



# ADVANCES IN FOREST FIRE RESEARCH 2018

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# Factors Contributing to High and Low Risk Fires in the United States: An Analysis of the Relative Risk Assessment

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## Abstract

Discussion of risk permeates every U.S. federal wildland fire agency directive before, during and after fire season. In this study, we explore patterns of wildfire risk across the U.S. from the systematic operational risk assessments conducted by land managers on 5,087 wildfire incidents from 2010 - 2017. The Relative Risk Assessment (RRA) is a systematic, semi-quantitative assessment of risk which integrates ratings of high, moderate, and low ‘Values’, ‘Hazard’, and ‘Probability’ for each wildland fire. Each entry also includes notes, where decision makers describe qualitatively their reasons for their rating. The RRA is a mandated component of the Wildland Fire Decision Support System – WFDSS, decision making system for U.S. federal wildland fires. We know that perceptions of risk are different in geographic areas of the United States. The Southwest region perceives low risk while the Northwest perceives high risk more frequently when compared to the U.S. as a whole. The reasons for differences in risk perceptions are complex, but previous analysis of the relative risk data suggest the Southwest has a greater frequency of low ratings for Values in comparison to the Northwest. Other geographic areas follow similar trends. Here, we strive to define the attributes of the RRA that are most prevalent for high versus low risk fires by evaluating qualitative content associated with the RRA. “Private” values in the Northwest are documented with greater frequency for the Values element compared to the Southwest, where “cultural” values occur with greater frequency. Qualitative analysis illuminated specific geographic trends previously analyzed quantitatively. As we strive to make a better connection between perceived and actual risk, we hope the results of this analysis demonstrates that there are components of perceived risk that should be addressed with greater emphasis before and during wildland fire planning efforts.

**Keywords:** wildland fire, United States, WFDSS, risk

## 1. Introduction

The topic of risk permeates every facet of U.S. federal wildland fire decision-making. Attempts have been made to identify how individual decision makers address risk. Maguire and Albright (2005) contribute excessive risk aversion in wildland fire management decision making to mental shortcuts developed during uncertain and conflicting decision environments. The flexibility in fire management policy has inadvertently resulted in more suppression strategies to manage wildland fire due to the lack of planning (Seielstad 2014). Yet the need to embrace the uncertainty of wildland fire is necessary to adequately achieve the missions and goals of long-term land management. Solutions to address limitations in risk perception have manifested in solutions such as those proposed by Marcot et al. 2012, with formal procedures encompassing the four stages of structured decision making: problem structuring; analysis; decision point; and monitoring; addressing uncertainty with decision making in planning environments. Taber et al. (2013) specified a decision making process specific to incident level wildland fires that alluded to the same principles as (Marcot et al. 2012). A step by step case study of the incident level risk management process was demonstrated for the Gold Pan Fire 2013 using the tools and information available in Wildland Fire Decision Support System – WFDSS (Noonan-Wright and Opperman 2014).

We can learn something about how real/actual risk is conceived and what factors govern its formulation by examining spatial patterns of risk where the rubber meets the road- in the systematic operational risk assessments conducted by land managers on thousands of wildfire incidents. By illuminating these patterns, we hope to stimulate examination of the social, cultural, and physiographic factors that drive risk-informed decision-making and expect that improved understanding of the geographic diversity of risk will ultimately lead to improvements in decision making. We illustrate differences between two geographic areas in the United States: the Southwest and Northwest by evaluating their selection preferences towards Values and the notes that support these preferences.

### 1.1. The Wildland Fire Decision Support System and The Relative Risk Assessment

The Wildland Fire Decision Support System – WFDSS was created to facilitate a deliberate risk assessment process on wildland fires by establishing a web-enabled collection of tools and information to support decision making (Calkin et al. 2011; Noonan-Wright et al. 2011). WFDSS was chartered in 2005 to capitalize on the availability of existing spatial fire behavior models to predict fire behavior spread, co-incident with the availability of a plethora of national-scale GIS cadastral and critical infrastructure data, ultimately leading to the ability to better quantify the threat and hazard to values at risk. This was an important step in the advancement of quantifying risk on wildland fires (Finney 2005).

