Hazard Analysis of Post-Fire Debris-Flow Potential in Arizona

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I. SUMMARY

Using date from the 2010 Schultz Fire near Flagstaff, Arizona, and the 2011 Monument and Horseshoe 2 Fires in southeastern Arizona (Figure 1), we tested 3 models developed by the USGS to predict the probability of postwildfire debris-flow occurence [Cannon and others, 2010, GSA Bull, 122(1-2), 127-144].

II. MOTIVATION

Following the 2011 Wallow, Monument, and Horseshoe 2 Fires one of the models tested here (Model A) was used to identify burned basins with a high probability for post-fire debris-flows [Ruddy, 2011, OFR 2011-1181, OFR 2011-1197, OFR 2011-1214]. Neither Model A, nor the other 2 Intermountain West USGS models (Models B and C), however, have been tested for the varied physiographic provinces of Arizona.

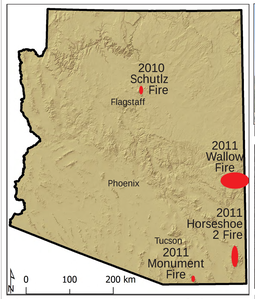


Figure 1. Location map of the 2010 Schultz Fire and the 2011 Wallow, Horseshoe 2 and Monument Fires.

Burned slopes of the Schultz Fire. (D. Neary, RMRS)

Basin condition in the Schultz Fire burned area: post-fire, pre-storm (above), post-storms (right). (Numbers match trees between photos)

III. POST-FIRE DEBRIS FLOW MODELS

The models use a combination of basin morphometric data, derived using GIS, STATSGO soils data and rainfall to predict the probability of post-fire debris-flow occurrence [Cannon and others, 2010]. The probability of debris-flow occurrence is calculated by: $P = e^x/(1+e^x)$. Three models calculate the variable 'x'.

Model A uses basin data (SGE30%), (R), and (%AB). soils data (C) and (LL) and rainfall intensity (I).

Model B uses basin data (R) and (%AB), soils data (C) and (OM) and rainfall intensity (I).

Model C uses basin data (%AB), soils data (C), (LL) and (HG) and rainfall intensity (I).

Model Parameters

SGE30 = %basin area w/slopes ≥ 30%
R = ruggedness (elev range/basin area$^{1/2}$)
%AB = %basin area burned at high and moderate severity
↔ GIS Data

C = %average clay content
LL = liquid limit
OM = %organic matter
HG = hydrologic group
↔ STATSGO Soils Data

I = average storm intensity (mm/hr)
↔ Rainfall Data

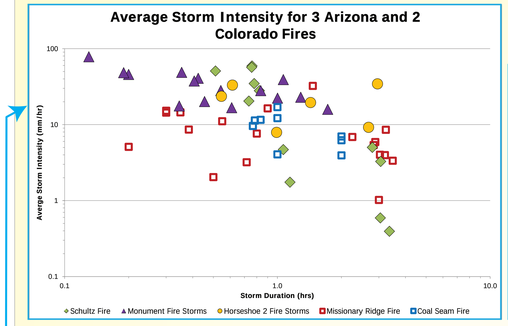
IV. METHODS

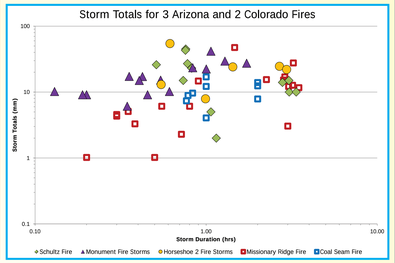
Field Data

During the first summer after each fire, test basins were monitored to document debris-flow occurrence (yes/no) after significant rainfall.

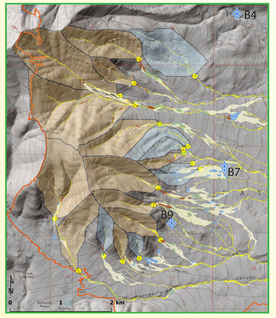
Rainfall Data

Rainfall data from tipping-bucket rain gauges were analyzed for the significant rainfall events to calculate total storm precipitation and average rainfall intensity.

