FVS-OpCost: A New Forest Operations Cost Simulator Linked with FVS

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Abstract

Increasing wildland-urban interface has pressured land managers to find innovative and cost-efficient ways to reduce the threat from wildfire. Accomplishing this task will require a suite of management tools designed to account for a variety of geospatial and forest stand characteristics present on the landscape, providing accurate cost estimates on which to base their decisions. We are developing an expanded forest fuels treatment cost analysis program that enhances the capabilities of the Fuels Reduction Cost Simulator (FRCS) (Hartsough et. al. 2006). FRCS has been reprogrammed in R and linked directly to the Forest Vegetation Simulator (FVS) (Dixon 2002) and the BioSum model (Fried and Christensen 2004). The new version of FRCS is called FVS-OpCost. FVS-OpCost makes it possible to choose between different harvest systems, and incorporates new production and cost equations from recently published literature. Gaps in the model are being filled with production and cost equations from recent literature. This work will deliver a finished product capable of interacting with BioSum and FVS, while covering a greater range of treatment options and cost algorithms, and improving the utility of the programs. After linking BioSum to FVS-OpCost, an array of simulations will be evaluated to characterize and map the cost-effectiveness of fuel treatments over the Pacific Northwest using the Forest Inventory Analysis (FIA) and other inventory data. The new simulator will also be able to simultaneously simulate a variety of prescription options and create cost estimations for future treatments, comparing real and ideal equipment options by region.

Keywords: Modelling, Fuel Treatment, Programming, Simulation

Introduction: Fires play an important role in North American forests. Fire events fundamentally shape the ecosystem and the communities within them. Some systems have naturally occurring fire intervals that can be allowed to run their course without interference, but in other environments (i.e. the wildland urban interface), fires need to be controlled. In post-World War II America, this control has traditionally come through reacting to and suppressing active wildfires. It is now known that this effective system of wildfire suppression has allowed forest fuels to accumulate unnaturally, resulting in catastrophic wildfires (Agee and Skinner 2005). One method that has been developed within the last few decades to address the accumulated fuel loading is an active reduction or manipulation of the pre-fire biomass within a forested stand. This practice is becoming increasingly common, motivated by evolving fire management practices and a better understanding of the benefits (Reinhardt et al. 2008). In many circumstances, it is cheaper, safer, and environmentally advantageous to treat the fuel loading in the stand before a fire occurs, rather than react to a wildfire with the full amount of available fuel to burn (Jain et al. 2012).

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It has been demonstrated that manipulating the fuel loading in a forest stand prior to a wildfire event can reduce the fire intensity, which reduces the impact on tree mortality, offers greater control opportunities, and increases firefighter safety (Jain et al. 2012). However, these treatments can be expensive and forest managers need to understand the cost benefit associated with them (McHugh 2006). Often times, it can be difficult to estimate the cost of these treatments because of the variety of equipment, treatment methods, and biotic and abiotic variables (Robichaud and Ashmun 2013). Moreover, the extent to which costs change through the course of stand development, and the relative cost-effectiveness of fuel treatments, is poorly understood.

One of the most commonly used cost simulation programs, the Fuels Reduction Cost Simulator (FRCS), provides effective estimates, but is due for improvement through the inclusion of updated algorithms and machine data. Further, coding of FRCS in an open source platform such as R and linking it with FVS will both expand the model's existing capabilities and make it available to a wider audience. We refer to this new simulation program as FVS-OpCost, because the model includes algorithms that estimate logging costs associated with silvicultural prescriptions within FVS as part of stand growth projections, and provides automated routines for choosing among available equipment options. The stand-alone version of FVS-OpCost will also incorporate a user-friendly graphical user interface (GUI) to make running the simulations as simple as possible.

