Firebrand flux

186 m

0 m

320 m

FBP X

FBP Y

FBP Z

FCS X

FCS Y

FCS Z

Fire line

Road

320 m

160 m

300 m

250 m

150 m

100 m

50 m

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case | Wind velocity(m/s) | Particle velocity  (U,V,W) | Ember input rate pcs/s | **Flux (pcs/m2. s)** | | |
| FCS X | FCS Y | FCS Z |
| TR1 |  | (0.0,0.0,2.0) | 14 446 | 0.076 | 0.937 | 3.027 |
| TR2(1500 mm grid) | ~3.9 | (0.0,0.0,2.0) | 10 203 | 0.683 | 1.019 | 1.564 |
| TR3(1500 mm grid) | ~4.2 | (0.0,0.0,2.0) | 9880 | 0.598 | 1.032 | 1.428 |
| TR4(750 mm grid) | ~ 4.4 | (0.0,0.0,2.0) | 9880 | 0.700 | 0.950 | 1.451 |
| TR5(1500 mm grid) | ~2.2 | (6.2, 0.0,2.1) | 9880 | 0.255 | 1.499 | 1.332 |
| TR6(1500 mm grid) | ~ 2.1 | (8.3, 0.0,2.1) | 9880 | 0.625 | 1.284 | 0.667 |
| TR6(1500 mm grid and no fire) | ~2.3 | (0.0,0.0,2.1) | 9880 | 0.303 | 2.016 | 1.512 |
| Experiment | 1.4±0.6 | NA | NA | 0.824 | 0.902 | 1.361 |

**Determining particles’ initial velocity of TR5 (based on single tree and wind velocity)**

Single tree burning particles initial velocity(U,V,W) (m/s) =(2.1,0, 0.7)

Forest fire particles’ initial velocity (U,V,W) (m/s) =(8.3, 0, 2.1)

Wind velocity of forest fire (m/s) = 1.4 ± 0.6 --- > 2.0

U velo = 3 x U velo of single tree particle + wind velocity

= (3 x 2.1 + 2)

= 8.3 m/s

W velocity = 3 x W velo of single tree particle

= 3 x 0.7

= 2.1 m/s

Forest fire simulations

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case | Wind velocity  (m/s) | Particle velocity  (U,V,W) m/s | Ember input rate pcs/s | **Flux (pcs/m2. s)** | | |
| FCS Z | FCS Y | FCS X |
| T A | ≈1.94 | (4.2, 0.0, 2.1) | 9881 | 2.1054 | 1.562 | 0.074 |
| T B | ≈2.02 | (6.2, 0.0, 2.1) | 9881 | 1.332 | 1.499 | 0.255 |
| T C | ≈1.93 | (8.3, 0.0, 4.2) | 9042 | 1.218 | 1.120 | 0.522 |
| T D | ≈1.89 | (8.3, 0.0, 5.2) | 9042 | 1.253 | 1.341 | 0.306 |
| T E | ≈1.87 | (8.3, 0.0, 6.2) | 9042 | 1.154 | 1.196 | 0.271 |
| T F | ≈1.95 | (9.3, 0.0, 4.2) | 8907 | 1.343 | 1.230 | 0.289 |
| T G | ≈1.98 | Varied on particle | 9881 | 0.738 | 1.415 | 0.214 |
| T H | ≈2.0 | (8.3, 0.0, 2.1) | 11006 | 1.465 | 1.302 | 0.701 |
|  |  |  |  | 7.1% | 30.7% | -17.5% |
|  |  |  | Adjust the input number |  |  |  |
| TI | ≈2.13 | (8.3, 0.0, 2.1) | 14436 | 2.835 | 1.355 | 0.203 |
| TJ | ≈2.16 | (8.3, 0.0, 2.1) | 12367 | 1.392 | 1.788 | 0.752 |
| Experiment | 1.4±0.6 | NA | NA | 1.361 | 0.902 | 0.824 |
| Difference(%) |  |  |  | 2.2% | 49.5% | -09.5% |

* Lower initial horizontal velocity – results more particles accumulating on FCS Z (case T A).
* Higher initial horizontal velocity – results more particles moving away from the fire line and landing on Y, X locations. However, increasing vertical velocity results landing less firebrands on X location (TH, TD, TE, TF).
* So, TH case is being used to adjust the input composition of firebrands to get a closer value to the experiment.
* After adjusting input number according to the composition of landing flux, TI, TJ results were obtained. The TJ was obtained after adjusting the results of TI.

