

## **AN ENHANCED ONLINE *PILED FUELS BIOMASS CALCULATOR***

Final Report to the Joint Fire Science Program

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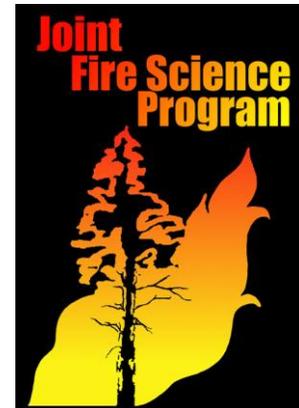
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### **ABSTRACT:**

A web-programming project was undertaken to allow users of the online *Hand-piled Fuels Biomass Calculator* to also estimate the volume, biomass and potential emissions of mechanically piled fuels. Machine pile calculations encoded in the decision support software CONSUME 3.0 were added to the online *Calculator* to achieve this objective. In addition, the ability to batch process piled fuels data was added to the online *Calculator* to ease data input for large analysis projects. A stand-alone version of the *Calculator* was developed for users without access to the Internet. As it is executed within a standard web browser (e.g., Microsoft Internet Explorer, Mozilla Firefox, etc.)<sup>1</sup>, the *Calculator* can be used on any device capable of running browser software (e.g., personal computer, netbook PC, smart phone, etc.).

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<sup>1</sup> The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.



**BACKGROUND AND PURPOSE:**

In 2007 the Joint Fire Science Program funded the Fire and Environmental Research Applications (FERA) team of the U.S. Forest Service (JFSP#: 07-2-1-57; PI: Clinton S. Wright) to undertake a field-based project with the objective of developing a tool to characterize hand-piled fuels as a means of improving estimates of biomass and smoke emissions (Wright et al. 2010a). This project was selected, in part, because it addressed research priorities and recommendations put forth by participants in the JFSP Biomass Roundtable held in Midway, UT in January, 2007 (Joint Fire Science Program, Biomass Roundtable, Research Needs Assessment). A deliverable of this project was an online calculator accessible to all prospective users for estimating the volume and biomass of hand-constructed piles, and the potential emissions when those piles are burned (<http://depts.washington.edu/nwfire/handpiles/>).

The *Hand-piled Fuels Biomass Calculator* (Wright et al. 2010b) was released for use in the spring of 2009 and has been presented to groups of fire and fuels professionals at a number of joint-agency training workshops. The research findings and a brief demonstration of the *Calculator* were also presented to a re-convened JFSP Biomass Roundtable (Biomass Roundtable II) in Boise, Idaho in November, 2009. At the close of the presentation to the Biomass Roundtable II in Boise, several potential future RD&A needs were suggested, including incorporation of machine pile calculation algorithms (*sensu* Hardy 1996, Prichard et al. no date) into the online *Calculator* to provide users the flexibility to characterize biomass and emissions of both hand- and machine-piled fuels with a single tool. In addition, several Roundtable participants expressed interest in adding functionality to the online *Calculator*. In total three specific items were suggested: (1) incorporation of the machine-pile algorithms presently available in CONSUME 3.0 (Tim Swedberg, National Interagency Fire Center, Joint Fire Science Program), (2) the ability to batch process pile data for biomass and emissions estimates (Mark Fitch, National Interagency Fire Center, National Park Service), and (3) the ability to operate the *Calculator* while disconnected from the Internet (several participants).

**STUDY DESCRIPTION:**

The online *Hand-piled Fuels Biomass Calculator* was enhanced to include calculation algorithms for machine piles that are currently embedded in CONSUME 3.0 (Hardy 1996, Prichard et al. no date). This new tool, re-named the *Piled Fuels Biomass and Emissions Calculator*, now also allows users to batch process their pile data by uploading an appropriately formatted input file. A desktop version of the *Calculator* that uses the MicroWeb server emulator was also developed.

**KEY FINDINGS:**

The resulting enhanced online *Calculator* maintains the simplicity of the original, hand-pile-only version while adding the capacity to characterize machine-piled fuels (Figure 1) and batch process inputs from projects with multiple piles simultaneously. In addition a

**Piled Fuels Biomass and Emissions Calculator**

1. You have selected **English** units. [Reset (clear piles and start over)]

2. Add Pile Group of Pile Type:  Hand  Machine

Describe this pile group:

Pile group name:

Number of piles:

Pile shape:  Half sphere  Paraboloid  Half cylinder  Half-frustum of cone  Cone w/ rounded ends  Half ellipsoid  Irregular solid

Pile dimensions (ft):

W1:  W2:

H1:  H2:

L1:  L2:

Estimated pile volume that is soil:  %

Packing ratio:

1. 10%: Piles with species content dominated by long-needled pines and/or broadleaf deciduous litter. Mean diameters of large woody fuels < 10 inches.

