Introducing the Canopy Fuel Stratum Characteristics Calculator

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Cruz et al. (2003) developed regression equations for estimating canopy base height (CBH), canopy fuel load (CFL) and canopy bulk density (CBD) for use in assessing crown fire potential in four broad coniferous forest fuel types found in western North America.
The Cruz et al. (2003) regressions for estimating the CBH, CFL and CBD of these fuel types have recently been evaluated for their performance*.

A simple software application (i.e., an excel spreadsheet) of the Cruz et al. (2003) equations has recently been developed.

* Cruz, M.G.; Alexander, M.E. Evaluating regression model estimates of canopy fuel stratum characteristics in four fuel types in western North America. Accepted for publication in the International Journal of Wildland Fire (subject to revision) 6 October 2010.
The main features of the **Canopy Fuel Stratum Characteristics Calculator** are:

- Provides for both SI or metric and English unit inputs/outputs.

- Given three user inputs (i.e., stand area basal area, average stand height and stand density), CBH, CFL and CBD are automatically calculated for one of the four fuel types.

- Cautionary “pop-up” messages for input values that exceed a maximum reliable value.
Cruz, Alexander and Wakimoto (2003)

Canopy Fuel Stratum Characteristics Calculator
Version 1.0 - October 2010

Canopy fuel stratum characteristics determine to a large extent the behavior of crown fires. By linking an extensive forest stand database with foliage dry weight allometric equations, we developed regression equations to estimate the following canopy fuel stratum characteristics:1:
- Canopy base height (CBH)
- Canopy fuel load (CFL)
- Canopy bulk density (CBD)

Equations are available for the following fuel types that commonly occur in western North America:
- Ponderosa Pine
- Lodgepole Pine
- Douglas-Fir
- Mixed Conifer

The Cruz et al. (2003) regressions for estimating the CBH, CFL and CBD of these four fuel types are included within the present software. The outputs will serve as inputs in predicting crown fire behavior potential using, for example, the Crown Fire Initiation and Spread (CFIS) software[2].

### SI or Metric Unit Input/Output Example

**Cruz, Alexander and Wakimoto (2003)**  
**Canopy Fuel Stratum Characteristics Calculator**  
**Version 1.0 - October 2010**

**Inputs:**
- **Step 1:** Select Unit System  
  - SI
- **Step 2:** Select Fuel Type  
  - Ponderosa Pine
- **Step 3:** Input Stand Basal Area (m²/ha)  
  - 25
- **Step 4:** Input Average Stand Height (m)  
  - 15
- **Step 5:** Input Stand Density (trees/ha)  
  - 1000

**Outputs:**
- Canopy Base Height (m)  
  - 7.3
- Canopy Fuel Load (kg/m²)  
  - 0.96
- Canopy Bulk Density (kg/m³)  
  - 0.29
## English Unit Input/Output Example

### Cruz, Alexander and Wakimoto (2003)
Canopy Fuel Stratum Characteristics Calculator
Version 1.0 - October 2010

**Inputs:**
- **Step 1:** Select Unit System
  - English
- **Step 2:** Select Fuel Type
  - Ponderosa pine
- **Step 3:** Input Stand basal area (ft²/ac)
  - 309
- **Step 4:** Input Average Stand Height (ft)
  - 49
- **Step 5:** Input Stand Density (trees/ac)
  - 405

**Outputs:**
- Canopy Base Height (ft)
  - 2.2
- Canopy Fuel Load (tons/ha)
  - 0.19
- Canopy Bulk Density (lb/ft³)
  - 0.02
Example of a CAUTION Message for Exceeding Reliable Input Value

<table>
<thead>
<tr>
<th>Step</th>
<th>Input/Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Select Unit System</td>
</tr>
<tr>
<td>2</td>
<td>Select Fuel Type</td>
</tr>
<tr>
<td>3</td>
<td>Input Stand Basal Area (m²/ha)</td>
</tr>
<tr>
<td>4</td>
<td>Input Average Stand Height (m)</td>
</tr>
<tr>
<td>5</td>
<td>Input Stand Density (trees/ha)</td>
</tr>
<tr>
<td>6</td>
<td>Canopy Base Height (m)</td>
</tr>
<tr>
<td>7</td>
<td>Canopy Fuel Load (kg/m²)</td>
</tr>
<tr>
<td>8</td>
<td>Canopy Bulk Density (kg/m³)</td>
</tr>
</tbody>
</table>

Caution! The maximum value in the original database used to develop the regression equation was approximately 20 m.
Maximum Reliable Input Values in the Canopy Fuel Stratum Characteristics Calculator

<table>
<thead>
<tr>
<th>Conifer fuel type</th>
<th>Basal area (m²/ha)</th>
<th>Stand height (m)</th>
<th>Stand density (no./ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ponderosa pine</td>
<td>40</td>
<td>1-20</td>
<td>3000</td>
</tr>
<tr>
<td>Lodgepole pine</td>
<td>50</td>
<td>3-20</td>
<td>4000</td>
</tr>
<tr>
<td>Douglas-fir</td>
<td>55</td>
<td>2-25</td>
<td>3000</td>
</tr>
<tr>
<td>Mixed conifer</td>
<td>70</td>
<td>3-25</td>
<td>4000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Conifer fuel type</th>
<th>Basal area (ft²/acre)</th>
<th>Stand height (ft)</th>
<th>Stand density (no./acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ponderosa pine</td>
<td>175</td>
<td>60</td>
<td>1200</td>
</tr>
<tr>
<td>Lodgepole pine</td>
<td>220</td>
<td>80</td>
<td>1200</td>
</tr>
<tr>
<td>Douglas-fir</td>
<td>240</td>
<td>80</td>
<td>1200</td>
</tr>
<tr>
<td>Mixed conifer</td>
<td>300</td>
<td>80</td>
<td>1600</td>
</tr>
</tbody>
</table>
The Canopy Fuel Stratum Characteristics Calculator can be downloaded from the FRAMES website.
Canopy Fuel Calculations: Homework #3

Your fuels crew was able to inventory three different areas in the Black Hills, S.D. over the past month. Each of these areas has been selected as a potential for thinning operations to reduce the risk of crown fire hazard. All surface fuel calculations have been completed, but the canopy fuels have not be calculated as of yet. I have provided you with an excel spread sheet which contains 3 workbooks. The first one is labeled load over depth, the 2nd Cruz and the third canopy profile.

The **Canopy Fuel Stratum Characteristics Calculator** was informally tested by a group of undergraduate students at the University of Idaho in April 2010 as part of a fire management course exercise.

According to their instructor, Chad Hoffman, “The class really liked the calculator. They thought it was easy to use and very straight forward … Several of the students decided to recommend this approach in the fuels inventory plan they are developing …”.

- Estimate the canopy bulk density using the biomass percentile load over depth method.
- Estimate the canopy bulk density as the highest 9 foot running mean
- Estimate the canopy base height as the point where at least 0.011 kg/m² occurs.

Present your Canopy bulk density estimates and canopy base height estimates in a table.

Reminder: make sure you have all table and figures correctly labeled with a title.
For further information or questions about the **Canopy Fuel Stratum Characteristics Calculator** contact:

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- Miguel G. Cruz, CSIRO Bushfire Dynamics and Applications, Canberra, Australia: Miguel.Cruz@csiro.au

The **Canopy Fuel Stratum Characteristics Calculator** is a product in part of the Joint Fire Science Program Project JFSP 09-S-03-1