Appendix

1. Geological and Vegetational Features in Fire Isochrones

Fire isochrones are located in the valley and contain rugged terrain where the highest is more than 1000 m and the lowest is less than 500 m. Although isochrone #2 is included in #1 and area size is nearly one-quarter, ruggedness is well-reflected (**Table 1**).

**Table 1.** 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 50 m.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Isochrone | Area ($km^{2}$) | Mean (m) | STD (m) | Min (m) | Max (m) |
| #1 [94] | 97.24 | 595 | 104 | 452 | 1071 |
| #2 [93001] | 23.27 | 570 | 110 | 468 | 1071 |
| #3 [94006] | 16.28 | 517 | 56 | 452 | 802 |
| Entire area | 350.37 | 589 | 156 | 291 | 1256 |

In contrast, isochrone #3 is the smallest, 16.28 $km^{2}$, and least rugged, 56m. The combination of vegetation group adds up the conditions for rapid fire spread. Distribution of vegetation group exhibit in **Table 2**. Dominant vegetation is moorland including buttongrass and accounts for more than half in all three ischrones. Buttongrass can carry fire on to other vegetation types (Marsden-Smedley et al., 2001). In addition, there are both dry and wet eucalypt forest in each isochrone and account for more than one-quarter in each isochrone. Forest type is one of the requirements to incur lateral fire channel which also comes into fire spots (Sharples et al., 2011, 2017).

**Table 2.** 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 complexes, (j) Wet eucalypt forest and woodland, (k) Other natural environments.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Isochrone | a | b | c | d | e | f | g | h | i | j | k |
| #1 [94] | 10.10 | 11.13 | 0.01 | 55.20 | 0.00 | 0.33 | 1.15 | 0.00 | 7.29 | 14.63 | 0.15 |
| #2 [93001] | 14.27 | 0.05 | 0.00 | 61.03 | 0.00 | 1.34 | 0.50 | 0.00 | 10.12 | 12.69 | 0.00 |
| #3 [94006] | 14.89 | 0.00 | 0.07 | 66.64 | 0.00 | 0.00 | 0.14 | 0.00 | 6.09 | 12.16 | 0.00 |
| Entire area | 12.78 | 4.28 | 0.08 | 43.19 | 0.00 | 0.28 | 4.31 | 0.00 | 10.38 | 22.84 | 1.87 |

1. Result
	1. Fire Simulation

### Isochrone #1 [94]

Fractions skill scores (FSS) in Isochrone #1 are all below thresholds in both types of wild fields (**Table 3** and **Table 4**).

**Table 3.** Fire simulation with downscaled wind. 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).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Delaunay | Diamond | Hexagon | Square | Voronoi | Average | Medium |
| Elapse (days) | 7.09 | 7.63 | 7.92 | 5.37 | 7.72 | 7.14 | 7.63 |
| Cohen’s Kappa score | 0.44 | 0.44 | 0.45 | 0.44 | 0.44 | 0.44 | 0.44 |
| Fractions Skill Score (FSS) | 0.52 | 0.51 | **0.52** | 0.52 | 0.52 | 0.52 | 0.52 |
| FSS useful | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 |
| Confusion matrix |  |  |  |  |  |  |  |
| True negative | 57187 | 57092 | 33305 | 28572 | 28601 | 40951 | 33305 |
| False positive | 6 | 58 | 10 | 3 | 1 | 16 | 6 |
| False negative | 9674 | 9796 | 5502 | 4872 | 4855 | 6940 | 5502 |
| True positive | 4853 | 4804 | 2798 | 2428 | 2418 | 3460 | 2798 |
| Total | 71720 | 71750 | 41615 | 35875 | 35875 | 51367 | 41615 |
| Accuracy | 0.87 | 0.86 | 0.87 | 0.86 | 0.86 | 0.86 | 0.86 |
| Misclassification rate | 0.13 | 0.14 | 0.13 | 0.14 | 0.14 | 0.14 | 0.14 |
| Precision | 1.00 | 0.99 | 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 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| 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 | 0.33 | 0.33 | 0.33 | 0.33 |
| Fireline intensity $(kWm^{-1})$ |  |  |  |  |  |  |  |
| Mean | 881.06 | 703.06 | 563.55 | 667.80 | 603.02 | 683.70 | 667.80 |
| Median | 219.60 | 169.97 | 137.33 | 205.28 | 132.01 | 172.84 | 169.97 |
| Standard deviation | 1944.58 | 1691.32 | 1214.61 | 1209.14 | 1278.70 | 1467.67 | 1278.70 |

