DISASTER MANAGEMENT

VICTORIA
BUSHFIRE DISASTER MANAGEMENT USING GIS TECHNOLOGY

APPLICATIONS OF GIS (GEOM20013)

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ABSTRACT

This report was completed in order to identify which areas of the state are most at risk when confronted with a bushfire scenario. The accompanying maps in this report were constructed using the ArcGIS software, allowing for easy manipulation of the selected data to obtain the desired results. In using this, a final map was constructed by adding up the hazard values of all of the other maps, showing which areas of the state are the most prone.

INTRODUCTION

One of the most threatening natural disasters to Australians is bushfire. Bushfires can cause vast amounts of damage to the environment infrastructure, and human life, thereby making them a key concern to authorities. Although bushfires can affect all states of Australia, the state of Victoria is one of the most heavily hit states when it comes to this natural disaster.

To determine the risk of bushfires to all areas in the state of Victoria, several geographical, climatic and demographical aspects were considered. For each potential hazard, information was gathered from prior research and each hazard was given a weighting value; how important it is in calculating the total risk. Also each of the elements at risk, were divided into the four categories of population, environment, industry and infrastructure. Each was again given a weighting value to determine how necessary it is to protect them.

This report will collate these hazards and elements at risk with spatial data in order to depict a picture of which areas of the state of Victoria are most at risk.

HAZARDS & ELEMENTS AT RISK RESEARCH

Hazards Research

We define hazards as something that increases the possibility of a fire occurring and contribute to fire behavior. These hazards include tree density, aspect such as wind direction, slope (topography), previous fires, access to road, distance from fire brigades, and distance from electrical lines, and land use. These hazards are chosen in our report as our research shows that these factors are the main contributors to bushfires.

Tree Density

Tree density is the number of trees per unit area, usually per 1 hectare (Greatlakeswormwatch.org, 2017). The higher tree density the higher amount of fuel, thus a higher hazard rating. The main types of vegetation or fuel types in Kilmore East Area in Victoria are dry and wet sclerophyll forests, which consist of peppermint, eucalypt trees and stringybark, and some rainforests that include myrtle beech and southern sassfras tree species (Cruz 2012).

Aspect – Wind Direction

Wind direction influences fire spread. According to study done by Cruz et al. (2012), during the Black Saturday fire in Victoria, at the highest Forest Fire Danger Index (FFDI) times, the winds were coming from the North to Northwest, followed with a frontal transition with an abrupt change in direction from Northwest to Southwest that increased wind speed and gust (Cruz et al., 2012).

Another study done by Long (2006), which studied the climatology during extreme weather fire days (EWFD) in Victoria during 1970-1999 found that during EWFD the wind direction is dominantly in the Northwestern direction. The data was taken from measurements in weather stations in Victoria including Colac, Kilmore Gap. In Kilmore Gap, the winds came from West to Northwest and North to Northwest. On average on EWFD, the highest percentage of extreme fire danger ratings correspond to winds that came from Nortwest and North with West and Southwest following. Eastern winds have the lowest percentage on average (Long, 2006).

These studies correspond with the information by the Country Fire Authority (CFA) that dangerous winds in Victoria come from the Northwest and North followed by a wind change from Southwest (Country Fire Authority, 2017).

Slope

Generally, the speed of a fire will double for every 10° slope. Thus for 20°, the speed will increase fourfold. An increase in speed is proportional to increase intensity. Moreover, fire travels faster uphill and slows downhill (Country Fire Authority, 2017).

Previous Fires

In most weather conditions, research has found that the severity and likelihood of a fire occurring decreases the more recent the fire occurred in an area. Most interestingly, it has been found that at low FFDI, the more recent the higher the severity and at high FFDI, the less recent the higher the severity (Storey, Price, and Tasker, 2016).

Land Use

According to the Victorian State Government, there are three classifications for bushfire prone areas in the state: Hazard Level 2, Hazard Level 1 and Hazard Level Low (Victoria State Government, 2017). Hazard Level 2 areas include forests, woodlands and shrubs that are at high risk, and host potential for extreme radiant heat and extreme ember attacks. Hazard Level 1 areas include forests, woodlands, shrubs and grasslands that host the potential for grass fires and ember attacks. Hazard Level Low areas include residential land, managed grasslands, recreational areas and airports, and are at the lowest level of risk in the event of a bushfire.

Access to Roads

Road access is of importance in the event of a bushfire. It provides a way for occupants of a house to escape and enables fire trucks and other emergency vehicles to aid those affected. Without these roads, both human life and property are put in greater danger (CFA, 2014).

Distance from Fire Brigades

The likelihood of not receiving sufficient help in time increases as the distance from the nearest fire brigade increases. Thereby having a greater potential of loss of property or life.

Distance from Electrical Lines

Trees and other vegetation must be kept away from electrical lines or else they may catch fire and potentially starting a bushfire.

Elements at Risk

From our previous research in our literature review, we defined risk as the amalgamation of likelihood and consequence. The risk triangle developed by Crichton (1999), composed of hazards, exposure, and vulnerability, can be used to support our approach in analyzing bushfire risk. The elements at risk are the consideration of how much the vulnerabilities, such as population density and railway networks, are exposed to the hazard. We divided them into four groups, infrastructure, industry, environment, and population, and considered the vulnerabilities relevant for each element at risk.

METHODOLOGY (HAZARDS & ELEMENTS AT RISK)

Hazards

<table>
<tr><th>Hazard</th><th>Tree Density</th><th>Aspect (Wind Direction)</th><th>Slope</th><th>Previous Fires</th></tr>
<tr><td>Weighting Value</td><td>0.8</td><td>0.75</td><td>0.8</td><td>0.8</td></tr>
<tr><td>Data</td><td>State Tree Density</td><td>DEM</td><td>DEM</td><td>Last Burn Fire History</td></tr>
<tr><td>Source</td><td>Land Channel
http://services.land.vic.gov.au/landchannel/</td><td>Geoscience Australia
http://nedf.ga.gov.au/geoportal/catalog/main/home.page</td><td>Geoscience Australia
http://nedf.ga.gov.au/geoportal/catalog/main/home.page</td><td>Land Channel
http://services.land.vic.gov.au/landchannel/</td></tr>
<tr><td>Method</td><td>The tree densities were divided into 3 types: dense, medium and scattered. We created a new field and assigned a risk level of 100 for the dense type, 70 for the medium type and 40 for the scattered type. We entered 0 as the risk level for the areas in Victoria which weren't included in the tree density file to avoid data being deleted in the raster calculations. The 4 risk levels were merged using the merge tool and converted to a raster of Hazard values using the Polygon to Raster tool.</td><td>The aspect tool was used on the DEM raster to obtain the aspect. The aspect was then reclassified into hazard values with the aid of research.
<table>
<tr><td>N</td><td>90</td></tr>
<tr><td>NW</td><td>100</td></tr>
<tr><td>W</td><td>80</td></tr>
<tr><td>SW</td><td>80</td></tr>
<tr><td>S</td><td>50</td></tr>
<tr><td>SE</td><td>20</td></tr>
<tr><td>E</td><td>10</td></tr>
<tr><td>NE</td><td>20</td></tr>
</table></td><td>The slope tool was used on the DEM raster to calculate the slope as a percentage value. We used the reclassify tool on the slope percentage to change then to hazard values according to our research results.
<table>
<tr><th>Slope %</th><th>Hazard Value</th></tr>
<tr><td>0 - 10</td><td>20</td></tr>
<tr><td>10 – 15</td><td>40</td></tr>
<tr><td>15 – 25</td><td>60</td></tr>
<tr><td>25 – 35</td><td>80</td></tr>
<tr><td>35 +</td><td>100</td></tr>
</table></td><td>To visualize previous fires which happened only in Victoria use the ‘Clip’ tool from ‘Analysis’. The given hazard values should be assigned to the respective ranges(years) using ‘select by attribute’. Then, using the ‘polygon to raster tool’ a raster was created with the hazard values. Using the ‘erase’ tool from ‘Analysis’ a base layer of hazard value: 1 should be created for areas which hadn’t experienced a fire. Finally, these two layers should be linked using the ‘merge’ tool to create a hazard map and different colours should be set for each hazard value.
<table>
<tr><th>Years</th><th>Hazard Value</th></tr>
<tr><td>1903-1953</td><td>100</td></tr>
<tr><td>1953-1973</td><td>80</td></tr>
<tr><td>1973-1993</td><td>50</td></tr>
<tr><td>1993-2013</td><td>10</td></tr>
</table></td></tr>
</table>

Hazard	Access to Road	Distance from Fire Brigades	Distance from Electrical Lines	Land Use
Weighting Value	0.8	0.7	0.6	0.6
Data	State Road Network	Fire Brigade locations	State Power Line Network	Land Use Layer
Source	Open Street Map	CFA	Open Street Map	Land use layer.
Method	To visualize the road network only in Victoria, use the 'Clip' tool from 'Analysis'. Find the straight-line distance from roads using the 'Euclidean Distance' tool from 'Spatial Analyst'. To visualise the distances, from roads, only for Victoria use the 'Clip' tool from 'Data Management' to manipulate the raster. Then using the 'reclassify' tool from 'Spatial Analyst', classify the ranges using natural breaks and give them reasonable hazard values. Finally, set different colours for each hazard value.	The Fire Brigade datasets consist of a point that signifies the location of Fire Brigade in Victoria. Firstly, 'Euclidean Distance Tool' was used to calculate certain distance from the point. Afterwards, 'Reclassify' tool was used to make a classification upon distance from the point using Natural Breaks and give a reasonable hazard values. Finally the colour for different hazard value was set to give clear visualisation.	The provided data in OSM covers all Australia. Therefore, 'Clip' Tool was used to cut down the data into Victoria's LGA. And 'Feature Vertices to Points' Tool to convert the line into points. Afterwards, to attach the hazard value from the raster hazard map, 'Extract Values to Points' tool was used, resulting into a classified point incorporated with its weighted hazard value. Lastly, set colour for each distinct hazard value.	To visualize the types of land use in Victoria use the 'Clip' tool from 'Analysis'. Using 'select by attributes' select the required types of land use mentioned below and export the data onto a new layer. The given hazard values should be assigned to the respective types of land use by adding a new field and entering the values using 'select by attributes'. Then, using the 'polygon to raster' tool a raster must be created with the hazard values. Using the 'erase' tool from 'Analysis' a base layer of hazard value: 1 should be created for land areas which weren't mentioned in the types of land use given below. Finally, these two layers were linked using the 'merge' tool to create a hazard map and different colours were set for each hazard value.

Land Use	Hazard Value
Allotments	20
Residential	45
Industrial	50
Meadow	65
Farm	75
Forest	100

Elements at Risk

Elements at risk	**Population** *Weighting Value = 1.0*	
Vulnerability Weighting Value	0.6	0.4
Vulnerability	Population Density	Population Age
Data	LGA Population and People Data - 2015	LGA Population and People Data - 2015
Source	Australian Bureau of Statistics (ABS) http://www.abs.gov.au/	Australian Bureau of Statistics (ABS) http://www.abs.gov.au/
Method	The initial dataset contained data for years 2011-2015, therefore using 'select by attributes' select data only for 2015 and export it to a new layer. Using the 'Add Join' tool link the data to the Victorian LGAs. Add a new field to the layer and calculate population density by dividing the total population by the Area in square km for each LGA using the 'field calculator'. Then, using the 'polygon to raster' tool a raster must be created for the population densities for each LGA. Using the 'Raster Calculator' tool multiply the hazard value for each point, using the final hazard map, with the raster containing the population densities. Finally, using the 'Reclassify' tool, classify the hazard values from 1-100 for natural breaks and a different colour for each hazard value.	The initial dataset contained data for years 2011-2015, therefore using 'select by attributes' select data only for 2015 and export it to a new layer. Using the 'Add Join' tool link the data to the Victorian LGAs. Add new fields to the layer to calculate the number of people divided by total population for each LGA for each of the age ranges mentioned below. Then, multiply the values for the age ranges by the corresponding Vulnerability Values and add them. Then, using the 'polygon to raster' tool a raster must be created for the newly calculated field. Using the 'Raster Calculator' multiply the hazard value for each point, using the final hazard map, with the raster containing the vulnerabilities. Finally, using the 'Reclassify' tool, classify the hazard values from 1-100 for equal breaks and a different colour for each hazard value.
	After both Population Density and Age Distribution maps are created, they must be merged using the 'Raster Calculator' tool, taking into account the Vulnerability Value for each raster. The following formula should be used: "(0.6 * 'Population Density') + (0.4 * 'Population Age Distribution')". Then, this final raster should be given hazard values (10-100) with natural breaks for better visualisation using the 'Reclassify' tool, and different colours should be set to represent these hazard values.	

