Nat. Hazards Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/nhess-2019-74-AC2, 2019

Natural Hazards and Earth System Sciences
Discussions
Open Access

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, 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 #2: In the United States, flood and debris-flow hazard assessments are conducted routinely after major wildfires. Such assessments are used by local emergency management officials to identify areas at risk and develop emergency response plans. Often, however, there is insufficient time between the fire and the first rain storm to fully develop emergency response and evacuation plans. This study describes how more complete planning can be achieved by assessing the potential for debris flows before a fire occurs. The study uses an established fire model to create a wildfire scenario in Coconino County, Arizona, USA. The authors then use the simulated burn severity and a series of models to evaluate the potential for flooding and debris flow to design rain storms. The hazard assessment includes estimates of flood and debris-flow inundation, which is an analysis that is generally too time consuming to perform during post-fire hazard assessments. There is growing interest in pre-fire hazard assessments, and this the third pre-fire analysis that I am aware of. The study is clearly valuable for Coconino County, and the discussion of lessons learned during the assessment may appeal to a broader audience. However, I do not think a summary of a published hazard assessment is appropriate for this journal. The manuscript does not test a method/hypothesis or present a significant new concept. I acknowledge that the addition of runout modeling to pre-fire planning is new and important, but this aspect of the manuscript is not fully developed or tested. I think the manuscript would be much stronger if it were reframed to test the proposed methods for pre-fire assessment and demonstrate how well they work. Some questions that could be addressed are: How well does modeled crown fire activity match observed distributions of soil burn severity? How well do the simulated levels of forest treatment reflect burn severity in real fires with real treatments? How accurate are the flood runout predictions? How transferable are estimates of curve numbers from one area to another? How accurate are the estimates of debris-flow probability, volume, and runout? What are the uncertainties? I think this question is particularly important because the predictions of who/what will be impacted will be scrutinized heavily. In addition, or alternatively, the paper could dig deeper into the planning and mitigation challenges that pre-fire hazard assessments uncover. The end of the paper mentions there were unexpected challenges that came during implementation of the mitigation measures, but these challenges are not described. Lastly, I think the paper needs to provide more details on the specific methods used in the study. These details are probably included in the engineering reports that the paper references, but more of this information needs to be included in a journal paper to make it easier for readers to understand the assumptions that go into the modeling.

Reply to Reviewer #2: Thank you for your very helpful and constructive comments. We have used your comments as a guide for restructuring the paper (in progress). In addition to the above discussion, we address your comments as follows:

1. Your questions regarding how well fire modeling simulates soil burn severity are important and necessary questions. This is an area that sorely needs research. It was, however, beyond the scope of our project, thus we followed previously used procedures to develop our soil burn severity maps. 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 methodology. This is discussed in the discussion section.

2. To better quantify our assessments of model performances, we use ROC analyses to assess mapped deposits and modeled inundation zones. This also helps to define uncertainty levels.

3. The use of curve numbers for assessing the hydrologic impacts of a wildfire is another area of research that is much needed but beyond the scope of this project. For this project, we worked with Coconino National Forest watershed staff and used guidance from the National Resources Conservation Service (2016) to select appropriate curve numbers. This was described in one of the OFR appendices; the revised manuscript has a more detailed description of the choice of this parameter.

4. In the discussion section we elaborate on the unexpected challenges and lessons learned during this project, and our revised steps to help avoid these pitfalls that we will use in two upcoming assessments.

5. We expand our manuscript to provide more detailed descriptions of the models and our methodology.

Again, thank you for the 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-AC2-supplement.pdf

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