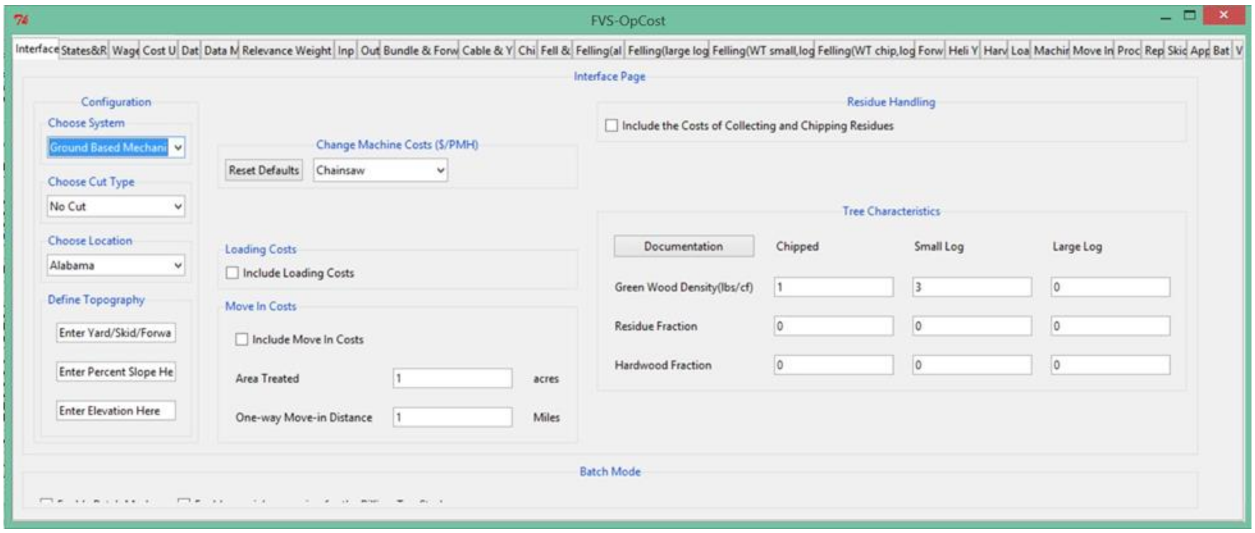

Figure 1. The R FVS-OpCost GUI closely resembles the existing FRCS GUI, but is being linked directly with FVS

Objectives: Our primary research objective in this work is for FVS-OpCost to operate as a flexible, advanced cost simulator with the latest mechanized forestry systems incorporated into the FVS and BioSum models. Integrating FRCS into FVS will make it possible to estimate the net present value (NPV) of multiple future treatment alternatives, coupled with stand growth and yield projections.

