Potato Point Bushfire Risk Assessment

This report was commissioned by National Parks and Wildlife Service, Office of Environment and Heritage, NSW as specified in a brief sent 5 March 2014 by Tony Baxter, Area Manager.

Report by:

Dr Kevin Tolhurst
Associate Professor Fire Ecology and Management
Department of Forest and Ecosystem Science
University of Melbourne
Creswick, Vic. 3363

THE UNIVERSITY OF MELBOURNE

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CREDITS

- All photographs were taken by Dr Kevin Tolhurst.
- All GIS maps except Figure 1 was prepared by Dr Kevin Tolhurst using data supplied by NSW Rural Fire Service or the Office of Environment and Heritage. Base maps were publicly available via ESRI ArcGIS.
- Figure 1 was supplied by the Office of Environment and Heritage.
- All aerial photographs were captured from Google Earth/Maps, accessed on 14 April 2014.

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Executive Summary

The protection of people and houses from bushfire in Potato Point has been contentious. This report was commissioned by the National Parks and Wildlife Service, Office of Environment and Heritage, NSW to provide an objective input for bushfire planning and management.

Fuels and potential bushfire threats have been assessed and analyzed for Potato Point. A landscape level analysis has been conducted using PHOENIX RapidFire. A more localized analysis of bushfire risk was also undertaken using the House Ignition Likelihood tool to evaluate the relative benefits of five mitigation scenarios. The details of these analyses are provided in this report.

In a landscape context, Potato Point is in a relatively low bushfire risk part of the State due to the nature of the fuels and terrain in the area and the proximity to the ocean. At a more local level, the greatest threat to house survival during a bushfire is the nature of the fuels in gardens on private property and the level of prevention works undertaken in and around houses. The level of bushfire threat to human life at Potato Point is low due to a number of factors including the ability to find safe places within Potato Point to take refuge from a bushfire.

A well managed Asset Protection Zone extending 50 m from the private property boundary is adequate to make houses defendable from a bushfire. There is little extra benefit from extending the APZ beyond 50 m, although there may be other practical reasons for doing more fuel modification to assist in safe access and egress during a bushfire event.

Retaining an area of Swamp Sheoak in the SFAZ beyond the 50 m zone does not compromise the protection of houses.

Removing all trees and shrubs for a distance of 200 m from the private property boundary increases the exposure to wind and embers and would make house defence more difficult than retaining the current APZ structure. Too much tree removal is counterproductive to fire protection of houses.

A more comprehensive set of fundamental management objectives needs to be developed if a sensible and objective discussion about bushfire risk mitigation strategies and works is to be achieved. These objectives need to include social, environmental, and economic values and the potential consequence of each bushfire risk mitigation strategy on meeting these objectives. Results of the bushfire risk analysis reported here would contribute to this discussion and trade-off process.

Extracts from brief

Purpose

To provide an independent assessment of the risk of bushfire affecting Potato Point under various enhanced fire management scenarios.

Tasks

A. Assess the bushfire risk to Potato Point under the following scenarios:

1. RFS modelled fuels in the Potato Point area, taking into account no extra clearing i.e. the existing APZs of up to 70 meters in total (Fig. 1).
2. Stage one clearing (Fig. 2).
3. Stage two clearing assuming 80% canopy removal over the area east of the Jemison's Point Fire trail (Fig. 2).
4. Stage two clearing with mapped EECs retained and non EEC in the study area cleared by 80% tree removal (Fig. 2).
5. Other options as directed.

For worst case weather conditions, use

- T = 40^0 C
- RH = 10%
- Wind W-NW 50-60 km/hr with southerly change for 2 hrs, winds gusting 30-50km/hr

B. Assessments can be made using numerical modelling, expert knowledge and community input.

C. Attend a community workshop to discuss the outcomes of the assessments and to address any issues raised by the community.

Figure 1. **Map of Potato Point showing the extent of the current Asset Protection Zone (APZ) (red hatch) and the area in which a review of environmental factors (REF) is being undertaken (yellow hatch) before any further fire protection works are undertaken.**

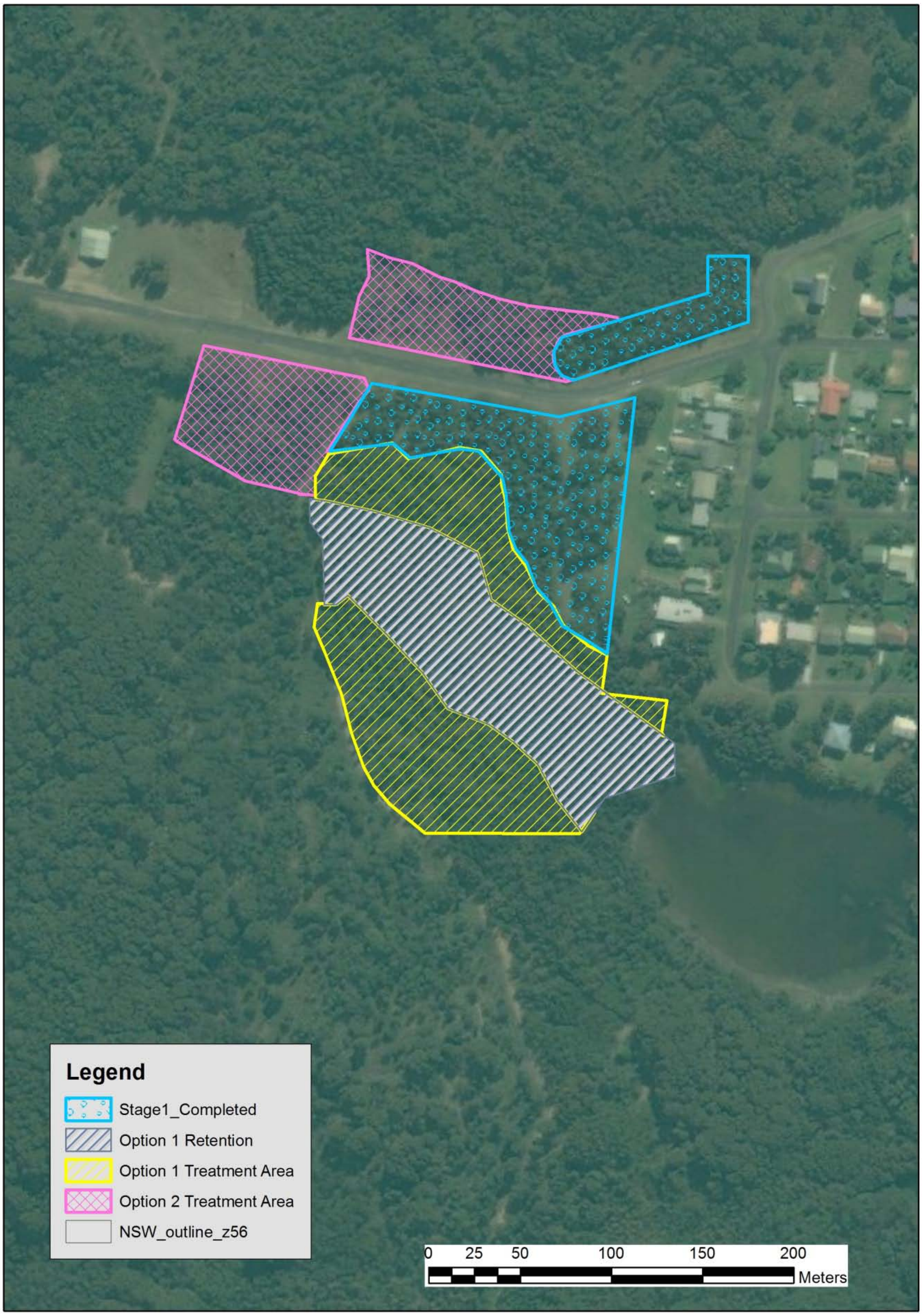


Figure 2. Map of Potato Point showing extent of existing treatments and Options 1 and 2 for possible future treatment. Data provided by the Office of Environment and Heritage.

Fire Context for Potato Point

Potato Point is on the east coast of Australia, in southern NSW (36.1^{o}S, 150.1^{o}E), adjacent to Eurobodalla National Park. The terrain is gently undulating to flat. Native vegetation, lakes and wetlands surround Potato Point for at least 3 km in all directions. It is a 7 km drive through native forest and some cleared private property to more open and populated areas along the Princes Highway.

Figure 3. Aerial photos of Potato Point (from Google Maps). Photo A, shows Potato Point directly east from Bodalla on the Princes Highway. Photo B shows detail of the town.

History of Fire near Potato Point

The best known bushfire to have almost impacted on Potato Point was a wildfire in 1985 starting near Bodalla and burning towards the coast under the influence of a strong westerly wind and followed by a southerly wind change. The fire was close to Potato Point, but did not burn into the settlement.

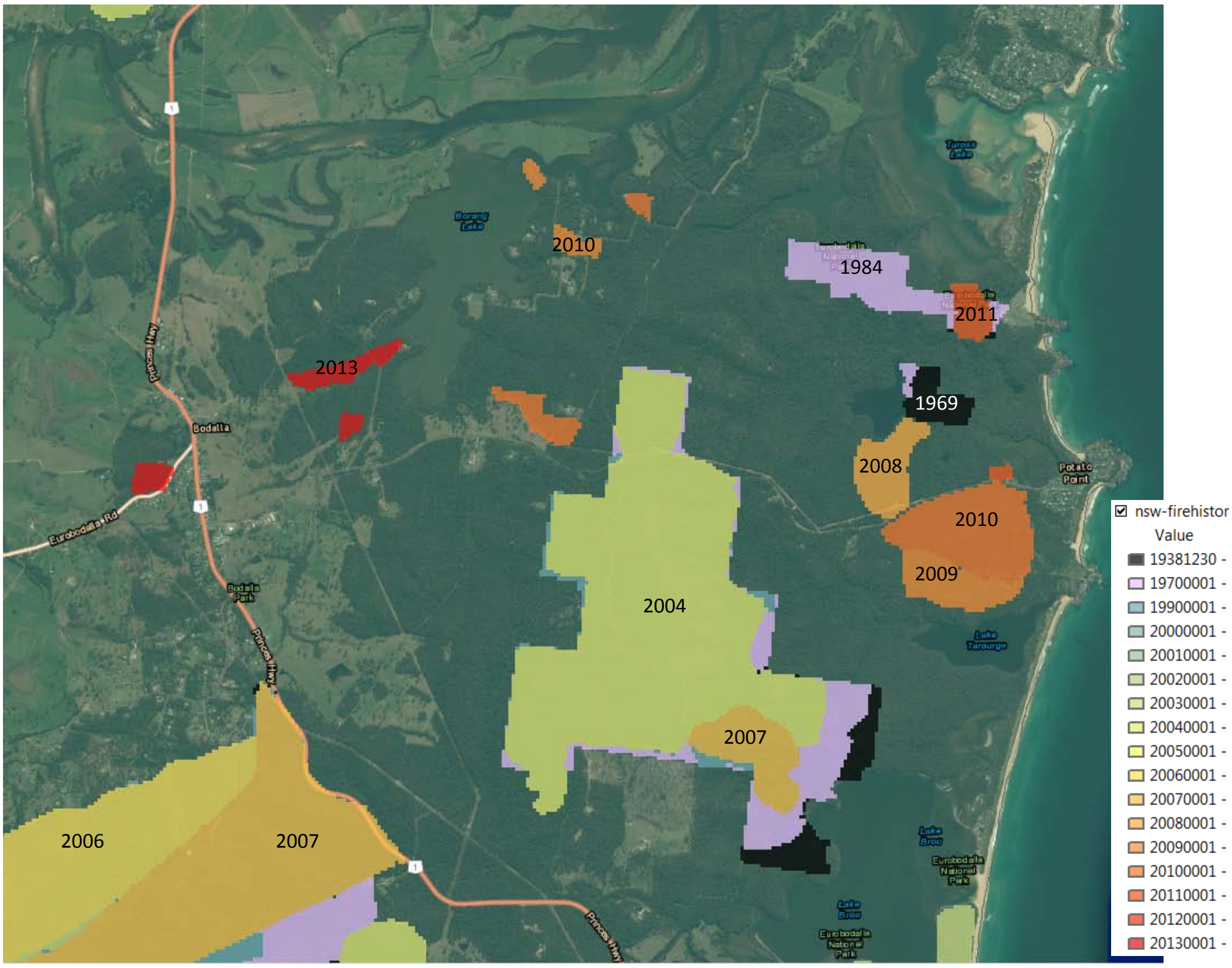


Figure 4. Fire history, as recorded by NSW Rural Fire Service, for the Potato Point area. It appears that this fire history is not complete since the 1985 fire is only partially shown. Many of the more recent fires shown are planned burns rather than wildfires.