2. 20%: Piles dominated by short-needled conifers. Mean diameters of large woody fuels < 10 inches.

3. 25%: Highly compacted, clean piles with large logs (diameters > 10 inches), especially those built with a crane or loader.

Pile composition:

Primary species (wood density in lb/ft<sup>3</sup>):   %

Secondary species (wood density in lb/ft<sup>3</sup>):   % } percents must sum to 100%

Pile quality:  Clean (0% soil)  Dirty (>0 - 10% soil)  Very dirty (>10% soil)

Consumption:  % of piled material

OR browse to csv file template for batch option:

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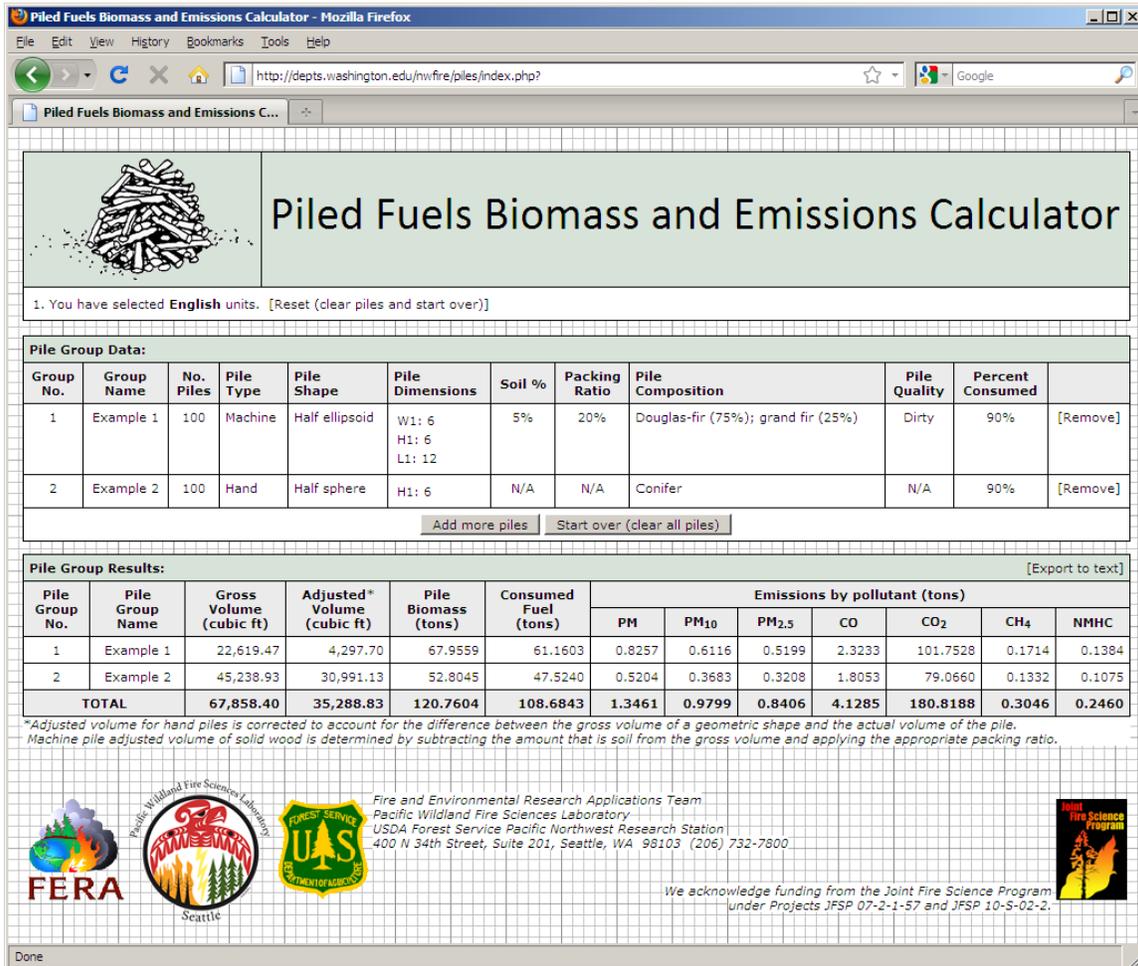
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**Figure 1.** Screen capture of machine pile data entry screen. Data inputs are comparable to those found in CONSUME 3.0.

stand-alone version is available for users who required access to the *Calculator* in a field setting or where Internet access is unavailable.