Age Range	Vulnerability Value
(0-9) + (70+)	100
(10-19) + (55-69)	60
(20-54)	10

Element at Risk	**Industry** *Weighting Value = 0.80*			
Vulnerability Weighting Value	0.9	0.5	0.8	0.7
Vulnerability	Hospitals	Commercial Forestry	Agricultural Production	Fire Management Infrastructure
Data	Victorian Hospital Locations	Vic Land Use 100	Vic Land Use 100	Fire Instalments + Fire Brigade Locations
Source	Land Channel http://services.land.vic.gov.au/SpatialDatamart/	Land Channel http://services.land.vic.gov.au/SpatialDatamart/	Land Channel http://services.land.vic.gov.au/SpatialDatamart/	Land Channel http://services.land.vic.gov.au/SpatialDatamart/ CFA www.cfa.vic.gov.au/about/locations/brigade_locations.kml
Method	We used Extract Values to Points Tool to obtain a new field containing the risk values of the underlying hazard a raster for each point.	All the areas used for commercial forestry was selected using select by attribute. The hazard values for the commercial forestry polygons were obtained using Extract by Mask tool.	All the areas used for agriculture was selected using select by attribute. The hazard values for the agriculture polygons were obtained using Extract by Mask tool.	Merged Fire Instalment points and Fire Brigade Locations points to obtain a dataset contain all the required points. We used Extract Values to Points Tool to obtain the underlying Hazard value for each point. Infrastructure Included: - Water points - Radio Towers - Fire Watch Towers - Work Centres - Airfields - Helipads - Fire Stations - Base Camps - Water Points
	To create the map for Industry as a whole, we used raster calculator. However, since all 4 elements had areas with no data, we were not able to use raster calculator straight away to combine them. We converted all 4 elements into raster using point to raster tool or polygon to raster tool as necessary. To add a layer of zero values for the areas without any data we used the following expression in raster calculator “con(isNull(“RASTER_NAME”),0,”RASTER_NAME”)” for the 4 raster. Afterwards we clipped the 4 resulting raster to fit Victoria. Finally, we used raster calculator on the clipped 4 raster to create a combined raster for Industry. The following expression was used: = 0.9 * “Hospitals” + 0.5 * “Commercial Forestry” + 0.8 * “Agricultural Production” + 0.7 * “Fire Management Infrastructure”			

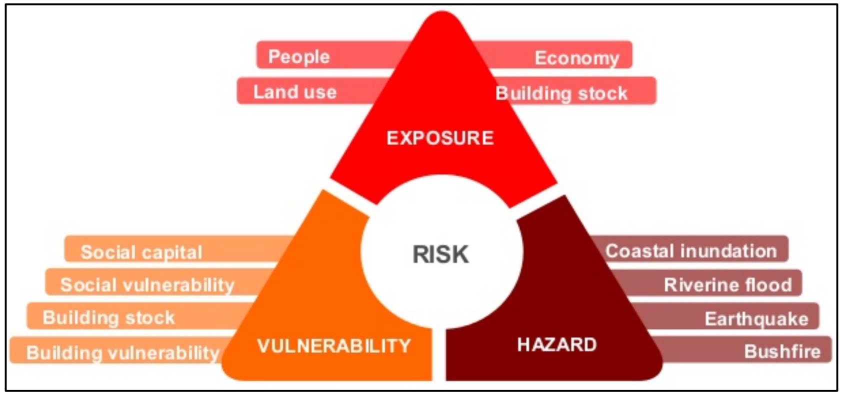
Elements at risk	**Environmental** *Weighting Value = 0.40*
Vulnerability Weighting Value	0.4
Vulnerability	Environmental Conservation
Data	Vic Land Use 100
Source	Land Channel http://services.land.vic.gov.au/SpatialDatamart/
Method	Use ‘select by attribute’ in the attribute table of the land use shape file, select rows with the descriptions in the list below. Afterwards, export the data, resulting a new layer contains the area in relation to the environment. Use Extract by mask tool to obtain the hazard values for the environmental area. Environmental Conservation Areas Included: - Conservation and Natural Environments - Nature Conservation - Strict Nature Reserves - National Park - Natural Feature Protection - Habitat/ Species - Management Area - Protected Landscape - Other Conserved Area - Managed Resource Protection
	Did not need to combine since we only have one map. However, to aid us in combing the elements at risk, we created a base layer with 0 as the risk value for the areas with no data in the environmental layer. The following expression was used in the raster calculator to obtain the base layer: “con(isNull(“RASTER_NAME”),0,”RASTER_NAME”)”. The resulting raster was clipped to the shape of Victoria to obtain a raster ready for combination with the other elements at risk.

Element at Risk	**Infrastructure** *Weighting Value = 0.60*			
Vulnerability Weighting Value	0.85	0.30	0.40	0.60
Vulnerability	Over Ground Power Line Network	Railway Network	Railway Stations	Property
Data	State Power Line Network	State Railway Infrastructure	State Railway Infrastructure	Vicmap - Address Points
Source	Open Street Map http://www.openstreetmap.org/	Open Street Map http://www.openstreetmap.org/	Open Street Map http://www.openstreetmap.org/	Land Channel http://services.land.vic.gov.au/SpatialDatamart/
Method	The provided data in OSM covers all Australia. Therefore, 'Clip' Tool was used to cut down the data into Victoria's LGA. And 'Feature Vertices to Points' Tool to convert the line into points. Afterwards, to attach the hazard value from the raster hazard map, 'Extract Values to Points' tool was used, resulting into a classified point incorporated with its weighted hazard value. Lastly, set colour for each distinct hazard value.	Since the provided datasets already focuses on Victoria LGA. Therefore, it can be directly used. The method was using 'Extract Values to Points' tool to attach the hazard value from the raster hazard map, resulting into a classified point incorporated with its weighted hazard value. Lastly, set colour for each distinct hazard value.	The provided data in OSM covers all Australia. Therefore, 'Clip' Tool was used to cut down the data into Victoria's LGA. And 'Feature Vertices to Points' Tool to convert the line into points. Afterwards, to attach the hazard value from the raster hazard map, 'Extract Values to Points' tool was used, resulting into a classified point incorporated with its weighted hazard value. Lastly, set colour for each distinct hazard value.	Since the provided datasets already focuses on Victoria LGA. Therefore, it can be directly used. The method was using 'Extract Values to Points' tool to attach the hazard value from the raster hazard map, resulting into a classified point incorporated with its weighted hazard value. Lastly, set colour for each distinct hazard value.
	All the layers are converted to raster using the 'Point to Raster' tool from 'Conversion'. Using the 'Raster Calculator' tool create a new raster with the null areas in the layer with a hazard value of 0. Using the 'Clip' tool from 'Data Management' these new rasters should be clipped to fit shape of Victoria. Then the clipped raster must be merged using 'Raster Calculator', considering the Vulnerability Value for each raster. The following formula should be used: "(0.85 * 'Powerline Network') + (0.3 * 'Railway Network') + (0.4 * 'Railway Stations') + (0.6 * 'Property')". This raster should then be classified (using natural breaks for better visualisation) using the 'Reclassify' tool giving the raster hazard values from 0-100. The datasets containing information on all four layers should be combined using the 'Merge' tool to give the points used in the maps. Then, using the 'Extract Values to Point' tool obtain a new field containing the risk values for each point in the previous merge layer. Finally, different colours should be set for the hazard values.			

Methodology on Creating the Final Risk Map

Formula:

Risk Value = Hazard x Vulnerability x Elements at Risk (Exposure)



(Image Reference: Global Risk Forum GRF Davos, 2016)

Risk Triangle Models

This is a fundamental model to justify the risk value. This model provides an illustration on how risk value should be calculated, giving emphasize on the combination of Vulnerability, Elements at Risk (Exposure), and Hazard. This model gives rise to formula used to calculate the Risk value (*as shown above*)

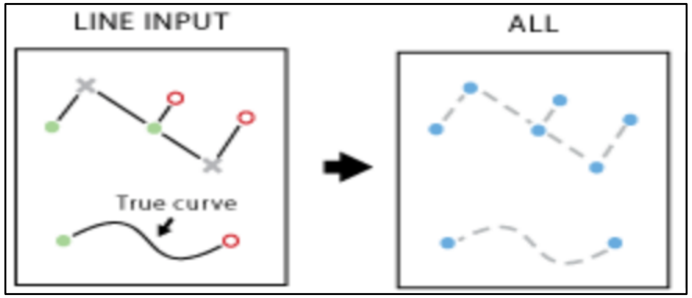
Justification:

Since all the polygons of the elements at risk were converted to raster and added with a base layer of 0 hazard value, 'Raster Calculator' tool was used to execute the following expression.

= (0.6 x Infrastructure) + (0.8 x Industry) + (1.0 x Population) + (0.4 x Environmental)

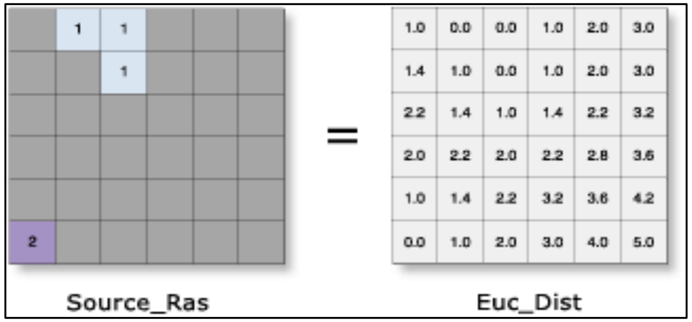
The result of the calculation provides a raster, which was reclassified to obtain the final risk map. To show the risk values at all the points, 'Merge' tool was used to merge all the points from all the elements at risk and used 'Extract Values to Point' tool to attach the risk value to a certain point in the maps.

Quick Overview on Important & Fundamental Tools Used:



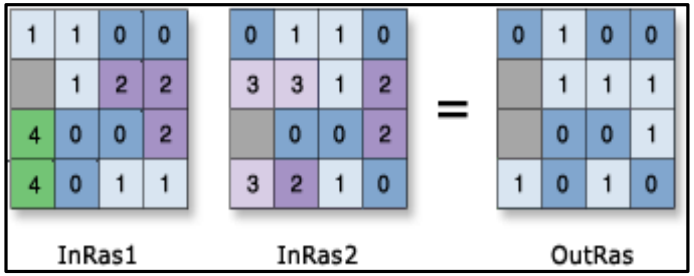
__Feature Vertices to Points Tool__

Given a dataset with line feature, this tool is very useful to convert the line into points in the maps, which makes it eligible to perform further analysis such as justifying the hazard value, by using 'Euclidean Distance' Tool since it only takes point features as input (Example of dataset with line feature: Railway Networks and Electrical Networks).



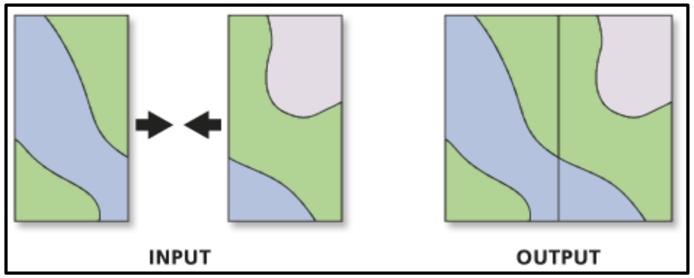
__Euclidean Distance Tool__

Used to calculate the distance to certain point. It assigns particular raster cell with certain value (the distance to the point, and choose the shortest distance available). This tool is very useful as a fundamental step for justifying the hazard value if the provided datasets is a point.



__Raster Calculator Tool__

The tool enables performance of calculation for certain inputs of raster cells, and this tools is important to give the final raster value as a result of the calculation which is the final risk map. (in this case, this tool was used to calculate the combination of weighting from hazard, vulnerability, and elements at risks raster)



__Merge Tool__

The tool was used to merge all of the point from all of the elements at risks, since some of the elements were represented in points (such as Hospitals, etc.)

RESULTS (*MAPS*)

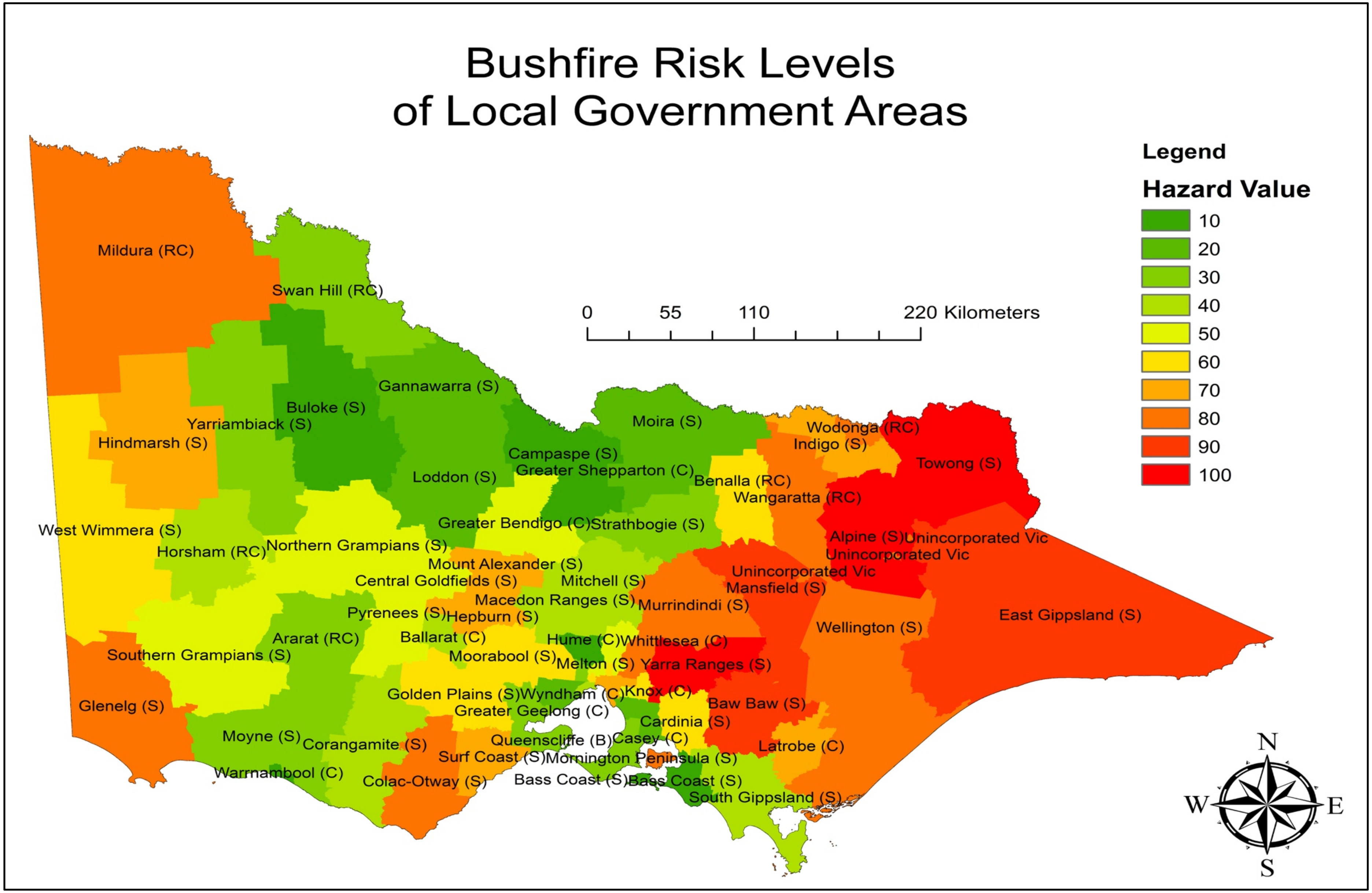


Figure 1
Victoria Hazard Map by LGA – Showing Victoria's Local Government Areas along with its Hazard Weighting

