not have groundcover recovery and stable surfaces; » Increase riparian exclusion buffers on class one and two streams » Apply additional site-based measures to establish stable surfaces for drainage structures. » Reduce maximum slope limits. » Avoid harvesting in areas with identified mass movement hazard or dispersible / erodible soils based on expert advice.

Table 9: Regional specific management considerations and actions and additional site specific measures

Regional specific management considerations and actions		
Region	Broad strategies to mitigate risks to local biodiversity priorities	Additional site specific conditions to be applied over and above the CIFOA
Tumut	» Harvest only moderate to severely burnt Alpine Ash trees which are likely to die due to the fire sensitivity of the species » Retain live trees of all species to the greatest extent practical within harvested areas » Retain all unburnt patches » Avoid disturbance to forest types preferred by regionally significant Yellow-bellied Glider endangered population for minimum three years. » Continue to apply additional site specific measures until December 2021 » Review application of site specific measures beyond December 2021	**In areas where ground cover < 70%** » Slope limited to 20 degrees » Increased drainage buffers on 1st and 2nd order streams **Where moderate to severe fire has affected >50% of a Local Landscape Area (LLA)** » Add 5% additional temporary wildlife habitat clumps (WHC) **Minimise damage to live trees >30cm diameter**

Eden	» Harvesting to focus on moderate - severely burnt regrowth Silvertop Ash stands for the next two to 10 years
	» Harvesting minimised in unburnt and low severity areas
	» Actions to support regionally significant Southern Brown Bandicoot and Long-nosed Potoroo populations
	  • Identify additional areas of preferred habitat to exclude from harvesting in additional clumps
	  • Continue and expand predator control
	  • Continue and expand species monitoring.
	» Continue to apply additional measures until December 2020
	» Review application of site specific measures beyond December 2020
		Where ground cover < 70%
		» Slope limited to 20 degrees
		» Increased drainage buffers on 1st and 2nd order streams
		
		Where moderate to severe fire has affected >50% of an LLA
		» Add 5% additional temporary WHC
		
		Where moderate to severe fire has affected >50% of a compartment
		» Add 5% additional temporary tree retention clumps

South Coast	» Avoid harvesting in steep areas until improved groundcover recovery occurs
	  • No harvesting in Narooma Foothills Zone before January 2021 and not until a suitably qualified expert assessment indicates the landscape and soils are stable
	  • Additional ground cover assessments for all operations
	» Minimise harvesting in areas unburnt or burnt at low severity
	» Undertake landscape assessment of glider populations and determine if additional reserve areas should be identified in suitable habitat on State forest.
	» Continue to apply additional measures until December 2020
	» Review application of site specific measures beyond December 2020
		Where ground cover < 70%
		» Slope limited to 20 degrees
		» Increased drainage buffers on 1st and 2nd order streams
		
		Where moderate to severe fire has affected >50% of an LLA
		» Add 5% additional temporary WHC
		
		Where moderate to severe fire has affected >50% of a compartment
		» Add 5% additional temporary tree retention clumps

Regional specific management considerations and actions		
Region	**Broad strategies to mitigate risks to local biodiversity priorities**	**Additional site specific conditions to be applied over and above the CIFOA**
North Coast	» Increase harvesting in hardwood plantations to reduce harvesting required in burnt forests for 18 months » Selective harvesting only to be applied in the short term » In heavily burnt landscapes, minimise harvesting in unburnt and low severity patches through the establishment of additional temporary clumps » In largely unburnt landscapes, normal provisions apply » Continue koala research programs. » Continue to apply additional measures until December 2020 » Review application of site specific measures beyond December 2020	**Where ground cover < 70%** » Slope limited to 20 degrees » Increased drainage buffers on 1st and 2nd order stream **Where moderate to severe fire has affected >50% of an LLA** » Add 5% additional temporary WHC **Where moderate to severe fire has affected >50% of a compartment** » Add 5% additional temporary tree retention clumps **Selective harvest only in fire affected areas up to January 2021**