Fire and fuels managers now have the ability to characterize the volume, biomass and potential emissions of both hand- and machine-constructed piles with a single application. Input data can be entered manually through the graphical user interface, or in a batch mode by uploading a properly formatted text file. Data inputs and calculation results are available within the user interface (Figure 2), and also in a downloadable format for reporting and archiving.

A comprehensive list of wood density and specific gravity values for North American species and for several internationally important species was compiled and incorporated into the machine pile calculation algorithms using data in Miles and Smith (2009). This represents an update to the machine pile characterization capabilities of CONSUME 3.0 that the enhanced *Calculator* was developed to emulate.



**Figure 2.** Screen capture of pile calculation results screen. Users can input as many unique pile groups as needed. Data inputs and results can be exported to a text file for reporting and archiving.

During informal discussions, current and prospective users have expressed interest in using the online *Calculator* to estimate biomass in piles for commercial/industrial utilization operations (i.e., sales of forest operations debris for biomass energy utilization). Although not developed with this end-use in mind, should this prove to be a viable and useful tool for this purpose, the original RD&A project may deliver benefits above and beyond its originally intended application, in large part owing to the simplicity and ease of use of the application that was developed.

## **MANAGEMENT IMPLICATIONS:**

Regulations in Oregon, Washington and several other Western states require prescribed fire practitioners to estimate emissions from prescribed burning activities, including burning piled debris. Emissions predictions require estimates of preburn pile biomass (see Hardy et al. 2001 for a thorough discussion of fire and smoke management and regulation), therefore, it is important that fuel managers and air quality regulators have the tools necessary to accurately estimate the volume and biomass of all types of piled fuels to better estimate emissions from pile burning activities to address both mitigation and regulatory compliance. This project developed a tool to simplify the work processes of fuel managers tasked with managing fire hazard and air quality.

Like the calculator developed for estimating hand-pile biomass and emissions, the enhanced *Calculator* produced for this development project is executed by using standard web browser software (e.g., Microsoft Internet Explorer, Mozilla Firefox, etc.) so no software installation is necessary.<sup>2</sup> Users will always have the most up to date version for use at their disposal. Furthermore, since the *Calculator* is executed within a standard web browser, it can be used on any device capable of running any commercially available browser software, such as a personal computer, netbook PC, or smart phone, for example.

The addition of a batch processor will also allow users to more quickly and easily characterize piled fuels and to assess potential cumulative smoke impacts from pile burning activities where piles of many different types are present, or where multiple pile burning projects are being considered. The ability to determine the biomass of multiple different pile types using simple measurements and inputs may be useful for planning concerning biomass energy, carbon management, and hazardous fuels reduction.

## **RELATIONSHIPS TO OTHER RECENT FINDINGS AND ONGOING WORK:**

This project grew out of the JFSP Biomass Roundtable and a subsequently funded field study to quantify hand piles (JFSP#: 07-2-1-57). Trends towards web-based applications, including the JFSP's own Interagency Fuels Treatment Decision Support System (IFT-DSS), suggested that the initial web-based tool intended to help fuel managers estimate the biomass and emissions of hand-piled fuels for improved smoke-management planning, which was designed to accommodate only a relatively narrow scope of analysis, could provide added value and benefit with further development.

Two ongoing software development efforts will utilize a version of the enhanced *Piled Fuels Biomass and Emissions Calculator* developed for this project. Dr. Nancy French

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<sup>2</sup> It is necessary to copy a small piece of software to the local device to run the *Calculator* in stand-alone mode when disconnected from the Internet. An application called MicroWeb, a web emulator, is simply copied to the user's hard disk as one would copy a document or spreadsheet file. MicroWeb is not "installed" in the manner typical of commercial software.

(Michigan Tech Research Institute) is working to develop software tools for inventorying carbon emissions from wildfires for North America (<http://www.mtri.org/fire.html>), and Dr. Roger Ottmar (U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Pacific Wildland Fire Sciences Laboratory) is leading the integration of several fuel and smoke-management tools (Fuel Characteristic Classification System, CONSUME 3.0, Fire Emissions Production Simulator). The integration of FCCS, CONSUME 3.0, and FEPS is a technical cousin of the JFSP IFT-DSS. The enhanced *Calculator* is being translated from its current form in PHP to Python so that it will integrate with both of the above-mentioned software development efforts more readily.

#### **FUTURE WORK NEEDED:**

*Pile Characteristics* – Only limited research has been conducted to characterize and estimate the physical properties of piled fuels (e.g., Hardy 1996; Johansen 1981; Little 1982; McNab 1980, 1981; McNab and Saucier 1980; Wright et al. 2010a). Additional research is needed to characterize piles composed of material that has heretofore not been studied. For example, it appears that the relationships developed by Wright et al. (2010a) for hand-piled pre-commercial thinning debris and understory brush are not adequate when hand piles are constructed of large-diameter (>30 cm) logs (Hubbert et al. 2010).

