Appendix

1. Geological and Vegetational Features in Fire Isochrones

Ruggedness of the terrain and vegetation distribution for each isochrone and entire fire area are shown (Table 1 and Table 2).

Table : Comparison of ruggedness between isochrones and whole fire area from digital elevation model (DEM) shows the elevation gap in each isochrone is more than 350 m and standard deviation is more than 70 m.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Isochrone | Area ($km^{2}$ ) | Mean (m) | STD (m) | Min (m) | Max (m) |
| 1 | 14.86 | 894.01 | 73.04 | 651 | 1002 |
| 2 | 3.46 | 617.86 | 73.36 | 425 | 719 |
| Entire area | 511.85 | 984.41 | 162.03 | 411 | 1366 |

Table : Comparison of vegetation distribution (%) between isochrones and whole fire area indicate vegetation groups labelled with (a) dry eucalypt forest and woodland, (b) Highland and treeless vegetation, (c) Modified land, (d) Moorland sedgeland and rushland, (e) Native grassland, (f) Non eucalypt forest and woodland, (g) Rainforest and related scrub, (h) Saltmarsh and wetland, (i) Scrub heathland and coastal com-plexes, (j) Wet eucalypt forest and woodland, (k) Other natural environments.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Isochrone | a | b | c | d | e | f | g | h | i | j | k |
| 1 | 60.74 | 0.36 | 10.58 | 4.46 | 1.47 | 0.95 | 0.00 | 0.00 | 0.28 | 18.54 | 2.60 |
| 2 | 85.88 | 0.00 | 5.68 | 0.00 | 8.01 | 0.00 | 0.00 | 0.00 | 0.43 | 0.00 | 0.00 |
| Entire area | 63.75 | 16.24 | 1.63 | 4.93 | 1.98 | 0.14 | 0.00 | 0.15 | 0.87 | 9.76 | 0.55 |

1. Results
	1. Fire simulation
		1. Isochrone 1 (341001)

The area of this isochrone is around 15 $km^{2}$ and the elevation of the pseudo weather station is approximately 900 m, which is equivalent to 900-925 hPa. The fire appeared to converge into valley like a funnel. The rates of fire spread (ROS) have already been adjusted. Fraction skills score (FSS) of all results were above their thresholds, “usefulness” and FSS in both wind types were very close each other (Table 3 and Table 4).

Table : Fire simulation scores with downscaled wind in fire isochrone #1 with pseudo weather station 1. Threat score1 is originally independent indicator from confusion matrix; however, it is included in confusion matrix in this study because the parameters in confusion matrix are used in this indicator (Faggian et al., 2017; Sharples et al., 2017). Goodness of fit indicates degree of spatial concordance (Hargrove et al., 2006)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Delaunay | Diamond | Hexagon | Square | Voronoi | Average | Median |
| kappa | 0.52 | 0.52 | 0.52 | 0.53 | 0.52 | 0.52 | 0.52 |
| fraction skills score |  |  |  |  |  |  |  |
| fss | 0.56 | 0.56 | 0.56 | **0.57** | 0.56 | 0.56 | 0.56 |
| useful | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 |
| confusion matrix |  |  |  |  |  |  |  |
| true negative | 122883 | 122920 | 71047 | 61476 | 61463 | 87958 | 71047 |
| false positive | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| false negative | 1347 | 1336 | 773 | 652 | 667 | 955 | 773 |
| true positive | 738 | 744 | 430 | 372 | 370 | 531 | 430 |
| total | 124968 | 125000 | 72250 | 62500 | 62500 | 89444 | 72250 |
| accuracy | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| misclassification rate | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| precision | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| specificity | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| prevalence | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| true positive rate | 0.35 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 |
| false positive rate | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| threat score1 | 0.35 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 |
| goodness of fit2 | 0.35 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 |
| Fireline intensity (kW$m^{-1}$) |  |  |  |  |  |  |  |
| Mean | 2278.26 | 2324.67 | 40787274.91 | 2541.85 | 2544.28 | 8159392.79 | 2541.85 |
| Median | 1565.72 | 1576.02 | 6619.50 | 1786.67 | 1909.83 | 2691.55 | 1786.67 |
| Standard deviation | 2573.34 | 2770.24 | 613072958.64 | 2998.25 | 2797.64 | 122616819.62 | 2797.64 |