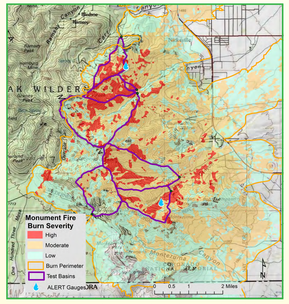




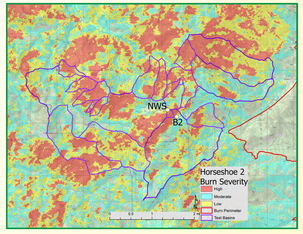
Test Basins and GIS Data



Schultz Fire Basins (n = 19) with outlets based on flood and debris-flow deposit locations at or just below the base of the steep, upper slopes. There are 3 ALERT gauges.



Monument Fire Basins (n = 7) with outlets based on flood and debris-flow deposit locations, or at road crossings. There are 2 ALERT gauges.



Horseshoe 2 Fire Basins (n = 18) with outlets based on flood and debris-flow deposit locations, or at road crossings. There was 1(!) Bioshpere 2 gauge and 1 NWS temporary weather station that operated during the significanct storms.

Data Assessment

A success/failure matrix was used to compare successes (model predicts a high probability and debris flows occur) with overprediction (model predicts a high probability but no debris flows occur).

Success curves were used to compare model results between fires. The greater the volume of area under the curve and above the 1:1 line the better the model results are.

V. RESULTS

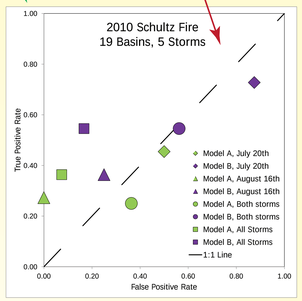
Success/Failure Matrix

	debris flows	no debris flows
High Prob	True Pos = hi P w/DFs (TPsuccess)	False Pos = hi P w/o DFs (overpredict)
Low Prob	False Neg = lo P w/DFs (underpredict)	True Neg = lo P w/oDFs (TNsuccess)
	Σ(#DFs)	Σ(#no DFs)

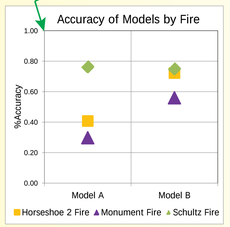
Ratio of the True Positive Rate (#TPsuccess/#DFs) to the False Positive Rate (#overprediction/#no DFs) indicates model performance.

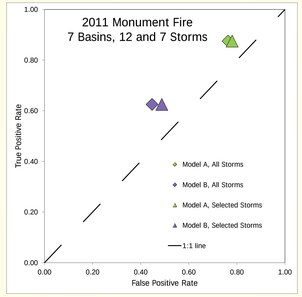
Better performing models plot in this region.

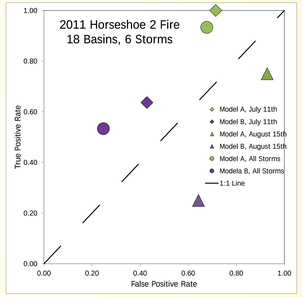
Models with random results plot on the 1:1 line.



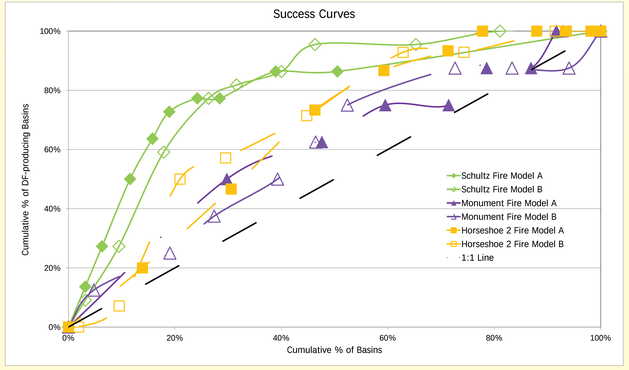
More accurate models plot closer to 1.







Success Curves for Models A and B, All Fires



VI. CONCLUSIONS AND ONGOING WORK

- Model A generally performed better than Model B in northern AZ, but not as well in SE AZ. Model C did not work in any of the environments.
- Results from both Model A and Model B plot above and to the left of the 1:1 line on the success/failure graphs, with the exception of the July 20th results from the Schultz Fire.
- Average Storm Intensity was higher for the more poorly performing models.