**Table 4.** Fire simulation with BARRA-TA wind. 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).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Delaunay | Diamond | Hexagon | Square | Voronoi | Average | Medium |
| Elapse (days) | 6.36 | 6.68 | 6.57 | 6.36 | 6.63 | 6.52 | 6.57 |
| Cohen’s Kappa score | 0.44 | 0.43 | 0.41 | 0.44 | 0.42 | 0.43 | 0.43 |
| Fractions Skill Score (FSS) | 0.52 | 0.51 | 0.49 | **0.52** | 0.50 | 0.51 | 0.51 |
| FSS useful | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 |
| Confusion matrix |  |  |  |  |  |  |  |
| True negative | 57188 | 57066 | 33122 | 28575 | 28485 | 40887 | 33122 |
| False positive | 5 | 84 | 193 | 0 | 117 | 80 | 84 |
| False negative | 9695 | 9822 | 5685 | 4869 | 4954 | 7005 | 5685 |
| True positive | 4832 | 4778 | 2615 | 2431 | 2319 | 3395 | 2615 |
| Total | 71720 | 71750 | 41615 | 35875 | 35875 | 51367 | 41615 |
| Accuracy | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 |
| Misclassification rate | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 |
| Precision | 1.00 | 0.98 | 0.93 | 1.00 | 0.95 | 0.97 | 0.98 |
| Specificity | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 |
| Prevalence | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| True positive rate | 0.33 | 0.33 | 0.32 | 0.33 | 0.32 | 0.33 | 0.33 |
| False positive rate | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Threat score1 | 0.33 | 0.33 | 0.31 | 0.33 | 0.31 | 0.32 | 0.33 |
| Fireline intensity $(kWm^{-1})$ |  |  |  |  |  |  |  |
| Mean | 711.31 | 925.43 | 826.37 | 888.32 | 902.49 | 850.78 | 888.32 |
| Median | 154.20 | 246.04 | 232.94 | 151.06 | 269.02 | 210.65 | 232.94 |
| Standard deviation | 1335.49 | 2084.26 | 1933.44 | 1791.91 | 1951.32 | 1819.28 | 1933.44 |

### Isochrone #2 [93001]

Fractions skill scores (FSS) in Isochrone #2 are all above thresholds in both types of wild fields (**Table 5** and **Table 6**).

**Table 5.** Fire simulation with downscaled wind. 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).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Delaunay | Diamond | Hexagon | Square | Voronoi | Average | Medium |
| Elapse (days) | 0.16 | 0.17 | 0.15 | 0.16 | 0.15 | 0.16 | 0.16 |
| Cohen’s Kappa score | 0.64 | 0.64 | 0.63 | 0.63 | 0.65 | 0.64 | 0.64 |
| Fractions Skill Score (FSS) | 0.69 | 0.69 | 0.68 | 0.69 | **0.70** | 0.69 | 0.69 |
| FSS useful | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 |
| Confusion matrix |  |  |  |  |  |  |  |
| True negative | 69661 | 69723 | 40439 | 34831 | 34855 | 49902 | 40439 |
| False positive | 202 | 189 | 126 | 94 | 90 | 140 | 126 |
| False negative | 882 | 863 | 504 | 462 | 436 | 629 | 504 |
| True positive | 975 | 975 | 546 | 488 | 494 | 696 | 546 |
| Total | 71720 | 71750 | 41615 | 35875 | 35875 | 51367 | 41615 |
| Accuracy | 0.98 | 0.99 | 0.98 | 0.98 | 0.99 | 0.98 | 0.98 |
| Misclassification rate | 0.02 | 0.01 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 |
| Precision | 0.83 | 0.84 | 0.81 | 0.84 | 0.85 | 0.83 | 0.84 |
| Specificity | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Prevalence | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| True positive rate | 0.53 | 0.53 | 0.52 | 0.51 | 0.53 | 0.52 | 0.53 |
| False positive rate | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Threat score1 | 0.47 | 0.48 | 0.46 | 0.47 | 0.48 | 0.47 | 0.47 |
| Fireline intensity $(kWm^{-1})$ |  |  |  |  |  |  |  |
| Mean | 15658.02 | 16360.56 | 16897.36 | 17429.42 | 18603.04 | 16989.68 | 16897.36 |
| Median | 8009.53 | 8550.19 | 7706.21 | 9391.55 | 8800.20 | 8491.54 | 8550.19 |
| Standard deviation | 21787.05 | 25783.25 | 25255.26 | 23108.41 | 27581.35 | 24703.06 | 25255.26 |