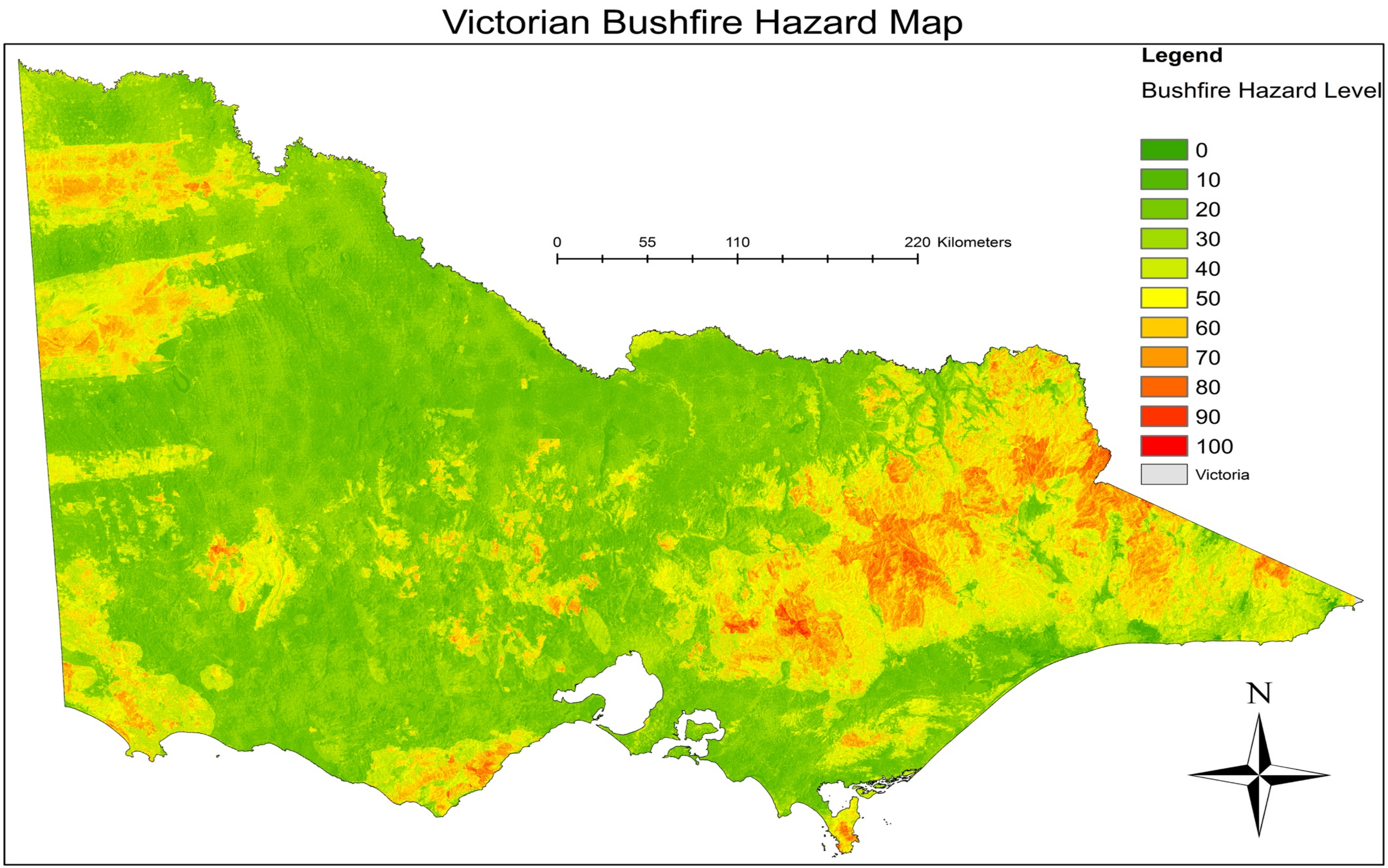


Figure 2
Victoria Hazard Map – Showing Hazard Weighting for All Regions in Victoria

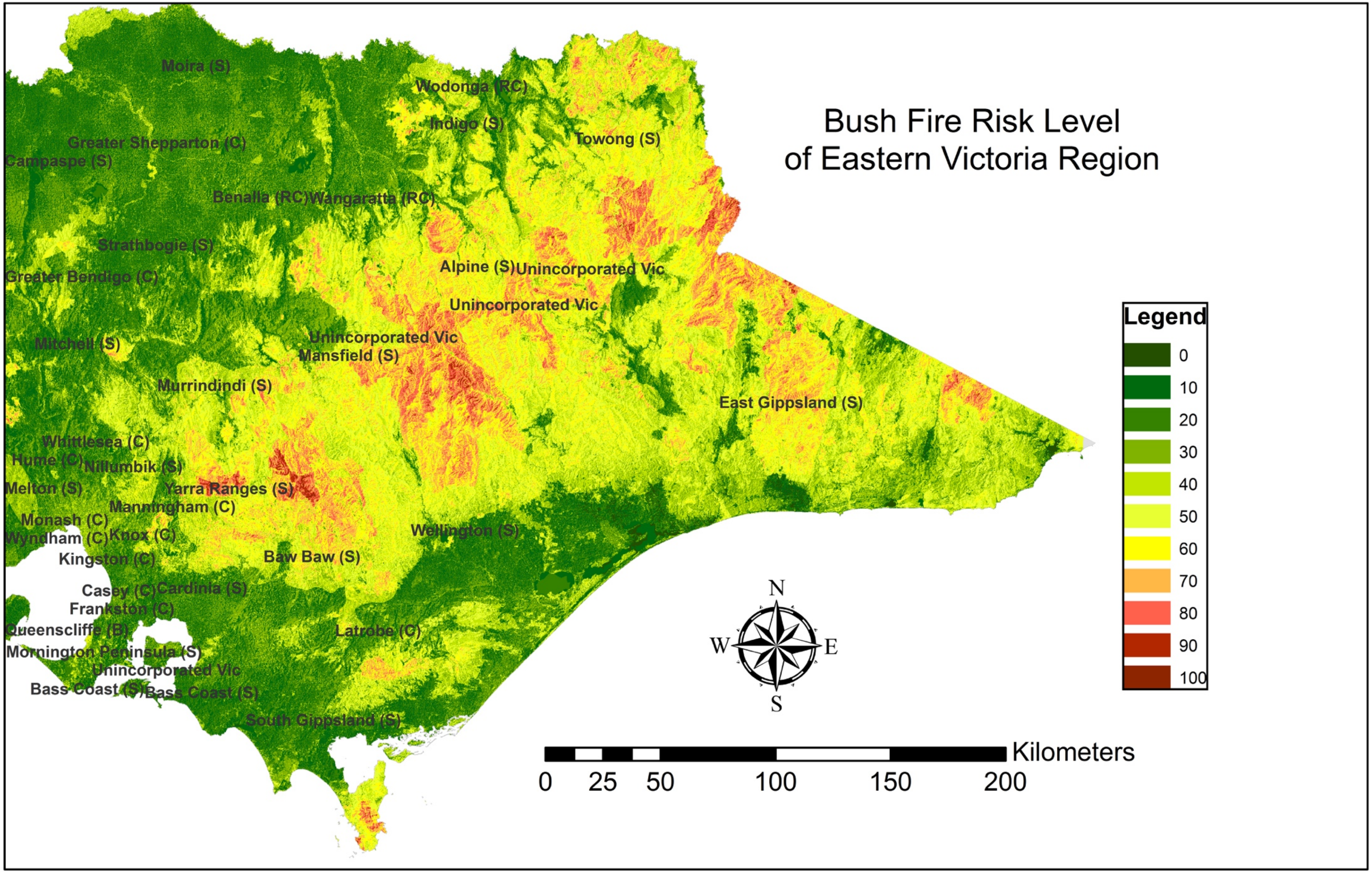


Figure 3
Eastern Victoria Hazard Map – Focuses on the Hazard Weighting on Eastern Region of Victoria

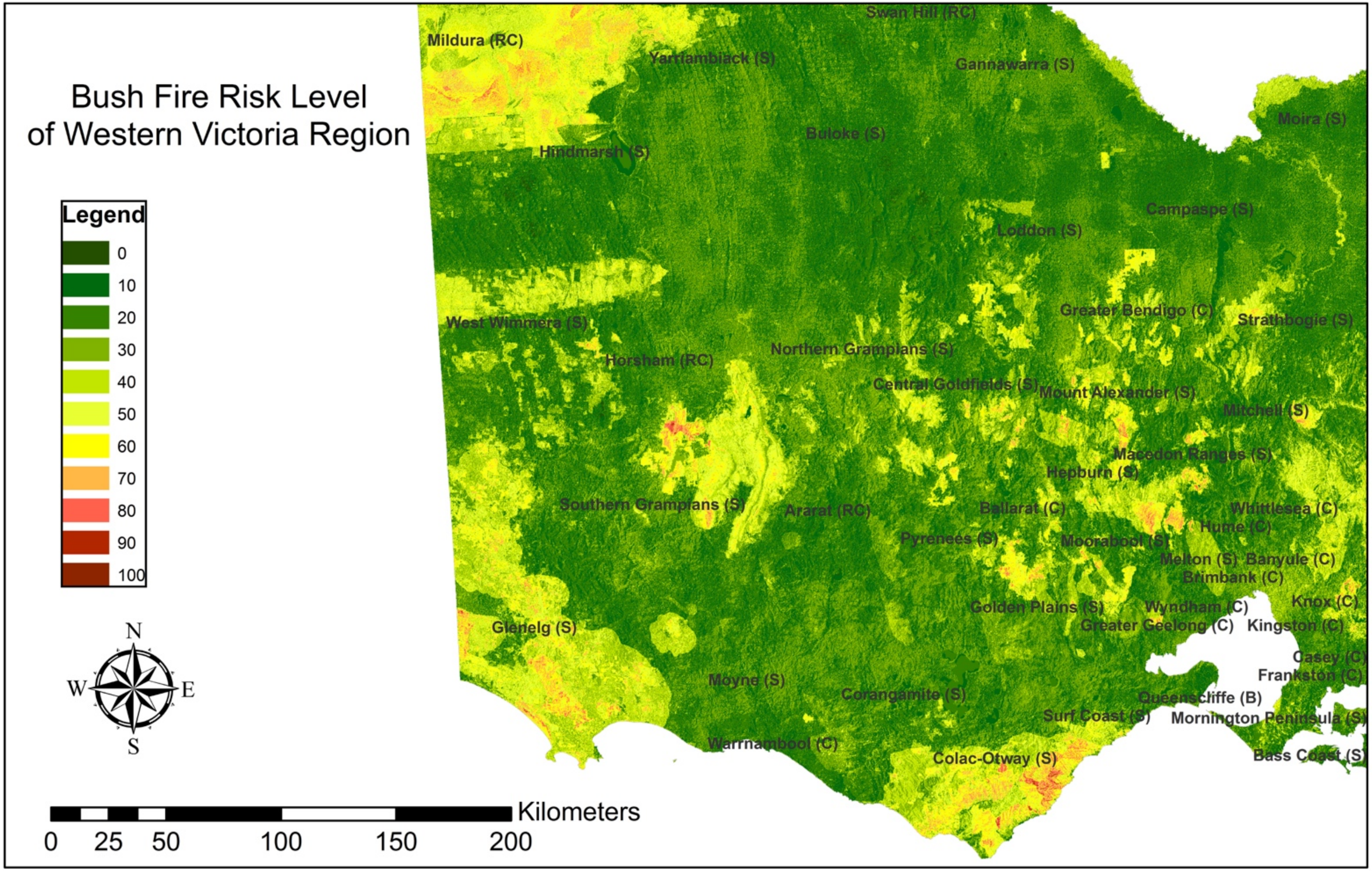


Figure 4
Western Victoria Hazard Map – Focuses on the Hazard Weighting on Western Region of Victoria

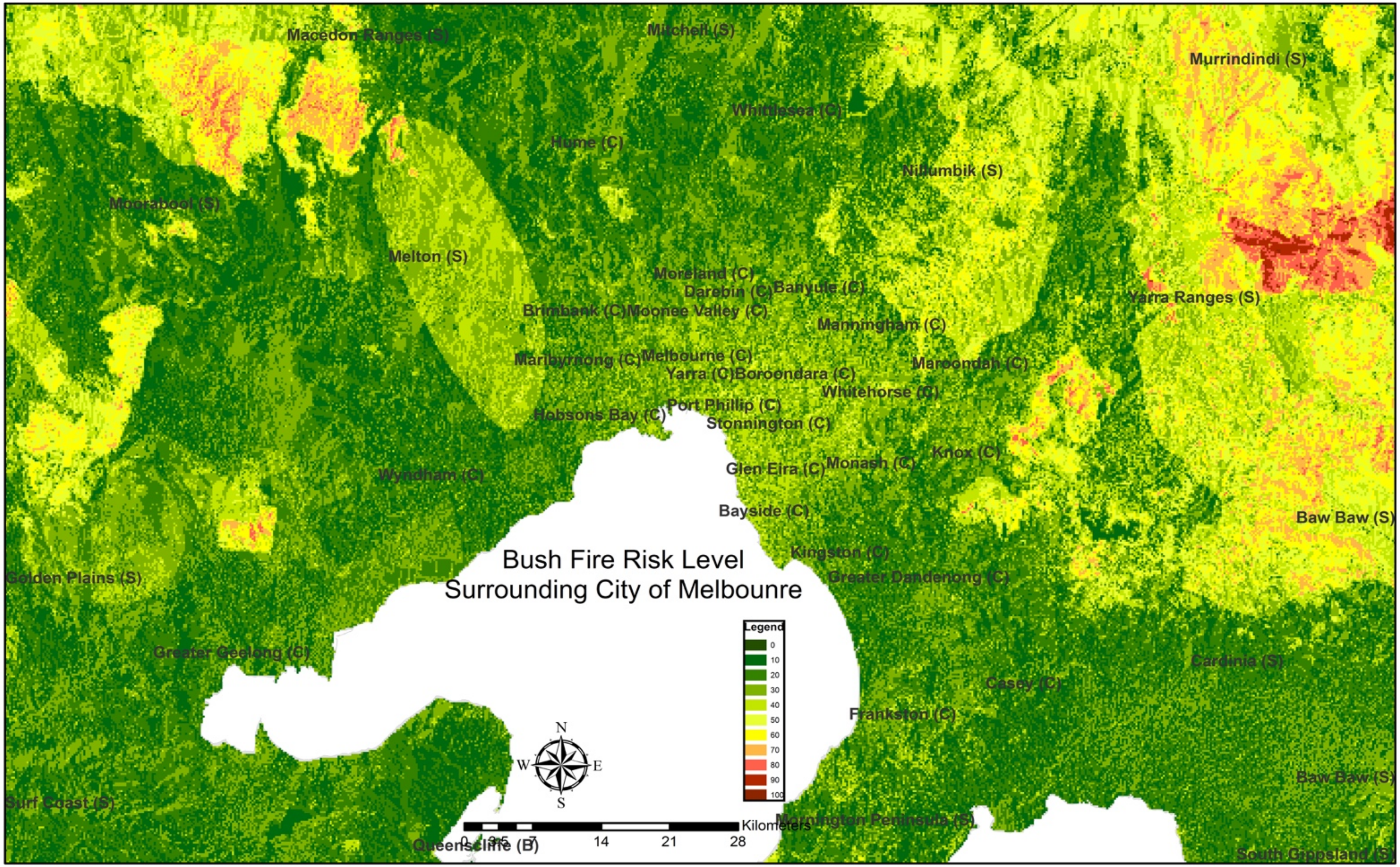


Figure 5

Melbourne Hazard Map – Focuses on the Hazard Weighting on Area Surrounding Melbourne

