Results and Application of the National Wildfire Risk Assessment

Gregory K. Dillon, USDA Forest Service, Rocky Mountain Research Station,
Fire Modeling Institute, Missoula, Montana

INTRODUCTION

Spatial wildfire risk assessments that account for both the probability and consequences of wildfire events are becoming an important element of strategic wildland fire and fuels planning (Calkin et al. 2011; Finney 2005; Gilbertson-Day et al. 2017, 2018; Thompson et al. 2013, 2016a). Using a standardized framework (Scott et al. 2013), these assessments can be scaled from local communities up to the continental scale. Inputs, spatial resolution, and methodology considerations change with different assessment scales, as do the types of questions that can be addressed with the results. The Fire Modeling Institute (FMI), a unit of the Rocky Mountain Research Station, Forest Service, U.S. Department of Agriculture, recently completed analysis for a national-scale risk assessment for all National Forest System (NFS) lands in the conterminous U.S. (CONUS). This assessment is known as the National Wildfire Risk Assessment for Forest Service Lands (or NaWRA-FS, for short). We present here some brief results from that analysis as well as intended applications, including a Wildfire Risk Index that the Forest Service plans to use to monitor performance toward the agency's broad objective of mitigating wildfire risk.

What Is A Wildfire Risk Assessment?

The term "risk" is used in many contexts in relation to wildland fire. It is important to clarify that we are dealing here with risk in a strategic context that considers the potential effects of fire on things of value on the landscape, not with operational risks to firefighters. We use the following definition of wildfire risk: a measure of the probability and consequences of uncertain future wildfire events (Thompson et al. 2016b). There are three fundamental components involved in a quantitative assessment of risk: (1) the likelihood of fire occurrence, (2) the potential intensity of wildfire if it occurs, and (3) the susceptibility of highly-valued resources and assets (HVRAs) to fire of different intensities.

Why A National Risk Assessment?

The reasons for doing a national-scale assessment are inherently different than reasons for doing more local assessments. From a national perspective, having risk metrics calculated consistently across all units of the Forest Service is very valuable for national-level decisions about wildfire policy and resource allocation. Funding for hazardous fuels reduction work, for example, is allocated from the national budget to each of eight Forest Service regions in CONUS. Nationally-consistent risk metrics can help to inform allocation of this funding. The level of detail in a national assessment, however, is necessarily coarse and is not intended to inform placement or design of specific project areas; those decisions need to be informed by more detailed assessments at finer scales.

From a policy perspective, a national risk assessment can help to broadly articulate agency-wide perspectives on wildfire management. National risk assessment results can highlight, in a scientifically-based and spatially-specific way, the potential risks and benefits from wildfire across NFS lands. They can also help to tie national wildfire policy to overarching guidance such as the Forest Service Strategic Plan

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(USFS 2015) and the national cohesive strategy (WFLC 2014). In fact, in 2016 the USDA Office of the Inspector General completed an audit of the hazardous fuels program in the Forest Service and recommended the agency "fully develop and implement a national risk assessment model," (OIG 2016). Notably, the first iteration of a national risk assessment was completed several years earlier. Known as the "first approximation", that assessment established a proof-of-concept that risk assessment methodologies could be applied nationally (Calkin et al. 2010). The assessment presented here represents a revision that capitalizes on significant advances in recent years.

NATIONAL-SCALE METHODS

The discussion of assessment methods is intentionally brief here, and more detailed information about our methods are available online at: https://www.firelab.org/project/national-wildfire-risk-assessment. The main elements of the risk assessment methodology (Scott et al. 2013) include wildfire simulation, HVRA characterization, and effects analysis. In the sections below, we briefly address how we dealt with each.

The spatial scope of this assessment was all NFS lands in the conterminous U.S. This includes a total of approximately 170 million acres of land in Forest Service ownership. However, to include the potential effects of wildfire on developed adjacent lands, we included all area within 5 km of NFS lands. This totaled just over 330 million acres.

