Risks to the NSW Coastal Integrated Forestry Operations Approvals Posed by the 2019/2020 Fire Season and Beyond: A Report to the New South Wales Natural Resources Commission

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September 2021

Executive Summary

The 2019/20 fire season affected a large area of NSW (over 5 million hectares burned) including a significant proportion of the area (41 percent of the forested portion) covered by the Coastal Integrated Forestry Operations Approvals (CIFOA). This was the largest fire season affecting forests in eastern NSW in recorded history.

Substantial changes to fire regimes resulted from the 2019/20 fires season. These changes are likely to have affected the objectives and outcomes of the CIFOA. This report examines patterns of fire regimes across the domain of the CIFOA and the way these patterns were altered by the 2019/20 fires and other disturbances such as harvesting. This overview of changes to fire regimes was used to assess likely implications for forest structure, regeneration, indicators of biodiversity, key threatened species and water quality. The likely direction and magnitude of future fire regimes under climate change was also assessed, along with concurrent changes in predicted suitable habitat for a range of threatened vertebrate species.

Fire was relatively infrequent (zero or one fire) across the bulk of the domain of the CIFOA as of mid-2019, based on mapped records dating back to 1970. A considerable proportion of this domain (about 40 percent) was subject to moderately frequent fire (two, three or four fires), with high proportions evident in State Forests and National Parks estate. As a result, a relatively large proportion of the CIFOA was long unburnt (circa 20 to 50 percent range) or else had experienced only one fire (about 20%). Hotspots of high frequency wildfires (four or more) were restricted to small proportions of the CIFOA (< 10 percent).

The 2019/20 fires burned about 60 percent of the area of State Forests and National Parks estate within the CIFOA. More than 15 percent of the area within the CIFOA that burned in 2019/20 was affected by high or extreme fire severity (i.e. partial or full crown fire in forests), with higher proportions of National Parks estate and State Forests experiencing fire severity of this kind (> 20 percent).The 2019/20 fires diminished the proportion of the CIFOA that was long unburnt, with corresponding increases in the proportions burnt at intermediate and high frequency. The proportion of the CIFOA subjected to high frequency wildfire was generally doubled. Ridges and upper slopes were strongly affected by high or extreme fire severity (circa 25 percent) but relatively large proportions of lower slopes and valley bottoms were also burnt by fires in this severity range. Small proportions (circa 4 percent) of the CIFOA were subjected to high frequency wildfires (four or more wildfires), plus high or extreme fire severity in 2019/20. While large proportions of dominant wet and dry sclerophyll forest formations were affected by high or extreme fire severity in the 2019/20 fires (up to 33 percent), high proportions of rainforest (up to 40 percent) and other less extensive vegetation formations were burnt.

These changes to fire regimes, wrought by the 2019/20 fires, were likely to pose significant risks to the CIFOA objectives and outcomes. Importantly the magnitude of the fires and their effect on disturbance regimes have placed the CIFOA, generally, in a highly vulnerable state where risk may be maintained at an elevated level into the immediate future. In particular, the integrity of riparian buffers, regeneration, hollows and carbon stocks may have been negatively directly affected by the 2019/20 fires and resultant changes to disturbance regimes.

Indicators of plant biodiversity responses were significantly shifted into a vulnerable state (circa 50 percent of the area of National Parks estate and State Forests), along with a small increase in the proportion of area of most vegetation formations that were deemed to be too frequently burnt. Notably, a large proportion of rainforest assessed was shifted into this state (> 50 percent). Predicted suitable habitat for 25 threatened vertebrate species (including 17 focal species listed for the CIFOA) was substantially burnt by the 2019/20 fires (up to 62 percent) and resultant shifts in fire regimes for the bulk of these species may constitute a significant risk to key habitat elements such as hollows, nesting and food resources. A substantial proportion (about 15 percent) of a sample of major catchments across the CIFOA was burned in 2019/20. The magnitude of burning and severity patterns, coupled with well above average rainfall post-fire throughout 2020 into early 2021were likely to have resulted in significant erosion, transport and deposition of soil, ash and other material into waterways and estuaries. Resultant compromised water quality was likely to have posed significant risk to aquatic biodiversity.

Increases in adverse fire weather were predicted across CIFOA using the NSW and ACT Regional Climate Modelling (NARCliM) ensemble, in both the near (2020 to 2039) and far (2060 to 2079) future. Such shifts in fire weather were likely to result in increased area burned by wildfires in sample case studies corresponding to the range of CIFOA regions across the domain of the CIFOA. Such trends potentially elevate risks to CIFOA objectives and outcomes, while capacity to mitigate these risks may be constrained. Changes in projected suitable habitat for the range of threatened vertebrate species may either elevate or buffer risks sustained by changes in future fire regimes.

The monitoring program for the CIFOA needs to be tailored to encompass and scrutinise effects of contrasting, long-term disturbance regime patterns emergent from the 2019/20 fire season. In particular, such a program needs to focus on rapidly changing extremes of disturbance regimes (e.g. fire and harvesting) plus interactions with drought. This is needed to better understand likely responses of forest regeneration, structure, threatened species and other aspects of biodiversity to increasing fire frequency, driven by likely warming and drying. This will supply information crucial for understanding adaptation and intervention.

Contents

Introduction

The aims of the project are to articulate:

1. the specific risks to achieving the Coastal Integrated Forestry Operation Approval (CIFOA) objectives and outcomes as result of the legacy landscape scale impacts of the NSW 2019/20 wildfire season;
2. the broad implications of predicted changing fire regimes on the achievement of the CIFOA's objectives and outcomes;
3. options to mitigate risks.

The first of these tasks involves quantification of the disturbance regimes that evolved across the landscapes within the domain of CIFOA, and the way these disturbance regimes were altered by the 2019/20 fires. This provides the basis for assessment of the consequences of fire regimes for the key objectives and outcomes of the CIFOA (Appendix 1). Such an assessment requires establishment of relevant indicators of response to disturbance for each objective of the CIFOA, in order to address risks and implications ensuing from the 2019/20 fire season. These indicators can also be used to assess future risks.

Disturbance regimes and their implications for 2019/20

The 2019/20 fires affected an unprecedented area of forested ecosystems in south eastern Australia (Bowman et al. 2020a). It is estimated that about 5 million hectares of forest burned in NSW alone, including about 41 percent (39,073 km^2) of the forested area within the CIFOA domain. Given the current CIFOA and associated monitoring programs were derived before the 2019/20 fire season was completed it is imperative to assess the likely consequences of this unprecedented season. Given that this extraordinary fire season has been linked to climate change, such an assessment provides the basis to consider the effects of future fire regimes.

Disturbances occur in all ecosystems. Disturbance can be defined as any process that consumes, damages or removes biomass, thereby altering the composition, structure and functioning of ecosystems (Peters et al. 2011). The timing, rate of recurrence and intensity of disturbances can vary. The concept of the disturbance regime encapsulates these components and their variations (Bond and van Wilgen 1996; Huston 2003). Many different disturbance regimes are therefore possible as a consequence of variation in each of these components and their resultant combinations.

In local forests, fire is the principal disturbance, though other phenomena, such as storms and harvesting also impose disturbances. Fire ecology is the science of understanding the ecological consequences of differing fire regimes (Gill 1975, Bond and van Wilgen 1996, Whelan 1995). The fire regime is commonly defined as the frequency, intensity and season of fire (Gill et al. 2002). An additional component of the fire regime is the fire type: typically a distinction between above- or below-ground fires, such as in the case of soil peat deposits. Fires above ground prevail in the bulk of forested vegetation subject to the CIFOA.

Fire regimes typically result from a mix of ignition types, such as lightning and human sources. Often, fire regimes will be a composite of natural, accidental and planned ignitions, depending on the spatial and temporal scale of vegetation that is being considered. The footprints of fires from disparate sources will overlap to produce potentially complex and varied patterns of fire regimes across landscapes as a consequence of variations in the location, size, intensity and timing of each individual fire. Thus the fire regime prevailing at a point or plot within a forest may be a subset of what occurs across the region. At large spatial scales, fire regime variation and patterns can be described on an area or proportional basis and illustrated as maps.

The massive area burned in 2019/20 has substantially altered fire regimes across the forested estate of NSW. In order to evaluate the nature and consequences of these changes, a number of steps are required.

- First, the state of fire regimes at the commencement of the 2019/20 season needs to be estimated. This provides a baseline for the assessment of changes and their consequences.
- Second, the changes to fire regimes wrought by the 2019/20 fires need to be estimated, so that critical responses attributable to both pre-existing fire regimes and the additive effects of the 2019/20 fires can be considered and distinguished.
- Third, the consequences of pre and post 2019/20 fires also need to be considered in relation to the history of timber harvesting, which constitutes the other significant disturbance in local forests.

Execution of these three steps will provide an integrated picture of disturbance regime and any crucial transformation in their consequences for CIFOA objectives and outcomes imposed by the 2019/20 fires.

Potential effects of disturbance regimes on CIFOA outcomes and objectives.

How are disturbance regimes likely to affect the main CIFOA outcomes: i.e. forest health and structure; biodiversity and threatened species; water quality; and timber supply? Additionally, the potential consequences of these disturbance regime patterns on the monitoring program that supports these objectives and outcomes needs to be assessed.

A wide variety of fire regimes is likely to be evident in the forests subject to the CIFOA (Murphy et al. 2013, Clarke et al. 2015). These reflect variation in ignition sources, rates, locations, along with biophysical influences such as climate, fire weather, fuel dynamics, vegetation type and structure, along with other human influences such as road networks, population density, infrastructure and development patterns (Penman et al. 2013; Clarke et al. 2020). It is therefore of fundamental importance to understand how species and ecosystems respond to variations in fire regimes.

Conceptually, fire regimes can be regarded as occupying a spectrum. There will be a point on that spectrum that demarcates fire regimes that may be favourable as opposed to unfavourable to various biotic and physical values of concern to managers (Kelly et al. 2020). For example, fire regimes at one end of the spectrum may cause decline and eventual loss of some species, whereas those at the other end may result in persistence. This general concept is applied in this assessment. Additionally fire regimes can be characterised and effects interpreted at multiple scales: e.g. at a point on the ground versus across a landscape. Primarily, fire regime variation at large spatial scales is described here.

The fundamental characteristics of species and ecological processes determine their sensitivity and response to fire regimes. For example, plants that resprout after burning may be relatively robust to wide variations in fire frequency and capable of persistence under relatively frequent cycles of fire (Clarke et al. 2013, 2015). By contrast, plants that don't resprout when their foliage is killed by fire, or other disturbances, may be sensitive to variations in fire frequency (Clarke et al. 2013; Kelly et al. 2020). This is because their persistence is dependent on post-fire or disturbance establishment from seeds. New cohorts of juveniles that establish post fire need time to grow, mature and replenish seed storages. The recurrence of fire during this critical phase can deplete or even eliminate populations. Other biota such as large-bodied, arboreal mammals may be sensitive to fire intensity because they are unable to access shelter during fires (Banks et al. 2011; Gill and Catling 2002). Thus high intensity fires may cause high mortality of such species. In a similar vein, soils in eucalypt forest may be predisposed to erosion under high intensity rainfall soon after the passage of a high intensity fire. Such erosion can compromise water quality and quantity in forested catchments. Thus key biota and landscape processes can be characterised as vulnerable to certain components of the fire regimes: e.g. sensitive to fire frequency or sensitive to fire intensity. Additionally, these components of the fire regime can have interactive effects: e.g. very high frequency, low intensity fire may cause higher mortality that occasional high intensity fire in some eucalypts (Noble 2001).This provides a basis for interpretation of the likely responses of the CIFOA.

Potential effects of disturbance regimes on forest health, regeneration and structure

The forest health, regeneration and structure objectives of the CIFOA primarily hinge on the dynamics of overstorey trees, which in these forests are predominantly eucalypts (i.e. *Eucalyptus*, *Angophora* and *Corymbia* spp.). Eucalypt mortality and regeneration are strongly affected by fire regimes in interaction with species characteristics such as bark type (Burrows 2013; Nolan et al. 2020a). Other key aspects of forest structure such as the availability of hollows is also a function of fire regimes (Banks et al. 2011; Gill and Catling 2002). Given that trees constitute the bulk of above-ground carbon in eucalypt forests their fire regime driven dynamics will be a potentially crucial determinant of overall carbon storage in these ecosystems.

Generally, eucalypts are highly resilient to fire, with the bulk of species capable of resprouting from aerial buds on branches and the main stem (epicormics) and also at the stem base from lignotubers. Different species exhibit various combinations of these resprouting modes and additionally the capacity for basal resprouting may be diminished in trees with a large stem. Thus fires of a given intensity can have highly variable effects on mortality of aerial parts of the tree, outright survival and recovery patterns. Mortality due to fires in resprouting eucalypts is generally low (circa 1 to 10 percent, Vivian et al. 2008), though some exceptional instances of high mortality have been recorded (e.g. Fairman et el.

2019). Mortality is generally a function of high fire intensity as indicated by fire severity (i.e. vertical profile of scorch and consumption, Collins 2020). Antecedent drought may also be a factor in elevating mortality during fires though further research is required to confirm the magnitude and generality of such an effect (Nolan et al. 2020ab).

Bark type and thickness affect the vulnerability of eucalypt stems during fires and thus the mode of resprouting. Bark attributes also determine the propensity for scarring and injuries, which in turn affect survival of stems and individuals. Once scarred, a tree may become vulnerable to further injury and eventual collapse, with recovery limited to basal resprouting (Collins 2020). Scarring however also contributes to hollow formation (McLean et al. 2015). Thus there is balance between loss of stems and hollow formation that is a function of fire frequency and injuries to stems: too much fire can lead to stem collapse and loss of hollows whereas too little fire may lead to low levels of hollows (Banks et al. 2011; McLean et al. 2015; Collins 2020).

Seedling regeneration of eucalypts is generally keyed to fire, through provision of resources and changes to predation/herbivory. Thus regeneration is often positively related to fire intensity (e.g. Vivian et al. 2008). Seedling regeneration can be relatively insensitive to variations in fire frequency and intensity across a wide range of eucalypt-dominated communities, chiefly because of the capacity of many eucalypt species to rapidly form lignotubers (e.g. Watson et al. 2020).

A relatively small but important group of species do not resprout following fire, or else have limited resprouting (e.g. lack of epicormic sprouting). These are known as the 'Ash' group (Monocalyptus) and include *E. delegatensis*, *E. fraxinoides*, *E. oreades* (Alpine Ash, White Ash, Blue Mountains Ash) as significant forest trees with potential to dominate tall wet sclerophyll forest types (Nicolle 2006; Gill 1997; Burrows 2013). Another species in this group, *E. sieberi* (Silvertop Ash) is a widespread dry sclerophyll forest dominant with resprouting capacity (NSW Forestry Commission 1982). Individuals of these species are prone to death in high intensity fires, though large trees can survive fires of lower intensity, provided the canopy is partially intact (Vivian et al. 2008). High intensity fires cause 'stand replacement' with tree mortality followed by recovery via seed germination. Following such fires there is a vulnerable period (circa 15 years) where juvenile regrowth can be eliminated without replacement, causing severe depletion or loss of these species (Bowman et al. 2016).

There is mixed evidence concerning the sensitivity of carbon stocks to fire regimes in eucalypt forests (Bowman et al. 2020). A range of experimental studies have documented negative relationships between frequency of low intensity burning and above-ground carbon stocks, with harvesting in some cases contributing to a decline (Collins et al. 2019). However in other instances above-ground carbon stocks have been found to be robust to variations in fire intensity and frequency (Gordon et al. 2019). Antecedent prescribed burning had little effect on above-ground carbon stocks in mixed forests following a wildfire (Bennett et al. 2017) though the intensity of the wildfire negatively affected carbon stocks. Such outcomes reflect a complex interplay between established tree mortality, resprouting capacity and regeneration (Bowman et al. 2020b).

Fires can have short term effects on soil carbon stocks, ash quantities for example, being positively related to fire severity in some cases (e.g. Chafer et al. 2016). Recalcitrant, pyrogenic carbon may be higher after low intensity versus high intensity wildfires with overall depletion of carbon near the soil surface occurring after intense fire cf. low intensity fire (Bennett et al. 2017). Such effects may be exacerbated by post-fire erosion and movement of ash and burnt material (e.g. Santin et al. 2015). However soil carbon tends to initially decline in the initial years after fire (Hobley et al. 2017) but then may increase cross decadal time scales (Sawyer et al. 2018a). Soil carbon in eucalypt forests can thus be relatively robust to long-term variations in fire regimes though there are relatively few studies available to examine such effects (e.g. Sawyer et al. 2018b).

Given the positive relationships between fire intensity, frequency, bark type and tree scarring (Collins 2020), an overview of fire regimes can provide some indication of impacts of consequences for mortality and regeneration and thus the ongoing stocking of trees in forests.

In summary, fire regimes that may be of concern in terms of the forest regeneration, structure and tree dynamics of the CIFOA are likely to be extremes of frequency and intensity/severity. In particular high frequencies of unplanned fires on ridge tops may have the greatest potential for negative effects on these criteria, because such fires are more likely to be severe than prescribed fires and/or fires on slopes and in gullies. The intersection of high fire severity in 2019/20 with this combination of fire frequency, fire type and topographic position may have potential to exacerbate any negative effects on these CIFOA criteria.

Potential effects of disturbance regimes on biodiversity and threatened species

As indicated above, plant and animal species show varying degrees of sensitivity to different fire regime components, particularly fire frequency and fire intensity. These reflect aspects of life-history, morphology and recovery/regeneration capacity.

Various approaches have been developed to predict responses of plant species to variations in fire frequency. Systems based on knowledge of key life history traits (i.e. maturation time, life span, seed storage mode) of non-resprouters in different plant communities, have been developed and applied in different parts of the world. Such approaches provide a basis for estimation of potential effects of changes in fire frequency on plant diversity by delineating upper and lower limits of fire frequency. These approaches can be applied at local, landscape and regional scales in ways that account for variations in vegetation types to indicate the state of fire regimes at any point in time. These approaches are outlined in more detail below.

The response of animals to fire regimes is also governed by aspects of life history, morphology and habitat (Enright et al. 2011; Kelly et al. 2017). There are direct and indirect effects of fire regimes on the ability of species to persist. Direct effects encompass the 'combustion phase' and its immediate aftermath, whereas indirect effects may be a function of the cumulative effects of multiple fires including intensity of fires, their seasonal timing and length of inter-fire intervals.

The ability to avoid lethal heating during fires is fundamental to understanding animal responses to fire regimes (Whelan 1995). Most terrestrial invertebrates and vertebrates have some mobility, which may either enable them to avoid fires (e.g. through flight in the case of birds) or seek shelter, or to disperse and recolonise if eliminated from an area by fire. The potential for survival is thus partially a function of characteristics of mobility, body size, and availability of refugia (e.g. rocks, burrows, hollows), along with the intensity of fire. Thus many animal species can typically survive a fire, though inherently large bodied animals with low mobility are vulnerable (e.g. arboreal mammals, large birds with restricted flight ability). For many species, the most vulnerable period may be the months following when predation and starvation risks may be high (Dawson et al. 2007, Keith 2012). When fires are large, as in 2019/20, ability to persist and recolonise will be dependent on a mixture of these responses and their interactions with topography, fire severity variations and many other factors governed by local context and variations in conditions during the spread of the fire (Bradstock et al. 2005, Bradstock 2008).

In the longer term, cumulative direct effects of multiple fires, the capacity to recover in the intervening intervals and long-term dynamics of vegetation will determine abundance and persistence for many species (Enright et al. 2011; Kelly et al. 2017, 2020). For example, the abundance of tree hollows may be positively related to the number of fires experienced over time but conversely the abundance of Greater Gliders is negatively related to the number of fires (McLean et al. 2018). In this case, fires, via the creation of tree injury, increase the supply of habitat (hollows) but directly reduce abundance via mortality, with very slow recovery of populations between fires, possibly due to low rates of dispersal.

Given the fire-prone nature of most eucalypt forests, disturbance regimes will be governed by the joints effects of fire and harvesting in areas subject to timber extraction, along with other aspects of environmental heterogeneity (Rainsford et al. 2020). Harvesting may be followed deliberate burning to promote tree regeneration and remove slash, or else by subsequent prescribed fires for fuel reduction or unplanned wildfires.

Harvesting alone or in combination with planned fires may have variable effects on animal species (Kavanagh and Stanton 2005, Flynn et al. 2011) depending on taxonomic group and associated habitat and resource requirements. For example, Kavanagh and Stanton (2005) documented negative effects of harvesting on various mammals birds and reptiles that were due to either decreases in large trees through harvesting in forests or increases in tree density following harvesting in more open woodlands. Such effects represented different sensitivities to resources and habitats either provided directly by trees or indirectly affected by the presence of trees. By contrast Flynn et al. (2011) found that abundances of a group of mammals and associated habitat metrics were not strongly affected by harvesting. York and Tarnawski (2004) found complex effects of harvesting, grazing and burning on invertebrates modulated by landscape-level variations in soils and vegetation. Generally, abundance and diversity of invertebrates were positively related to soil organic matter, which in turn tended to be lower in parts of the landscape subject to combined effects of harvesting, burning and grazing (York and Tarnawski 2004). Combined effects of harvesting and frequent prescribed burning differentially affected shrubs and ground cover species (Penman et al. 2008), with shrub diversity reduced by frequent burning and but increased by harvesting, whereas frequent burning elevated herb diversity.

In summary, critical diagnostics of fire regimes for biodiversity and threatened species will be governed by extremes of disturbance frequency and intensity. In particular, the concurrence of frequent intense fires, perhaps compounded by harvesting, will be critically important for many species and their habitats. Conversely, the long-term absence of fire may also be detrimental for species which are dependent on regular fire. Here we evaluate trends in long term trends in fire frequency, the likelihood of intensity and the intersection with higher levels of severity of the 2019/20 fires as key diagnostics for assessment. We also examine the extent of such trends in relation to recent harvesting. Here we focus on aspects of vascular plant diversity and assessment of impact and risk for some threatened vertebrate species. It is acknowledged that a wider assessment should also include invertebrates, though the capacity to undertake such assessment is limited by major knowledge gaps, in relation to many aspects of fire regimes (York and Lewis 2018, Saunders et al. 2021). While responses of some invertebrates groups (e.g. ants, beetles, spiders) to variations in the frequency of low intensity fires are known, via long-term experiments (York and Lewis 2018, Butler et al. 2021) responses to long-term sequences of wildfires and variations in fire intensity and season are less well explored (York et al. 2012).

Potential effects of disturbance regimes on catchments, water quality and aquatic biodiversity

Fire is a critical influence on the integrity of catchments, the water they yield and the consequent responses of streams, water bodies and resident aquatic biota (Smith et al 2011, Bixby et al. 2015, Alexander and Finlayson 2020). The removal of vegetation cover, changes to soil properties via heating and the production of ash and char by fire can directly and indirectly affect geomorphological processes, water and biota. Much attention in fire prone Australian eucalypt forests on the effects of fire on water yield, erosion and debris flows and resultant consequences for water supply (Smith et al. 2011). For example, the wildfire complex that affected much of the ACT in 2003, not only destroyed much property and caused death and injury to people but also compromised the water supply of Canberra (White et al. 2006). This resulted from a combination of high fire intensity and high intensity rainfall immediately post-fire that triggered significant erosion and transport of debris iand ash into streams and reservoirs (White et al. 2006).

High intensity fire on ridges and upper slopes in eucalypt forests predisposes soils to erosion during high intensity rainfall events (e.g. Shakesby and Doerr 2006, Yang et al. 2018, 2020). The effective post-fire window where there is potential for soil movement is relatively short: circa two years. Heavy rain post fire may also result in significant flows of debris and ash in streams and water bodies (Smith et al. 2011, Chafer et al. 2016). The intersection of the conjoint probabilities of high fire intensity and high intensity rainfall determines the potential for significant erosion, and movement of debris and ash in forested catchments.

The transport of eroded material, debris, including significant ash, charcoal and plant debris, into streams and water bodies can potentially result in changes to aquatic habitats water chemistry and quality (e.g. Smith et al. 2011, Santin et al. 2015). Such changes to water quality can be long lasting (Yu et al. 2019). Impacts of physical changes to stream beds from debris and sediment flows, removal of shading from riparian vegetation and changes in water chemistry (e.g. elevated concentrations of N, P and metals) can have major deleterious impacts on biota such as freshwater fish species (Lyon and O'Connor 2008, Alexander and Finlayson 2020). Wider negative effects on estuarine and coastal species may also result from changes to water chemistry and sedimentation (Smyth 2020). Usage of fire retardant chemicals and their entry in streams and waterbodies may also elevate risks to aquatic biodiversity (Gimenez et al. 2004), though Australian studies are lacking.

Regrowth forests, particularly those dominated by Mountain Ash and Alpine Ash, may deplete stream flow and water supply in catchments through strong evapotranspiration in young stands with such effects lasting for decades (Smith et al. 2011, Nolan et al. 2015). There is less evidence of such depletion in stream flows in forests dominated by resprouting species of trees where water yield may be unaffected or depleted for a short-period (e.g. < 10 years, Webb and Jarrett 2013, Heath et al. 2014; Nolan et al. 2015). Typically, crown cover in such forests is re-established within about five years after burning, irrespective of the level of fire intensity (e.g. Caccamo et al. 2015).

Given widespread heavy rainfall, both early (i.e. February) and continuing throughout 2020 and into early 2021 across the forested regions of eastern NSW, it is likely that there has been major movements of soils, debris and ash throughout catchments, with likely, consequent adverse effects on water quality and aquatic biodiversity. An indicator of this potential will be the area of ridge tops and upper slopes of forested catchments affected by the upper levels of fire severity during the 2019/20 season. The question remains whether such effects are compounding longer term syndromes of vulnerability and risk to CIFOA objectives concerning water quality and aquatic species (Silva et al. 2020). Therefore the overlap between these areas recently affected by high severity wildfires and longer term trends (e.g. areas of ridges, frequently and persistently burnt by wildfires) will provide some longer term perspective on risk and how it may have been changed by the 2019/20 fires.

Evaluation of current and future risks to the CIFOA

We use the diagnostics of disturbance regimes and their consequences outlined above to address the three project aims. First, we analyse past disturbance regimes and the way these changed as a consequence of the 2019/20 fires. Second, we evaluate the consequences of these disturbance regimes against the key diagnostics, including aspects of biodiversity, threatened species and catchment impacts. Third, we examine some possible future trends in fire weather and area burned under the influence of climatic change, along with potential changes in habitat for some threatened animal species. We briefly consider possible changes in management that may emerge from changes in policies and operations in the aftermath of 2019/20. We outline possible consequent effects on risks to core objectives of the CIFOA.

We use statements of CIFOA objectives and outcomes as the basis of each stage of our evaluation (Appendix 1), which cover: ecological function and landscape connectivity; biodiversity conservation; aquatic habitat and water quality; forest regeneration and structure; and monitoring. We use the general geographic domain of the CIFOA as a the frame of reference, noting that while the terms of the CIFOA are directed principally at State Forest tenure within this domain, a wider context that includes other land tenure types (i.e. Crown Lands, National Park estate, private land) is required to fully assess likely implications of the 2019/20 fires.

We evaluate syndromes of fire frequency as altered by the 2019/20 fires as well as patterns of fire severity resulting from the 2019/20 fires. We also examine the extent to which harvesting history intersected with aspects of fire frequency and intensity in order quantify its contribution to the overall disturbance regime. We focus on evaluation of consequences of extremes of these disturbance regimes in relation to the responses of species communities and ecosystem processes outlined above, given that such extremes are likely to create the greatest risk to achievement of the CIFOA objectives and outcomes. We also compare likely responses to disturbance regimes across land tenure to assess how the consequences of different management priorities may affect current and future risks to the CIFOA. This evaluation of disturbance regimes not only included changes across time and cross tenure comparisons but also comparisons across vegetation types and landforms. These provide the context for assessment of disturbance regime effects on species and ecosystem process.

1. Analysis of pre and post 2019/20 disturbance regimes

Methods

To assess disturbance regimes across the domain of the CIFOA in the steps outlined above we used vegetation information based on the classification of Keith (2004). Vegetation classified to class level was assessed using a 10 m raster derived from the State Vegetation Type Map as compiled by the NSW Department of Planning Industry and Environment (NSW DPIE), using a version provided by the NSW Natural Resources Commission (NSW NRC) as of early 2021.

All vegetation not classified as either forest or woodland formations (Keith 2004) was excluded, within the general boundaries of the area subject to the CIFOA. This includes a relatively small proportion of semi-arid woodland (circa 4,000 ha), mostly unaffected by the fires, that occurs on the western fringes of the CIFOA domain. All subsequent analyses were therefore based on retained forest and woodland vegetation, which for convenience is termed the forested domain. This was 83329 km^2 in area and equated to ~56 percent of the total CIFOA domain area.

Information on land tenure was provided by the NSW NRC. We divided land tenure in the study into four categories: State Forest, National Parks (including Nature Reserves and Conservation Areas), Crown Lands and Other (which included predominantly private land but some other categories of public land).

Table 1.1 Area of different land tenures and extent of the forest domain (i.e. all vegetation formations classified as forest and woodland) within tenure categories within the CIFOA domain.

Tenure	Total (km^2)	Forest (km^2)
Crown Land	3898	2443
National Park	37086	33712
Other	93157	33982
State Forest	15723	13193

Fire history data, including area burned during 2019/20, was provided by the NSW Bushfire Risk Management Research Hub which in turn was sourced from the NSW Rural Fire Service. These data were also used for analyses to support the NSW Independent Bushfire Inquiry, as outlined in relevant reports: https://www.bushfirehub.org/publications. This provided a chronology of fires dating back to approximately 1970. It is acknowledged that mapped fire history information was variable in quantity and quality, with early records being more incomplete and less precise than those collected since the 1990s. The bulk of the fire history information was originally derived from NSW National Parks and Wildlife Service and NSW Forestry Corporation mapping, though records from both sources encompass other land tenures. It is likely that records on private land are less complete throughout the chronology. Thus there is relatively high confidence about the accuracy of fire history information on State Forest and NPWS estates, but much lower confidence in the accuracy of information for other land tenures.

Mapping of the severity of the 2019/20 fires was sourced from Fire Extent and Severity Mapping (FESM) Version 3 (December 2020, NSW DPIE) at a resolution of 10 m. Information on harvesting was sourced from layers provided by the NSW Natural Resources Commission (NRC). All spatial data were converted to a common resolution of 25 m for all analyses provided in this report.

Areas containing harvesting, between 2000 and 2019, in State Forests, within the forested portion of the CIFOA domain, were located, based on mapping supplied via the NSW NRC. The data consisted of annual polygons that defined boundaries within which some harvesting had taken place in the nominated area. We did not discriminate the proportion and location of harvesting within each polygon, nor the type of harvesting. The polygons contained a variety of mapped vegetation, including riparian buffers that in many locations was mapped as rainforest. It is emphasized that vegetation such as rainforest and other riparian forest in these polygons, were explicitly excluded from harvesting under the conditions of the CIFOA: i.e. no harvesting occurred within them.

We examined the effects of the 2019/20 fires on all mapped vegetation formations within the mapped areas of State Forests subjected to harvesting. This analysis was done for the sum of all areas harvested between 2000 and 2019, as well as the sum of areas recently harvested prior to the 2019/20 fires season (i.e. 2014 to 2019).

A breakdown of patterns for each management area across the CIFOA domain, for both time periods, was also produced (Appendix 3).

Results

1.1 Fire regimes immediately prior to the 2019/20 season

1.1.1 Number of fires.

The number of fires over the 50-year period prior to 2019/20 followed a broadly similar pattern across all CIFOA domain land tenure categories (Fig. 1). In all cases, the majority of the area had few fires: i.e. zero, one or two fires. The National Park estate had less area unburnt (circa 20 percent zero fire) compared with the other tenure categories, particularly the ‘Other’ category which had circa 60 percent unburnt.

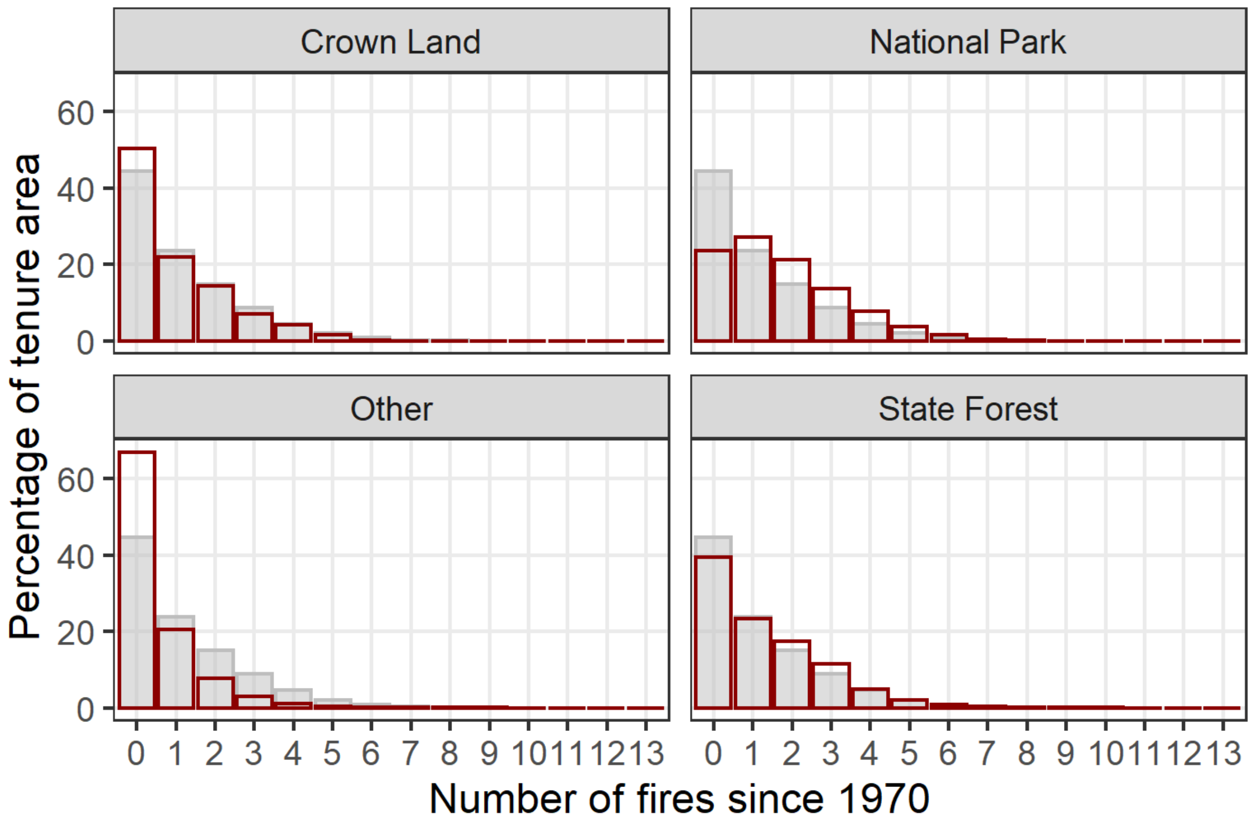


Figure 1.1 Number of fires recorded in the period 1970 to July 2019 across the forested portion of the CIFOA domain area. Grey bars indicate the pooled trend across all land tenure categories. Red bars indicate specific responses for each tenure category.

By contrast, the National Parks estate was more exposed to a relatively high numbers of fires (i.e. four or more fires) than other land tenures (Fig. 1.1). The reasons for this are potentially complex. For example, many National Parks are located in higher elevation hinterlands which are more prone to lightning ignitions than low elevation areas near the coast (Clarke et al. 2018). Also, many areas of National Park were formerly State Forest or Crown Land and have therefore experienced changes in fire history associated with changes in management practices.

1.1.2 Inter-fire intervals

The fire history chronology contains many localities where the interval between fires is incomplete. For example, the data commenced in 1970, thus with exception of a minority of area burnt in that year, the date of last fire prior to 1970 is unknown. Thus the passage of a fire after 1970, in such cases, results in an interval of unknown length: this is an incomplete or open interval. Many fire history studies censor such intervals by assuming that all intervals begin at the origin of the chronology irrespective of whether a fire occurred then or not. The same situation can occur at the other end of the fire history chronology, though in this case we can partially examine the patterns by documenting time since last fire (see below). Instances also occur where only one fire has occurred in a locality during the chronology. This leaves a pair of incomplete or open intervals at either end of the chronology. We did not censor intervals at the beginning of the chronology. Here we only report the patterns of the subset of intervals that were completed or 'closed' by the occurrence of two or more fires within the chronology.

In all land tenure types the vast bulk of completed inter-fire intervals were less than 30 years in length, with very few completed intervals in excess of this length. The distribution of intervals was 'left skewed' with the majority < 15 years in length (Fig. 1.2). The median interval between all fires ranged from seven to nine years across all land tenures in the forested portion of the CIFOA domain. The corresponding range of maximum intervals was 42 to 48 years, with a minimum of one year in all tenure categories.

Crown Land and State Forests had a greater proportion of their area subjected to relatively short inter-fire intervals (i.e. < 10 years) than the other land tenure types (Fig. 1.2).

The National Park estate had a greater proportion of completed intervals in the 20 to 30 year range compared with other land tenure types (Fig. 1.2).

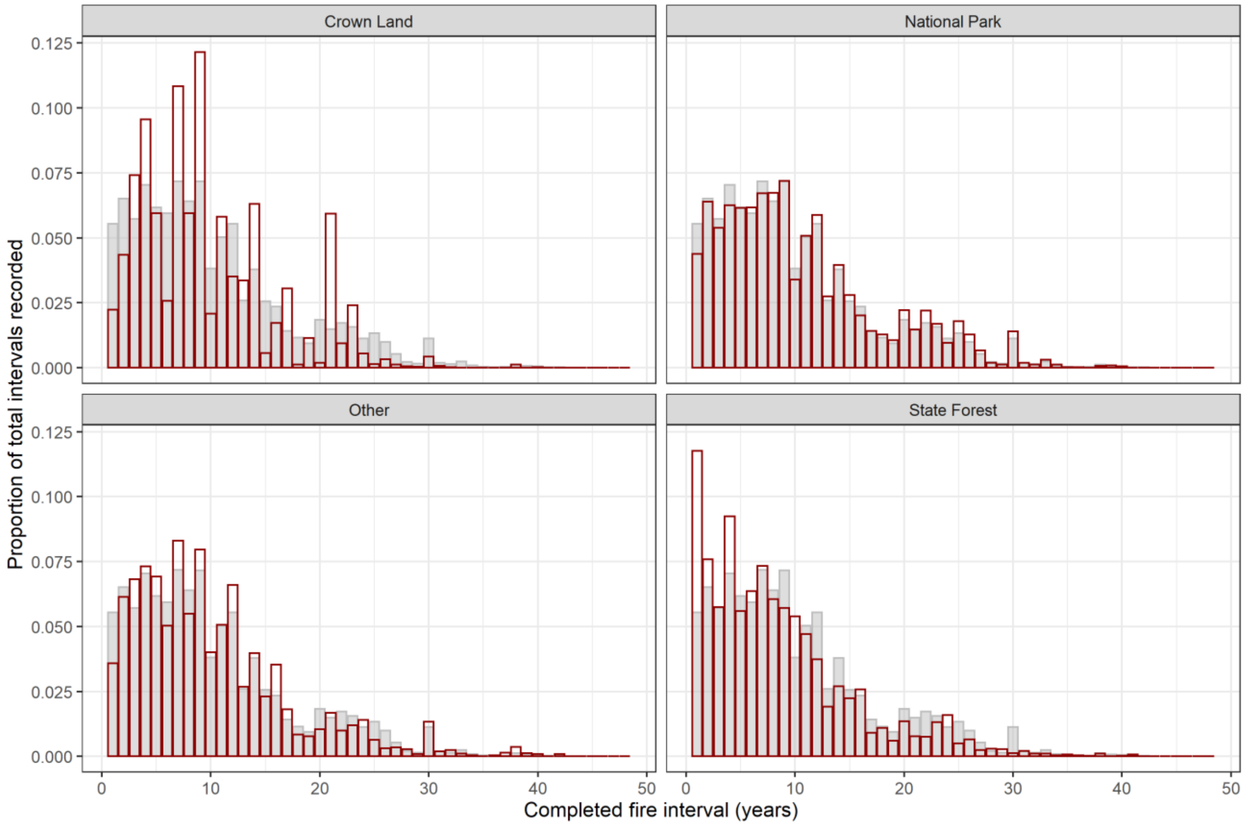


Figure 1.2 Proportion of area with completed inter-fire intervals of different length (1970 to July 2019) across the forested portion of the CIFOA area. Data are for all fires (planned and unplanned wildfires). Grey bars indicate the pooled trend across all land tenure categories. Red bars indicate specific responses for each tenure category.

1.1.3 Time since last fire

A relatively large proportion of the forested area of the CIFOA domain was long unburnt (> 50 years) in mid-2019, though there was considerable variation among land tenures (Figs. 1.1, 1.3). Greater proportions of Crown Land and the 'Other' category were long unburnt compared with State Forests and National Parks. Conversely, the proportion of recently burnt forest (e.g. < 10 years) was higher in National Parks and State Forests compared with the other categories. This is likely to reflect the outcome of recent large fire seasons (e.g. 2013/14) along with increased levels of prescribed burning for fuel reduction and risk mitigation: e.g. the Enhanced Bushfire Management Program undertaken by NSW NPWS.

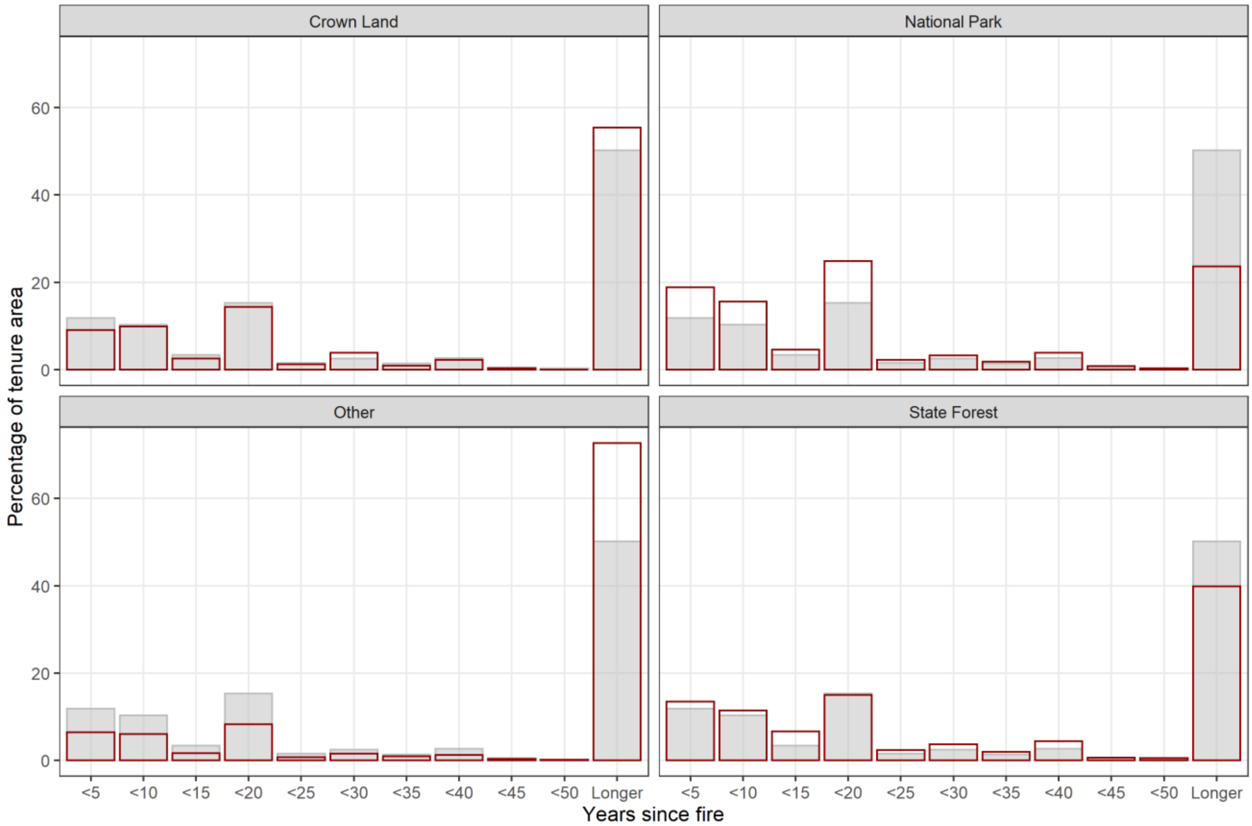


Figure 1.3. Proportion of forest in differing classes of time since last fire as of mid-2019, across land tenure categories within the CIFOA domain.