Landscape context

Potato Point is clearly in a bushfire-prone area, however, its location on a coastal point with the ocean to the east means that it is largely protected from bushfires. Inland from the coast, there are also a considerable number of lakes and wetlands where fire cannot carry. These provide a level of fire protection, but not complete protection.

To help understand how fire-prone Potato Point is, a risk analysis was undertaken using a bushfire risk analysis tool, PHOENIX RapidFire (Tolhurst et al. 2008).

The risk analysis was based on what was considered to be the worst-case weather scenario where a strong west-north-westerly wind under very hot and dry conditions was followed by a strong southerly change. This pattern of weather was similar to that experienced in 1985. The scenario weather conditions are shown in Table 1. These conditions produce a maximum Forest Fire Danger Index of 110, the boundary between Extreme and Catastrophic fire danger.

Table 1. Weather conditions used for the worst-case scenario for a fire in the vicinity of Potato Point.

Time	Temp	RH	WindDir	WindSpd	DF	Curing	Cloud
19/01/2014 9:00	30	30	300	40	10	100	0
19/01/2014 12:00	40	15	290	55	10	100	0
19/01/2014 16:00	40	15	280	60	10	100	0
19/01/2014 17:30	38	15	270	55	10	100	0
19/01/2014 18:00	35	25	180	45	10	100	0
19/01/2014 20:00	30	35	180	40	10	100	0
19/01/2014 21:00	25	50	180	15	10	100	0
19/01/2014 23:30	20	60	160	10	10	100	0

Because fires under such severe weather conditions can travel several kilometres, fires were simulated from ignition points within an area of about 100 x 100 km with Potato Point in the middle eastern (coastal) edge of the area (Fig. 5). Simulated fires were started on a 1 x 1 km ignition grid. A total of 8159 individual fires were simulated assuming that the fires started at 1100 hrs and let run until 2300 hrs.

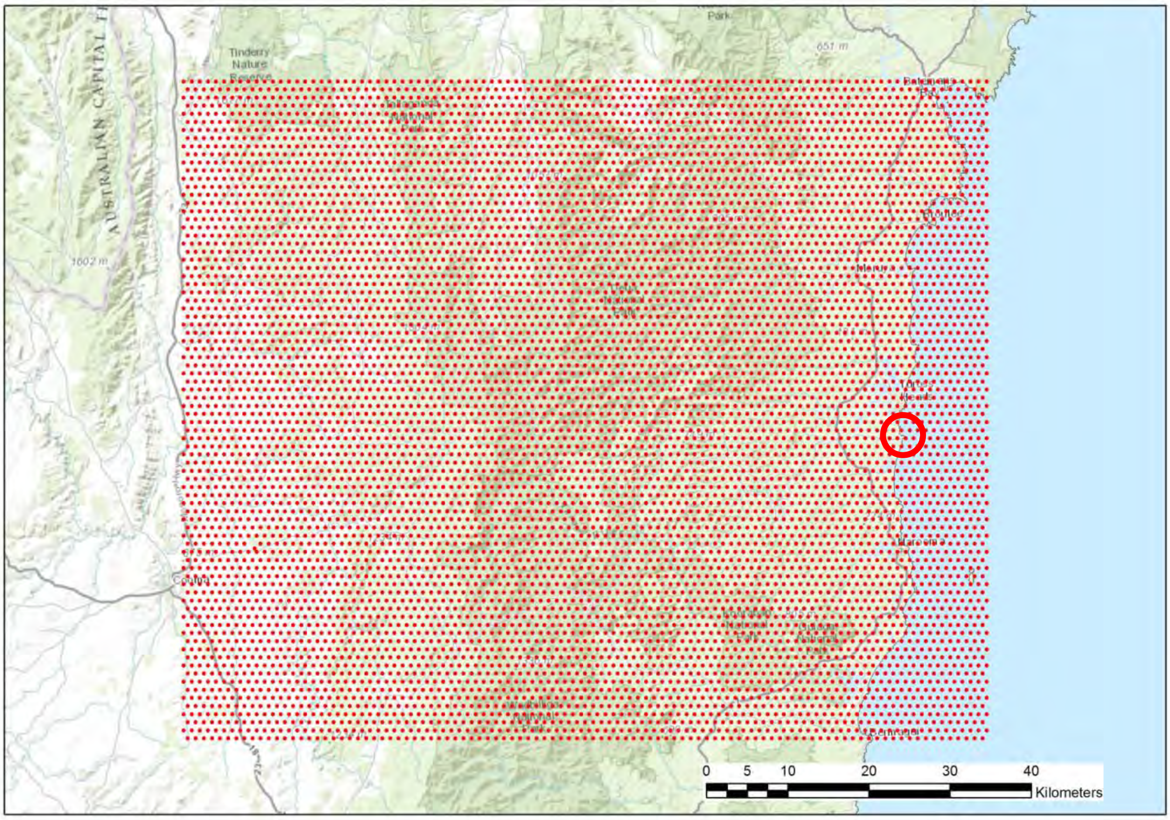


Figure 5. Ignition grid used for a landscape-scale risk analysis for Potato Point. Red circle shows the location of Potato Point. Red dots indicate ignition points.

Potential Fire Size under Simulation Conditions

The largest fires simulated in the 12 hour window were about 110,000 ha. These fires occurred 30 km or more from the coast in the hilly western part of the area studied (Fig. 6). Fires within about 20 km of Potato Point reached up to 20,000 ha, significantly smaller than fires inland from the coast (Fig. 7). Fires between the Princes Highway and the coast rarely exceeded 10,000 ha.

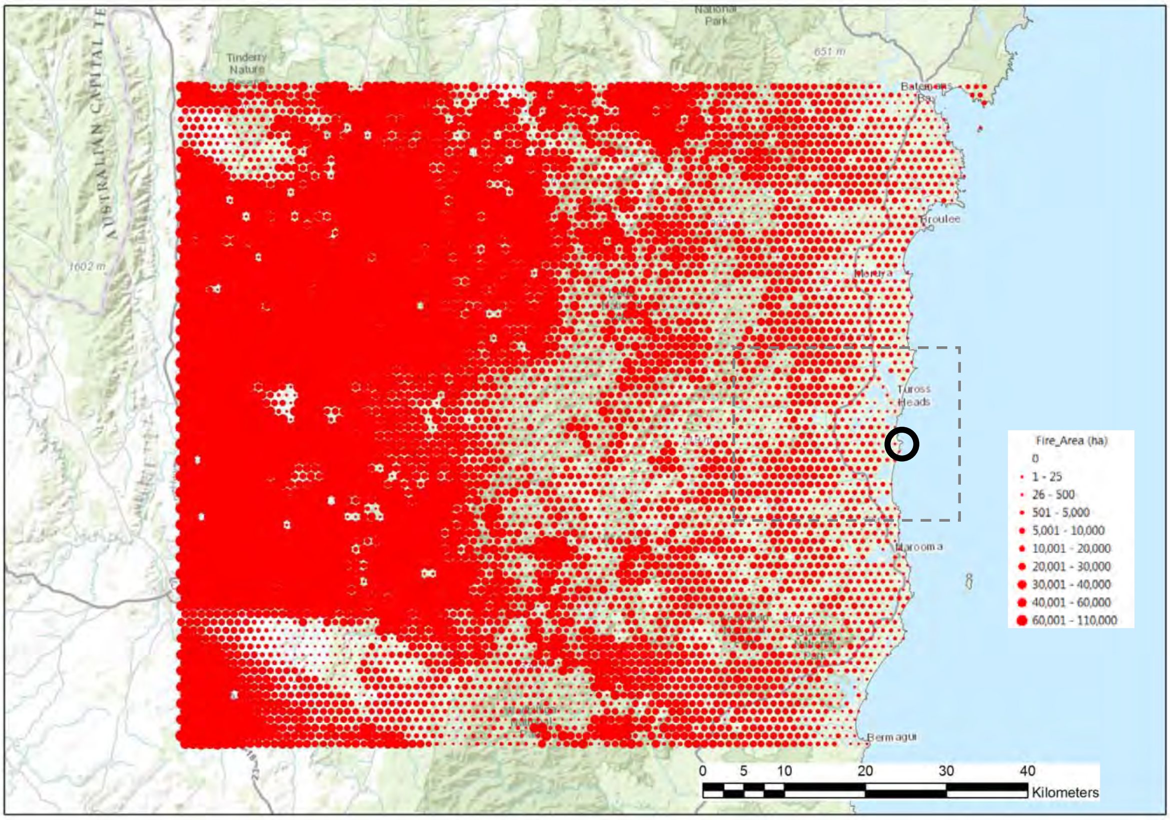


Figure 6. Simulated fire size after burning for 12 hours. Location of Potato Point indicated by black circle. Dashed rectangle is an area enlarged in Fig. 7.

The pattern of fire size is a reflection of how the weather, terrain and fuels in the landscape combine. Because in the simulations performed here, the weather is the same, it is the fuels and the terrain that make the nature of the fires so different along the coastal plains to that observed in the foothills and along the Great Divide.

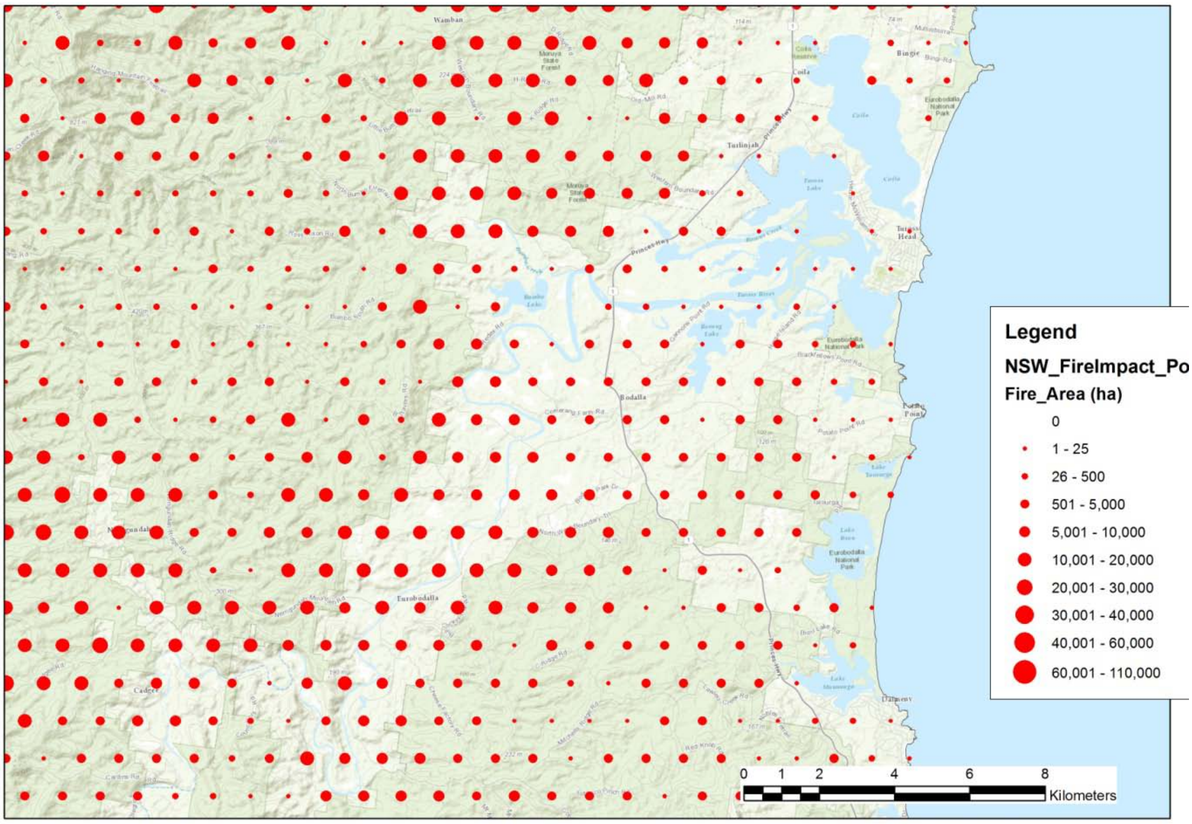


Figure 7. Fire size resulting from simulations under "worst-case" scenario conditions. Most fires east of Princes Highway are less than 5,000 ha.