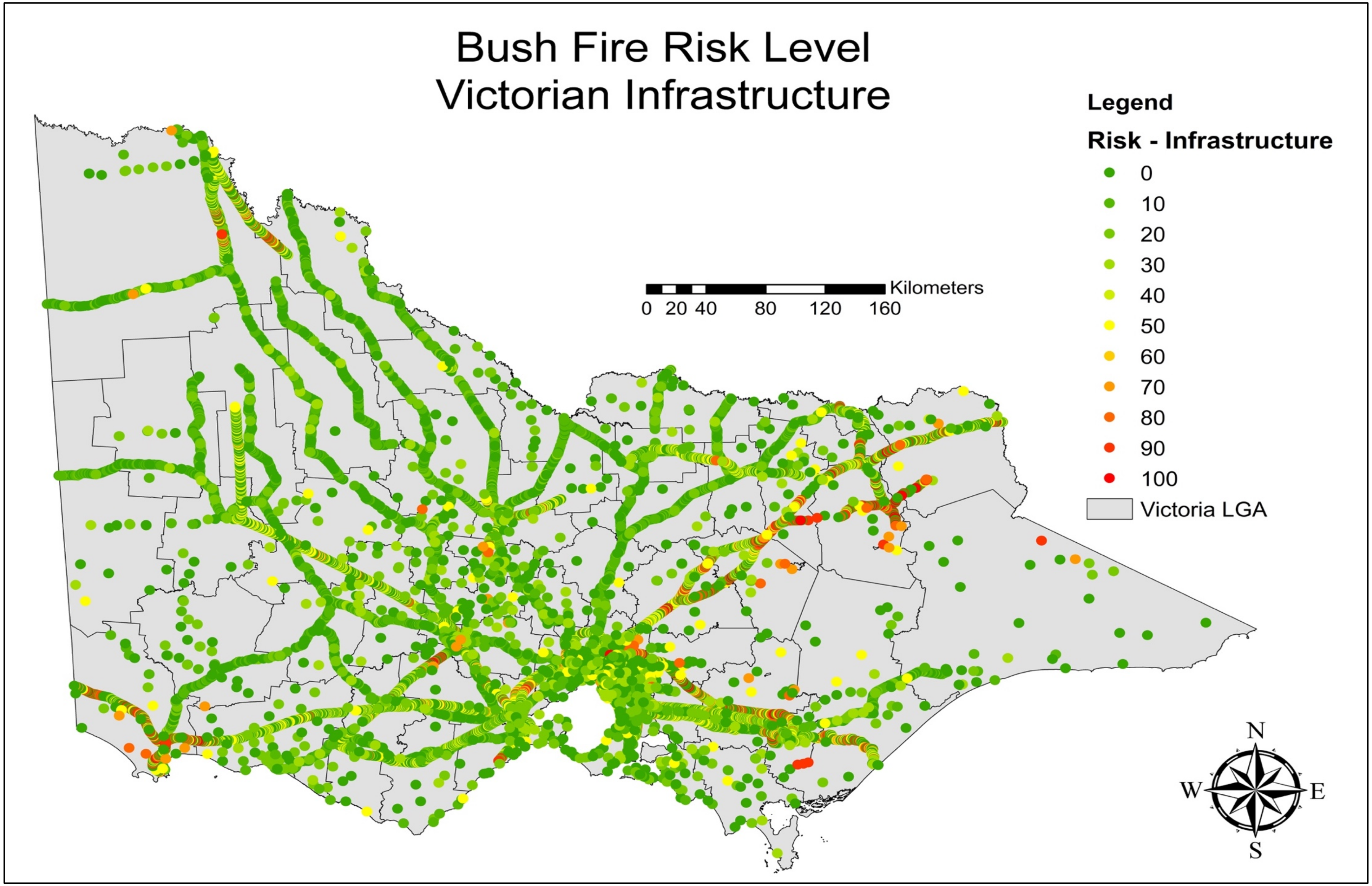


Figure 6
Victoria's Infrastructure Hazard Map – Showing Hazard Weighting for All Considered Infrastructures
(*Comprises: Railway Station, Railway Network, Electrical Network, and Places*)

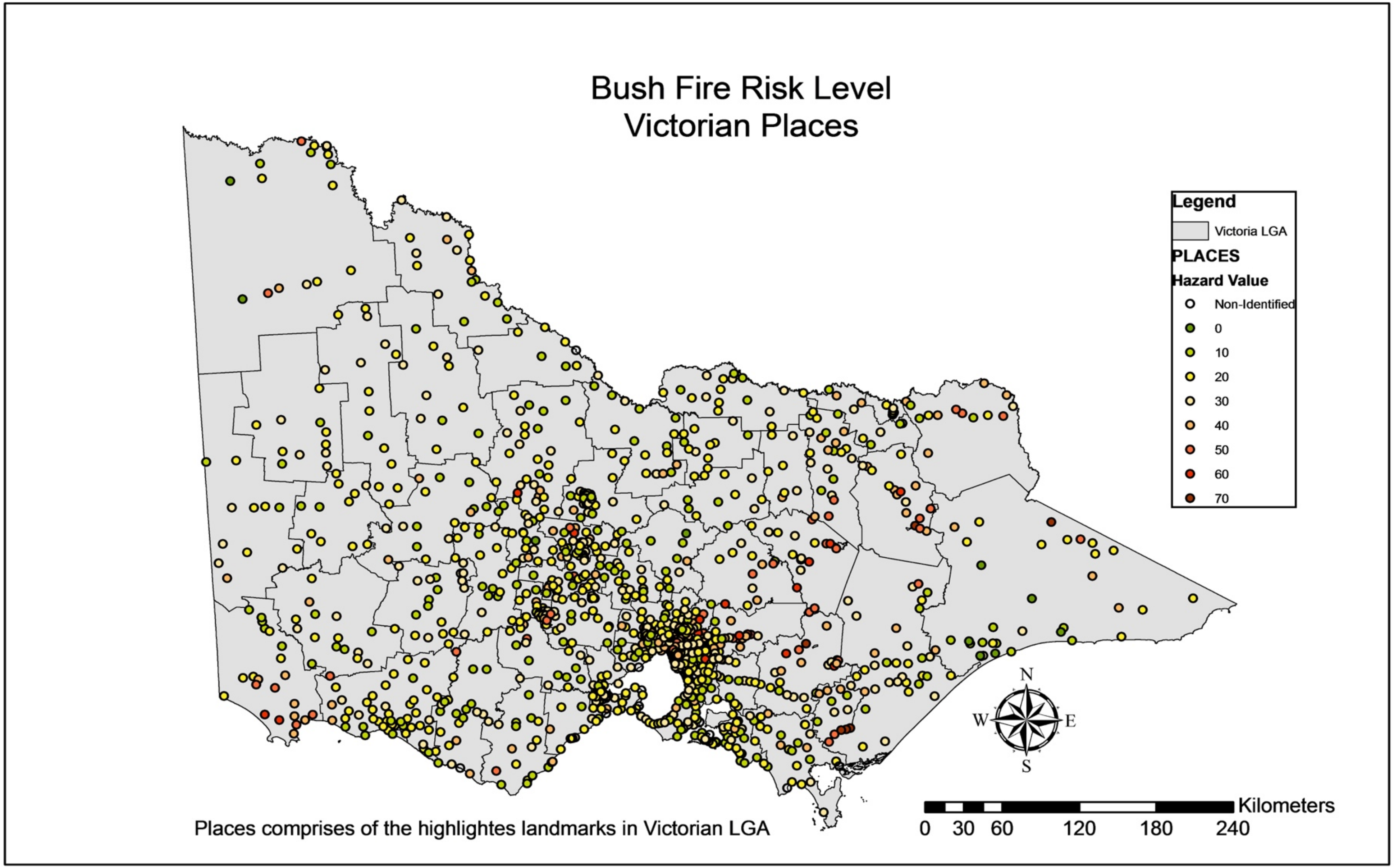


Figure 7

Places Hazard Map – Showing Hazard Weighting for all Victoria's Highlighted Places

(*Comprises: Victoria's Landmark such as Monument, Government's Workplace , and Other Important Places.*)

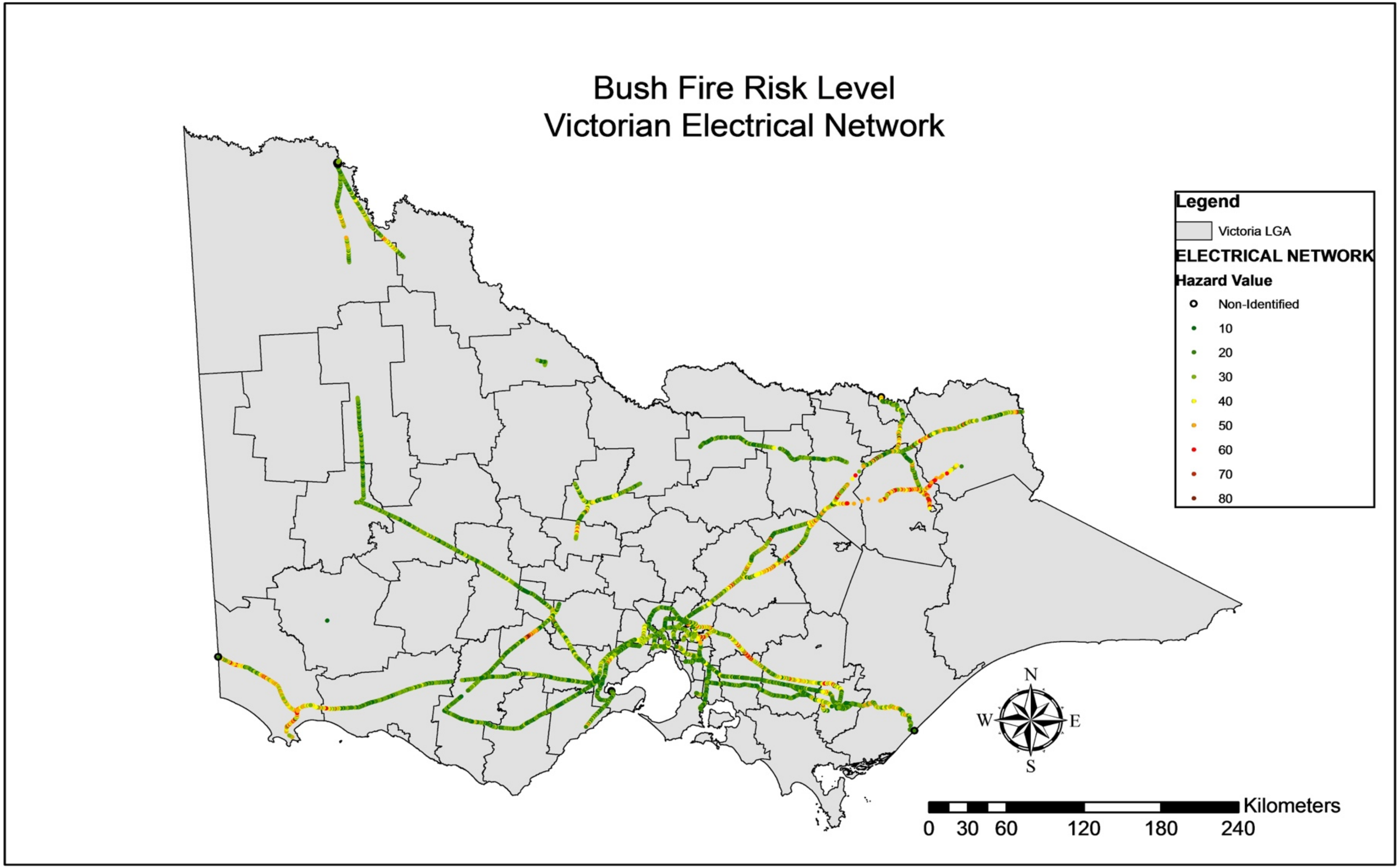


Figure 8
Electrical Network Hazard Map – Showing the Electrical Network across Victoria along with its Hazard Weighting

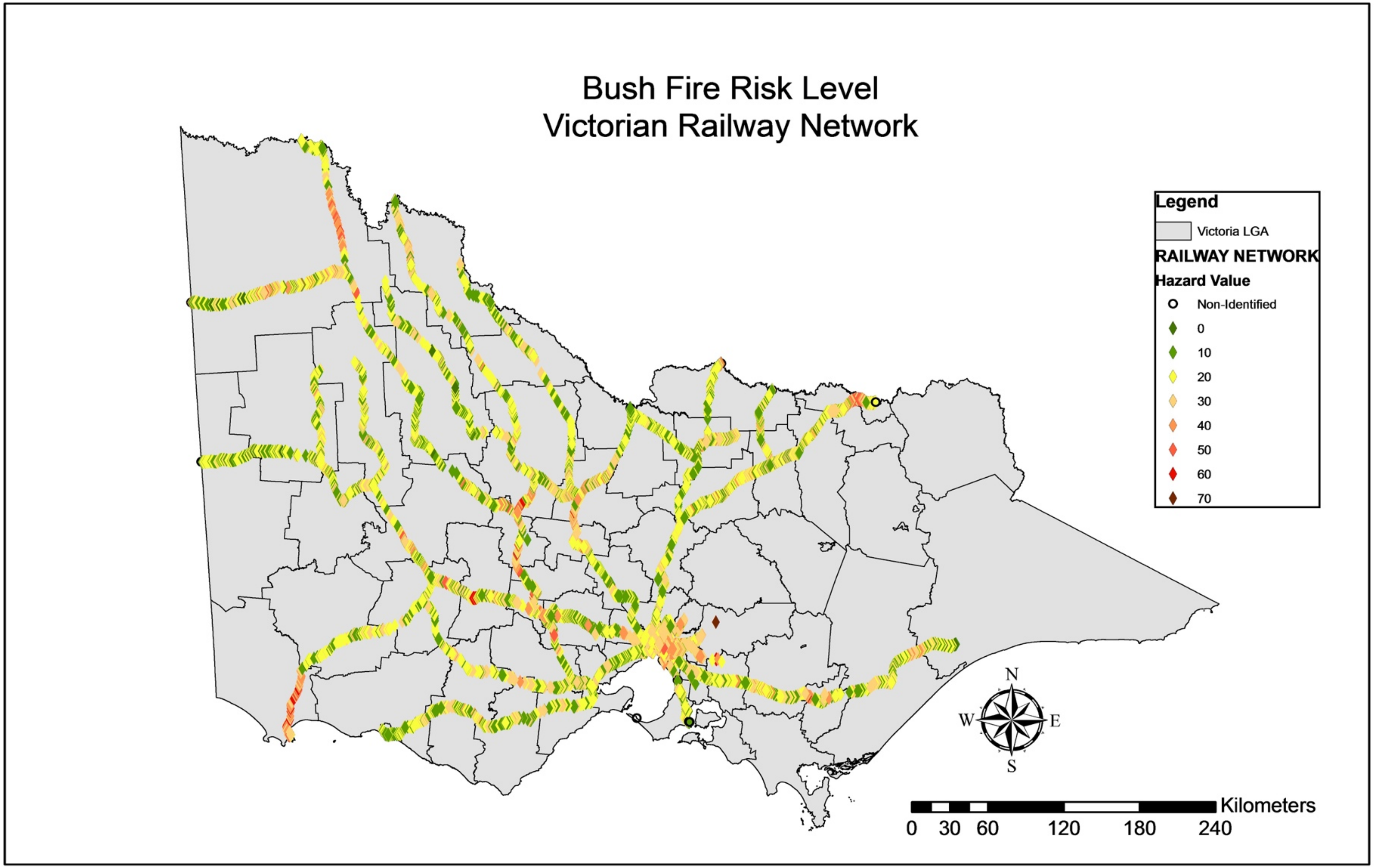


Figure 9
Railway Network Hazard Map – Showing the Railway Network across Victoria along with its Hazard Weighting