1.1.4 Fire frequency 'hotspots'

The overall area exposed to high frequency fire (> 4 fires of any type; ≥ 4 unplanned wildfires) was relatively small (< 11 percent) (Appendix Table 2.1), though this varied among vegetation formations and land tenure categories. As expected, given trends in number of fires, intervals and time since fire (see above), the exposure to high frequency fire was greatest in National Parks and State Forests. Dry and wet sclerophyll forest and forested wetlands were the most exposed to high frequency fire, in part reflecting their status as the most extensive formations.

In most combinations of land tenure and vegetation formation, the disparity between areas burnt by ≥ 4 fires of any type and ≥ 4 unplanned wildfires was relatively small. Some exceptions were the sclerophyll forest formations in State Forests and National Parks, where the disparity was wider (Appendix Table 2.1): i.e. there was greater area exposed to high frequency burning by all fire types than by wildfires only in these particular tenure/formation categories. This probably reflected relatively widespread use of prescribed fire in these land tenure categories.

On average < 2 percent of Crown Land and Other categories were exposed to high frequency fire, whereas for National Parks and State Forests the corresponding average area was 5 -10 percent.

The location of high frequency wildfire 'hotspots', as of mid-2019, was unevenly spread (Fig. 1.4). Concentrations of areas that had been frequently burnt were evident in both the northern and southern parts of the CIFOA domain, with a particular concentration in the vicinity of the lower Hunter and Central Coast hinterlands. Generally there was a similar pattern of area exposed to frequent burning by all fire types to that exposed to frequent fire resulting only from wildfires.

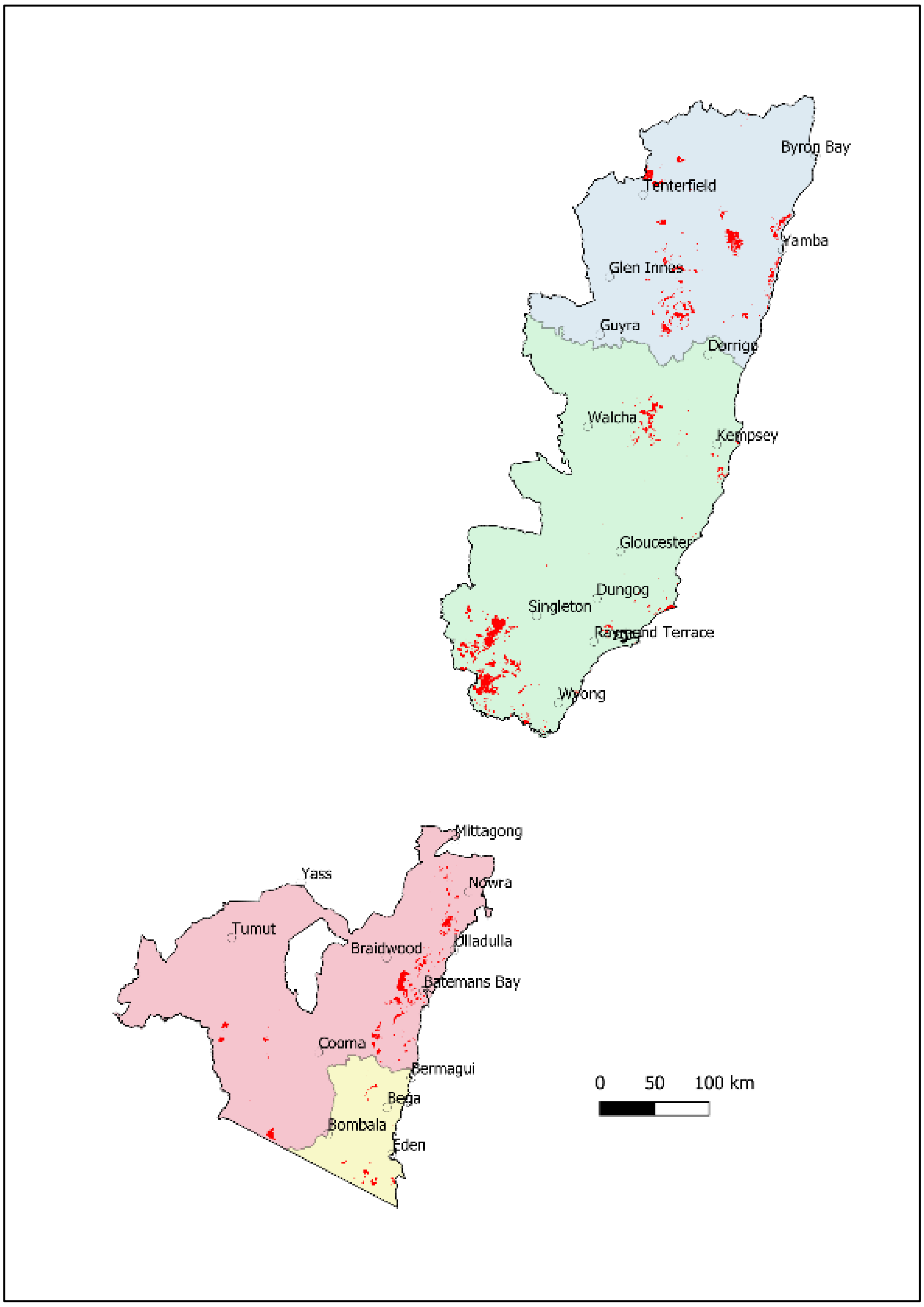


Figure 1.4a Location of high frequency fire 'hotspots' across the CIFOA, as of mid-2019, all fires.

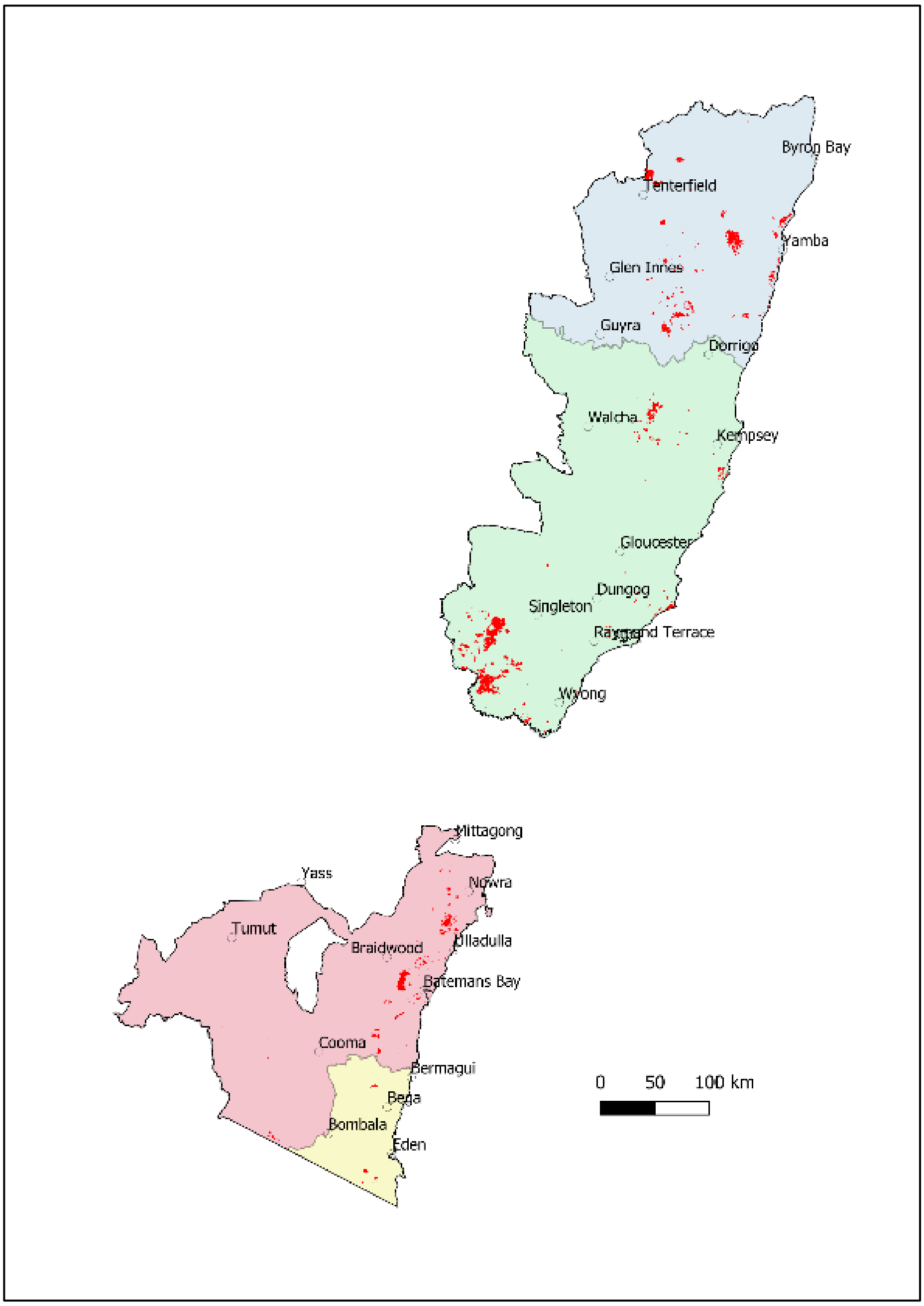


Figure 1.4b Location of high frequency fire 'hotspots' across the CIFOA domain, as of mid-2019, wildfires only.

1.2 Fire regimes resulting from the 2019/20 season

Large proportions of all land tenure types across the CIFOA domain were burned in the 2019/20 season (Table 1.2). The area burned in National Parks estate and State Forests (circa 60 percent) was approximately double that burned in the other land tenure categories. This in part was due to distribution of State Forests and National Park estate, which occupy a large areas near the coast, hinterlands and eastern parts of the ranges. As well, these types of land tenure occupy large intact areas of forest, in rugged terrain often with limited access. Thus fire spread can occur rapidly, resulting in large areas being burned.

Table 1.2 Area burned in the 2019/20 season across all land tenure categories for the forested portion of the CIFOA domain.

Tenure	Total Area (ha)	Area burnt (ha)	Percent burnt
Crown Land	192,835	63,724	33.0
National Park	3,085,929	1,868,044	60.5
Other	3,691,649	918,570	24.9
State Forest	1,243,808	737,516	59.3

1.2.1 Number of fires

Given the magnitude of the area burned in 2019/20 across all land tenure categories, the most immediate effect was a substantial reduction in the proportion of each category in the zero-fire category (Figs 1.5, 1.6). For example, the proportion of area in State Forests with zero fires was reduced by about 15 to 20 percent, in National Park estate by about 9 to 12 percent and in the Other tenure by about 12 percent. Commensurate shifts in other categories of number of fires occurred, particularly in the highest category ($\geq$ 4 fires) for both all fires and wildfires only: e.g. a 5 to 10 percent increase in National Park and State Forest estate (Fig. 1.6).

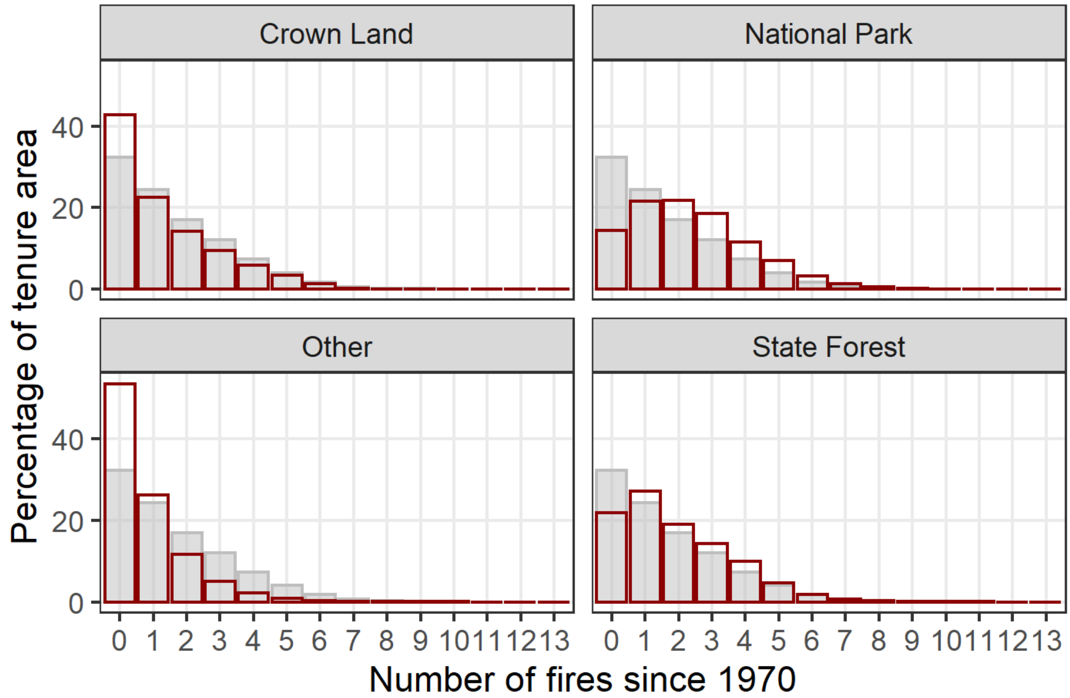
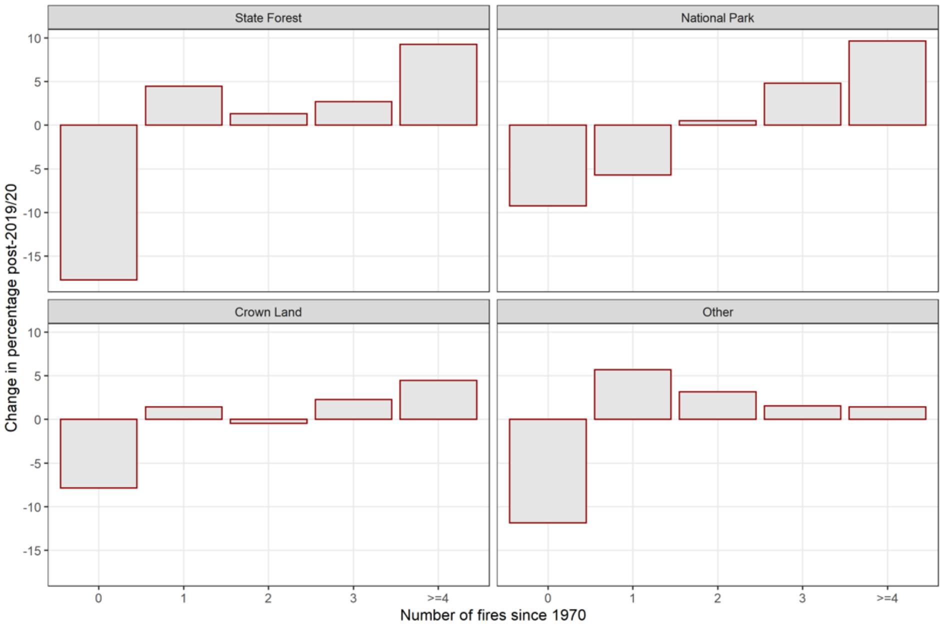


Figure 1.5 Number of fires recorded in the period 1970 to July 2020, including the effects of the 2019/20 season, across the forested portion of the CIFOA domain area. Grey bars indicate the pooled trend across all land tenure categories. Red bars indicate specific responses for each tenure category.

a)



b)

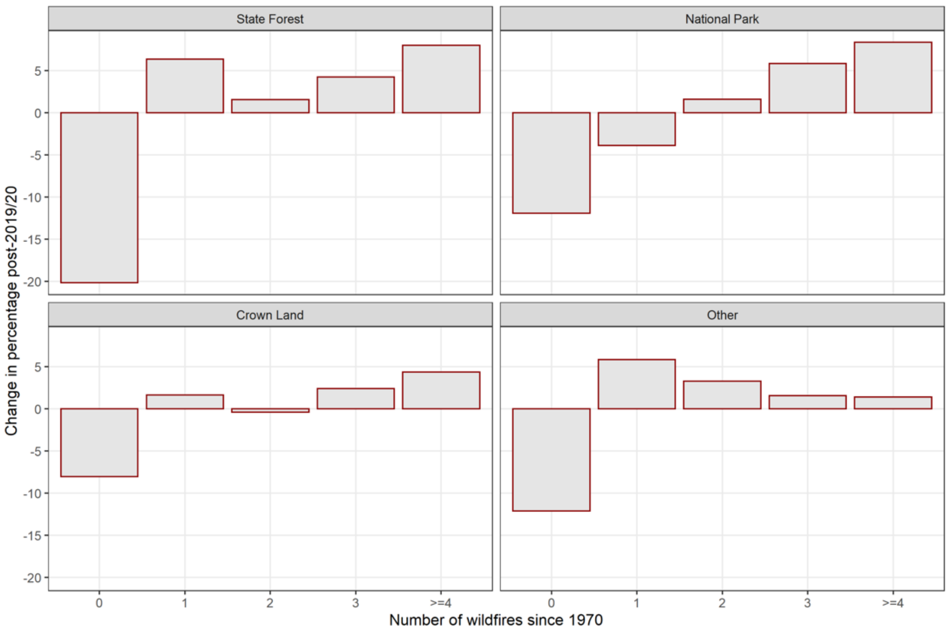


Figure 1.6 Changes in proportion of area with inter-fire intervals of different length (1970 to July 2020) across the forested portion of the CIFOA domain area, as a result of the 2019/20 fire season (i.e. change measured as July 2019 cf. July 2020). Data are for a) all fires (planned and unplanned wildfires); b) wildfires only.

1.2.2 Inter-fire intervals

While the overall distribution of the proportion of inter-fire intervals remained strongly 'left skewed' (Fig. 1.7), the 2019/20 fires substantially increased the proportion of intervals in the 15 to 20 year range (Fig.1.7) across all categories of land tenure. In part, this may have resulted from the burning across the relatively high proportion of area in the 15 to 20 year time since fire class in mid-2019 (Fig.1.3): i.e. the closure of intervals in this range.

Overall, however, the relative patterns of intervals between land tenure categories remained broadly similar to those in mid-2019.

Overall there was no major change in the median interval across all land tenure categories, compared with July 2019. This reflected the cancelling out of changes in proportions of shorter intervals (i.e. less than 25 years, Fig. 1.8) and the relatively small increase in longer intervals. The latter effect reflected the relatively small proportion of intervals in the 25 to 50 year range as of mid-2019 (Fig. 1.3). The median interval between all fires ranged from nine to 10 years across all land tenures in the forested portion of the CIFOA domain. The corresponding range of maximum intervals was 48 to 49 years, with a minimum of one year in all tenure categories.

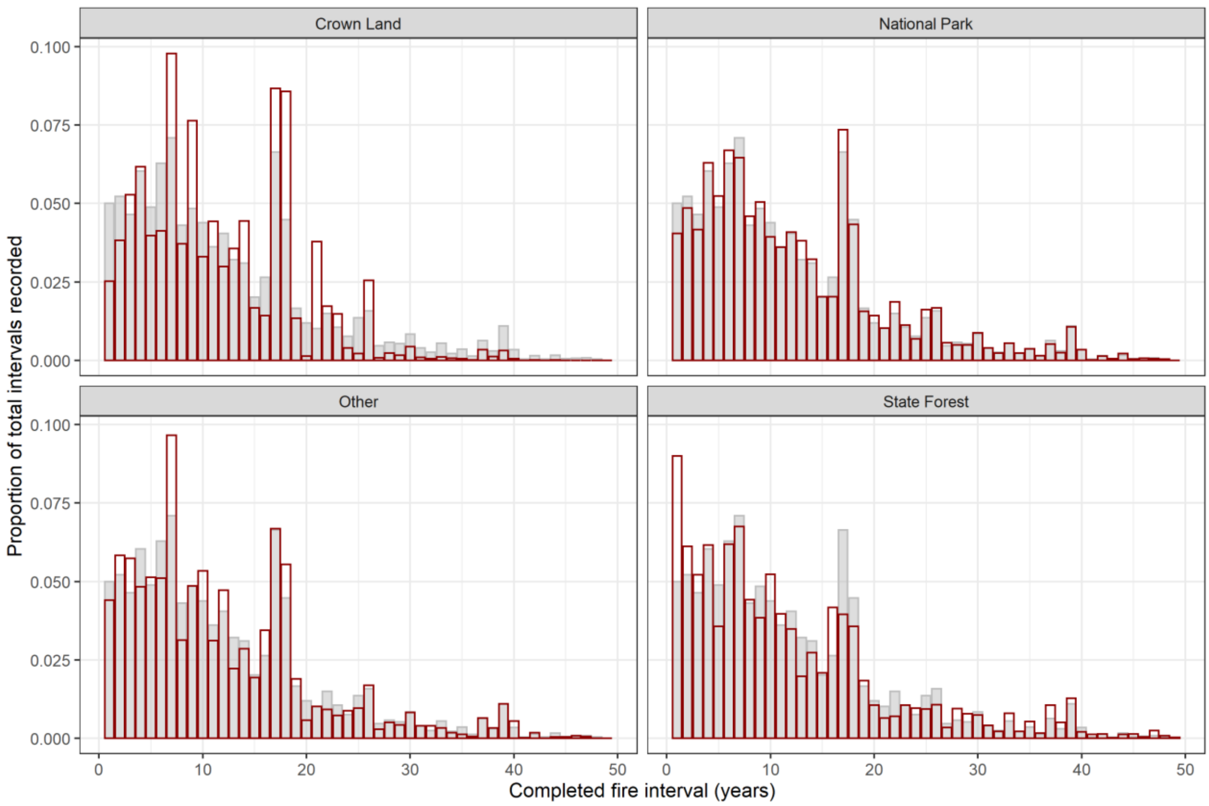


Figure 1.7 Proportion of area with inter-fire intervals of different length (1970 to July 2020) across the forested portion of the CIFOA area, incorporating the effects of the 2019/20 fire season. Data are for all fires (planned and unplanned wildfires). Grey bars indicate the pooled trend across all land tenure categories. Red bars indicate specific responses for each tenure category.

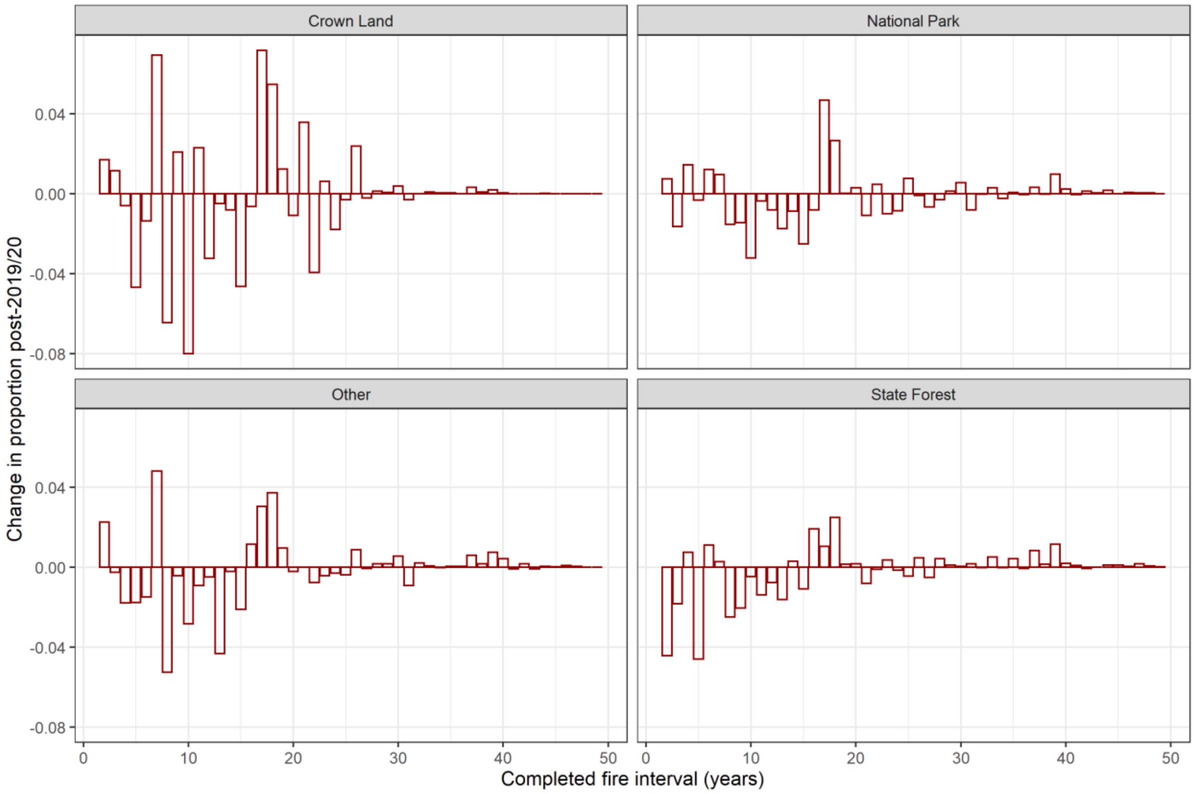


Figure 1.8 Changes in the proportion of inter-fire intervals across the forested portion of the CIFOA area, resulting from the 2019/20 season: i.e. change in the intervals as at July 2020 versus July 2019. Data are for all fires (planned and unplanned wildfires).

1.2.3 Time since last fire

As expected, there were major shifts in time since last fire in the aftermath of the 2019/20 fires (Fig. 1.9). About half of the total area of the CIFOA was shifted into the < 5 year since last fire category, though the proportions in National Parks and State Forests were higher (about 60 percent). This shift mainly came about through burning of intermediate categories of time since last fire. The proportions in the long unburnt category were only reduced by a relatively small amount in all land tenure categories: circa 10 percent. Thus in all land tenure categories, long unburnt proportions in excess of 20 percent remained after the 2019/20 fires.

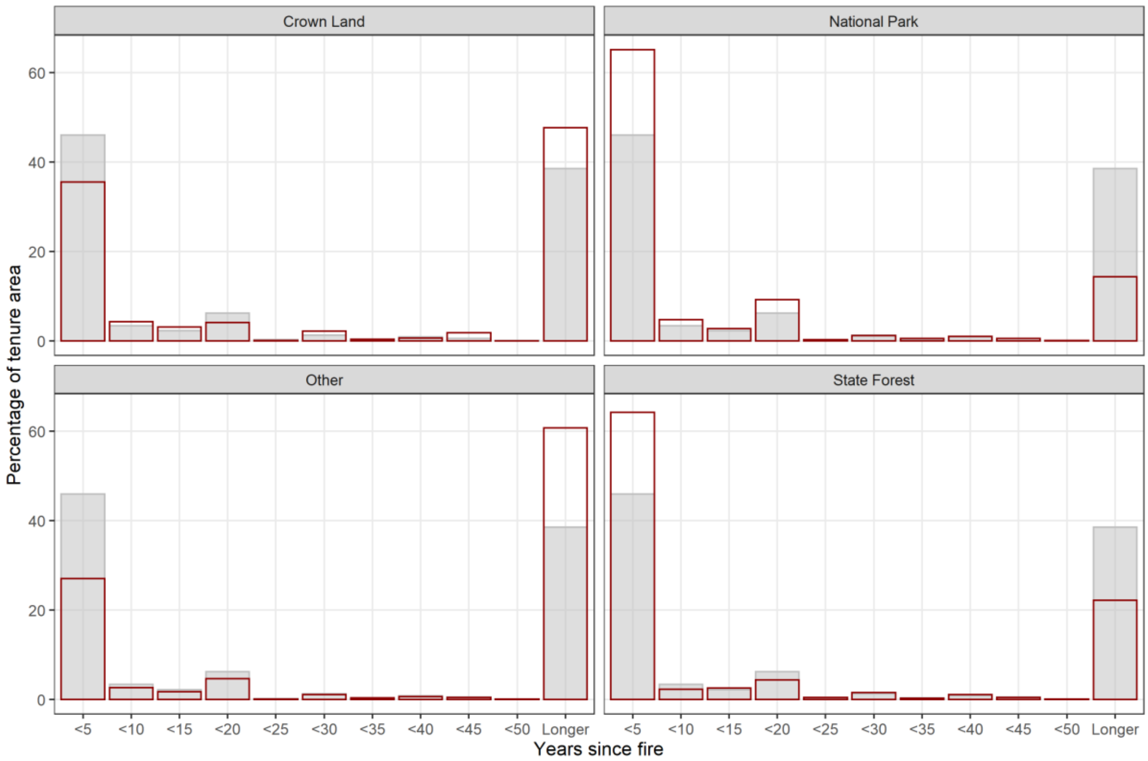


Figure 1.9 Proportion of forest in differing classes of time since last fire as of mid-2020, following the 2019/20 fire season, across land tenure categories within the CIFOA domain.

1.2.4 High frequency fire 'hotspots'

The 2019/20 fires substantially increased the area exposed to high frequency fire (up to 22 percent, Appendix Table 2.2). For example, the area of high frequency fire and high frequency wildfires doubled across the dry sclerophyll (shrubby sub-formation) category compared with mid-2019. Similar changes occurred in the other sclerophyll sub formations and forested wetlands. These large changes were consistent across all land tenure categories. While the overall area of rainforest is small, the 2019/20 fires resulted in a doubling of the area exposed to high frequency fire (up to 2.8 percent in National Parks, Appendix Table 2.2). The relative differences between > 4 fires of any type and > 4 unplanned wildfires remained similar to mid-2019 (Appendix Table 2.1).

On average < 5 percent of Crown Land and Other categories were exposed to high frequency fire, whereas for National Parks and State Forests the corresponding average area was > 10 percent.

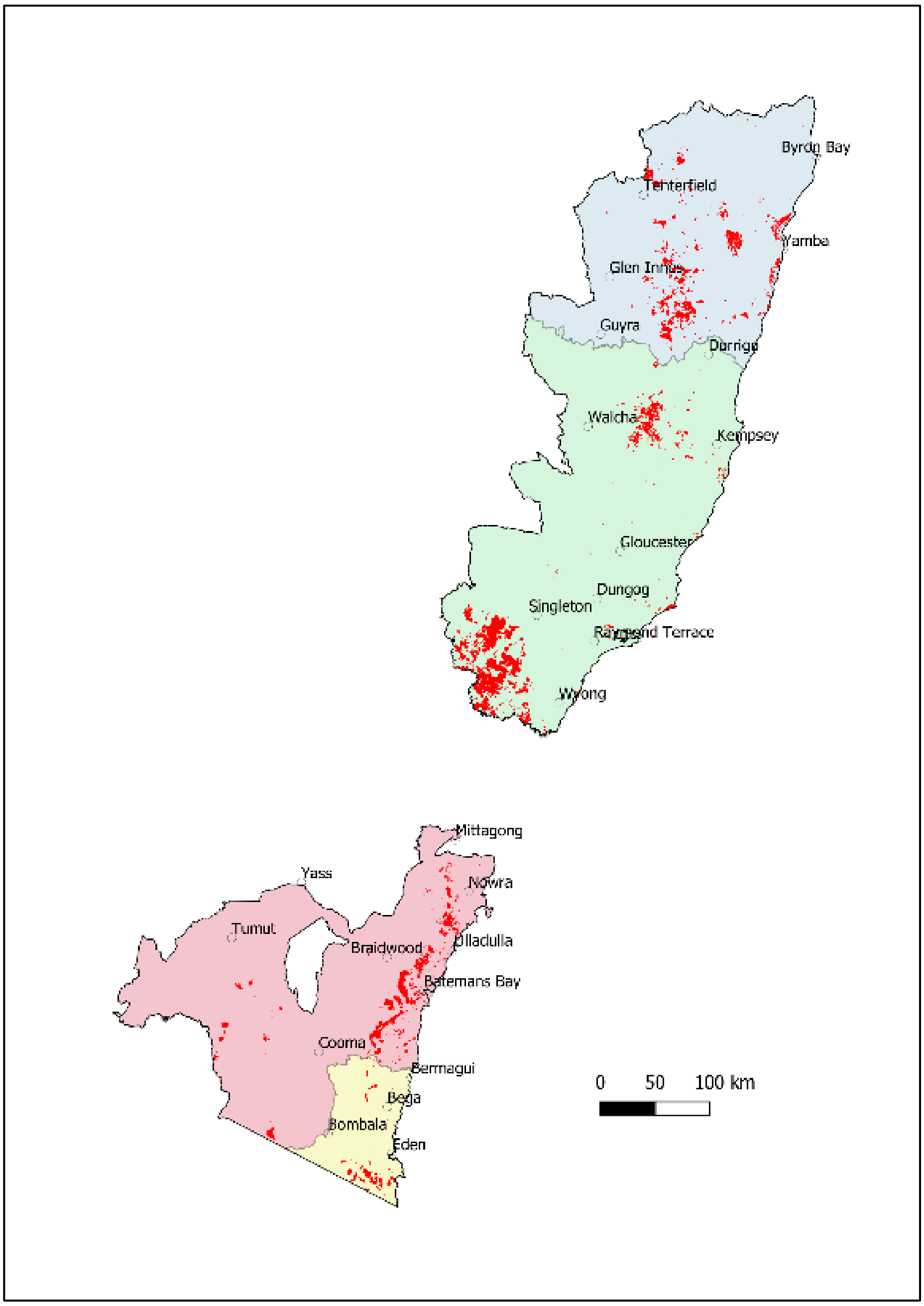


Figure 1.10a Location of high frequency fire 'hotspots' across the CIFOA domain, as of mid-2020, following the 2019/20 fire season, all fires.

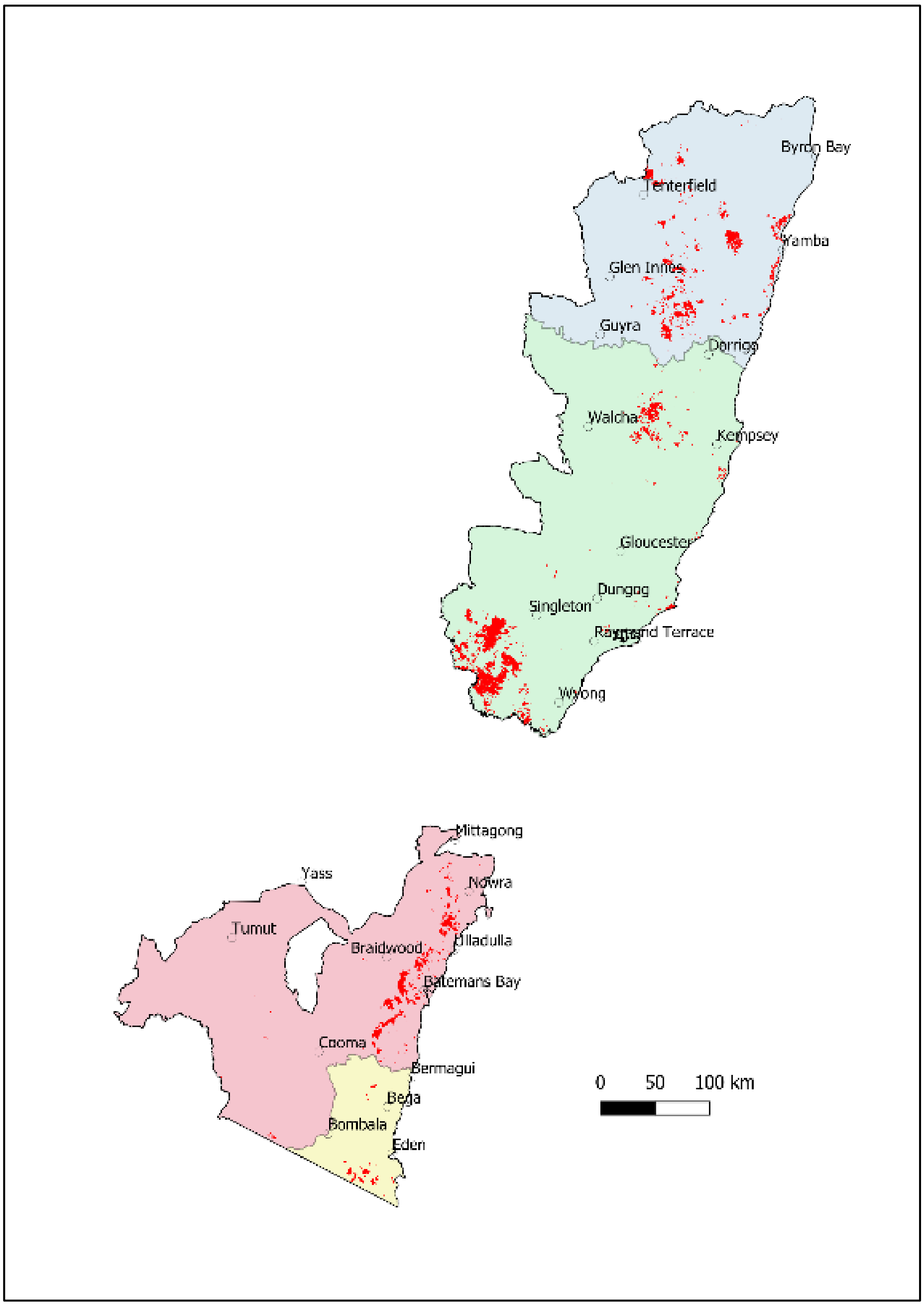


Figure 1.10b Location of high frequency fire 'hotspots' across the CIFOA domain, as of mid-2020, following the 2019/20 fire season, wildfires only.

These increases in the area high frequency fire resulted largely from an expansion of the location of the previous high frequency fire 'hotspots' that existed in mid-2019 (Fig. 1.4 cf. Fig. 1.10).

1.2.5 Severity of the 2019/20 fires and effects on fire regime

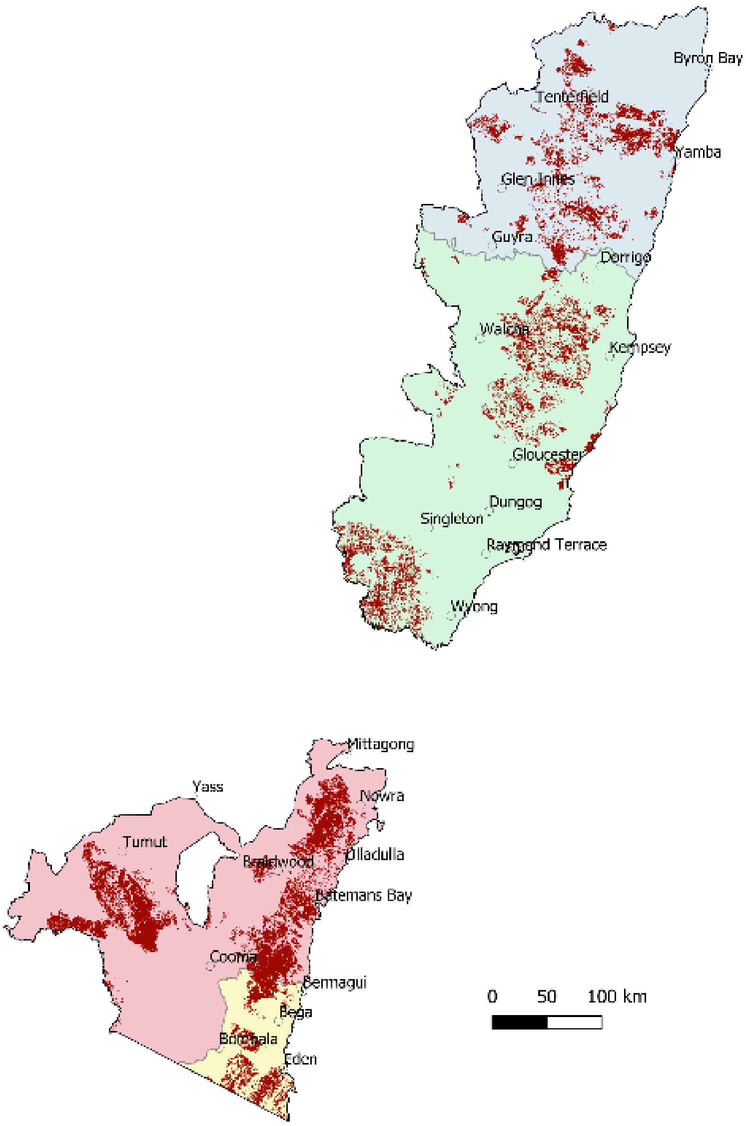


Figure 1.11. Patterns of high and extreme severity of the 2019/20 fires across the CIFOA domain, as derived from the FESM version 3 severity product.

Patterns of high and extreme severity within the 2019/20 fires were variable across the CIFOA domain (Fig. 11). A considerably greater area of these most severe categories was evident in the south and patches were larger and more homogenous. This reflected, in part, the conditions that prevailed during January 2020 when the fires in the south were burning (Williamson 2020).

Overall, an average of 14 percent of Crown Land, 27 percent of National Park estate, 24 percent of State Forests and 10 percent of the 'Other' land tenure were burnt at high and extreme severity. The remainder was either unburnt or burnt moderate severity.

Table 1.3 Patterns of burn severity in the 2019/20 fires in relation to land tenure and vegetation formations across the domain of the CIFOA domain.

Tenure	Formation	Total area (ha)	Unburnt area (ha)	Moderate area (ha)	High & Extreme area (ha)	High & Extreme percent
State Forest	Dry Sclerophyll Forests (Shrub/grass sub-formation)	182985.8	69868.5	61701.9	51415.4	28.1
State Forest	Dry Sclerophyll Forests (Shrubby sub-formation)	222642.5	67130.7	81321.1	74190.7	33.3
State Forest	Forested Wetlands	12419.9	5565.9	4283	2570.9	20.7
State Forest	Grassy Woodlands	29383.6	14406.1	7289.5	7688	26.2
State Forest	Rainforests	109137.1	50463	48092.8	10581.4	9.7
State Forest	Wet Sclerophyll Forests (Grassy sub-formation)	446516.8	171685.5	176616.8	98214.5	22
State Forest	Wet Sclerophyll Forests (Shrubby sub-formation)	325466.4	141161.8	110196.4	74108.2	22.8
National Park	Dry Sclerophyll Forests (Shrub/grass sub-formation)	520575.2	191605.9	157467.8	171501.6	32.9
National Park	Dry Sclerophyll Forests (Shrubby sub-formation)	947980.4	321044.8	313426.2	313509.3	33.1
National Park	Forested Wetlands	65260.9	37294.1	14066.9	13899.9	21.3
National Park	Grassy Woodlands	257426	145317.2	43547.1	68561.8	26.6
National Park	Rainforests	329701.2	179854.9	127095.5	22750.8	6.9
National Park	Wet Sclerophyll Forests (Grassy sub-formation)	766155.1	274053.9	301913.2	190188	24.8
National Park	Wet Sclerophyll Forests (Shrubby sub-formation)	485273.6	202869.5	165364.3	117039.8	24.1
Crown Land	Dry Sclerophyll Forests (Shrub/grass sub-formation)	48789.5	35019.2	8526.5	5243.8	10.7
Crown Land	Dry Sclerophyll Forests (Shrubby sub-formation)	96927.3	66493.6	15232.5	15201.2	15.7
Crown Land	Forested Wetlands	14342.3	10772.6	2627.9	941.8	6.6
Crown Land	Grassy Woodlands	50420.8	47004.8	2107.9	1308	2.6
Crown Land	Rainforests	8467.3	4393.1	2749.7	1324.5	15.6
Crown Land	Wet Sclerophyll Forests (Grassy sub-formation)	47662	21144.4	14318.4	12199.2	25.6
Crown Land	Wet Sclerophyll Forests (Shrubby sub-formation)	11014.8	6909.8	2460.4	1644.6	14.9
Other	Dry Sclerophyll Forests (Shrub/grass sub-formation)	1106243.7	774668.6	189162.9	142412.2	12.9
Other	Dry Sclerophyll Forests (Shrubby sub-formation)	806939.7	616738.3	109209.5	80991.9	10
Other	Forested Wetlands	211347	166399.4	31645.4	13302.2	6.3
Other	Grassy Woodlands	888089.4	814357.6	42483.9	31247.9	3.5
Other	Rainforests	266517.8	201540.2	46964.1	18013.5	6.8
Other	Wet Sclerophyll Forests (Grassy sub-formation)	864792.1	556538.6	183011.2	125242.3	14.5
Other	Wet Sclerophyll Forests (Shrubby sub-formation)	397599.9	272615.1	75333.8	49651.1	12.5

Relatively large areas of the various wet and dry sclerophyll forest formations were exposed to the upper levels of burn severity (Table 1.3) across land tenure categories, (e.g. > 30 percent of dry sclerophyll and > 20 percent of wet sclerophyll in State Forests and

National Parks). A high proportion of grassy woodland and forested wetlands (> 20 percent) burned at high and extreme severity in State Forests. While the overall area of rainforest was relatively small, about 5 to 15 percent burned at high and extreme severity across the land tenure categories.