Table 10: Long-term initiatives

Long-term initiatives to protect and enhance environmental values on State Forests	
Biodiversity monitoring and adaptive management	» The CIFOA includes a requirement to undertake a program of monitoring with regular reviews to ensure that the results of this monitoring are incorporated into management actions » Forestry Corporation will continue to undertake and report on landscape scale surveys continue in forests to assess population impacts and support whole of government surveys. » This program will allow Forestry Corporation to assess species recovery in different fire severity classes over time.
Forest regeneration	» The CIFOA includes a requirement to undertake proactive monitoring of forest regeneration and restorative actions as necessary » Forestry Corporation will continue to undertake and report on forest regeneration as well as identify and implement forest regeneration works where natural regeneration is not likely to recover a productive forest » These measures will ensure that future forest cover or productivity will not be negatively impacted by management actions.
Forest infrastructure recovery projects	» Since the fires, Forestry Corporation has been undertaking a large-scale infrastructure restoration program across the State forest estate to ensure that forest roads and crossing structures are brought back to reasonable standard. This program achieves a significant environmental gain by ensuring that the road network does not cause excessive erosion and water pollution, which was high potential risk after the fire impacts left much of the forest road network in very poor condition. » The road re-opening and bridge replacement program is also accompanied by dangerous tree removal to allow for progressive re-opening of forest recreation areas for forest users, permit holders and the public.
Sustainable yield review	» Forestry Corporation is currently undertaking a systematic review of sustainable yield from all the CIFOA regions post-fire » This work will ensure that that timber supply to industry remains within the definition of ecologically sustainable forest management as set out in the RFA and the *NSW Forestry Act 2012*.

Appendix 1: Threatened Species – post fire classifications

Common name	Records in fire-affected areas (%)	Assessment approach	CIFOA management	Consider for inclusion in clumps	Other management response
Parma wallaby	73.7	Modified CRA Habitat Model	ESAs	Include unburnt/ low severity burnt habitat in clumps	Predator control
Glandular frog	53.1	Used state-wide record assessment	ESAs		Preferred habitat protected in existing exclusion zones
Davies' tree-frog	51.4	Used state-wide record assessment	ESAs		Preferred habitat protected in existing exclusion zones
White-footed dunnart	47.8	Used state-wide record assessment	ESAs	Include unburnt/ low severity burnt habitat in clumps	Predator control
Stuttering frog	46	CRA Habitat model	ESAs		Preferred habitat protected in existing exclusion zones
Rufous bettong	43.2	Public forest record assessment	ESAs	Include unburnt/ low severity burnt habitat in clumps	Predator control
Eastern false pipistrelle	42	Public forest record assessment	ESAs, hollow-trees, roost protection, harvest limits	Include unburnt/ low severity burnt habitat, particularly hollows, in clumps	
Golden-tipped bat	41.8	Public forest record assessment	ESAs, harvest limits		Preferred rainforest habitat protected in existing exclusion zones
Sooty owl	41.3	Public forest record assessment	ESAs, hollow-trees, roost protection, harvest limits	Include unburnt/ low severity burnt habitat in clumps	Acoustic monitoring
Long-nosed potoroo	39.5	Used state-wide record assessment	ESAs, harvest limits	Include unburnt/ low severity burnt habitat in clumps	Predator control, monitoring
Masked owl	37.4	CRA Habitat model	ESAs, hollow-trees, roost protection, harvest limits, owl landscape exclusion	Include unburnt/ low severity burnt habitat in clumps	Acoustic monitoring
Spotted-tailed quoll	37.4	CRA Habitat model	ESAs, hollow-trees, latrine and den protection, harvest limits	Include unburnt/ low severity burnt habitat in clumps	

Common name	Records in fire-affected areas (%)	Assessment approach	CIFOA management	Consider for inclusion in clumps	Other management response
Fleay's barred frog	37.1	Used state-wide record assessment	ESAs		Preferred habitat protected in existing exclusion zones
Northern (Beccarri's) free-tailed bat	32.2	Used state-wide record assessment	ESAs, hollow-trees, roost protection, harvest limits	Include unburnt/ low severity burnt habitat, particularly hollows, in clumps	
Southern brown bandicoot	32	Potential habitat assessment	Species Management Plan		Predator control, monitoring
Gang-gang cockatoo	31.3	Public forest record assessment	ESAs, hollow-trees, roost protection, harvest limits	Include unburnt/ low severity burnt habitat in clumps	
Hoary wattled bat	29.8	Used state-wide record assessment	ESAs, hollow-trees, roost protection, harvest limits	Include unburnt/ low severity burnt habitat, particularly hollows, in clumps	
Olive whistler	27.9	Used state-wide record assessment	ESAs	Potential unburnt/ low severity habitat	Preferred rainforest habitat protected in existing exclusion zones
Powerful owl	26.4	Habitat model	ESAs, hollow-trees, roost protection, harvest limits, owl landscape exclusion	Include unburnt/ low severity burnt habitat in clumps	Acoustic monitoring
Emu (NC bioregion)	25.8	Used state-wide record assessment	Adequately protected	Potential unburnt/ low severity habitat	
Stephens' banded snake	24.2	Used state-wide record assessment	ESAs, hollow-trees, roost protection, harvest limits	Include unburnt/ low severity burnt habitat, particularly hollows, in clumps	
Green-thighed frog	24	Used state-wide record assessment	ESAs	Include unburnt/ low severity burnt habitat in clumps	
Smoky mouse	23.6	Used state-wide record assessment	Species Management Plan	Potential unburnt/ low severity habitat	Predator control
Alberts' lyrebird	23.4	Used state-wide record assessment	Site-specific surveys and record protection	Potential unburnt/ low severity habitat	Predator control
Greater broad-nosed bat	22.1	Used state-wide record assessment	ESAs, hollow-trees, roost protection, harvest limits	Include unburnt/ low severity burnt habitat, particularly hollows, in clumps	

