Crown Scorch

Version 1.0

User’s Guide

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What is Crown Scorch?

Crown Scorch is a physical process model that predicts necrosis heights of tree crown components up to approximately 1 cm in diameter (Bi ≤ 0.2), i.e. small branches, buds, and foliage. This User’s Guide is intended to provide a brief introduction to the program and instructions for how to get started using the program. Users should also consult Michaletz and Johnson (2006a), which provides more detailed documentation, including model derivation and validation. Crown Scorch can be downloaded from http://pubs.nrc-cnrc.gc.ca/cgi-bin/rp/rp2_supp_e?cjfr_x06-158_cjfr11-06 and is available as freeware, provided that users cite the original publications by Michaletz and Johnson (2006a, 2006b).

Crown Scorch is written in Java, so in addition to the Crown Scorch application files you will need a Java Runtime Environment installed on your machine. If a Java Runtime Environment is not already installed on your machine, it will be automatically installed the first time you launch Crown Scorch (provided your machine has internet access). You can also manually download a Java Runtime Environment from http://www.java.com.

It should be noted that the term “crown scorch” is ambiguous and has an inconsistent definition in the literature. In the literature, “crown scorch” most commonly refers to foliage necrosis, because foliage necrosis is the easiest effect to estimate visually from the ground. However, the term has also referred to branch and bud necrosis. Here, “crown scorch” is defined as the necrosis of any tree crown component, including small branches, buds and foliage under approximately 1 cm in diameter (Bi ≤ 0.2). In order to get the most functionally relevant crown scorch predictions, particular crown components should be identified, e.g., foliage necrosis rather than crown scorch.

Crown Scorch includes parameter estimates for buds of twelve tree species and foliage of two tree species. These parameter estimates should be used with caution, because the thermal properties (hA/ρcV) for both buds and foliage are strongly affected by phenology. The estimates included for *Picea glauca* and *Pinus contorta* buds are means calculated from samples collected in the eastern Canadian Rocky Mountains from May to October 2004. The estimates included for *Pinus sylvestris* and *Populus tremuloides* buds are means calculated from samples collected in the eastern Canadian Rocky Mountains during April 2003. The estimates included for *Acer saccharum*, *Carya ovata*, *Fagus grandifolia*, *Quercus alba*, *Quercus ellipsoidalis*, *Quercus macrocarpa*, *Quercus rubra*, and *Tilia americana* buds are means calculated from samples collected at the University of Wisconsin – Madison Arboretum during October 2003. The estimates included for *Picea glauca* and *Pinus sylvestris* foliage are means calculated from samples collected on the University of Calgary campus during March 2005.

In order to make the most accurate predictions, it is recommended that you enter custom parameter estimates for crown components from the stand, date, and phenological stage for which predictions are desired. Methods of estimating parameters for a forest canopy are outlined in Michaletz and Johnson...
To use custom parameter estimates, Crown Scorch requires inputs of diameter, wetted (convective) surface area, fresh mass, and oven dried mass. Thermal properties $hA/\rho cV$ are then calculated by Crown Scorch using the methods outlined in Michaletz and Johnson (2006a). Calculations are simplified by recognizing that $hA/\rho cV = hA/mc$, where $m$ is the fresh mass. Diameter (for calculation of $h$; Michaletz and Johnson 2006b) and surface area $A$ can be easily measured using a flatbed scanner and digital imaging software (e.g. WinSEEDLE™, Regent Instruments Inc., http://www.regentinstruments.com).

Foliage reduces rates of convection to crown components which will reduce necrosis heights. Crown Scorch also allows users to include this “shielding” effect. The current version (1.0) allows users to use foliage from *Picea glauca* or *Pinus contorta* (Michaletz and Johnson 2006b).