Table 1.4 Patterns of burn severity in the 2019/20 fires in relation to land tenure and landform across the domain of the CIFOA domain.

Tenure	Landform	Total area (ha)	Unburnt (ha)	Moderate (ha)	High & Extreme (ha)	High & Extreme percent
State Forest	ridge/upper-slope	667084.8	260151.6	234222.6	172710.6	25.9
State Forest	valley/lower-slope	661750.7	260409.6	255278.2	146062.9	22.1
National Park	ridge/upper-slope	1723735.8	688655.2	532111.1	502969.4	29.2
National Park	valley/lower-slope	1649340.8	664248.1	590705.3	394387.4	23.9
Crown Land	ridge/upper-slope	141337.8	98604.7	21033.4	21699.8	15.4
Crown Land	valley/lower-slope	136211.8	93064.9	26984.4	16162.4	11.9
Other	ridge/upper-slope	2280390.9	1721535.2	308746.2	250109.6	11
Other	valley/lower-slope	2263113	1682489.1	369332.2	211291.7	9.3

Ridges and upper slopes were slightly more prone to high and extreme burn severity in the 2019/20 fires, across all land tenure categories (Table 1.4). About 20 to 30 percent of the area of ridges and upper slopes in State Forests and National Parks experienced these upper levels of burn severity.

Overall, 4.8 percent of total area of the CIFOA domain was exposed to high frequency fire plus high severity fire in 2019, made up of 2.8 percent and 2.0 percent exposure on ridges/upper slopes and valley/lower slopes respectively. The corresponding area of the CIFOA domain exposed to the combination of high frequency antecedent wildfires and high severity in the 2019/20 fires was 4 percent. This was composed of 2.3 percent ridges/upper slopes and 1.7 percent valley/lower slopes.

Table 1.5 Distribution of fire severity extremes of the 2019/20 fires across landform classes within the area exposed to high frequency wildfires (≥ 4 wildfires; wildfire hotspots). Presence of harvesting within the last 20 years is indicated for State Forests.

Tenure	Landform	Harvested	Total area (ha)	Unburnt (ha)	Unburnt percent	Moderate (ha)	Moderate percent	High & extreme (ha)	High & extreme percent
State Forest	ridge/upper-slope	no	87655	7774	8.9	45937	52.4	33944	38.7
State Forest	ridge/upper-slope	yes	35963	2028	5.6	19670	54.7	14264	39.7
State Forest	valley/lower-slope	no	96110	7574	7.9	55692	57.9	32844	34.2
State Forest	valley/lower-slope	yes	18611	1218	6.5	10658	57.3	6734	36.2
National Park	ridge/upper-slope	N/A	425699	59770	14	180146	42.3	185784	43.6
National Park	valley/lower-slope	N/A	367871	49432	13.4	187251	50.9	131188	35.7
Crown Land	ridge/upper-slope	N/A	14480	1748	12.1	5255	36.3	7477	51.6
Crown Land	valley/lower-slope	N/A	12354	1373	11.1	6373	51.6	4609	37.3
Other	ridge/upper-slope	N/A	67260	10252	15.2	32809	48.8	24199	36
Other	valley/lower-slope	N/A	62156	8988	14.5	35174	56.6	17993	28.9

Between about a third and half of the ridges and upper slopes exposed to high frequency wildfires (area of wildfire hotspots) were burnt at the highest categories of fire severity by the 2019/20 fires (Table 1.5). The proportion of wildfire hotspots on ridges/upper slopes burnt at high/extreme severity was higher on Crown Lands and National Parks than State Forest and the Other land tenure category. The proportion of wildfire hotspots in valleys and lower slopes that burned at high/extreme severity was slightly lower in all land tenure categories (29 to 36 percent).

By contrast, the proportion of area of wildfire hotspots burnt at moderate severity was higher in State Forests than National Park estate, across all landform categories. However the converse applied to unburnt areas of wildfire hotspots: their area was greater in National Parks estate than State Forests.

1.2.6 2019/20 fire patterns in relation to harvesting

Fire severity patterns in wildfire hotspots within State Forests were unrelated to harvesting within the last 20 years, across both landform types (Table 1.5)

The total area of State Forest within the forested portion of the CIFOA domain considered for further exploration of patterns of burning across vegetation formations and havresting history was 1,328,550 hectares, with 22 percent of that area being mapped as containing some harvesting between 2000 and 2019. The wet sclerophyll forest formations comprised the bulk of State Forest within this portion of the CIFOA domain (> 55 percent of the area, Table 1.6), with the remainder consisting mostly of dry sclerophyll forest formations (circa 31 percent, Table 1.6). Rainforests were the next most common formation (8 percent, Table 1.6).

Table 1.6 Patterns of burning and severity during 2019/20 across vegetation formations within areas of State Forests across the CIFOA domain in which harvesting occurred (2000 to 2019).

Forest formation	Area within SF ha (percent SF)	Area within harvesting zones within SF ha (percent SF)	Percent Unburnt 2019/20 within harvested & unharvested portions	Percent Low/ Moderate severity 2029/20 within harvested & unharvested portions	Percent High/extreme severity 2029/20 within harvested & unharvested portions
Dry Sclerophyll Forests (Shrub/grass sub-formation)	182986 (13.8)	34521 (18.9)	Unharvested: 38.2 Harvested: 37.9	Unharvested: 33.4 Harvested: 35.0	Unharvested: 28.3 Harvested: 27.1
Dry Sclerophyll Forests (Shrubby sub-formation)	222642 (16.8)	37377 (16.8)	Unharvested: 31.0 Harvested: 25.9	Unharvested: 36.3 Harvested: 37.8	Unharvested: 32.7 Harvested: 36.3
Forested Wetlands	12419 (0.9)	1054 (8.5)	Unharvested: 43.4 Harvested: 60.5	Unharvested: 35.8 Harvested: 20.5	Unharvested: 20.9 Harvested: 19.0
Grassy Woodlands	29384 (2.2)	2608 (8.9)	Unharvested: 50.3 Harvested: 36.5	Unharvested: 24.1 Harvested: 32.1	Unharvested: 25.7 Harvested: 31.4
Rainforests	109137 (8.2)	8225 (7.5)	Unharvested: 45.8 Harvested: 51.2	Unharvested: 44.6 Harvested: 37.1	Unharvested: 9.5 Harvested: 11.7
Wet Sclerophyll Forests (Grassy sub-formation)	446516 (33.6)	127966 (28.7)	Unharvested: 37.3 Harvested: 41.3	Unharvested: 41.1 Harvested: 35.7	Unharvested: 21.6 Harvested: 23.1
Wet Sclerophyll Forests (Shrubby sub-formation)	325466 (24.5)	77162 (23.7)	Unharvested: 43.4 Harvested: 43.3	Unharvested: 34.6 Harvested: 31.6	Unharvested: 22.0 Harvested: 25.1

The proportions of formations within the area mapped as containing some harvesting (2000 to 2019) varied widely, with wet and dry sclerophyll forests comprising the bulk of area containing harvesting (circa 25 percent and 18 percent respectively) (Table 1.6). The area mapped as containing some harvesting covered a minor proportion of the other formations within State Forests (about 7 to 9 percent each).

Overall, the 2019/20 burned more than 50 percent of the area occupied by the major vegetation formations within State Forests, across the forested portion of the CIFOA domain (Table 1.6). The proportion burned in the dry sclerophyll forest formations was generally higher (up to 75 percent) compared with the wet sclerophyll forest formations (up to 63 percent). High proportions of the other formations also burned (circa 40 to 60 percent range).

The proportion of unburnt area was marginally higher in unharvested areas than in areas mapped as containing some harvesting (2000 to 2019) in all formations (Table 1.6), except rainforests, forested wetlands and wet sclerophyll forest (grassy sub-formation). In these formations a greater proportion of the mapped area containing harvesting was unburnt.

The bulk of the area mapped as containing some harvesting from 2000 to 2019 burned (i.e. > 50 percent), with the exception of forested wetlands (circa 40 percent burned) (Table 1.6). The burnt area containing some harvesting (2000 to 2019) was about evenly split between the low to moderate and high and extreme categories of severity across all formations, except rainforests. In the latter case, more the proportion of area burned at low to moderate severity was more than double that burned at high to extreme severity.

The area mapped as containing some recent harvesting (2014 to 2019) comprised between about 20 to 40 percent of the area mapped as containing some harvesting from 2000 to 2019 (Tables 1.6, 1.7). Generally the proportion of areas containing some recent harvesting that remained unburnt during 2019/20 was lower compared with the total area subjected to some harvesting between 2000 to 2019 (Tables 1.6, 1.7). The proportions burned at low and moderate versus high and extreme severity were similar in areas containing some recent harvesting, except in rainforests (lower proportion of high and extreme severity) and wet and dry sclerophyll forests (shrubby sub-formations) where a greater proportion burned at high and extreme severity (Table 1.7).

Table 1.7 Patterns of burning and severity during 2019/20 across vegetation formations within areas of State Forests across the CIFOA domain in which recent harvesting occurred (2014 to 2019). Areas containing some recent harvesting are a subset of the data contained in Table 1.6.

Forest formation	Area within harvesting zones (since 2014) within SF ha (Percent SF)	Percent Unburnt 2019/20 within harvested & unharvested portions	Percent Low/Moderate severity 2019/20 within harvested & unharvested portions	Percent High/extreme severity 2019/20 within harvested & unharvested portions
Dry Sclerophyll Forests (Shrub/grass sub-formation)	6238 (3.4)	Harvested: 22.9	Harvested: 37.5	Harvested: 39.6
Dry Sclerophyll Forests (Shrubby sub-formation)	9551 (4.3)	Harvested: 14.7	Harvested: 34.9	Harvested: 50.4
Forested Wetlands	196 (1.6)	Harvested: 39.6	Harvested: 32.9	Harvested: 27.5
Grassy Woodlands	336 (1.1)	Harvested: 21.8	Harvested: 27.8	Harvested: 50.4
Rainforests	2838 (2.6)	Harvested: 45.7	Harvested: 39.0	Harvested: 15.3
Wet Sclerophyll Forests (Grassy sub-formation)	40863 (9.2)	Harvested: 44.5	Harvested: 28.6	Harvested: 26.9
Wet Sclerophyll Forests (Shrubby sub-formation)	23068 (7.1)	Harvested: 37.2	Harvested: 27.2	Harvested: 35.6

There was widespread variation in patterns of burning and fire severity during the 2019/20 fires, across State Forests within the CIFOA Management Areas, both within the general areas mapped as containing some harvesting from 2000 to 2019, and in areas containing more recent harvesting (Appendix 3).

Implications of fire regime patterns

Extreme disturbance regimes such as high frequency of fire, long-term absence of fire and high intensity of fire can pose risks to the objectives and outcomes of the CIFOA. Prior to 2019/20 syndromes of extreme fire frequencies were evident across the CIFOA domain but also a large proportion of all land tenure categories remained long unburnt. Each extreme of these fire regimes poses risks to differing entities and functions underpinning the CIFOA objectives.

The 2019/20 altered these syndromes, by effectively doubling the area exposed to high frequency fire, through large scale occurrence of high intensities of fire (e.g. about 25 percent of State Forests and National Parks estate) as indicated by fire severity information. Importantly, the magnitude of the fires created a state of heightened vulnerability to future high frequency disturbance by wildfires, reflected in major changes in the time since fire distribution pre and post 2019/20: i.e. more than half of State Forests and National Parks left in < 5 year since last fire class. Importantly this shift only came through a partial diminution of the area that was long unburnt (about 10 percent reduction). This reflected the fact that the fires spread through virtually all stages of time since fire, as extant pre 2019/20, as a function of exceptional dryness and unrelenting adverse fire weather conditions during the 2019/20 season. The overall result of these changes to fire regimes is greatly elevated risk to the CIFOA objectives and outcomes, particularly in the short-term: i.e. next 5 to 10 years.

The magnitude of these effects has obvious negative implications for the connectivity objectives of the CIFOA, with relevance to maintenance of species, positioning of harvesting operations, and water quality. Some of the general implications of heightened risk are illustrated by the exposure of different land form classes within the major vegetation formations to both disturbance frequency hotspots resulting from the 2019/20 and the corresponding exposure to these fires in general and to high and extreme fire severity in particular: i.e. 20 to 30 percent of the area of both ridges/upper slopes and valleys/lower slopes were exposed to these highest levels of fire severity in State Forests and National Parks estate, in approximately equal measure. The evenness of this exposure across these landform categories again reflects the exceptional nature of fire spread during 2019/20 and the underpinning of widespread, homogeneous dryness in particular. Thus key areas such as riparian buffer zones, wet forest refugia, young post-harvest regrowth and soil/slope combinations prone to erosion have potentially been affected to a major degree.

While exposure of rainforest to the 2019/20 is of concern, the general patterns of fire regimes culminating in large areas burned in 2019/20 within the main sclerophyll forest formations in National Parks estate and State Forests poses high levels of risk to the CIFOA objectives and outcomes. Key short issues are likely to be the loss of hollow bearing trees, compromised regeneration in areas burnt and/or harvested shortly before 2019/20 fires, carbon loss and the exposure of wet forest refugia to burning. The similarity in fire regime patterns and area affected by the 2019/20 fires across both land public means that the burden of risk to CIFOA objectives and outcomes is equally shared. It may also place major constraints on planning and recovery options, which may be exacerbated in the medium term if the climatic conditions governing the 2019/20 fires season are to return in the near future. Further aspects of these patterns are explored below and the following sections.

The examination of 2019/20 fire severity patterns across areas mapped as containing harvesting within State Forests across the CIFOA indicated a high level of potential impact on forest regeneration, structure and habitat values which are likely to pose significant risks to the CIFOA objectives and outcomes.

Previous analyses covering the entire State Forest estate estimated that on average about 50 percent of the area containing some harvesting since 1985 had been exposed to high and extreme severity fire in the 2019/20 fires (NSW DPI 2020). Our analyses showed mostly lower but nonetheless important levels of exposure to crown damaging fires (high and extreme severity) particularly within the dry and wet sclerophyll forest formations where harvesting has been mostly focussed in the last 20 years. Our overview also did not show a strong difference in proportion burnt and exposure to different fire severity levels across both recently harvested (i.e. 2014 to 2019) or longer term harvested (2000 to 2019) areas. Similar conclusions have been reached in other studies (DPI 2020, Bowman et al. 2021). The overwhelming factor that appears to have governed patterns of burning across major vegetation formations, land tenure types (e.g. the general equivalence of severity across State Forests and National Parks estate in the major sclerophyll forest types) was the extremity of drought and unrelenting nature elevated fire weather during the 2019/20 season (Clarke 2020; Nolan 2020c; Bowman et al. 2021).

The extent of burning in general and high intensity fire in particular (i.e. high and extreme severity) in recently harvested areas may have had adverse effects on regeneration. Seedlings and juveniles of eucalypts may take some years to reach a size where they acquire tolerance to fire via a well-developed lignotuber (Noble 1984; Burrows 2013) or stems of sufficient size to initiate epicormic resprouting (e.g. *E. sieberi*, Bridges 1983). Seed stocks in recently harvested areas may also be jeopardised by subsequent fires (NSW Forestry Commission 1982). Thus the areas which burned in 2019/20 and contained recent harvesting (2014 to 2019) may be considered particularly vulnerable, though general adverse effects on regeneration across other harvested areas (2000 to 2019) are possible. Such effects on regeneration may be relatively long lasting, particularly given their magnitude as summarised here and elsewhere (DPI 2020).

We discriminated significant areas of rainforest within areas mapped as containing some harvesting. These rainforests and some components of wet sclerophyll forests are likely to compose the bulk of riparian buffer zones in areas subjected to harvesting under the CIFOA conditions. Given that about half of these rainforests burnt both within areas containing recent harvesting and in unharvested areas within State Forests (Tables 1.6, 1.7) it is likely that the integrity of riparian areas has been widely compromised. This specifically illustrates the more general concerns arising from the high proportion of lower slope/valley landform class that was burned in 2019/20, discussed above. These patterns of burning within State Forest riparian areas may not only place at risk their purpose and function in relation to recent harvesting but may limit their potential functioning, during the recovery phase, in relation to future harvesting.

2. Impacts and consequences of the 2019/20 fires on biodiversity and catchments

2.1 Analyses of plant biodiversity thresholds

Methods

A system of 'thresholds of potential concern' is used in NSW (e.g. NSW Government 2012), and elsewhere (e.g. Tolerable Fire Intervals, https://www.safertogether.vic.gov.au/, Cheal 2010; South Africa e.g. Kraaij et al. 2013), to interpret the potential effects of fire frequency on the status of plant biodiversity for fire management and planning. This approach couples observations of the fire response of plant species, their life history traits and consequent ability to tolerate variations in fire frequency, with state-wide vegetation mapping. This coupling allows predictions to be generated, locally as well as at landscape and regional scales. The approach is used to categorise the potential condition of vegetation (see below) as a result of the patterns of fire frequency that prevail at any point in time.

These simple categories reflect the potential responses of the species that are most vulnerable to fluctuations in fire frequency, namely obligate seeders (i.e. non-resprouting species) that rely on either *in situ* seed storages for post fire recovery or dispersal of seeds from neighbouring unburnt areas. In the former case, species with storages of seeds that tend to be exhausted by post-fire germination, fall into the most vulnerable category (Bradstock and Kenny 2003, Pausas et al. 2004). Plant species regarded as less vulnerable to variations in fire frequency are those that resprout following fire and those that possess seed storages that are not fully exhausted through post-fire germination (Kenny et al. 2004; Bradstock and Kenny 2003).

Obligate seeder species that rely on post-fire germination and seedling survival for persistence are vulnerable to a recurrence of fire before they begin to flower and set seed. Thus frequent fire can deplete populations of these species. Obligate seeders which depend on fire for successful seedling establishment are also vulnerable to long periods without fire. If mature plants senesce before fire re-occurs, establishment and recruitment of new juveniles may be inhibited, resulting in population decline or even loss.

Thus the time to maturation (juvenile period) and life-span of obligate seeders are critical life history attributes that can be used to demarcate the range of fire frequencies that may be compatible with persistence of populations of species of this type. Information on these key life history attributes can be used to establish 'thresholds of potential concern' that demarcate this domain of fire frequency. Analyses of variations in these attributes among groups of obligate seeders known to occur within the range of particular vegetation types can be used to tailor 'thresholds' to suit.

Many studies have characterised plant species into four basic life history types (i.e. all combinations of +/- resprouting; +/- persistent seedbanks) and explored the sensitivity of these types to fire frequency and other environmental (e.g. moisture gradients) variations (e.g. Pausas and Bradstock 2007; Clarke et al. 2005, 2013, 2015; Hammill et al. 2016), across different morphological groups (i.e. trees, shrubs, herbs). In local, fire prone vegetation, the obligate resprouting group (+ resprouting, - persistence seedbank) is comprised of relatively few species, especially compared with similar fire-prone, temperate vegetation on other continents (Keeley et al. 2011). Most species, across all morphological types fall into the obligate seeder (- resprouting, + persistent seedbank), facultative resprouter (+resprouting, + persistent seedbank), with obligate recolonisers (- resprouting, - persistent seedbank) being represented by a few herb species (e.g. circa 1 percent of species, Hammill et al. 2016). In local forests and sclerophyll shrublands, resprouters dominate (e.g. circa 50 to 90 percent of species, Clarke et al. 2005, Hammill et al. 2016).

Thus the ‘thresholds of potential concern’ system is focussed on the known diagnostics of the minority, obligate seeder component of any particular vegetation type. There are a number of key assumptions and limitations of this system. First, it assumes that populations of resprouter species and or those with 'non-exhausted' seedbanks are robust and buffered against changes in fire frequency. Second, it relies on comprehensive attribution of species into functional types, based on suitable observations and data collection. Third, it assumes fidelity of responses of key attributes of species across time, space and underlying environmental variations. Fourth, fire history patterns are mapped and interpreted with high levels of accuracy and precision. None of these assumptions are completely satisfied in reality, introducing many uncertainties into predictions. Some of these are discussed further below in relation to the results of analyses. Nonetheless the underlying principles have proved amenable to successful empirical testing at a wide range of scales: e.g. Pausas et al. (2004), Clarke et al. (2005), Keith et al. (2007), Clarke et al. (2015). Further discussion of the appropriate use and interpretation of results is given below.

It should be emphasised that the ‘threshold’ approach is intended to function as a prompt for decision making and further investigation. The analyses constitute a set of prediction, based on known principles, biotic attributes and incomplete observations. These predictions need to be tested through a further cycle of on-ground work. This is discussed further below.

The FireTools algorithm (http://ft.bushfirehub.org/) has been developed by the NSW Bushfire Risk Management Hub to define and apply thresholds for evaluation of fire frequency information derived from fire history mapping, primarily for use in the development of Reserve Fire Management Strategies by NSW NPWS.

FireTools uses thresholds derived in this way to classify vegetation into four states representing its status relative to fire occurrence, at a particular point in time. **Long Unburnt** vegetation has not been burnt in a long time, past the upper threshold (i.e. recommended maximum interval between fires). **Too Frequently Burnt** vegetation has been burnt at intervals less the lower threshold (i.e. recommended minimum interval). **Vulnerable** vegetation has been frequently burnt, and due to recent burning may become **Too Frequently Burnt** if a fire occurs again soon. **Within Threshold** vegetation has current fire intervals that sit within the domain of recommended minimum and maximum intervals between fire and is in a state where an additional fire will not leave it too frequently burnt.

We used thresholds derived at the vegetation formation level (Kenny et al. 2004, Table 2.1) to predict the effects of the 2019/20 fire season on the plant diversity within the domain of the CIFOA. We coupled these thresholds to fire history (UOW Centre for Environmental Risk Management of Bushfires (CERMB) & NSW Bushfire Risk Management Research Hub (BRMR) databases) and vegetation mapping (State Vegetation Type Mapping updated in February 2021: https://www.environment.nsw.gov.au/vegetation/state-vegetation-type-map.htm; https://datasets.seed.nsw.gov.au/dataset/nsw-bionet-vegetation-map-catalogue-collection36515) using FireTools to perform these analyses. Analyses using the fire history data sets held by the NSW BRMR (see description in section 1.) as of mid-2019 were used to evaluate the pre-fire state of plant diversity. Resultant changes to fire history patterns stemming from the 2019/20 fire season were used to assess its impacts.

The threshold values derived below are strictly derived from available data on plant species fire responses, maturation, seedbank attributes and life spans, as held in the NSW Plant Species Fire Response Database. Other variants of these thresholds have been promulgated and used, based on anecdotes, opinion and observations not included in relevant publications and databases. Such variants are not considered here.

Table 2.1 Minimum and maximum fire interval thresholds for major vegetation formations in NSW. NA = not applicable: i.e. any fire is deemed to be adverse for rainforests

Formation	Minimum threshold (years)	Maximum threshold (years)
Dry Sclerophyll Forests (Shrub/grass sub-formation)	8	50
Dry Sclerophyll Forests (Shrubby sub-formation)	10	30
Forested Wetlands	10	35
Grassy Woodlands	8	50
Rainforests	NA	NA
Wet Sclerophyll Forests (Grassy sub-formation)	15	60
Wet Sclerophyll Forests (Shrubby sub-formation)	20	60

2.1 Analyses of fire frequency: fire and plant biodiversity thresholds

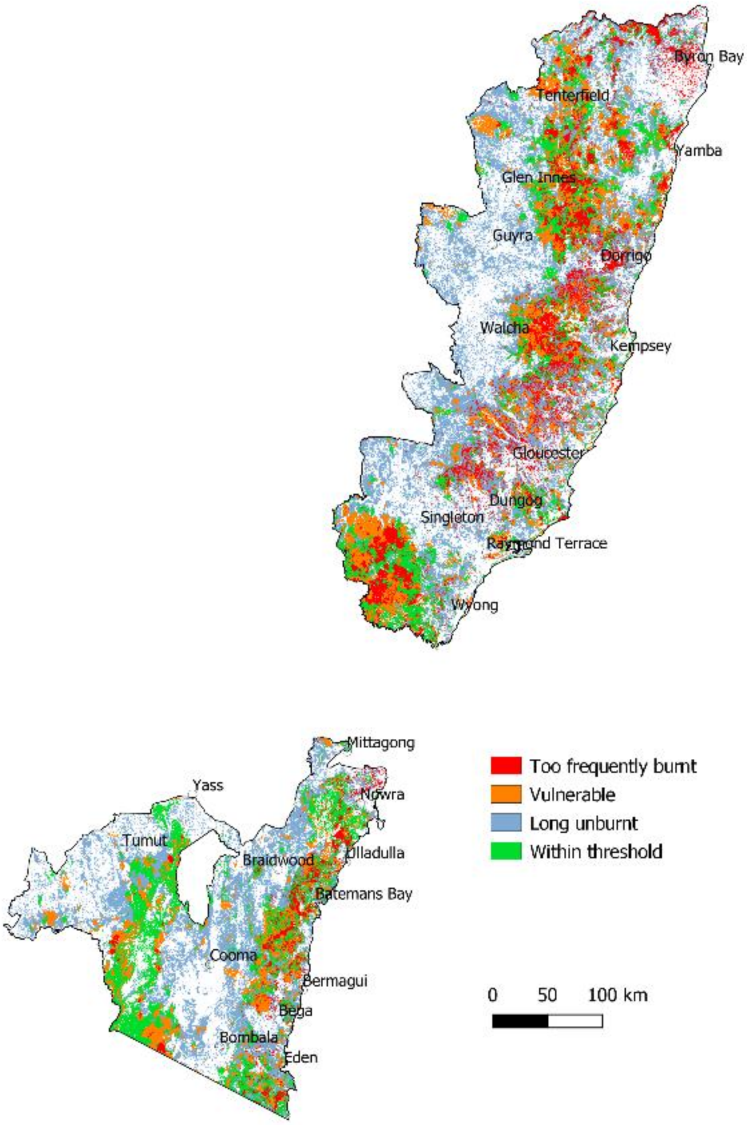


Figure 2.1.1a The status of 'threshold' categories indicating plant biodiversity responses to fire frequency across the CIFOA domain within NSW, reflecting fire intervals extant in mid-2019

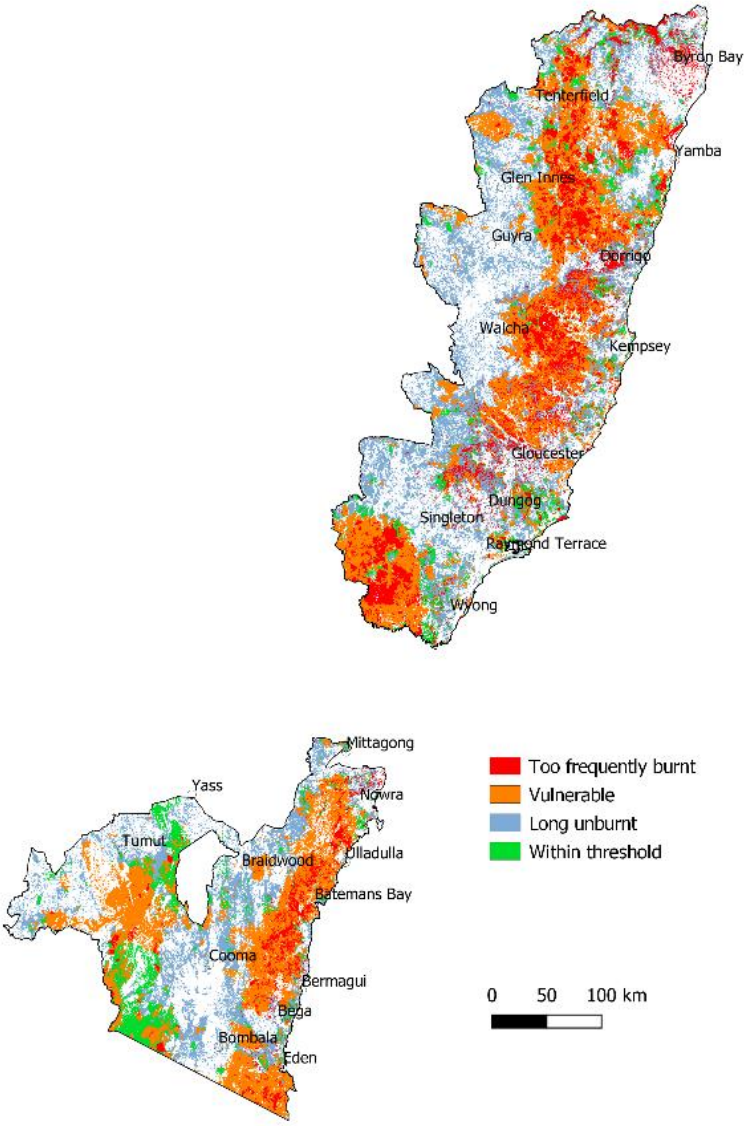


Figure 2.1.1b The status of 'threshold' categories indicating plant biodiversity responses to fire frequency across the CIFOA domain within NSW, reflecting the effects of the 2019/20 fire season on fire intervals.

General patterns

The 2019/20 fire resulted in major shifts in fire regimes, as expected, due to the magnitude of the fires. Changes to fire frequency as reflected in changes to the plant biodiversity indicators ('thresholds') that indicate potential responses of species known to be sensitive to fire frequency were relatively evenly spread across the regions covered by the CIFOA domain (Fig. 2.1.1), though there was a pronounced and widespread shift across the south into the 'vulnerable' category, following the 2019/20 fires.

Effects across different land tenure

Overall, there were reductions in the long unburnt category across the categories of land tenure (circa 7 to 17 percent) with the largest change occurring in State Forests (Table 2.1.1). The area that remained 'within threshold' (i.e. within the range of fire frequency compatible with species persistence) generally declined. The range of decline varied from circa 4 to 19 percent across the land tenure categories, with the largest decline occurring in National Park tenure. Corresponding increases occurred in the 'vulnerable' and 'too frequently' burnt categories (circa 15 to 28 percent; 1 to 4 percent), with largest increases occurring in State Forests, in both cases.

Table 2.1.1 Area of fire frequency threshold categories within the forested portion of the CIFOA domain before (mid 2019) and after the 2019/20 fire season, in relation to land tenure.

Tenure	Fire threshold status	Mid 2019 (km^2)	Mid 2019 (percent)	Post 2019/20 season (km^2)	Post 2019/20 season (percent)
State Forest	Long unburnt	4887.6	36.78	2631.9	19.81
State Forest	Too frequently burnt	2470	18.59	2950.4	22.2
State Forest	Vulnerable	2945.4	22.17	6693	50.37
State Forest	Within threshold	2985.5	22.47	1013.2	7.62
National Park	Long unburnt	6500.7	19.27	3578.8	10.61
National Park	Too frequently burnt	6967.5	20.65	8075.6	23.94
National Park	Vulnerable	9612.6	28.49	17876.2	52.99
National Park	Within threshold	10657.4	31.59	4207.6	12.47
Crown Land	Long unburnt	1551.5	55.87	1342.4	48.34
Crown Land	Too frequently burnt	228.1	8.21	265.6	9.56
Crown Land	Vulnerable	469.2	16.89	878.6	31.64
Crown Land	Within threshold	528.3	19.02	290.5	10.46
Other	Long unburnt	31171.5	68.59	26064.4	57.35
Other	Too frequently burnt	3500.1	7.7	3990.8	8.78
Other	Vulnerable	5072.4	11.16	11634.4	25.6
Other	Within threshold	5701.7	12.55	3756	8.26

Vegetation formation-level effects

Consistent and large shifts in fire frequency status were recorded across the most extensive formations, dry sclerophyll and wet sclerophyll forests (Fig. 2.1.2, 2.1.5) as well as forested wetlands (Fig. 2.1.3) as a result of the 2019/20 fires. There was an approximate doubling of the area in the 'vulnerable' category in dry and wet sclerophyll forest formations when averaged across land tenure categories. The corresponding shift was even greater in forested wetlands. Substantial increases in the proportion of area in the 'vulnerable' category also occurred in grassy woodlands but these were confined to National Parks and State Forests.

Reductions in the proportion of area ‘within thresholds’ were also substantial across wet and dry sclerophyll forests, grassy woodlands forested wetlands (Figs 2.1.2,3,5), though variable across land tenure categories. Small increases (< 4 percent) in the area within the ‘too frequently burnt’ category occurred consistently in the dry sclerophyll, forested wetlands, grassy woodland and wet sclerophyll (shrubby) formations as a result of the 2019/20 fires. By contrast, larger increases in the proportion of area in this category occurred in the rainforest (Fig. 2.1.4) and wet sclerophyll (grassy) forest formations (5 to 25 percent range).

Overall, the 2019/20 fires resulted in the bulk of dry sclerophyll and wet sclerophyll forests and forested wetlands as being ‘vulnerable’ in National Parks and State Forests. By contrast, for these formations, ‘long unburnt’ remained the dominant status in other land tenure categories, with the exception of the wet sclerophyll (grassy) where 'vulnerable' remained the dominant category on Crown Land, following the 2019/20 fires. The bulk of the area of the rainforest formation within the forested portion of the CIFOA domain was shifted into ‘too frequently burnt’ category by the 2019/20 fires (Fig. 2.1.4).

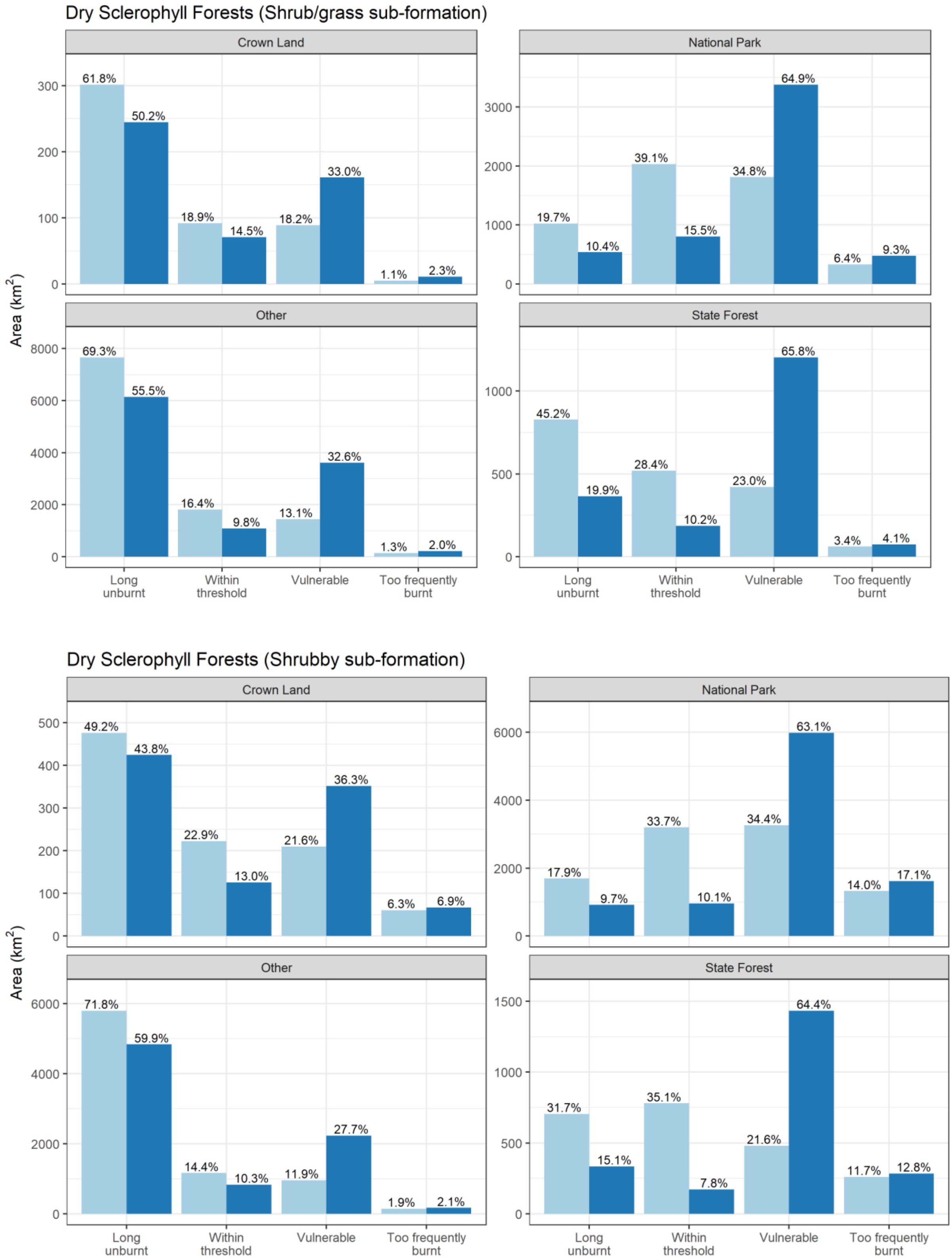


Figure 2.1.2. Area of fire frequency threshold categories before and after the 2019/20 fire season (light shading mid 2019; dark shading mid 2020), within the dry sclerophyll forest formation, (sub-formations shown in individual sets of panels) across different land tenure categories within the forested portion of the CIFOA domain. Percentages of the area each category within the area of each formations or sub-formation are indicated. Note differences in scale on the y axis (area) between the panels.

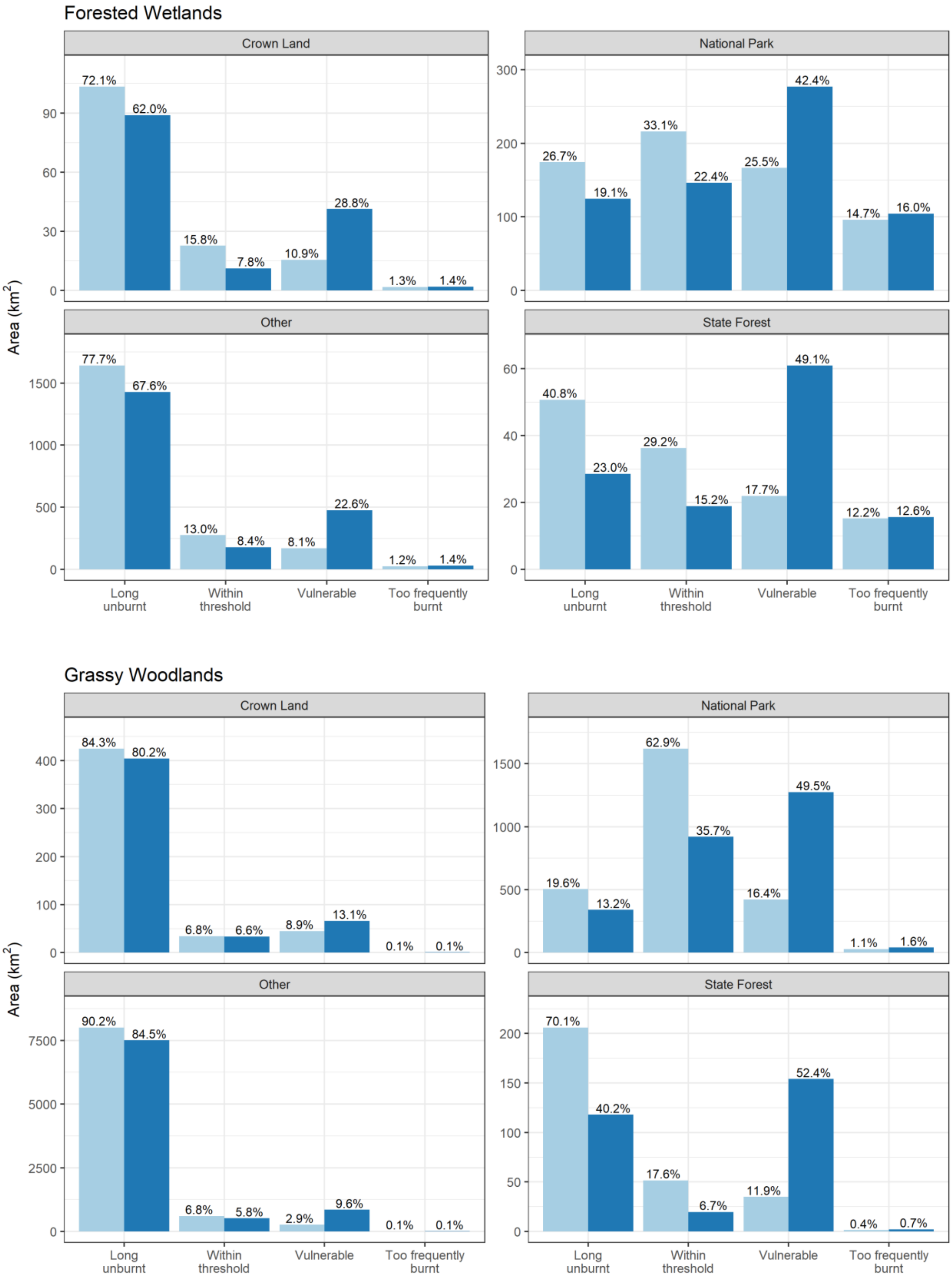


Figure 2.1.3. Area of fire frequency threshold categories before and after the 2019/20 fire season (light shading mid 2019; dark shading mid 2020), within forested wetlands and grassy woodlands, across different land tenure categories within the forested portion of the CIFOA domain. Percentages of the area each category within the area of each formations or sub-formation are indicated. Note differences in scale on the y axis (area) between the panels.

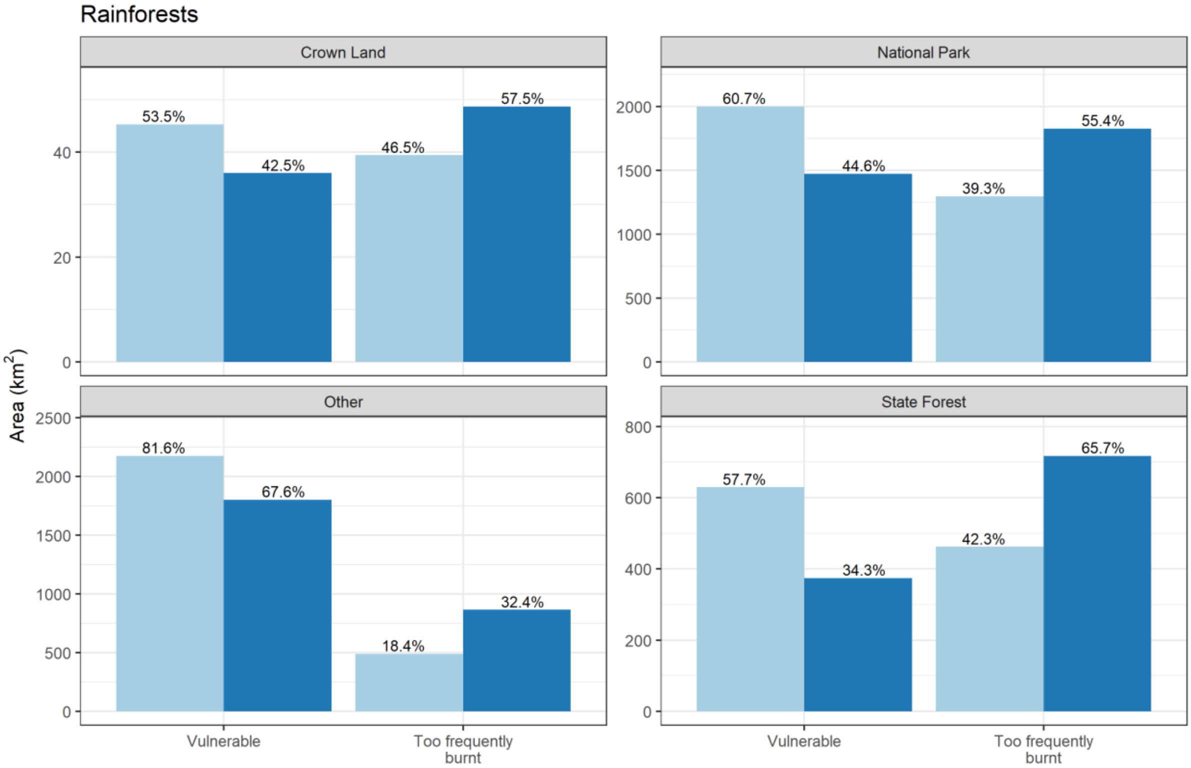


Figure 2.1.4. Area of fire frequency threshold categories before and after the 2019/20 fire season (light shading mid 2019; dark shading mid 2020), within rainforests across different land tenure categories within the forested portion of the CIFOA domain. Percentages of the area each category within the area of each formations or sub-formation are indicated. Note differences in scale on the y axis (area) between the panels.