Common name	Records in fire-affected areas (%)	Assessment approach	CIFOA management	Consider for inclusion in clumps	Other management response
Scarlet robin	21.9	Used state-wide record assessment	ESAs, hollow-trees, roost protection, harvest limits, limit firewood collection	Potential unburnt/ low severity habitat	Exclude fire wood collection near known records in high intensity burn areas
Large-eared pied bat	21.5	Used state-wide record assessment	ESAs, hollow-trees, roost protection, harvest limits	Include unburnt/ low severity burnt habitat, particularly hollows, in clumps	
Red-backed button-quail	18.8	Used state-wide record assessment	Adequately protected	Potential unburnt/ low severity habitat	
Brush-tailed phascogale	18.6	Public forest record assessment	ESAs, hollow-trees, den protection, harvest limits, carry-over exclusion zones	Include unburnt/ low severity burnt habitat, particularly hollows, in clumps	
White-crowned snake	18	Used state-wide record assessment	Adequately protected	Potential unburnt/ low severity habitat	Exclude fire wood collection near known records in high intensity burn areas
Marbled frogmouth	17.9	Used state-wide record assessment	Site-specific surveys and record protection		Preferred habitat protected in existing exclusion zones
Little bent-winged bat	17.6	Used state-wide record assessment	ESAs, hollow-trees, roost protection, harvest limits		Preferred habitat protected in existing exclusion zones
Large bent-winged bat	17.6	Used state-wide record assessment	ESAs, hollow-trees, roost protection, harvest limits		Preferred habitat protected in existing exclusion zones
Flame robin	16.4	Used state-wide record assessment	ESAs, hollow-trees, roost protection, harvest limits, limit firewood collection	Include unburnt/ low severity burnt habitat in clumps	Exclude fire wood collection near known records in high intensity burn areas
Common planigale	16.2	Used state-wide record assessment	Adequately protected	Include unburnt/ low severity burnt habitat in clumps	Predator control
Varied sitella	16.1	Used state-wide record assessment	ESAs, hollow-trees, roost protection, harvest limits, limit firewood collection	Include unburnt/ low severity burnt habitat, particularly hollows and dead trees, in clumps	

Common name	Records in fire-affected areas (%)	Assessment approach	CIFOA management	Consider for inclusion in clumps	Other management response
Eastern pygmy possum	16	Used state-wide record assessment	ESAs, hollow-trees, harvest limits, limit firewood collection	Include unburnt/ low severity burnt habitat, particularly hollows, in clumps	
Wompoo fruit dove	15.8	Used state-wide record assessment	ESAs		Preferred rainforest habitat protected in existing exclusion zones
Little lorikeet	15	Used state-wide record assessment	ESAs, hollow-trees, nest protection, harvest limits	Include unburnt/ low severity burnt habitat (nectar producing trees) in clumps	
Rosenberg's goanna	14.7	Used state-wide record assessment	Adequately protected	Include unburnt/ low severity burnt habitat in clumps	Little burnt habitat scheduled for harvesting
Pink robin	14.3	Used state-wide record assessment	ESAs	Include unburnt/ low severity burnt habitat in clumps	
Barking owl	14.1	Used state-wide record assessment	ESAs, hollow-trees, roost protection, harvest limits, owl landscape exclusion		
Giant burrowing frog	13.3	Public forest record assessment	Species Management Plan		Targeted surveys/ monitoring
Giant-barred frog	13.2	CRA Habitat model	ESAs		Preferred habitat protected in existing exclusion zones
Eastern cave bat	12.4	Used state-wide record assessment	ESAs, hollow-trees, roost protection, harvest limits		Preferred habitat protected in existing exclusion zones
Squirrel glider	12.3	Used state-wide record assessment	ESAs, hollow-trees, roost protection, harvest limits, carry-over exclusion zones	Include unburnt/ low severity burnt habitat (hollows, nectar producing trees) in clumps	
Tusked frog (NET bioregion)	11.7	Used state-wide record assessment	ESAs		Preferred habitat protected in existing exclusion zones
Red-crowned toadlet	10.2	Used state-wide record assessment	ESAs		Preferred habitat protected in existing exclusion zones