It should be noted that Crown Scorch makes simplifying assumptions about several other model parameters, e.g. vertical plume velocity $U = 5.0 \text{ m s}^{-1}$. Users who wish to change these values should use the models reported in Michaletz and Johnson (2006a).
How to Use Crown Scorch

Crown Scorch includes parameter estimates for predicting necrosis heights of buds of twelve tree species and foliage of two tree species. These bud and foliage crown components can also be “shielded” by foliage of two tree species. Users can also enter custom parameter estimates for branches, buds, and foliage up to approximately 1 cm in diameter ($B_i \leq 0.2$). The latter option is encouraged, since results will vary with site conditions and phenological stage (Michaletz and Johnson 2006a).

Using Crown Scorch with included parameter estimates:

1. From the Crown Scorch window, select your desired **Species** from the drop-down menu.

   ```
   (Select)
   (Select)
   Acer saccharum (sugar maple)
   Carya ovata (shagbark hickory)
   Fagus grandifolia (American beech)
   Picea glauca (white spruce)
   Pinus contorta (lodgepole pine)
   Pinus sylvestris (Scots pine)
   Populus tremuloides (trembling aspen)
   (Select)
   ```

   Parameter estimates are included for buds of *Acer saccharum*, *Carya ovata*, *Fagus grandifolia*, *Picea glauca*, *Pinus contorta*, *Pinus sylvestris*, *Populus tremuloides*, *Quercus alba*, *Quercus ellipsoidalis*, *Quercus macrocarpa*, *Quercus rubra*, and *Tilia americana* and foliage of *Picea glauca* and *Pinus contorta*. Please see the help section “What is Crown Scorch?” for more information.

2. Select your desired **Crown Component** from the drop-down menu. Crown Scorch includes parameter estimates for vegetative buds and foliage. You will be unable to select Foliage if parameter estimates are not available for the species you selected in step 1.

   ```
   Vegetative Buds
   Vegetative Buds
   Foliage
   ```
3. You can apply the “shielding” effects of foliage to your Crown Component. Crown Scorch currently includes convection correlations for *P. glauca* (white spruce) and *P. contorta* (lodgepole pine). To “shield” your crown component with foliage from one of these species, select the appropriate species from the **Foliage** box. If you are interested in a dormant or otherwise leafless Crown Component, select (None) from the drop-down menu.

<table>
<thead>
<tr>
<th>(None)</th>
<th>(None)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picea glauca (white spruce)</td>
<td>Pinus contorta (lodgepole pine)</td>
</tr>
</tbody>
</table>

4. Enter your desired ambient temperature and select the appropriate units (°C or °F) from the drop-down menu.

5. Enter the fireline residence time in seconds.

6. You can run up to four simulations at one time. If you would like to run additional simulations, repeat steps 1 through 5.

7. To run the models, click the **Run** button at the bottom of the Crown Scorch window.

8. To restore default values to all of the drop-down menus, click the **Reset** button at the bottom of the Crown Scorch window.

**Using Crown Scorch with custom parameter estimates:**

1. If Crown Scorch does not include parameter estimates for your desired tree species, select (custom) from the **Species** drop-down menu. A new row will appear that will allow you to parameterize Crown Scorch for your desired crown component or species.
2. Follow steps 3 through 7 above. Be sure to indicate what type of Crown Component you are using, because this will change the specific heat capacity value used in the simulation. You can apply *P. glauca* (white spruce) or *P. contorta* (lodgepole pine) Foliage, or simulate a leafless Crown Component (None).

3. For your desired Crown Component, enter the Diameter, Wetted Surface Area, Mass (Fresh), and Mass (Oven Dry). These should ideally be mean values sampled from the stand canopy (see Michaletz and Johnson 2006a for more information). Select the appropriate units for each measurement from drop-down menus. Crown Scorch will automatically calculate $hA/\rho cV$ as described in Michaletz and Johnson (2006a).

To save the settings of an analysis:

1. From the Crown Scorch window, click File, and then click Save.
2. In the Filename field, type in the path to the file, a name for the file (or keep the current name), and then click **Save**.