Wildfire Simulation

For wildfire simulation inputs, we used the national mosaics of burn probability and flame-length probabilities produced by the Forest Service, Rocky Mountain Research Station (Short et al. 2016). These data include CONUS 270-m raster mosaics of burn probability (annual likelihood of fire occurrence) and conditional probability of six fire intensity levels (0 to 1 for each of six flame length classes; all six sum to one for any pixel).

HVRA Characterization

To characterize HVRAs at the national level, we selected five primary HVRAs: (1) Communities, (2) Infrastructure, (3) Surface Drinking Water, (4) Ecosystem Function, and (5) Air Quality. In the risk assessment framework, these represent things on the ground that are of value, could be potentially affected by wildfire (negatively or positively), and are important enough that they could influence fire management decisions. Another critically important criterion is that quality, nationally comprehensive and consistent GIS data must exist for each HVRA. Some HVRAs that are common in assessments at finer scales were considered, but excluded from this assessment because they did not meet one or more selection criteria. Habitat for specific plant and animal species and commercial timber resources are examples.

Most of the five primary HVRAs were sub-divided into finer categories for the purposes of estimating fire effects and relative importance. In consultation with Forest Service personnel at the national and regional levels, we assigned response functions for each sub-HVRA and calculated weighting factors based on relative importance and relative extent of each, following methods outlined in Scott et al. (2013).

Effects Analysis

The primary focus of this risk assessment has been on producing effects analysis outputs. These outputs include metrics of wildfire risk such as conditional Net Value Change (cNVC) and expected Net Value Change (eNVC). We can also break these metrics into their component parts of conditional or expected benefits and losses. We followed methods for these calculations outlined in other publications (Scott and Thompson 2015; Scott et al. 2013; Thompson et al. 2016a)

Given the objectives of this assessment, we also summarized all calculated metrics by each of the eight Forest Service regions. For each region, we calculated both the mean and sum of cNVC, eNVC, and conditional and expected benefits and losses. We evaluated each of these for use as a Wildfire Risk Index that could track changes over time.

Lastly, we summarized the calculated risk metrics by each of 109 separate National Forest units. While these forest-level summaries are not intended as the primary use of this assessment, they can help to provide nationally-consistent information for national-level decision making.

RESULTS AND APPLICATION

We present the results of our effects analysis in two categories: conditional versus expected. Conditional measures are exactly that – they reflect likely changes at any location *if a fire occurs there*. Returning to the three primary components of risk (likelihood, intensity, and susceptibility), conditional measures account for only two of them—the intensity of fire and the susceptibility of (or effects on) HVRAs. Conditional risk metrics are very useful for response planning, where you need to prepare for what to do once you have a fire.

Expected measures of risk account for all three components of risk, integrating the conditional metrics with the overall likelihood of fire occurrence, or burn probability. Expected risk metrics are useful for most other purposes besides response planning, particularly resource allocation. Expected risk measures most closely meet our objective of creating a relative measure of overall wildfire risk among Forest Service regions, specifically to help guide resource allocation and policy questions.

We present a sample of maps (fig. 1) and charts (fig. 2) depicting some of our results. More results are available online at: https://www.firelab.org/project/national-wildfire-risk-assessment. The maps reflect the spatial sum, by National Forest, for both the cNVC and eNVC metrics, with regional boundaries overlaid as bold lines. The difference between cNVC (which does not include burn probability) and eNVC (which does include burn probability) is evident in these maps. Several forests in the southeastern U.S., for example, have strongly negative cNVC values but once burn probability is factored in they have relatively mild to moderate eNVC values. This is because burn probability values are much lower in the southeastern U.S. compared to most western regions. However, many factors are combined into the summaries depicted in these maps. It is important to consider these contributing factors to fully understand and give context to the NVC results.