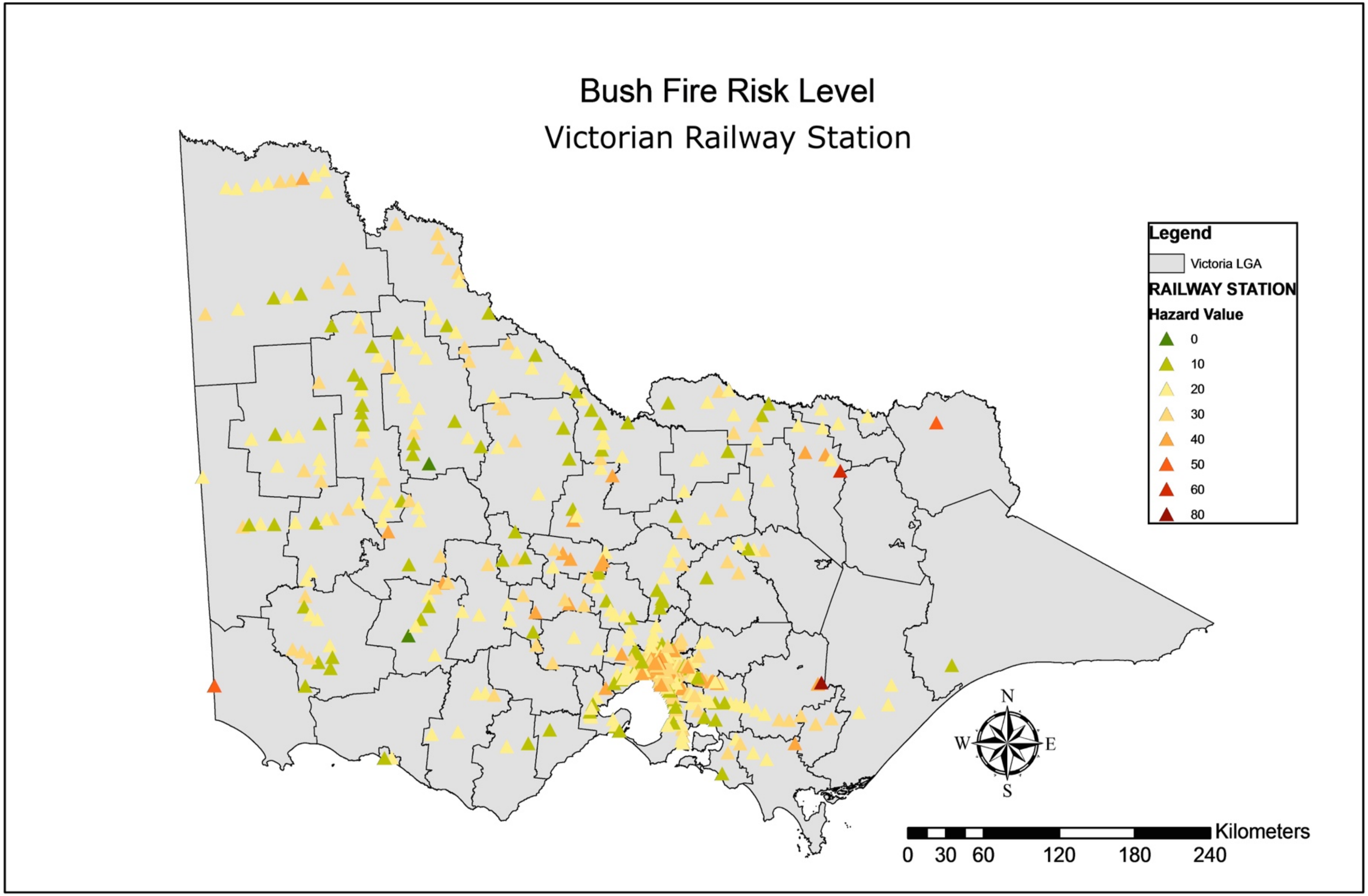


Figure 10
Railway Station Hazard Map – Showing All of the Railway Station in Victoria along with its Hazard Weighting

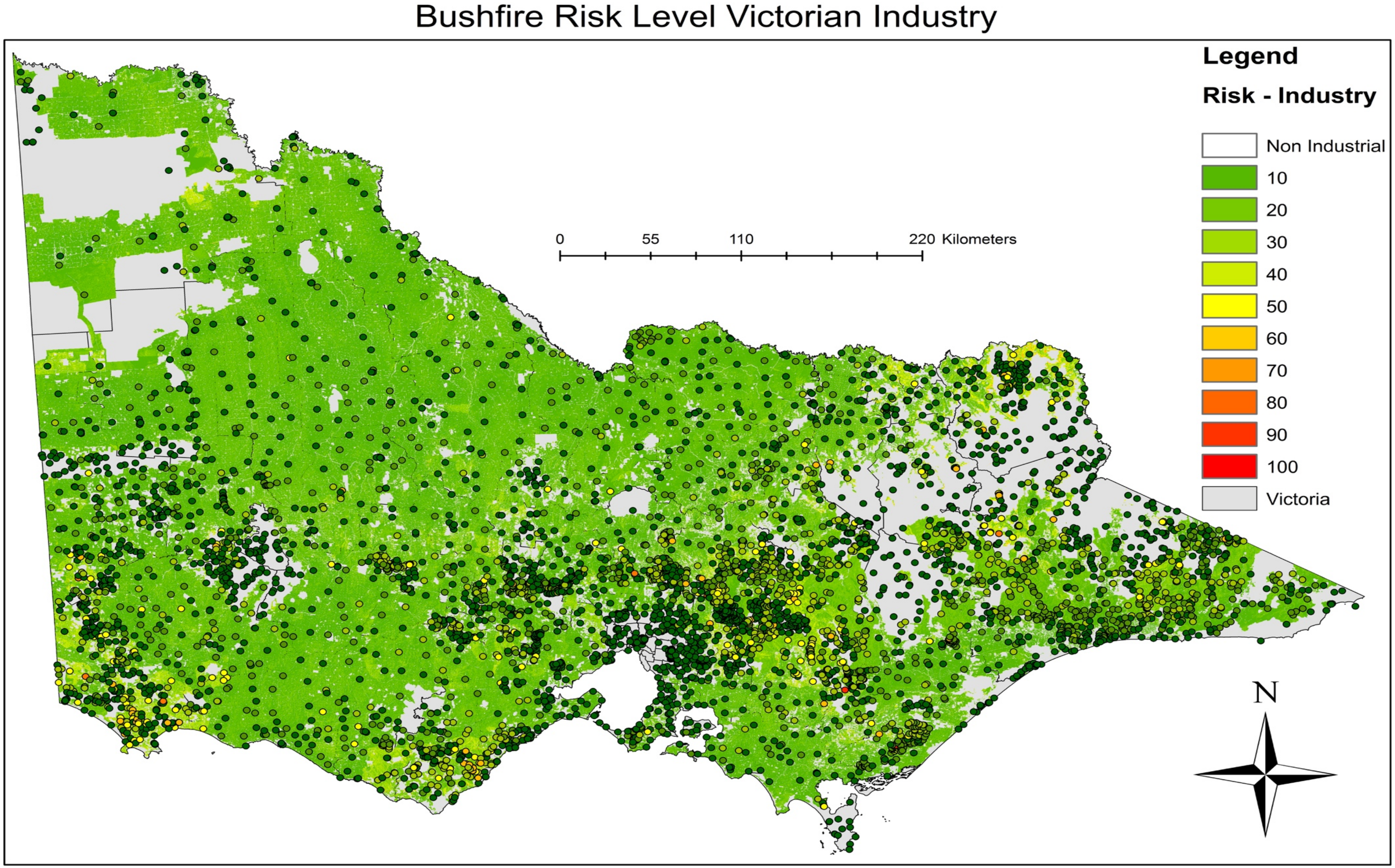


Figure 11
Victoria's Industry Hazard Map – Showing Hazard Weighting for All Considered Industry in Victoria
(*Comprises: Agriculture, Commercial Forestry, Hospital, and Fire Management Infrastructure*)

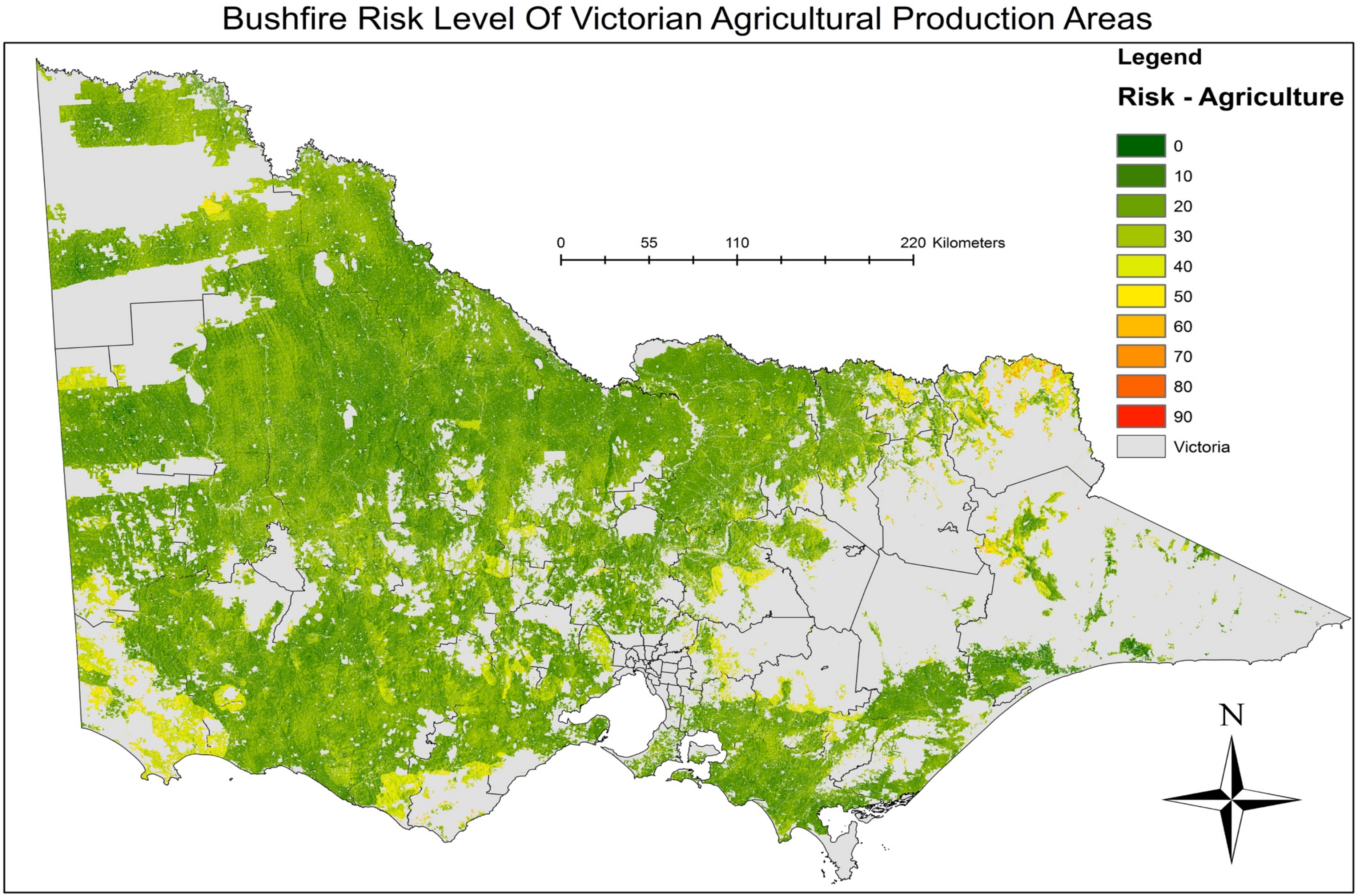


Figure 12
Agriculture Hazard Map – Showing the Agricultural Production Areas in Victoria along with its Hazard Weighting

Bushfire Risk Level Of Victorian Commercial Forestry Areas

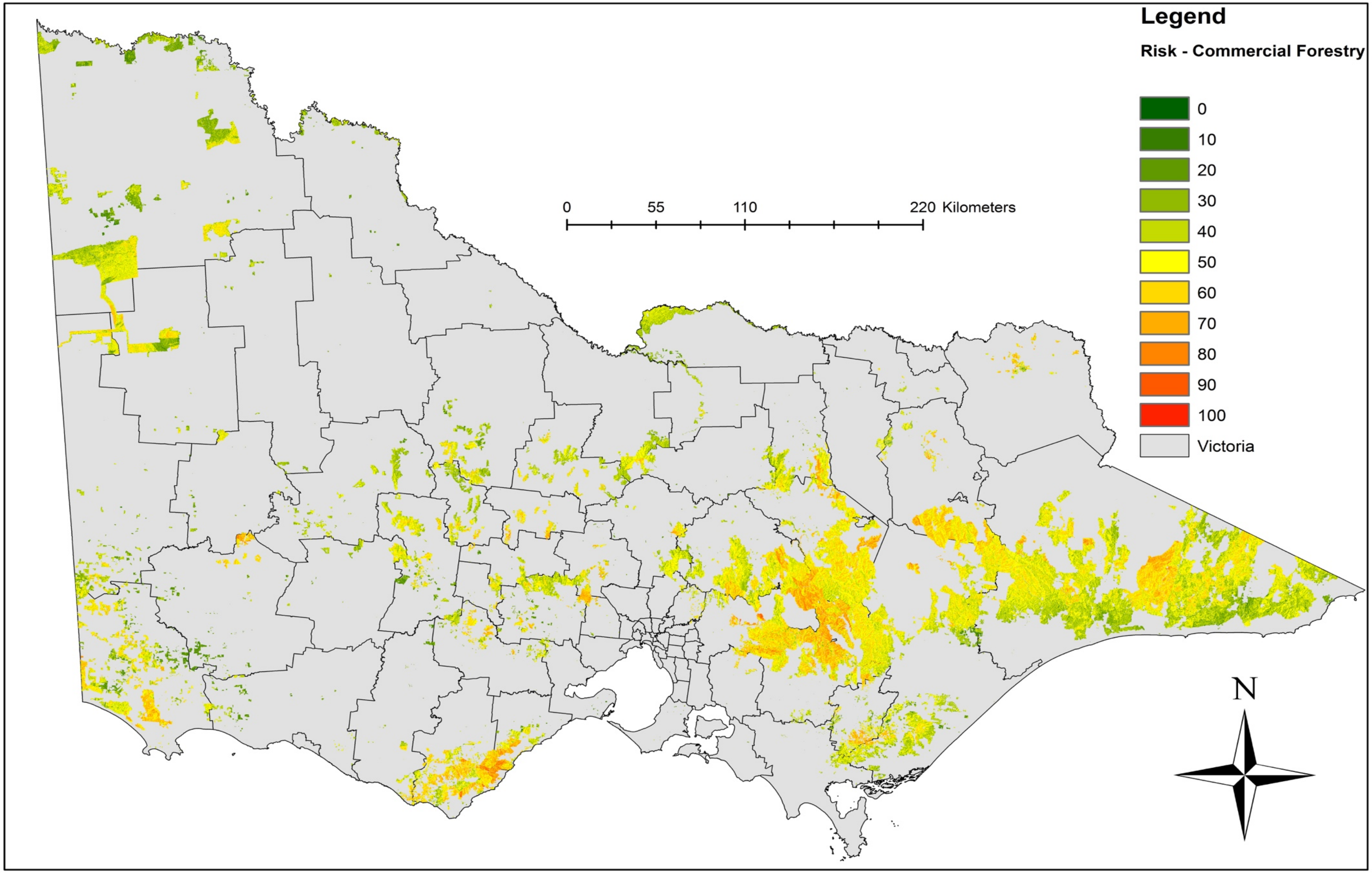


Figure 13
Commercial Forestry Hazard Map – Showing Victoria's Commercial Forestry Areas along with its Hazard Weighting

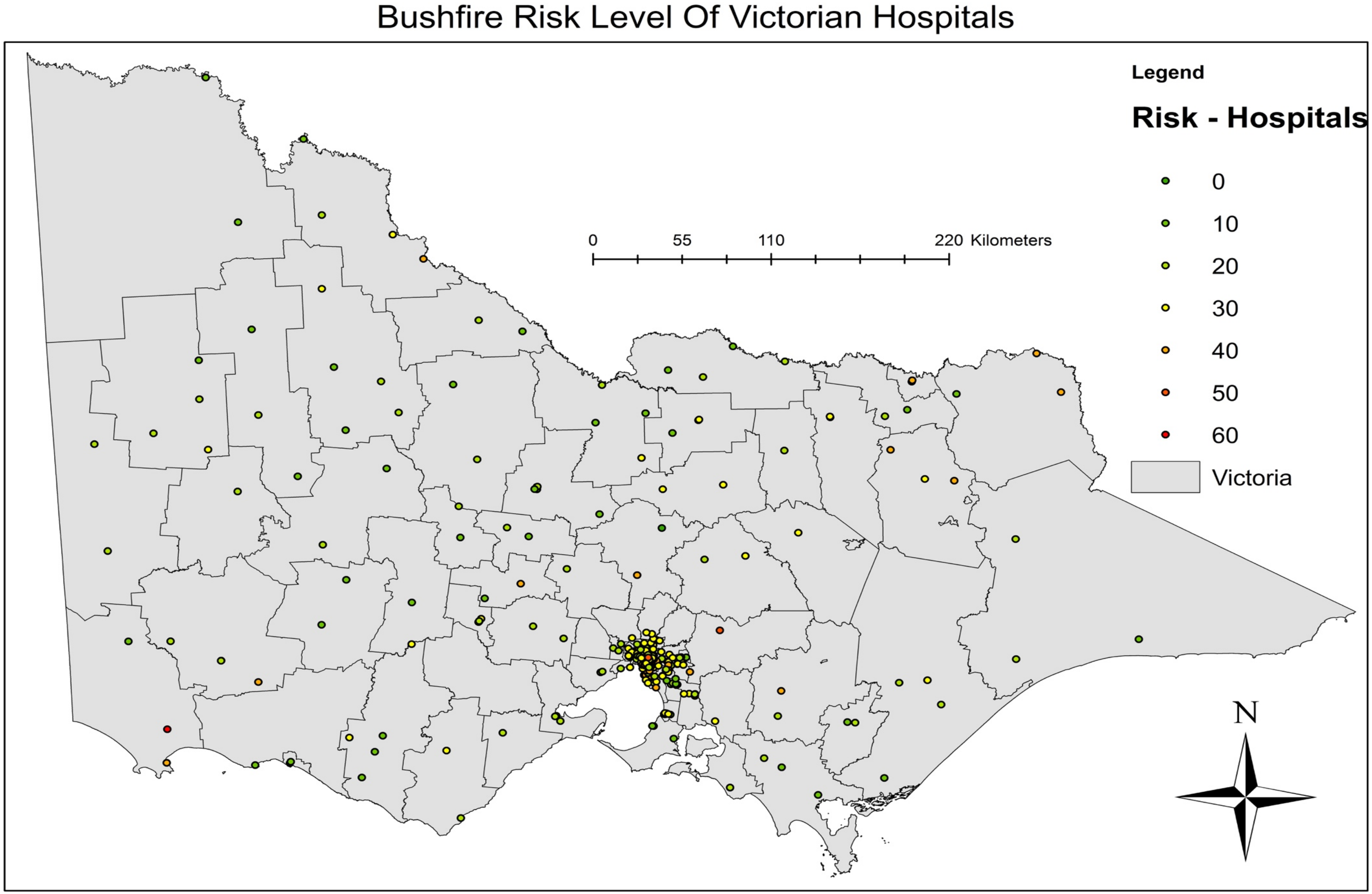


Figure 14
Hospital Hazard Map – Showing Distribution of Hospitals in Victoria along with its Hazard Weighting

Bushfire Risk Level Of Victorian Fire Management Infrastructure

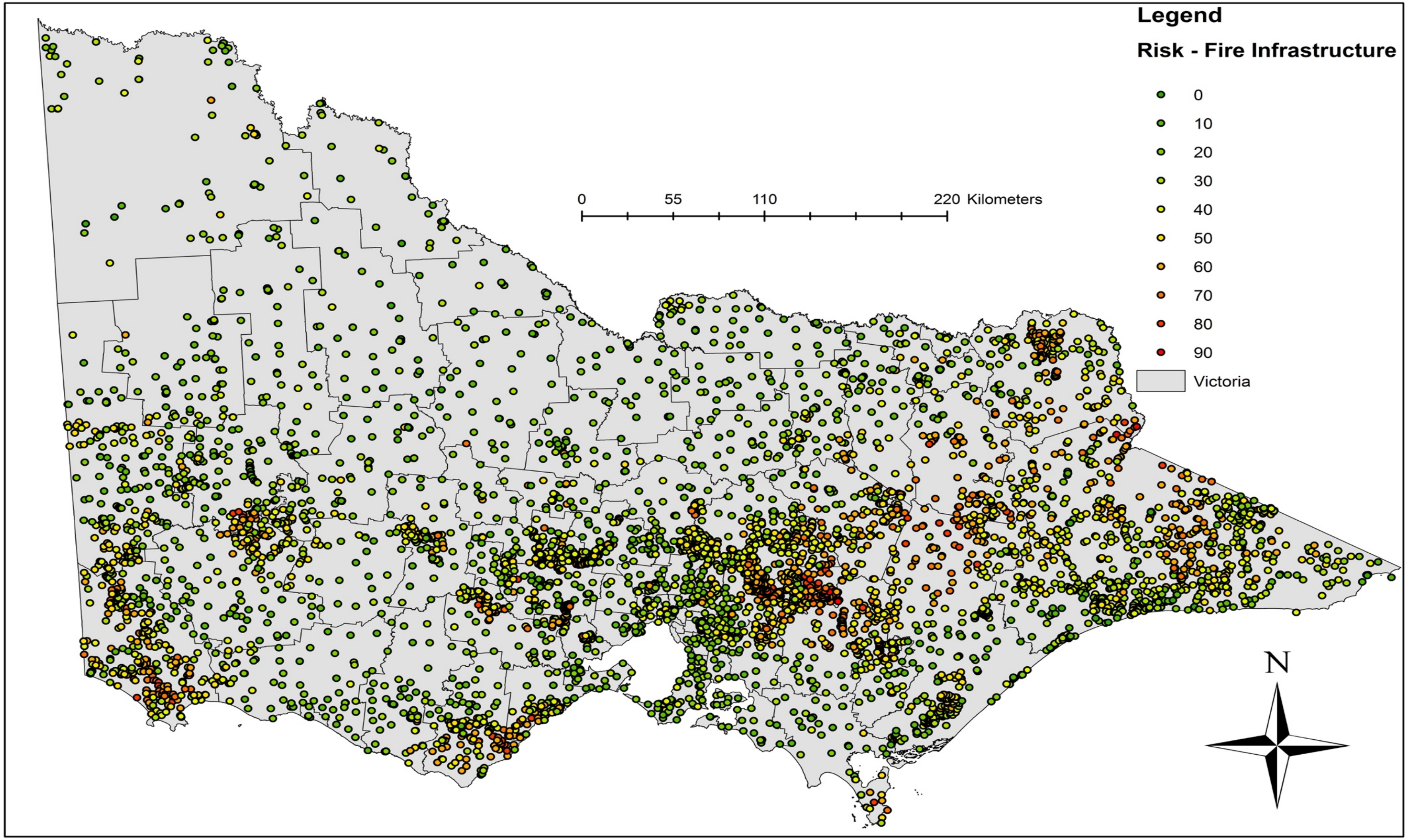


Figure 15
Fire Infrastructure Hazard Map – Showing distribution of Fire Management Infrastructure in Victoria along with its Hazard Weighting (*Comprises: Radio Towers, Fire Watch Towers, Water Points, Work Centers, Airfields, Helipads, Fire Stations, and Base Camps*)

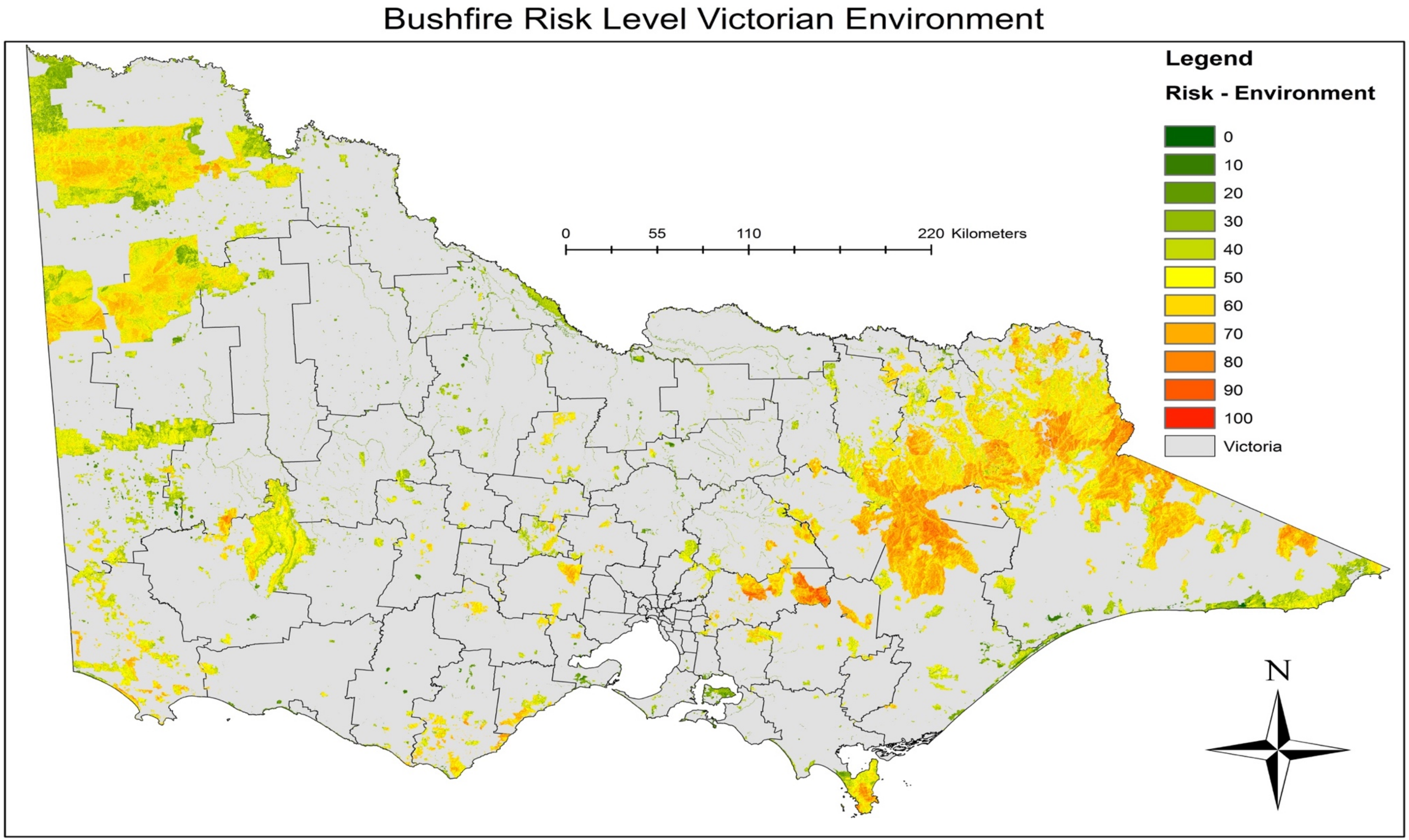


Figure 16
Environmental Conservation Hazard Map – Showing the Environmental Conservation Areas along with its hazard weighting (*Comprises: Conservation & Natural Environments, Nature Conservation, Strict Nature Reserves, National Park, Natural Feature Protection, Habitat/ Species Management Area, Protected Landscape, Managed Resource Protection, and Other Conserved Area*)

