Firebrand flux

**186 m**

**0 m**

**336m**

**FBP X**

**FBP Y**

**FBP Z**

**FCS X**

**FCS Y**

**FCS Z**

Fire line

Road

**336 m**

**162 m**

**300 m**

**250 m**

**150 m**

**100 m**

**50 m**

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| Wind profile before starting the fire. |
| Temperature profile after starting the fire. |

Fire line location: x= 186 m – 188 m

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| --- | --- |
| Trail | Total input number (pcs/s) |
| TR1 | 14 446 |
| TR2 | 10203 |
| TR3, TR4 | 9880 |

Firebrands landing time span in experiment

FCS X 407 s

FCS Y 513 s

FCS Z 394 s

Previous simulation **1500** mm grid

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| location | **Firebrand density (pcs/m2)** | | | **Diff%**  **Exp vs TR4** | **Flux (pcs/m2. s)** | | | **Diff%**  **Exp vs TR4** |
| Exp | **TR3** | **TR4** | **Exp** | **TR3** | **TR4** |
| FCS X | 335 | 260 | 285 | +14.9 | 0.824 | 0.776 | 0.700 | +15.1 |
| FCS Y | 463 | 478 | 487 | -05.1 | 0.902 | 0.931 | 0.950 | -05.3 |
| FCS Z | 536 | 738 | 571 | -06.5 | 1.361 | 1.377 | 1.451 | -06.6 |

Current simulation **750** mm grid

Prediction after **193** seconds

Total number of firebrands collected in the field experiment = 335+463+536

=1334

Total number of firebrands received at X,Y,Z in the simulation =285+487+571

=1343

Difference =[(1334-1343)/1334] x 100%

=-0.67%

Comparison of firebrand flux at X, Y and, Z location in the experiment and the simulation.

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| --- | --- | --- | --- | --- | --- | --- |
| **Area**  **(x 10-5)[m2]** | **Firebrand flux at collection sites (pcs)** | | | | | |
| **Experiment** | | | **Simulation** | | |
| **FCS X** | **FCS Y** | **FCS Z** | **FCS X** | **FCS Y** | **FCS Z** |
| **0.75 - 5** | 0.6483 | 0.6858 | 1.0473 | 0.697364 | 0.919257 | 1.087356 |
| **5 - 10** | 0.1034 | 0.1352 | 0.1873 | 0.001642 | 0.019453 | 0.219632 |
| **10 -20** | 0.0537 | 0.0618 | 0.0856 | 0.000545 | 0.007546 | 0.083238 |
| **20 -30** | 0.0054 | 0.0075 | 0.0236 | 0.000000 | 0.002889 | 0.038234 |
| **30 - 50** | 0.0081 | 0.0043 | 0.0118 | 0.000000 | 0.000369 | 0.010233 |
| **>50** | 0.0054 | 0.0075 | 0.0059 | 0.000000 | 0.000514 | 0.011933 |

Estimated number of firebrands landed on the collection points X, Y and Z during the collection times of 335 s, 463 s, 536 s

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| --- | --- | --- | --- | --- | --- | --- |
| **Area**  **(x 10-5)[m2]** | **Number of firebrands received by collection sites (pcs)** | | | | | |
| **Experiment** | | | **Simulation** | | |
| **FCS X** | **FCS Y** | **FCS Z** | **FCS X** | **FCS Y** | **FCS Z** |
| **0.75 - 5** | 264 | 352 | 413 | 284 | 472 | 428 |
| **5 - 10** | 42 | 69 | 74 | 1 | 10 | 87 |
| **10 -20** | 22 | 32 | 34 | 0 | 4 | 33 |
| **20 -30** | 2 | 4 | 9 | 0 | 1 | 15 |
| **30 - 50** | 3 | 2 | 5 | 0 | 0 | 4 |
| **>50** | 2 | 4 | 2 | 0 | 0 | 5 |
| **Total** | 335 | 463 | 536 | 285 | 487 | 572 |

Number of firebrands inputting vs time.

Firebrands accumulation on X, Y, Z collection sites.