The Relative Risk Assessment (RRA) is not a quantitative risk assessment; however, the process of evaluating risk could include elements of quantitative risk. Alternatively, the RRA capitalizes on the knowledge of the decision-maker to qualitatively assign ratings of high, moderate or low to values, hazard and probability elements. Each main element (values, hazard or probability) is composed of sub-elements that are rated to determine a final rating for each main element and the relative risk (Figure 1). Each land manager must evaluate their perspective risk using the RRA for every wildland fire in WFDSS.

The RRA was initially composed of a square box to support a decision of whether to aggressively suppress a wildland fire or allow it to burn to achieve some natural resource benefit. When the fire policy was revised in 1995, there was a need to create a quick justification for this ‘Go/No Go’ decision to allow a wildland fire to burn to achieve resource objectives without aggressive suppression tactics and

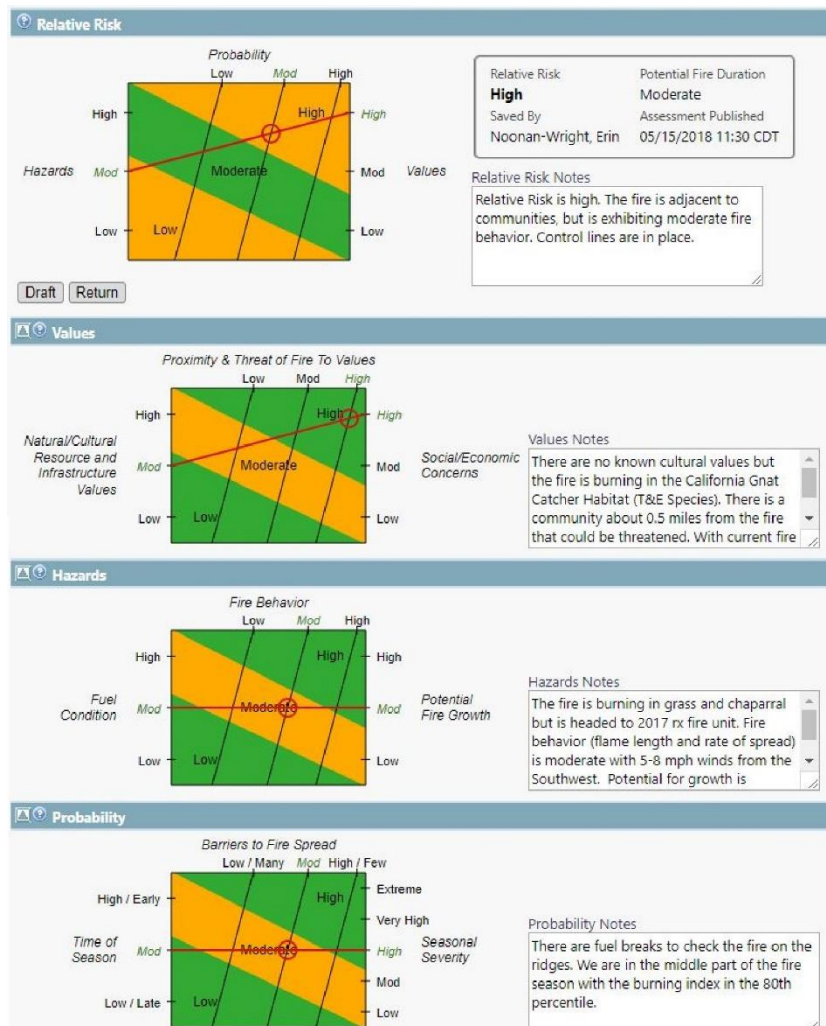


Figure 1 - An example of the Relative Risk Assessment process in the Wildland Fire Decision Support System – WFDSS

strategy. Initially the preliminary relative risk assessment was purely subjective and qualitative and intended to be done in about ten minutes given that few climatological/fire behavior tools existed to quantify this first assessment. However, the process to compute an initial assessment of risk resulted in some confusion and was revised in 2005. The revision was based, in part, on the incorporation of the hauling chart (Andrews and Rothermel 1982) and the National Fire Danger Rating System (Deeming, Burgan, Cohen 1978). Because the assessment documented the initial, qualitative risk, it was termed a “relative” risk assessment (Zimmerman 2017).