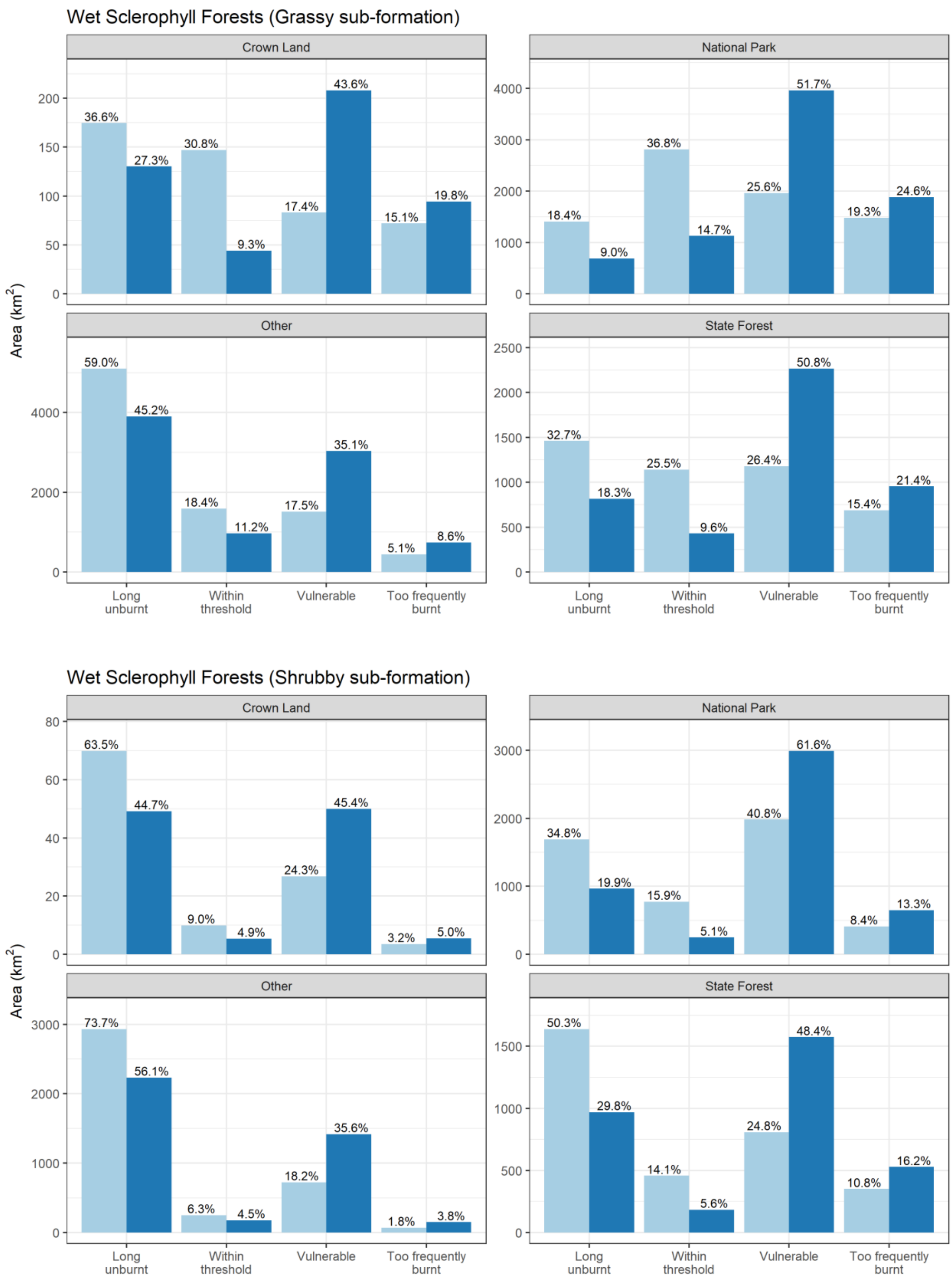


Figure 2.1.5. Area of fire frequency threshold categories before and after the 2019/20 fire season (light shading mid 2019; dark shading mid 2020), within wet sclerophyll forest formation (sub-formations shown in individual sets of panels) across different land tenure categories within the forested portion of the CIFOA domain. Percentages of the area each category within the area of each formations or sub-formation are indicated. Note differences in scale on the y axis (area) between the panels.

Implications

The 2019/20 fire season has resulted in fire frequency patterns that render more than half of the vegetation in the forested portion of the CIFOA domain as prone to a decline in plant diversity. This situation stems from two opposing effects: the continuing predominance of long unburnt areas that exceed upper thresholds, on the one hand, and a large shift into the 'vulnerable' and 'too frequently burnt' categories through exceedance of lower thresholds, on the other. The magnitude of the 2019/20 fires greatly reduced the predominance of the area classified as 'long unburnt' across the CIFOA domain, but it nonetheless remained as the largest category by area, outside of National Parks and State Forests.

The large shift into the 'vulnerable' category in National Parks and State Forests, particularly in the sclerophyll forest formations, is of particular concern given their status: i.e. biodiversity conservation is a key objective on these public lands. Sclerophyll forests contain relatively high floristic diversity and in turn this diversity plays a role in shaping habitat via effects on composition (e.g. nectar form flowering plants) and structure (e.g. shrub and herbaceous diversity provide complex ground cover and understorey). Rainforests are of particular concern given the extent of recent burning, prior to and including 2019/20.

The magnitude of the shifts in the status vegetation into the 'vulnerable' greatly elevates the risk that the relevant key objectives and outcomes of the CIFOA (i.e. 'maintain ecological function and habitat connectivity', 'maintain persistence of native species', Appendix 1) will be compromised. Given the nature of the thresholds, such an increase in risk will remain elevated over much the domain of the CIFOA for the next five to 10 years.

A considerable proportion of State Forests and National Parks remained classified as long unburnt, despite the transfer of a considerable portion of the area from this category into other categories, as a result of the 2019/20 fires. This outcome has a number of varied consequences.

First, the conversion from long unburnt to the other classes preconditions a switch to too frequently burnt if another fire was to occur in the immediate future: i.e. within the next five years. In this sense, risk is elevated in the short term but may decline if no such fire occurs in the near future. Second, despite such an effect, in many of the parts of the sclerophyll formations that make up the bulk of State Forests and National Park estate the passage of the 2019/20 fires will have beneficial effects in terms of stimulation of regeneration from stored seedbanks and consequent rejuvenation of senescent or competitively suppressed plant species. Positive effects on herbaceous plant diversity in particular may ensue. Third, the penetration of the 2019/20 fires into valleys and gullies, as broadly indicated in Table 1.4, was extensive: i.e. in State Forests and National Park estate, about 60 percent of valleys/lower slopes were burnt, with over 20 percent burnt at high and extreme severity. This means that moist vegetation (e.g. many areas of wet sclerophyll formations) with plant species that provide complex habitat structure and hollows and thus refugia for many animal species have been adversely affected. Recovery in such systems can often be slow even though many of the constituent plant species, including rainforest species, are able to resprout (e.g. Clarke et al. 2014). Thus long term risk to CIFOA objectives and outcomes will be elevated across a proportion of the previously long unburnt areas affected by the 2019/20 fires. Further on-ground validation of the extent of burning and its impacts on moist refugia in valleys and gullies, along with rainforests, is a high priority for further investigation.

The results broadly reflected those reported by Williamson (2020) for the wider domain of eastern NSW affected by the 2019/20 fires, including the very large areas of forest burned across the Sydney Basin bioregion. The threshold analysis also provides a general context and perspective on the fire regime consequences for plant diversity in general and threatened taxa in particular.

Various analyses have documented the consequences of the 2019/20 fires for floristic diversity and threatened species, both nationally and for NSW. Keith et al. (2020) defined a national risk assessment framework for ecological communities which corresponded generally with the thresholds used here: i.e. risk was likely to be high when >50 percent of a community was burnt in 2019/20, following recent antecedent burning. By these criteria (Keith et al. 2020), all formations shown here (Fig. 2.1.2) in National Parks estate and State Forests, plus wet sclerophyll and rainforests formations on Crown Lands are now in a state of high risk. Given that the fire history is less reliable for private lands (see below), which make up the bulk of the Other category, there is some chance that risk be may be underestimated in this tenure category.

Gallagher et al (2021) estimated that between 59 to 91 percent of the 700 listed threatened plant species in NSW had some part of their range burnt in 2019/20, with about 5 percent having > 90 of their range burnt. Auld et al. (2020) and Ooi (2020) estimated that 411 out of circa 1600 threatened and/or endemic plant species in NSW (i.e. the total of species listed in IUCN, EPBC Act and NSW BC ACT schedules, plus non-listed endemics) were at high risk as a result of the 2019/20 fires. Many of these species may be situated within the CIFOA domain, though many are also found in high diversity communities outside the CIFOA domain, such as the Sydney Basin. Nonetheless, these results reinforce the broad perspective and conclusions provided by the threshold analyses.

As noted above there are many biases and limitations in the use of threshold analyses. Uncertainties and variability in space and time in the fire history data are one of the principal limitations. There are both errors of commission and omission in these data. These include

- Omission of whole fires: more likely for small fires especially at the beginning of the chronology, plus those on non-public land tenure.
- False mapping of burnt patches within perimeters: more likely until recently (i.e. circa last decade) due to improvements in capacity and technology.

- False mapping of perimeters leading to under and over estimation of area burned: more likely until recently (i.e. circa last decade) due to improvements in capacity and technology.

The main consequence of these areas will be over-estimation of vegetation in the long unburnt category and errors in the balance of proportions of other categories. Given the emphasis on the risk posed by high frequency burning, some allowance can be made for inaccuracy. However, given improvements in mapping plus the overwhelming nature of the 2019/20 fire season, if such an allowance is made, the conclusions drawn here are robust.

The other source of uncertainty is the incomplete nature of the plant attribute data which forms the basis of the approach. The fire responses and key life history attributes of many species are unknown (e.g. > 15,000 species of threatened plants listed nationally, Gallagher et al. 2021). For some species, there is known variability in key responses such as resprouting, maturation times, seedbank characteristics and life form. The current system deals crudely and imperfectly with such variations. Furthermore, some of the critical attributes such as maturation times in obligate seeders may be changing in response to climate change (i.e. hotter and drier climates may compromise post-fire germination, cause slower growth and lengthen maturation times, leading to 'interval-squeeze' (Enright et al. 2015). Such changes may already be underway. The critical assumption that resprouters are invulnerable to high frequencies of fire may also not hold in all cases (e.g. Enright et al. 2011), leading to potential underestimation of the consequences of frequent fire.

It is reemphasised here that the threshold analysis is a set of predictions to assess decision making, based on known principles, biotic attributes and incomplete observations. These predictions need to be tested through a further cycle of on-ground work, as with all assessments made after the 2019/20 fires (Gallagher et al. 2021). The advantage of the system is that it provides a structure for further targeted monitoring that can improve the veracity of future predictions. Monitoring programs therefore need to be tailored to examine and verify responses of key plant species across the full spectrum of patterns of fire frequency and fire threshold categories. Monitoring also needs to be planned in a way that can capitalise on opportunities to examine responses to new fires (planned and unplanned) and the way they may interact with pre-existing fire regimes. Detection of fire responses of species with unknown attributes is a priority for monitoring.

2.2 Analyses of suitable habitat of threatened animal species

Methods

Analyses of effects of disturbance regimes on predicted suitable habitat were carried out for a range of threatened mammal (10), bird (7), bat (5) and amphibian species (2). Selection of species was based on availability of predicted suitable habitat information compiled by NSW Department of Planning Industry and Environment (https://climatechange.environment.nsw.gov.au/Adapting-to-climate-change/Adaptation-Research-Hub/Biodiversity-Node) using the climatic refuge modelling approaches described in Baumgartner et al. (2018) and Beaumont et al. (2019).

The study species were initially selected from the list of 28 focal species nominated for assessment and monitoring under the CIFOA (Table 2.2.1 a). Modelling of predicted suitable habitat was only available for a subset of these 17 of these species (Table 2.2.1a): i.e. from species within the Saving our Species (SoS) program landscape and site streams (Beaumont et al. 2019). We therefore augmented these with a further seven species (Table 2.2.1b) for which modelling was available, representing additional diversity of threatened mammals, birds and bats. These were also selected from the relevant streams compiled for the SoS program. Habitat feature dependence for these species was sourced from relevant profiles: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile

Briefly, the modelling of suitable habitat used machine learning techniques to develop models of suitable habitat based on contemporary records of species occurrence and key climatic predictors. We used models for the selected species developed under current climate (i.e. 1990 to 2009 climatic records) to predict suitable habitat for each species across NSW. It is emphasised that climatic modelling of suitable habitat does not indicate other attributes such as vegetation structure and composition that will govern the realisation of this habitat for individual species. Thus it provides an indication of the general envelope of suitable habitat that will in turn be constrained by other factors.

To initially assess the significance of predicted suitable habitat within the CIFOA domain, we intersected these predictions with the boundaries of the CIFOA domain and the forested portion within it. We then examined the area within the forested CIFOA domain exposed to disturbances (wildfire, harvesting) prior to the 2019/20 fire season. Patterns of exposure of predicted suitable habitat to the 2019/20 fires season were then investigated to determine levels of exposure to combinations of high/extreme fire severity, havresting in the previous 20 years, high wildfire frequency, as outlined in the previous section.

Modelling of suitable habitat for the Koala was done separately from the other species. A habitat suitability model was available (Law et al. 2017) but this predominantly used non-climatic predictors as its basis. We compiled raster layers for Koala habitat suitability (probability scale), based on the modelling of Law et al. (2017), that were provided on the DPIE Sharing and Enabling Environmental Data (SEED) website: https://datasets.seed.nsw.gov.au/anzlic_dataset/koala-habitat-information-base-habitat-suitability-models-v1-0.

Separate layers were provided for regions such as south coast, central coast etc. Layers represented 'current' habitat suitability. We merged the regional layers into a single continuous layer across the CIFOA domain, and then derived a binary habitat layer (more suitable versus less suitable habitat) for reporting to be consistent with the treatment of modelled habitat for other species from the climate refugia project (Beaumont et al., 2019).

We compared two alternative habitat suitability thresholds: one calculated using the True Skill Statistic (TSS) cited by Beaumont et al. (2019) which seeks to balance the sensitivity and specificity of model predictions; and a second higher threshold based on expert knowledge. For each threshold we calculated the proportion of BioNet occurrence records, dating from 1980 onwards and thinned to remove replicate observations within 25m raster cells that were captured by the resulting binary habitat layer (Appendix 4).

Based on this comparison, we selected the expert threshold value to derive a binary habitat layer. We then estimated the area of predicted suitable habitat only within the forest portion of the CIFOA domain and the area affected by the disturbance frequency hotspots pre and post the 2019/20 fires, as for the other species.

Table 2.2.1a Threatened animal species selected for exploration of suitable habitat via climatic modelling from Saving Our Species landscape and site streams. Focal species selected for the CIFOA monitoring program are indicated by asterisks.

Species	Habitat feature dependence	SoS habitat modelling available
Grey-headed flying fox	Nectar and pollen	
Koala*	Eucalypts	
Squirrel glider	Hollows	x
Yellow-bellied glider*	Hollows	x
Sugar glider	Hollows	
Greater glider*	Hollows	
Rufous bettong	Understorey	x
Long-nosed bandicoot	Understorey	
Southern brown bandicoot*	Understorey	x
Spotted-tail quoll*	Logs	x
Long-nosed potoroo	Understorey	x
Barking owl*	Hollows	x
Masked owl*	Hollows	x
Powerful owl*	Hollows	x
Sooty owl*	Hollows	x
Boobook owl*	Hollows	
Glossy black cockatoo	Hollows and feed trees	x
Brown treecreeper	Hollows	
Rufous scrub-bird*	N/A	x
Noisy friarbird	Nectar and pollen	
Varied sittella	N/A	x
Eastern false pipistrelle	Hollows	x
Eastern freetail bat	Hollows	
Greater broad-nosed bat	Hollows	x

Southern myotis	Hollows	
Yellow-bellied sheath-tailed bat	Hollows	
Giant barred frog*	Water bodies	x
Stuttering frog*	Water bodies	x

Table 2.2.1b Threatened animal species selected for exploration of suitable habitat via climatic modelling from Saving Our Species landscape and site streams. Selected additional species with available modelling.

Species	Habitat feature dependence
Eastern pygmy possum	Nectar and pollen
Brush-tailed phascogale	Hollows
White-footed dunnart	Understorey (open)
Red-legged pademelon	Understorey
Golden-tipped bat	Hollows
Corben's Long-eared bat	Hollows
Eastern cave bat	Caves and cliffs

Habitat patterns

Large areas of NSW were predicted to contain suitable habitat for all ten threatened mammal species (Table 2.2.2). In all species, except *Petaurus norfolcensis* (Squirrel Glider), considerably more than half of the area suitable habitat was predicted to occur in the domain of the CIFOA. In turn, suitable habitat was predicted across the bulk of the area CIFOA domain (> 70 percent) for all species except *P. norfolcensis*. Predicted habitat occurred across more than half the area of the forested portion of the CIFOA domain for all species.

Similar patterns of predicted habitat were found for threatened bird species, bats and amphibians (Tables 2.2.3, 2.2.4, 2.2.5). Six of the eight bird species had more than 60 percent of area in the CIFOA domain as predicted habitat (Table 2.2.3). For two species (a Sittella, *Daphoenositta chrysoptera* and the Barking Owl, *Ninox connivens*) the CIFOA domain represented a relatively low proportion of the area of predicted habitat (< 35 percent). Within the CIFOA predicted habitat of all threatened bird species was predominantly situated in the forested portion (> 50 percent of the area).

Table 2.2.2 Area of predicted suitable habitat of threatened mammal species, derived from climatic modelling, across NSW and within the CIFOA domain. Area and proportions of predicted habitat for each species within the total CIFOA domain and the forested portion of the CIFOA domain are given.

Species	*Common name*	*Area NSW (km^2)*	*Area CIFOA domain (km^2)*	*Percent of CIFOA area*	*Area CIFOA forest (km^2)*	*Percent CIFOA Forest*
Aepyprymnus rufescens	Rufous Bettong	71044	62036	87.3	41800.3	67.38071
Cercartetus nanus	Eastern Pygmy-possum	83180	58564	70.4	44159	75.40298
Dasyurus maculatus	Spotted-tailed Quoll	142981	112328.4	78.6	78362.6	69.76205
Isoodon obesulus obesulus	Southern Brown Bandicoot (eastern)	8091	7278.6	90	5565	76.45701
Petaurus australis australis	Yellow-bellied Glider	112069	95154.8	84.9	71405.7	75.04162

Petaurus norfolcensis	Squirrel Glider	171053	60418.1	35.3	34006.7	56.28562
Phascogale tapoatafa tapoatafa	Brush-tailed Phascogale	74375	53724.6	72.2	32798.6	61.0495
Potorous tridactylus	Long-nosed Potoroo	70242	63477.1	90.4	47799.2	75.30149

Table 2.2.3 Area of predicted suitable habitat of threatened bird species, derived from climatic modelling, across NSW and within the CIFOA domain. Area and proportions of predicted habitat for each species within the total CIFOA domain and the forested portion of the CIFOA are given.

Species	*Common name*	*Area NSW (km^2)*	*Area CIFOA domain (km^2)*	*% of CIFOA area*	*Area CIFOA forest (km^2)*	*% CIFOA Forest*
Atrichornis rufescens	Rufous Scrub-bird	23272	20760.9	89.2	17672.6	85.1
Calyptorhynchus lathami	Glossy Black-Cockatoo	156379	104347.9	66.7	71609.5	68.6
Daphoenositta chrysoptera	Varied Sittella	396198	130875.3	33	83009.8	63.4
Ninox connivens	Barking Owl	377977	54616.6	14.4	28939.6	52.9
Ninox strenua	Powerful Owl	149880	119660.2	79.8	82818.1	69.2
Tyto novaehollandiae	Masked Owl	119877	105166.8	87.7	73109.1	69.5
Tyto tenebricosa	Sooty Owl	80015	70468.9	88.1	56879.9	80.7

Two of the four threatened species of bats had a relatively low area of predicted suitable habitat within the CIFOA (Table 2.2.4), whereas for both threatened frog species the CIFOA domain represented a relatively high proportion of predicted suitable habitat (Table 2.2.5). For all threatened bat and frog species, high proportions of the area of the forested portion of the CIFOA were predicted to be suitable habitat (> 60 to 70 percent).

Table 2.2.4 Area of predicted suitable habitat for threatened bat species, derived from climatic modelling, across NSW and within the CIFOA domain. Area and proportions of predicted habitat for each species within the total CIFOA domain and the forested portion of the CIFOA are given.

Species	*Common name*	*Area NSW (km^2)*	*Area CIFOA domain (km^2)*	*Percent of CIFOA area*	*Area CIFOA forest (km^2)*	*Percent CIFOA Forest*
Falsistrellus tasmaniensis	Eastern False Pipistrelle	143161	105154.5	73.5	73405.5	69.8
Kerivoula papuensis	Golden-tipped Bat	59816	56175	93.9	44458.2	79.1
Nyctophilus corbeni	Corben's Long-eared Bat	264943	13247.6	5	8233.5	62.2
Scoteanax rueppellii	Greater Broad-nosed Bat	95785	82554.4	86.2	56696.1	68.7
Vespadelus troughtoni	Eastern Cave Bat	123435	33931.6	27.5	21126.9	62.3

Table 2.2.5 Area of predicted suitable habitat of threatened amphibian species, derived from climatic modelling, across NSW and within the CIFOA domain. Area and proportions of predicted habitat for each species within the total CIFOA domain and the forested portion of the CIFOA are given.

Species	*Common name*	*Area NSW (km^2)*	*Area CIFOA domain (km^2)*	*Percent of CIFOA area*	*Area CIFOA forest (km^2)*	*Percent CIFOA Forest*
Mixophyes balbus	Stuttering Frog	44026	39461.4	89.6	31293.4	79.3
Mixophyes iteratus	Giant Barred Frog	31037	30680.3	98.9	23013	75.0

The area of predicted suitable habitat for the Koala within the forested portion of the CIFOA domain was 59800 km^2. This was intermediate within the comparable range of predicted suitable habitat for the other ten endangered mammal species (Table 2.2.2).

In summary, for the overall suite of threatened species, the CIFOA represented an important and widespread area of predicted suitable habitat for a majority of species. Within the CIFOA domain the forested portion represented the bulk of predicted suitable habitat for most of this group of species.

Disturbance regimes

Overall, for this set of threatened species, about 27 to 62 percent of predicted suitable habitat of this set of threatened mammal, bird, bat and amphibian species in the forested portion of the CIFOA domain burned in 2019/20 (Tables 2.2.6, 2.2.7, 2.2.8, 2.2.9, 2.2.10). The area of predicted habitat for this set of species in the forested portion of the CIFOA domain that was exposed to high or extreme fire severity in 2019/20 ranged from 13 to 32 percent: i.e. on average about half of the burnt area of predicted habitat for this group of species in the forested portion of the CIFOA domain was burnt at the highest levels of severity in the 2019/20 fires (Tables 2.2.6, 2.2.7, 2.2.8, 2.2.9, 2.2.10).

Table 2.2.6 Area (km^2) of predicted suitable habitat of threatened mammal species, subjected to various disturbance regimes climatic modelling, within the forested portion of the CIFOA domain. Percentages of area of the forested portion of the CIFOA domain are given in parentheses.

Species	Common name	Area burnt 2019/20	High & extreme fire severity	Area harvested	Area harvested, burnt 2019/20	Area harvested, burnt high ext. severity 2019/20	High fire frequency pre 2019/20	High fire frequency post 2019/20	High ext. fire frequency & severity post 2019/20	Harvested, high ext. fire frequency & severity post 2019/20
Aepyprymnus rufescens	Rufous Bettong	19974 (47.8)	7009 (16.8)	1580 (3.8)	854 (2.0)	292 (0.7)	2194 (5.2)	4513 (10.8)	1600 (3.8)	46 (0.1)
Cercartetus nanus	Eastern Pygmy-possum	20478 (46.4)	9191 (20.8)	1655 (3.7)	953 (2.2)	431 (1.0)	2297 (5.2)	4571 (10.4)	1837 (4.2)	88 (0.2)
Dasyurus maculatus	Spotted-tailed Quoll	36212 (46.2)	15233 (19.4)	2324 (3.0)	1381 (1.8)	578 (0.7)	4302 (5.5)	8402 (10.7)	3289 (4.2)	111 (0.1)
Isoodon obesulus obesulus	Southern Brown Bandicoot (eastern)	3096 (55.6)	1144 (20.6)	514 (9.2)	394 (7.1)	165 (3.0)	410 (7.4)	949 (17.1)	356 (6.4)	55 (1.0)
Petaurus australis	Yellow-bellied Glider	35164 (49.2)	14177 (19.9)	2784 (3.9)	1683 (2.4)	710 (1.0)	4618 (6.5)	9078 (12.7)	3536 (5.0)	158 (0.2)
Petaurus norfolcensis	Squirrel Glider	10678 (31.4)	4498 (13.2)	1029 (3.0)	294 (0.9)	145 (0.4)	2069 (6.1)	3408 (10.0)	1164 (3.4)	17 (0.0)
Phascogale tapoatafa	Brush-tailed Phascogale	12477 (38.0)	5147 (15.7)	1380 (4.2)	633 (1.9)	292 (0.9)	2063 (6.3)	3527 (10.8)	1298 (4.0)	65 (0.2)
Potorous tridactylus	Long-nosed Potoroo	25092 (52.5)	9666 (20.2)	2366 (4.9)	1414 (3.0)	582 (1.2)	3174 (6.6)	6445 (13.5)	2495 (5.2)	148 (0.3)
Sminthopsis leucopus	White-footed Dunnart	8905 (62.2)	4637 (32.4)	801 (5.6)	644 (4.5)	326 (2.3)	1252 (8.7)	2438 (17.0)	1165 (8.1)	108 (0.8)
Thylogale stigmatica	Red-legged Pademelon	13381 (56.2)	4828 (20.3)	1436 (6.0)	955 (4.0)	393 (1.6)	1192 (5.0)	2634 (11.1)	1052 (4.4)	107 (0.5)

Table 2.2.7 Area (km^2) of predicted suitable habitat of the Koala, subjected to various disturbance regimes climatic modelling, within the forested portion of the CIFOA domain. Percentages of area of the forested portion of the CIFOA domain are given in parentheses.

Species	Common name	Area burnt 2019/20	High & extreme fire severity	Area harvested	Area harvested, burnt 2019/20	Area harvested, burnt high ext. severity 2019/20	High fire frequency pre 2019/20	High fire frequency post 2019/20	High ext. fire frequency & severity post 2019/20	Harvested, high ext. fire frequency & severity post 2019/20
Phasco-larctos cinereus	Koala	24059 (40.2)	10046 (16.8)	2541 (4.2)	1515 (2.5)	640 (1.1)	2512 (4.2)	4957 (8.3)	1857 (3.1)	139 (0.2)

Table 2.2.8 Area (km^2) of predicted suitable habitat of threatened bird species, subjected to various disturbance regimes climatic modelling, within the forested portion of the CIFOA domain. Percentages of area of the forested portion of the CIFOA domain are given in parentheses.

Species	Common name	Area burnt 2019/20	High & extreme fire severity	Area harvested	Area harvested, burnt 2019/20	Area harvested, burnt high ext. severity 2019/20	High fire frequency pre 2019/20	High fire frequency post 2019/20	High ext. fire frequency & severity post 2019/20	Harvested, high ext. fire frequency & severity post 2019/20
Atrichornis rufescens	Rufous Scrub-bird	10312 (58.4)	3283 (18.6)	767 (4.3)	561 (3.2)	199 (1.1)	789 (4.5)	1823 (10.3)	658 (3.7)	27 (0.2)
Calyptorhynchus lathami	Glossy Black-Cockatoo	33628 (47.0)	13432 (18.8)	2547 (3.6)	1534 (2.1)	637 (0.9)	4835 (6.8)	9242 (12.9)	3548 (5.0)	155 (0.2)
Daphoenositta chrysoptera	Varied Sittella	36002 (43.4)	15344 (18.5)	2569 (3.1)	1538 (1.9)	642 (0.8)	4824 (5.8)	9264 (11.2)	3611 (4.3)	157 (0.2)
Ninox connivens	Barking Owl	8292 (28.7)	3699 (12.8)	888 (3.1)	268 (0.9)	138 (0.5)	1668 (5.8)	2544 (8.8)	791 (2.7)	11 (0.0)
Ninox strenua	Powerful Owl	37437 (45.2)	15372 (18.6)	2865 (3.5)	1726 (2.1)	731 (0.9)	5007 (6.0)	9572 (11.6)	3698 (4.5)	160 (0.2)
Tyto novaehollandiae	Masked Owl	35221 (48.2)	14298 (19.6)	2658 (3.6)	1606 (2.2)	666 (0.9)	4987 (6.8)	9494 (13.0)	3651 (5.0)	156 (0.2)
Tyto tenebricosa	Sooty Owl	31447 (55.3)	12466 (21.9)	2451 (4.3)	1502 (2.6)	611 (1.1)	4261 (7.5)	8520 (15.0)	3339 (5.9)	153 (0.3)

Long term patterns of extreme disturbance frequency affected a relatively small proportion of the predicted suitable habitat of this set of threatened species, within the forested portion of the CIFOA domain. The area of predicted suitable habitat affected by high frequency wildfire as of mid-2019 ranged from 2 to 9 percent across the entire set of threatened species. The 2019/20 fires resulted in an average doubling of the proportion of area of suitable habitat for this set of species. Of this resultant area of predicted suitable habitat affected by high frequency wildfires, about 30 to 40 percent was burnt at high or extreme severity in 2019/20, across the entire group of threatened species. In summary, the most extreme combination of fire frequency and recent fire severity affected up to about 6 percent of the predicted habitat of this set of threatened species across the forested portion of the CIFOA domain. An exception to this was *Sminthopsis leucopis* (White-footed Dunnart) for which the proportion of predicted suitable habitat subjected to this extreme fire regime combination was 8 percent (Table 2.2.6).

Table 2.2.9 Area (km^2) of predicted suitable habitat of threatened bat species, subjected to various disturbance regimes climatic modelling, within the forested portion of the CIFOA domain. Percentages of area of the forested portion of the CIFOA domain are given in parentheses.

Species	Common name	Area burnt 2019/20	High & extreme fire severity	Area harvested	Area harvested, burnt 2019/20	Area harvested, burnt high ext. severity 2019/20	High fire frequency pre 2019/20	High fire frequency post 2019/20	High ext. fire frequency & severity post 2019/20	Harvested, high ext. fire frequency & severity post 2019/20
Falsistrellus tasmaniensis	Eastern False Pipistrelle	34687 (47.3)	14512 (19.8)	2287 (3.1)	1482 (2.0)	590 (0.8)	4411 (6.0)	8582 (11.7)	3336 (4.5)	132 (0.2)
Phoniscus papuensis	Golden-tipped Bat	23489 (52.8)	8726 (19.6)	1981 (4.5)	1147 (2.6)	456 (1.0)	2821 (6.3)	5960 (13.4)	2268 (5.1)	112 (0.3)
Nyctophilus corbeni	Corben's Long-eared Bat	2228 (27.1)	1063 (12.9)	0 (0.0)	0 (0.0)	0 (0.0)	124 (1.5)	255 (3.1)	74 (0.9)	0 (0.0)
Scoteanax rueppellii	Greater Broad-nosed Bat	27123 (47.8)	10372 (18.3)	2219 (3.9)	1246 (2.2)	485 (0.9)	4157 (7.3)	7783 (13.7)	2880 (5.1)	94 (0.2)
Vespadelus troughtoni	Eastern Cave Bat	7084 (33.5)	2887 (13.7)	373 (1.8)	106 (0.5)	64 (0.3)	1423 (6.7)	2392 (11.3)	872 (4.1)	9 (0.0)

Harvesting between 2000 and 2019 affected between 1 and 7 percent of the area of predicted suitable habitat of this set of threatened species, within the forested portion of the CIFOA domain (Tables 2.2.6, 2.2.7, 2.2.8, 2.2.9, 2.2.10), with the exception of a Long-eared Bat, *Nyctophilus corbeni* (predicted habitat unharvested Table 2.2.8). Mammal species were generally affected by harvesting toward the higher end of this range (Tables 2.2.6, 2.2.7).

A large proportion (50 to 70 percent) of the area of predicted suitable habitat, harvested prior to 2019, was burnt in 2019 (Tables 2.2.6, 2.2.7, 2.2.8, 2.2.9, 2.2.10). In turn the proportion of harvested and burned (2019/20) predicted suitable habitat that experienced high to extreme fire severity was also substantial (i.e. a range of 20 to 60 percent of the overall harvested and burned area).

The combination of past harvesting and extreme fire regimes (i.e. > 4 wildfires plus high or extreme plus severity post 2019/20) affected 1 percent or less of the area of predicted suitable habitat of this group of threatened species.

Table 2.2.10 Area (km^2) of predicted suitable habitat of threatened amphibian species, subjected to various disturbance regimes climatic modelling, within the forested portion of the CIFOA domain. Percentages of area of the forested portion of the CIFOA domain are given in parentheses.

Species	Common name	Area burnt 2019/20	High & extreme fire severity	Area harvested	Area harvested, burnt 2019/20	Area harvested, burnt high ext. severity 2019/20	High fire frequency pre 2019/20	High fire frequency post 2019/20	High ext. fire frequency & severity post 2019/20	Harvested, high ext. fire frequency & severity post 2019/20
Mixophyes balbus	Stuttering Frog	16794 (53.7)	5375 (17.2)	1394 (4.5)	818 (2.6)	268 (0.9)	1723 (5.5)	3810 (12.2)	1257 (4.0)	44 (0.1)
Mixophyes iteratus	Giant Barred Frog	11320 (49.2)	3818 (16.6)	1354 (5.9)	686 (3.0)	233 (1.0)	1026 (4.5)	2112 (9.2)	676 (2.9)	34 (0.1)

Implications.

The domain of the CIFOA contains a significant area of potential suitable habitat for this group of threatened animal species that is of state-wide significance. Given the large proportion of the area of predicted habitat of this group of species that was burnt in 2019/20, immediate effects of this fire season are likely to be widespread across the CIFOA domain and, in turn, of corresponding state-wide significance. Notably the majority of area of predicted suitable habitat for this set of threatened species was burned in 2019/20. Potential effects were likely to be reinforced by the magnitude of potential suitable habitat that was exposed to high or extreme fire severity, if it is assumed that adverse effects on potential occupancy and habitat suitability are positively related to fire severity.

This conclusion is reasonable given that the bulk of the species reviewed here are listed as being dependent on hollows and logs (13 out of 24 species, Table 2.2.1), with a further five species dependent on dense understorey (Table 2.2.1) and several species on nectar or specific food plants, it is likely that immediate impacts of the 2019/20 have been widespread and severe in terms of magnitude of short-term habitat loss. The core habitat of the Rufous Scrub Bird, being particularly associated with rainforests, may have been significantly compromised by the area of rainforest burnt in the northern part of the CIFOA domain (see earlier sections). While the overall proportion of the area of harvested predicted habitat burned in 2019/20 within the forested portion of the CIFOA domain was relatively low (< 7 percent), compounding effects of these disturbances may have been acute. Given the size of the fires, their overlay across dispersed pockets of recent harvesting may have diminished connectivity of suitable potential habitat in the short term.

Thus for the bulk of species examined here, major losses of potential suitable habitat are likely to have occurred across the bulk of this set of species although some of these losses may be short-lived, while others may be more persistent. The risk of not achieving key relevant aims of the CIFOA domain (i.e. 'maintain ecological function and habitat connectivity', 'maintain persistence of native species', Appendix 1) has therefore been highly elevated by the passage of the 2019/20 fires. Such risk will remain high in the short-term: i.e. the next few years.

Persistence of these effects is likely to be variable. Losses of hollow-bearing trees through collapse in severely burnt forests may be long lasting: i.e. many years may be required for hollow formation to result in replacement, though the severity of these fires may have increased the likelihood of the scarring and injury required to initiate hollow development. By contrast loss of dense grassy habitat (e.g. Southern Brown Nosed Bandicoot) or open understorey (e.g. White-footed Dunnart) may be short-lived or possibly promoted by these widespread fires, particularly in areas that have experienced regular burning.

High frequency wildfires are likely to compromise habitat suitability and therefore create a core area that may be degraded and less habitable for the bulk of threatened animal species considered here. In this regard, the 2019/20 fires had a major potential impact by doubling the area subjected to high wildfire fire frequency (up to about 17 percent). Thus the core of likely degraded suitable habitat resulting from 2019/20 is substantial. Compounding effects of extreme wildfire frequency and high/extreme fire severity (up to about 8 percent) and antecedent harvesting (up to 1 percent) would reinforce this conclusion and, in particular may compromise connectivity with this matrix of frequently burnt area. While immediate effects of these disturbance regime patterns on existing populations are unknown, their magnitude reinforces the conclusion that risk to the core CIFOA objectives and related outcomes have been significantly elevated by the 2019/20 fires. The nature and scale of such impacts warrants further on-ground investigation and validation as a priority.

In summary, the elevated risks to CIFOA objectives and outcomes, stemming from concerns about potential loss of habitat for this group of species are primarily the result of the compound consequences of the huge area burnt in 2019/20, the relatively high proportion burnt by severe fires and the resultant area exposed as high frequency wildfire ‘hotspots’. Identification and consideration of the areas in the checking of recent occupancy records, design of monitoring programs and planning of harvesting operations and associated activities may be an immediate priority.

2.3 Disturbance regimes across catchments

Methods

We assessed the effects of the 2019/20 fires on disturbance across a sample of drinking water catchments within the CIFOA domain (Fig. 2.3.1). This was to indicate the likely magnitude of effects on catchments in general and some possible consequences for the water quality and aquatic species components of the CIFOA objectives and outcomes. We used catchment boundaries defined in the Environmental Planning Instrument – Drinking Water Catchments layer sourced from the NSW Planning Portal https://www.planningportal.nsw.gov.au/opendata/dataset/epi-drinking-water-catchment. The total mapped catchment area is 13249 km^2 (8.8 percent of total CIFOA domain area) which occupied 8125 km^2 (8.5 percent) of the total CIFOA domain forested area. The mapped drinking water catchments overlapped some harvested State Forest areas, e.g. Tallaganda near Braidwood and Clouds Creek near Dorrigo. It is likely that other major catchments within the CIFOA will have been subjected to higher levels of harvesting. Therefore the results presented here may underrepresent disturbance regime patterns and changes found elsewhere.

We examined the area of catchments within the forested domain of the CIFOA domain that were exposed to disturbances (wildfire, harvesting) prior to the 2019/20 fire season. Patterns of exposure of the catchments to the 2019/20 fires season were then investigated to determine areas subject to combinations of high/extreme fire severity, harvesting, high wildfire frequency, as outlined in the previous section. We subdivided terrain within the catchments into two categories (ridge/upper slope; valley lower slope) for these analyses.

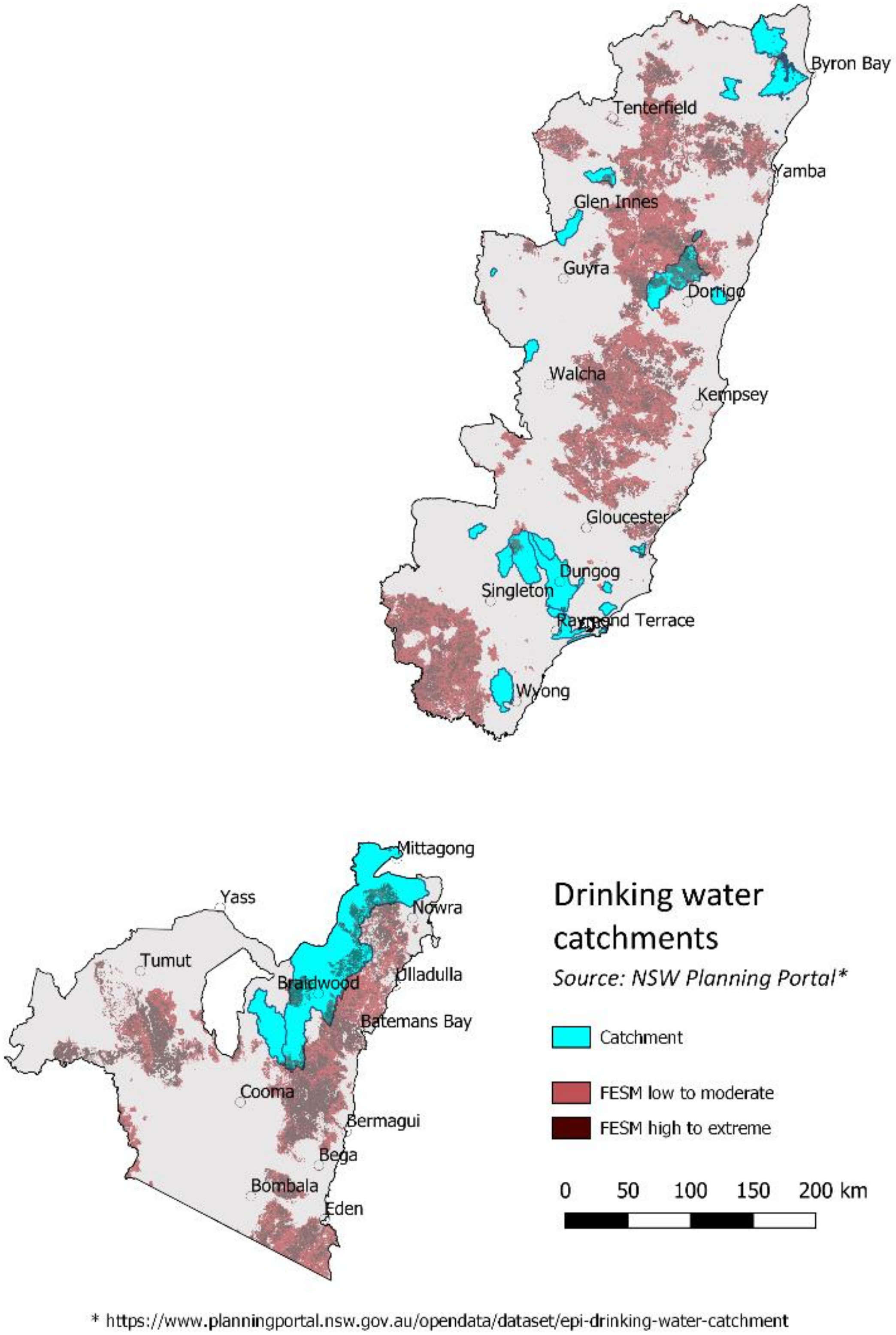


Figure 2.3.1 Drinking water catchment boundaries within the CIFOA domain across eastern NSW. Patterns of severity of the 2019/20 fires are shown.

The catchment mapping was extensive (Fig. 2.3.1) but did not include major catchments with other primary objectives, such as irrigation and hydro-electricity generation (e.g. Snowy Mountains catchments), or other major catchments that do not contain significant reservoirs.

Results

About 15 percent of the area of the sample catchments within the forested portion of the CIFOA domain burned in 2019/20 (Table 2.3.1). Similar area and proportions of both landform types were burned. About half the area of the catchments affected by the 2019/20 fires burned at high/extreme severity (Fig. 2.3.1, Table 2.3.1). Slightly more ridges/upper slopes were affected by high and extreme severity fires, compared with valleys/lower slopes.

Table 2.3.1 Area (km^2) of drinking water catchments in two land form categories, subjected to various disturbance regimes, within the forested portion of the CIFOA domain. Percentages of area of the forested portion of the CIFOA domain are given in parentheses.

Landform	Area	Area burnt 2019/20	High & extreme fire severity	Area harvested	Area harvested, burnt 2019/20	Area harvested, burnt high ext. severity 2019/20	High fire frequency pre 2019/20	High fire frequency post 2019/20	High ext. fire frequency & severity post 2019/20	Harvested, high ext. fire frequency & severity post 2019/20
ridge/upper-slope	4125 (50.8)	1241 (15.3)	605 (7.4)	134 (1.7)	89 (1.1)	28 (0.3)	41 (0.5)	102 (1.3)	51 (0.6)	4 (0.1)
valley/lower-slope	4000 (49.2)	1182 (14.5)	501 (6.2)	78 (1.0)	54 (0.7)	17 (0.2)	25 (0.3)	75 (0.9)	34 (0.4)	3 (0.0)

Long term patterns of extreme disturbance frequency affected a relatively small proportion of the catchments, within the forested portion of the CIFOA domain. The area of catchments affected by high frequency wildfire was small ($\leq$ 0.5 percent) with a higher level of exposure on ridges/upper-slopes (Table 2.3.1). The 2019/20 fires more than doubled the area exposed to high frequency wildfires in both landform types. Of this resultant area affected by high frequency wildfires, about half was burnt at high or extreme severity in 2019/20, in both landform types. In summary, the most extreme combination of fire frequency and recent fire severity affected up to about 0.5 percent of the area of drinking water catchments across the forested portion of the CIFOA domain.

Harvesting between 2000 and 2019 affected < 2 percent of the area of the drinking water catchments, within the forested portion of the CIFOA domain (Tables 2.3.1), with harvesting more widespread on ridges/upper slopes. A large proportion (about 65 percent) of the area of the catchments, harvested prior to 2019, was burnt in 2019. About a third of harvested and burned area of the catchments experienced high to extreme fire severity in the 2019/20 season.

The combination of past harvesting and extreme fire regimes (i.e. > 4 wildfires plus high or extreme plus severity post 2019/20) affected only a very small area of ridges/upper slopes (0.1 percent) of the area of the catchments in the forested portion of the CIFOA domain.

Implications

The 2019/20 fires affected a considerable proportion of this sample of drinking water catchments situated with the CIFOA domain. In turn, within this burn footprint, about half of the area was exposed to high or extreme fire severity. It is evident from the mapping (Fig. 2.3.1.) that other major catchments within the CIFOA domain not included in this sample, such as in the Snowy Mountains, were also significantly exposed to high and extreme fire severity. It is therefore likely that the 2019/20 fires provided some of the pre-conditions for significant erosion, particularly on ridges and upper slopes, given the removal of vegetation cover and enhanced vulnerability of soils created by the passage high and extreme severity fire.

The potential for erosion, sedimentation and the consequent diminution of water quality created by extensive high severity fire (Nyman et al. 2015) was strongly fulfilled by the occurrence high intensity rainfall in the first year after fire. Such circumstances occurred in the aftermath of the 2019/20 fire season throughout 2020 and into early 2021 (Fig. 2.3.2). Record breaking rainfall also occurred in March 2021.

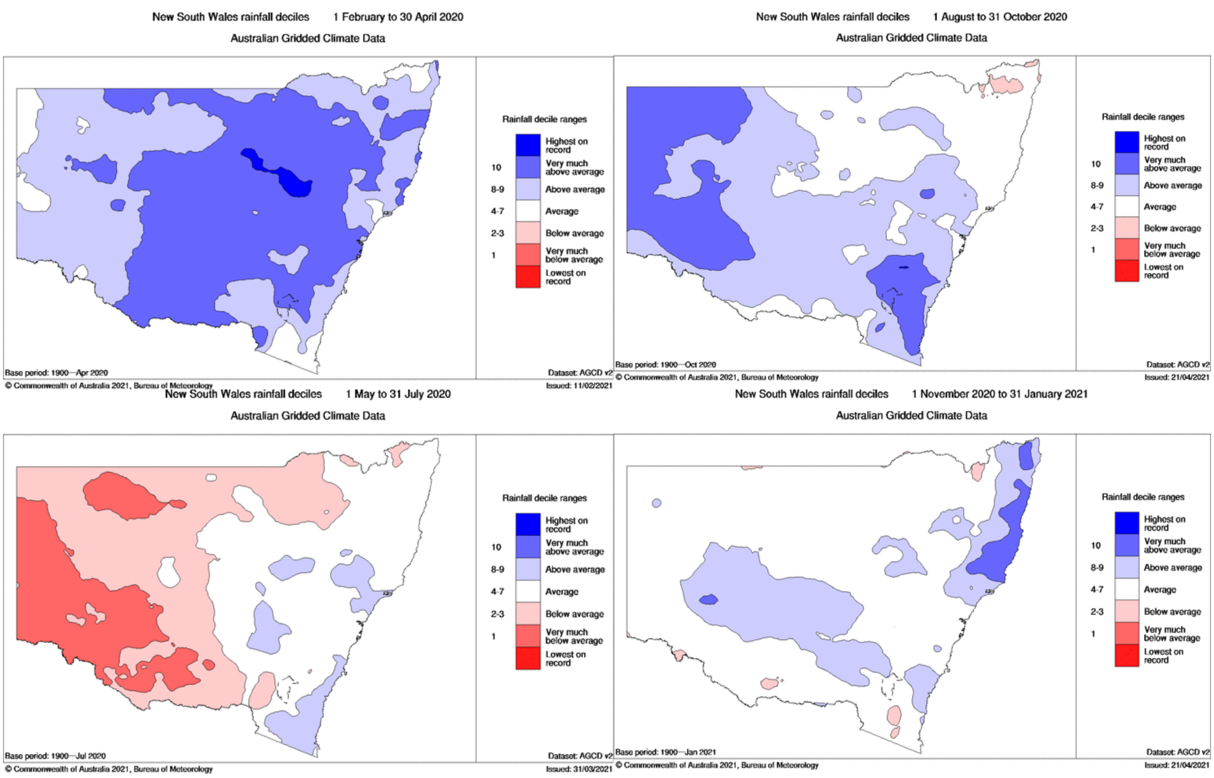


Figure 2.3.2 Quarterly rainfall patterns across NSW from February 2020 to February 2021 (source: Australian Bureau of Meteorology, http://www.bom.gov.au/climate/maps/rainfall/)

Effectively, most of this sample of catchments within the CIFOA domain experienced periods of 'very much above average' rainfall at some time between February 2020 and February 2021: i.e. within the vulnerable window of time in terms of significant erosion risk. As a result, it highly likely that widespread erosion has occurred within the fire-affected parts of the water catchments within the CIFOA domain. For example, Yang et al. (2020), estimated up to a 30 fold increase in erosion occurred in February 2020 in areas burnt in 2019/20, compared with pre-fire levels in 2019 in the Lake Burragorang catchment near Sydney, due to high intensity rainfall. Observations of large quantities of deposition of large quantities of soil, debris and ash were reported in parts of this catchment after high intensity rainfall in February 2020 (Neris et al. 2021). Observations of water chemistry in this catchment indicate that effects of previous major fires (e.g. 2001/2) may be long-lasting (Yu et al. 2019).

Further investigation of erosion and ash and debris flows resulting from the 2019/20 fires is required across all affected catchments to better understand where and how much movement of material has occurred and how such movements and subsequent deposition have affected water quality trends. Neris et al. (2021) also described the development of new tools for predicting the movement of ash that will be critical for predicting post-fire effects on water chemistry and overcoming deficiencies in linking post-fire erosion and debris transport to changes in water quality and aquatic values (Nunes et al. 2018). Exploration of these opportunities would be a fundamental pre-requisite for establishing a baseline for further targeted monitoring.

Harvesting and the patterns of past wildfires, resulting in high frequency disturbance hotspots, have affected only a very small proportion of the drinking water catchments, both pre and post the 2019/20 fires season. Past wildfires have undoubtedly had significant impacts, in terms of erosion, ash, debris, sediment transport and water quality in some individual catchments though it is unlikely that we have seen potential concurrent, erosive events of the scale evident post 2019/20 in recent history. Inbar et al. (2020) related aridity and fire frequency to soil depth, indicating that both processes act in an integrated way to heighten erosion and reduce soil depth. Given the patterns of the 2019/20 fires, the extreme antecedent drought, and their compounding effects on fire frequency it is likely that soil loss has been elevated to a high degree across this sample of catchments within the CIFOA domain. Given the extreme, immediate post-fire rainfall and further sustained precipitation across the subsequent year it is that likely that the 2019/20 fires have affected water quality across the domain of the CIFOA domain. Resultant effects on aquatic biodiversity in are also likely to be extensive, as documented in a preliminary survey of vertebrates and invertebrates by Silva et al. (2020) and in other observations (Smyth 2020). The magnitude of the fires and the consequent widespread exposure of streams and water bodies to post-fire conditions resulted in a preliminary assessment of high risk for many threatened aquatic taxa (Legge et al. 2020).

Verification of the high level of risk posed by the fires to aquatic biodiversity requires further linkage of the models above to sedimentation, water chemistry and fauna survey data in affected and unaffected catchments. Further concerns include the extensive use of fire retardants in catchments and extensive roadworks (e.g. clearing and widening) and mechanical fuel break construction during the 2019/20 fire season. Given that road networks in forested catchments can contribute to erosion and adverse water quality outcomes (Croke and Hairsine 2006, Silva et al. 2020), further examination of impacts may provide a more complete overview of the total effects of the season on catchments and related CIFOA objectives and outcomes. Archived records of mechanical works in NSW Rural Fire Service Operational Action Plans, Situation Reports and GPS tracking of aircraft movements provide important sources information in this regard. Such work could help to refine the template for further monitoring to help verify and achieve CIFOA catchment objectives and outcomes.

3. Future risks to the CIFOA

Methods

3.1 Climate change effects on future fire weather and area burned.

Effects of scenarios of climate change on fire danger/fire weather were explored across the domain of the CIFOA in order to evaluate possible future changes in fire activity and consequences for risk across the remainder of the 21st century. We explored projected changes in the McArthur Forest Fire Danger Index (FFDI, Noble et al. 1980), which is the main index of fire danger and fire weather used in fire management across forested regions of eastern Australia.

The FFDI is a dimensionless number estimated from a combination of temperature, relative humidity, wind speed, days since last rain and the drought index, in turn an index of soil moisture intended to indicate the state of moisture in surface leaf litter. The FFDI was originally conceived to cover a scale from 1 to 100, with the maximum representing worse case conditions (Black Friday, 13th January 1939 in Melbourne). It has been recognised that FFDI can exceed 100: e.g. Black Saturday 7th January 2009, FFDI circa 150 maximum at Melbourne Airport. The FFDI is categorised into: Low to Moderate (1 to 11), High (12 to 24), Very High (25 to 49), Severe (50 to 74), Extreme (75 to 99) and Catastrophic (>100), with the latter category being added after the 2009 Black Saturday fires in Victoria. These categories are commonly illustrated in road side fire danger meters and used in fire weather forecasts. The FFDI can be estimated continuously (minute by minute, hour by hour) but fire weather analysis commonly uses maximum daily estimates, as these are likely to correspond to the peak of fire behaviour, usually in mid-afternoon.

We used scenarios of FFDI derived from weather predictions generated by the NSW and ACT Regional Climate Modelling (NARCliM) project: https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/About-NARCliM. This is a NSW and ACT Government initiative, in collaboration with academic partners, that details future, regional climate projections. Briefly, NarCLIM used an ensemble of four global climate models (GCMs) and a regional climate model (RCM) in three configurations to project future changes in climate at high spatial resolution across eastern Australia, encompassing NSW and adjacent states. The ensemble of models used encompassed known variation in performance in terms of climate parameters.

Projections from NarCLiM therefore traversed a projected space of future climate possibilities under a single future emissions scenario. These condense into four different configurations of projected future climate, representing potential trends in temperature and rainfall (Beaumont et al. 2019): Warmer/Wetter, Hotter/Wetter, Warmer/Drier, Hotter/Little change. These scenarios encapsulate the uncertainty in future rainfall projections but the high degree of certainty in temperature change. This was achieved in 12 runs, representing all combinations of the GCMs and RCM configurations. These runs produced projections of meteorological variable for three time periods representing the present (1990 to 2009), near future (2020 to 2039) and far future (2060 to 2079) epochs.

Output from NARCliM included all the variables required to estimate FFDI, on a daily basis over each relevant time series. Here we used maximum daily FFDI estimation generated from relevant NARCliM weather estimates to assess current and future fire weather and some of its likely effects on future fire activity and risk in various case study areas distributed across or adjacent to the CIFOA domain and its constituent regions (Fig. 3.1).

The case study landscapes cover the range of biophysical influences on fire (climate, vegetation, terrain etc.) as well as development types, assets and infrastructure. Each is positioned within a bioregion, in order to represent the typical mix of these influences that are prevalent across each bioregion. These landscapes were chosen for estimation of risk and effectiveness of risk mitigation via use of prescribed fire using the Phoenix RapidFire fire spread simulator. The simulations use probabilistic methods to account for variations in ignition type, probability, fire weather and fuel dynamics as a function of vegetation types extant in each case study landscape. The case studies have been divided into two sets.

The first set of four case studies (Fig. 3.1), were derived as part of the Prescribed Burn Atlas project funded by the Bushfire and Natural Hazards CRC (Cooperative Research Centre). Results for these case studies include estimation of area burned by wildfires under current and future climate, along with effects of a wide variety of prescribed burning strategies and resultant effects on a range of values. This information can be viewed interactively: www.prescribedburnatlas.science

The four case studies in this first set flank the extremes of the CIFOA domain and therefore provide broad context concerning climate change effects on fire across the latitudinal range encompassed by the CIFOA domain and each of its constituent regions:

- NSW South East Corner case study and Eden Region IFOA;
- ACT case study and higher altitude areas of the Southern Region IFOA
- Blue Mountains case study and southern fringe of the Lower North East Region IFOA
- South East Qld case study and Upper North East Region IFOA.

Here, information is presented on projected FFDI and area burned by wildfires for current and future climate (2060 to 2079 projections) for this first set of case studies.

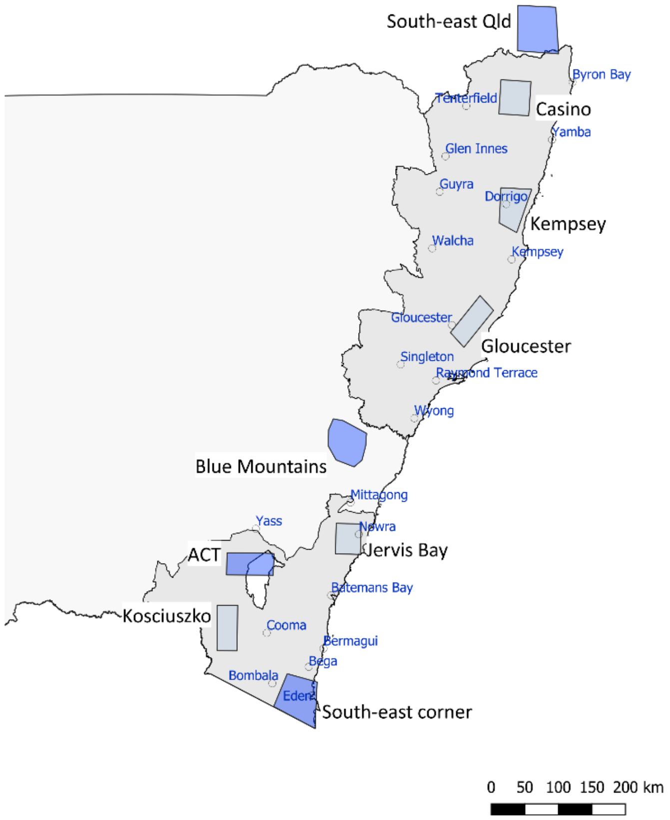


Figure 3.1 Location of case study landscapes used to assess future changes in fire weather and simulated area burned, in relation the area of the CIFOA domain (grey shading) in eastern NSW. Dark shaded areas indicate landscapes used for the Prescribed Fire Atlas simulations, and light shaded areas indicate landscapes used in NSW Bushfire Risk Management Research Hub simulations.

The second set of five case study landscapes have been developed to support risk estimation research by the NSW Bushfire Risk Management Research Hub. These case studies fall across the domain of the CIFOA and are interspersed between the case studies presented in the first set (Fig. 3.1):

- Kosciuzsko case study and high altitude areas of the Southern Region IFOA;
- Jervis Bay case study and the northern part of the Southern Region IFOA;
- Gloucester case study and mid-hinterlands of the Lower North East Region IFOA
- Kempsey case study and northern fringe of the Lower North East Region IFOA
- Casino case study and hinterlands of the Upper North east Region IFOA

These case studies use an identical methodology and range of values as the Atlas case studies described above, however the results that are currently available only explore effects on area burned by wildfires under current climate. Therefore only information on current and future FFDI is presented here. This enables some wider, comparative inferences on likely trends in wildfire and fire management to be derived, using results for the first set of case studies as a baseline.

We refer to the two sets of case studies as the Atlas and Hub case studies, respectively, throughout. After evaluation of degree of change in FFDI across the NARCliM ensemble, outputs from the ECHAM5_R3 and MIROC3.2_R1 models were used to estimate maximum and minimum future fire weather scenarios. Respectively these represent the Hotter/Little change and Warmer/Wetter futures explored in NARCliM.

3.2. Threatened animal species: projected changes in habitat

The effects of climate change on the projected area of suitable habitat for the target group of threatened animal species was estimated. The models underpinning these estimates are predominantly bioclimatic. Therefore scenarios from the NARCliM modelling ensemble were selected for the approximate mid-point of each epoch (i.e. 2030, 2070) to estimate potential habitat change using the corresponding output described in Beaumont et al. (2019). We used results generated by the corresponding climate models (i.e. ECHAM5, Hotter/Little change; MIROC3.2 Warmer/Wetter) for each of these future years. This provided an overview of the range of projected change in suitable habitat, for each species, that could be matched against projected changes in FFDI and area burned (far future epoch only).

The lack of climatic modelling for the Koala prevented exploration of future scenarios of habitat under climate change for this species.

Results

3.1.1 Current fire weather

Scenarios of fire weather, as indicated by the forest fire danger index under current climate (1990-2009; 7035 days in total) varied widely within and between all case study landscapes (Tables 3.1, 3.2). The bulk of days, in all landscapes, had Low-Moderate FFDI, with progressively smaller tallies in higher FFDI categories.

Among the Atlas landscapes, stronger fire weather conditions were evident under both current and future climate in the Blue Mountains and SE Queensland landscapes (indicative of Lower and Upper North East IFOA Regions, respectively), compared with NSW South East Corner and ACT (indicative of Eden and Southern IFOA Regions, respectively): i.e. higher number of days in the Extreme, Severe and Very High categories with a corresponding lower number of days in the Low-Moderate and High categories (Tables 3.1, 3.2). These contrasts are important given that most significant unplanned fires coincide with periods of fire weather in these categories. Contrast between high and low scenarios of FFDI under current climate, were similar across all four Atlas landscapes: i.e. differences in number of days between each FFDI category were relatively similar (Tables 3.1, 3.2). Notably, for ACT and NSW South East Corner and ACT case studies (indicative of Eden and Southern IFOA Regions, respectively) there were zero days in the Severe category and the Low scenario for current climate, whereas there were one and four days respectively under the High scenario. No predicted days of Catastrophic FFDI occurred under either scenario in the Atlas landscapes.

Fire weather in the Hub landscapes was similar to or exceeded that predicted for most of the Atlas landscapes, under current climate. The exception to this was Kosciuszko (indicative of the high-altitude portion of the Southern IFOA Region), where FFDI was generally milder than all other landscapes. The Casino, Gloucester and Jervis Bay landscapes (indicative of Upper North East, Lower North East and Southern IFOA Regions, respectively), in particular, had a few more days of Severe FFDI than the Blue Mountains and SE Queensland landscapes. Contrasts between High and Low climate scenarios were relatively consistent and similar to those predicted for the Atlas landscapes. No Catastrophic FFDI were predicted for the Atlas landscapes.

3.1.2 Future fire weather

The High and Low scenarios had divergent effects on projected fire weather under climate change (Tables 3.1, 3.2, 3.3, 3.4). Generally, the Low scenario resulted in little change or even a slightly subdued level of overall FFDI: i.e. a general shift toward more days in the Low to Moderate Category with a reduction in other categories. This trend was evident for both epochs, though in most cases the shift from categories of High FFDI or above was more subdued in the far (2060-2079) epoch (Tables 3.3, 3.4) than in the near future epoch (2020-2039, Tables 3.1, 3.2).

By contrast the High scenario resulted in strong shifts towards to FFDI categories of High and above with a commensurate decline in the Low to Moderate FFDI category across the case study landscapes (Tables 3.1, 3.2, 3.3, 3.4). Such shifts were more pronounced in the far future epoch compared with the near future epoch, though the bulk of this shift was concentrated in the Very High to Severe categories: i.e. little absolute change in Extreme days occurred and no Catastrophic days were projected in either epoch.

Table 3.1 Daily distribution (number of days per category) of fire weather (maximum Forest Fire Danger Index) under present weather (1990-2009) in the PB Atlas case study landscapes. Values with near future epoch (2020-2039) projected change (percent change in days) are given in brackets. Categories of FFDI are; LM Low-Moderate; H High; VH Very High; S Severe; E Extreme; C Catastrophic.

Scenario	Case study (IFOA Region)	LM	H	VH	S	E	C
High	ACT (Southern)	6528 (-3)	654 (29)	122 (24)	1 (200)	0 (-)	0 (-)
Low	ACT (Southern)	7066 (1)	217 (-23)	22 (-50)	0 (-)	0 (-)	0 (-)
High	BM (Lower North East)	6250 (-5)	827 (33)	220 (31)	8 (25)	0 (-)	0 (-)
Low	BM (Lower North East)	6507 (2)	658 (-6)	131 (-38)	7 (-86)	2 (-100)	0 (-)
High	NSW SEC (Eden)	6767 (-1)	472 (13)	62 (16)	4 (-75)	0 (-)	0 (-)
Low	NSW SEC (Eden)	6873 (1)	404 (-20)	28 (-7)	0 (-)	0 (-)	0 (-)
High	SE QLD (Upper North East)	5978 (-9)	1141 (34)	175 (66)	9 (233)	2 (50)	0 (-)
Low	SE QLD (Upper North East)	6713 (1)	503 (-2)	85 (-32)	4 (-50)	0 (-)	0 (-)

Table 3.2 Daily distribution (number of days per category) of fire weather (maximum Forest Fire Danger Index) under present weather (1990-2009) in the NSW BRMR Hub case study landscapes. Values with near future epoch (2020-2039) projected change (percent change in days) are given in brackets. Categories of FFDI are; LM Low-Moderate; H High; VH Very High; S Severe; E Extreme; C Catastrophic.

Scenario	Case Study (IFOA Region)	LM	H	VH	S	E	C
High	Casino (Upper North East)	6030 (-8)	1016 (31)	247 (55)	12 (117)	0 (-)	0 (-)
Low	Casino (Upper North East)	6561 (3)	627 (-20)	111 (-49)	6 (-100)	0 (-)	0 (-)
High	Gloucester (Lower North East)	6428 (-4)	688 (30)	171 (30)	17 (-35)	1 (0)	0 (-)
Low	Gloucester (Lower North East)	6586 (2)	596 (-10)	113 (-27)	9 (-78)	1 (-100)	0 (-)
High	Jervis Bay (Southern)	6313 (-5)	774 (34)	198 (41)	19 (-21)	1 (-100)	0 (-)
Low	Jervis Bay (Southern)	6395 (2)	752 (-13)	147 (-34)	10 (-10)	1 (-100)	0 (-)
High	Kempsey (Lower North East)	6765 (-3)	444 (32)	91 (47)	5 (-20)	0 (-)	0 (-)
Low	Kempsey (Lower North East)	6819 (1)	424 (-17)	58 (-45)	4 (-75)	0 (-)	0 (-)
High	Kosciuszko (Southern)	7014 (-2)	248 (54)	41 (-2)	2 (50)	0 (-)	0 (-)
Low	Kosciuszko (Southern)	7225 (0)	76 (-33)	4 (0)	0 (-)	0 (-)	0 (-)

Table 3.3 Projected change in daily FFDI in the far future epoch (2060-2079) in the PB Atlas case study landscapes. Values are percent change in days relative to the present (1990-2009, see Table 3.1)

Scenario	Landscape	LM	H	VH	S	E	C
High	ACT	-7	47	85	1500	-	-
Low	ACT	1	-34	-41	-	-	-
High	BM (Lower North East)	-8	45	53	462	-	-
Low	BM (Lower North East)	2	-7	-56	-71	-100	-
High	NSW SEC (Eden)	-5	55	76	200	-	-
Low	NSW SEC (Eden)	0	1	-4	-	-	-
High	SE QLD (Upper North East)	-8	31	61	211	50	-
Low	SE QLD (Upper North East)	2	-16	-31	-25	-	-

Table 3.4 Projected change in daily FFDI in the far future epoch (2060-2079) in the NSW BRMR Hub case study landscapes. Values are percent change in days relative to the present (1990-2009, see Table 3.2)

Scenario	landscape	LM	H	VH	S	E	C
High	Casino (Upper North East)	-5	12	55	250	-	-
Low	Casino (Upper North East)	3	-26	-14	-67	-	-
High	Gloucester (Lower North East)	-5	34	22	135	900	-
Low	Gloucester (Lower North East)	3	-21	-37	-67	-100	-
High	Jervis Bay (Southern)	-7	43	48	189	300	-
Low	Jervis Bay (Southern)	3	-13	-38	-30	-100	-
High	Kempsey (Lower North East)	-2	23	53	220	-	-
Low	Kempsey	2	-27	-5	-100	-	-

	(Lower North East)						
High	Kosciuszko (Southern)	-4	102	137	50	-	-
Low	Kosciuszko (Southern)	0	-36	0	-	-	-

3.1.3 Future changes in area burned

Projections of effects of climate change on simulated area burned by wildfires were available for the Atlas case study landscapes (Table 3.5). These estimates represent potential effects of climate change on annualised expected area burned by wildfires that approximates an average. These were based on the corresponding FFDI scenarios for the 2060 to 2079 epoch, as summarised in Table 3.5.

The projected future change in expected area burned by wildfires varied among the case study landscapes, with the widest range evident for the NSW SE Corner case study landscape and the narrowest range evident for SE Queensland.

Table 3.5 Simulated change in expected annual area burned by wildfire (approximate average) in the PB Atlas case study landscapes, under two scenarios of far future climate (2060-2079).

Case Study Landscape	IFOA Region	High scenario percent change	Low scenario percent change
ACT	Southern (high altitude)	+10.5	- 0.9
Blue Mountains	Lower North Eastern (southern edge)	+20.2	- 6.6
NSW SE Corner	Eden	+26.3	- 1.4
SE Qld	Upper North Eastern (northern edge)	+5.3	- 1.4

Overall, the results for all case studies indicated the potential for a change in FFDI conducive to a substantial increase in area burned in the latter part of the 21st century across the gradients of latitude and altitude of the CIFOA domain, particularly under the Hotter/Little change climate scenario. The low change scenarios, under a Warmer/Wetter projected future indicated potential for either little change or a small decline in overall FFDI and area burned in the far future epoch. This represents the lower bound of the futures generally explored in NARCliM with other scenarios likely to produce results that intermediate between the two scenarios presented here. This reinforces the conclusion that the likely future trend is for increased fire danger and area burned by wildfires. However, it is stressed that these results are indicative and do not represent a simple multiplier that can be applied to current area burned information. Also greater exploration of climatic variation across the CIFOA domain would be useful.

The distribution of area burned over time in most ecosystems is strongly skewed, with most area burned usually accounted for by relatively few large fires. Often large fires may be up to six orders of magnitude larger than the smallest fires: i.e. > 10,000 ha cf. <1 ha. The estimates provided here pertain to an expected approximate average annual area burned by wildfires that lies toward the bottom of this range in each case study landscape: i.e. circa 100 to 1,000 ha. The indicated change in this annualised average is best regarded as an indicator of the trend under climate change and its relative magnitude.

Given these results, there is potential for the area of the CIFOA domain that is exposed to frequent and severe fire to increase substantially with a consequent increase in risk to CIFOA objectives and outcomes. The results in Table 3.5 projected the magnitude and direction of potential change in area burned by wildfires for the far future. However, the relative magnitude of change in FFDI projected for the near future (Tables 3.1, 3.2), indicates the potential for such an increase in area burned by wildfires to occur in coming decades.

Given the exceptional nature of the 2019/20 fire season and its probable links to climate change (Abram et al. 2021), such a shift is already likely to be underway. Such increases in area burned, in general, will lead to increases in fire frequency and a likely increase in the area exposed to extremes of fire frequency and intensity, though local factors will shape where and when such changes to the fire regime will occur.

The management of changes in fire regimes of this kind and the heightened risks they pose to people, property and environmental values such as those embodied in the CIFOA domain is a critical challenge. There are a broad range of possibilities such as changes to rapid detection of ignition, suppression and hazard reduction (i.e. manipulation of fuel), all of which involve interventions in the landscape. Some of these options were the subject of review and recommendations by the NSW Independent Bushfire Inquiry, during 2020. For example, the Inquiry recommended changes to detection and aerial suppression capabilities and an increase in hazard reduction activities that strategically target areas of high ignition probability from lightning on the one hand, and the interface between bushland and development on the other.

Insights into the effectiveness of these actions in mitigating the consequences of climate change are lacking. However, the Prescribed Fire Atlas Project provides some information on possible effects of climate change in altering the risk mitigation potential of differing prescribed fire strategies.

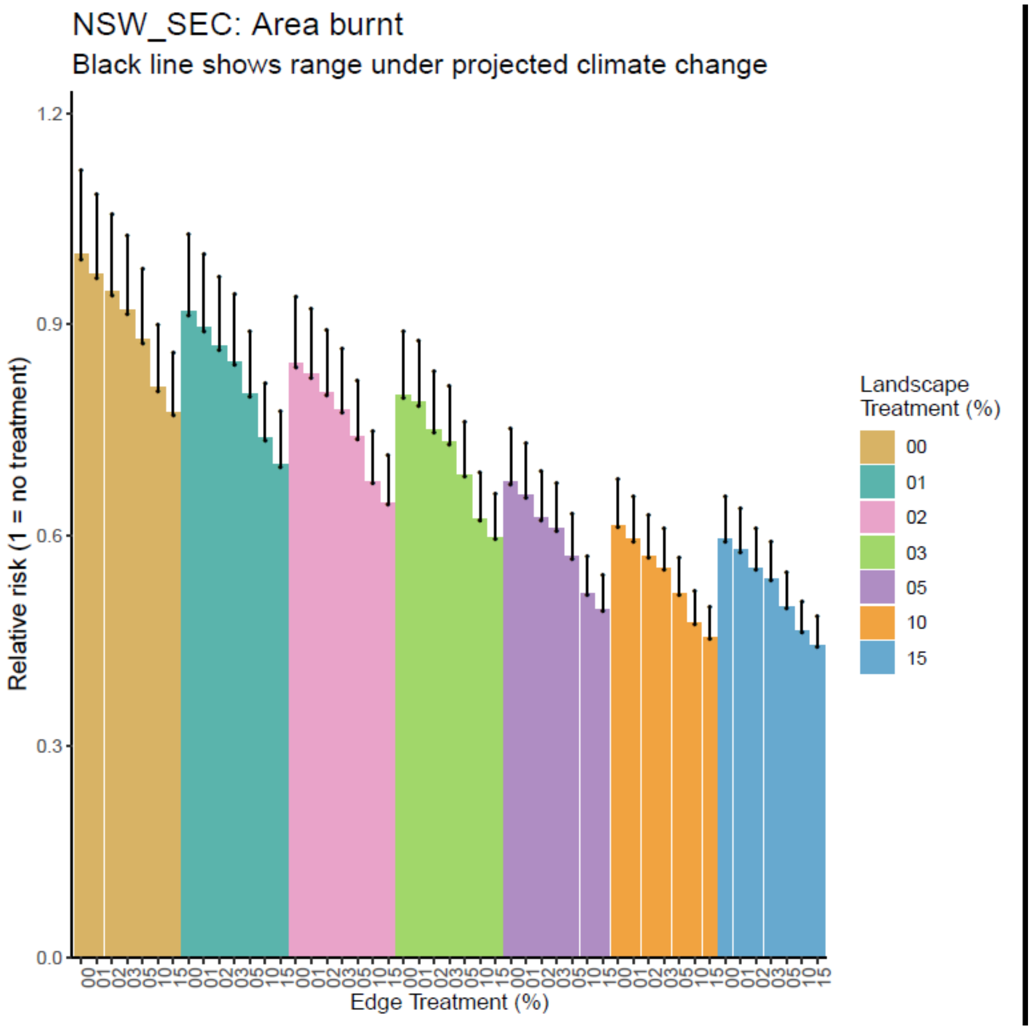


Figure 3.2 Estimated response of area burned by wildfire to variations in prescribed burning rate (percent landscape treated per annum) and spatial patterns (treatment concentrated on the edge or distributed across the landscape). Area burned by wildfires is normalised. The estimated range of effects of climate change (2060 to 2079) is indicated by vertical black lines.

For example, for the NSW South East Corner case study landscape (Eden Region IFOA), simulated area burned by wildfires declines as the annual rate of prescribed burning (percent of landscape treated per annum) increases (Fig. 3.2). Wildfire area is also sensitive to the spatial pattern of treatment: treatments focussed at the interface between built assets and bushland (Edge treatments, different rates represented by different subdivisions in each colour block, Fig. 3.2) and treatments distributed broadly across the landscapes (Landscape treatments, different rates represented by different colour blocks, Fig. 3.2) have differential effects on simulated area burned by wildfires.

Climate change, in this example of the SE Corner case study (Eden Region IFOA), generally counteracts the effectiveness of prescribed fire in reducing predicted area burned by wildfire (Fig. 3.2). For example, at the upper limit of projected climate change (far future epoch, Fig. 3.2) an approximate 300 percent increase in the rate of prescribed fire in the landscape is required to reduce predicted area burned to levels under current climate: e.g. a shift from a treatment rate of 1 percent p.a. to 3 percent p.a. in landscape treatment is required, assuming edge treatment rate remains constant (Fig. 3.2). In general, this implies that current treatment rates (circa 1 percent) would need to be tripled in order to hold area burned by wildfires and consequent risks at current levels under this degree of influence of climate change. Further reductions in risk beyond this would require a commensurate higher level of increase in rates of treatment. The cost implications of such changes are formidable.

3.2 Threatened animal species: projected changes in habitat

The projected area of suitable habitat for the target group of threatened animal species under climate change varied substantially (Table 3.6).

Table 3.6 Changes in predicted suitable habitat of various threatened animal species across the CIFOA domain under climate change. Hotter/Little change (ECHAM5) and Warmer/Wetter (MIROC32) scenarios of change are presented for the near 2030 and far 2070 future.

Group	Common name	Scientific name	Current area in CIFOA domain (ha)	Percent change ECHAM5 2030	Percent change MIROC32 2030	Percent change ECHAM5 2070	Percent change MIROC32 2070
mammal	Rufous Bettong	*Aepyprymnus rufescens*	6,203,605	40.0	-1.7	28.5	-8.2
mammal	Eastern Pygmy-possum	*Cercartetus nanus*	5,856,397	-63.2	-29.3	-75.1	-29.4
mammal	Spotted-tailed Quoll	*Dasyurus maculatus*	11,232,835	-33.9	-20.9	-61.0	-34.7
mammal	Southern Brown Bandicoot (eastern)	*Isoodon obesulus obesulus*	727,859	385.8	52.8	207.6	1.1
mammal	Yellow-bellied Glider	*Petaurus australis*	9,515,484	-51.4	-25.2	-78.9	-24.0
mammal	Squirrel Glider	*Petaurus norfolcensis*	6,041,808	20.8	1.9	63.2	42.8
mammal	Brush-tailed Phascogale	*Phascogale tapoatafa*	5,372,465	-45.7	-3.5	28.5	40.0
mammal	Long-nosed Potoroo	*Potorous tridactylus*	6,347,713	16.5	21.8	-14.7	4.7
mammal	White-footed Dunnart	*Sminthopsis leucopus*	1,740,582	-93.9	-64.7	-99.2	-90.4
mammal	Red-legged Pademelon	*Thylogale stigmatica*	2,877,976	-16.8	1.8	-38.8	-29.2
bird	Glossy Black-Cockatoo	*Calyptorhynchus lathami*	10,434,790	-31.7	-16.0	-58.0	0.5
bird	Varied Sittella	*Daphoenositta chrysoptera*	13,087,527	6.3	0.5	6.9	-2.3

Group	Common name	Scientific name	Current area in CIFOA domain (ha)	Percent change ECHAM5 2030	Percent change MIROC32 2030	Percent change ECHAM5 2070	Percent change MIROC32 2070
bird	Barking Owl	*Ninox connivens*	5,461,661	63.5	13.1	81.2	44.5
bird	Powerful Owl	*Ninox strenua*	11,966,017	-38.7	-10.7	-54.7	-7.5
bird	Masked Owl	*Tyto novaehollandiae*	10,516,682	-51.5	-16.0	-76.1	-13.2
bird	Sooty Owl	*Tyto tenebricosa*	7,046,894	-60.7	-22.3	-81.4	-15.8
bird	Rufous Scrub-bird	*Atrichornis rufescens*	2,076,085	146.6	68.5	70.4	-14.9
bat	Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	10,515,450	-22.7	-16.1	-49.3	-32.6
bat	Golden-tipped Bat	*Phoniscus papuensis*	5,617,498	-53.2	-63.1	-81.2	-22.6
bat	Corben's Long-eared Bat	*Nyctophilus corbeni*	1,324,760	-0.6	-65.2	18.4	-49.4
bat	Greater Broad-nosed Bat	*Scoteanax rueppellii*	8,255,435	-70.6	-51.3	-62.3	-14.0
bat	Eastern Cave Bat	*Vespadelus troughtoni*	3,393,158	-6.6	-48.2	82.9	-4.7
amphibian	Stuttering Frog	*Mixophyes balbus*	3,946,135	-53.0	-46.2	-78.1	-30.6
amphibian	Giant Barred Frog	*Mixophyes iteratus*	3,068,027	-45.2	-13.6	-53.4	-16.4

Broadly, the projected responses fell into two groups: consistent decline versus varied mix of increase and decline (Table 3.6). Respectively, these groups included 14 and 10 species. Suitable habitat for the bulk of mammal (5), bird (4), bat (3) and all amphibian (2) species were predicted to decline under all projected 2030 and 2070 scenarios. By contrast, suitable habitat for the mammals, *Isoodon obesulus obesulus* (a glider) and *Petaurus norfolcensis* (a bandicoot) and *Ninox connivens,* (an owl) was predicted to increase under both climate change scenarios for both future years. For the remaining seven species, a potential for both an increase and decline under some of the future scenarios was predicted, and the magnitude of any projected increases was highly variable.

In general, these projections of suitable habitat represent responses to extremes of future dryness arising from the NARCliM ensemble, with Hotter/Little change representing the greatest degree of warming and little change in rainfall (the driest future) and Warmer/Wetter representing a more moist future. The responses of each species are assumed to reflect their relative sensitivity to these projected coupled changes in temperature, rainfall and their combined effects on dryness, along with other climate variables.

In the group species with predicted consistent decline, such declines were consistently greatest under the Hotter/Little change (ECHAM5) future scenario compared with the Warmer/Wetter (MIROC32) future in 11 species. For eight of these species, predicted decline was greater for 2070 compared with 2030 under the Hotter/Little change (ECHAM5) scenario. However, the opposite was the case for some of this group of species under the Warmer/Wetter (MIROC32), with differences being smaller between 2030 and 2070 under this scenario. Overall, this may indicate that this group of species is generally more sensitive to a drier future.

For the species with mixed future responses, five exhibited consistent increases in habitat for both future dates, with higher increases under the Hotter/Little change (ECHAM5) compared with the Warmer/Wetter (MIROC32) scenario. The remaining species showed mixed responses (predicted increases and decreases in suitable habitat) though the magnitude of change was generally greater under Warmer/Wetter (MIROC32) compared with the Hotter/Little change (ECHAM5) scenario: i.e. there was a tendency for a higher level of increase or lower level of decline under the Warmer/Wetter (MIROC32) future. Thus this group contains subsets of species which tended to be favoured by either drier or moister futures.

Overall the patterns reflected the outcome of the study by Beaumont et al. (2019). This study indicated that the extent of future (2070) may be 'broadest' under the Warmer/Wetter (MIROC32) scenario and 'narrowest' under the Hotter/Little change (ECHAM5) scenario, though Beaumont et al. (2019) used a greater number of species in their study.

This dichotomy of projected habitat responses gives a coarse basis for assessment of the consequences of possible future changes in fire. If it is assumed that frequent, severe wildfires are likely to be deleterious to most of the nominated species, based on their key habitat attributes (Table 2.2.1), as discussed above, then species in the group with predicted consistent decline will possibly the most vulnerable to an increase in future fire activity, of the kind discussed above. Increased dryness as reflected in the Hotter/Little change (ECHAM5) scenario may concurrently act to diminish predicted habitat and increase wildfire activity to the greatest degree in these species. Thus risk to the majority of the species considered here may be high. For the remainder of species, the outcome may be more complex though some of these species may be buffered to some degree by a predicted increase in area of suitable habitat, against possible negative effects of increased fire activity in the future.

Given that this sample of threatened species exhibits a mixture of responses, there is a need to more fully investigate a wider range of potential responses among threatened species and more common species. In particular it would be informative to explicitly couple the future prediction of refugia for threatened species, as done by Beaumont et al. (2019) with explicit fire simulation of the kind described in the Prescribed Burn Atlas. Given that fire spread simulators of the kind used in the Atlas, can incorporate terrain, vegetation and climate surfaces, such approaches may give great insight into how landscape-scale refugia and emergent risk to threatened species may be shaped by the coupled effects of climatic and fire regime change.

Implications

Worsening fire weather (Jolly et al. 2016) and a corresponding elevation in area burned across the 21st century is a common prognosis for many forested regions across the world (e.g. Abatzaglou and Williams 2016). Current evidence, as presented here confirms this possibility for eastern NSW and the domain of the CIFOA. The 2019/20 significantly changed disturbance regimes and the direction and magnitude of this change are likely to be reinforced in coming decades. One major concern is that 2019/20 fire season possibly exceeded late 21st century scenarios of increased fire activity under climate change (Sanderson and Fisher 2020). Thus predictions presented here could be regarded as conservative.

The area of the CIFOA domain that will be exposed to extremes of disturbance (i.e. high frequency and high intensity wildfires, Collins et al. 2021) is likely to increase substantially. Commensurate increases in risk to all the objectives and outcomes of the CIFOA, such as water quality, forest regeneration and structure, carbon storage and threatened species conservation, as outlined in preceding sections will ensue. The capacity of management to counter such changes may be limited, given their magnitude, as illustrated by the example of the level of increase in prescribed burning needed to hold wildfire area at close to current levels. Major interventions, such as targeted defence of refugia and key populations (e.g. as carried out for the Wollemi Pine during the Gosper’s Mountain Fire in late 2019) may be required in concert with other actions such as translocations.

As indicated above, the NSW Independent Bushfire Inquiry recommended changes to rapid response, suppression capacity (particularly aircraft), communications, improved technology for surveillance and situational awareness during major fires, and changes to prescribed burning strategies. Thus far, the capacity of agencies has been augmented with significant increases in funding, fire personnel, equipment and planning capacity. Despite these changes, the sum total of their impact and ability to deal with future fires is likely to be incremental rather than transformative. Should another season occur soon that is somewhere in magnitude between 2019/20 (circa 5 million ha burnt in forested regions of NSW) and 2002/3 (circa 1.4 million) it is likely that our capacity to deal with such a season will be overwhelmed as it was 2019/20.

Other key recommendations of the Inquiry, such as granting the capacity for landowners to clear vegetation along boundaries and upgrades to the fire trail network, will require careful implementation to avoid negative consequences for soil movement and water quality. The precedents for fire retardant usage in water catchments established during the 2019/20 season may be difficult to reverse. The resultant potential for adverse consequences on water quality and aquatic biodiversity requires attention. Given the likelihood of increased risk to catchments, water quality and aquatic biodiversity posed by future fire regimes, it is imperative that these risk are not additionally elevated by operational management responses.

Given the current state of vulnerability of ecosystems and biodiversity within the domain of the CIFOA, a central priority may be to identify and prioritise the most critical ecological elements and their localities. This would not only include known locations of threatened species, their habitat features and endangered ecological communities but also features such as landforms that remain vulnerable to soil and carbon loss. Priorities and strategies and options for actions may need to be developed and debated. Emphasis should be placed on areas containing these elements that were unburnt in 2019/20 or else burnt but where recovery is known to be strong. Ascertaining the recovery strength trajectory for regeneration across areas affected by the 2019/20 fires is a priority that would help to inform development of actions plans to cope with imminent large, severe fires.

As a first priority, the monitoring project may need to be structured to explicitly to take into account contrasting fire regime patterns and their effects on the core ecological values that are targeted in the CIFOA objectives, particularly aspects of forest structure and regeneration. This would complement other current initiatives that are targeted at assessing species recovery. In this overview, we have made predictions based on key assumptions about responses of species and their habitat elements to particular fire regimes. Some of these assumptions are based on reasonable evidence but the veracity of emergent predictions require testing. Given that comprehensive fire mapping and fire history knowledge is constantly improving, monitoring needs to be structured in a way that can compare outcomes of contrasting fire regimes, especially those deemed to be either benign or deleterious to particular species and their habitats.

The NSW Rural Fire Service is embarking on a new Bushfire Risk Management Planning process that will be based around the fire simulation capacity outlined here and as developed in the Prescribed Burn Atlas project. The NSW National Parks and Wildlife Service has been allocated the task of developing the environmental and cultural heritage components of the risk estimation process. The priorities outlined above need to be comprehensively shaped and incorporated into the risk planning process, as a high priority. A pathway needs to be created that ensures that the key objectives and outcomes of the CIFOA are clearly represented in the new risk planning process. This is an important priority.

Altered fire regimes result from an increase in area burned by wildfires and in response, planned fires may pose certain risks to objectives and processes. However, as shown in the threatened animal species examples, other changes driven by climate change need to be accounted for in order to more fully evaluate risks. For example, an increase in temperature is more likely to substantially reduce above- and below-ground carbon stocks in some dry sclerophyll forests, than changes in fire frequency and severity (Sawyer et al. 2018b, Gordon et al. 2019). Given that most above-ground carbon is stored in large trees, such a change may go hand in hand with reduction of tree density in general and large trees in particular. This may also act as an indicator of a potential reduction in hollow-bearing trees (Gordon et al. 2019).

Recent harvesting was found to reduce above-ground carbon stocks in NSW South Coast forests, compared with long unburnt and less recently harvested forests (Wilson et al. 2021a). Given likely future trends in fire, there will be a heightened need to protect regenerating forests, post-harvesting, via enhanced prevention and suppression measures. This will be required to maintain the resilience of carbon stocks, habitats and forest structure. This may be challenging given that recent harvesting can also result in a forest structure that provides greater vertical continuity between the understorey and tree canopy (Wilson et al. 2021b) potentially increasing the potential for higher fire severity. Further refinement of burning prescriptions that protect regrowth and habitat values but alter vertical fuel continuity may be required.

Overall, the concurrence of drought with severe wildfire may elevate risks to tree populations through higher mortality, reduced post fire seedling recruitment and compromised resprouting (Nolan et al. 2020ab). The overriding effects of elevated fire weather may outstrip legacy effects of forest harvesting, planned fire and variations in forest types in shaping the size and severity of wildfires (Bowman et al. 2021, Collins et al. 2021). Given that many of the key processes that govern the likely future dynamics of eucalypt forests under climate change remain incompletely understood, future scenarios of change in structure and composition remain speculative (Bowman et al. 2020). Nonetheless, under a hotter and possibly drier future risks to the integrity of forests are likely to be directly and indirectly elevated (i.e. through changed fire regimes). Whether or not such changes are incremental or sudden, as wrought by the 2019/20 fire season, there remains a strong likelihood that change will be rapid.

An informed monitoring program that provides rapid comparative insight into changes wrought by extremes of disturbance regimes and other external drivers such as drought and extreme temperature events will be required to provide the ongoing intelligence required for adaptive management. Therefore the monitoring program needs to be designed and implemented in a way that can scrutinise the coupled effects of fire regime extremes of disturbance regimes (i.e. fire, harvesting) and drought.

References

Abatzoglou JT, Williams AP (2016). Impact of anthropogenic climate change on wildfire across western US forests. *Proceedings of the National Academy of Sciences USA*, 113, 11770-5.

Abram N J, Henley BJ, Sen Gupta A, Lippmann TJR, Clarke H, Dowdy AJ, Sharples JJ, Nolan RH, Zhang T, Wooster MJ, Wurtzel JB, Meissner KJ, Pitman AJ, Ukkola AM, Murphy BP, Tapper NJ, Boer MM (2021). Connections of climate change and variability to large and extreme forest fires in southeast Australia. *Communications Earth & Environment* 2, 8.

Alexandra J, Finlayson CM (2020). Floods after bushfires: rapid responses for reducing impacts of sediment, ash, and nutrient slugs. *Australasian Journal of Water Resources*, 24, 9-11.

Auld TD, Mackenzie BDE, Le Breton T, Keith DA, Ooi MKJ, Allen S, Gallagher RV (2020) *A preliminary assessment of the impact of the 2019/2020 fires on NSW plants of national significance.* Report to the NSW Department of Planning, Industry and Environment.

Banks S, Knight E, McBurney L, Blair D, Lindenmayer D (2011). The effects of wildfire on mortality and resources for an arboreal marsupial: resilience to fire events but susceptibility to fire regime change. *PLoS ONE* 6, 1–12.

Baumgartner JB, Esperón-Rodríguez M, Beaumont LJ (2018). Identifying in situ climate refugia for plant species. *Ecography* 41, 1850–1863.

Beaumont LJ, Esperón-Rodríguez M, Nipperessa DA, Wauchope-Drumm M, Baumgartner JM (2019). Incorporating future climate uncertainty into the identification of climate change refugia for threatened species. *Biological Conservation* 237, 230–237.

Bennett LT, Bruce MJ, Machunter J, Kohout M, Krishnaraj SJ, Aponte C. (2017). Assessing fire impacts on the carbon stability of fire-tolerant forests. *Ecological Applications* 27, 2497-513.

Bino G, Hawke T, Kingsford RT (2021). Synergistic effects of a severe drought and fire on platypuses. *Science of The Total Environment* 777**,** 146137.

Bixby RJ, Cooper SD, Gresswell RE, Brown LE, Dahm CN, Dwire KA (2015). Fire effects on aquatic ecosystems: an assessment of the current state of the science. *Freshwater Science* 34, 1340–1350.

Bond, WJ, van Wilgen, BW (1996) *Fire and Plants.* Population and Community Biology series 14, (Springer, Netherlands).

Bowman DMJS, Williamson GJ, Prior LD, Murphy BP (2016). The relative importance of intrinsic and extrinsic factors in the decline of obligate seeder forests. *Global Ecology and Biogeography* 25, 1166-1172.

Bowman D, Williamson G, Yebra M, Lizundia-Loiola J, Pettinari ML, Shah S, Bradstock R, Chuvieco E (2020a) Wildfires: Australia needs a national monitoring agency. *Nature* 584, 188 -191

Bowman D, Williamson G, Price O, Ndalila M, Bradstock, R. (2020b). Australian forests, megafires and the risk of dwindling carbon stocks. *Plant Cell and Environment*, doi.org/10.1111/pce.13916

Bowman DMJS, Williamson GJ, Gibson R, Bradstock RA, Keenan RJ (2021). The severity and extent of the Australia 2019-20 Eucalyptus forest fires are not the legacy of forest management. *Nature Ecology & Evolution* doi.org/10.1038/s41559-021-01464-6

Bradstock RA (2008). Effects of large fires on biodiversity in south-eastern Australia: disaster or template for diversity? *International Journal of Wildland Fire* 17, 809–822.

Bradstock RA, Kenny BJ (2003). Application of plant functional traits to fire management in a conservation reserve in south-eastern Australia. *Journal of Vegetation Science* 14, 345-354.

Bradstock RA, Bedward M, Gill AM, Cohn JS (2005). Which mosaic? A landscape ecological approach for evaluating interactions between fire regimes, habitat and animals. *Wildlife Research* 32, 409-423.

Bridges RG (1983). *Integrated logging and regeneration in the Silvertop Ash – Stringybark Forests of the Eden Region.* New South Wales Forestry Commission Research Report No. 2.

Burrows GE. 2013. Buds, bushfires and resprouting in the eucalypts. *Australian Journal of Botany* 61, 331–349.

Butler OM, Lewis T, Maunsell SC, Rezaei Rashti M, Elser JJ, Mackey B, Chen C (2021). The stoichiometric signature of high-frequency fire in forest floor food webs. *Ecological Monographs*, e1477

Caccamo G, Bradstock RA, Collins L, Penman TD, Watson P (2015). Using MODIS data to analyse post-fire vegetation recovery in Australian eucalypt forests. *Journal of Spatial Science,* 60, 341-352.

Chafer CJ, Santín C, Doerr SH (2016). Modelling and quantifying the spatial distribution of post - wildfire ash loads. *International Journal of Wildland Fire*, 25, 249–255.

Cheal D (2010). *Growth stages and tolerable fire intervals for Victoria's native vegetation data sets: Fire and adaptive management,* Report No. 84. In: Environment DoSa, editor. East Melbourne, Victoria: Department of Sustainability and Environment; 2010.

Clarke H (2020) Fire weather. *Report for NSW Independent Bushfire Inquiry*, NSW Bushfire Risk Management Research Hub. https://www.bushfirehub.org/wp-content/uploads/2021/02/1.3_Fire-weather_NSW-Inquiry-Seasonal-Context-analyses-report.pdf

Clarke H, Penman T, Boer M, Cary GJ, Fontaine JB, Price O, Bradstock R (2020) The proximal drivers of large fires: a pyrogeographic study. *Frontiers in Earth Science*. 8:90.doi: 10.3389/feart.2020.00090

Clarke PJ, Knox, KJE, Wills KE, Campbell M (2005). Landscape patterns of woody plant response to crown fire: disturbance and productivity influence sprouting ability. *Journal of Ecology* 93, 544–555.

Clarke PJ, Lawes MJ, Midgley JJ, Lamont BB, Ojeda F, Burrows GE, et al. (2013). Resprouting as a key functional trait: how buds, protection and resources drive persistence after fire. *New Phytologist* 197, 19-35.

Clarke PJ, Knox KJE, Bradstock RA, Munoz C, Kumar L (2014). The landscape template for flammability: How vegetation mediates the climate control of crown fire severity. *Journal of Vegetation Science* 25, 1033–1044.

Clarke PJ, Lawes MJ, Murphy BP, Russell-Smith J, Nano CEM, Bradstock R, et al. (2015). A synthesis of postfire recovery traits of woody plants in Australian ecosystems. *Science of The Total Environment* 534, 31-42.

Collins L, Bradstock R, Ximenes F, Horsey B, Sawyer R, Penman T (2019). Aboveground forest carbon shows different responses to fire frequency in harvested and unharvested forests. *Ecological Applications*, 29, e01815-1-e01815-14.

Collins L (2020). Eucalypt forests dominated by epicormic resprouters are resilient to repeated canopy fires. *Journal of Ecology*, 108(1):310-24.

Collins LC, Bradstock RA, Clarke H, Clarke MF, Nolan RH, Penman TD (2021). The 2019/2020 mega-fires exposed Australian ecosystems to an unprecedented extent of high-severity fire. *Environmental Research Letters* 16 044029 doi.org/10.1088/1748-9326/abeb9e

Croke JC, Hairsine PB (2006). Sediment delivery in managed forests: a review. *Environmental Reviews*, 14, 59-87.

Dawson JP, Claridge AW, Triggs B, Paull DJ (2007). Diet of a native carnivore, the spotted-tailed quoll (*Dasyurus maculatus*), before and after an intense wildfire. *Wildlife Research* 34, 342–351

Enright NJ, Fontaine JB, Westcott JB, Lade JC, Miller BP (2011) Fire interval effects on persistence of resprouter species in Mediterranean-type shrublands. *Plant Ecology* 212, 2071–2083.

Enright NJ, Fontaine JB, Bowman DMJS, Bradstock RA, Williams RJ (2015). Interval squeeze: Altered fire regimes and demographic responses interact to threaten woody species persistence as climate changes. *Frontiers in Ecology and the Environment* 13, 265–272

Fairman TA, Bennett LT, Nitschke CR (2019). Short-interval wildfires increase likelihood of resprouting failure in fire-tolerant trees. *Journal of Environmental Management 231 (2019) 59–65*

Flynn EM, Jones SM, Jones ME, Jordan GJ, Munks SA (2011) Characteristics of mammal communities in Tasmanian forests: exploring the influence of forest type and disturbance history. *Wildlife Research* 38**,** 13-29.

Gallagher RV, Allen S, Mackenzie BDE, et al. (2021). High fire frequency and the impact of the 2019-2020 megafires on Australian plant diversity. *Diversity and Distributions* 00:1-14. doi.org/10.1111/ddi.13265

Gill AM (1975) Fire and the Australian flora: a review. *Australian Forestry* 38, 4-25.

Gill AM (1997) Eucalypts and fire: interdependent or independent? In '*Eucalypt ecology: Individuals to Ecosystems.*' (Eds JE Williams and JCZ Woinarski) pp 151-167. (Cambridge University Press: Melbourne).

Gill AM, Catling PC (2002). Fire regimes and biodiversity of forested landscapes of southern Australia. In '*Flammable Australia: the Fire Regimes and Biodiversity of a Continent*.' (Eds RA Bradstock, JE Williams and AM Gill) pp. 351-372. (Cambridge University Press: Cambridge)

Gill AM, Bradstock RA, Williams JE (2002) Fire regimes and biodiversity: legacy and vision. In "*Flammable Australia: The Fire Regimes and Biodiversity of a Continent*", (Eds. RA Bradstock JE Williams and AM Gill), pp.429-446. Cambridge University Press, Cambridge.

Gimenez A, Pastor E, Zarate L, Planas E, Arnaldos J (2004). Long-term forest fire retardants: a review of quality, effectiveness, application and environmental considerations. *International Journal of Wildland Fire* 13, 1-15.

Gordon CE, Bendall ER, Stares MG, Collins LC, Bradstock RA (2019) Above ground carbon sequestration in dry temperate forests varies with climate not fire regime. *Global Change Biology* doi.org/10.1111/gcb.14308

Hammill K, Penman T, Bradstock RA (2016). Responses of resilience traits to gradients of temperature, rainfall and fire frequency in fire-prone, Australian forests: potential consequences of climate change. *Plant Ecology,* 217, 725-74.

Heath JT, Chafer CJ, Van Ogtrop FF, Bishop CJ (2014). Post-wildfire recovery of water yield in the Sydney Basin water supply catchments: An assessment of the 2001/2002 wildfires *Journal of Hydrology* 519, 1428–1440 doi.org/10.1016/j.jhydrol.2014.09.033

Hobley EU, Le Gay Brereton AJ, Wilson B (2017). Forest burning affects quality and quantity of soil organic matter. *Science of the Total Environment* 575**,** 41-49.

Huston M (2003) Understanding the effects of fire and other mortality-causing disturbances on species diversity. In: Abbott I & Burrows ND (eds) *Fire in ecosystems of south west Western Australia: impacts and management*. Backhuys, Leiden, pp 37-70.

Inbar A, Nyman P, Lane PNJ, Sheridan GJ (2020). The role of fire in the coevolution of soils and temperate forests. *Water Resources Research*, *56*, e2019WR026005. doi.org/10.1029/2019WR026005

Jolly WM, Cochrane MA, Freeborn PH, Holden ZA, Brown TJ, Williamson GJ, Bowman, DMJS (2016). Climate-induced variations in global wildfire danger from 1979 to 2013, *Nature Communications*, 6 Article 7537, doi.org/10.1038/ncomms8537

Kavanagh RP, Stanton MA (2005). Vertebrate species assemblages and species sensitivity to logging in the forests of north-eastern New South Wales. *Forest Ecology and Management* 209**,** 309-341.

Keeley JE, Bond WJ, Bradstock RA, Pausas JG, Rundel PW (2011) *Fire Ecology, Evolution and Management in Mediterranean Climate Ecosystems* Cambridge University Press, Melbourne

Keith D (2004). *Ocean Shores to Desert Dunes: The Native Vegetation of New South Wales and the ACT.* Sydney: NSW Department of Environment and Conservation; 353 pp.

Keith DA, Holman L, Rodoreda S, Lemmon J, Bedward M (2007) Plant functional types can predict decade-scale changes in fire-prone vegetation. *Journal of Ecology* 95, 1324-1337.

Keith DA, (2012) Functional traits: their roles in understanding and predicting biotic responses to fire regimes from individuals to landscapes. In, '*Flammable Australia: fire regimes and biodiversity in a changing world*'. (Eds RA Bradstock, RJ Williams, AM Gill) CSIRO Publishing pp. 97-125

Keith DA, Gallagher R, Mackenzie B, Tozer M, Auld T, Yates C, Van Leeuwen S, Williams D (2020). *Framework for prioritising impact assessments for Ecological Communities following the 2019-2020 bushfires* Version 1.5, 24th May 2020. Report to Commonwealth Department of Agriculture Water and Environment.

Kelly LT, Haslem A, Holland GJ, Leonard SWJ, MacHunter J, Bassett M, Bennett AF, Bruce MJ, Chia EK, Christie FJ, Clarke MF, Di Stefano J, Loyn R, McCarthy MA, Pung A, Robinson N, Sitters H, Swan M, York A (2017). Fire regimes and environmental gradients shape vertebrate and plant distributions in temperate eucalypt forests. *Ecosphere* 8, e01781. 10.1002/ecs2.1781

Kelly LT, Giljohann KM, Duane A, Aquilué N, Archibald S et al. (2020). Fire and biodiversity in the Anthropocene, *Science* 370 (6519), doi: 10.1126/science.abb0355

Kenny B.J. Bradstock R.A., & Tasker E. (2004). *Guidelines for ecologically sustainable fire management. Final Report – NSW Biodiversity Strategy Project (Priority Action no. 43)*

Kraaij T, Cowling RM, van Wilgen BW, Schutte-Vlok A-L (2013) Proteaceae juvenile periods and post-fire recruitment as indicators of minimum fire return interval in eastern coastal fynbos. *Applied Vegetation Science.* 16, 84–94.

Law B, Caccamo G, Roe P, et al. (2017). Development and field validation of a regional, management-scale habitat model: A koala *Phascolarctos cinereus* case study. *Ecology and Evolution* ; 7:7475–7489 doi.org/10.1002/ece3.3300

Legge S, Woinarski J, Garnett S, Nimmo D, Scheele B, Lintermans M, Mitchell N, Whiterod N, Ferris J (2020). *Rapid analysis of impacts of the 2019–20 fires on animal species, and prioritisation of species for management response – Technical Report*, Report prepared for the Wildlife and Threatened Species Bushfire Recovery Expert Panel, 14th March 2020, 30 pp. https://www.environment.gov.au/biodiversity/ bushfire-recovery/research-and-resource

Lyon JP, O'Connor JP (2008). Smoke on the water: Can riverine fish populations recover following a catastrophic fire-related sediment slug? *Austral Ecology* 33, 794–806.

Murphy BP, Bradstock RA, Boer MM, Carter J, Cary GJ, Cochrane MA, et al. (2013). Fire regimes of Australia: a pyrogeographic model system. *Journal of Biogeography* 40, 1048-58.

McLean CM, Bradstock RA, Price OF, Kavanagh RP (2015). Tree hollows and forest stand structure in Australian warm temperate Eucalyptus forests are adversely affected by logging more than wildfire. *Forest Ecology and Management* 341, 37-44.

McLean CM, Kavanagh RP, Penman T, Bradstock RA (2018). The threatened status of the hollow dependent arboreal marsupial, the Greater Glider (*Petauroides volans*), can be explained by impacts from wildfire and selective logging. *Forest Ecology and Management* 415-416, 19-25

New South Wales Forestry Commission (1982). *Notes on the silviculture of major N.S.W. forest types.* New South Wales. Forestry Commission.

Neris J, Santin C, Lew R, Robichaud PR, Elliot WJ, Lewis SA, Sheridan G,Rohlfs A, Ollivier Q, Oliveira L, Doerr SH (2021). Designing tools to predict and mitigate impacts on water quality following the Australian 2019/2020 wildfires: Insights from Sydney's largest water supply catchment. *Integrated Environmental Assessment and Management* 2021:1–11 DOI: 10.1002/ieam.4406

New South Wales Department of Primary Industries, I. E. (2020). *Fire severity in harvested areas.*

Nicolle D (2006). A classification and census of regenerative strategies in the eucalypts (*Angophora*, *Corymbia* and *Eucalyptus*—Myrtaceae), with special reference to the obligate seeders. *Australian Journal of Botany* 54, 391–407.

Noble IR (1984). Mortality of lignotuberous seedlings *of Eucalyptus* species after an intense fire in montane forest. *Australian Journal of Ecology* 9, 41-50.

Noble IR, Bary GA, Gill AM (1980) McArthur's fire-danger meters expressed as equations. *Australian Journal of Ecology* 5, 201-203.

Noble JC (2001) Lignotubers and meristem dependence in mallee (*Eucalyptus*spp.) coppicing after fire. *Australian Journal of Botany* 49, 31–41.

Nolan et al 2015 Nolan RH, Lane PNJ, Benyon RG, Bradstock RA, Mitchell PJ (2015). Trends in evapotranspiration and streamflow following wildfire in resprouting eucalypt forests. *Journal of Hydrology.* 2015;524(Supplement C):614-24.

Nolan RH, Blackman CJ, Resco de Dios V, Choat B, Medlyn BE, Li X, Bradstock RA, Boer MM (2020a). Linking forest flammability and plant vulnerability to drought. *Forests*, 11, 779; doi.org/10.3390/f11070779

Nolan RH, Rahmani S, Samson SS, Simpson-Southward HM, Boer MM, Bradstock RA (2020b). Bark attributes determine variation in fire resistance in resprouting tree species. *Forest Ecology and Management* 474:118385 doi: 10.1016/j.foreco.2020.118385

Nolan RH 2020c *Fuel dryness.* Report for NSW Independent Bushfire Inquiry, NSW Bushfire Risk Management Research Hub. https://www.bushfirehub.org/wp-content/uploads/2021/02/1.1_Fuel-dryness_NSW-Inquiry-Seasonal-Context-analyses-report.pdf

Nunes JP, Doerr SH, Sheridan G, Neris J, Santín C, Emelko MB, Silins U, Robichaud PR, Elliot WJ, Keizer J (2018). Assessing water contamination risk from vegetation fires: Challenges, opportunities and a framework for progress *Hydrological Processes*, 1–8.

Nyman P, Smith HG, Sherwin CB, Langhans C, Lane PNJ, Sheridan GJ (2015). Predicting sediment delivery from debris flows after wildfire. *Geomorphology* 250, 173–186.

Ooi M. (2020) *Impact on priority NSW flora.* Report for NSW Independent Bushfire Inquiry, NSW Bushfire Risk Management Research Hub. https://www.bushfirehub.org/wp-content/uploads/2021/02/3b.2_Plant-species-impacts__NSW-Inquiry-Biodiversity-and-Environmental-Impacts-report.pdf

Pausas JG, Bradstock RA, Keith, DA, Keeley JE & GCTE fire network (2004). Plant functional traits in relation to fire in crown-fire ecosystems. *Ecology,* 85, 1085–1100

Pausas J, Bradstock RA (2007). Plant persistence fire traits along a productivity and disturbance gradient in Mediterranean shrublands of SE Australia. *Global Ecology and Biogeography* 16*,* 330-340.

Penman TD, Binns DL, Shiels RJ, Allen RM, Kavanagh RP (2008). Changes in understorey plant species richness following logging and prescribed burning in shrubby dry sclerophyll forests of south-eastern Australia. *Austral Ecology* 33, 197–210

Penman TD, Bradstock RA, Price O (2013). Modelling the determinants of ignition in the Sydney Basin, Australia: implications for future management. *International Journal of Wildland Fire* 22, 469-478

Peters DPC, Lugo AE, Chapin III FS, Pickett STA et al. (2011). Cross-system comparisons elucidate disturbance complexities and generalities. *Ecosphere* 2, 7, 1-26, doi:10.1890/ES11-00115.1

Rainsford FW, Kelly LT, Leonard SW, Bennett AF (2020). Post-fire development of faunal habitat depends on plant regeneration traits. *Austral Ecology,* 45**,** 800-812.

Sanderson BM, Fisher RA (2020). A fiery wake-up call for climate scientists. *Nature Climate Change* 10**,** 175–177 doi.org/10.1038/s41558-020-0707-2

Santın C, Doerr SH, Otero XL, Chafer CJ (2015). Quantity, composition and water contamination potential of ash produced under different wildfire severities. *Environmental Research* 142, 297–308. doi:10.1016/J.ENVRES.2015.06.041

Saunders ME, Barton PS, Bickerstaff JRM, Frost L, et al. (2021). Limited understanding of bushfire impacts on Australian invertebrates. *Insect Conservation and Diversity*, doi: 10.1111/icad.12493

Sawyer RB, Bradstock RA, Bedward M, Morrison RJ (2018a) Fire intensity drives post-fire temporal pattern of soil carbon accumulation in Australian fire-prone forests. *Science of the Total Environment* 610–611, 1113–1124.

Sawyer RB, Bradstock RA, Bedward M, Morrison RJ (2018b). Soil carbon in Australian fire-prone forests determined by climate more than fire regimes. *Science of the Total Environment* 639, 526-537.

Shakesby RA, Doerr SH (2006) Wildfire as a hydrological and geomorphological agent. *Earth-Science Reviews* 74, 269-307.

Silva LGM, Doyle KE, Duffy D, Humphries P, Horta A, Baumgartner LJ (2020). Mortality events resulting from Australia's catastrophic fires threaten aquatic biota *Global Change Biology* 26, 5345-5350.

Smith HG, Sheridan GJ, Lane PNJ, Nyman P, Haydon S (2011) Wildfire effects on water quality in forest catchments: a review with implications for water supply. *Journal of Hydrology* 396, 170–192. doi:10.1016/J.JHYDROL.2010.10.043

Smyth C (2020). *The impacts of bushfires on coastal and marine environments. A review and recommendations for change.* A report for the Australian Marine Conservation Society. 42 pp.

Vivian LM, Cary GJ, Bradstock RA, Gill AM (2008). Influence of fire severity on the regeneration, recruitment and distribution of eucalypts in the Cotter River Catchment, Australian Capital Territory. *Austral Ecology* 33, 55-67.

Watson, G. M., French, K., Collins, L. (2020). Timber harvest and frequent prescribed burning interact to affect the demography of eucalypt species. *Forest Ecology and Management,* 475, 118463

Webb AA and Jarrett BW (2013). Hydrological response to wildfire, integrated logging and dry mixed species eucalypt forest regeneration: The Yambulla experiment. *Forest Ecology and Management* 306, 107-117.

Whelan RJ (1995). *The Ecology of Fire*, Cambridge University Press, Cambridge, UK.

White I, Wade A, Worthy M, Mueller N, Daniell T, Wasson R (2006). The vulnerability of water supply catchments to bushfires: impacts of the January 2003 wildfires on the Australian Capital Territory. *Australasian Journal of Water Resources* 10, 179-194.

Williamson GJ (2020). Fire threshold analysis. Report for NSW Independent Bushfire Inquiry, NSW Bushfire Risk Management Research Hub. https://www.bushfirehub.org/wp-content/uploads/2021/02/3b.1_Fire-thresholds_NSW-Inquiry-Biodiversity-and-Environmental-Impacts-report.pdf

Wilson N, Bradstock RA, Bedward M (2021a). Comparing forest carbon stock losses between logging and wildfire in forests with contrasting responses to fire. *Forest Ecology and Management* 481, doi.org/10.1016/j.foreco.2020.118701

Wilson N, Bradstock RA, Bedward M (2021b). Detecting the effects of logging and wildfire on forest fuel structure using terrestrial laser scanning (TLS). *Forest Ecology and Management* 488, 119037 doi.org/10.1016/j.foreco.2021.119037

Yang X, Zhu Q, Tulau M, McInnes-Clarke S, Sun L, Zhang XP (2018) Near real-time monitoring of post-fire erosion after storm events: A case study in Warrumbungle National Park, Australia. *International Journal of Wildland Fire* 27, 413–422.

Yang X , Zhang M , Oliveira L, Ollivier QR, Faulkner S, Roff A (2020). Rapid Assessment of Hillslope Erosion Risk after the 2019–2020 Wildfires and Storm Events in Sydney Drinking Water Catchment. *Remote Sensing* 12, doi.org/10.3390/rs12223805

York A, Tarnawski J (2004). Impacts of grazing and burning on terrestrial invertebrate assemblages in dry eucalypt forests of north-eastern New South Wales: implications for biodiversity conservation. In '*Conservation of Australia's Forest Fauna* (second edition)'. (Ed D Lunney) Royal Zoological Society of New South Wales. pp 845 - 859

York A, Lewis T (2018). Understanding the effects of fire on invertebrates in Australian temperate and sub-tropical forests: the value of long-term experiments. *Australian Zoologist* 39, 633-645

York A, Bell TL, Weston C (2012). Fire regimes and soil-based ecological processes: implications for biodiversity. In '*Flammable Australia: Fire Regime, Biodiversity and Ecosystems in a Changing World'.* (Eds RA Bradstock, RJ Williams, AM Gill) CSIRO Publishing pp. 127-148

Yu M, Bishop TFA, Van Ogtrop FF (2019). Assessment of the decadal impact of wildfire on water quality in forested catchments. *Water* 11, 533; doi.org/10.3390/w11030533

Appendix 1.

Table 1.1 Integrated summary of CIFOA objectives and outcomes complied and supplied by the NSW Natural Resources Commission

Outcome objective	Coastal IFOA Outcome
Maintain ecological function and habitat connectivity	• Habitat and environmental features are identified and retained to provide refuge, connectivity and to support forest regeneration. • Environment features, habitat, landscapes and communities are identified, and protections are permanently established, to mitigate the impact of the forestry operation. • Environment features, habitat and risks are identified to ensure that protections and management actions are implemented to mitigate the impact of the forestry operation. • Environment features, habitat and risks are identified, and site-specific protections and management practices are developed to mitigate the impact of the forestry operation.
	• Woody debris is retained across operational areas to provide shelter and foraging habitat for native species to support their persistence.
	• Environment features, habitat and risks are identified to ensure that protections and management actions are implemented to mitigate the impact of the forestry operation.
	• ESAs and important habitat are managed during burning operations to maintain their intended, specific environmental values and provide short-term refuge habitat.
	• Environmentally Significant Areas are protected during forestry operations to maintain their intended, specific environmental values.

	• Environment features, habitat, landscapes and communities are maintained through the implementation of best management practices for pre-harvest burns and post-harvest burns.
Maintain persistence of native species	Important trees are retained and protected for shelter and food resources for native species, and to support their persistence.
	Environment features, habitat and risks are identified and site-specific protections and management practices are developed to mitigate the impact of the forestry operation.
	• Site-specific measures are implemented to mitigate the impact of the forestry operation on **fauna** species and their habitat, and to support their persistence. • Site-specific measures are implemented to mitigate the impact of the forestry operation on **flora** species and their habitat, and to support their persistence.
Protect of aquatic habitat and water quality	• Vegetation adjacent to drainage features and wetlands is protected, and groundcover is retained, to maintain water quality, stream stability, riparian habitat and contribute to habitat connectivity.
	• Water quality, aquatic habitat and native fish movement are maintained through the implementation of best management practices for roads, tracks and crossings.

	• Water quality and aquatic habitat are protected and maintained through the implementation of best management practices. • Dust and waste are managed to minimise pollution around operational areas.
Promote forest regeneration and structure	• Harvesting operations are distributed across the landscape and over time, to support a mosaic of forest age classes and maintenance of forest structure in the operational area or local landscape area.
	• Harvested areas are adequately stocked with a natural floristic composition to maintain ecological function and sustainable timber supplies.
Monitoring	• Monitoring programs are applied at multiple landscape scales to ensure the ongoing effectiveness of the approval in delivering the objectives of the approval and outcome statements. • Monitoring, management and protection measures are identified, planned and implemented for specific native species to support their persistence.

Appendix 2

Table 2.1 Area and proportions of different vegetation formations exposed to high frequency fire and high frequency wildfire 'hotspots', as of mid-2019, across different land tenure categories in the CIFOA domain.

Tenure	Formation	Total area (ha)	All fires Hotspot area (ha)	All fires Hotspot percent	Wildfires Hotspot (ha)	Wildfires Hotspot percent
State Forest	Dry Sclerophyll Forests (Shrub/grass sub-formation)	182986	10242	5.6	7630	4.2
State Forest	Dry Sclerophyll Forests (Shrubby sub-formation)	222642	42688	19.2	32262	14.5
State Forest	Forested Wetlands	12420	1163	9.4	921	7.4
State Forest	Grassy Woodlands	29384	1085	3.7	445	1.5
State Forest	Rainforests	109137	3661	3.4	2548	2.3
State Forest	Wet Sclerophyll Forests (Grassy sub-formation)	446517	39927	8.9	29208	6.5
State Forest	Wet Sclerophyll Forests (Shrubby sub-formation)	325466	17118	5.3	8816	2.7
National Park	Dry Sclerophyll Forests (Shrub/grass sub-formation)	520575	69692	13.4	50251	9.7
National Park	Dry Sclerophyll Forests (Shrubby sub-formation)	947980	230498	24.3	182039	19.2
National Park	Forested Wetlands	65261	11803	18.1	10666	16.3
National Park	Grassy Woodlands	257426	10309	4	4847	1.9
National Park	Rainforests	329701	12361	3.7	9945	3
National Park	Wet Sclerophyll Forests (Grassy sub-formation)	766155	106058	13.8	74427	9.7
National Park	Wet Sclerophyll Forests (Shrubby sub-formation)	485274	27697	5.7	22260	4.6
Crown Land	Dry Sclerophyll Forests (Shrub/grass sub-formation)	48790	751	1.5	643	1.3
Crown Land	Dry Sclerophyll Forests (Shrubby sub-formation)	96927	8485	8.8	7248	7.5
Crown Land	Forested Wetlands	14342	198	1.4	161	1.1
Crown Land	Grassy Woodlands	50421	73	0.1	68	0.1
Crown Land	Rainforests	8467	194	2.3	168	2
Crown Land	Wet Sclerophyll Forests (Grassy sub-formation)	47662	4507	9.5	3856	8.1
Crown Land	Wet Sclerophyll Forests (Shrubby sub-formation)	11015	233	2.1	206	1.9
Other	Dry Sclerophyll Forests (Shrub/grass sub-formation)	1106244	13592	1.2	12267	1.1
Other	Dry Sclerophyll Forests (Shrubby sub-formation)	806940	20353	2.5	17369	2.2
Other	Forested Wetlands	211347	3226	1.5	3145	1.5
Other	Grassy Woodlands	888089	1827	0.2	1449	0.2
Other	Rainforests	266518	1268	0.5	1196	0.4
Other	Wet Sclerophyll Forests (Grassy sub-formation)	864792	18821	2.2	17279	2
Other	Wet Sclerophyll Forests (Shrubby sub-formation)	397600	3026	0.8	2793	0.7

Table 2.2 Area and proportions of different vegetation formations exposed to high frequency fire and high frequency wildfire 'hotspots', as of mid-2020 following the 2019/20 fires, across different land tenure categories in the domain of the CIFOA.

Tenure	Formation	Total area (ha)	All fires Hotspot area (ha)	All fires Hotspot percent	Wildfires Hotspot (ha)	Wildfires Hotspot
State Forest	Dry Sclerophyll Forests (Shrub/grass sub-formation)	182986	22172	12.1	18192	9.9
State Forest	Dry Sclerophyll Forests (Shrubby sub-formation)	222642	75717	34	62102	27.9
State Forest	Forested Wetlands	12420	2054	16.5	1807	14.5
State Forest	Grassy Woodlands	29384	2102	7.2	1029	3.5
State Forest	Rainforests	109137	8409	7.7	6128	5.6
State Forest	Wet Sclerophyll Forests (Grassy sub-formation)	446517	84684	19	68525	15.3
State Forest	Wet Sclerophyll Forests (Shrubby sub-formation)	325466	43201	13.3	30556	9.4
National Park	Dry Sclerophyll Forests (Shrub/grass sub-formation)	520575	119897	23	93100	17.9
National Park	Dry Sclerophyll Forests (Shrubby sub-formation)	947980	365449	38.6	310900	32.8
National Park	Forested Wetlands	65261	16006	24.5	14834	22.7
National Park	Grassy Woodlands	257426	19474	7.6	10727	4.2
National Park	Rainforests	329701	26110	7.9	20111	6.1
National Park	Wet Sclerophyll Forests (Grassy sub-formation)	766155	186874	24.4	142637	18.6
National Park	Wet Sclerophyll Forests (Shrubby sub-formation)	485274	59826	12.3	43494	9
Crown Land	Dry Sclerophyll Forests (Shrub/grass sub-formation)	48790	1786	3.7	1567	3.2
Crown Land	Dry Sclerophyll Forests (Shrubby sub-formation)	96927	14450	14.9	13157	13.6
Crown Land	Forested Wetlands	14342	402	2.8	362	2.5
Crown Land	Grassy Woodlands	50421	120	0.2	97	0.2
Crown Land	Rainforests	8467	488	5.8	462	5.5
Crown Land	Wet Sclerophyll Forests (Grassy sub-formation)	47662	9227	19.4	8561	18
Crown Land	Wet Sclerophyll Forests (Shrubby sub-formation)	11015	361	3.3	330	3
Other	Dry Sclerophyll Forests (Shrub/grass sub-formation)	1106244	30533	2.8	28426	2.6
Other	Dry Sclerophyll Forests (Shrubby sub-formation)	806940	35366	4.4	32256	4
Other	Forested Wetlands	211347	4652	2.2	4563	2.2
Other	Grassy Woodlands	888089	3554	0.4	2767	0.3
Other	Rainforests	266518	3108	1.2	2987	1.1
Other	Wet Sclerophyll Forests (Grassy sub-formation)	864792	45951	5.3	43125	5
Other	Wet Sclerophyll Forests (Shrubby sub-formation)	397600	6255	1.6	5882	1.5

Appendix 3

Table 3.1 Patterns of burning and severity during 2019/20 across vegetation formations within areas of State Forests across the CIFOA Management Areas, in which harvesting occurred (2000 to 2019).

Management area	Forest formation	Area within SF ha (percent SF)	Harvested area within SF (percent SF)	Percent Unburnt 2029/20 within harvested & unharvested portions	Percent Low/Moderate severity 2029/20 within harvested & unharvested portions	Percent High/extreme severity 2029/20 within harvested & unharvested portions
Badja	Dry Sclerophyll Forests (Shrub/grass sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Badja	Dry Sclerophyll Forests (Shrubby sub-formation)	2145 (30.1)	361 (16.8)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 57.5 Harvested: 58.5	Unharvested: 42.5 Harvested: 41.5
Badja	Forested Wetlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Badja	Grassy Woodlands	387 (5.4)	14 (3.6)	Unharvested: 0.4 Harvested: 5.0	Unharvested: 72.1 Harvested: 66.5	Unharvested: 27.5 Harvested: 28.5
Badja	Rainforests	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Badja	Wet Sclerophyll Forests (Grassy sub-formation)	1539 (21.6)	458 (29.8)	Unharvested: 0.0 Harvested: 0.3	Unharvested: 70.4 Harvested: 71.0	Unharvested: 29.6 Harvested: 28.7
Badja	Wet Sclerophyll Forests (Shrubby sub-formation)	3062 (42.9)	454 (14.8)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 53.2 Harvested: 68.2	Unharvested: 46.8 Harvested: 31.8
Bago-Maragle	Dry Sclerophyll Forests (Shrub/grass sub-formation)	20316 (47.5)	1316 (6.5)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 55.5 Harvested: 66.0	Unharvested: 44.5 Harvested: 34.0
Bago-Maragle	Dry Sclerophyll Forests (Shrubby sub-formation)	51 (0.1)	5 (9.4)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 45.0 Harvested: 49.4	Unharvested: 55.0 Harvested: 50.6
Bago-Maragle	Forested Wetlands	30 (0.1)	3 (10.8)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 32.6 Harvested: 59.6	Unharvested: 67.4 Harvested: 40.4
Bago-Maragle	Grassy Woodlands	6350 (14.9)	929 (14.6)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 67.2 Harvested: 54.3	Unharvested: 32.8 Harvested: 45.7
Bago-Maragle	Rainforests	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Bago-Maragle	Wet Sclerophyll Forests (Grassy sub-formation)	2550 (6.0)	230 (9.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 36.6 Harvested: 51.5	Unharvested: 63.4 Harvested: 48.5
Bago-Maragle	Wet Sclerophyll Forests (Shrubby sub-formation)	13457 (31.5)	4899 (36.4)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 56.2 Harvested: 33.3	Unharvested: 43.8 Harvested: 66.7
Batemans Bay	Dry Sclerophyll Forests (Shrub/grass sub-formation)	144 (0.2)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 13.0 Harvested: 0.0	Unharvested: 87.0 Harvested: 0.0

Management area	Forest formation	Area within SF ha (percent SF)	Harvested area within SF (percent SF)	Percent Unburnt 2029/20 within harvested & unharvested portions	Percent Low/Moderate severity 2029/20 within harvested & unharvested portions	Percent High/extreme severity 2029/20 within harvested & unharvested portions
Batemans Bay	Dry Sclerophyll Forests (Shrubby sub-formation)	25819 (32.1)	7098 (27.5)	Unharvested: 1.3 Harvested: 2.1	Unharvested: 55.2 Harvested: 48.6	Unharvested: 43.5 Harvested: 49.3
Batemans Bay	Forested Wetlands	105 (0.1)	19 (18.5)	Unharvested: 7.4 Harvested: 0.0	Unharvested: 38.2 Harvested: 73.3	Unharvested: 54.4 Harvested: 26.7
Batemans Bay	Grassy Woodlands	557 (0.7)	145 (26.1)	Unharvested: 3.8 Harvested: 1.2	Unharvested: 24.1 Harvested: 14.9	Unharvested: 72.2 Harvested: 83.9
Batemans Bay	Rainforests	3901 (4.9)	295 (7.6)	Unharvested: 0.6 Harvested: 1.2	Unharvested: 71.1 Harvested: 57.3	Unharvested: 28.3 Harvested: 41.5
Batemans Bay	Wet Sclerophyll Forests (Grassy sub-formation)	33829 (42.1)	13856 (41.0)	Unharvested: 2.1 Harvested: 1.4	Unharvested: 50.8 Harvested: 41.1	Unharvested: 47.1 Harvested: 57.5
Batemans Bay	Wet Sclerophyll Forests (Shrubby sub-formation)	15969 (19.9)	3661 (22.9)	Unharvested: 1.0 Harvested: 0.1	Unharvested: 63.3 Harvested: 50.4	Unharvested: 35.8 Harvested: 49.5
Bulahdelah	Dry Sclerophyll Forests (Shrub/grass sub-formation)	4235 (10.7)	334 (7.9)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Bulahdelah	Dry Sclerophyll Forests (Shrubby sub-formation)	1653 (4.2)	530 (32.0)	Unharvested: 99.8 Harvested: 100.0	Unharvested: 0.2 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Bulahdelah	Forested Wetlands	746 (1.9)	52 (7.0)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Bulahdelah	Grassy Woodlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Bulahdelah	Rainforests	2343 (5.9)	157 (6.7)	Unharvested: 99.7 Harvested: 100.0	Unharvested: 0.3 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Bulahdelah	Wet Sclerophyll Forests (Grassy sub-formation)	19937 (50.3)	4891 (24.5)	Unharvested: 99.5 Harvested: 100.0	Unharvested: 0.5 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Bulahdelah	Wet Sclerophyll Forests (Shrubby sub-formation)	10723 (27.1)	3367 (31.4)	Unharvested: 99.2 Harvested: 100.0	Unharvested: 0.8 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Casino	Dry Sclerophyll Forests (Shrub/grass sub-formation)	41578 (43.1)	12083 (29.1)	Unharvested: 14.8 Harvested: 19.9	Unharvested: 33.9 Harvested: 34.7	Unharvested: 51.3 Harvested: 45.4
Casino	Dry Sclerophyll Forests (Shrubby sub-formation)	5146 (5.3)	729 (14.2)	Unharvested: 16.8 Harvested: 3.8	Unharvested: 49.9 Harvested: 66.1	Unharvested: 33.3 Harvested: 30.1
Casino	Forested Wetlands	4019 (4.2)	274 (6.8)	Unharvested: 16.0 Harvested: 7.3	Unharvested: 44.3 Harvested: 39.9	Unharvested: 39.6 Harvested: 52.8
Casino	Grassy Woodlands	426 (0.4)	137 (32.2)	Unharvested: 98.7 Harvested: 100.0	Unharvested: 0.3 Harvested: 0.0	Unharvested: 1.0 Harvested: 0.0

Management area	Forest formation	Area within SF ha (percent SF)	Harvested area within SF (percent SF)	Percent Unburnt 2029/20 within harvested & unharvested portions	Percent Low/Moderate severity 2029/20 within harvested & unharvested portions	Percent High/extreme severity 2029/20 within harvested & unharvested portions
Casino	Rainforests	6199 (6.4)	659 (10.6)	Unharvested: 23.6 Harvested: 70.9	Unharvested: 66.1 Harvested: 25.0	Unharvested: 10.3 Harvested: 4.1
Casino	Wet Sclerophyll Forests (Grassy sub-formation)	24476 (25.4)	5809 (23.7)	Unharvested: 17.7 Harvested: 41.0	Unharvested: 54.5 Harvested: 42.4	Unharvested: 27.9 Harvested: 16.5
Casino	Wet Sclerophyll Forests (Shrubby sub-formation)	14525 (15.1)	3873 (26.7)	Unharvested: 28.5 Harvested: 32.3	Unharvested: 53.2 Harvested: 49.6	Unharvested: 18.3 Harvested: 18.1
Chichester	Dry Sclerophyll Forests (Shrub/grass sub-formation)	1075 (2.0)	153 (14.3)	Unharvested: 99.4 Harvested: 89.0	Unharvested: 0.6 Harvested: 11.0	Unharvested: 0.0 Harvested: 0.0
Chichester	Dry Sclerophyll Forests (Shrubby sub-formation)	2532 (4.8)	312 (12.3)	Unharvested: 99.7 Harvested: 100.0	Unharvested: 0.3 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Chichester	Forested Wetlands	9 (0.0)	0 (0.0)	Unharvested: 94.6 Harvested: 0.0	Unharvested: 5.4 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Chichester	Grassy Woodlands	1239 (2.3)	113 (9.1)	Unharvested: 99.6 Harvested: 91.9	Unharvested: 0.4 Harvested: 8.1	Unharvested: 0.0 Harvested: 0.0
Chichester	Rainforests	14061 (26.4)	325 (2.3)	Unharvested: 96.6 Harvested: 98.7	Unharvested: 3.3 Harvested: 1.3	Unharvested: 0.1 Harvested: 0.0
Chichester	Wet Sclerophyll Forests (Grassy sub-formation)	8672 (16.3)	324 (3.7)	Unharvested: 85.2 Harvested: 100.0	Unharvested: 12.7 Harvested: 0.0	Unharvested: 2.1 Harvested: 0.0
Chichester	Wet Sclerophyll Forests (Shrubby sub-formation)	25597 (48.1)	2321 (9.1)	Unharvested: 98.1 Harvested: 100.0	Unharvested: 1.7 Harvested: 0.0	Unharvested: 0.2 Harvested: 0.0
Coffs Harbour	Dry Sclerophyll Forests (Shrub/grass sub-formation)	1395 (2.8)	568 (40.7)	Unharvested: 49.6 Harvested: 89.9	Unharvested: 39.7 Harvested: 7.4	Unharvested: 10.7 Harvested: 2.7
Coffs Harbour	Dry Sclerophyll Forests (Shrubby sub-formation)	2511 (5.0)	613 (24.4)	Unharvested: 81.0 Harvested: 90.0	Unharvested: 13.4 Harvested: 7.4	Unharvested: 5.6 Harvested: 2.7
Coffs Harbour	Forested Wetlands	676 (1.3)	60 (8.9)	Unharvested: 48.9 Harvested: 87.6	Unharvested: 29.5 Harvested: 8.4	Unharvested: 21.6 Harvested: 4.0
Coffs Harbour	Grassy Woodlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Coffs Harbour	Rainforests	7004 (14.0)	907 (13.0)	Unharvested: 62.0 Harvested: 67.3	Unharvested: 33.2 Harvested: 22.9	Unharvested: 4.9 Harvested: 9.9
Coffs Harbour	Wet Sclerophyll Forests (Grassy sub-formation)	24332 (48.5)	11159 (45.9)	Unharvested: 55.7 Harvested: 71.8	Unharvested: 33.2 Harvested: 16.8	Unharvested: 11.0 Harvested: 11.4
Coffs Harbour	Wet Sclerophyll Forests (Shrubby sub-formation)	14250 (28.4)	5330 (37.4)	Unharvested: 76.1 Harvested: 72.6	Unharvested: 22.7 Harvested: 24.9	Unharvested: 1.2 Harvested: 2.5

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Coopernook	Dry Sclerophyll Forests (Shrub/grass sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Coopernook	Dry Sclerophyll Forests (Shrubby sub-formation)	88 (1.2)	46 (52.0)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Coopernook	Forested Wetlands	35 (0.5)	3 (7.4)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Coopernook	Grassy Woodlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Coopernook	Rainforests	895 (11.8)	165 (18.4)	Unharvested: 96.6 Harvested: 99.0	Unharvested: 3.4 Harvested: 1.0	Unharvested: 0.0 Harvested: 0.0
Coopernook	Wet Sclerophyll Forests (Grassy sub-formation)	5298 (69.8)	3312 (62.5)	Unharvested: 97.3 Harvested: 99.2	Unharvested: 2.7 Harvested: 0.8	Unharvested: 0.0 Harvested: 0.0
Coopernook	Wet Sclerophyll Forests (Shrubby sub-formation)	1271 (16.8)	563 (44.3)	Unharvested: 96.8 Harvested: 92.3	Unharvested: 3.2 Harvested: 7.7	Unharvested: 0.0 Harvested: 0.0
Dorrigo	Dry Sclerophyll Forests (Shrub/grass sub-formation)	6637 (13.0)	2149 (32.4)	Unharvested: 18.2 Harvested: 18.4	Unharvested: 72.9 Harvested: 74.5	Unharvested: 9.0 Harvested: 7.1
Dorrigo	Dry Sclerophyll Forests (Shrubby sub-formation)	182 (0.4)	71 (39.1)	Unharvested: 14.7 Harvested: 11.2	Unharvested: 82.1 Harvested: 80.7	Unharvested: 3.2 Harvested: 8.1
Dorrigo	Forested Wetlands	464 (0.9)	11 (2.4)	Unharvested: 37.6 Harvested: 21.0	Unharvested: 58.4 Harvested: 78.4	Unharvested: 4.0 Harvested: 0.6
Dorrigo	Grassy Woodlands	56 (0.1)	3 (4.6)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 64.8 Harvested: 68.3	Unharvested: 35.2 Harvested: 31.7
Dorrigo	Rainforests	5235 (10.2)	626 (12.0)	Unharvested: 44.1 Harvested: 13.6	Unharvested: 54.0 Harvested: 77.6	Unharvested: 1.9 Harvested: 8.8
Dorrigo	Wet Sclerophyll Forests (Grassy sub-formation)	31122 (60.8)	12615 (40.5)	Unharvested: 10.3 Harvested: 6.6	Unharvested: 70.0 Harvested: 70.3	Unharvested: 19.6 Harvested: 23.1
Dorrigo	Wet Sclerophyll Forests (Shrubby sub-formation)	7494 (14.6)	2545 (34.0)	Unharvested: 41.0 Harvested: 21.0	Unharvested: 57.6 Harvested: 72.0	Unharvested: 1.5 Harvested: 7.0
Eden	Dry Sclerophyll Forests (Shrub/grass sub-formation)	15411 (9.4)	4340 (28.2)	Unharvested: 14.0 Harvested: 15.4	Unharvested: 49.6 Harvested: 52.6	Unharvested: 36.4 Harvested: 32.0
Eden	Dry Sclerophyll Forests (Shrubby sub-formation)	61472 (37.6)	16165 (26.3)	Unharvested: 26.6 Harvested: 19.8	Unharvested: 39.7 Harvested: 44.3	Unharvested: 33.7 Harvested: 36.0
Eden	Forested Wetlands	162 (0.1)	0 (0.0)	Unharvested: 46.3 Harvested: 0.0	Unharvested: 37.3 Harvested: 0.0	Unharvested: 16.4 Harvested: 0.0

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Eden	Grassy Woodlands	1295 (0.8)	122 (9.4)	Unharvested: 75.3 Harvested: 59.6	Unharvested: 16.1 Harvested: 27.9	Unharvested: 8.5 Harvested: 12.5
Eden	Rainforests	4009 (2.5)	345 (8.6)	Unharvested: 47.1 Harvested: 27.8	Unharvested: 35.6 Harvested: 48.4	Unharvested: 17.3 Harvested: 23.8
Eden	Wet Sclerophyll Forests (Grassy sub-formation)	5682 (3.5)	1214 (21.4)	Unharvested: 61.8 Harvested: 36.3	Unharvested: 22.7 Harvested: 25.0	Unharvested: 15.6 Harvested: 38.7
Eden	Wet Sclerophyll Forests (Shrubby sub-formation)	75246 (46.1)	19818 (26.3)	Unharvested: 24.4 Harvested: 19.2	Unharvested: 41.3 Harvested: 42.9	Unharvested: 34.3 Harvested: 38.0
Glen Innes	Dry Sclerophyll Forests (Shrub/grass sub-formation)	5326 (24.2)	1534 (28.8)	Unharvested: 31.5 Harvested: 50.0	Unharvested: 52.4 Harvested: 43.6	Unharvested: 16.1 Harvested: 6.4
Glen Innes	Dry Sclerophyll Forests (Shrubby sub-formation)	3749 (17.1)	633 (16.9)	Unharvested: 9.0 Harvested: 12.3	Unharvested: 44.9 Harvested: 69.4	Unharvested: 46.1 Harvested: 18.3
Glen Innes	Forested Wetlands	41 (0.2)	0 (0.0)	Unharvested: 19.6 Harvested: 0.0	Unharvested: 76.5 Harvested: 0.0	Unharvested: 3.9 Harvested: 0.0
Glen Innes	Grassy Woodlands	24 (0.1)	0 (1.8)	Unharvested: 7.6 Harvested: 0.0	Unharvested: 39.5 Harvested: 100.0	Unharvested: 52.9 Harvested: 0.0
Glen Innes	Rainforests	521 (2.4)	26 (4.9)	Unharvested: 13.2 Harvested: 8.1	Unharvested: 85.7 Harvested: 86.6	Unharvested: 1.1 Harvested: 5.4
Glen Innes	Wet Sclerophyll Forests (Grassy sub-formation)	11988 (54.6)	4328 (36.1)	Unharvested: 20.4 Harvested: 16.2	Unharvested: 67.1 Harvested: 66.8	Unharvested: 12.5 Harvested: 17.0
Glen Innes	Wet Sclerophyll Forests (Shrubby sub-formation)	326 (1.5)	75 (23.0)	Unharvested: 38.2 Harvested: 27.6	Unharvested: 51.9 Harvested: 60.0	Unharvested: 9.9 Harvested: 12.4
Grafton	Dry Sclerophyll Forests (Shrub/grass sub-formation)	20989 (22.8)	6471 (30.8)	Unharvested: 48.0 Harvested: 87.7	Unharvested: 40.9 Harvested: 8.8	Unharvested: 11.1 Harvested: 3.6
Grafton	Dry Sclerophyll Forests (Shrubby sub-formation)	3905 (4.2)	968 (24.8)	Unharvested: 97.2 Harvested: 100.0	Unharvested: 1.0 Harvested: 0.0	Unharvested: 1.7 Harvested: 0.0
Grafton	Forested Wetlands	1576 (1.7)	181 (11.5)	Unharvested: 61.2 Harvested: 94.0	Unharvested: 33.6 Harvested: 4.8	Unharvested: 5.2 Harvested: 1.2
Grafton	Grassy Woodlands	176 (0.2)	2 (0.9)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 57.5 Harvested: 20.8	Unharvested: 42.5 Harvested: 79.2
Grafton	Rainforests	5816 (6.3)	798 (13.7)	Unharvested: 12.6 Harvested: 10.5	Unharvested: 69.9 Harvested: 76.2	Unharvested: 17.5 Harvested: 13.3
Grafton	Wet Sclerophyll Forests (Grassy sub-formation)	56616 (61.5)	19525 (34.5)	Unharvested: 15.3 Harvested: 11.8	Unharvested: 59.7 Harvested: 63.2	Unharvested: 25.0 Harvested: 25.1
Grafton	Wet Sclerophyll Forests (Shrubby sub-formation)	2924 (3.2)	817 (27.9)	Unharvested: 65.3 Harvested: 54.3	Unharvested: 26.4 Harvested: 33.5	Unharvested: 8.3 Harvested: 12.2

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Inverell	Dry Sclerophyll Forests (Shrub/grass sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Inverell	Dry Sclerophyll Forests (Shrubby sub-formation)	626 (100.0)	0 (0.0)	Unharvested: 100.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Inverell	Forested Wetlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Inverell	Grassy Woodlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Inverell	Rainforests	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Inverell	Wet Sclerophyll Forests (Grassy sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Inverell	Wet Sclerophyll Forests (Shrubby sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Kempsey	Dry Sclerophyll Forests (Shrub/grass sub-formation)	181 (0.5)	0 (0.0)	Unharvested: 4.8 Harvested: 0.0	Unharvested: 65.6 Harvested: 0.0	Unharvested: 29.6 Harvested: 0.0
Kempsey	Dry Sclerophyll Forests (Shrubby sub-formation)	1217 (3.6)	89 (7.3)	Unharvested: 15.0 Harvested: 100.0	Unharvested: 30.4 Harvested: 0.0	Unharvested: 54.5 Harvested: 0.0
Kempsey	Forested Wetlands	492 (1.5)	22 (4.4)	Unharvested: 61.3 Harvested: 93.1	Unharvested: 35.3 Harvested: 6.6	Unharvested: 3.4 Harvested: 0.3
Kempsey	Grassy Woodlands	48 (0.1)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 71.6 Harvested: 0.0	Unharvested: 28.4 Harvested: 0.0
Kempsey	Rainforests	4904 (14.5)	631 (12.9)	Unharvested: 13.9 Harvested: 80.7	Unharvested: 70.4 Harvested: 9.9	Unharvested: 15.7 Harvested: 9.5
Kempsey	Wet Sclerophyll Forests (Grassy sub-formation)	21071 (62.5)	6351 (30.1)	Unharvested: 34.7 Harvested: 82.8	Unharvested: 46.5 Harvested: 10.1	Unharvested: 18.8 Harvested: 7.1
Kempsey	Wet Sclerophyll Forests (Shrubby sub-formation)	5822 (17.3)	2583 (44.4)	Unharvested: 47.7 Harvested: 96.4	Unharvested: 44.0 Harvested: 2.4	Unharvested: 8.4 Harvested: 1.2
Kendall	Dry Sclerophyll Forests (Shrub/grass sub-formation)	8 (0.0)	0 (0.0)	Unharvested: 100.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Kendall	Dry Sclerophyll Forests (Shrubby sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Kendall	Forested Wetlands	566 (2.7)	64 (11.3)	Unharvested: 41.0 Harvested: 52.1	Unharvested: 17.1 Harvested: 9.1	Unharvested: 41.8 Harvested: 38.8

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Kendall	Grassy Woodlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Kendall	Rainforests	2349 (11.1)	614 (26.1)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Kendall	Wet Sclerophyll Forests (Grassy sub-formation)	15422 (73.1)	9176 (59.5)	Unharvested: 94.0 Harvested: 97.6	Unharvested: 2.6 Harvested: 1.6	Unharvested: 3.4 Harvested: 0.8
Kendall	Wet Sclerophyll Forests (Shrubby sub-formation)	2756 (13.1)	1705 (61.9)	Unharvested: 96.1 Harvested: 97.4	Unharvested: 3.3 Harvested: 2.6	Unharvested: 0.6 Harvested: 0.0
Monaro South	Dry Sclerophyll Forests (Shrub/grass sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Monaro South	Dry Sclerophyll Forests (Shrubby sub-formation)	128 (4.8)	15 (11.5)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Monaro South	Forested Wetlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Monaro South	Grassy Woodlands	447 (17.0)	0 (0.0)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Monaro South	Rainforests	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Monaro South	Wet Sclerophyll Forests (Grassy sub-formation)	2039 (77.5)	100 (4.9)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Monaro South	Wet Sclerophyll Forests (Shrubby sub-formation)	18 (0.7)	5 (27.9)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Morisset	Dry Sclerophyll Forests (Shrub/grass sub-formation)	1591 (2.0)	39 (2.5)	Unharvested: 99.2 Harvested: 100.0	Unharvested: 0.6 Harvested: 0.0	Unharvested: 0.2 Harvested: 0.0
Morisset	Dry Sclerophyll Forests (Shrubby sub-formation)	43685 (53.7)	1621 (3.7)	Unharvested: 33.9 Harvested: 11.5	Unharvested: 46.8 Harvested: 42.9	Unharvested: 19.2 Harvested: 45.6
Morisset	Forested Wetlands	195 (0.2)	0 (0.2)	Unharvested: 82.3 Harvested: 100.0	Unharvested: 15.1 Harvested: 0.0	Unharvested: 2.6 Harvested: 0.0
Morisset	Grassy Woodlands	354 (0.4)	5 (1.3)	Unharvested: 68.3 Harvested: 0.0	Unharvested: 27.9 Harvested: 80.8	Unharvested: 3.8 Harvested: 19.2
Morisset	Rainforests	4297 (5.3)	142 (3.3)	Unharvested: 74.9 Harvested: 93.5	Unharvested: 23.3 Harvested: 3.6	Unharvested: 1.8 Harvested: 2.8

Management area	Forest formation	Area within SF ha (percent SF)	Harvested area within SF (percent SF)	Percent Unburnt 2029/20 within harvested & unharvested portions	Percent Low/Moderate severity 2029/20 within harvested & unharvested portions	Percent High/extreme severity 2029/20 within harvested & unharvested portions
Morisset	Wet Sclerophyll Forests (Grassy sub-formation)	20319 (25.0)	2185 (10.8)	Unharvested: 74.1 Harvested: 92.1	Unharvested: 22.8 Harvested: 6.3	Unharvested: 3.1 Harvested: 1.5
Morisset	Wet Sclerophyll Forests (Shrubby sub-formation)	10834 (13.3)	1322 (12.2)	Unharvested: 90.6 Harvested: 92.4	Unharvested: 7.0 Harvested: 4.1	Unharvested: 2.3 Harvested: 3.5
Moss Vale	Dry Sclerophyll Forests (Shrub/grass sub-formation)	1284 (11.3)	0 (0.0)	Unharvested: 83.6 Harvested: 0.0	Unharvested: 10.6 Harvested: 0.0	Unharvested: 5.8 Harvested: 0.0
Moss Vale	Dry Sclerophyll Forests (Shrubby sub-formation)	7595 (67.1)	0 (0.0)	Unharvested: 63.4 Harvested: 0.0	Unharvested: 11.7 Harvested: 0.0	Unharvested: 24.9 Harvested: 0.0
Moss Vale	Forested Wetlands	55 (0.5)	0 (0.0)	Unharvested: 70.3 Harvested: 0.0	Unharvested: 27.9 Harvested: 0.0	Unharvested: 1.8 Harvested: 0.0
Moss Vale	Grassy Woodlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Moss Vale	Rainforests	203 (1.8)	0 (0.0)	Unharvested: 22.8 Harvested: 0.0	Unharvested: 39.5 Harvested: 0.0	Unharvested: 37.8 Harvested: 0.0
Moss Vale	Wet Sclerophyll Forests (Grassy sub-formation)	491 (4.3)	0 (0.0)	Unharvested: 23.5 Harvested: 0.0	Unharvested: 12.2 Harvested: 0.0	Unharvested: 64.3 Harvested: 0.0
Moss Vale	Wet Sclerophyll Forests (Shrubby sub-formation)	1687 (14.9)	0 (0.0)	Unharvested: 52.7 Harvested: 0.0	Unharvested: 18.6 Harvested: 0.0	Unharvested: 28.7 Harvested: 0.0
Narooma	Dry Sclerophyll Forests (Shrub/grass sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Narooma	Dry Sclerophyll Forests (Shrubby sub-formation)	28374 (42.5)	3433 (12.1)	Unharvested: 3.9 Harvested: 19.4	Unharvested: 24.9 Harvested: 19.4	Unharvested: 71.1 Harvested: 61.2
Narooma	Forested Wetlands	141 (0.2)	0 (0.0)	Unharvested: 3.9 Harvested: 0.0	Unharvested: 51.4 Harvested: 0.0	Unharvested: 44.7 Harvested: 0.0
Narooma	Grassy Woodlands	3669 (5.5)	95 (2.6)	Unharvested: 0.7 Harvested: 6.4	Unharvested: 9.4 Harvested: 2.7	Unharvested: 89.9 Harvested: 90.9
Narooma	Rainforests	5369 (8.0)	233 (4.3)	Unharvested: 10.6 Harvested: 50.7	Unharvested: 34.2 Harvested: 26.2	Unharvested: 55.2 Harvested: 23.1
Narooma	Wet Sclerophyll Forests (Grassy sub-formation)	6250 (9.4)	1716 (27.5)	Unharvested: 37.0 Harvested: 54.5	Unharvested: 33.8 Harvested: 28.8	Unharvested: 29.2 Harvested: 16.7
Narooma	Wet Sclerophyll Forests (Shrubby sub-formation)	22931 (34.4)	2140 (9.3)	Unharvested: 6.4 Harvested: 28.1	Unharvested: 31.0 Harvested: 24.5	Unharvested: 62.6 Harvested: 47.4
Nowra	Dry Sclerophyll Forests (Shrub/grass sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0

Management area	Forest formation	Area within SF ha (percent SF)	Harvested area within SF (percent SF)	Percent Unburnt 2029/20 within harvested & unharvested portions	Percent Low/Moderate severity 2029/20 within harvested & unharvested portions	Percent High/extreme severity 2029/20 within harvested & unharvested portions
Nowra	Dry Sclerophyll Forests (Shrubby sub-formation)	3027 (23.6)	134 (4.4)	Unharvested: 20.3 Harvested: 39.2	Unharvested: 42.1 Harvested: 39.6	Unharvested: 37.7 Harvested: 21.2
Nowra	Forested Wetlands	376 (2.9)	76 (20.2)	Unharvested: 50.8 Harvested: 74.7	Unharvested: 39.4 Harvested: 15.5	Unharvested: 9.8 Harvested: 9.8
Nowra	Grassy Woodlands	80 (0.6)	0 (0.0)	Unharvested: 98.5 Harvested: 0.0	Unharvested: 0.8 Harvested: 0.0	Unharvested: 0.7 Harvested: 0.0
Nowra	Rainforests	1065 (8.3)	33 (3.1)	Unharvested: 2.3 Harvested: 0.0	Unharvested: 80.5 Harvested: 27.5	Unharvested: 17.2 Harvested: 72.5
Nowra	Wet Sclerophyll Forests (Grassy sub-formation)	6719 (52.3)	649 (9.7)	Unharvested: 7.9 Harvested: 23.5	Unharvested: 65.2 Harvested: 47.4	Unharvested: 26.9 Harvested: 29.0
Nowra	Wet Sclerophyll Forests (Shrubby sub-formation)	1576 (12.3)	63 (4.0)	Unharvested: 1.8 Harvested: 16.6	Unharvested: 84.8 Harvested: 62.6	Unharvested: 13.5 Harvested: 20.8
Queanbeyan	Dry Sclerophyll Forests (Shrub/grass sub-formation)	295 (1.3)	63 (21.4)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Queanbeyan	Dry Sclerophyll Forests (Shrubby sub-formation)	10404 (44.7)	2374 (22.8)	Unharvested: 66.4 Harvested: 66.4	Unharvested: 14.9 Harvested: 13.6	Unharvested: 18.7 Harvested: 20.1
Queanbeyan	Forested Wetlands	1 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 72.7 Harvested: 0.0	Unharvested: 27.3 Harvested: 0.0
Queanbeyan	Grassy Woodlands	1409 (6.1)	135 (9.6)	Unharvested: 57.3 Harvested: 52.2	Unharvested: 29.2 Harvested: 24.3	Unharvested: 13.5 Harvested: 23.5
Queanbeyan	Rainforests	20 (0.1)	0 (1.0)	Unharvested: 37.7 Harvested: 33.3	Unharvested: 61.6 Harvested: 66.7	Unharvested: 0.6 Harvested: 0.0
Queanbeyan	Wet Sclerophyll Forests (Grassy sub-formation)	1821 (7.8)	330 (18.1)	Unharvested: 74.4 Harvested: 69.5	Unharvested: 13.7 Harvested: 8.2	Unharvested: 11.9 Harvested: 22.3
Queanbeyan	Wet Sclerophyll Forests (Shrubby sub-formation)	9302 (40.0)	3205 (34.5)	Unharvested: 68.6 Harvested: 58.7	Unharvested: 18.1 Harvested: 18.1	Unharvested: 13.3 Harvested: 23.2
Styx River	Dry Sclerophyll Forests (Shrub/grass sub-formation)	2352 (13.0)	150 (6.4)	Unharvested: 4.9 Harvested: 0.0	Unharvested: 60.8 Harvested: 67.2	Unharvested: 34.3 Harvested: 32.8
Styx River	Dry Sclerophyll Forests (Shrubby sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Styx River	Forested Wetlands	256 (1.4)	0 (0.0)	Unharvested: 6.4 Harvested: 0.0	Unharvested: 80.1 Harvested: 100.0	Unharvested: 13.5 Harvested: 0.0
Styx River	Grassy Woodlands	460 (2.6)	25 (5.3)	Unharvested: 86.5 Harvested: 0.0	Unharvested: 10.7 Harvested: 77.6	Unharvested: 2.9 Harvested: 22.4
Styx River	Rainforests	2104 (11.7)	15 (0.7)	Unharvested: 17.0 Harvested: 0.0	Unharvested: 81.7 Harvested: 79.8	Unharvested: 1.3 Harvested: 20.2

Management area	Forest formation	Area within SF ha (percent SF)	Harvested area within SF (percent SF)	Percent Unburnt 2029/20 within harvested & unharvested portions	Percent Low/Moderate severity 2029/20 within harvested & unharvested portions	Percent High/extreme severity 2029/20 within harvested & unharvested portions
Styx River	Wet Sclerophyll Forests (Grassy sub-formation)	11842 (65.7)	2204 (18.6)	Unharvested: 7.4 Harvested: 0.1	Unharvested: 62.9 Harvested: 58.5	Unharvested: 29.7 Harvested: 41.4
Styx River	Wet Sclerophyll Forests (Shrubby sub-formation)	1012 (5.6)	62 (6.2)	Unharvested: 7.8 Harvested: 0.0	Unharvested: 85.7 Harvested: 47.6	Unharvested: 6.5 Harvested: 52.4
Taree	Dry Sclerophyll Forests (Shrub/grass sub-formation)	80 (0.9)	58 (72.6)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 29.6 Harvested: 7.9	Unharvested: 70.4 Harvested: 92.1
Taree	Dry Sclerophyll Forests (Shrubby sub-formation)	2 (0.0)	2 (100.0)	Unharvested: 0.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Taree	Forested Wetlands	111 (1.3)	38 (33.8)	Unharvested: 18.2 Harvested: 3.2	Unharvested: 65.0 Harvested: 89.5	Unharvested: 16.8 Harvested: 7.3
Taree	Grassy Woodlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Taree	Rainforests	424 (4.8)	58 (13.8)	Unharvested: 12.4 Harvested: 16.8	Unharvested: 63.8 Harvested: 22.6	Unharvested: 23.7 Harvested: 60.6
Taree	Wet Sclerophyll Forests (Grassy sub-formation)	6641 (75.9)	2892 (43.5)	Unharvested: 35.9 Harvested: 22.7	Unharvested: 21.0 Harvested: 20.2	Unharvested: 43.0 Harvested: 57.1
Taree	Wet Sclerophyll Forests (Shrubby sub-formation)	1490 (17.0)	398 (26.7)	Unharvested: 23.6 Harvested: 6.3	Unharvested: 55.8 Harvested: 49.7	Unharvested: 20.7 Harvested: 43.9
Tenterfield	Dry Sclerophyll Forests (Shrub/grass sub-formation)	10141 (17.6)	1011 (10.0)	Unharvested: 57.4 Harvested: 68.9	Unharvested: 26.9 Harvested: 14.8	Unharvested: 15.7 Harvested: 16.4
Tenterfield	Dry Sclerophyll Forests (Shrubby sub-formation)	8241 (14.3)	1228 (14.9)	Unharvested: 65.7 Harvested: 84.1	Unharvested: 32.7 Harvested: 13.4	Unharvested: 1.7 Harvested: 2.4
Tenterfield	Forested Wetlands	615 (1.1)	27 (4.4)	Unharvested: 12.9 Harvested: 50.8	Unharvested: 65.7 Harvested: 27.8	Unharvested: 21.4 Harvested: 21.4
Tenterfield	Grassy Woodlands	8 (0.0)	0 (0.0)	Unharvested: 100.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Tenterfield	Rainforests	1035 (1.8)	12 (1.2)	Unharvested: 35.6 Harvested: 40.3	Unharvested: 61.8 Harvested: 56.5	Unharvested: 2.5 Harvested: 3.1
Tenterfield	Wet Sclerophyll Forests (Grassy sub-formation)	35350 (61.4)	5887 (16.7)	Unharvested: 22.2 Harvested: 41.6	Unharvested: 53.3 Harvested: 38.3	Unharvested: 24.5 Harvested: 20.1
Tenterfield	Wet Sclerophyll Forests (Shrubby sub-formation)	2213 (3.8)	369 (16.7)	Unharvested: 25.4 Harvested: 22.6	Unharvested: 69.2 Harvested: 70.3	Unharvested: 5.4 Harvested: 7.1
Tumut	Dry Sclerophyll Forests (Shrub/grass sub-formation)	32577 (54.6)	547 (1.7)	Unharvested: 76.3 Harvested: 99.1	Unharvested: 6.4 Harvested: 0.0	Unharvested: 17.4 Harvested: 0.8

Management area	Forest formation	Area within SF ha (percent SF)	Harvested area within SF (percent SF)	Percent Unburnt 2029/20 within harvested & unharvested portions	Percent Low/Moderate severity 2029/20 within harvested & unharvested portions	Percent High/extreme severity 2029/20 within harvested & unharvested portions
Tumut	Dry Sclerophyll Forests (Shrubby sub-formation)	3597 (6.0)	0 (0.0)	Unharvested: 64.9 Harvested: 0.0	Unharvested: 3.6 Harvested: 0.0	Unharvested: 31.5 Harvested: 0.0
Tumut	Forested Wetlands	79 (0.1)	0 (0.0)	Unharvested: 89.1 Harvested: 0.0	Unharvested: 2.5 Harvested: 0.0	Unharvested: 8.4 Harvested: 0.0
Tumut	Grassy Woodlands	6614 (11.1)	73 (1.1)	Unharvested: 84.2 Harvested: 100.0	Unharvested: 4.2 Harvested: 0.0	Unharvested: 11.6 Harvested: 0.0
Tumut	Rainforests	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Tumut	Wet Sclerophyll Forests (Grassy sub-formation)	13154 (22.0)	145 (1.1)	Unharvested: 66.7 Harvested: 100.0	Unharvested: 10.7 Harvested: 0.0	Unharvested: 22.6 Harvested: 0.0
Tumut	Wet Sclerophyll Forests (Shrubby sub-formation)	3664 (6.1)	634 (17.3)	Unharvested: 99.5 Harvested: 100.0	Unharvested: 0.2 Harvested: 0.0	Unharvested: 0.2 Harvested: 0.0
Urbenville	Dry Sclerophyll Forests (Shrub/grass sub-formation)	2781 (8.9)	475 (17.1)	Unharvested: 44.8 Harvested: 11.8	Unharvested: 19.9 Harvested: 12.2	Unharvested: 35.3 Harvested: 76.0
Urbenville	Dry Sclerophyll Forests (Shrubby sub-formation)	282 (0.9)	90 (31.9)	Unharvested: 99.9 Harvested: 100.0	Unharvested: 0.1 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Urbenville	Forested Wetlands	182 (0.6)	1 (0.5)	Unharvested: 66.3 Harvested: 0.0	Unharvested: 13.3 Harvested: 0.0	Unharvested: 20.5 Harvested: 100.0
Urbenville	Grassy Woodlands	541 (1.7)	92 (17.0)	Unharvested: 63.5 Harvested: 70.9	Unharvested: 12.6 Harvested: 29.1	Unharvested: 23.9 Harvested: 0.0
Urbenville	Rainforests	3507 (11.2)	68 (1.9)	Unharvested: 65.7 Harvested: 61.2	Unharvested: 31.3 Harvested: 32.6	Unharvested: 3.0 Harvested: 6.2
Urbenville	Wet Sclerophyll Forests (Grassy sub-formation)	11737 (37.4)	1830 (15.6)	Unharvested: 43.6 Harvested: 20.7	Unharvested: 21.1 Harvested: 16.1	Unharvested: 35.3 Harvested: 63.3
Urbenville	Wet Sclerophyll Forests (Shrubby sub-formation)	12321 (39.3)	1838 (14.9)	Unharvested: 75.7 Harvested: 63.5	Unharvested: 16.4 Harvested: 15.7	Unharvested: 7.9 Harvested: 20.8
Urunga	Dry Sclerophyll Forests (Shrub/grass sub-formation)	57 (0.1)	0 (0.3)	Unharvested: 0.5 Harvested: 0.0	Unharvested: 96.8 Harvested: 0.0	Unharvested: 2.6 Harvested: 100.0
Urunga	Dry Sclerophyll Forests (Shrubby sub-formation)	7 (0.0)	3 (41.0)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Urunga	Forested Wetlands	732 (1.4)	109 (14.9)	Unharvested: 95.5 Harvested: 96.7	Unharvested: 4.3 Harvested: 2.9	Unharvested: 0.2 Harvested: 0.3
Urunga	Grassy Woodlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0

Management area	Forest formation	Area within SF ha (percent SF)	Harvested area within SF (percent SF)	Percent Unburnt 2029/20 within harvested & unharvested portions	Percent Low/Moderate severity 2029/20 within harvested & unharvested portions	Percent High/extreme severity 2029/20 within harvested & unharvested portions
Urunga	Rainforests	10910 (21.1)	824 (7.6)	Unharvested: 67.4 Harvested: 65.0	Unharvested: 28.0 Harvested: 27.2	Unharvested: 4.7 Harvested: 7.8
Urunga	Wet Sclerophyll Forests (Grassy sub-formation)	23337 (45.1)	5900 (25.3)	Unharvested: 62.8 Harvested: 71.4	Unharvested: 24.8 Harvested: 14.4	Unharvested: 12.4 Harvested: 14.2
Urunga	Wet Sclerophyll Forests (Shrubby sub-formation)	16656 (32.2)	4358 (26.2)	Unharvested: 80.1 Harvested: 89.3	Unharvested: 17.5 Harvested: 8.5	Unharvested: 2.4 Harvested: 2.2
Walcha-Nundle	Dry Sclerophyll Forests (Shrub/grass sub-formation)	13922 (20.6)	3166 (22.7)	Unharvested: 27.0 Harvested: 24.3	Unharvested: 48.3 Harvested: 47.2	Unharvested: 24.6 Harvested: 28.5
Walcha-Nundle	Dry Sclerophyll Forests (Shrubby sub-formation)	4860 (7.2)	786 (16.2)	Unharvested: 54.4 Harvested: 11.8	Unharvested: 28.9 Harvested: 44.7	Unharvested: 16.7 Harvested: 43.5
Walcha-Nundle	Forested Wetlands	96 (0.1)	1 (1.1)	Unharvested: 68.1 Harvested: 0.0	Unharvested: 30.7 Harvested: 88.2	Unharvested: 1.3 Harvested: 11.8
Walcha-Nundle	Grassy Woodlands	5225 (7.7)	718 (13.8)	Unharvested: 76.5 Harvested: 58.5	Unharvested: 19.5 Harvested: 23.9	Unharvested: 4.0 Harvested: 17.6
Walcha-Nundle	Rainforests	6910 (10.2)	606 (8.8)	Unharvested: 22.4 Harvested: 13.8	Unharvested: 71.0 Harvested: 64.4	Unharvested: 6.6 Harvested: 21.8
Walcha-Nundle	Wet Sclerophyll Forests (Grassy sub-formation)	10148 (15.0)	2450 (24.1)	Unharvested: 62.0 Harvested: 34.9	Unharvested: 27.9 Harvested: 37.7	Unharvested: 10.2 Harvested: 27.4
Walcha-Nundle	Wet Sclerophyll Forests (Shrubby sub-formation)	26476 (39.1)	7593 (28.7)	Unharvested: 41.0 Harvested: 39.3	Unharvested: 41.0 Harvested: 30.5	Unharvested: 18.1 Harvested: 30.2
Wauchope	Dry Sclerophyll Forests (Shrub/grass sub-formation)	214 (0.4)	57 (26.6)	Unharvested: 39.6 Harvested: 38.6	Unharvested: 47.6 Harvested: 44.0	Unharvested: 12.8 Harvested: 17.4
Wauchope	Dry Sclerophyll Forests (Shrubby sub-formation)	499 (1.0)	50 (10.1)	Unharvested: 3.7 Harvested: 13.2	Unharvested: 65.1 Harvested: 32.1	Unharvested: 31.2 Harvested: 54.7
Wauchope	Forested Wetlands	631 (1.3)	112 (17.7)	Unharvested: 71.5 Harvested: 95.0	Unharvested: 24.1 Harvested: 3.5	Unharvested: 4.4 Harvested: 1.5
Wauchope	Grassy Woodlands	10 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 44.1 Harvested: 0.0	Unharvested: 55.9 Harvested: 0.0
Wauchope	Rainforests	9544 (19.5)	411 (4.3)	Unharvested: 9.5 Harvested: 10.8	Unharvested: 81.8 Harvested: 67.7	Unharvested: 8.7 Harvested: 21.5
Wauchope	Wet Sclerophyll Forests (Grassy sub-formation)	32720 (66.7)	8423 (25.7)	Unharvested: 19.8 Harvested: 36.5	Unharvested: 48.9 Harvested: 33.1	Unharvested: 31.3 Harvested: 30.4
Wauchope	Wet Sclerophyll Forests (Shrubby sub-formation)	5448 (11.1)	1076 (19.7)	Unharvested: 11.4 Harvested: 8.7	Unharvested: 60.0 Harvested: 64.8	Unharvested: 28.7 Harvested: 26.5

Management area	Forest formation	Area within SF ha (percent SF)	Harvested area within SF (percent SF)	Percent Unburnt 2029/20 within harvested & unharvested portions	Percent Low/Moderate severity 2029/20 within harvested & unharvested portions	Percent High/extreme severity 2029/20 within harvested & unharvested portions
Wingham	Dry Sclerophyll Forests (Shrub/grass sub-formation)	394 (1.5)	3 (0.7)	Unharvested: 4.4 Harvested: 0.0	Unharvested: 42.2 Harvested: 95.7	Unharvested: 53.4 Harvested: 4.3
Wingham	Dry Sclerophyll Forests (Shrubby sub-formation)	845 (3.3)	21 (2.5)	Unharvested: 13.2 Harvested: 0.0	Unharvested: 45.9 Harvested: 57.4	Unharvested: 40.8 Harvested: 42.6
Wingham	Forested Wetlands	28 (0.1)	0 (0.0)	Unharvested: 4.2 Harvested: 0.0	Unharvested: 84.7 Harvested: 0.0	Unharvested: 11.1 Harvested: 0.0
Wingham	Grassy Woodlands	9 (0.0)	0 (0.0)	Unharvested: 12.0 Harvested: 0.0	Unharvested: 71.8 Harvested: 0.0	Unharvested: 16.2 Harvested: 0.0
Wingham	Rainforests	6513 (25.4)	275 (4.2)	Unharvested: 37.8 Harvested: 47.2	Unharvested: 56.5 Harvested: 49.1	Unharvested: 5.8 Harvested: 3.6
Wingham	Wet Sclerophyll Forests (Grassy sub-formation)	1411 (5.5)	4 (0.3)	Unharvested: 1.6 Harvested: 0.0	Unharvested: 68.6 Harvested: 100.0	Unharvested: 29.8 Harvested: 0.0
Wingham	Wet Sclerophyll Forests (Shrubby sub-formation)	16413 (64.1)	2086 (12.7)	Unharvested: 17.4 Harvested: 25.9	Unharvested: 63.1 Harvested: 55.7	Unharvested: 19.5 Harvested: 18.4

Table 3.2 Patterns of burning and severity during 2019/20 across vegetation formations within areas of State Forests across the CIFOA Management Areas, in which recent harvesting occurred (2014 to 2019). Areas containing some recent harvesting are a subset of the data contained in Table 3.1 above.