Probability of fire impacting on Potato Point

There are three main factors that contribute to the probability of a bushfire impacting on a particular point in the landscape like Potato Point. First there is the probability of the weather conditions used in the simulations occurring. Second there is the probability that a fire will start in an area from where it can reach Potato Point. Third, there is the probability that once a fire starts, it will reach Potato Point.

There are no weather statistics readily available that would indicate the return period of the weather conditions like those in Table 1 and used in this simulation, but it is assumed that they will realistically occur in this area. These conditions have been taken to be "worst-case".

Likewise, there is insufficient data available to assess the likelihood of a fire starting at each of the locations of the 8,159 ignition points shown in Fig.5, so all ignition points have been assumed to be of equal likelihood here even though this is not true.

The third factor contributing to the probability of bushfire impact is the likelihood it will reach a particular point. This is shown in the simulations as the number of times a point in the landscape is impacted by fire in the simulations. "Bushfire impact" is taken here to mean any location impacted by flame, embers or convective winds. In the analysis undertaken here, the 8,159 ignitions resulted in up to 1,000 fires hitting a location. The frequency of fire impact is a reflection of the flammability of the fuel and preferred fire paths. In Figure 8, the most likely area to be impacted by bushfire is in the ranges 40 to 50 km inland from the coast. The outer 15 to 20 km of Figure 8 should be discounted because fewer fires had the potential to impact these areas because of the edge of the ignition grid. Fires are about a factor of ten less likely to occur on the coast, like near Potato Point, as they are in the forested ranges (Fig. 9).

Conclusion 1:
"Fires are about a factor of ten less likely to occur on the coast, like near Potato Point, as they are in the forested ranges."

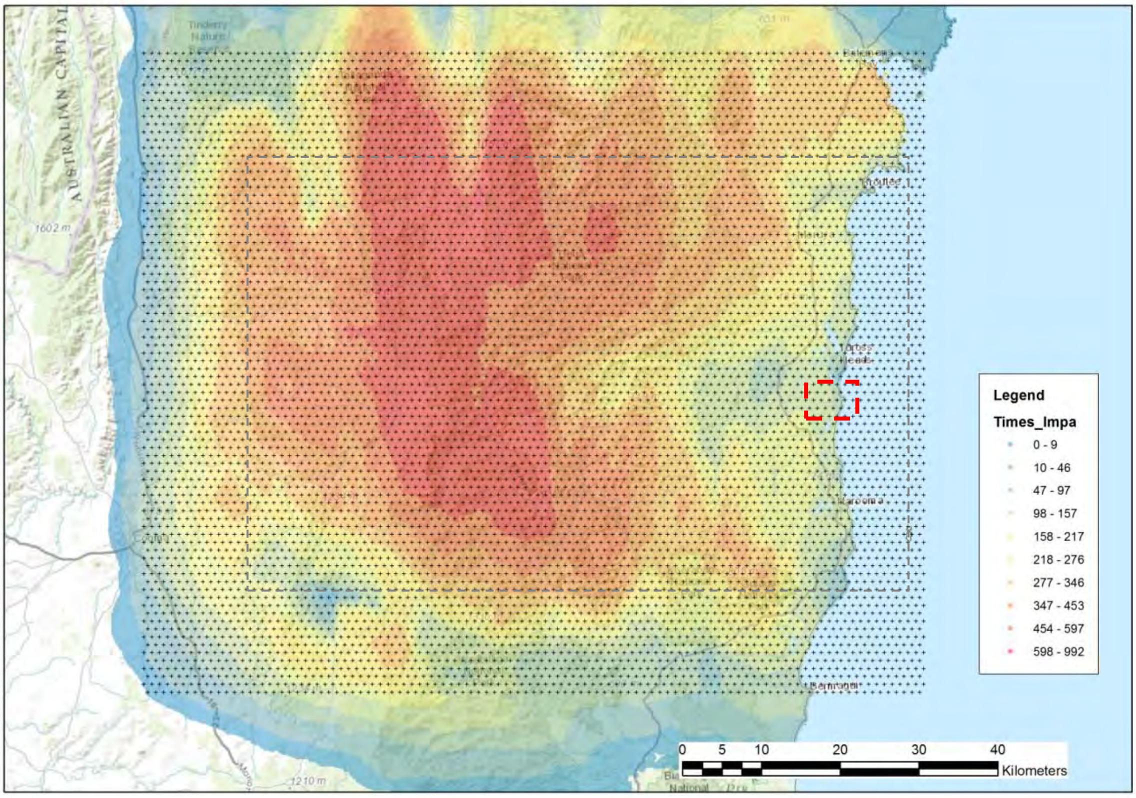


Figure 8. Number of times each point in the landscape was impacted by a fire as a result of the 8,159 individual fires. The maximum number of impacts at a point was 992 fires. Details inside red dashed rectangle are shown in Fig.9.

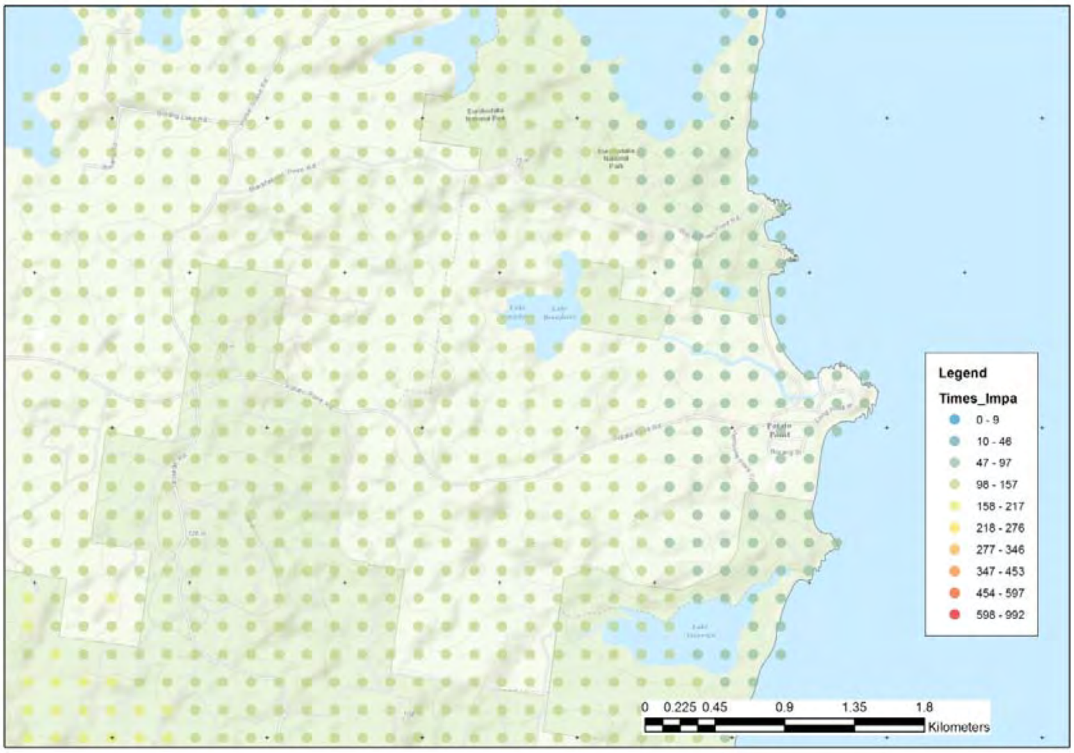


Figure 9. Number of times each point in the landscape was impacted by a fire as a result of the 8,159 individual fires. In the vicinity of Potato Point, 50 to 100 fires impacted on the area.

Probability of House Loss

House loss probability in these simulations have been based on a relationship developed using PHOENIX RapidFire and a survey of 5,000 houses in the bushfire affected area in Victoria in 2009 (Tolhurst & Chong 2011). Three factors were found to be statistically related to the probability of house loss: ember density, fire intensity/radiation, and convective strength/fire induced wind speed of the fire.

A house with an estimated loss probability of less than 0.5 has a good chance of being defended if it is well prepared and defended. Many of the areas where there is very high probability of house loss, there are no houses (Fig. 10), but even where there are no houses, there is a wide range of house loss probability due to variation in fuels, terrain and potential fire size.

The area along the coast near Potato Point, including Potato Point, has a house loss probability of up to 0.5 (Fig. 11), meaning that there is a potential to lose houses in a bushfire under extreme fire weather in Potato Point, but there is a good chance of successfully defending and saving well prepared houses.

Conclusion 2:
"… there is a potential to lose houses in a bushfire under extreme fire weather in Potato Point, but there is a good chance of successfully defending and saving well prepared houses."

However, fire simulations are broadscale and therefore there is a need to explore the bushfire threat at a more local level as well.

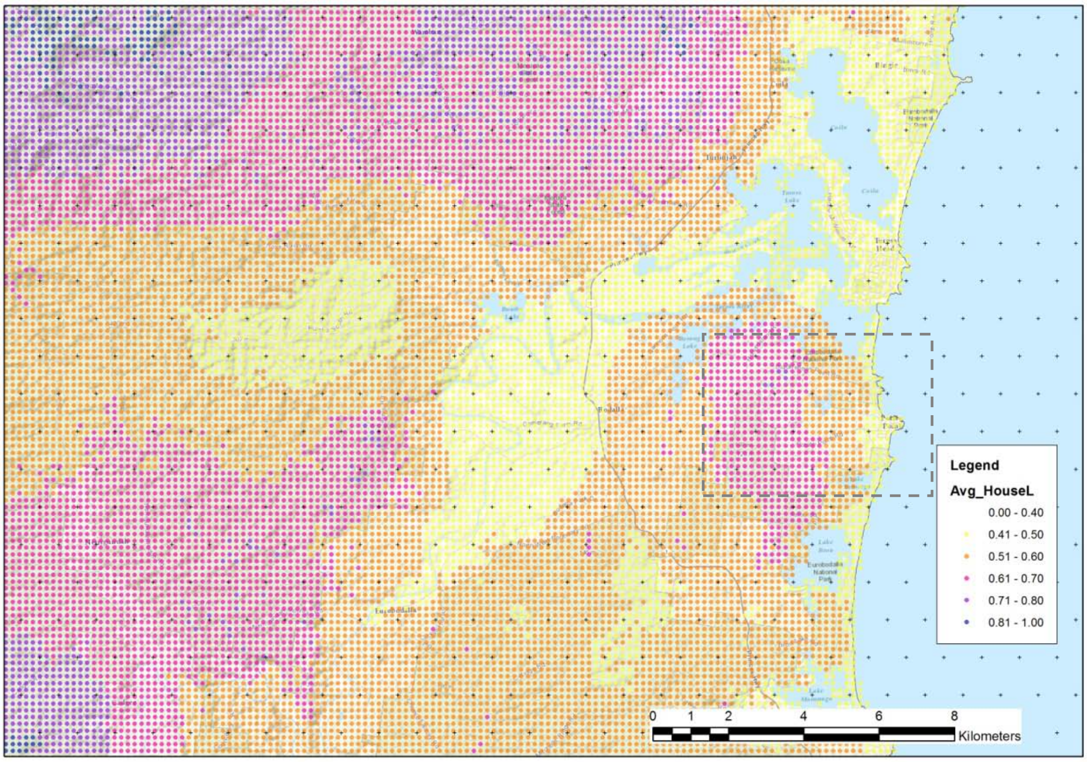


Figure 10. Estimated house loss probability for a standard house in Extreme Fire Danger at any point in the landscape. Dashed rectangle is enlarged in Fig.11.

