Nat. Hazards Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/nhess-2019-74-AC3, 2019

Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Before the fire: Assessing post-wildfire flooding and debris-flow hazards for pre-disaster mitigation" *by* Ann M. Youberg et al.

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Received and published: 12 July 2019

General Comments: The authors appreciate the time and efforts of the three reviewers of this manuscript. The comments and suggestions made in these reviews have helped us to refocus and reframe the manuscript. This requires a significant re-write on our part, and we are continuing to work on the manuscript. Here, we present our rational for why this is an important and original contribution, and the scientific questions we address in this revised manuscript. We then address each reviewers' individual comments.

The post-wildfire debris flows and flooding following 2010 Schultz Fire near Flagstaff,

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Discussion paper

Arizona, significantly impacted forest resources, downstream developed areas and the local economy, which we have described in our paper. This scenario, unfortunately, is not unique to northern Arizona (e.g. Kean et al., 2019; Cannon and Gartner, 2005), nor to the western United States (e.g. Jordan, 2016; Nyman et al., 2015). More densely vegetated forests, longer fire seasons, drought and other climatic influences are expected to contribute to general trends of more frequent and severe wildfires (Kitzberger et al., 2017; Littell et al., 2016; Liu et al., 2013; Krawchuk et al., 2009). This highlights the need for local and regional entities to consider and plan for wildfires and their post-fire impacts to reduce risks and increase community resiliency (Schoennagel et al., 2017).

We hypothesize that risks from post-wildfire debris flows and floods can be assessed, prior to the start of a wildfire, as a function of probability of occurrence, predicted magnitude of flow, and the projected distribution of inundation, and that these data can then be used to identify planning-level risk zones and mitigation opportunities to reduce risks and increase resiliency. Here, we use a post-Schultz Fire dataset that we have compiled over years of working in this area (described below) to test and evaluate the USGS models used to predict the probability of occurrence and magnitude of post-fire debris flows, and Laharz for modeling, prior to a wildfire, potential post-fire debris-flow inundation zones. Most of this work was described in detail in an appendix to the Open File Report (OFR) we referenced in our paper. Here, we describe in more detail that work, and we include a more robust assessment of Laharz by comparing model results with mapped deposits using receiver operator characteristics (ROC) analyses (Fawcett, 2006). We also use our dataset to compare mapped flood inundation areas with modelled FLO-2D inundation zones, again using ROC. Finally, we evaluate the methodology used in this study to assess potential post-fire hazards before a wildfire begins to assess 1) what could be done better, and 2) how other communities could adapt this methodology for their own use.

While the Schultz Fire is only one small fire, the authors, through our continued work on

the post-Schultz Fire flows, have a unique dataset of detailed rainfall data, geomorphic responses of burned basins to rainfall, geomorphic mapping of flood and debris-flow deposits on the piedmont below the burned basins, and 1- and 2-dimensional modeling of design-storm flood flows immediately after the fire and in the years following the fire that are used to inform mitigation efforts and to document post-fire hydrologic recovery. Moreover, there is high resolution (i.e. 1 m) elevation data derived from airborne lidar for our entire study area. Additionally, Coconino County Flood Control District has mapped extents of flood inundation within the burned area and through the downstream developed areas from the July and August, 2010, storms. Therefore, the Shultz Fire presents a rare opportunity to develop and test a methodology that can be more generally applied to assess risks from post-wildfire debris flows and floods.

Reviewer #3, and replies to:

Thank you for the opportunity to review this interesting manuscript. It is an original work on an increasingly important problem in environmental management that attempts to assess the potential flooding and debris flow hazards following a wildfire in mountainous northern Arizona and how these hazards might be mitigated by pre-fire fuels treatments. The authors do a good job in the discussion of noting some of the modelling limitations as well as noting some of the social issues in applying this methodology. Overall, this is a well-organized and well-written manuscript, but there are some problems that need to be addressed. Major issues in no particular order of priority:

Thank you for your helpful and constructive comments. In addition to what we've already outlined above, we are addressing your comments as follows:

There are many terms that need to be better defined: o On Page 2, how is a 'full-cost accounting' different than an accounting? o On Page 2, what is a 'reasonable scenario wildfire' as opposed to any other kind of wildfire? The 2010 Schultz Fire is used as a metric throughout this paper because of proximity and the post-fire data available from various studies. The Schultz Fire is commonly referred to as a 'devastating' wildfire.

Is the Schultz Fire a ‘reasonable-scenario’ wildfire? o On Page 2, what does it mean to define the extent and severity of post-wildfire risks at the ‘planning level’? o First occurring on Page 13, what is a ‘non-regulatory’ risk zone map and how does it differ from a risk zone map? o On Pages 15 and 16, what does it mean to ‘increase the resiliency’ of the City of Williams should a fire occur? o On Page 16, what is a ‘Table Top Exercise’?

1. Thank you for pointing out the use of jargon, confusing and undefined terms. Where possible, we will change the text to plain language. Otherwise we better define our use of unfamiliar terms.

2. Reasonable scenario wildfire – as used here, a likely, high-severity wildfire that can occur under current vegetation and climatic conditions. We will change the text to explain what that fire would look like (e.g. size, severity) on a given landscape with current fuels and climatic conditions.

3. We will better define non-regulatory risk zone maps which are used to inform and for planning purposes but do not carry any regulatory requirements.