Management area	Forest formation	Area within SF (percent SF)	Harvested area (since 2014) within SF (percent SF)	Percent Unburnt 2029/20 within harvested & unharvested portions	Percent Low/Moderate severity 2029/20 within harvested & unharvested portions	Percent High/extreme severity 2029/20 within harvested & unharvested portions
Badja	Dry Sclerophyll Forests (Shrub/grass sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Badja	Dry Sclerophyll Forests (Shrubby sub-formation)	2145 (30.1)	93 (4.3)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 57.7 Harvested: 57.2	Unharvested: 42.3 Harvested: 42.8
Badja	Forested Wetlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Badja	Grassy Woodlands	387 (5.4)	1 (0.2)	Unharvested: 0.6 Harvested: 0.0	Unharvested: 71.9 Harvested: 75.0	Unharvested: 27.5 Harvested: 25.0
Badja	Rainforests	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Badja	Wet Sclerophyll Forests (Grassy sub-formation)	1539 (21.6)	65 (4.2)	Unharvested: 0.1 Harvested: 0.0	Unharvested: 70.8 Harvested: 64.7	Unharvested: 29.1 Harvested: 35.3
Badja	Wet Sclerophyll Forests (Shrubby sub-formation)	3062 (42.9)	178 (5.8)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 55.6 Harvested: 52.2	Unharvested: 44.4 Harvested: 47.8
Bago-Maragle	Dry Sclerophyll Forests (Shrub/grass sub-formation)	20316 (47.5)	109 (0.5)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 56.2 Harvested: 63.7	Unharvested: 43.8 Harvested: 36.3
Bago-Maragle	Dry Sclerophyll Forests (Shrubby sub-formation)	51 (0.1)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 45.4 Harvested: 0.0	Unharvested: 54.6 Harvested: 0.0
Bago-Maragle	Forested Wetlands	30 (0.1)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 35.6 Harvested: 0.0	Unharvested: 64.4 Harvested: 0.0
Bago-Maragle	Grassy Woodlands	6350 (14.9)	138 (2.2)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 65.9 Harvested: 38.1	Unharvested: 34.1 Harvested: 61.9
Bago-Maragle	Rainforests	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Bago-Maragle	Wet Sclerophyll Forests (Grassy sub-formation)	2550 (6.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 38.0 Harvested: 0.0	Unharvested: 62.0 Harvested: 0.0
Bago-Maragle	Wet Sclerophyll Forests (Shrubby sub-formation)	13457 (31.5)	2310 (17.2)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 53.6 Harvested: 20.3	Unharvested: 46.4 Harvested: 79.7
Batemans Bay	Dry Sclerophyll Forests (Shrub/grass sub-formation)	144 (0.2)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 13.0 Harvested: 0.0	Unharvested: 87.0 Harvested: 0.0
Batemans Bay	Dry Sclerophyll Forests (Shrubby sub-formation)	25819 (32.1)	2451 (9.5)	Unharvested: 1.5 Harvested: 1.3	Unharvested: 55.5 Harvested: 33.1	Unharvested: 43.0 Harvested: 65.6

Management area	Forest formation	Area within SF (percent SF)	Harvested area (since 2014) within SF (percent SF)	Percent Unburnt 2029/20 within harvested & unharvested portions	Percent Low/Moderate severity 2029/20 within harvested & unharvested portions	Percent High/extreme severity 2029/20 within harvested & unharvested portions
Batemans Bay	Forested Wetlands	105 (0.1)	6 (5.9)	Unharvested: 6.4 Harvested: 0.0	Unharvested: 43.8 Harvested: 59.6	Unharvested: 49.8 Harvested: 40.4
Batemans Bay	Grassy Woodlands	557 (0.7)	78 (14.0)	Unharvested: 3.5 Harvested: 0.6	Unharvested: 23.4 Harvested: 11.2	Unharvested: 73.1 Harvested: 88.1
Batemans Bay	Rainforests	3901 (4.9)	117 (3.0)	Unharvested: 0.7 Harvested: 0.1	Unharvested: 71.0 Harvested: 40.7	Unharvested: 28.4 Harvested: 59.2
Batemans Bay	Wet Sclerophyll Forests (Grassy sub-formation)	33829 (42.1)	5315 (15.7)	Unharvested: 1.8 Harvested: 1.9	Unharvested: 50.5 Harvested: 26.9	Unharvested: 47.6 Harvested: 71.2
Batemans Bay	Wet Sclerophyll Forests (Shrubby sub-formation)	15969 (19.9)	1554 (9.7)	Unharvested: 0.9 Harvested: 0.0	Unharvested: 63.2 Harvested: 33.8	Unharvested: 36.0 Harvested: 66.2
Bulahdelah	Dry Sclerophyll Forests (Shrub/grass sub-formation)	4235 (10.7)	109 (2.6)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Bulahdelah	Dry Sclerophyll Forests (Shrubby sub-formation)	1653 (4.2)	1 (0.0)	Unharvested: 99.8 Harvested: 100.0	Unharvested: 0.2 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Bulahdelah	Forested Wetlands	746 (1.9)	11 (1.5)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Bulahdelah	Grassy Woodlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Bulahdelah	Rainforests	2343 (5.9)	75 (3.2)	Unharvested: 99.7 Harvested: 100.0	Unharvested: 0.3 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Bulahdelah	Wet Sclerophyll Forests (Grassy sub-formation)	19937 (50.3)	1698 (8.5)	Unharvested: 99.6 Harvested: 100.0	Unharvested: 0.4 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Bulahdelah	Wet Sclerophyll Forests (Shrubby sub-formation)	10723 (27.1)	1593 (14.9)	Unharvested: 99.3 Harvested: 99.9	Unharvested: 0.7 Harvested: 0.1	Unharvested: 0.0 Harvested: 0.0
Casino	Dry Sclerophyll Forests (Shrub/grass sub-formation)	41578 (43.1)	3159 (7.6)	Unharvested: 16.7 Harvested: 11.3	Unharvested: 34.5 Harvested: 29.0	Unharvested: 48.8 Harvested: 59.6
Casino	Dry Sclerophyll Forests (Shrubby sub-formation)	5146 (5.3)	392 (7.6)	Unharvested: 16.1 Harvested: 1.9	Unharvested: 50.9 Harvested: 67.5	Unharvested: 33.0 Harvested: 30.6
Casino	Forested Wetlands	4019 (4.2)	28 (0.7)	Unharvested: 15.5 Harvested: 0.2	Unharvested: 44.2 Harvested: 26.2	Unharvested: 40.3 Harvested: 73.6
Casino	Grassy Woodlands	426 (0.4)	0 (0.1)	Unharvested: 99.1 Harvested: 100.0	Unharvested: 0.2 Harvested: 0.0	Unharvested: 0.7 Harvested: 0.0
Casino	Rainforests	6199 (6.4)	105 (1.7)	Unharvested: 28.4 Harvested: 41.9	Unharvested: 62.1 Harvested: 43.3	Unharvested: 9.5 Harvested: 14.8

Management area	Forest formation	Area within SF (percent SF)	Harvested area (since 2014) within SF (percent SF)	Percent Unburnt 2029/20 within harvested & unharvested portions	Percent Low/Moderate severity 2029/20 within harvested & unharvested portions	Percent High/extreme severity 2029/20 within harvested & unharvested portions
Casino	Wet Sclerophyll Forests (Grassy sub-formation)	24476 (25.4)	1172 (4.8)	Unharvested: 21.3 Harvested: 61.9	Unharvested: 53.3 Harvested: 17.5	Unharvested: 25.4 Harvested: 20.6
Casino	Wet Sclerophyll Forests (Shrubby sub-formation)	14525 (15.1)	814 (5.6)	Unharvested: 28.5 Harvested: 47.6	Unharvested: 53.4 Harvested: 32.4	Unharvested: 18.2 Harvested: 20.0
Chichester	Dry Sclerophyll Forests (Shrub/grass sub-formation)	1075 (2.0)	14 (1.3)	Unharvested: 97.9 Harvested: 100.0	Unharvested: 2.1 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Chichester	Dry Sclerophyll Forests (Shrubby sub-formation)	2532 (4.8)	82 (3.2)	Unharvested: 99.7 Harvested: 100.0	Unharvested: 0.3 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Chichester	Forested Wetlands	9 (0.0)	0 (0.0)	Unharvested: 94.6 Harvested: 0.0	Unharvested: 5.4 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Chichester	Grassy Woodlands	1239 (2.3)	10 (0.8)	Unharvested: 98.9 Harvested: 100.0	Unharvested: 1.1 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Chichester	Rainforests	14061 (26.4)	63 (0.4)	Unharvested: 96.7 Harvested: 100.0	Unharvested: 3.2 Harvested: 0.0	Unharvested: 0.1 Harvested: 0.0
Chichester	Wet Sclerophyll Forests (Grassy sub-formation)	8672 (16.3)	160 (1.8)	Unharvested: 85.5 Harvested: 100.0	Unharvested: 12.4 Harvested: 0.0	Unharvested: 2.1 Harvested: 0.0
Chichester	Wet Sclerophyll Forests (Shrubby sub-formation)	25597 (48.1)	374 (1.5)	Unharvested: 98.3 Harvested: 100.0	Unharvested: 1.6 Harvested: 0.0	Unharvested: 0.1 Harvested: 0.0
Coffs Harbour	Dry Sclerophyll Forests (Shrub/grass sub-formation)	1395 (2.8)	21 (1.5)	Unharvested: 67.1 Harvested: 0.0	Unharvested: 26.0 Harvested: 60.5	Unharvested: 6.9 Harvested: 39.5
Coffs Harbour	Dry Sclerophyll Forests (Shrubby sub-formation)	2511 (5.0)	167 (6.7)	Unharvested: 83.7 Harvested: 75.9	Unharvested: 11.7 Harvested: 14.3	Unharvested: 4.5 Harvested: 9.8
Coffs Harbour	Forested Wetlands	676 (1.3)	4 (0.7)	Unharvested: 52.6 Harvested: 8.5	Unharvested: 27.3 Harvested: 62.0	Unharvested: 20.0 Harvested: 29.6
Coffs Harbour	Grassy Woodlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Coffs Harbour	Rainforests	7004 (14.0)	326 (4.7)	Unharvested: 63.1 Harvested: 54.7	Unharvested: 32.0 Harvested: 27.6	Unharvested: 4.9 Harvested: 17.7
Coffs Harbour	Wet Sclerophyll Forests (Grassy sub-formation)	24332 (48.5)	4027 (16.6)	Unharvested: 60.0 Harvested: 78.6	Unharvested: 29.1 Harvested: 8.6	Unharvested: 10.9 Harvested: 12.8
Coffs Harbour	Wet Sclerophyll Forests (Shrubby sub-formation)	14250 (28.4)	2039 (14.3)	Unharvested: 75.3 Harvested: 71.4	Unharvested: 23.3 Harvested: 24.4	Unharvested: 1.3 Harvested: 4.2
Coopernook	Dry Sclerophyll Forests (Shrub/grass sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0

Management area	Forest formation	Area within SF (percent SF)	Harvested area (since 2014) within SF (percent SF)	Percent Unburnt 2029/20 within harvested & unharvested portions	Percent Low/Moderate severity 2029/20 within harvested & unharvested portions	Percent High/extreme severity 2029/20 within harvested & unharvested portions
Coopernook	Dry Sclerophyll Forests (Shrubby sub-formation)	88 (1.2)	1 (1.3)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Coopernook	Forested Wetlands	35 (0.5)	0 (1.1)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Coopernook	Grassy Woodlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Coopernook	Rainforests	895 (11.8)	71 (8.0)	Unharvested: 96.9 Harvested: 98.4	Unharvested: 3.1 Harvested: 1.6	Unharvested: 0.0 Harvested: 0.0
Coopernook	Wet Sclerophyll Forests (Grassy sub-formation)	5298 (69.8)	1258 (23.8)	Unharvested: 98.3 Harvested: 99.2	Unharvested: 1.7 Harvested: 0.8	Unharvested: 0.0 Harvested: 0.0
Coopernook	Wet Sclerophyll Forests (Shrubby sub-formation)	1271 (16.8)	214 (16.9)	Unharvested: 94.1 Harvested: 98.4	Unharvested: 5.9 Harvested: 1.6	Unharvested: 0.0 Harvested: 0.0
Dorrigo	Dry Sclerophyll Forests (Shrub/grass sub-formation)	6637 (13.0)	771 (11.6)	Unharvested: 19.2 Harvested: 10.8	Unharvested: 72.1 Harvested: 83.2	Unharvested: 8.7 Harvested: 6.0
Dorrigo	Dry Sclerophyll Forests (Shrubby sub-formation)	182 (0.4)	6 (3.4)	Unharvested: 13.8 Harvested: 0.0	Unharvested: 80.9 Harvested: 100.0	Unharvested: 5.3 Harvested: 0.0
Dorrigo	Forested Wetlands	464 (0.9)	2 (0.4)	Unharvested: 37.3 Harvested: 10.7	Unharvested: 58.8 Harvested: 89.3	Unharvested: 3.9 Harvested: 0.0
Dorrigo	Grassy Woodlands	56 (0.1)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 65.0 Harvested: 0.0	Unharvested: 35.0 Harvested: 0.0
Dorrigo	Rainforests	5235 (10.2)	271 (5.2)	Unharvested: 41.9 Harvested: 15.4	Unharvested: 55.7 Harvested: 75.8	Unharvested: 2.4 Harvested: 8.8
Dorrigo	Wet Sclerophyll Forests (Grassy sub-formation)	31122 (60.8)	1632 (5.2)	Unharvested: 8.7 Harvested: 11.9	Unharvested: 69.8 Harvested: 76.6	Unharvested: 21.6 Harvested: 11.5
Dorrigo	Wet Sclerophyll Forests (Shrubby sub-formation)	7494 (14.6)	903 (12.0)	Unharvested: 33.7 Harvested: 38.0	Unharvested: 63.2 Harvested: 56.9	Unharvested: 3.1 Harvested: 5.1
Eden	Dry Sclerophyll Forests (Shrub/grass sub-formation)	15411 (9.4)	750 (4.9)	Unharvested: 14.5 Harvested: 12.5	Unharvested: 50.3 Harvested: 52.1	Unharvested: 35.1 Harvested: 35.4
Eden	Dry Sclerophyll Forests (Shrubby sub-formation)	61472 (37.6)	4533 (7.4)	Unharvested: 26.0 Harvested: 9.1	Unharvested: 41.2 Harvested: 37.1	Unharvested: 32.8 Harvested: 53.8
Eden	Forested Wetlands	162 (0.1)	0 (0.0)	Unharvested: 46.3 Harvested: 0.0	Unharvested: 37.3 Harvested: 0.0	Unharvested: 16.4 Harvested: 0.0
Eden	Grassy Woodlands	1295 (0.8)	7 (0.6)	Unharvested: 74.2 Harvested: 5.1	Unharvested: 17.1 Harvested: 38.1	Unharvested: 8.6 Harvested: 56.8

Management area	Forest formation	Area within SF (percent SF)	Harvested area (since 2014) within SF (percent SF)	Percent Unburnt 2029/20 within harvested & unharvested portions	Percent Low/Moderate severity 2029/20 within harvested & unharvested portions	Percent High/extreme severity 2029/20 within harvested & unharvested portions
Eden	Rainforests	4009 (2.5)	69 (1.7)	Unharvested: 46.1 Harvested: 10.4	Unharvested: 36.3 Harvested: 61.2	Unharvested: 17.6 Harvested: 28.5
Eden	Wet Sclerophyll Forests (Grassy sub-formation)	5682 (3.5)	260 (4.6)	Unharvested: 58.3 Harvested: 16.0	Unharvested: 22.8 Harvested: 30.8	Unharvested: 19.0 Harvested: 53.3
Eden	Wet Sclerophyll Forests (Shrubby sub-formation)	75246 (46.1)	6354 (8.4)	Unharvested: 23.6 Harvested: 16.9	Unharvested: 42.5 Harvested: 33.6	Unharvested: 33.9 Harvested: 49.5
Glen Innes	Dry Sclerophyll Forests (Shrub/grass sub-formation)	5326 (24.2)	35 (0.6)	Unharvested: 37.1 Harvested: 0.9	Unharvested: 49.6 Harvested: 94.9	Unharvested: 13.3 Harvested: 4.2
Glen Innes	Dry Sclerophyll Forests (Shrubby sub-formation)	3749 (17.1)	87 (2.3)	Unharvested: 9.4 Harvested: 14.3	Unharvested: 48.9 Harvested: 56.1	Unharvested: 41.7 Harvested: 29.6
Glen Innes	Forested Wetlands	41 (0.2)	0 (0.0)	Unharvested: 19.6 Harvested: 0.0	Unharvested: 76.5 Harvested: 0.0	Unharvested: 3.9 Harvested: 0.0
Glen Innes	Grassy Woodlands	24 (0.1)	0 (0.0)	Unharvested: 7.5 Harvested: 0.0	Unharvested: 40.6 Harvested: 0.0	Unharvested: 51.9 Harvested: 0.0
Glen Innes	Rainforests	521 (2.4)	22 (4.3)	Unharvested: 13.4 Harvested: 2.2	Unharvested: 85.5 Harvested: 91.6	Unharvested: 1.1 Harvested: 6.1
Glen Innes	Wet Sclerophyll Forests (Grassy sub-formation)	11988 (54.6)	1163 (9.7)	Unharvested: 17.1 Harvested: 35.5	Unharvested: 68.2 Harvested: 55.5	Unharvested: 14.7 Harvested: 9.0
Glen Innes	Wet Sclerophyll Forests (Shrubby sub-formation)	326 (1.5)	37 (11.5)	Unharvested: 38.5 Harvested: 14.7	Unharvested: 51.5 Harvested: 71.5	Unharvested: 10.0 Harvested: 13.9
Grafton	Dry Sclerophyll Forests (Shrub/grass sub-formation)	20989 (22.8)	918 (4.4)	Unharvested: 59.8 Harvested: 69.7	Unharvested: 31.5 Harvested: 19.8	Unharvested: 8.7 Harvested: 10.5
Grafton	Dry Sclerophyll Forests (Shrubby sub-formation)	3905 (4.2)	199 (5.1)	Unharvested: 97.8 Harvested: 100.0	Unharvested: 0.8 Harvested: 0.0	Unharvested: 1.4 Harvested: 0.0
Grafton	Forested Wetlands	1576 (1.7)	3 (0.2)	Unharvested: 65.1 Harvested: 1.9	Unharvested: 30.2 Harvested: 83.3	Unharvested: 4.7 Harvested: 14.8
Grafton	Grassy Woodlands	176 (0.2)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 57.2 Harvested: 0.0	Unharvested: 42.8 Harvested: 0.0
Grafton	Rainforests	5816 (6.3)	377 (6.5)	Unharvested: 12.8 Harvested: 5.7	Unharvested: 70.0 Harvested: 82.5	Unharvested: 17.2 Harvested: 11.8
Grafton	Wet Sclerophyll Forests (Grassy sub-formation)	56616 (61.5)	7055 (12.5)	Unharvested: 15.1 Harvested: 6.6	Unharvested: 60.5 Harvested: 63.6	Unharvested: 24.3 Harvested: 29.8
Grafton	Wet Sclerophyll Forests (Shrubby sub-formation)	2924 (3.2)	151 (5.2)	Unharvested: 65.2 Harvested: 8.4	Unharvested: 26.5 Harvested: 63.3	Unharvested: 8.4 Harvested: 28.2

Management area	Forest formation	Area within SF (percent SF)	Harvested area (since 2014) within SF (percent SF)	Percent Unburnt 2029/20 within harvested & unharvested portions	Percent Low/Moderate severity 2029/20 within harvested & unharvested portions	Percent High/extreme severity 2029/20 within harvested & unharvested portions
Inverell	Dry Sclerophyll Forests (Shrub/grass sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Inverell	Dry Sclerophyll Forests (Shrubby sub-formation)	626 (100.0)	0 (0.0)	Unharvested: 100.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Inverell	Forested Wetlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Inverell	Grassy Woodlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Inverell	Rainforests	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Inverell	Wet Sclerophyll Forests (Grassy sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Inverell	Wet Sclerophyll Forests (Shrubby sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Kempsey	Dry Sclerophyll Forests (Shrub/grass sub-formation)	181 (0.5)	0 (0.0)	Unharvested: 4.8 Harvested: 0.0	Unharvested: 65.6 Harvested: 0.0	Unharvested: 29.6 Harvested: 0.0
Kempsey	Dry Sclerophyll Forests (Shrubby sub-formation)	1217 (3.6)	1 (0.1)	Unharvested: 21.2 Harvested: 100.0	Unharvested: 28.2 Harvested: 0.0	Unharvested: 50.6 Harvested: 0.0
Kempsey	Forested Wetlands	492 (1.5)	6 (1.1)	Unharvested: 62.6 Harvested: 72.7	Unharvested: 34.1 Harvested: 26.1	Unharvested: 3.3 Harvested: 1.1
Kempsey	Grassy Woodlands	48 (0.1)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 71.6 Harvested: 0.0	Unharvested: 28.4 Harvested: 0.0
Kempsey	Rainforests	4904 (14.5)	391 (8.0)	Unharvested: 18.1 Harvested: 73.1	Unharvested: 67.1 Harvested: 11.7	Unharvested: 14.9 Harvested: 15.2
Kempsey	Wet Sclerophyll Forests (Grassy sub-formation)	21071 (62.5)	3657 (17.4)	Unharvested: 44.0 Harvested: 73.9	Unharvested: 39.9 Harvested: 14.7	Unharvested: 16.1 Harvested: 11.3
Kempsey	Wet Sclerophyll Forests (Shrubby sub-formation)	5822 (17.3)	776 (13.3)	Unharvested: 66.2 Harvested: 89.2	Unharvested: 28.4 Harvested: 6.9	Unharvested: 5.4 Harvested: 3.9
Kendall	Dry Sclerophyll Forests (Shrub/grass sub-formation)	8 (0.0)	0 (0.0)	Unharvested: 100.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Kendall	Dry Sclerophyll Forests (Shrubby sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Kendall	Forested Wetlands	566 (2.7)	35 (6.2)	Unharvested: 44.2 Harvested: 13.3	Unharvested: 16.2 Harvested: 16.4	Unharvested: 39.5 Harvested: 70.3

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Kendall	Grassy Woodlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Kendall	Rainforests	2349 (11.1)	230 (9.8)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Kendall	Wet Sclerophyll Forests (Grassy sub-formation)	15422 (73.1)	3606 (23.4)	Unharvested: 96.2 Harvested: 96.0	Unharvested: 2.0 Harvested: 1.9	Unharvested: 1.8 Harvested: 2.0
Kendall	Wet Sclerophyll Forests (Shrubby sub-formation)	2756 (13.1)	392 (14.2)	Unharvested: 96.5 Harvested: 99.5	Unharvested: 3.3 Harvested: 0.5	Unharvested: 0.3 Harvested: 0.0
Monaro South	Dry Sclerophyll Forests (Shrub/grass sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Monaro South	Dry Sclerophyll Forests (Shrubby sub-formation)	128 (4.8)	0 (0.0)	Unharvested: 100.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Monaro South	Forested Wetlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Monaro South	Grassy Woodlands	447 (17.0)	0 (0.0)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Monaro South	Rainforests	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Monaro South	Wet Sclerophyll Forests (Grassy sub-formation)	2039 (77.5)	67 (3.3)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Monaro South	Wet Sclerophyll Forests (Shrubby sub-formation)	18 (0.7)	5 (27.9)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Morisset	Dry Sclerophyll Forests (Shrub/grass sub-formation)	1591 (2.0)	20 (1.2)	Unharvested: 99.2 Harvested: 100.0	Unharvested: 0.6 Harvested: 0.0	Unharvested: 0.2 Harvested: 0.0
Morisset	Dry Sclerophyll Forests (Shrubby sub-formation)	43685 (53.7)	170 (0.4)	Unharvested: 33.1 Harvested: 21.0	Unharvested: 46.7 Harvested: 43.5	Unharvested: 20.2 Harvested: 35.5
Morisset	Forested Wetlands	195 (0.2)	0 (0.0)	Unharvested: 82.4 Harvested: 0.0	Unharvested: 15.0 Harvested: 0.0	Unharvested: 2.6 Harvested: 0.0
Morisset	Grassy Woodlands	354 (0.4)	0 (0.0)	Unharvested: 67.4 Harvested: 0.0	Unharvested: 28.6 Harvested: 0.0	Unharvested: 4.0 Harvested: 0.0
Morisset	Rainforests	4297 (5.3)	43 (1.0)	Unharvested: 75.3 Harvested: 99.0	Unharvested: 22.8 Harvested: 0.6	Unharvested: 1.8 Harvested: 0.4

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Morisset	Wet Sclerophyll Forests (Grassy sub-formation)	20319 (25.0)	788 (3.9)	Unharvested: 75.2 Harvested: 97.8	Unharvested: 21.8 Harvested: 1.6	Unharvested: 3.0 Harvested: 0.7
Morisset	Wet Sclerophyll Forests (Shrubby sub-formation)	10834 (13.3)	574 (5.3)	Unharvested: 90.4 Harvested: 99.5	Unharvested: 7.0 Harvested: 0.4	Unharvested: 2.6 Harvested: 0.0
Moss Vale	Dry Sclerophyll Forests (Shrub/grass sub-formation)	1284 (11.3)	0 (0.0)	Unharvested: 83.6 Harvested: 0.0	Unharvested: 10.6 Harvested: 0.0	Unharvested: 5.8 Harvested: 0.0
Moss Vale	Dry Sclerophyll Forests (Shrubby sub-formation)	7595 (67.1)	0 (0.0)	Unharvested: 63.4 Harvested: 0.0	Unharvested: 11.7 Harvested: 0.0	Unharvested: 24.9 Harvested: 0.0
Moss Vale	Forested Wetlands	55 (0.5)	0 (0.0)	Unharvested: 70.3 Harvested: 0.0	Unharvested: 27.9 Harvested: 0.0	Unharvested: 1.8 Harvested: 0.0
Moss Vale	Grassy Woodlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Moss Vale	Rainforests	203 (1.8)	0 (0.0)	Unharvested: 22.8 Harvested: 0.0	Unharvested: 39.5 Harvested: 0.0	Unharvested: 37.8 Harvested: 0.0
Moss Vale	Wet Sclerophyll Forests (Grassy sub-formation)	491 (4.3)	0 (0.0)	Unharvested: 23.5 Harvested: 0.0	Unharvested: 12.2 Harvested: 0.0	Unharvested: 64.3 Harvested: 0.0
Moss Vale	Wet Sclerophyll Forests (Shrubby sub-formation)	1687 (14.9)	0 (0.0)	Unharvested: 52.7 Harvested: 0.0	Unharvested: 18.6 Harvested: 0.0	Unharvested: 28.7 Harvested: 0.0
Narooma	Dry Sclerophyll Forests (Shrub/grass sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Narooma	Dry Sclerophyll Forests (Shrubby sub-formation)	28374 (42.5)	497 (1.8)	Unharvested: 5.3 Harvested: 32.4	Unharvested: 24.2 Harvested: 24.7	Unharvested: 70.4 Harvested: 42.9
Narooma	Forested Wetlands	141 (0.2)	0 (0.0)	Unharvested: 3.9 Harvested: 0.0	Unharvested: 51.4 Harvested: 0.0	Unharvested: 44.7 Harvested: 0.0
Narooma	Grassy Woodlands	3669 (5.5)	1 (0.0)	Unharvested: 0.9 Harvested: 100.0	Unharvested: 9.2 Harvested: 0.0	Unharvested: 89.9 Harvested: 0.0
Narooma	Rainforests	5369 (8.0)	18 (0.3)	Unharvested: 12.1 Harvested: 77.5	Unharvested: 34.0 Harvested: 2.8	Unharvested: 53.9 Harvested: 19.6
Narooma	Wet Sclerophyll Forests (Grassy sub-formation)	6250 (9.4)	313 (5.0)	Unharvested: 39.5 Harvested: 85.4	Unharvested: 33.4 Harvested: 14.6	Unharvested: 27.2 Harvested: 0.0
Narooma	Wet Sclerophyll Forests (Shrubby sub-formation)	22931 (34.4)	308 (1.3)	Unharvested: 8.0 Harvested: 41.1	Unharvested: 30.7 Harvested: 9.9	Unharvested: 61.3 Harvested: 48.9
Nowra	Dry Sclerophyll Forests (Shrub/grass sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0

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Nowra	Dry Sclerophyll Forests (Shrubby sub-formation)	3027 (23.6)	4 (0.1)	Unharvested: 21.1 Harvested: 3.2	Unharvested: 42.0 Harvested: 38.1	Unharvested: 36.9 Harvested: 58.7
Nowra	Forested Wetlands	376 (2.9)	27 (7.2)	Unharvested: 52.2 Harvested: 100.0	Unharvested: 37.2 Harvested: 0.0	Unharvested: 10.6 Harvested: 0.0
Nowra	Grassy Woodlands	80 (0.6)	0 (0.0)	Unharvested: 98.5 Harvested: 0.0	Unharvested: 0.8 Harvested: 0.0	Unharvested: 0.7 Harvested: 0.0
Nowra	Rainforests	1065 (8.3)	3 (0.2)	Unharvested: 2.2 Harvested: 0.0	Unharvested: 78.9 Harvested: 58.5	Unharvested: 18.9 Harvested: 41.5
Nowra	Wet Sclerophyll Forests (Grassy sub-formation)	6719 (52.3)	133 (2.0)	Unharvested: 8.1 Harvested: 75.1	Unharvested: 64.5 Harvested: 12.5	Unharvested: 27.4 Harvested: 12.4
Nowra	Wet Sclerophyll Forests (Shrubby sub-formation)	1576 (12.3)	9 (0.6)	Unharvested: 1.8 Harvested: 100.0	Unharvested: 84.4 Harvested: 0.0	Unharvested: 13.8 Harvested: 0.0
Queanbeyan	Dry Sclerophyll Forests (Shrub/grass sub-formation)	295 (1.3)	36 (12.3)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Queanbeyan	Dry Sclerophyll Forests (Shrubby sub-formation)	10404 (44.7)	562 (5.4)	Unharvested: 66.9 Harvested: 57.4	Unharvested: 14.7 Harvested: 12.6	Unharvested: 18.4 Harvested: 30.0
Queanbeyan	Forested Wetlands	1 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 72.7 Harvested: 0.0	Unharvested: 27.3 Harvested: 0.0
Queanbeyan	Grassy Woodlands	1409 (6.1)	43 (3.1)	Unharvested: 57.0 Harvested: 52.8	Unharvested: 28.8 Harvested: 26.7	Unharvested: 14.2 Harvested: 20.5
Queanbeyan	Rainforests	20 (0.1)	0 (0.0)	Unharvested: 37.7 Harvested: 0.0	Unharvested: 61.7 Harvested: 0.0	Unharvested: 0.6 Harvested: 0.0
Queanbeyan	Wet Sclerophyll Forests (Grassy sub-formation)	1821 (7.8)	98 (5.4)	Unharvested: 74.6 Harvested: 54.9	Unharvested: 13.2 Harvested: 3.5	Unharvested: 12.2 Harvested: 41.7
Queanbeyan	Wet Sclerophyll Forests (Shrubby sub-formation)	9302 (40.0)	840 (9.0)	Unharvested: 66.3 Harvested: 53.8	Unharvested: 18.6 Harvested: 13.6	Unharvested: 15.2 Harvested: 32.7
Styx River	Dry Sclerophyll Forests (Shrub/grass sub-formation)	2352 (13.0)	23 (1.0)	Unharvested: 4.6 Harvested: 0.0	Unharvested: 61.6 Harvested: 24.1	Unharvested: 33.8 Harvested: 75.9
Styx River	Dry Sclerophyll Forests (Shrubby sub-formation)	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Styx River	Forested Wetlands	256 (1.4)	0 (0.0)	Unharvested: 6.4 Harvested: 0.0	Unharvested: 80.1 Harvested: 0.0	Unharvested: 13.5 Harvested: 0.0
Styx River	Grassy Woodlands	460 (2.6)	0 (0.0)	Unharvested: 81.8 Harvested: 0.0	Unharvested: 14.3 Harvested: 0.0	Unharvested: 3.9 Harvested: 0.0
Styx River	Rainforests	2104 (11.7)	15 (0.7)	Unharvested: 17.0 Harvested: 0.0	Unharvested: 81.7 Harvested: 79.4	Unharvested: 1.3 Harvested: 20.6

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Styx River	Wet Sclerophyll Forests (Grassy sub-formation)	11842 (65.7)	1588 (13.4)	Unharvested: 7.0 Harvested: 0.1	Unharvested: 63.5 Harvested: 53.0	Unharvested: 29.5 Harvested: 46.9
Styx River	Wet Sclerophyll Forests (Shrubby sub-formation)	1012 (5.6)	48 (4.8)	Unharvested: 7.7 Harvested: 0.0	Unharvested: 85.6 Harvested: 38.5	Unharvested: 6.8 Harvested: 61.5
Taree	Dry Sclerophyll Forests (Shrub/grass sub-formation)	80 (0.9)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 13.9 Harvested: 0.0	Unharvested: 86.1 Harvested: 0.0
Taree	Dry Sclerophyll Forests (Shrubby sub-formation)	2 (0.0)	0 (0.0)	Unharvested: 100.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Taree	Forested Wetlands	111 (1.3)	38 (33.8)	Unharvested: 18.2 Harvested: 3.2	Unharvested: 65.0 Harvested: 89.5	Unharvested: 16.8 Harvested: 7.3
Taree	Grassy Woodlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Taree	Rainforests	424 (4.8)	21 (5.0)	Unharvested: 13.7 Harvested: 0.0	Unharvested: 60.5 Harvested: 14.9	Unharvested: 25.8 Harvested: 85.1
Taree	Wet Sclerophyll Forests (Grassy sub-formation)	6641 (75.9)	757 (11.4)	Unharvested: 33.9 Harvested: 0.9	Unharvested: 19.5 Harvested: 29.6	Unharvested: 46.6 Harvested: 69.5
Taree	Wet Sclerophyll Forests (Shrubby sub-formation)	1490 (17.0)	44 (3.0)	Unharvested: 19.6 Harvested: 0.0	Unharvested: 54.7 Harvested: 34.8	Unharvested: 25.7 Harvested: 65.2
Tenterfield	Dry Sclerophyll Forests (Shrub/grass sub-formation)	10141 (17.6)	156 (1.5)	Unharvested: 58.9 Harvested: 34.2	Unharvested: 25.7 Harvested: 23.1	Unharvested: 15.4 Harvested: 42.7
Tenterfield	Dry Sclerophyll Forests (Shrubby sub-formation)	8241 (14.3)	169 (2.0)	Unharvested: 69.7 Harvested: 4.7	Unharvested: 28.8 Harvested: 80.0	Unharvested: 1.5 Harvested: 15.3
Tenterfield	Forested Wetlands	615 (1.1)	0 (0.0)	Unharvested: 14.6 Harvested: 0.0	Unharvested: 64.0 Harvested: 0.0	Unharvested: 21.4 Harvested: 0.0
Tenterfield	Grassy Woodlands	8 (0.0)	0 (0.0)	Unharvested: 100.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Tenterfield	Rainforests	1035 (1.8)	0 (0.0)	Unharvested: 35.7 Harvested: 0.0	Unharvested: 61.8 Harvested: 0.0	Unharvested: 2.5 Harvested: 0.0
Tenterfield	Wet Sclerophyll Forests (Grassy sub-formation)	35350 (61.4)	1101 (3.1)	Unharvested: 26.2 Harvested: 0.0	Unharvested: 50.9 Harvested: 46.8	Unharvested: 22.9 Harvested: 53.2
Tenterfield	Wet Sclerophyll Forests (Shrubby sub-formation)	2213 (3.8)	8 (0.4)	Unharvested: 25.0 Harvested: 0.0	Unharvested: 69.4 Harvested: 67.7	Unharvested: 5.6 Harvested: 32.3
Tumut	Dry Sclerophyll Forests (Shrub/grass sub-formation)	32577 (54.6)	5 (0.0)	Unharvested: 76.7 Harvested: 0.0	Unharvested: 6.2 Harvested: 2.7	Unharvested: 17.1 Harvested: 97.3

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Tumut	Dry Sclerophyll Forests (Shrubby sub-formation)	3597 (6.0)	0 (0.0)	Unharvested: 64.9 Harvested: 0.0	Unharvested: 3.6 Harvested: 0.0	Unharvested: 31.5 Harvested: 0.0
Tumut	Forested Wetlands	79 (0.1)	0 (0.0)	Unharvested: 89.1 Harvested: 0.0	Unharvested: 2.5 Harvested: 0.0	Unharvested: 8.4 Harvested: 0.0
Tumut	Grassy Woodlands	6614 (11.1)	0 (0.0)	Unharvested: 84.4 Harvested: 0.0	Unharvested: 4.1 Harvested: 0.0	Unharvested: 11.5 Harvested: 0.0
Tumut	Rainforests	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Tumut	Wet Sclerophyll Forests (Grassy sub-formation)	13154 (22.0)	0 (0.0)	Unharvested: 67.1 Harvested: 0.0	Unharvested: 10.5 Harvested: 0.0	Unharvested: 22.4 Harvested: 0.0
Tumut	Wet Sclerophyll Forests (Shrubby sub-formation)	3664 (6.1)	0 (0.0)	Unharvested: 99.6 Harvested: 0.0	Unharvested: 0.2 Harvested: 0.0	Unharvested: 0.2 Harvested: 100.0
Urbenville	Dry Sclerophyll Forests (Shrub/grass sub-formation)	2781 (8.9)	0 (0.0)	Unharvested: 39.1 Harvested: 0.0	Unharvested: 18.6 Harvested: 100.0	Unharvested: 42.3 Harvested: 0.0
Urbenville	Dry Sclerophyll Forests (Shrubby sub-formation)	282 (0.9)	0 (0.0)	Unharvested: 100.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Urbenville	Forested Wetlands	182 (0.6)	0 (0.0)	Unharvested: 65.9 Harvested: 0.0	Unharvested: 13.2 Harvested: 0.0	Unharvested: 20.9 Harvested: 0.0
Urbenville	Grassy Woodlands	541 (1.7)	39 (7.3)	Unharvested: 63.9 Harvested: 76.0	Unharvested: 14.7 Harvested: 24.0	Unharvested: 21.4 Harvested: 0.0
Urbenville	Rainforests	3507 (11.2)	1 (0.0)	Unharvested: 65.6 Harvested: 92.9	Unharvested: 31.3 Harvested: 7.1	Unharvested: 3.1 Harvested: 0.0
Urbenville	Wet Sclerophyll Forests (Grassy sub-formation)	11737 (37.4)	7 (0.1)	Unharvested: 40.0 Harvested: 77.2	Unharvested: 20.3 Harvested: 22.8	Unharvested: 39.7 Harvested: 0.0
Urbenville	Wet Sclerophyll Forests (Shrubby sub-formation)	12321 (39.3)	29 (0.2)	Unharvested: 73.9 Harvested: 41.2	Unharvested: 16.2 Harvested: 58.8	Unharvested: 9.9 Harvested: 0.0
Urunga	Dry Sclerophyll Forests (Shrub/grass sub-formation)	57 (0.1)	0 (0.3)	Unharvested: 0.5 Harvested: 0.0	Unharvested: 96.8 Harvested: 0.0	Unharvested: 2.6 Harvested: 100.0
Urunga	Dry Sclerophyll Forests (Shrubby sub-formation)	7 (0.0)	2 (23.8)	Unharvested: 100.0 Harvested: 100.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0
Urunga	Forested Wetlands	732 (1.4)	2 (0.3)	Unharvested: 95.9 Harvested: 24.3	Unharvested: 3.9 Harvested: 73.0	Unharvested: 0.2 Harvested: 2.7
Urunga	Grassy Woodlands	0 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0	Unharvested: 0.0 Harvested: 0.0

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Urunga	Rainforests	10910 (21.1)	172 (1.6)	Unharvested: 67.2 Harvested: 69.3	Unharvested: 28.1 Harvested: 15.0	Unharvested: 4.7 Harvested: 15.7
Urunga	Wet Sclerophyll Forests (Grassy sub-formation)	23337 (45.1)	1948 (8.3)	Unharvested: 64.4 Harvested: 71.1	Unharvested: 23.5 Harvested: 6.9	Unharvested: 12.1 Harvested: 22.0
Urunga	Wet Sclerophyll Forests (Shrubby sub-formation)	16656 (32.2)	645 (3.9)	Unharvested: 82.2 Harvested: 91.4	Unharvested: 15.6 Harvested: 3.9	Unharvested: 2.3 Harvested: 4.7
Walcha-Nundle	Dry Sclerophyll Forests (Shrub/grass sub-formation)	13922 (20.6)	98 (0.7)	Unharvested: 26.5 Harvested: 10.1	Unharvested: 48.1 Harvested: 48.8	Unharvested: 25.4 Harvested: 41.1
Walcha-Nundle	Dry Sclerophyll Forests (Shrubby sub-formation)	4860 (7.2)	110 (2.3)	Unharvested: 48.6 Harvested: 0.0	Unharvested: 31.4 Harvested: 32.7	Unharvested: 20.0 Harvested: 67.3
Walcha-Nundle	Forested Wetlands	96 (0.1)	0 (0.0)	Unharvested: 67.3 Harvested: 0.0	Unharvested: 31.3 Harvested: 0.0	Unharvested: 1.4 Harvested: 0.0
Walcha-Nundle	Grassy Woodlands	5225 (7.7)	19 (0.4)	Unharvested: 74.1 Harvested: 46.4	Unharvested: 20.0 Harvested: 42.4	Unharvested: 5.9 Harvested: 11.3
Walcha-Nundle	Rainforests	6910 (10.2)	110 (1.6)	Unharvested: 22.0 Harvested: 0.0	Unharvested: 70.4 Harvested: 74.8	Unharvested: 7.6 Harvested: 25.2
Walcha-Nundle	Wet Sclerophyll Forests (Grassy sub-formation)	10148 (15.0)	192 (1.9)	Unharvested: 55.9 Harvested: 31.1	Unharvested: 30.3 Harvested: 26.2	Unharvested: 13.8 Harvested: 42.6
Walcha-Nundle	Wet Sclerophyll Forests (Shrubby sub-formation)	26476 (39.1)	1521 (5.7)	Unharvested: 42.7 Harvested: 3.8	Unharvested: 37.5 Harvested: 45.7	Unharvested: 19.8 Harvested: 50.5
Wauchope	Dry Sclerophyll Forests (Shrub/grass sub-formation)	214 (0.4)	12 (5.4)	Unharvested: 35.9 Harvested: 100.0	Unharvested: 49.3 Harvested: 0.0	Unharvested: 14.8 Harvested: 0.0
Wauchope	Dry Sclerophyll Forests (Shrubby sub-formation)	499 (1.0)	26 (5.1)	Unharvested: 4.9 Harvested: 0.0	Unharvested: 64.0 Harvested: 20.5	Unharvested: 31.1 Harvested: 79.5
Wauchope	Forested Wetlands	631 (1.3)	33 (5.2)	Unharvested: 75.2 Harvested: 84.6	Unharvested: 20.9 Harvested: 11.2	Unharvested: 3.9 Harvested: 4.2
Wauchope	Grassy Woodlands	10 (0.0)	0 (0.0)	Unharvested: 0.0 Harvested: 0.0	Unharvested: 44.1 Harvested: 0.0	Unharvested: 55.9 Harvested: 0.0
Wauchope	Rainforests	9544 (19.5)	181 (1.9)	Unharvested: 9.6 Harvested: 9.4	Unharvested: 81.6 Harvested: 59.3	Unharvested: 8.8 Harvested: 31.3
Wauchope	Wet Sclerophyll Forests (Grassy sub-formation)	32720 (66.7)	2804 (8.6)	Unharvested: 22.7 Harvested: 39.0	Unharvested: 46.6 Harvested: 26.0	Unharvested: 30.7 Harvested: 35.0
Wauchope	Wet Sclerophyll Forests (Shrubby sub-formation)	5448 (11.1)	413 (7.6)	Unharvested: 10.9 Harvested: 9.7	Unharvested: 61.4 Harvested: 55.4	Unharvested: 27.7 Harvested: 34.9

Management area	Forest formation	Area within SF (percent SF)	Harvested area (since 2014) within SF (percent SF)	Percent Unburnt 2029/20 within harvested & unharvested portions	Percent Low/Moderate severity 2029/20 within harvested & unharvested portions	Percent High/extreme severity 2029/20 within harvested & unharvested portions
Wingham	Dry Sclerophyll Forests (Shrub/grass sub-formation)	394 (1.5)	2 (0.4)	Unharvested: 4.4 Harvested: 0.0	Unharvested: 42.4 Harvested: 92.0	Unharvested: 53.2 Harvested: 8.0
Wingham	Dry Sclerophyll Forests (Shrubby sub-formation)	845 (3.3)	0 (0.0)	Unharvested: 12.9 Harvested: 0.0	Unharvested: 46.2 Harvested: 0.0	Unharvested: 40.9 Harvested: 0.0
Wingham	Forested Wetlands	28 (0.1)	0 (0.0)	Unharvested: 4.2 Harvested: 0.0	Unharvested: 84.7 Harvested: 0.0	Unharvested: 11.1 Harvested: 0.0
Wingham	Grassy Woodlands	9 (0.0)	0 (0.0)	Unharvested: 12.0 Harvested: 0.0	Unharvested: 71.8 Harvested: 0.0	Unharvested: 16.2 Harvested: 0.0
Wingham	Rainforests	6513 (25.4)	156 (2.4)	Unharvested: 37.8 Harvested: 54.3	Unharvested: 56.5 Harvested: 42.0	Unharvested: 5.7 Harvested: 3.7
Wingham	Wet Sclerophyll Forests (Grassy sub-formation)	1411 (5.5)	0 (0.0)	Unharvested: 1.6 Harvested: 0.0	Unharvested: 68.7 Harvested: 0.0	Unharvested: 29.7 Harvested: 0.0
Wingham	Wet Sclerophyll Forests (Shrubby sub-formation)	16413 (64.1)	931 (5.7)	Unharvested: 18.5 Harvested: 18.4	Unharvested: 63.0 Harvested: 47.6	Unharvested: 18.5 Harvested: 34.0

Appendix 4

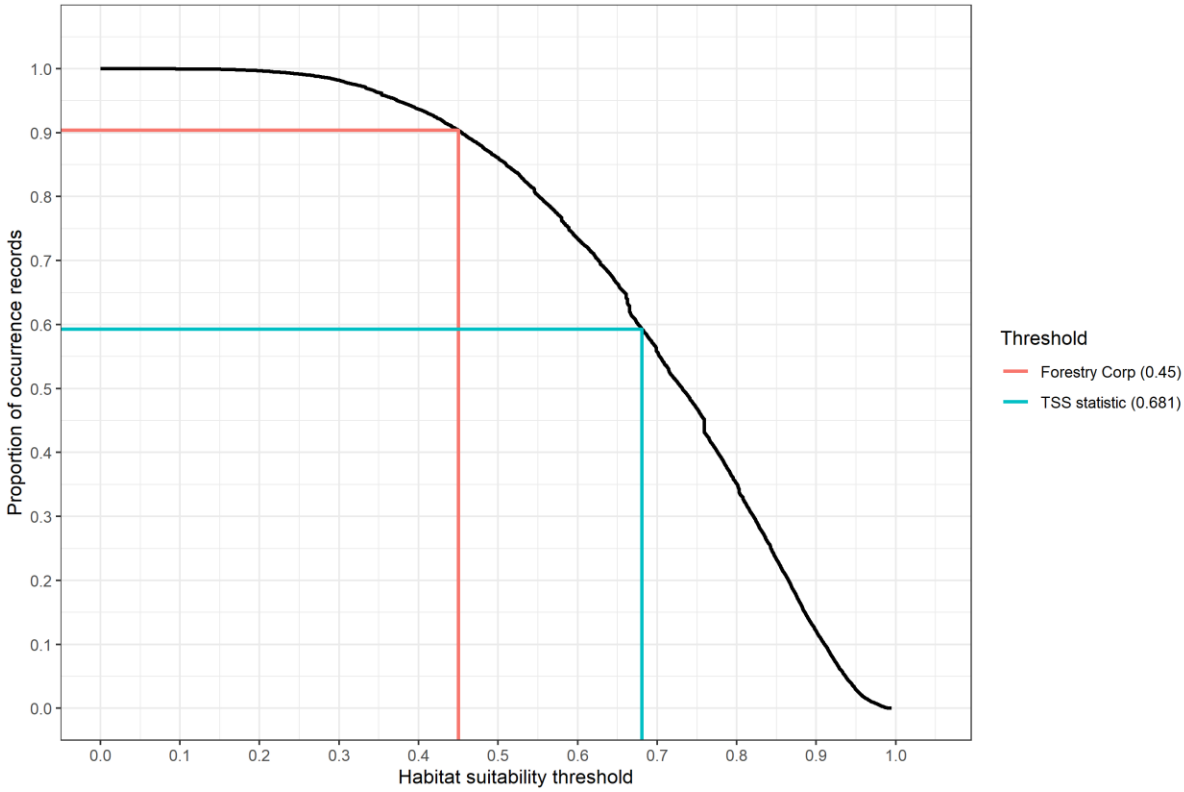

Figure 4.1 Relationship between occurrence records from BioNet (1980 to 2020, DPIE) and habitat thresholds derived from the model of Law et al. (2017).