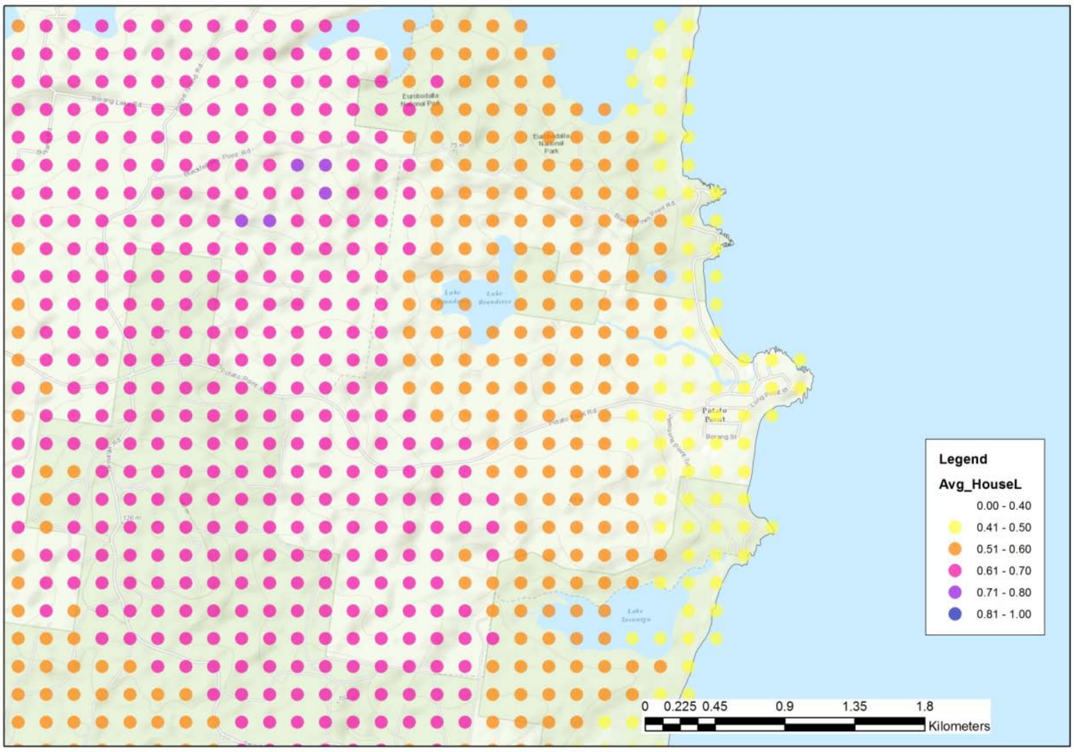


Figure 11. Estimated house loss probability for a standard house in Extreme Fire Danger weather at any point in the landscape near Potato Point

Fuels within 5 km of Potato Point

Along the coast near Potato Point, heathlands and shrublands dominate the vegetation for a few hundred metres. Behind the heathlands, dry sclerophyll forest dominate and on higher hills, wet sclerophyll forests dominate. The distribution of the main vegetation formations around Potato Point are shown in Figure 12. Some of the areas shown as "heathland" in Figure 12 have developed into shrublands and woodlands due to revegetation since the time of the mapping.

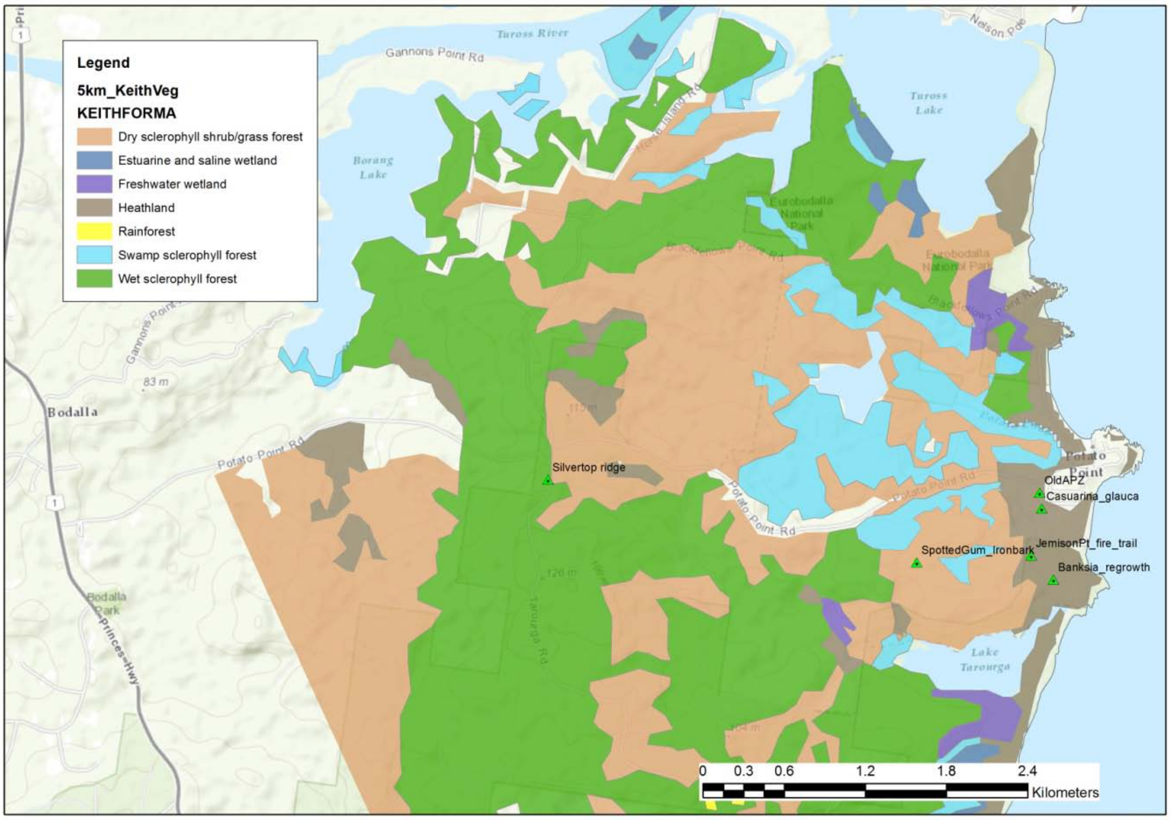


Figure 12. Vegetation formations as mapped by David Keith (Keith 2012). The labelled green triangles are locations where fuel assessments were made.

Fuel assessments were made in the field on 22 March 2014 with some supplementary surface fine fuel measurements taken on 1 April 2014. Details of the assessment are given in Appendix 1 and details of the surface fine fuel measurements are given in Appendix 2.

The greatest accumulation of fine fuel in the Potato Point area were found in the vegetation formation mapped as "wet sclerophyll forest" on the ridge about 4 km to the west and 2 km to the south-west of Potato Point (Fig. 12). The overall fine fuel hazard level in these forests was **Extreme**. A breakdown of the fuel assessment is shown in Table 2. The combined fine fuel load was assessed to be 29 t/ha. Fires would readily spread in this fuel type and because of the tree species present, would produce a large number of burning embers, creating spotfires under hot dry windy conditions. The overall fine fuel assessment is in general agreement with the assumed fuel loads from statewide mapping by NSW Rural Fire Service where the estimated fuel loads in the area of this assessment are 21-27 t/ha (Fig. 13).

Table 2. Fine fuel assessment for the wet sclerophyll forest west of Potato Point. Silvertop ridge (-36.095181, 150.092469). WRF = wind reduction factor comparing wind speed at 10 m in the open to 1.5 m in the forest.

Strata	Rating	Height (m)	Fuel Load (t/ha)	Comments
Surface	VH	40mm	16	Eucalypt leaf & twig
Near-surface	VH	0.35	5	Sedges, rushes
Elevated	H	2	3	Casuarina, Macrozamia
Bark	VH		5	Tight stringy, ribbons
Overall	**Extreme**		**29**	**Silvertop, stringybark, Blackbutt (WRF=3.5)**

Fine fuels in the dry sclerophyll forests (Fig. 12) are less hazardous than for the wet sclerophyll forest. The overall fine fuel hazard in these areas was assessed as being **High** (Table 3). A major difference between the wet sclerophyll forest and the dry sclerophyll forest fuels is the bark hazard. The spotted gum and ironbark trees do not produce many embers so the potential to produce spotfires is much reduced compared with the eucalypt species in the wet sclerophyll forests.

The field assessed combined fine fuel levels in the dry sclerophyll forest of 15 t/ha is consistent with the estimated fuel levels used by NSW Rural Fire Service of 13-20 t/ha (Fig. 13).

Table 3. Fine fuel assessment for the dry sclerophyll forest west of Potato Point. Spotted Gum / Ironbark (-36.101422, 150.122537). WRF = wind reduction factor comparing wind speed at 10 m in the open to 1.5 m in the forest.

Strata	Rating	Height (m)	Fuel Load (t/ha)	Comments
Surface	M	20mm	8	Eucalypt leaf, bark & twig
Near-surface	H	0.25	3	Small shrubs
Elevated	M	1.5	2	Macrozamia, grasses
Bark	H		2	Limited rough bark
Overall	**High**		**15**	**Spotted gum, ironbark (WRF=3)**

Fuels within 500 m to 1 km of the township of Potato Point are not mapped correctly in the Rural Fire Service data (Fig. 13). Much of this area is assumed to be grassland as it was when it was used as farmland, however, since the 1980's, much of this area has gradually revegetated and is now woodland or shrubland.

The overall fine fuel hazard rating of both the Banksia woodland and the Sheoak shrubland are **Very High** (Appendix 1). However, this fuel hazard rating is largely due to the high amounts of near-surface and elevated fine fuels, not the bark hazard or surface fine fuels. This means that a fire burning in these vegetation types on a day of Extreme fire weather would produce high flaming and spread easily. Under Extreme fire weather, flame heights could be expected to be 2 to 3 times the height of the vegetation. This would produce a significant radiation heat load. However, there would not be a lot of burning ember material produced from these fuels thus the exposure of houses at Potato Point to the fire would be largely due to radiation and not embers and thus confined to distances of 20 to 30 metres.

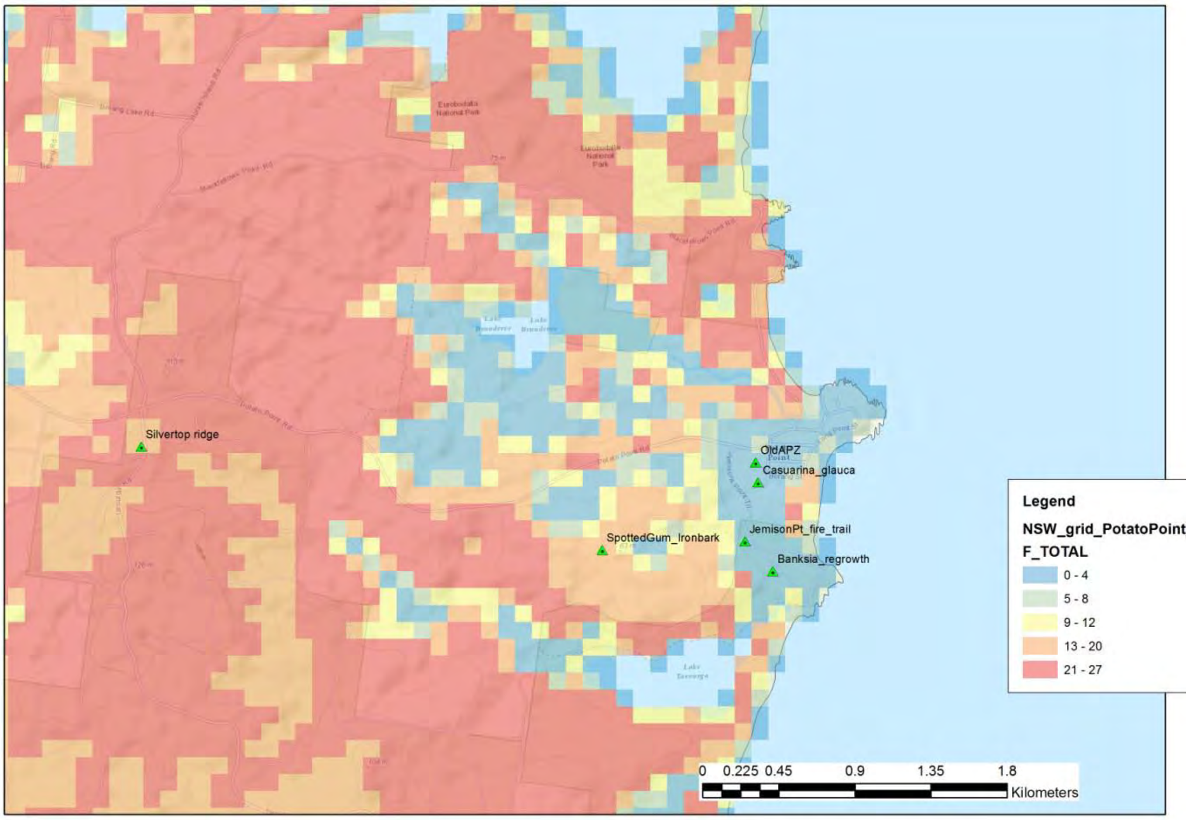


Figure 13. Total fine fuel loads as used by Rural Fire Service for fire simulations. Based on work by Dr Penny Watson, University of Wollongong (Watson et al. 2012). Green triangles are locations of field assessments on 22 March 2014.