Specific mitigation measures or fuels treatments desperately need to be defined. There are tangential references to mechanical thinning and controlled burning, but nothing about exactly what has changed as a result of these treatments to reduce post-fire hazards. Presumably, biomass has been reduced and fuel loads have been reduced, but how and to what degree? Has stand density been altered? What about stand structure? Dead and down removed? We get no picture of what the landscape will look like, only that the model input parameters have somehow changed. Also, on Page 4, how will the study results and hazard maps identify potential mitigation measures?

More needs to be presented about the existing vegetation in both Fort Valley and Bill Williams Mountain. We are told generally about the vegetation types in the Colorado Plateau, but virtually nothing about the specific study areas. Fort Valley has a meadow at the bottom and BWM has watersheds with heavily forested slopes, but no other

details are provided. Better information must be out there in order to create the burn severity maps, so please share these details with the reader.

1. We will include text that better describes a) current conditions above Fort Valley and on Bill Williams Mountain, b) fuels treatments (mechanical biomass reduction, reduced stand densities, controlled burning), and c) the treatments planned for implementation on Bill Williams Mountain.

2. We will better describe how the results from the study were used to identify specific infrastructures at risk from post-fire flows and, where available, the proposed mitigation measures to reduce those risks.

A much better case needs to be developed to equate Crown Fire Activity with Soil Burn Severity. A crown fire will definitely affect residual canopy percentage and tree mortality, but there are many examples of the soil surface being unaffected by a crown fire. Perhaps something like biomass consumption and energy release along with the height of the canopy would help here. Or just say that 'this is our proxy and we're sticking to it' so the reader can understand the potential limitations.

1. Yes, this is an area that requires research but was beyond the scope of this project. In our upcoming assessments, we plan to use the methods of Staley et al (2018) to generate historically based burn severity metrics for a high severity fire and a low severity fire that will then be used in our models. This is part of the discussion section.

It would be helpful to know if the model FLO-2D PRO has been verified for this area by citing other studies (not your own) where it has been successfully used.

1. Noted. We will expand the text to include a discussion of other studies and include citations (e.g. Stevens et al., 2011).

The flood modelling uses the 2/10/100 year rainfall events and the debris flow modelling uses the 1/2/5 year rainfall events. It would be helpful to know the magnitude of these values, the length of record that exists, and the methodology by which these storm

classes were derived.

1. Noted. The text will be revised to reflect this information which was derived from NOAA Atlas 14.

It is unclear how the runoff curve numbers were assigned. It seems pretty qualitative ('we know there is going to be a lot of runoff, so we will just pick big numbers'). You might also provide a sentence about what this means for the non-specialists who will likely read this paper.

1. The curve numbers were selected with guidance from the Coconino National Forest watershed staff and from the National Resources Conservation Service (2016). This is an area that needs more research but was beyond the scope of this project.

For the debris flow modelling, it is unclear how the design storms and the peak I15 relate (if at all).

1. The text will be revised to explain how the peak I15 was derived for each design storm. Basically, the NOAA Atlas 14 was used to determine I15 for each design storm in the study watersheds.

On Page 11, debris flow hazard rankings are based on probability and potential magnitude. More information is needed here to understand how these factors were combined to arrive at these rankings.

1. This follows the procedures that the USGS uses in assessing post-fire probability and magnitude and was described in detail in one of the OFR appendices. The text will be revised to better explain these models and this method. Appropriate citations will be added.

Why are debris flow volumes of 104.5 and 105 m3 topographically unrealistic (Page 13 and Figure 10)?

1. The volumes of post-fire debris flows are most often derived from channel scour as

these debris flows are triggered by runoff, not landslides. The largest post-fire debris flows that have been documented in Arizona are ∼ 10,000 m3. The text will be revised to explain this, and citations added.

Minor issues in no particular order of priority:

In some cases, the text is too detailed: o On Page, does it matter that the Schultz Fire burned most of its area in the first 24 hours? o On Page 3, does it matter that the peak directly above Fort Valley is Agassiz Peak? o On Page 3, does it matter that BWM is a cluster of Pliocene dacite, andesite, and benmoreite (whatever that is) domes?

1. We will strive to include important details and delete unnecessary information.

On Page 3, does Cataract Creek really originate on the south side of BWM?

1. No, on the north side. Thank you for catching that.

On Page 5, a reference is needed for the Scott/Reinhardt crown fire calculation method.

1. Done.

On Page 6, Line 1, this should be the topic sentence for the next paragraph.

1. Done

In the text, one of the Fort Valley sub-areas is Treated8200; on Figure 4 it is TreatedNW.

1. Fixed

Table 3 is missing a hyphen in one of the columns.

1. Fixed

On Page 14, the text labels (Post-fire Debris Flow; Post-fire Hyperconcentrated Flow) do not match those in Figure 11. Also, the legend in Figure 11 is way too small.

1. Fixed

On Page 16, Lines 8-9, the structural damage that would be sustained in the City of Williams would result from the flooding and erosion.

1. Noted.

On Page 18, Line 27, the authors had 'not anticipated some of the difficulties local entities have encountered with some of these measures'. Please explain what this means.

1. We will expand our text to better describe this.

Overall this manuscript needs a bit more work. Hopefully these changes will not prove too onerous.

Thank you again for your helpful comments.

Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2019-74/nhess-2019-74-AC3-supplement.pdf

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Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2019-74, 2019.

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