Common name	Records in fire-affected areas (%)	Assessment approach	CIFOA management	Consider for inclusion in clumps	Other management response
Southern myotis	10.2	Used state-wide record assessment	ESAs, hollow-trees, roost protection, harvest limits		Preferred habitat protected in existing exclusion zones
Long-footed potoroo	97.1	Used state-wide record assessment	Requires species specific condition if detected		Not considered further
Peppered tree frog	47.2	Used state-wide record assessment	Requires species specific condition if detected		Not considered further
Spotted tree frog	30.8	Used state-wide record assessment	Requires species specific condition if detected		Not considered further
Red-browed Treecreeper	*	CRA Habitat model	Not listed in NSW	Include unburnt/low severity burnt habitat in clumps	
Rock Warbler	*	Record and known habitat assessment	Not listed in NSW		Little burnt habitat scheduled for harvesting
Pilot Bird	*	Record and known habitat assessment	Not listed in NSW	Include unburnt/low severity burnt habitat in clumps	
Koala	*	DPI North Coast Habitat model	ESAs, browse tree retention, harvest limits	Include unburnt/low severity burnt habitat in clumps	Research and monitoring program
Grey-headed Flying Fox	*	Record and known habitat assessment	ESAs, hollow-trees, camp protection, harvest limits	Include unburnt/low severity burnt habitat (nectar trees) in clumps	Camp surveys
Dusky Antechinus	*	Record and known habitat assessment	Not listed in NSW		
Little Johns Tree Frog	*	Record and known habitat assessment	ESAs (North Coast)/ Requires species specific condition if detected		Preferred habitat protected in existing exclusion zones
Philoria pughi	89.3	DRAFT DPI Habitat model	Site-specific surveys and record protection		
Hastings River Mouse	81.9	DPI Habitat Model	Site-specific surveys and record protection	Include potential habitat in temporary clumps in absence of records	Predator control, monitoring
Greater Glider (Eurobodalla)	71.7	CRA Habitat model	ESAs, hollow-trees, roost protection, harvest limits	Include unburnt/low severity burnt habitat (hollow-trees) in clumps	Target surveys & habitat protection in South Coast Region

Common name	Records in fire-affected areas (%)	Assessment approach	CIFOA management	Consider for inclusion in clumps	Other management response
Yellow-bellied glider	53.6	CRA Habitat model	ESAs, hollow-trees, feed-trees, den protection, harvest limits	Include unburnt/ low severity burnt habitat (hollow-trees, nectar trees) in clumps	Target surveys & habitat protection in South Coast Region. Acoustic monitoring.
Glossy black-cockatoo	45.4	CRA Habitat model	ESAs, hollow-trees, feed-trees, nest protection, harvest limits	Include feed trees in clumps	
Sphagnum frog	43.8	DRAFT DPI Habitat model	Site-specific surveys and record protection		
Pouched frog	26.6	DRAFT DPI Habitat model	Site-specific surveys and record protection		
Rufous scrub-bird	24.4	CRA Habitat model	Site-specific surveys and record protection		Include recovering habitat in exclusion zones
Broad-headed snake	26.3	Unlikely to occur within harvestable estate	N/A		Not considered further
Grey falcon	20.5	Unlikely to occur within harvestable estate	N/A		Not considered further
Red goshawk	18	Unlikely to occur within harvestable estate	N/A		Not considered further
Brush-tailed rock-wallaby	81.7	Unlikely to occur within harvestable estate	N/A		Not considered further
Blue Mountains water-skink	66.4	Unlikely to occur within harvestable estate	N/A		Not considered further
Giant dragonfly	52.9	Unlikely to occur within harvestable estate	N/A		Not considered further
Mountain pygmy-possum	45.6	Unlikely to occur within harvestable estate	N/A		Not considered further
Red-tailed Black-cockatoo	40	Unlikely to occur within harvestable estate	N/A		Not considered further
Bathurst copper butterfly	27.7	Unlikely to occur within harvestable estate	N/A		Not considered further
Striated fieldwren	22.4	Unlikely to occur within harvestable estate	N/A		Not considered further