## 2. Methods

WFDSS is a J2EE, java server faces (JSF) web application using a service-orientated architecture (SOA) which integrates a number of other technologies in order to store, create, query, and display geospatial and tabular data through the application server as well as other services (Noonan-Wright et al. 2011). Data are stored in a relational data stream management system (RDSMS) and are queried through the use of Structured Query Language (SQL) to link data tables and extract all the fire records in WFDSS from 2010 through 2017. Duplicates and other anomalies with the data were remedied using CRAN – R (R Core Team 2013) and various packages to compute time (Grolemund, Wickham 2011), create and append data tables (Wickham 2011, Wickham et al. 2017) and expedite processes (Bache and Wickham 2014). While numerous relative risk assessments are done for long-duration fires as conditions change, we chose the most frequently used relative risk rating to represent the wildland fire. Consequently, each fire record has one relative risk rating to represent its relative risk. The two most different risk profiles by geographic area (G.A.), the Southwest and the Northwest, were compared for their rating selections of the sub-elements (Noonan-Wright and Seielstad, in prep). The Southwest tends to prefer ‘low’ ratings while the Northwest prefers ‘moderate’ and ‘high’ ratings for sub elements, main elements and relative risk. When these G.A.s are compared to the U.S. frequencies, the Northwest more clearly prefers ‘high’ ratings while the Southwest prefers ‘low’ ratings.

Individual responses to each of the sub-elements (time of season – tos, barriers to fire spread – bar, seasonal severity – ss, fuel condition – fuel, fire behavior –fbeh, potential fire growth – pot, natural/cultural resource and infrastructure values – res, proximity and threat of fire to values – threat, and social and economic concerns – conc) were tallied by geographic area (Southwest and Northwest) and the rating (high, moderate, or low). Extreme and very high ratings are only applicable to seasonal severity. A preference metric was computed to show preference or aversion to specific ratings:

$$\text{Preference metric} = (\% \text{ observed} \div \% \text{ expected}) - 1$$

Where percent expected was based on expectation values from the United States for a particular rating. Percent observed were tallied ratings for a specific sub-element normalized by the totals for specific geographic area.

In addition, CRAN – R, the text mining package, ‘tm’ (Feinerer et al. 2008) was used to evaluate word frequencies and associations from the ‘Values’ notes from the relative risk assessment (Figure 1). Word frequencies identified the words of ‘private’ being one of the most frequently used for the Northwest, while the word ‘cultural’ was more frequently used in the Southwest. Correlations with those words by geographic area more clearly identify the specific ‘values’ each geographic area is most concerned with.

## 3. Results

The Northwest (NW) geographic area prefers ‘high’ then ‘moderate’ ratings for the Values sub-elements: conc - social, economic and political concerns; threat - proximity and threat of the fire to values at risk; and res - natural/cultural resources or infrastructure values. Comparatively, the Southwest (SW) prefers mostly ‘low’ or ‘moderate’ ratings for those same elements, when compared

to the United States frequencies. In general, the Southwest does not prefer 'high' ratings and the Northwest does not prefer 'low' ratings.