Total input number of firebrands (193 s) = 632 384 pcs

Total landed number of firebrands at X, Y, Z locations (300 m2) = 17 821 pcs

Landing percentage =(17 821 pcs/632 384 pcs) x 100

=2.81%

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Heat release rate and mass loss rate

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Pitch pine forest

Average heat release rate (MW) = 2392 [122 s to 193 s]

Firebrands inputting rate (pcs/s) =9881

Total firebrands input from 130 s to 193 s (pcs) =632 384

Firebrands inputting rate vs fire intensity =

Douglas fir tree

Average heat release rate (MW) = 3.396 [11.6 s to 26.4 s: where HRR reached 300 kW]

Total firebrands’ input (pcs) =350 pcs within 32 seconds

Firebrands inputting rate (pcs/s) =23.33 pcs/s

Firebrands inputting rate vs fire intensity =

=

Forest fire simulations

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| --- | --- | --- | --- | --- | --- | --- |
| Case | Initial velo | Total pcs | Pcs/s vs MW | **Flux (pcs/m2. s)** | | |
| (UVW) | FCS X | FCS Y | FCS Z |
| TR1 |  | 14 446 | 6.039 | 0.076 | 0.937 | 3.027 |
| TR2 |  | 10 203 | 4.265 | 0.714 | 0.935 | 1.638 |
| TR3 | (0, 0, 2) | 9880 | 4.130 | 0.776 | 0.931 | 1.377 |
| TR4 |  | 9880 | 4.130 | 0.700 | 0.950 | 1.451 |

Comparison of single tree burning and forest fire variables

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| variable | Single tree | | | | | | Forest fir | | | | | | | |
| Wind (m/s) | No wind | | | | | | 12.18 U2 and 4.4 at fire line | | | | | | | |
| TMPA (0C) | 20 | | | | | | 13 | | | | | | | |
| RH (%) | 40 | | | | | | 22 | | | | | | | |
| Fuel |  | % | D(mm) | L(mm) | MPV(kg/m3) | |  | % | D(mm) | L(mm) | | | MPV(kg/m3) | |
| Needles | 65 | 3 | 100 | 4.208 | | Needles | 62 | 3.175 | 100 | | | 0.2915 | |
| Twig 1 | 17.5 | 3 | 100 | 1.133 | | twigs | 38 | 7.5 | 100 | | | 0.1783 | |
| Twig 2 | 17.5 | 8 | 100 | 1.133 | |  |  |  |  | | |  | |
| Density (kg/m3) | | | 571 | | | Density (kg/m3) | | | 787 (Needle), 512 (Twig) ref: | | | | |
| Conductivity(W/m.K) | | | 2.0 | | | Conductivity(W/m.K) | | | 0.1744 (N), 0.1737(T) | | | | |
| Specific heat (KJ/kg. K) | | | 1.2 | | | Specific heat (KJ/kg. K) | | | 1.691(N), 1.610 (T) | | | | |
| HOC (KJ/kg) | | | 17 700 | | | HOC (KJ/kg) | | | 18 700 | | | | |
| Moisture (%) | | | 10 | | | Moisture (%) | | | 55(N), 24(T) | | | | |
| tree | Height (m) | | | 2.6 | | | Height (m)  Understorey | | | | 18  1 | | | |
| girth (m) | | | 1.5 | | |
| Conical shape | | | | | | Cubic shape, built with individual particles | | | | | | | |
| firebrands | shape | | | Cylindrical | | | shapes | | | | | Cylinder, sphere, cube | | |
| Number of types | | | 30 | | | Number of types | | | | | 42 | | |
| Initial temperature (0C) | | | 200 | | | Initial temperature (0C) | | | | | 361 | | |
| Initial velocity (m/s) | | | 2.1 verti: | | 0.7 horiz: | Initial velocity (m/s) | | | | | 2.1 verti: | | 0.0 horiz: |
| Density (kg/m3) | | | 514 | | | Density (kg/m3) | | | | | Bark: 354 | | Needle: 389 |
| Fire intensity | HRRPUA (kW/m) | | | 136 | | | HRRPUA (kW/m) | | | | 9230 | | | |
| Release 30 KW by the burner. Average HRR = 3.396 MW after the tree ignition) | | | | | | Average HRR =2392 MW | | | | | | | |
| Collection pan | 0.5 m x 0.3 m | | | | | | 10 m x 10 m | | | | | | | |