Additional research is necessary to investigate the feasibility and validity of using the current pile characterization algorithms to estimate biomass for commercial/industrial piled forest debris removal and bio-energy operations.

*Pile Burning Effects* – As with research to characterize the physical properties of piled fuels, only minimal research has been conducted to evaluate combustion properties and ecological effects of burning piled material (e.g., Covington et al. 1991, Ghuman and Lal 1989, Johnson 1984, Seymour and Tecle 2005, Sikes and Muir 2009). Little is known about how different pile characteristics (size, age, composition) affect combustion rate and duration; soil structure and nutrition; and vegetation injury and response.

*Application Development* – This project added functionality to an existing application (i.e., the original *Hand-piled Fuels Biomass Calculator*; Wright et al. 2010b). Further application development to improve user interfaces, calculations, and outputs could be conceived and implemented as management and regulatory demands dictate. Furthermore, as new data are collected that are relevant to the topic, new scientific developments should be added to the existing applications to improve the accuracy, precision, and resolution of model results. For example, research to quantify combustion rates and duration could be integrated with current estimates of total emissions to more robustly model potential smoke and air quality impacts over the course of one or more burning periods.

The enhanced *Calculator* developed for this study was written in the Hypertext Preprocessor (PHP) scripting language. Translating existing applications into programming languages, such as Python or Java, could increase the ease with which quantities associated with piled fuels are incorporated into different decision support frameworks (e.g., IFT-DSS, Fire and Fuels Application, BlueSky).

#### **DELIVERABLES:**

The Enhanced Online *Piled Fuels Biomass Calculator* project was proposed as an eight month programming effort to add functionality to an existing web-based application. Proposed and delivered products are reported in Table 1. Programming to incorporate the machine pile calculation functions of CONSUME 3.0 has been completed. The enhanced *Calculator* is available at <http://depts.washington.edu/nwfire/piles> with a link from the U.S. Department of Agriculture, Forest Service, Fire and Environmental Research Applications (FERA) web page (<http://fs.fed.us/pnw/fera/piles>). Included in the new *Piled Fuels Biomass and Emissions Calculator* is a batch processing function that allows users to enter data for multiple piles into a simple template that uploads the required inputs for multiple, simultaneous pile biomass and emissions calculations. A stand-alone version of the *Calculator* is also available for download from the FERA web page. Although not part of the proposed scope of work, the enhanced *Calculator* is being translated into the Python programming language so that it can be more readily incorporated into other fire, fuels, and air quality decision support tools and research applications.

In addition to the proposed software deliverables, to date the enhanced *Calculator* has been presented to and demonstrated for fire and fuels managers and planners on four occasions:

1. Forty-five participants at the *Suite of Fuel Management Tools* training workshop at the International Association of Wildland Fire, 3<sup>rd</sup> Fire Behavior and Fuels Conference in Spokane, WA on October 25, 2010.
2. Thirty participants at the U.S. Department of Agriculture, Forest Service, Region 3, Rx 410 Smoke Management training in Tucson, AZ on November 2, 2010.
3. Fifteen participants at the *Demonstration Workshop for Several Decision Support Tools for Fuels Management* training workshop at the Tahoe Science Consortium, Symposium on Forest Management Decision Support Tools in Incline Village, NV on November 5, 2010.
4. Fire and Aviation staff of the U.S. Department of Agriculture, Forest Service, Pacific Northwest Region/Bureau of Land Management Oregon State Office in Portland, OR on December 1, 2010.

**Table 1.** Proposed and delivered products for the Enhanced Online *Piled Fuels Biomass Calculator* project.

<b>Proposed</b>	<b>Delivered</b>	<b>Status</b>
Add machine pile calculations to online calculator	Enhanced online <i>Piled Fuels Biomass and Emissions Calculator</i> (depts.washington.edu/nwfire/piles)	Complete
Develop a stand-alone version of online calculator	Desktop <i>Piled Fuels Biomass and Emissions Calculator</i> (available for download from: <a href="http://www.fs.fed.us/pnw/fera/research/smoke/piles">www.fs.fed.us/pnw/fera/research/smoke/piles</a> )	Complete
Pile biomass and emissions batch processing capabilities	Batch <i>Piled Fuels Biomass and Emissions Calculator</i> input template and upload capability	Complete
	Python <i>Piled Fuels Biomass and Emissions Calculator</i> calculation module	In progress
	Four presentations/demonstrations to fire and fuels managers	Complete

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