**Table 6.** Fire simulation with BARRA-TA wind. 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).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Delaunay | Diamond | Hexagon | Square | Voronoi | Average | Medium |
| Elapse (days) | 0.16 | 0.15 | 0.14 | 0.15 | 0.13 | 0.15 | 0.15 |
| Cohen’s Kappa score | 0.60 | 0.61 | 0.62 | 0.64 | 0.62 | 0.62 | 0.62 |
| Fractions Skill Score (FSS) | 0.65 | 0.65 | 0.67 | **0.69** | 0.67 | 0.67 | 0.67 |
| FSS useful | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 |
| Confusion matrix |  |  |  |  |  |  |  |
| True negative | 69615 | 69676 | 40432 | 34837 | 34835 | 49879 | 40432 |
| False positive | 248 | 236 | 133 | 88 | 110 | 163 | 133 |
| False negative | 929 | 910 | 511 | 456 | 452 | 652 | 511 |
| True positive | 928 | 928 | 539 | 494 | 478 | 673 | 539 |
| Total | 71720 | 71750 | 41615 | 35875 | 35875 | 51367 | 41615 |
| Accuracy | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 |
| Misclassification rate | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| Precision | 0.79 | 0.80 | 0.80 | 0.85 | 0.81 | 0.81 | 0.80 |
| Specificity | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Prevalence | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| True positive rate | 0.50 | 0.50 | 0.51 | 0.52 | 0.51 | 0.51 | 0.51 |
| False positive rate | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Threat score1 | 0.44 | 0.45 | 0.46 | 0.48 | 0.46 | 0.45 | 0.46 |
| Fireline intensity $(kWm^{-1})$ |  |  |  |  |  |  |  |
| Mean | 14711.47 | 15615.11 | 16617.84 | 14441.59 | 17754.27 | 15828.06 | 15615.11 |
| Median | 6695.90 | 7386.40 | 5424.52 | 6215.90 | 7272.38 | 6599.02 | 6695.90 |
| Standard deviation | 21353.59 | 20528.56 | 24561.29 | 19919.80 | 25762.54 | 22425.16 | 21353.59 |

### Isochrone #3 [94006]

Fractions skill scores (FSS) in Isochrone #3 are all above thresholds in both types of wild fields (**Table 7** and **Table 8**).

**Table 7.** Fire simulation with downscaled wind. 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).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Delaunay | Diamond | Hexagon | Square | Voronoi | Average | Medium |
| Elapse (days) | 0.02 | 0.03 | 0.03 | 0.03 | 0.02 | 0.03 | 0.03 |
| Cohen’s Kappa score | 0.50 | 0.53 | 0.54 | 0.51 | 0.53 | 0.04 | 0.52 |
| Fractions Skill Score (FSS) |  |  |  |  |  |  |  |
| FSS useful | 0.54 | 0.56 | **0.58** | 0.56 | 0.57 | 0.04 | 0.56 |
| Confusion matrix | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.00 | 0.51 |
| True negative |  |  |  |  |  |  |  |
| False positive | 69706 | 69751 | 40483 | 34866 | 34882 | 34885 | 49938 |
| False negative | 117 | 85 | 43 | 52 | 42 | 75 | 68 |
| True positive |  |  |  |  |  | 619 | 848 |
| Total | 71720 | 71750 | 41615 | 35875 | 35875 | 374 | 514 |
| Accuracy | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 35875 | 51367 |
| Misclassification rate | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.00 | 0.98 |
| Precision | 0.86 | 0.90 | 0.91 | 0.87 | 0.90 | 0.00 | 0.02 |
| Specificity | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.05 | 0.89 |
| Prevalence | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.00 | 1.00 |
| True positive rate | 0.37 | 0.38 | 0.39 | 0.37 | 0.38 | 0.00 | 0.03 |
| False positive rate | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.38 |
| Threat score1 | 0.34 | 0.36 | 0.38 | 0.35 | 0.37 | 0.00 | 0.00 |
| Fireline intensity $(kWm^{-1})$ |  |  |  |  |  |  |  |
| Mean | 60265.88 | 38311.76 | 46023.37 | 37653.02 | 59980.42 | 48446.89 | 46023.37 |
| Median | 6791.88 | 7108.80 | 7650.18 | 6971.14 | 7923.49 | 7289.10 | 7108.80 |
| Standard deviation | 138255.77 | 51173.30 | 70478.87 | 51002.42 | 142508.50 | 90683.77 | 70478.87 |

**Table 8.** Fire simulation with BARRA-TA wind. 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).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Delaunay | Diamond | Hexagon | Square | Voronoi | Average | Medium |
| Elapse (days) | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| Cohen’s Kappa score | 0.50 | 0.51 | 0.50 | 0.52 | 0.48 | 0.50 | 0.50 |
| Fractions Skill Score (FSS) | 0.54 | 0.54 | 0.54 | **0.55** | 0.52 | 0.54 | 0.54 |
| FSS useful | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 |
| Confusion matrix |  |  |  |  |  |  |  |
| True negative | 69692 | 69726 | 40455 | 34868 | 34849 | 49918 | 40455 |
| False positive | 131 | 110 | 71 | 50 | 75 | 87 | 75 |
| False negative | 1209 | 1210 | 690 | 600 | 616 | 865 | 690 |
| True positive | 688 | 704 | 399 | 357 | 335 | 497 | 399 |
| Total | 71720 | 71750 | 41615 | 35875 | 35875 | 51367 | 41615 |
| Accuracy | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 |
| Misclassification rate | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| Precision | 0.84 | 0.86 | 0.85 | 0.88 | 0.82 | 0.85 | 0.85 |
| Specificity | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Prevalence | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| True positive rate | 0.36 | 0.37 | 0.37 | 0.37 | 0.35 | 0.36 | 0.37 |
| False positive rate | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Threat score1 | 0.34 | 0.35 | 0.34 | 0.35 | 0.33 | 0.34 | 0.34 |
| Fireline intensity $(kWm^{-1})$ |  |  |  |  |  |  |  |
| Mean | 42351.66 | 47631.08 | 53256.90 | 46860.28 | 49079.13 | 47835.81 | 47631.08 |
| Median | 8517.11 | 9462.84 | 10078.36 | 8625.58 | 10029.40 | 9342.66 | 9462.84 |
| Standard deviation | 62161.33 | 67356.56 | 73111.36 | 65769.99 | 76523.24 | 68984.50 | 67356.56 |

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*.

Marsden-Smedley, J. B., Catchpole, W. R., & Pyrke, A. (2001). Fire modelling in Tasmanian buttongrass moorlands. IV. Sustaining versus non-sustaining fires. *International Journal of Wildland Fire*, *10*(2), 255–262.

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.

Sharples, J., Viegas, D., McRae, R., Raposo, J., & Farinha, H. (2011). *Lateral bushfire propagation driven by the interaction of wind, terrain and fire*. 235–241.