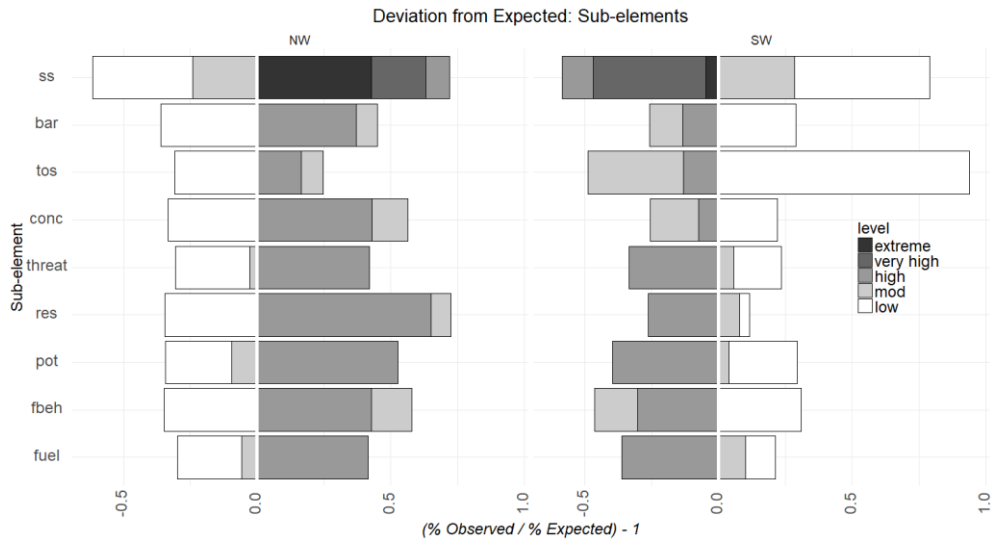


Figure 2 - Percent frequencies for each sub-element of the Relative Risk Assessment divided by the percent frequencies of the U.S. subtracted by one to show preference (positive) or aversion to (negative) a specific rating. The Values main element is composed of three sub-elements (conc – Social, Political, and Economic concerns; threat – proximity and threat of fire to values; and res – Natural/Cultural Resources or Infrastructure values). NW represents the sub-elements for the Northwest Geographic Area; while SW represents the Southwest Geographic Area.

To better identify specific values of concern described by each geographic area, we examined the 'Values' notes (Figure 1). The Northwest identified the word, "private" as one of the most frequently used in the Values notes; while the Southwest identified the word, "cultural" as one of the most frequently used. Correlations with those words further describe associations with those values (Figures 3, 4). The G.A.s share correlations with some words related to 'private' which include: "property", "land", and "blm". The Northwest also documents words related to values with discrete economic value such as, "structures", "property", "hut", and "snowmobile" that are not included in the Southwest notes. The Southwest appears to document commercial values associated with grazing. Words such as "lands", "property", "permittees", "holdings", and "allotments" are more commonly associated with the word "private". The influence of multiple jurisdictions seems evident. Both G.A.s use the word "blm" or Bureau of Land Management, while only the Northwest correlates "airforce" to the word "private".

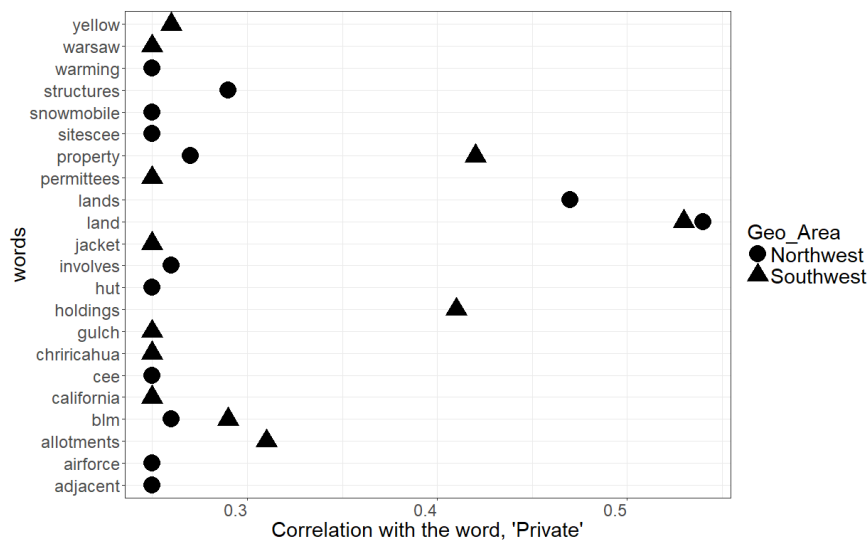


Figure 3 - Correlations with the word, "Private", for the Values notes in the Relative Risk Assessment.

Cultural values are included in the ‘res’ or ‘Natural/Cultural Resources and Infrastructure Values’ sub-element. The word, ‘cultural’ is frequently used for both G.A.s but more commonly in the Southwest. Both G.A.s associate the words “social”, “resources”, “proximity”, “natural”, “fire” and “economic” with the word, “cultural”. The word, “natural” appears to be the most highly correlated word with “cultural” for the Southwest while the words “resources” and “natural” are the most highly correlated for the Northwest, likely in reference to the name of the sub-element. The Southwest also correlates “infrastructure” and “sites” with “cultural”, suggesting that cultural resources may also have adjacency to infrastructure. The Northwest correlates the words “tribal” with “cultural” suggesting a link to cultural values associated with Northwest Native American tribes.

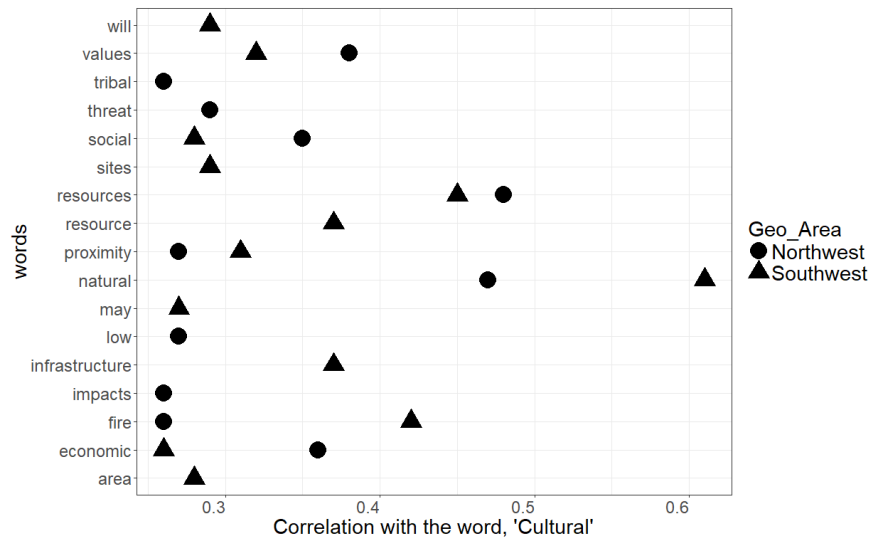


Figure 4 - Correlations with the word, “cultural”, for the Values notes in the Relative Risk Assessment.

#### 4. Discussion

While the Northwest perceives their values as higher compared to the U.S. and the Southwest perceives their values as lower compared to the U.S., one cannot conclude that these perceptions are real. Specific sub-elements are rated ‘high’, ‘moderate’ or ‘low’ by land managers for a specific wildland fire. These ratings compose the Relative Risk Assessment that becomes one part of strategic decision documented in WFDSS, ultimately signed by an authoritative land manager such as a district ranger or forest supervisor. However, perceptions of risk can influence strategic decision making and how wildland fire is managed. Fire management strategies that were costly and less risk averse were more favored by fire managers given social and political constraints simulated during hypothetical scenarios (Calkin, Wibbenmeyer, Thompson 2012).

Contextual analysis of qualitative information can help identify meaningful trends. When discussing Values, the Southwest uses words related to natural and cultural resources. The Southwest also prefers ‘low’ and ‘moderate’ ratings for the Values sub-elements, suggesting that the lack of infrastructure values threatened by wildland fires may result in lower perceptions of risk to values and a general acceptance of the role of fire interacting with cultural and natural resources. The Northwest uses the word “private” with the most frequency when documenting values, suggesting that non federal government lands and associated infrastructure are influential in determining high perceptions of risk related to values.

“Cultural” is a commonly used word for all geographic areas, regardless of the specific rating. Perhaps the difficulty in identifying these values during wildland fires plays a role in why they are discussed so frequently. During wildland fires, it is incumbent on the land manger and her staff to work with the local community to identify cultural values and make their general vicinity known to

limit the negative effects from fire fighting efforts. The general vagueness of what these values consist of and their exact location may be one reason they are discussed so frequently in the ‘Values’ notes.

WFDSS became the decision documentation support system in 2009 used by federal land management agencies to document wildland fires that exceeded initial attack or were to be managed as long duration events. Eight years of wildland fires (2010 – 2017) were used for this study to summarize perceptions of risk in an attempt to highlight decision making patterns during wildland fires. As we identify trends through this study, we hope the results will be a starting point for more thoughtful pre-season fire preparation and the evaluation of fire management strategies.

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