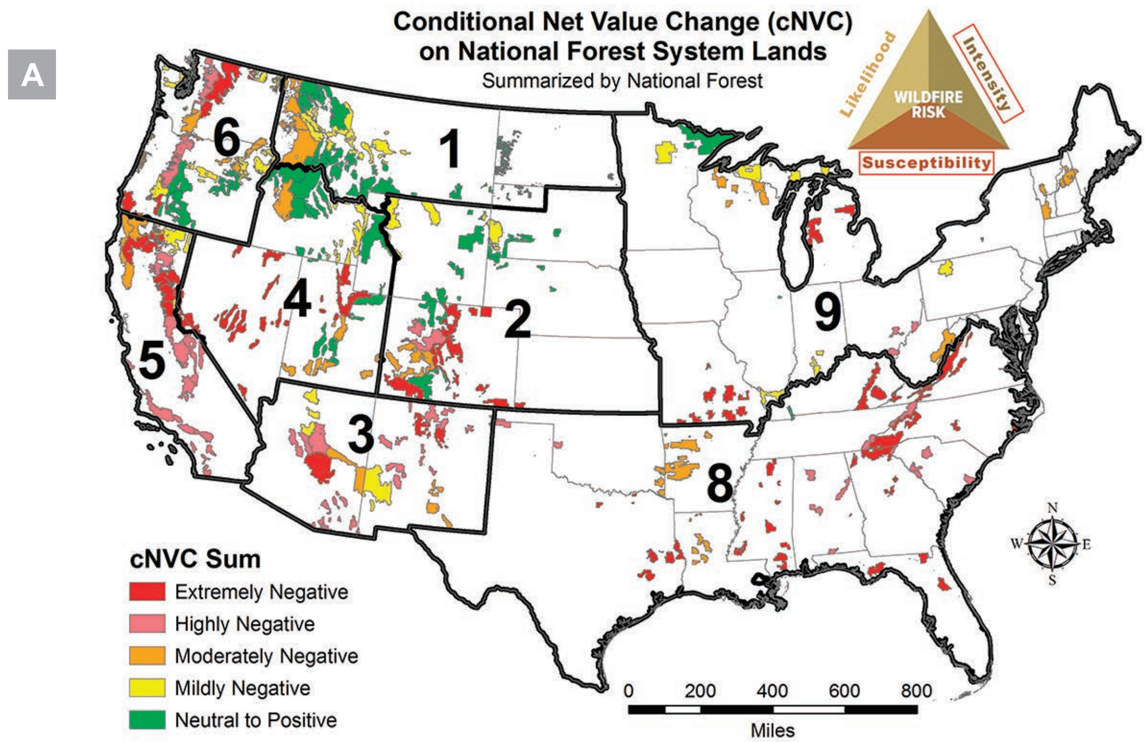
The charts in figure 2 help us to pull apart the NVC numbers into their component parts of benefits versus losses, and also help with further understanding of conditional versus expected metrics. In the bar charts (fig. 2a, 2b), we present the sum of cNVC and eNVC across each Forest Service region (gray bars). As wildfire can have a mix of positive and negative outcomes, depending on the HVRA and fire intensity, these measures truly represent the "net" outcome. The red and green bars show the negative outcomes (potential losses) and positive outcomes (potential benefits), respectively. We strongly encourage managers interpreting results such as this to consider these potential losses and benefits, and not just the NVC values.

The pie charts (fig. 2c, d), also should give managers and policy-makers an understanding of why there are uses for both conditional and expected risk metrics. The conditional losses for each region (red bars in fig. 2, wedges in fig. 2c) show that each region has the potential for a fair amount of loss from wildfire when fires occur there. Each region has roughly 10 percent to 20 percent of the total potential losses across all NFS lands. The expected losses, on the other hand, show that when burn probability is factored in, some regions have a much greater proportion of the total expected losses than others.

A National Risk Index

We evaluated several possible metrics, including all those shown in figure 2, as candidates for a Wildfire Risk Index and ultimately chose expected losses. While eNVC would seem like the best option, we found it problematic as an index because it can get almost zeroed out in regions that have more potential benefits. Given the objective in the Forest Service Strategic Plan (USFS 2015) to "mitigate wildfire risk," we felt that using potential losses focuses on what the agency can possibly mitigate. Potential wildfire benefits, as accounted for in this assessment, are an inherent property of ecosystems and can't be changed by management actions.