3. Double-click the folder where you would like to save the file, and then click **Save**.

4. Your current settings will be saved as a Crown Scorch settings file (*.csc).

**To open a saved Crown Scorch settings file (*.csc):**

1. From the Crown Scorch window, click **File**, and then click **Open**.

2. In the **Look in** list, click the drive, folder, or Internet location that contains the file you want to open.

3. In the folder list, locate and open the folder that contains the file.

4. Click the file, and then click **Open**.

5. Your saved Crown Scorch settings will be displayed and the models can be run or reset.

**Displaying and saving your results:**

1. Crown Scorch will automatically display your results after running the simulation(s). Results can be displayed as Figures (Necrosis height vs. Fireline intensity and Necrosis height vs. Fireline intensity^{2/3}) or a Table (Fireline intensity, Fireline intensity^{2/3}, and Necrosis height). You can switch between **Figures** or **Table** by clicking the tabs at the top of the Results window.
2. Below the figures, Crown Scorch will display the tree species, crown component, foliage type (shielding), and power-law function (relating necrosis height $z_n$ and fireline intensity $I$) for each simulation.

<table>
<thead>
<tr>
<th>Model</th>
<th>Tree Species</th>
<th>Crown Component</th>
<th>Foliage Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Acer saccharum (sugar maple)</td>
<td>Vegetative Buds</td>
<td>(None)</td>
</tr>
<tr>
<td>Equation</td>
<td>$z_n = 0.20036662 \cdot I^n$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Picea glauca (white spruce)</td>
<td>Foliage</td>
<td>Picea glauca (white spruce)</td>
</tr>
<tr>
<td>Equation</td>
<td>$z_n = 0.14549817 \cdot I^n$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Pinus sylvestris (Scots pine)</td>
<td>Vegetative Buds</td>
<td>Pinus contorta ( lodgepole pine)</td>
</tr>
<tr>
<td>Equation</td>
<td>$z_n = 0.13161929 \cdot I^n$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Fagus grandifolia (American beech)</td>
<td>Vegetative Buds</td>
<td>(None)</td>
</tr>
<tr>
<td>Equation</td>
<td>$z_n = 0.23679757 \cdot I^n$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. Below the table, Crown Scorch will display the tree species, crown component, and foliage type (shielding) for each simulation.

<table>
<thead>
<tr>
<th>Fireline intensity (kW/m²)</th>
<th>Fireline intensity (%)</th>
<th>Necrosis height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1</td>
<td>Model 2</td>
</tr>
<tr>
<td>50</td>
<td>13.672088</td>
<td>2.7162718</td>
</tr>
<tr>
<td>1000</td>
<td>100.0</td>
<td>20.013662</td>
</tr>
<tr>
<td>1500</td>
<td>131.03706</td>
<td>20.228315</td>
</tr>
<tr>
<td>2000</td>
<td>156.74011</td>
<td>31.769789</td>
</tr>
<tr>
<td>2500</td>
<td>184.20157</td>
<td>36.80548</td>
</tr>
</tbody>
</table>

Model 1  Acer saccharum (sugar maple)  Crown Component: Vegetative Buds  Foliage: (None)
Model 2  Picea glauca (white spruce)  Crown Component: Foliage  Foliage: Picea glauca (white spruce)
Model 3  Pinus sylvestris (Scots pine)  Crown Component: Vegetative Buds  Foliage: Pinus contorta (lodgepole pine)
Model 4  Fagus grandifolia (American beech)  Crown Component: Vegetative Buds  Foliage: (None)

4. You can print the active Figures or Table by clicking the **Print** button near the bottom of the Results window. Printing your results may occasionally obscure the Figure axis labels (this is a bug in the Java Runtime Environment). If this happens, you can restore the axis labels by minimizing and maximizing the Results window.

5. You can save the active Figures or Table by clicking the **Save** button near the bottom of the Results window. In the Filename field, type in the path to the file, a name for the file (or keep the current name), and then click **Save**. Double-click the folder where you would like to save the file, and then click **Save**.
6. Figures will be saved as JPEG image files (*.jpg). These figures can be imported into word processing or graphics programs.

7. Tables will be saved as tab-delimited text files (*.txt). Tab-delimited text files (*.txt) can be easily imported into spreadsheets or graphics programs for making custom figures.

References:
