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Response to Public Comments on Southwest Forest Restoration Document by Drs. Beverly E. Law and Tara Hudiburg

Dr. Law and Dr. Hudiburg,

Thank you for your detailed comments on this methodology. Below you will find our responses to your concerns along with references to changes in the methodology. We hope that you find this satisfactory and welcome future dialogue.

1. The landscape approach is lacking, baseline calculation is not accurate

While across the West, high severity fire only accounts for a small proportion of total fire, within the Southwest high severity fire is both a larger proportion and is increasing[1][2]. Within this methodology we do not assume that every acre experiences fire. We account for mixed severity fire, including low severity fire, and given our cumulative probability density function, the Weibull distribution, we never reach 100% of the area experiencing fire of any severity. That said, given the frequent fire regime of the Southwest, we expect some form of fire on much of the landscape within the project period, prescribed, natural or otherwise (see figure 1 which used an 18 year fire return interval, the mean for our test case in methodology development).

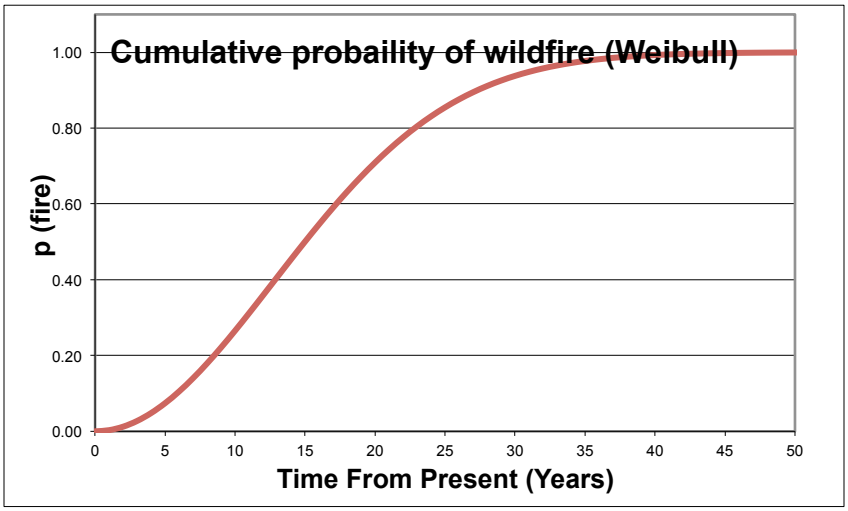

Figure 1 Example Weibull distribution

[1] Dillon, Gregory K., et al. "Both topography and climate affected forest and woodland burn severity in two

[2] Poling et al. 2016, in press, available upon request.

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Equation C.2: Weibull distribution of fire probability for calculated fire return interval

$f(t) = (ct^{(c-1)})/b^c \times \exp(-(t/b)^c)$	
Where:	
b	is the scaling parameter annual percent burned, with 1/b representing the fire rotation
c	is the shape parameter (>0), interpreted as a flammability index, with c=1 captures equal flammability with age, and c>1 captures increasing flammability with age (expected within this project)
t	is time for additional guidance see *Fire Ecology of Pacific Northwest Forests* [3].
$AW_{fireshed\ i}$	is the area weight of fireshed i, relative to total project area; %

We agree that fuels treatment/restoration emissions are committed carbon costs, and we account for these costs through treatment, transportation and processing emissions (E_{OPS}) along with the carbon residence time of small diameter wood products (C_{WP}) in accordance with the 2014 ARB Forest Protocol. Furthermore we conservatively assume 100% of carbon emissions from all slash which is not usable for harvested wood products, and claim no carbon benefit for offsetting fossil fuel emissions or a reduced emissions from slashpile burning.

Beyond the immediate committed emissions, restoration/fuels treatments within the Southwest have additional ecological benefits which maintain increased carbon storage on the landscape in comparison to the baseline scenario:

1. Restoration treatments in Southwest ponderosa pine forests slightly increase Net-Ecosystem Productivity due to increased health of and available resources to remaining trees
2. Restoration treatments increase resiliency of forests to climate-induced stress, decreasing mortality in the future
3. Restoration treatments decrease mortality when fire does occur, preserving more carbon in living trees and protecting sequestration capacity

2. Insufficient accounting for all carbon changes

a. We now require changes in all live and dead wood pools
b. Please see later comment regarding soil carbon
c. Please see previous comment regarding harvested wood products and operations emissions
d. We agree that a lifecycle approach is essential for this type of accounting, which is why we have addressed long term emissions sources and trajectories such as burnt woody debris decomposition, alternate

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ecosystem succession and carbon residence time in harvested wood products.

e. We would further like to note that Dr. Pete Fulé, Dr. Matt Hurteau, and Dr. Andrew Sanchez-Meador have all contributed to the framework and elements considered within this methodology, along with specific methods. They are all well regarded and published scientists on this topic. This methodology will further undergo additional rounds of scientific peer review.

3. Comments referenced to location in document:

a. Correct, the majority of carbon is released post-wildfire, thank you for catching this mistake. The line now reads 'Wildfires release pulses of carbon during wildfire events themselves, with significant quantities of carbon following high severity fire events as debris decompose [45]).

b. The issue stated here refers to fuel ladders provided by small diameter trees which create a mechanism for crown fire, increased wildfire spread, increased mortality, and ultimately larger scale carbon release, not the 'big tree' concept. We agree that through restoration treatments total carbon storage will initially decrease, and may not store as much as is currently on the landscape. The Southwest currently however is beyond its carbon carrying capacity, especially given current stand structure[6]. We are referencing increasing the canopy base height, reducing canopy bulk density etc to decrease active crown fire risk.

c. The authors are not arguing against structural diversity. This item is a metric used to determine forests that are outside of their natural range of forest structure and in need of restoration treatments[789].

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[4] M. D. Hurteau, M. T. Stoddard, P. Z. Fulé, *Glob. Chang. Biol.* **17**, 1516–1521 (2010).

[5] Kent, Larissa L. Yocom, et al. "Interactions of fuel treatments, wildfire severity, and carbon dynamics in dry conifer forests." *Forest Ecology and Management* 349 (2015): 66-72.

[6] M. D. Hurteau, M. T. Stoddard, P. Z. Fulé, *Glob. Chang. Biol.* **17**, 1516–1521 (2010).

[7] Fulé, Peter Z., W. Wallace Covington, and Margaret M. Moore. "Determining reference conditions for ecosystem management of southwestern ponderosa pine forests." *Ecological Applications* 7.3 (1997): 895-908.

[8] Covington, W. Wallace, et al. "Restoring ecosystem health in ponderosa pine forests of the Southwest." *Journal of Forestry* 95.4 (1997): 23.

[9] Mast, Joy Nystrom, et al. "Restoration of presettlement age structure of an Arizona ponderosa pine forest." *Ecological applications* 9.1 (1999): 228-239.

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d. We agree with your comments. This is a basic requirement for forest carbon methodologies under the American Carbon Registry Forest Carbon Project Standard and is a required boilerplate condition (http://americancarbonregistry.org/carbon-accounting/standards-methodologies/forest-carbon-project-standard)
e. We agree, lying dead wood pool is now mandatory, thank you for this suggestion.
f. We agree that this is a pool which could experience large scale carbon storage reversals under the baseline scenario, while the restoration scenario experiences little impact due to the form of mechanized treatment (no felling, no additional roads etc). Within Arizona wildfires high severity is most often observed on slopes greater than 30%, creating hydrophobic soils and large-scale mass wasting events, while mechanical fuel treatments are restricted to level areas where soil erosion and soil impacts are minimized. We further agree that this should be the focus of future research and possible inclusion into this methodology with additional information and methods. Methods to quantify and model this pool are currently lacking in other methodologies. Given the novel nature of this methodology we currently propose that soil carbon should be included in future iterations of this methodology.
g. Please see previous comments regarding 10% tree cover and lifecycle assessment. By definition forests must be in need of fuels treatments/thinning and these treatments must not be occurring on timelines important to restore forest health. Leakage/activity shifting is therefore *de minimis.*
h. We appreciate this comment, and with permission from Winrock/ACR are willing to make models such as FireBGC applicable. We have not recommended these types of models for the following reasons:
    i. This project is designed to be implemented on federal lands. We therefore advocate for tools that these agencies already use, and are common practice in the field of forest carbon. Process based models are only run by a few labs in the country and are not common place in either federal land management or forest carbon emission reduction ton generation.
    ii. ClimateFVS is a statistical model which allows us to investigate a range of statistical outcomes, uncertainty bounds and the like.
i. We agree and we have language within the methodology which requires locally validated or published combustion factors.

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j. Please see previous comment regarding harvested wood products, biomass energy and operations emissions.

We sincerely thank you for your detailed comments on this work. We welcome further discussion and contributions to this methodology and framework.

Best regards,

Katharyn Duffy M.S.
Methodology author

Spencer Plumb Ph.D
Methodology author