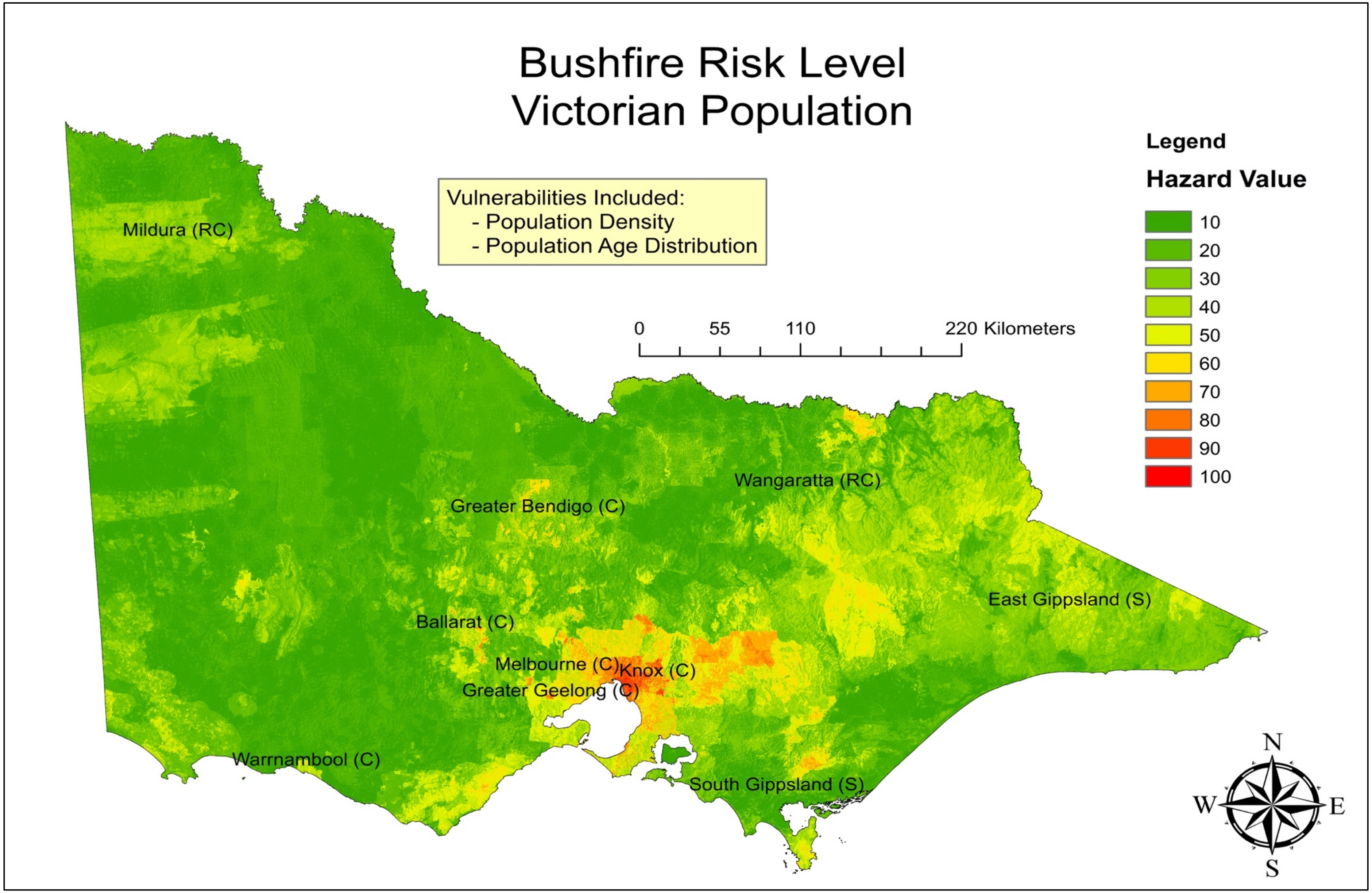


Figure 17
Population Hazard Map – Showing the Hazard Weighting for Population
(Comprises: Population Density & Population Age Distribution)

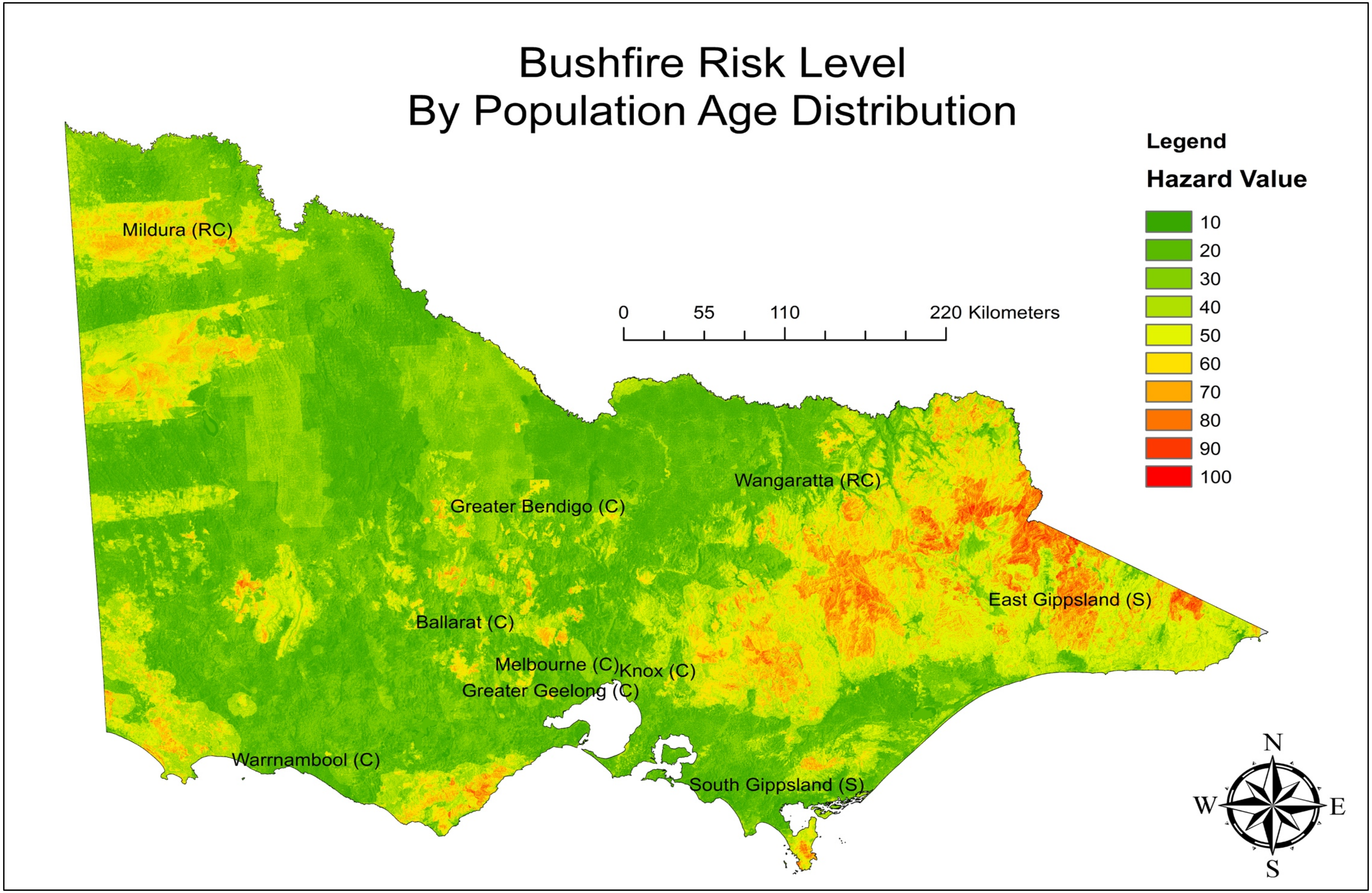


Figure 18

Population Age Distribution Hazard Map – Showing the Hazard Weighting for Population Age in Victoria's Area

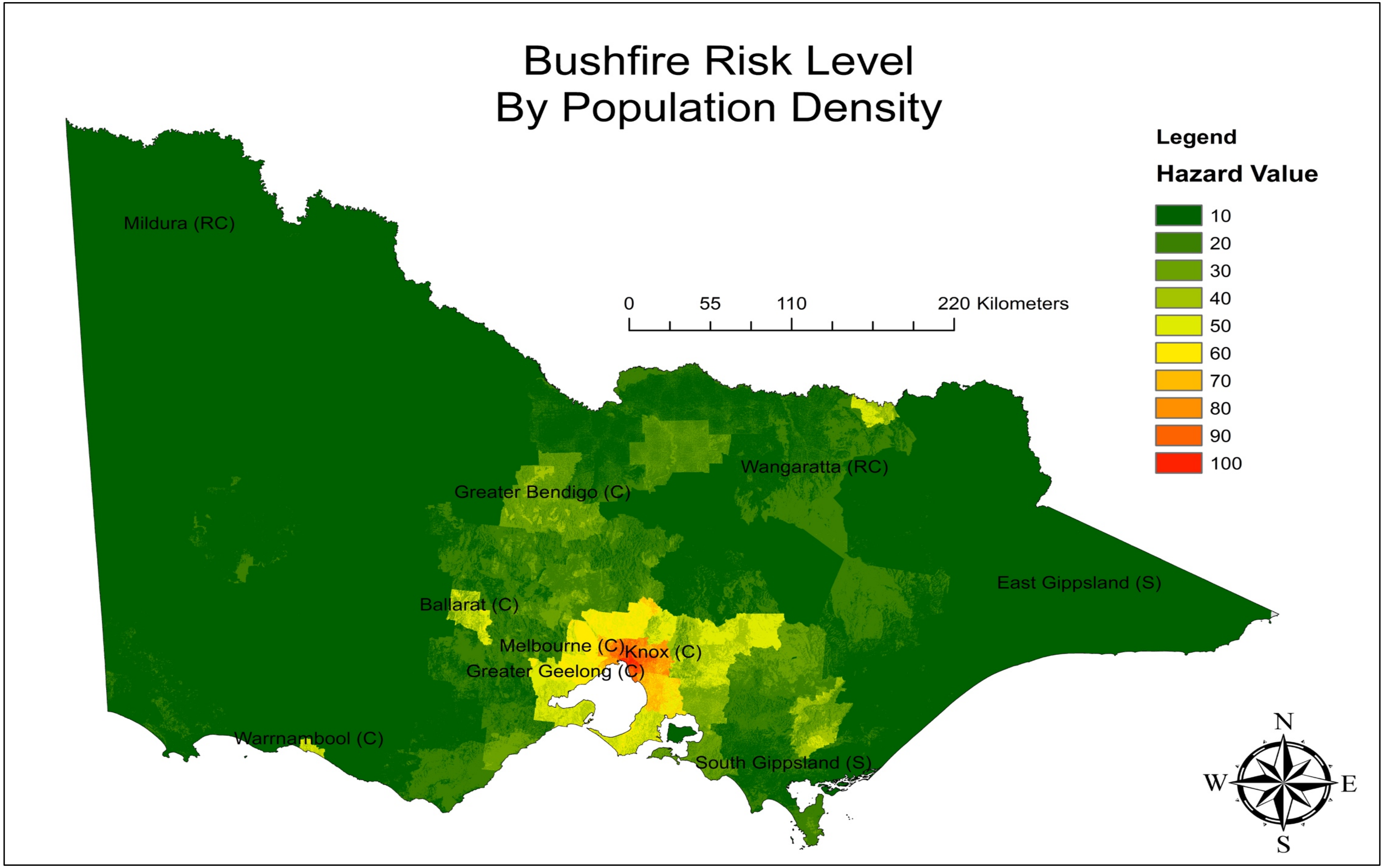


Figure 19
Population Density Hazard Map – Showing the Hazard Weighting for Population Density in Victoria's Area

Victorian Bushfire Risk Map

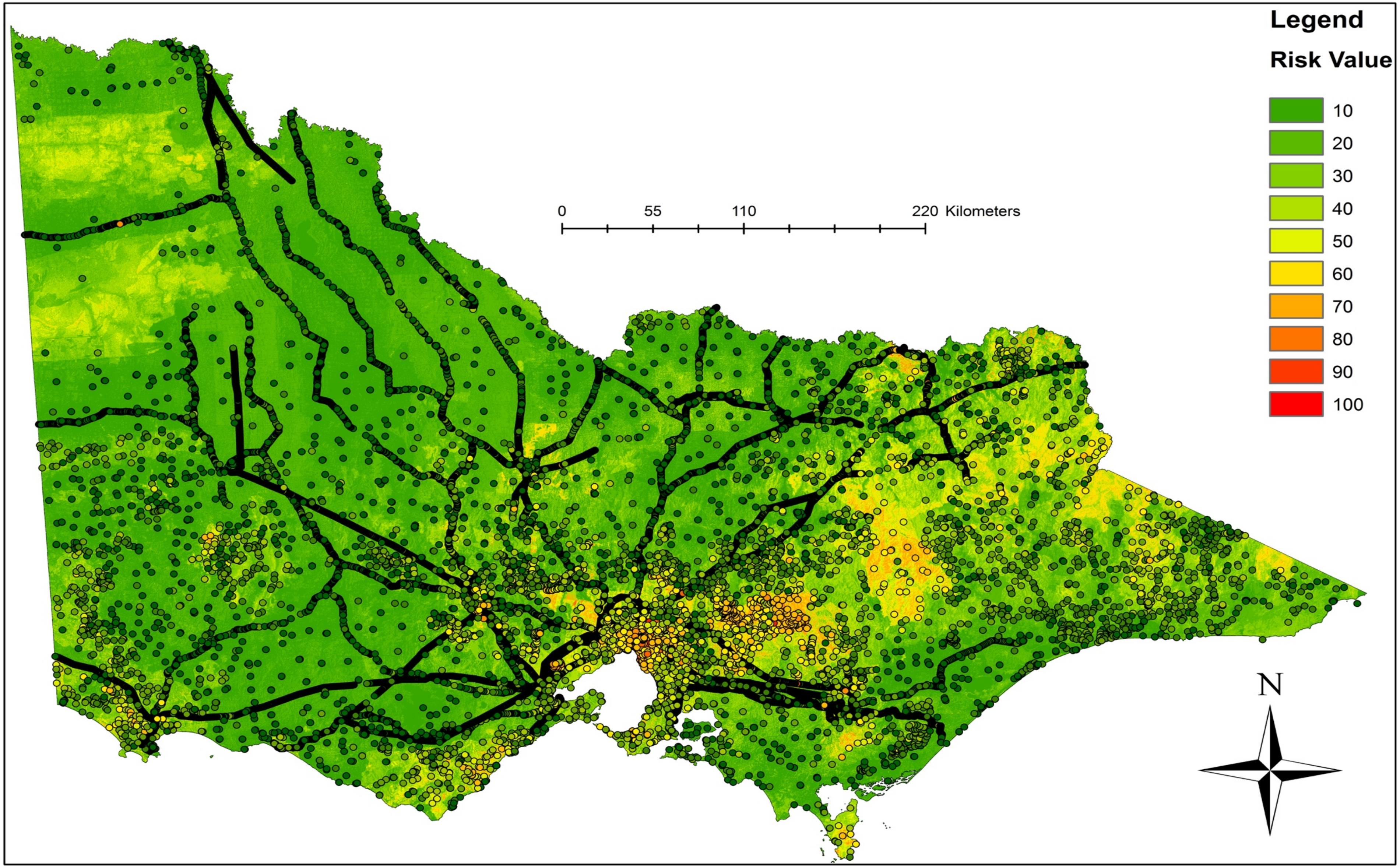


Figure 20A (Clear Visualization but Unclear Risk Value for Infrastructure's Network)
Final Victoria's Bushfire Risk Map – Showing the Risk Value for All Victoria's LGA and Other Discussed Aspects