To use expected losses as an index, we will use the analysis presented here, based on 2012 landscape conditions, as a baseline. The index value for any area (e.g., region, all NFS) at any point in time will always be the sum of expected losses for the area divided by the baseline sum of expected losses for the area. The initial index value for any area, therefore, is 100. That will become the reference, making it straightforward to assess changes to index values in the future.



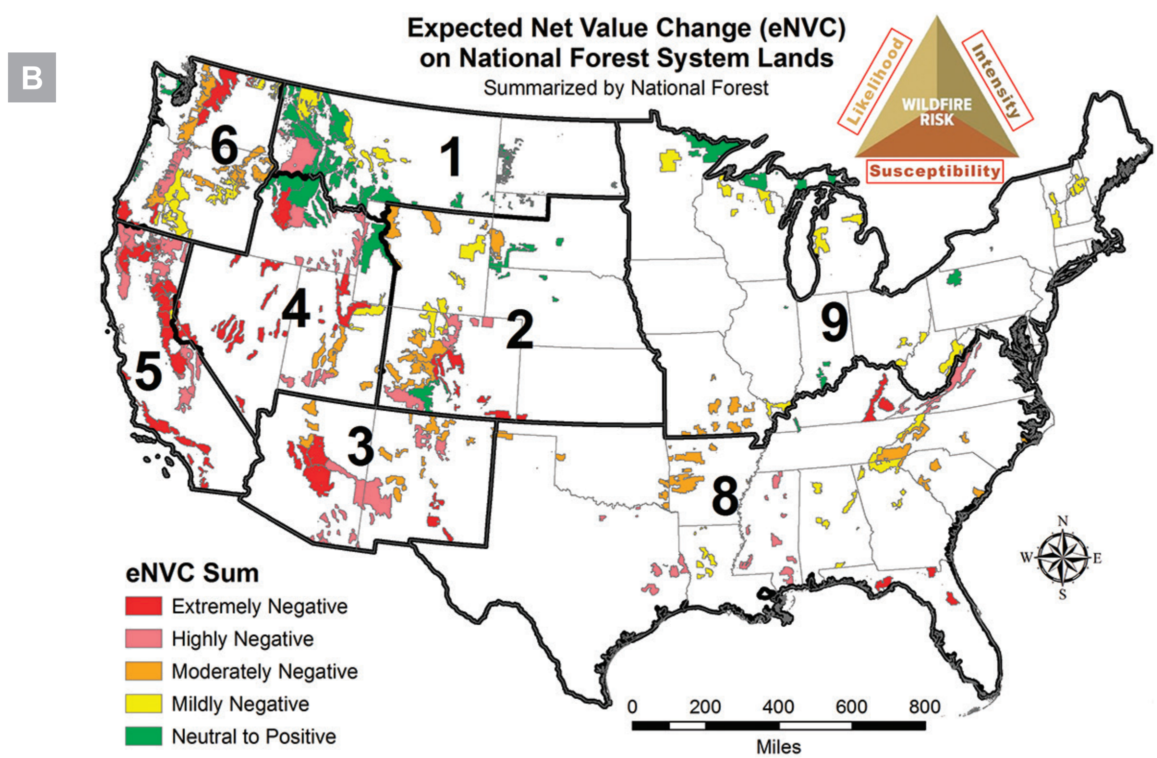


Figure 1—Maps showing cNVC (A) and eNVC (B) results summarized by National Forest. Forest Service regions are shown in bold outlines, with region numbers labeled. Classes shown reflect even quintiles of the data. Inset risk triangle shows which components of risk are included.