Fuels in the Asset Protection Zone (APZ) close to edge of Potato Point (Fig. 1) have been modified to reduce the potential fire hazard. Both the structure and quantity of fuel have been modified. In the shrubland and woodland area, the canopy cover has been reduced to leave 10 to 30% canopy cover, but about 80% of the stems have been removed. This has resulted in the overall fine fuel hazard rating dropping from **Very High** to **Moderate** in these modified areas (Appendix 1). The openness of the canopy means that it will no longer support a fire in the canopy of the trees, flame heights will be less than 4 or 5 metres and access to the area by firefighting vehicles is much easier. Retaining some of the trees will help reduce the wind speed and ember loads impacting on houses in the residential area. In contrast, fires burning across open grassy areas do so with much greater wind speed, therefore the further removal of trees with the intention of reducing the bushfire risk is counter-productive.

Fuels in the Asset Protection Zone along Jemison Point Fire Trail have also been reduced from **Very High** to **Moderate** (Appendix 1). This zone will not afford any direct protection of the residential area, but will make the fire trail more useful for fire control operations. Fuel modification along the fire trail will make this suitable for backburning operations, mopup works and direct attack on a flanking or backing fire, but it will not be adequate to stop a headfire or make it safe to undertake direct suppression of a headfire under Extreme fire weather conditions.

Prescribed burning within 2 km of Potato Point (Fig. 4) has reduced the actual fuel level below the potential levels. The greatest potential for hazard reduction by prescribed burning is in the wet sclerophyll forest where the overall fine fuel hazard could be reduced from **Extreme** to **Moderate** before gradually returning to **Extreme**. Prescribed burning in the dry sclerophyll forest could reduce the overall fine fuel levels from **High** to **Moderate**. Prescribed burning in the Swamp Sheoak areas would be very difficult to achieve because it is closed to wind and sun restricting the drying of the fine fuels and resulting in very slow fire spread in weather conditions where prescribed fires can be controlled. Prescribed burning in the Banksia woodland would be very hot and difficult to control due to the very high levels of near-surface and elevated fuels which would result in complete canopy removal when conditions are conducive to burning.

Conclusion 3:
"The fuel assessment made onsite is in general agreement with the fuel mapping used by NSW Rural Fire Service except for an area immediately to the west and southwest of Potato Point where a previously farmed area is revegetating."

Conclusion 4:
*"There are some **Extreme** fine fuels within 2 to 4 km of Potato Point and represent a potential spotfire threat. Some fuels within 2 km of Potato Point are **Very High**, but do not represent a significant source of burning embers."*

Scenario Analysis

The overall bushfire risk context has been discussed. In this landscape scaled context, it is now necessary to look in greater detail at each of the four proposed bushfire risk reduction plans. To help do this, I will use the House Ignition Likelihood Index (HILI) which was developed to look at the exposure of a house to bushfire hazards (radiation, flame contact, convective heat and embers) (Tolhurst & Howlett 2003).

The five planning scenarios to be considered are:

1. Maintenance of original Asset Protection Zone (APZ) (see Fig. 1)
2. Addition of "Stage 1" works to Asset Protection Zone (see Fig. 2)
3. Further addition to APZ "Options 1&2" works (see Fig. 2)
4. Further addition to APZ " Options 1&2" works, but with environmental constraints
5. Revert to pre-1970 condition with 200 m of grazed grassland around Potato Point.

Setting Fundamental Objectives

In order to compare the options, a set of objectives with specific consequences should be prepared. I am not aware of this having been done for Potato Point. Without a set of fundamental objectives that deal with some stated outcomes/consequences, it will be impossible to undertake a trade-off process to select the best option. Setting such objectives is beyond the scope of this report, but when such a set of objectives is developed it should include the potential consequence in relation to:

- Protection of human life
- Protection of houses
- Protection of critical infrastructure (e.g. water, power, sewerage, telecommunications, road assess/egress
- Protection of aesthetic values
- Protection of biodiversity values
- Economic impact (e.g. tourism, local business)

In this report, I will only consider the "protection of houses", knowing that there is a strong association between house loss and human life loss.

Scenario Settings

The scenarios will be compared assuming the Forest Fire Danger Index is about 100 using the weather conditions similar to those in Table 1.

I will consider the exposure of an imaginary single-storied house on the edge of the Potato Point settlement. I will assume that the fuels in the garden adjacent to the house are similar to those pictured on the cover of this report and shown in Figure 15.

Inputs	
1 in 30 year bushfire weather	
Air Temperature (oC)	39
Relative Humidity (%)	15
Wind @ 10m in open (km/h)	55
KBDI	100
Time since rain (days)	10
Last rainfall (mm)	10
Fine Fuel Moisture Content (%)	4
Drought Factor	10
Forest Fire Danger Index	100
Local Topography	
Slope below house (degrees)	0
Height of house above slope (m	4

Figure 14. Weather and site settings for House Ignition Likelihood Index (HILI) analysis.

Figure 15. Western and southern interface of Potato Point with the bushland. (Source: Aerial photo from Google Earth).

Scenario 1 - Existing APZ prior to Stage 1 works

The existing APZ consists of a 20 m mown grass strip before a 30 m wide woodland with a mown grass layer (see Fig.1).

	Local Fuels	Rating (blank,L,M,H,V H,E)	Equivalent Fuel Load (t/ha)	Distance (m) Start - Stop
Garden	Suite 1 (adjacent to house)			
	Surface FF	l	2	1
	Near-surface FF	m	2	15
	Elevated FF	m	0	4
	Bark FF	m	0.5	
	Overall FF	M	4.5	
APZ mown grass	Suite 2 (away from house)			
	Surface FF	l	2	15
	Near-surface FF	m	2	35
	Elevated FF	l	0	23
	Bark FF	l	0	
	Overall FF	M	4	
APZ woodland	Suite 3 (further away)			
	Surface FF	m	6	35
	Near-surface FF	m	2	65
	Elevated FF	l	0	48
	Bark FF	m	0.5	
	Overall FF	H	8.5	
Dry Sclerophyll Forest	Suite 4 (surrounding vegetation)			
	Surface FF	m	6	65
	Near-surface FF	h	4	2000
	Elevated FF	m	0	418
	Bark FF	h	2	
	Overall FF	H	12	

Figure 16. Fuel arrangement leading up to the notional house on the edge of Potato Point.

Outputs				
Fire Behaviour	Suite 1	Suite 2	Suite 3	Suite 4
Forward Rate of Spread (m/h)	539	479	1018	1438
Flame Height (m)	6.1	5.2	13.3	19.6
Spotting Distance (m)	1808	1575	3601	5065
Fireline Intensity (kW/m)	1253	990	4472	8914
Flame Length (m)	3.3	2.7	9.5	16.9
Duration (min)	2	3	2	81

Figure 17. Predicted fire behaviour in each of the fuel suites leading up to Potato Point.

As might be expected, the most intense fire leading into Potato Point would be in the dry forest where the rate of spread would be about 1.5 km/h, flame heights about 20 m and fireline intensity around 10,000 kW/m.

The predicted fireline intensities for the garden fuels and the mown 20 m APZ would be within a range where direct fire suppression could be achieved. Direct attack of a fire in the semi-cleared woodland might be just possible, but the fire in the dry sclerophyll forest would be too intense for direct attack.

Overall, the House Ignition Likelihood would be **Low** under this scenario, with the greatest threat to the houses coming from embers originating in the dry forest and fuels in the garden of the house (Fig. 18). In this analysis I have assumed that there is at least a 1 m gap between the garden vegetation and the house. If the garden is right against the house, then flame contact and excessive radiation is assured and the House Ignition Likelihood is **Extreme** (Fig. 19).

A well prepared house could easily be defended under Scenario 1 if there is a good separation of garden vegetation from the house.

Convective Heat Load				
Assumed rate of plume rise (m/min)	700			
	3,000 kW/r	10,000 kW/m		Default
Distance to convective heat (m)	35	100		100 m
Slope to house top (degrees)	6.5	2.3		
Plume slope (degrees)	37.4	37.4		
Convective Heat Index (0,1,2)	0			
Flame Zone Contact				
Flame contact Suite 1?	No			
Flame contact Suite 2?	No			
Flame contact Suite 3?	No			
Flame contact Suite 4?	No			
Flame Contact Index (0,1)	0			
Ember Attack Load				
Max duration of ember attack (min)	201			
Expected duration of ember attack(min)	87			
Max ember attack value (t*min)	40.9		Ember A.I.	Rating
Local ember attack value (t*min)	10.1		0 - 0.40	*Low*
Ember Viability (0-1)	0.84		0.41 - 0.80	*Medium*
Ember Attack Index	0.41		0.81 - 1.20	*High*
Ember Attack Class	Medium		> 1.20	*Extreme*
Radiant Heat Load				
Radiation Suite 1	19.0		Radiant I.I.	Rating
Radiation Suite 2	1.3		< 20	**0**
Radiation Suite 3	2.5		20-29	**1**
Radiation Suite 4	2.7		>29	**2**
Radiant Heat Flux (kW/m2)	19.0			
Radiant Heat Ignition Index (0,1,2)	0			
			House I.L.I.	Rating
			0 - 0.5	*Low*
House Ignition Likelihood Index	0.41		0.51 - 1.80	*Medium*
Ignition Rating	**Low**		1.81 - 2.80	*High*
			>2.80	*Extreme*

Figure 18. Outputs from HILI showing that the main bushfire exposure under Scenario 1 is to embers

Convective Heat Load				
Assumed rate of plume rise (m/min)	700			
	3,000 kW/r	10,000 kW/m		Default
Distance to convective heat (m)	35	100		100 m
Slope to house top (degrees)	6.5	2.3		
Plume slope (degrees)	37.4	37.4		
Convective Heat Index (0,1,2)	0			
Flame Zone Contact				
Flame contact Suite 1?	Yes			
Flame contact Suite 2?	No			
Flame contact Suite 3?	No			
Flame contact Suite 4?	No			
Flame Contact Index (0,1)	1			
Ember Attack Load				
Max duration of ember attack (min)	201			
Expected duration of ember attack(min)	87			
Max ember attack value (t*min)	40.9		Ember A.I.	Rating
Local ember attack value (t*min)	10.1		0 - 0.40	*Low*
Ember Viability (0-1)	0.84		0.41 - 0.80	*Medium*
Ember Attack Index	0.42		0.81 - 1.20	*High*
Ember Attack Class	Medium		> 1.20	*Extreme*
Radiant Heat Load				
Radiation Suite 1	59.1		Radiant I.I.	Rating
Radiation Suite 2	1.3		< 20	**0**
Radiation Suite 3	2.5		20-29	**1**
Radiation Suite 4	2.7		>29	**2**
Radiant Heat Flux (kW/m2)	59.1			
Radiant Heat Ignition Index (0,1,2)	2			
			House I.L.I.	Rating
			0 - 0.5	*Low*
House Ignition Likelihood Index	3.42		0.51 - 1.80	*Medium*
Ignition Rating	**Extreme**		1.81 - 2.80	*High*
			>2.80	*Extreme*

Figure 19. Outputs from HILI showing that if the garden vegetation is up against the house under Scenario 1, house loss is almost guaranteed.