Table : Fire simulation scores with BARRA-TA wind in fire isochrone #1 with pseudo weather station 1. Threat score1 is originally independent indicator from confusion matrix; however, it is included in confusion matrix in this study because the parameters in confusion matrix are used in this indicator (Faggian et al., 2017; Sharples et al., 2017). Goodness of fit indicates degree of spatial concordance (Hargrove et al., 2006)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Delaunay | Diamond | Hexagon | Square | Voronoi | Average | Median |
| kappa | 0.52 | 0.52 | 0.52 | 0.53 | 0.52 | 0.52 | 0.52 |
| fraction skills score |  |  |  |  |  |  |  |
| fss | 0.56 | 0.56 | 0.56 | 0.57 | 0.56 | 0.56 | 0.56 |
| useful | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 |
| confusion matrix |  |  |  |  |  |  |  |
| true negative | 122882 | 122920 | 71047 | 61476 | 61463 | 87958 | 71047 |
| false positive | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| false negative | 1349 | 1336 | 773 | 652 | 668 | 956 | 773 |
| true positive | 736 | 744 | 430 | 372 | 369 | 530 | 430 |
| total | 124968 | 125000 | 72250 | 62500 | 62500 | 89444 | 72250 |
| accuracy | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| misclassification rate | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| precision | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| specificity | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| prevalence | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| true positive rate | 0.35 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 |
| false positive rate | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| threat score1 | 0.35 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 |
| goodness of fit2 | 0.35 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 |
| Fireline intensity (kW$m^{-1}$) |  |  |  |  |  |  |  |
| Mean | 1571.10 | 2129.32 | 2106.06 | 1859.83 | 2477.53 | 2028.77 | 2106.06 |
| Median | 988.66 | 1414.77 | 1465.50 | 1134.67 | 1756.55 | 1352.03 | 1414.77 |
| Standard deviation | 2053.52 | 2680.22 | 2729.28 | 2433.06 | 2836.45 | 2546.51 | 2680.22 |

* + 1. Isochrone 2 with pseudo weather station 1 (386002-st18)

The area of this isochrone is around 3.5 $km^{2}$ and the elevation of the pseudo weather station is approximately 466 m, which is equivalent to 950 hPa. The fire appeared to follow the wind which was modified by terrain effect. The rates of fire spread (ROS) have already been adjusted. Fraction skills score (FSS) of 90% results were above their thresholds, “usefulness” and FSS in both wind types were very close each other (Table 5 and Table 6).

Table : Fire simulation scores with downscaled wind in fire isochrone #2 with pseudo weather station 2. Threat score1 is originally independent indicator from confusion matrix; however, it is included in confusion matrix in this study because the parameters in confusion matrix are used in this indicator (Faggian et al., 2017; Sharples et al., 2017). Goodness of fit indicates degree of spatial concordance (Hargrove et al., 2006)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Delaunay | Diamond | Hexagon | Square | Voronoi | Average | Median |
| kappa | 0.49 | 0.50 | 0.48 | 0.48 | 0.47 | 0.48 | 0.48 |
| fraction skills score |  |  |  |  |  |  |  |
| fss | 0.55 | 0.54 | 0.54 | 0.54 | 0.53 | 0.54 | 0.54 |
| useful | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| confusion matrix |  |  |  |  |  |  |  |
| true negative | 124446 | 124484 | 71951 | 62234 | 62237 | 89070 | 71951 |
| false positive | 3 | 2 | 5 | 2 | 6 | 4 | 3 |
| false negative | 348 | 343 | 199 | 179 | 176 | 249 | 199 |
| true positive | 171 | 171 | 95 | 85 | 81 | 121 | 95 |
| total | 124968 | 125000 | 72250 | 62500 | 62500 | 89444 | 72250 |
| accuracy | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| misclassification rate | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| precision | 0.98 | 0.99 | 0.95 | 0.98 | 0.93 | 0.97 | 0.98 |
| specificity | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| prevalence | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| true positive rate | 0.33 | 0.33 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 |
| false positive rate | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| threat score1 | 0.33 | 0.33 | 0.32 | 0.32 | 0.31 | 0.32 | 0.32 |
| goodness of fit2 | 0.32 | 0.33 | 0.31 | 0.31 | 0.29 | 0.31 | 0.31 |
| Fireline intensity (kW$m^{-1}$) |  |  |  |  |  |  |  |
| Mean | 1769.63 | 57349.98 | 54871.90 | 1943.11 | 2179.52 | 23622.82 | 2179.52 |
| Median | 1175.92 | 21334.00 | 18549.00 | 1009.66 | 1620.20 | 8737.76 | 1620.20 |
| Standard deviation | 1728.78 | 68337.18 | 68918.59 | 2540.95 | 1971.41 | 28699.38 | 2540.95 |