Total number of firebrands landed on a 1m2 area

|  |  |  |
| --- | --- | --- |
|  | Total number of firebrands(pcs)  landed on X, Y, Z | Difference with the experiment |
| Experiment | 1334 | - |
| TH | 1530 | 12.8% |
| TJ | 1771 | 24.6% |

**Oregon State University work**

1. Effect of species for firebrand generation

DF-Douglas fir, GF-Grand fir, PP- Ponderoa pine, WJ-Western Juniper

|  |  |  |
| --- | --- | --- |
| Total firebrand generation ratio (based on species) | | |
| DF/GF | DF/PP | DF/WJ |
| 1.2 | 2.0 | 2.2 |

|  |  |  |
| --- | --- | --- |
| Hot firebrand generation ratio (based on species) | | |
| DF/GF | DF/PP | DF/WJ |
| 0.5 | 4.8 | 0.8 |

**Note: Need to find a logical explanation why I use Douglas fir or Pine for the AS3959.**

Based on-

Which fuel has a closeness to Eucalyptus(Forests), Banksia(Scrub), Acacia (Mallee/Mulga) in terms of physical features, fuel MC etc.

1. Effect of tree height for firebrand generation

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Analysing trees with similar heights in terms of number of ember generation | | | | | | |
| Species | **height** | **firebrands** | **height** | **firebrands** | **height** | **firebrands** |
| DF | 2.60 | 1714 | 3.91 | 7548 | 5.71 | 10643 |
| PP | 2.71 | 4575 | 3.59 | 3600 | 5.65 | 3962 |
| SB | 2.53 | 9352 |  |  |  |  |
|  | **Height ratio** | **Ember ratio** | **Height ratio** | **Ember ratio** | **Height ratio** | **Ember ratio** |
| DF/PP | 0.96 | 0.37 | 1.09 | 2.10 | 1.01 | 2.69 |
| DF/SB | 1.03 | 0.18 |  |  |  |  |

Summary:

|  |  |  |
| --- | --- | --- |
| Tree height | Ember generation ratio | |
| DF/PP | DF/SB |
| When tree height is around 2.6 m | 0.37 | 0.18 |
| When tree height is around 3.8 m | 2.10 |  |
| When tree height is around 5.7 m | 2.69 |  |

1. Ember generation based on MC

Summary:

|  |  |  |  |
| --- | --- | --- | --- |
| **MC** | **Species** | **Number of firebrands** | **Ratio: DF/PP** |
| 40.1 | DF | 10611.4 | 2.19 |
| 41.7 | PP | 4847.2 |
|  |  |  | **Ratio: SB/PP** |
| 58.3 | PP | 4061.1 | 6.58 |
| 58.2 | SB | 26724.9 |

Note: There is no analysis about the effect of wind velocity for firebrand generation. The effect of wind is expected to be relatively small (compared to other parameters) because of the fairly wind speed.

According to Manzello et al. and Filkov et al. wind effect for firebrand generation is as below.

No wind = > 3.22 pcs/MW.s [Douglas fir]

Wind wind(2 m/s) = > (\_\_\_)pcs/MW.s [Pitch pine]

Fuel load comparison

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Vegetation Classification | Fuel | Understorey fuel load(t/ha) | Total fuel load(t/ha) | Vegetation height(m) |
| Forest | Eucalyptus | 25 | 35 | 30 |
| Scrub | Banksia | 25 | 25 | 3 |
| Mallee/Mulga | Acacia | 8 | 8 | 3 |
| Forest | Pitch pine (pinus rigida Mill.) | 20.6±7.02 | 46.84±7.9 | 14-22 |