Scenario 2 - Stage 1 thinning as completed in December 2013

In this scenario, the existing APZ is maintained and extended. The thinned woodland area would extend about 60 m back from the 20 m mown firebreak instead of 30 m. The fuel characteristics of each fuel type (suite) would remain the same (Fig. 20).

	Local Fuels	Rating (blank,L,M,H,VH,E)	Equivalent Fuel Load (t/ha)	Distance (m) Start - Stop
Garden	Suite 1 (adjacent to house)			
	Surface FF	l	2	1
	Near-surface FF	m	2	15
	Elevated FF	m	0	4
	Bark FF	m	0.5	
	Overall FF	M	4.5	
APZ mown grass	Suite 2 (away from house)			
	Surface FF	l	2	15
	Near-surface FF	m	2	35
	Elevated FF	l	0	23
	Bark FF	l	0	
	Overall FF	M	4	
APZ/SFAZ woodland	Suite 3 (further away)			
	Surface FF	m	6	35
	Near-surface FF	m	2	95
	Elevated FF	l	0	58
	Bark FF	m	0.5	
	Overall FF	H	8.5	
Dry Sclerophyll Forest	Suite 4 (surrounding vegetation)			
	Surface FF	m	6	95
	Near-surface FF	h	4	2000
	Elevated FF	m	0	490
	Bark FF	h	2	
	Overall FF	H	12	

Figure 20. Revised inputs to HILI to reflect a deeper modified fuel zone in the APZ.

Convective Heat Load				
Assumed rate of plume rise (m/min)	700			
	3,000 kW/r	10,000 kW/m		Default
Distance to convective heat (m)	35	100		100 m
Slope to house top (degrees)	6.5	2.3		
Plume slope (degrees)	37.4	37.4		
Convective Heat Index (0,1,2)	0			
Flame Zone Contact				
Flame contact Suite 1?	No			
Flame contact Suite 2?	No			
Flame contact Suite 3?	No			
Flame contact Suite 4?	No			
Flame Contact Index (0,1)	0			
Ember Attack Load				
Max duration of ember attack (min)	201			
Expected duration of ember attack(min)	87			
Max ember attack value (t*min)	40.9		Ember A.I.	Rating
Local ember attack value (t*min)	7.1		0 - 0.40	*Low*
Ember Viability (0-1)	0.84		0.41 - 0.80	*Medium*
Ember Attack Index	0.29		0.81 - 1.20	*High*
Ember Attack Class	Low		> 1.20	*Extreme*
Radiant Heat Load				
Radiation Suite 1	19.0		Radiant I.I.	Rating
Radiation Suite 2	1.3		< 20	**0**
Radiation Suite 3	2.5		20-29	**1**
Radiation Suite 4	1.8		>29	**2**
Radiant Heat Flux (kW/m2)	19.0			
Radiant Heat Ignition Index (0,1,2)	0			
			House I.L.I	Rating
			0 - 0.5	*Low*
House Ignition Likelihood Index	0.29		0.51 - 1.80	*Medium*
Ignition Rating	**Low**		1.81 - 2.80	*High*
			>2.80	*Extreme*

Figure 21. Outputs from HILI for Scenario 2.

Extending the APZ a further 30 m results in the ember attack load dropping from **Medium** to **Low** with a resulting House Ignition Likelihood Rating remaining **Low**. The duration of ember attack is still estimated to be about 1.5 hours.

The reduction in the ember attack load would make house defence a lot easier, however, if the garden vegetation caught alight, it would be difficult to get near it.

From the location of the stage 1 treatments, the benefit of the works would be extended to a few houses on the north-western interface of Potato Point.

Scenario 3 - Works to extend APZ and create a mechanically treated SFAZ

In this scenario, the thinning of the shrubland to convert it to a woodland would add a Strategic Fire Advantage Zone (SFAZ) to the APZ combining to give a fuel modified zone about 170 m from the boundary of the private property (Fig. 2). It is assumed that after this work is completed, it will look like the long-established APZ to the west of the settlement.

	Local Fuels	Rating (blank,L,M,H,VH,E)	Equivalent Fuel Load (t/ha)	Distance (m) Start - Stop
Garden	Suite 1 (adjacent to house)			
	Surface FF	l	2	1
	Near-surface FF	m	2	15
	Elevated FF	m	0	4
	Bark FF	m	0.5	
	Overall FF	M	4.5	
APZ mown grass	Suite 2 (away from house)			
	Surface FF	l	2	15
	Near-surface FF	m	2	35
	Elevated FF	l	0	23
	Bark FF	l	0	
	Overall FF	M	4	
APZ/SFAZ woodland	Suite 3 (further away)			
	Surface FF	m	6	35
	Near-surface FF	m	2	185
	Elevated FF	l	0	83
	Bark FF	m	0.5	
	Overall FF	H	8.5	
Dry Sclerophyll Forest	Suite 4 (surrounding vegetation)			
	Surface FF	m	6	185
	Near-surface FF	h	4	2000
	Elevated FF	m	0	653
	Bark FF	h	2	
	Overall FF	H	12	

Figure 22. Revised inputs to HILI to reflect a deeper modified fuel zone in the APZ.

This additional work does not make any significant change (Fig.23). There is a very slight reduction in the level of ember attack, but then the duration of ember attack is actually increased slightly because the fire is burning more slowly.

Convective Heat Load				
Assumed rate of plume rise (m/min)	700			
	3,000 kW/r	10,000 kW/m		Default
Distance to convective heat (m)	35	100		100 m
Slope to house top (degrees)	6.5	2.3		
Plume slope (degrees)	37.4	37.4		
Convective Heat Index (0,1,2)	0			
Flame Zone Contact				
Flame contact Suite 1?	No			
Flame contact Suite 2?	No			
Flame contact Suite 3?	No			
Flame contact Suite 4?	No			
Flame Contact Index (0,1)	0			
Ember Attack Load				
Max duration of ember attack (min)	201			
Expected duration of ember attack(min)	89			
Max ember attack value (t*min)	40.9		Ember A.I.	Rating
Local ember attack value (t*min)	4.8		0 - 0.40	*Low*
Ember Viability (0-1)	0.84		0.41 - 0.80	*Medium*
Ember Attack Index	0.20		0.81 - 1.20	*High*
Ember Attack Class	Low		> 1.20	*Extreme*
Radiant Heat Load				
Radiation Suite 1	19.0		Radiant I.I.	Rating
Radiation Suite 2	1.3		< 20	**0**
Radiation Suite 3	2.5		20-29	**1**
Radiation Suite 4	1.0		>29	**2**
Radiant Heat Flux (kW/m2)	19.0			
Radiant Heat Ignition Index (0,1,2)	0			
			House I.L.I	Rating
			0 - 0.5	*Low*
House Ignition Likelihood Index	0.20		0.51 - 1.80	*Medium*
Ignition Rating	**Low**		1.81 - 2.80	*High*
			>2.80	*Extreme*

Figure 23. Outputs for HILI for Scenario 3.

Scenario 4 - Options 1 & 2 to extend APZ, but with Environmental Constraints

This scenario is similar to Scenario 3 except that some areas in the Strategic Fire Advantage Zone (SFAZ) are excluded from thinning and regular mowing due to environmental constraints. The areas excluded from treatment are shown in Figure 2. The effect of this exclusion is to increase the amount of fuel in the SFAZ, particularly the near-surface and elevated fine fuels (Fig.24).

Retaining the Swamp Sheoak area within the "200 m" SFAZ increases the overall fuel load in the SFAZ woodland area. This has the effect of increasing the radiation hazard at a house from 2.5 kW/m^2 to 5.3 kW/m^2 (Fig.25). These radiation levels are still well below the levels where house damage can start (12.5 kW/m^2) or house ignition potential (25 kW/m^2) (See Appendix 3).

The result of leaving the extra fuel has little impact on the House Ignition Likelihood Index. In fact, the results might seem counterintuitive because the Ember Attack Index actually decreases (Fig.25). This is because the fire moves more quickly through the modified fuel in the APZ resulting in a decrease in the period of time embers attack the house. There is no direct impact of the greater level of fuel on the house so the effect of reducing the duration of ember attack by a few minutes is actually a marginal benefit.

The Option 2 component being considered (Fig.2) will not have a measurable impact on house ignition likelihood, but it will provide increased safety and access from the fire brigade facility to the residential area.

	Local Fuels	Rating (blank,L,M,H,V H,E)	Equivalent Fuel Load (t/ha)	Distance (m) Start - Stop
Garden	Suite 1 (adjacent to house)			
	Surface FF	l	2	1
	Near-surface FF	m	2	15
	Elevated FF	m	0	4
	Bark FF	m	0.5	
	Overall FF	M	4.5	
APZ mown grass	Suite 2 (away from house)			
	Surface FF	l	2	15
	Near-surface FF	m	2	35
	Elevated FF	l	0	23
	Bark FF	l	0	
	Overall FF	M	4	
APZ/SFAZ woodland and retained Swamp Sheoak	Suite 3 (further away)			
	Surface FF	m	6	35
	Near-surface FF	h	4	185
	Elevated FF	h	2	83
	Bark FF	m	0.5	
	Overall FF	H	12.5	
Dry Sclerophyll Forest	Suite 4 (surrounding vegetation)			
	Surface FF	m	6	185
	Near-surface FF	h	4	2000
	Elevated FF	m	0	653
	Bark FF	h	2	
	Overall FF	H	12	

Figure 24. Fuel levels increased in Suite 3 for Scenario 4 to reflect the greater amount of fuel resulting from leaving some vegetation unmodified.

Convective Heat Load				
Assumed rate of plume rise (m/min)	700			
	3,000 kW/r	10,000 kW/m		Default
Distance to convective heat (m)	35	100		100 m
Slope to house top (degrees)	6.5	2.3		
Plume slope (degrees)	37.4	37.4		
Convective Heat Index (0,1,2)	0			
Flame Zone Contact				
Flame contact Suite 1?	No			
Flame contact Suite 2?	No			
Flame contact Suite 3?	No			
Flame contact Suite 4?	No			
Flame Contact Index (0,1)	0			
Ember Attack Load				
Max duration of ember attack (min)	201			
Expected duration of ember attack(min)	86			
Max ember attack value (t*min)	39.3		Ember A.I.	Rating
Local ember attack value (t*min)	4.0		0 - 0.40	*Low*
Ember Viability (0-1)	0.84		0.41 - 0.80	*Medium*
Ember Attack Index	0.17		0.81 - 1.20	*High*
Ember Attack Class	Low		> 1.20	*Extreme*
Radiant Heat Load				
Radiation Suite 1	19.0		Radiant I.I.	Rating
Radiation Suite 2	1.3		< 20	**0**
Radiation Suite 3	5.3		20-29	**1**
Radiation Suite 4	1.0		>29	**2**
Radiant Heat Flux (kW/m2)	19.0			
Radiant Heat Ignition Index (0,1,2)	0			
			House I.L.I.	Rating
			0 - 0.5	*Low*
House Ignition Likelihood Index	0.17		0.51 - 1.80	*Medium*
Ignition Rating	**Low**		1.81 - 2.80	*High*
			>2.80	*Extreme*

Figure 25. Outputs from HILI for Scenario 4.

Scenario 5 - Clearing all vegetation for 200 m from the private property boundary

This is not a scenario being considered, but reflects the conditions at the site in 1985 when the last significant wildfire impacted on Potato Point.

If we assume that the fuels around the house are the same as for the previous four scenarios and the grass is mown or grazed, there will only be three fuel suites (Fig.26). However, now the wind speed across the open ground will be greater so the wind mitigation factor will be 0.8 instead of 0.3 when tree cover reduces the wind and embers. This increased wind speed at the houses means that any fires in the gardens will be driven by stronger winds increasing the flame height and flame angle.