Victorian Bushfire Risk Map

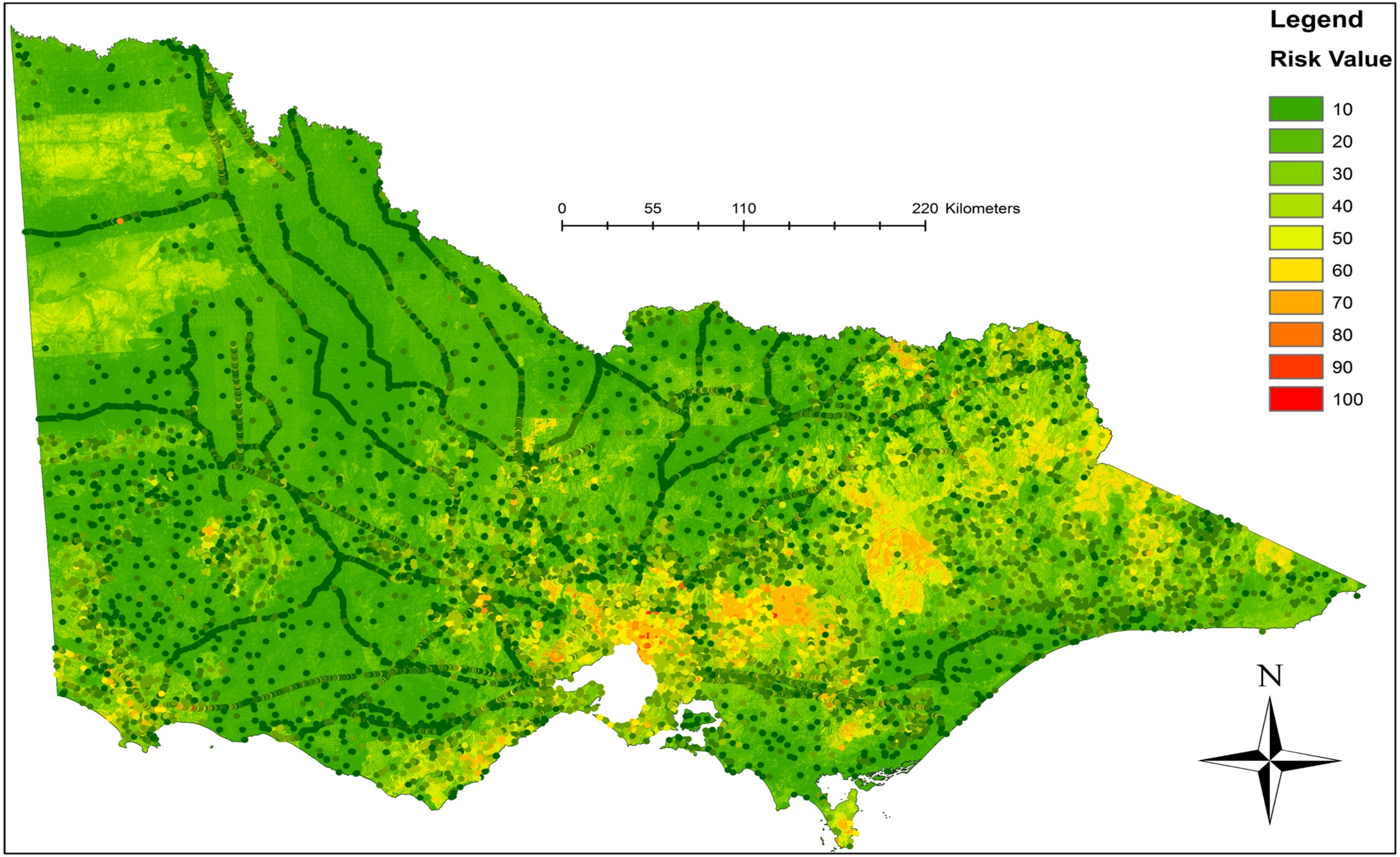


Figure 20B (Clear Risk Value but Unclear Visualization for Infrastructure's Network)
Final Victoria's Bushfire Risk Map – Showing the Risk Value for All Victoria's LGA and Other Discussed Aspects

DISCUSSION

Explanation of Results

Hazard Maps (Figures 1-5)

The overall hazard map shown in Figure 1 shows that the Northeastern area of Victoria has the highest hazard level. These include East Gippsland, Towong, and Alpine. A clearer image of the hazard weighting distributions across this area can be seen in Figure 3. We can see that the highest hazard levels in the West are mostly located in the outer areas including the Local Government Areas (LGAs) of Mildura, Glenelg and Colac-Otway. The detailed hazard level in this region is seen in Figure 4. In the surrounding areas of Melbourne, which can be seen in Figure 5, Yarra Ranges has the highest hazard level reaching 100 and 90 in some areas.

Elements at Risk Maps

Infrastructure (Figures 6 – 10)

The bush fire risk level for Victorian Infrastructure is shown in Figure 6. From this map, we can see that infrastructure in the Northeastern, Southwestern, and Southeastern areas near Melbourne have the highest risk levels. Infrastructure considered includes railway stations, railway and electrical networks, and places. The maps for these individual infrastructures can be seen in Figures 7-10. The regions with the highest risk values are similar to that of the hazard map depicted in Figure 1 in which mostly the Northeast, Southwest, and eastern areas surrounding Melbourne city have the highest risk.

Industry (Figures 11 – 15)

For the risk level of Victorian Industry shown in Figure 11, mostly the Southwest, Eastern, and Southeastern areas have a risk value of 50 and above. Industry consisted of agriculture, commercial forestry, hospital, and fire management infrastructure, in which these can be seen in Figures 12 – 15. The industrial regions with the highest risk levels in Figure 15 are mostly gathered in the mid-eastern, Southern, and Northeastern regions.

Environment (Figure 16)

Figure 16 shows the risk map for bushfire risk level of Victorian Environment. We can see that the eastern Victorian environment has the highest risk level. The elements of environment considered are environmental conservation areas including national parks, and nature conservations.

Population (Figures 17 – 19)

The bushfire risk level for Victorian Population shown on Figure 17 shows that population in the areas of Melbourne, Knox, and Greater Geelong have the highest risk values. The elements considered are population density and population age distribution. Figure 18 shows the population by age distribution, we considered the age range between 0-9 and above 70 years old to be at the most risk in a bushfire. The map for population age distribution shows that the area surrounding East Gippsland and some areas in South Victoria are at the highest risk. On the other hand in Figure 19, the risk map of population density shows that the region with the highest risk is mainly concentrated around Melbourne.

Bushfire Risk Map (Figures 20A and 20B)

The overall Victorian Bushfire Risk Map are shown in Figures 20A and 20B. These two maps are the same but Figure 20A shows clear visualization of combined hazards and elements at risk but unclear risk value for the infrastructure network, whereas Figure 20B shows clear risk values but unclear visualization of the infrastructure network such as railway stations. Referring to Figure 20B, mostly the areas surrounding Melbourne the Northeastern areas of Victoria have the highest risk levels. Furthermore, parts of Southern Victoria and Northwestern Victoria also have a high-risk level of 50 or above.

Strengths

The maps produced provide a visual image of bushfire risks in Victoria that can be easily understood by people from any occupation. The map explicitly provides quantitative information on risk values hence helps facilitate the understanding of which areas and assets are at most risk.

These maps can aid decision makers such as urban planners for future development in the State of Victoria. Furthermore, the maps do reflect the general areas of bushfire. Previous fires in Victoria occurred in the Dandenong Ranges and Mornington Peninsula in 1997, around Mount Macedon during 1983 Ash Wednesday, in LaTrobe Valley and East Gippsland during bushfires in 2014 and in 2009, Black Saturday started with the Kilmore East Fires (Australian Emergency Management Knowledge Hub, 2017). These regions in which fires have previously occurred are the Eastern and Southeastern areas are highlighted as the areas with the highest risk in our bushfire maps (Figure 20A and Figure 20B).

Weakness/Limitations:

Some weaknesses and limitations to consider are that we did not consider time, temperature, and seasons, and since bushfire is highly dependent on these aspects, our bushfire risk map may not depict an accurate representation of risk for the whole year. Moreover, our process of quantifying hazard values for each aspect and vulnerability value for elements at risk are based on rational considerations and/or adapted from research, thus affecting the accuracy of our results.

Some data used to create the maps were taken from open street map in which their contributors include the public; therefore the spatial data used may be inaccurate and/or outdated. Therefore our maps might not accurately reflect the present risk in Victoria.

In our methodology, we used ‘feature vertices to points tool’ in ArcMap, which converts line to points. This tool could be a limitation because the conversion may not cover all the points. When we converted from point to raster the cell size might not have been small enough. Moreover, the final raster cell size will be the largest cell size of the combined rasters (using raster calculator). Furthermore, it’s not possible to describe the edge of Victoria using cells, so there’s area that is not covered by raster cells. When we use the ‘Extract Values to Point’ tool and there’s a point on the edge, no data is extracted.

Some datasets were inaccurate such as there are stations in Figure 10 that is not in the vicinity of a railway network in Figure 9, thus leading to inaccuracy in the overall risk value.

Improvement for future research

Improvements that we could do for future research are to include a time dimension to reflect seasonal change and the risks associated and to include more data to provide a more comprehensive analysis such as vegetation, since some vegetation are more susceptible to fire than others and average rainfall.

Furthermore, we could do more research to be more accurate in assigning the hazard and vulnerability weighting values. Moreover, if we have more processing power to obtain smaller cell sizes, we could obtain more precise hazard values.

RECOMMENDATIONS

From Figure 20B and Figure 1, we recommend having more emergency services personnel in areas at high risk, especially during bushfire season that occurs typically in the summer, such as in Southeastern Victoria including the LGAs of Yarra Ranges, Macedon Ranges, and East Gippsland, and in the South and Northwest including Glenelg and Mildura. Furthermore, it is necessary to inform communities in these areas and other areas with high hazard as these areas are the most exposed to hazards thus having a higher risk such as Towong, Wellington, and Alpine. Informing communities in the bushfire prone areas could increase awareness and understanding of bushfires. Moreover, people affected would be aware of evacuation procedures and locations of shelters and other emergency services, hence be better prepared in the event of a bushfire.

For the people living in the most bushfire prone areas as mentioned above, the government could also tell them to remove flammable vegetation and materials to reduce exposure to hazards thus reducing risk of fire. Also, governments could instruct them to maintain fire equipment such as fire extinguisher to effectively be able to suppress a small fire in their properties.

Referring to the map of risk level for Victorian Electrical Network (Figure 8), it is recommended that the government closely monitor power lines in high-risk areas such as in the LGA of Glenelg in the Southwest, and areas in the Eastern area with a hazard value of 40 and above as power lines may start a fire. Furthermore, to reduce exposure to hazards, vegetation in close proximity to the poles and electrical network should be removed. Moreover, the government could improve their standards for construction of power lines to improve safety.

Referring to map of Bushfire Risk Level of Victorian Places (Figure 7), the government could set specific guidelines for building and other construction in bushfire prone areas, such as the areas surrounding Yarra Ranges, Glenelg, and other high-risk areas in the Northeast. These guidelines could be used in urban planning and as a point of reference in the review of older buildings such as monuments in high-risk areas. Therefore reducing exposure to hazards and risk for each property.

Referring to Figures 13 and 16 which shows the bushfire risk level of Victorian commercial forestry areas and Victorian environment respectively, the government could do prescribed burns in Northern, Southeastern, and outer Western areas of Victoria with high risk levels. These controlled burns could be a method of preventing bushfires to reduce the amount of fuel in an area such as litter, shrubs, and trees, thus reducing the risk of bushfires.

The government could closely monitor railway networks, roads, and fire management in areas at risk. Referring to Figures 9 and 10 which shows the bushfire risk level map for railway network and stations respectively, the government could monitor these networks in the outer metropolitan area, the Northwest regions including Mildura, the LGA of Glenelg in the Southwest and Northeastern areas that has a high hazard value. The monitoring of these networks during bushfire season would allow the government to be more prepared to cancel trains and stop vehicles from passing in the area thus reducing their exposure to hazards.

Referring to Figure 15, which shows the bushfire risk level map for fire management infrastructure, the government should have higher number of personnel in the points with high-risk values and to always check for faults in their communications systems and network to be ready in the event of a bushfire. Moreover, they should try to continually improve communication systems between emergency services and monitoring system, which is applicable to the whole state, to organize and execute plans as needed more effectively. Looking at Figure 20B, the government should also have contingency plans for evacuation, such as other possible routes for emergency services, and provision of shelter for areas at high risk and those surrounding areas, especially in the Eastern and Southeastern areas of Victoria that have a risk value of 50 an above.

CONCLUSION

In conclusion, we have analyzed the bushfire risk level for the state of Victoria by considering fire hazards, elements at risk, and the vulnerabilities of elements at risk to bushfires, which we then compiled into maps that showcases different components of our considerations. We used ArcMap as the main tool for spatial data analysis. From our analysis, we concluded that the areas with the highest risk are mostly in the Eastern, Southeastern region, and the edges of the Southwest and Northwestern regions of Victoria. By looking at the Hazard Map (Figure 1), we can further pinpoint these areas into the surrounding LGAs of East Gippsland, Towong, Yarra Ranges, Mildura, Glenelg, and Macedon Ranges.

We have provided recommendations for these bushfire prone areas based on what governments could do to reduce exposure to hazards for elements at risk and how they can be more prepared in the event of a fire in these regions. Furthermore, we discussed on the strengths, weaknesses, and limitations of our data highlighting how the many weaknesses and limitations could have lead to inaccuracy in our results. We also provided a discussion on how we could improve for further research into risk analysis.

ACKNOWLEDGMENTS

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