Table : Fire simulation scores with BARRA-TA wind in fire isochrone #2 with pseudo weather station 2. Threat score1 is originally independent indicator from confusion matrix; however, it is included in confusion matrix in this study because the parameters in confusion matrix are used in this indicator (Faggian et al., 2017; Sharples et al., 2017). Goodness of fit indicates degree of spatial concordance (Hargrove et al., 2006)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Delaunay | Diamond | Hexagon | Square | Voronoi | Average | Median |
| kappa | 0.50 | 0.43 | 0.51 | 0.49 | 0.50 | 0.49 | 0.50 |
| fraction skills score |  |  |  |  |  |  |  |
| fss | 0.57 | 0.48 | **0.57** | 0.55 | 0.55 | 0.55 | 0.55 |
| useful | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| confusion matrix |  |  |  |  |  |  |  |
| true negative | 124448 | 124462 | 71956 | 62235 | 62241 | 89068 | 71956 |
| false positive | 1 | 24 | 0 | 1 | 2 | 6 | 1 |
| false negative | 344 | 365 | 194 | 178 | 171 | 250 | 194 |
| true positive | 175 | 149 | 100 | 86 | 86 | 119 | 100 |
| total | 124968 | 125000 | 72250 | 62500 | 62500 | 89444 | 72250 |
| accuracy | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| misclassification rate | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| precision | 0.99 | 0.86 | 1.00 | 0.99 | 0.98 | 0.96 | 0.99 |
| specificity | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| prevalence | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| true positive rate | 0.34 | 0.29 | 0.34 | 0.33 | 0.33 | 0.33 | 0.33 |
| false positive rate | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| threat score1 | 0.34 | 0.28 | 0.34 | 0.32 | 0.33 | 0.32 | 0.33 |
| goodness of fit2 | 0.34 | 0.25 | 0.34 | 0.32 | 0.33 | 0.31 | 0.33 |
| Fireline intensity (kW$m^{-1}$) |  |  |  |  |  |  |  |
| Mean | 3504.12 | 7943.49 | 3563.63 | 4373.24 | 6727.95 | 5222.49 | 4373.24 |
| Median | 1970.40 | 2763.27 | 1091.47 | 1565.88 | 2350.78 | 1948.36 | 1970.40 |
| Standard deviation | 5006.52 | 12782.33 | 7213.19 | 7987.76 | 11720.55 | 8942.07 | 7987.76 |

* + 1. Isochrone 2 with pseudo weather station 2 (386002-st16)

The area of this isochrone is around 3.5 $km^{2}$ and the elevation of the pseudo weather station is approximately 520 m, which is equivalent to 950 hPa. The fire appeared to follow the wind which was modified by terrain effect. The rates of fire spread (ROS) have already been adjusted. Fraction skills score (FSS) of all results were above their thresholds, “usefulness” and FSS in both wind types were very close each other (Table 7 and Table 8).

Table : Fire simulation scores with downscaled wind in fire isochrone #2 with pseudo weather station 3. Threat score1 is originally independent indicator from confusion matrix; however, it is included in confusion matrix in this study because the parameters in confusion matrix are used in this indicator (Faggian et al., 2017; Sharples et al., 2017). Goodness of fit indicates degree of spatial concordance (Hargrove et al., 2006)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Delaunay | Diamond | Hexagon | Square | Voronoi | Average | Median |
| kappa | 0.49 | 0.49 | 0.50 | 0.49 | 0.49 | 0.49 | 0.49 |
| fraction skills score |  |  |  |  |  |  |  |
| fss | 0.56 | 0.54 | **0.56** | 0.55 | 0.56 | 0.55 | 0.56 |
| useful | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| confusion matrix |  |  |  |  |  |  |  |
| true negative | 124448 | 124482 | 71955 | 62235 | 62241 | 89072 | 71955 |
| false positive | 1 | 4 | 1 | 1 | 2 | 2 | 1 |
| false negative | 348 | 345 | 195 | 178 | 172 | 248 | 195 |
| true positive | 171 | 169 | 99 | 86 | 85 | 122 | 99 |
| total | 124968 | 125000 | 72250 | 62500 | 62500 | 89444 | 72250 |
| accuracy | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| misclassification rate | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| precision | 0.99 | 0.98 | 0.99 | 0.99 | 0.98 | 0.99 | 0.99 |
| specificity | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| prevalence | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| true positive rate | 0.33 | 0.33 | 0.34 | 0.33 | 0.33 | 0.33 | 0.33 |
| false positive rate | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| threat score1 | 0.33 | 0.33 | 0.34 | 0.32 | 0.33 | 0.33 | 0.33 |
| goodness of fit2 | 0.33 | 0.32 | 0.33 | 0.32 | 0.32 | 0.33 | 0.32 |
| Fireline intensity (kW$m^{-1}$) |  |  |  |  |  |  |  |
| Mean | 1569.08 | 1730.95 | 1795.12 | 1594.59 | 2181.14 | 1774.18 | 1730.95 |
| Median | 795.68 | 838.82 | 1080.53 | 886.23 | 871.69 | 894.59 | 871.69 |
| Standard deviation | 2341.53 | 2893.05 | 2614.29 | 2476.72 | 3328.64 | 2730.85 | 2614.29 |

Table : Fire simulation scores with BARRA-TA wind in fire isochrone #2 with pseudo weather station 3. Threat score1 is originally independent indicator from confusion matrix; however, it is included in confusion matrix in this study because the parameters in confusion matrix are used in this indicator (Faggian et al., 2017; Sharples et al., 2017). Goodness of fit indicates degree of spatial concordance (Hargrove et al., 2006)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Delaunay | Diamond | Hexagon | Square | Voronoi | Average | Median |
| kappa | 0.50 | 0.49 | 0.51 | 0.49 | 0.50 | 0.50 | 0.50 |
| fraction skills score |  |  |  |  |  |  |  |
| fss | **0.57** | 0.55 | 0.57 | 0.57 | 0.56 | 0.56 | 0.57 |
| useful | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| confusion matrix |  |  |  |  |  |  |  |
| true negative | 124448 | 124483 | 71956 | 62236 | 62242 | 89073 | 71956 |
| false positive | 1 | 3 | 0 | 0 | 1 | 1 | 1 |
| false negative | 343 | 344 | 194 | 177 | 171 | 246 | 194 |
| true positive | 176 | 170 | 100 | 87 | 86 | 124 | 100 |
| total | 124968 | 125000 | 72250 | 62500 | 62500 | 89444 | 72250 |
| accuracy | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| misclassification rate | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| precision | 0.99 | 0.98 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 |
| specificity | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| prevalence | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| true positive rate | 0.34 | 0.33 | 0.34 | 0.33 | 0.33 | 0.33 | 0.33 |
| false positive rate | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| threat score1 | 0.34 | 0.33 | 0.34 | 0.33 | 0.33 | 0.33 | 0.33 |
| goodness of fit2 | 0.34 | 0.33 | 0.34 | 0.33 | 0.33 | 0.33 | 0.33 |
| Fireline intensity (kW$m^{-1}$) |  |  |  |  |  |  |  |
| Mean | 3518.08 | 2517.40 | 4008.64 | 3723.10 | 2397.54 | 3232.95 | 3518.08 |
| Median | 1465.78 | 1252.44 | 1825.62 | 1566.08 | 1199.60 | 1461.90 | 1465.78 |
| Standard deviation | 5885.12 | 4666.92 | 6104.60 | 6981.29 | 4507.80 | 5629.15 | 5885.12 |

1. REFERENCES

Faggian, N., Bridge, C., Fox-Hughes, P., Jolly, C., Jacobs, H., Ebert, B., & Bally, J. (2017). An evaluation of fire spread simulators used in Australia. *Bushfire Predictive Services Final Report*.

Hargrove, W. W., Hoffman, F. M., & Hessburg, P. F. (2006). Mapcurves: A quantitative method for comparing categorical maps. *Journal of Geographical Systems*, *8*(2), 187–208. https://doi.org/10.1007/s10109-006-0025-x

Sharples, J., Richards, R., Hilton, J., Ferguson, S., Cohen, R., & Thatcher, M. (2017). *Dynamic simulation of the Cape Barren Island fire using the Spark framework*. 1111–1117.