	Local Fuels	Rating (blank,L,M,H,VH,E)	Equivalent Fuel Load (t/ha)	Distance (m) Start - Stop
Garden	Suite 1 (adjacent to house)			
	Surface FF	l	2	1
	Near-surface FF	m	2	15
	Elevated FF	m	0	4
	Bark FF	m	0.5	
	Overall FF	M	4.5	
APZ mown grass	Suite 2 (away from house)			
	Surface FF	l	2	15
	Near-surface FF	m	2	215
	Elevated FF	l	0	62
	Bark FF	l	0	
	Overall FF	M	4	
Dry Sclerophyll Forest	Suite 3 (further away)			
	Surface FF	m	6	215
	Near-surface FF	h	4	2000
	Elevated FF	m	0	698
	Bark FF	h	2	
	Overall FF	H	12	
	Suite 4 (surrounding vegetation)			
	Surface FF		FALSE	2000
	Near-surface FF		FALSE	2000
	Elevated FF		FALSE	2000
	Bark FF		FALSE	
	Overall FF	#N/A	0	
	Wind Mitigation Factor			
	Forest within 2 tree heights	0.3		
	Forest within 2 to 5 tree heights	0.5		
	Clear view to horizon or >100m	0.8		
	Hill top, ridge top	1		
	Factor here =	0.8		

Figure 26. Fuel levels assuming a 200 m grassy area between the forest and houses

The effect of removing all the trees and shrubs and just leaving grassland between the forest and the houses is to elevate the House Ignition Likelihood Rating to **Extreme**. Closer examination of the results indicates that this surprising result is due to the increased fire activity in the garden fuels. With all the tall vegetation removed from the public land interface, the wind increases the flames from the garden fires and the one metre gap between the garden and the house is no longer sufficient to protect the house so there is flame contact, radiation and convective heating combining to make the house indefensible (Fig.27). This is not dissimilar to what was observed in Canberra in 2003 when many of the houses destroyed were adjoining eaten-out grassy paddocks. In this situation, all fuels within 6 m around each house would need to be cleared to make the house defendable.

Convective Heat Load				
Assumed rate of plume rise (m/min)	700			
	3,000 kW/r	10,000 kW/m		Default
Distance to convective heat (m)	1	1		100 m
Slope to house top (degrees)	75.8	75.8		
Plume slope (degrees)	37.4	37.4		
Convective Heat Index (0,1,2)	2			
Flame Zone Contact				
Flame contact Suite 1?	Yes			
Flame contact Suite 2?	No			
Flame contact Suite 3?	No			
Flame contact Suite 4?	No			
Flame Contact Index (0,1)	1			
Ember Attack Load				
Max duration of ember attack (min)	237			
Expected duration of ember attack(min)	100			
Max ember attack value (t*min)	12.8		Ember A.I.	Rating
Local ember attack value (t*min)	1.2		0 - 0.40	*Low*
Ember Viability (0-1)	0.84		0.41 - 0.80	*Medium*
Ember Attack Index	0.16		0.81 - 1.20	*High*
Ember Attack Class	Low		> 1.20	*Extreme*
Radiant Heat Load				
Radiation Suite 1	57.7		Radiant I.I.	Rating
Radiation Suite 2	1.3		< 20	**0**
Radiation Suite 3	0.8		20-29	**1**
Radiation Suite 4	0.0		>29	**2**
Radiant Heat Flux (kW/m2)	57.7			
Radiant Heat Ignition Index (0,1,2)	2			
			House I.L.I	Rating
			0 - 0.5	*Low*
House Ignition Likelihood Index	5.16		0.51 - 1.80	*Medium*
Ignition Rating	**Extreme**		1.81 - 2.80	*High*
			>2.80	*Extreme*

Figure 27. Output from HILI for the option where there is 200 m of open grassland beyond the private property boundary.

Conclusions

In a landscape context, Potato Point is a relatively low bushfire risk location. It is an order of magnitude less likely to be impacted by fire than areas in the foothill and forested areas of the State. Potential fire severity at Potato Point is also much reduced compared with elsewhere due to the lack to significant terrain and relatively moderate level of fuel.

The scenario analysis has shown that the most critical fuels to impact on a house are those in the garden surrounding the house (Scenario 1).

The pre-2013 fuel treatment in the original Asset Protection Zone (APZ) (up to 70 m) is adequate to modify fire behaviour sufficiently to make a well prepared house defendable (Scenarios 1 & 2).

The benefit of extending the original APZ in 2013 has been to reduce the burning ember hazard, but the house ignition likelihood is still rated as **Low** (Scenario 2).

With this APZ in place, the main bushfire hazard for houses will be burning embers. The main source of these embers will be from the dry sclerophyll and wet sclerophyll forests (Scenarios 1 & 2).

Extending the APZ with a SFAZ out about 200 m from the house interface only has a minor impact on exposure of the houses to the bushfire hazards, in particular the exposure to burning embers (Scenario 3). Retaining an area of Swamp Sheoak along a drainage line in the extended APZ does not change the house ignition likelihood rating and there are only minor changes to the levels of radiation and ember exposure (Scenario 4).

Clearing all trees and shrubs for 200 m around the public land boundary exasperates the bushfire problem at a house because of increased exposure to wind (Scenario 5). Therefore removal of too many trees is counterproductive to protecting houses from bushfire exposure.

The 20 m fuel modification strip along Jemison Point Fire Trail does not provide a direct fire protection benefit to Potato Point, but it does make the use of the trail safer for fire suppression works.

Observations

There does not seem to be a set of fundamental objectives that consider the consequence of different management options. These objectives and their associated consequences should encompass a wide range of social, economic, and environmental values. Without these objectives, community engagement and debate about options is very difficult.

Houses at Potato Point are very close together. If one house catches fire, it would be very difficult to stop its neighbours also being burnt. There is a growing trend in North America, Europe and South America where wildfires turn into township fires because of the close proximity of houses. Consideration should be given to how a township fire would be handled if a bushfire was raging in the surrounding landscape.

The location of the many lakes and wetlands around Potato Point affords a considerable level of protection. Only a fire originating near Bodalla and driven by a westerly wind is likely to directly impact on the settlement. A fire starting anywhere else will not subject Potato Point to the full headfire intensity.

Prescribed burning in the dry and wet sclerophyll eucalypt forests within 6 to 8 km of Potato Point would be beneficial in reducing the likelihood of a fire reaching the Point. In particular, spotting from the wet sclerophyll forest on the ridge between Potato Point and Bodalla under hot dry westerly or north-westerly winds have the potential to start fires in and around Potato Point. The fire history around Potato Point shows that some prescribed burning has been done in the past decade or so and this should be continued as part of the bushfire protection of Potato Point.

References

Keith, D.A. (2012) Ocean shores to desert dunes: the native vegetation of New South Wales and the ACT. Office of Environment and Heritage, Sydney South, NSW.

Standards Australia (2011) Australian Standard AS 3959-2009, Construction of buildings in bushfire-prone areas. (Issued with amendments November 2011).

Tolhurst, K.G. and Chong, D.M. (2011) Assessing potential house losses using PHOENIX RapidFire. In: R.P. Thornton (Ed.) 'Proceedings of Bushfire CRC & AFAC 2011 Conference Science Day'. 1 September 2011, Sydney Australia. Bushfire CRC. Pp.74-86.

Tolhurst, K.G. and Howlett, K.A. (2003) House Ignition Likelihood Index - An Hazard Assessment Method for Land Managers in the Wildland-Urban Interface. 3rd International Wildland Fire Conference and 10th Annual AFAC Conference, 2-6 October 2003, Sydney, Australia. 10pp.

Tolhurst, K.G., Shields, B. and Chong, D.M. (2008). Phoenix: development and application of a bushfire risk management tool. *Australian Journal of Emergency Management*, **23**(4), 47-54.

Watson, P., Penman, S. and Horsey, B. (2012) Bushfire fuels in NSW forests and grassy woodlands. Fuels Modelling Project final report. Report for the Rural Fire Service of NSW. Centre for Environmental Risk Management of Bushfires, University of Wollongong, NSW. 64pp.