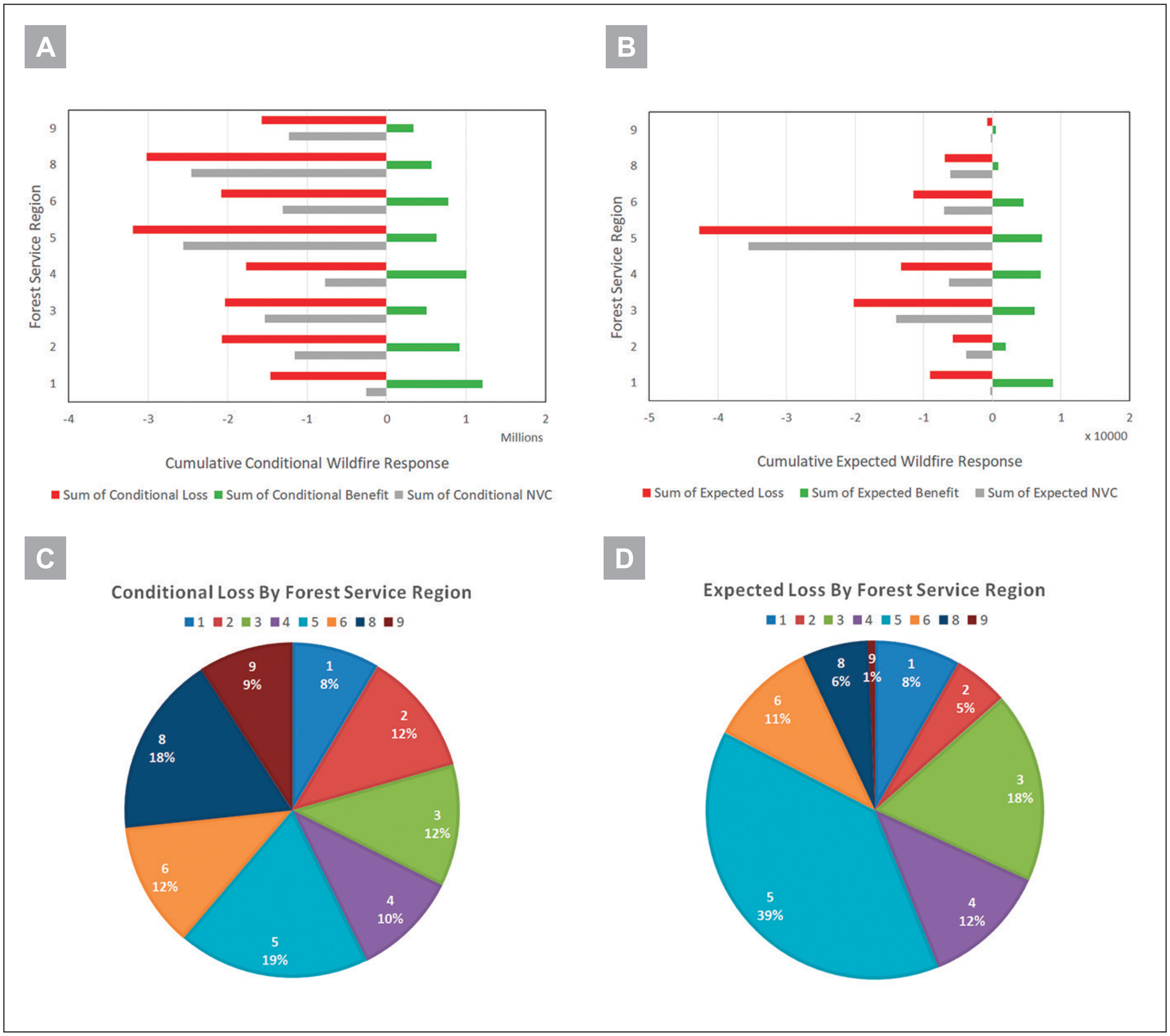


Figure 2—Regional summaries of conditional (A, C) and expected (B, D) risk metrics (regional sums; means not shown). We chose the sum of expected losses (red bars in B) as the basis for a risk index.

REMAINING WORK

Much work remains to fully understand the results and potential applications of this national risk assessment. Upcoming work includes further testing and analysis to better understand the sensitivity of each metric, and particularly the risk index, to landscape changes caused by both management actions and natural disturbances. We also must develop protocols for regular updates on an annual or bi-annual basis. Lastly, we plan to expand the analysis to all lands, to the extent possible, to further guide decision making consistent with principles of the cohesive strategy (WFLC 2014).

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