Common name	Records in fire-affected areas (%)	Assessment approach	CIFOA management	Consider for inclusion in clumps	Other management response
Southern corroboree frog	22.3	Unlikely to occur within harvestable estate	N/A		Not considered further
Common-blossom bat	21.6	Unlikely to occur within harvestable estate	N/A		Not considered further
Eastern chestnut mouse	16.2	Unlikely to occur within harvestable estate	N/A		Not considered further
Manning River helmeted turtle	16.1	Unlikely to occur within harvestable estate	N/A		Not considered further
Broad-toothed rat	14.9	Unlikely to occur within harvestable estate	N/A		Not considered further
Black-breasted button-quail	14.1	Unlikely to occur within harvestable estate	N/A		Not considered further
Olongburra frog	12.8	Unlikely to occur within harvestable estate	N/A		Not considered further
Bellinger river snapping turtle	12.5	Unlikely to occur within harvestable estate	N/A		Not considered further
Eastern grass owl	11.8	Unlikely to occur within harvestable estate	N/A		Not considered further
Wallum froglet	11	Unlikely to occur within harvestable estate	N/A		Not considered further
Booroolong frog	10.3	Unlikely to occur within harvestable estate	N/A		Not considered further
Coastal petaltail	10.2	Unlikely to occur within harvestable estate	N/A		Not considered further
New Holland Mouse	*	Unlikely to occur within harvestable estate	N/A		Not considered further

Notes:

Habitat models were used in preference to species records for assessment of fire severity impacts where they were available as they tend to be less biased than species records which are often a function of survey effort, detectability and proximity to roads.

CRA habitat model = relevant species model derived for the comprehensive regional assessment process. Model selected 'moderate' and 'high' quality habitat classes. See the NSW SEED portal for details.

DPI habitat model = DPI forest science developed models. This includes models reported on for Koala and Hastings River Mouse as well as recently developed draft models for *Assa darlingtonia* (Pouched Frog) and *Philora loveredgei, P. pughi* and *P. sphganicola* which had had limited expert review.

Public Forest record assessment = Bionet records that occur on public land intersected with fire severity category.

Record and known habitat assessment = consideration was based on Forestry Corporations Senior Ecologist reviewing species records and fire severity mapping on GIS along with his expert knowledge of relevant species ecology to identify what further considerations or mitigations were relevant.

State-wide record assessment = utilised data reported in DPIE (2020 a) – red list species Appendix 1.

Unlikely to occur within harvestable estate = species were allocated to this category by Forestry Corporation's Senior Ecologist based on expert opinion of species distribution and ecology.

Appendix 2: References

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Glossary

BMPs	Best management practices
CIFOA	Coastal Integrated Forestry Operations Approval
CRA	Comprehensive Regional Assessment. A procedure for investigating the natural, cultural, economic and social values of Australian forests that formed the basis for Regional Forest Agreements.
CWD	Coarse Woody Debris
DPI	NSW Department of Primary Industries
DPIE	NSW Department of Planning, Industry and Environment
DPI Forestry	NSW Department of Primary Industries Forest Research division, which provides evidence-based forest research services that underpin sustainable use of NSW's native forests and productive plantations.
ESFM	Ecologically Sustainable Forest Management
EPA	Environment Protection Authority
ESAs	Environmentally significant areas
FESM	Fire Extent and Severity Mapping
FRMP	Flora road management plan
FMZ	Forest Management Zoning is a land classification system based on nationally agreed reserve criteria that clearly differentiates which parts of State forests are set aside for conservation and those areas available for other activities including timber harvesting
NPWS	NSW National Parks and Wildlife Service
NRC	Natural Resources Commission
RFA	Regional Forest Agreements are bilateral agreements between the Australian Government and four state governments, and are given statutory effect under the *Commonwealth Regional Forest Agreements Act 2002* (RFA Act). They are long-term agreements that provide for the sustainable management and conservation of Australia's native forests.
RFS	NSW Rural Fire Service
SEED portal	The NSW Government's central resource for Sharing and Enabling Environmental Data
Sentinel 2	Satellite data
SMP	Species Management Plan
TECs	Threatened Ecological Communities