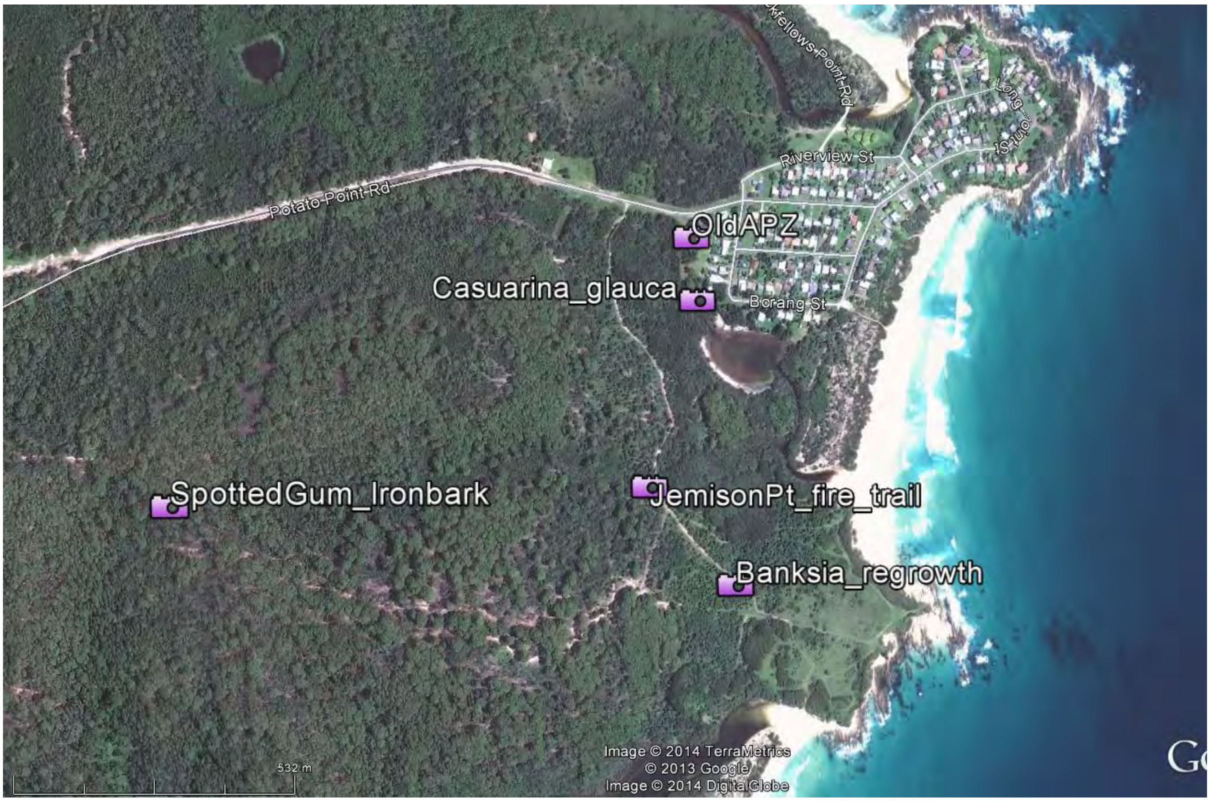
Appendix 1. Fine Fuel Assessment

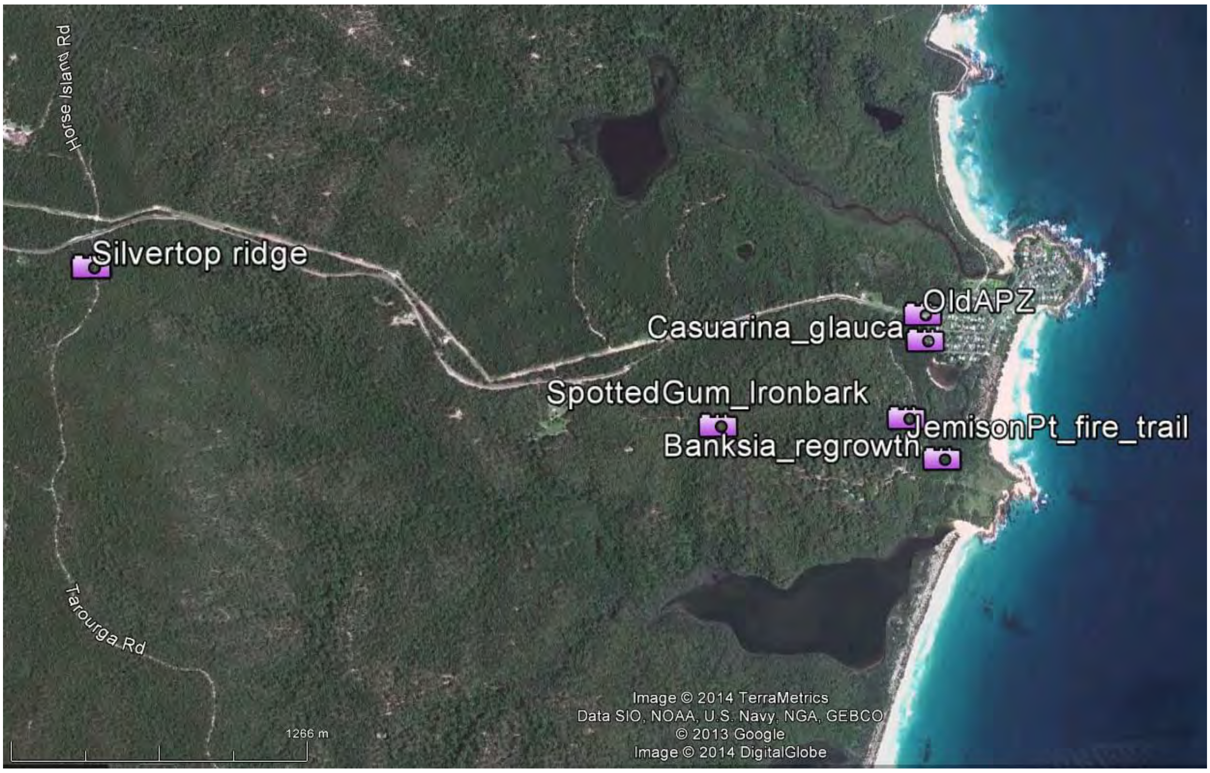
Potato Point Field Reconnaissance

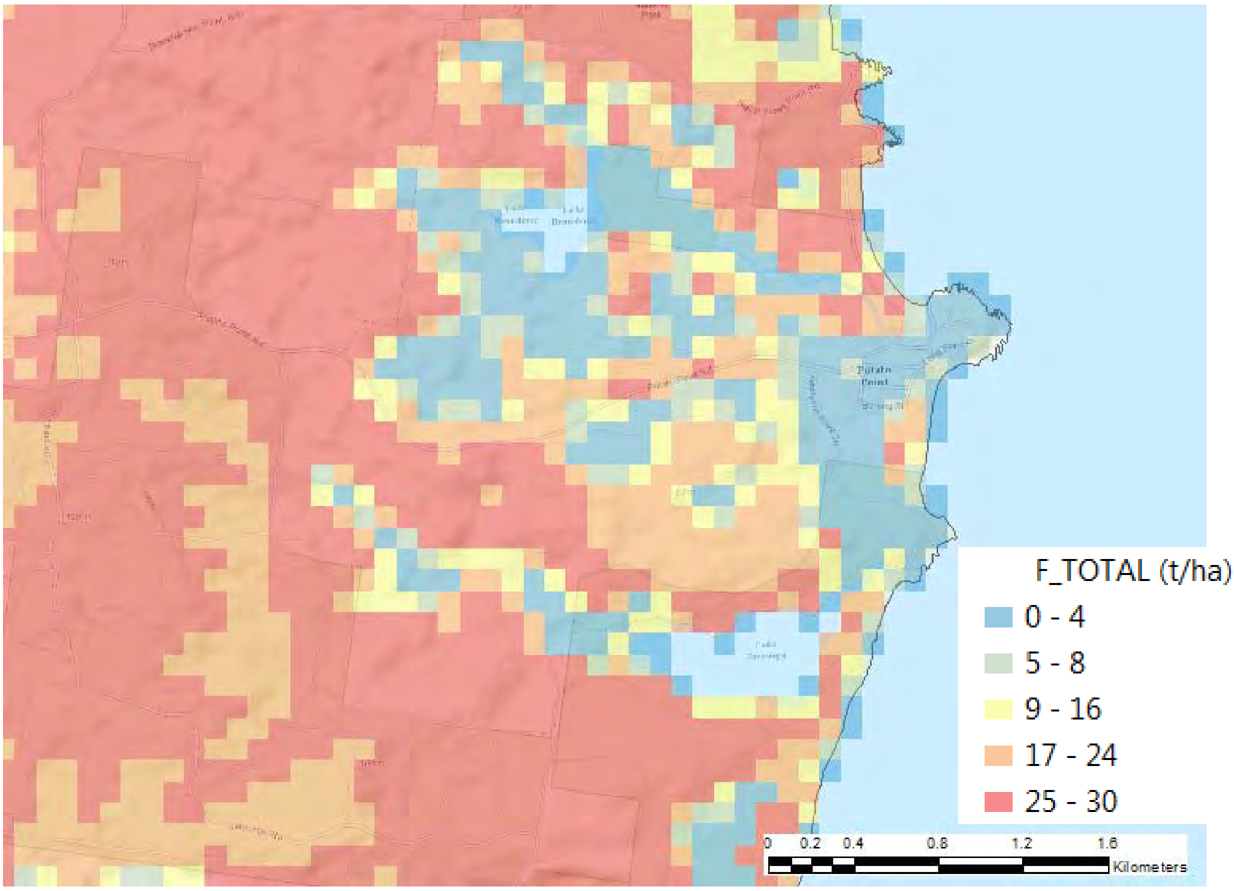
Observer: Kevin Tolhurst

Date: 22 March 2014

Accompanied by: Tim Shepherd, Tony Baxter, Tristan Ricketson (all National Parks and Wildlife Service, NSW)


Potato Point Rd
Riverview St
Borang St
OldAPZ
Casuarina_glauca
SpottedGum_Ironbark
JemisonPt_fire_trail
Banksia_regrowth
532 m
Image © 2014 TerraMetrics
© 2013 Google
Image © 2014 DigitalGlobe


Horse Island Rd
Silvertop ridge
OldAPZ
Casuarina_glauca
SpottedGum_Ironbark
JemisonPt_fire_trail
Banksia_regrowth
Tarourga Rd
1266 m
Image © 2014 TerraMetrics
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2013 Google
Image © 2014 DigitalGlobe



Data supplied by RFS based on work by Penny Watson from University of Wollongong.

Silvertop ridge (-36.095181, 150.092469)

Strata	**Rating**	**Height (m)**	**Fuel Load (t/ha)**	**Comments**
Surface	VH	40mm	16	Eucalypt leaf & twig
Near-surface	VH	0.35	5	Sedges, rushes
Elevated	H	2	3	Casuarina, Macrozamia
Bark	VH		5	Tight stringy, ribbons
Overall	**Extreme**		**29**	**Silvertop, stringybark, Blackbutt (WRF=3.5)**

Spotted Gum / Ironbark (-36.101422, 150.122537)

Strata	**Rating**	**Height (m)**	**Fuel Load (t/ha)**	**Comments**
Surface	M	20mm	8	Eucalypt leaf, bark & twig
Near-surface	H	0.25	3	Small shrubs
Elevated	M	1.5	2	Macrozamia, grasses
Bark	H		2	Limited rough bark
Overall	**High**		**15**	**Spotted gum, ironbark (WRF=3)**

Banksia regrowth (-36.102831, 150.133708)

Strata	**Rating**	**Height (m)**	**Fuel Load (t/ha)**	**Comments**
Surface	M	15mm	4	Leaf litter
Near-surface	VH	0.50	5	Grass tussocks and rushes
Elevated	VH	6	4	Banksia
Bark	M		0	No loose bark
Overall	**Very High**		**13**	**Banksia shrubland (WRF=4)**

Jemison Point Fire Trail (SFZ) (-36.101189, 150.131933)

Strata	**Rating**	**Height (m)**	**Fuel Load (t/ha)**	**Comments**
Surface	L	10mm	4	Leaf litter
Near-surface	H	0.20	3	Grass tussocks and rushes
Elevated	M	1.0	1	Bracken
Bark	M		1	Minimal loose bark
Overall	**Moderate**		**9**	**Open Woodland (WRF=2)**

Casuarina glauca (-36.098061, 150.132920)

Strata	Rating	Height (m)	Fuel Load (t/ha)	Comments
Surface	H	30mm	10	Leaf litter
Near-surface	H	0.40	3	Sedges and rushes
Elevated	H	8	3	Casuarina
Bark	M		1	Minimal loose bark
Overall	**Very High**		**17**	**Shrubland (WRF=5)**

Asset Protection Zone (long-established) (-36.097007, 150.132790)

Strata	**Rating**	**Height (m)**	**Fuel Load (t/ha)**	**Comments**
Surface	M	15mm	4	Leaf litter and dead grass
Near-surface	M	0.10	2	Mown grass
Elevated	L	0	0	absent
Bark	M		1	Minimal loose bark
Overall	**Moderate**		**7**	**Woodland (WRF=2)**

Asset Protection Zone (recent) (-36.097007, 150.132790)

Strata	**Rating**	**Height (m)**	**Fuel Load (t/ha)**	**Comments**
Surface	H	25mm	10	Mulch (fine and course mixed)
Near-surface	L	0	0	absent
Elevated	L	0	0	absent
Bark	M		1	Minimal loose bark
Overall	**Moderate**		**11**	**Woodland (WRF=2)**

Appendix 2 - Surface Fine Fuel Measurements

Potato Point Fuel Measurements – 1 & 2 April 2014

Surface fine fuel depth measurement taken every 10 paces for approx 200m transect

Assessors: Tony Baxter (Area Manager), Tristan Ricketson (Ranger)

Sample	Silvertop Ridge	Spotted Gum	Banksia regrowth	Fire Trail	Swamp Oak shrub	APZ (old)	SFAZ(new)
1	17	18	13	13	22	20	46
2	33	20	7	10	22	18	25
3	46	20	13	17	33	14	1
4	52	17	7	0	38	8	25
5	35	16	8	7	26	12	21
6	33	18	7	12	31	20	52
7	31	18	7	8	30	13	29
8	33	18	9	22	16	7	12
9	29	17	8	9	13	8	23
10	38	16	23	7	26	5	25
11	39	23	13	12	13	1	36
12	40	20	17	13	30	17	10
13	46	25	13	10	40	9	0
14	52	25	10	8	21	7	23
15	31	22	9	1	20	18	38
16	25	9	16	5	23	13	30
17	34	14	4	3	36	26	22
18	33	20	8	7	36	33	7
19	39	18	7	5	29	20	10
20	35	18	13	3	23	0	13

Mean	36	19	10	9	26	13	22
SE	**1.91**	**0.81**	**1.04**	**1.21**	**1.79**	**1.83**	**3.10**
Rating	V.High	Mod	Mod	Low	High	Mod	High
Fuel Load (t/ha)	16	8	4	4	10	6	10

Appendix 3 - Radiation Impact Levels (Extract from AS 3959-2009)

Standards Australia (2011)

G3 RADIANT HEAT THRESHOLDS OF PAIN AND IGNITION

In a bushfire, radiant heat levels may be unsafe for humans and could also ignite combustible materials in the vicinity. Table G1 provides an indication of the potential effects of radiant heat levels on both humans and selected materials to assist the reader in understanding the implications of the different BALs.

TABLE G1
TYPICAL RADIANT HEAT INTENSITIES FOR VARIOUS PHENOMENA

Phenomena	kW/m^2
Pain to humans after 10 s to 20 s	4
Pain to humans after 3 s	10
Ignition of cotton fabric after a long time (piloted) (see Note 2)	13
Ignition of timber after a long time 13 (piloted) (see Note 2)	13
Ignition of cotton fabric after a long time (non-piloted) (see Note 3)	25
Ignition of timber after a long time (non-piloted) (see Note 3)	25
Ignition of gaberdine fabric after a long time (non-piloted) (see Note 3)	27
Ignition of black drill fabric after a long time (non-piloted) (see Note 3)	38
Ignition of cotton fabric after 5 s (non-piloted) (see Note 3)	42
Ignition of timber in 20 s (non-piloted) (see Note 3)	45
Ignition of timber in 10 s (non-piloted) (see Note 3)	55

NOTES:
1 Source AS 1530.4—2005.
2 Introduction of a small flame to initiate ignition.
3 Flame not introduced to initiate ignition.