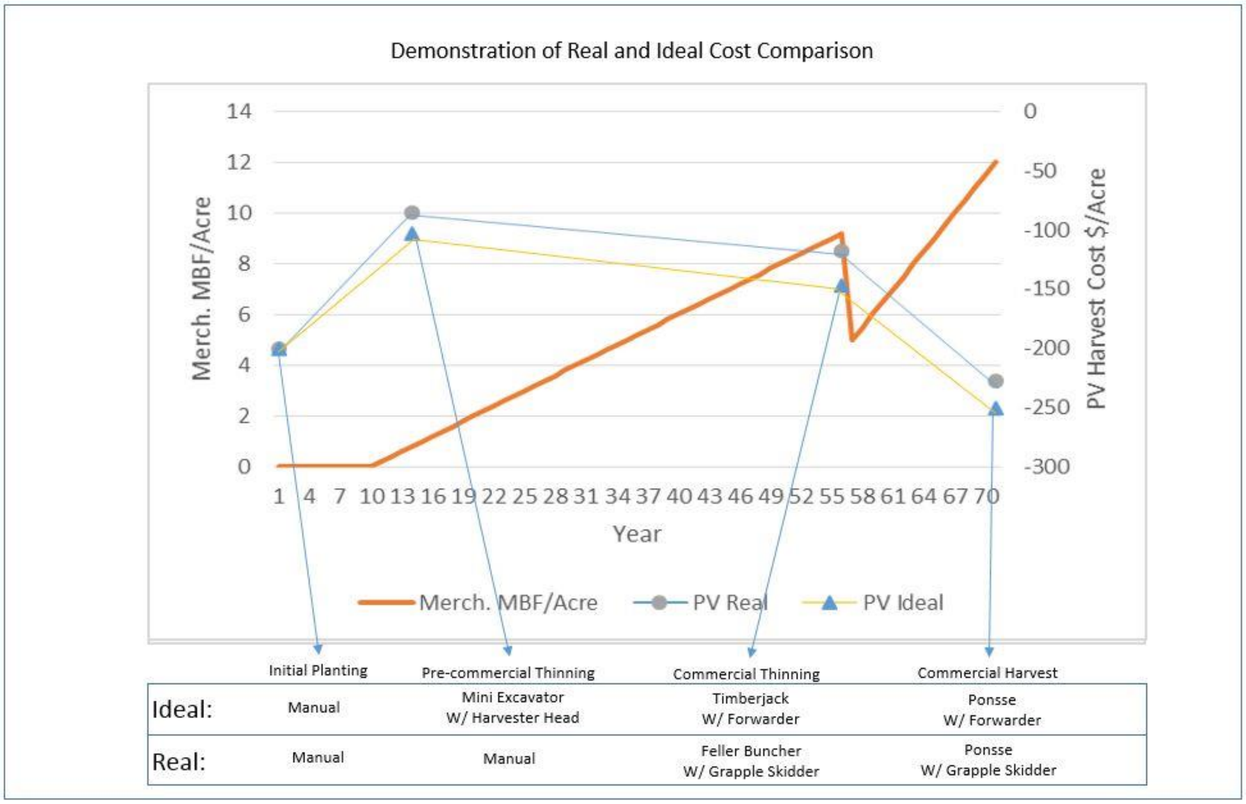

Figure 2. Comparison of real (available equipment) and ideal (regionally unavailable, preferable equipment) costs

FVS-OpCost is being designed to not only simulate the harvest system prescribed by the user, but also alternative systems in order to compare among treatment options and associated costs. This interface helps operations foresters and forest planners choose from among the range of possible harvest systems, and assigns rank based on the present value of future costs associated with possible silvicultural treatments. Additionally, FVS-OpCost also makes it possible to generate paired stand yield curves over time and the present value of both associated treatment costs and harvest revenue from the FVS-ECON extension. Together, the future revenue and cost data provide detailed estimates of net present value (NPV) that can be input into planning software such as SNAP for Arc-GIS (Sessions 1993).

FVS-OpCost also provides the user a unique option for comparison of real and ideal treatment options. In this case, the ideal treatment scenario is based on all possible equipment represented in the model, while the real scenario is based on regional surveys of actual equipment availability.

Methods: Currently, we are coding the available algorithms on forestry production rates into the FVS-OpCost simulator. The different forestry equipment is being organized and weighted by the machine type, horse power, and the harvest system that this equipment is generally utilized with. In the case of multiple studies showing different production rates for one piece of equipment the formulas are weighted equally, unless there is evidence in the literature that one formula is significantly more accurate than another.

Most productivity studies develop their formulas around the amount of mass removed per set amount of time. FVS-OpCost applies these kinds of formulas by using the estimated amount of removed or altered material within a forested stand, designated by FVS or by the user of the program, to predict the time it will take to complete an acre. Then the current regional labor and machine costs are applied to the amount of time per acre to estimate the cost to treat each acre. This information is saved within its own data matrix and can then be accessed by the operator or written back to the parent program. However, there are many productivity algorithms that express their outputs using different variables, and in these cases the algorithms are either directly adjusted or the outputs are used within a second formula to derive the required outputs. There are a small number of published algorithms that cannot be adjusted to work within this framework, and in an effort to keep the program user friendly and as simple as possible, those algorithms are not used within FVS-OpCost

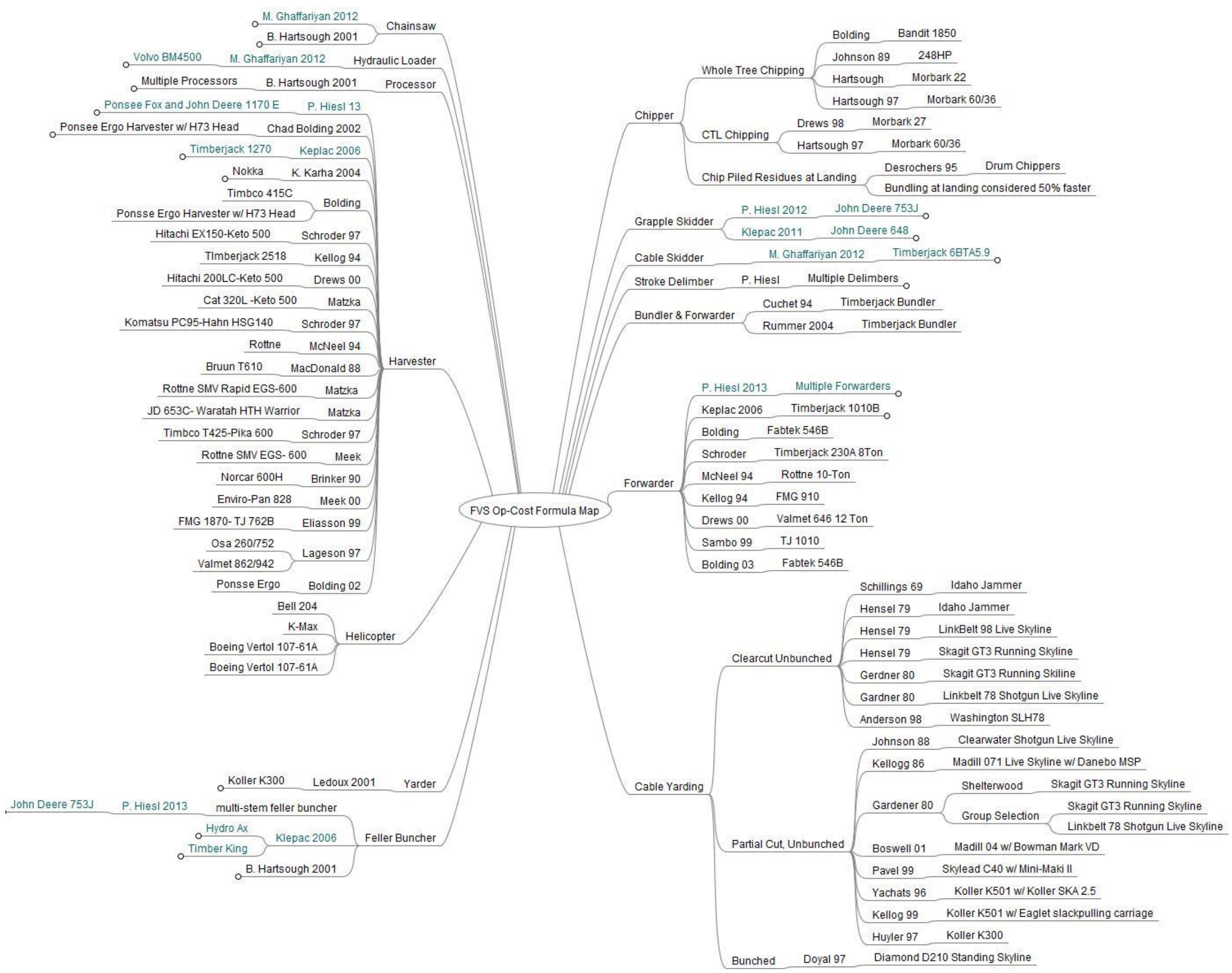

Figure 3. Illustration of currently coded publications and machines in FVS-OpCost

Input data for the current version of FVS-OpCost is acquired from a Microsoft Access database that is created by the BioSum simulator. Those Access databases are called using the RODBC R package (Ripley and Lapsley 2002) and a few custom created drivers. Once the R program has identified the driver linking it to Access, the cutlist data table is loaded and the information for the amount of the removed or altered material is used to estimate the cost associated with that operation. The estimated time required for each activity is used to predict cost on a per acre basis. The program then writes the cost estimations back into Access for further analysis in Biosum.

Before FVS-OpCost is released to the public, extensive testing is being done to evaluate how cost estimates provided for stand treatments compare to those from FRCS and to identify possible prediction errors. For systems that have not been previously modeled, we will confirm acceptable accuracy through comparison with regional logging cost indices (Meek 2014).

Our goal with FVS-OpCost is to represent as wide a range of current forestry equipment and harvest systems as possible. To accomplish this task, the latest production and cost estimates from published research need to be incorporated. Further, equipment and systems that have not been adequately studied will be identified. For 2-3 systems identified as being critical for fuel treatments, new work sampling or time and motion studies to characterize production are being completed during 2014 and 2015.

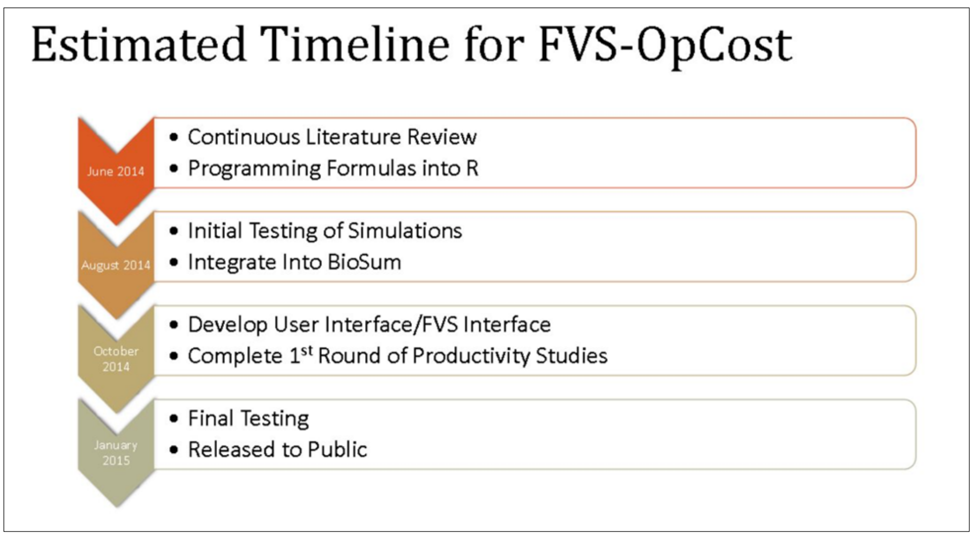

Figure 4. Flow chart showing the objective dates for FVS-OpCost.

Further Work: OpCost will be operating with FVS and the BioSum framework by August, 2014. Once the program is functioning within BioSum, the final design of the stand-alone system and the FVS system will be completed. The current goal is to have a functioning stand-alone system available by January 2015, including the addition of new published studies from the literature and 1-2 newly completed field studies.

References:

Agee, JK, and CN Skinner. 2005. “Basic Principles of Forest Fuel Reduction Treatments.” *Forest Ecology and Management*. http://www.sciencedirect.com/science/article/pii/S0378112705000411.

Bolding, M Chad, Bobby L Lanford, and M White Smith Hall. 2002. “Productivity of a Ponsse Ergo Harvester Working on Steep Terrain.”

Dixon, Gary E. "Essential FVS: A user’s guide to the Forest Vegetation Simulator." Fort Collins, CO: USDA-Forest Service, Forest Management Service Center (2002).

Drews, Erik S., Bruce R. Hartsough, James A. Doyal, and Loren D. Kellogg. 2001. “Harvester-Forwarder and Harvester-Yarder Systems for Fuel Reduction Treatments.” *Journal of Forest Engineering* 12 (1): 81–91. doi:10.1080/08435243.2001.10702766. http://www.tandfonline.com/doi/abs/10.1080/08435243.2001.10702766.

Fried, JS, and G Christensen. 2004. “FIA BioSum: A Tool to Evaluate Financial Costs, Opportunities, and Effectiveness of Fuel Treatments.” *Western Forester*. http://jeremyfried.net/pubs/biosum_western_forester_2004.pdf.

Ghaffariyan, Mohammad Reza, Ramin Naghdi, Ismael Ghajar, and Mehrdad Nikooy. 2012. “Time Prediction Models and Cost Evaluation of Cut-To-Length (CTL) Harvesting Method in a Mountainous Forest.” *Small-Scale Forestry* 12 (2) (March 21): 181–192. doi:10.1007/s11842-012-9204-4. http://link.springer.com/10.1007/s11842-012-9204-4.

Hartsough, BR, RD Fight, and P Noordijk. 2006. “Users Guide for FRCS: Fuel Reduction Cost Simulator Software.” http://www.academia.edu/download/30357824/fight_hartsough_noordjik_2006.pdf.

Hiesl, Patrick, and Jeffrey G. Benjamin. 2013. “A Multi-Stem Feller-Buncher Cycle-Time Model for Partial Harvest of Small-Diameter Wood Stands.” *International Journal of Forest Engineering* 24 (2) (September): 101–108. doi:10.1080/14942119.2013.841626. http://dx.doi.org/10.1080/14942119.2013.841626.

Jain, Theresa B, Mike A Battaglia, Han-sup Han, Russell T Graham, Christopher R Keyes, Jeremy S Fried, Jonathan E Sandquist, et al. 2012. “A Comprehensive Guide to Fuel Management Practices for Dry Mixed Conifer Forests in the Northwestern United States Planning and Implementation.”

Kärhä, Kalle, Esa Rönkkö, and Seppo-Ilmari Gumse. 2004. “Productivity and Cutting Costs of Thinning Harvesters.” *International Journal of Forest Engineering* 15 (2): 43–56. doi:10.1080/14942119.2004.10702496.

Klepac, John, Bob Rummer, and Jason Thompson. "Evaluation of a cut-to-length system implementing fuel reduction treatments on the Coconino National Forest in Arizona." *In*

Proceedings of the 29 th Council of Forest Engineering Meeting. Corvallis, OR, pp. 405-414. 2006.

Klepac, John, Bob Rummer, and Jason Thompson. "Harvesting small trees for bio-energy." *In Proceedings of the 34th Council on Forest Engineering Meeting.* 2011.

Ledoux, Chris B. “Cycle-Time Equation for the Koller K300 Cable Yarder Operating on Steep Slopes in the Northeast Neil K Huyler.”

McHugh, Charles W. "Considerations in the use of models available for fuel treatment analysis." Proceedings of the Fuels Management-How to Measure Success (2006): 81-105.

Meek, J. 2014. “Montana Logging Costs 2013-An Engineering Approach.” *web1.cnre.vt.edu*. Accessed May 1. http://web1.cnre.vt.edu/forestry/cofe/documents/2013/Meek_Hayes_Dodson.pdf.

Reinhardt, Elizabeth D., Robert E. Keane, David E. Calkin, and Jack D. Cohen. 2008. “Objectives and Considerations for Wildland Fuel Treatment in Forested Ecosystems of the Interior Western United States.” *Forest Ecology and Management* 256 (12) (December): 1997–2006. doi:10.1016/j.foreco.2008.09.016. http://www.sciencedirect.com/science/article/pii/S0378112708006944.

Ripley, Brian, and Michael Lapsley. 2002. “RODBC Database Access.”

Robichaud, Peter R., and Louise E. Ashmun. 2013. “Tools to Aid Post-Wildfire Assessment and Erosion-Mitigation Treatment Decisions.” *International Journal of Wildland Fire* 22 (1) (August 2): 95. doi:10.1071/WF11162. http://www.publish.csiro.au/view/journals/dsp_journal_fulltext.cfm?nid=114&f=WF11162.

Sessions, JB. 1993. “SNAP II+ Version 2.07 Users Guide.” *USDA Forest Service, Washington Office, Ft. Collins.* http://scholar.google.com/scholar?hl=en&q=Sessions%2C+J.+and+J.B.+Sessions.+1993.+SNAP+II%2B+version+2.07+user%27s+guide.+USDA+Forest+Service%2C+Washington+Office%2C+Ft.+Collins%2C+CO.&btnG=&as_sdt=1%2C13&as_sdtp=#1.