Matt Thompson, RMRS, 01 July 2015

# RBWFM Review

## Key Findings

**Finding #1: Risk Principles & Application**

- The RBWFM framework is risk-based, structured, and largely consistent with current state of wildfire risk science
- The national-scale RBWFM analysis is relatively simple, off the shelf, and helps set priorities
- Strategic Business Plans afford flexibility and tailored approaches to more accurately and comprehensively assess risks and risk mitigation options
- However, there are a number of issues in terms of how RBWFM is framed and implemented, which are described in more detail below

**Finding #2: Risk Concepts & Terminology – Reframing RBWFM as Exposure Analysis**

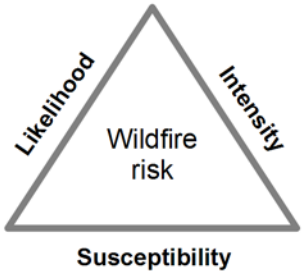


**Figure 1: Risk triangle, from RMRS-GTR-315**

The risk triangle in Figure 1 represents the three fundamental components for *quantifying* wildfire risk. This triangle is premised on implementation in a spatial context. However, the triangle concept does not speak to the *risk assessment process* or to the specific *analytical* steps. Figure 2 indicates the general steps of risk assessment, beginning with formulating the problem, analyzing exposure and effects, characterizing of risks, and lastly managing risk. Input from stakeholders helps frame the problem and evaluate risks and risk management options, but typically does not influence the analyses directly.

Problem formulation describes the potential hazards and identifies the assets and resources to be included in the analysis. Exposure analysis entails assessing wildfire likelihood and/or intensity where assets and resources are located. Using a fire modeling system like FSim, this can be done in two ways:

1. Aggregated across all simulated fires: pixel-based representations of burn probability (likelihood) and six conditional flame length probability classes (intensity)
2. Individual simulated fires: polygon-based representations of the footprints of individual fires; due to storage limitations fire intensity within each specific fire perimeter is not

retained. The *RBWFM analysis uses this approach, and therefore cannot directly estimate fire intensity associated with each fire perimeter*

Effects analysis entails estimating potential losses and benefits to assets and resources given their level of exposure, and is frequently tied to measures of fire intensity such as flame length. Risk characterization summarizes information from exposure and effects analysis in a way that is useful for decision making, including articulating preferences and priorities to evaluate and balance tradeoffs.

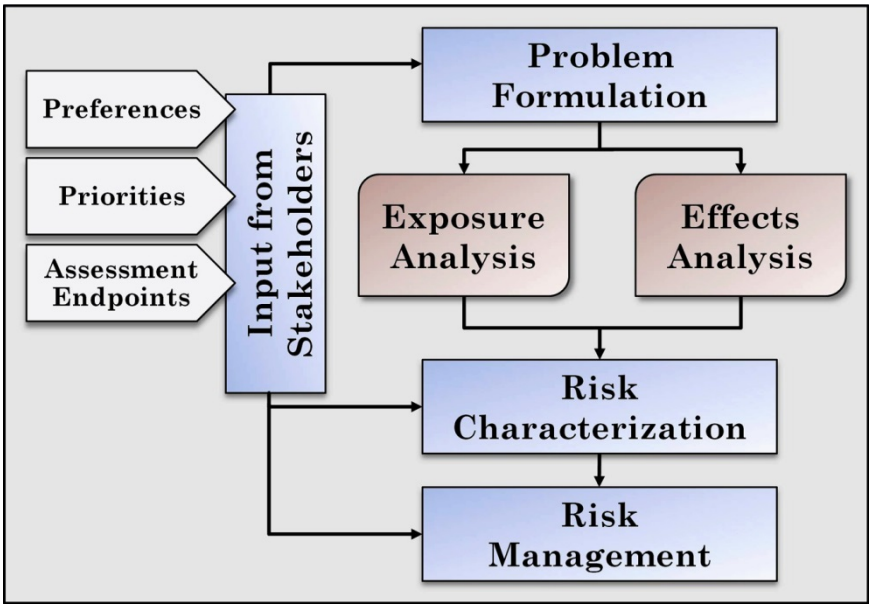


**Figure 2: Risk assessment framework, with two primary analytical steps highlighted in red, from RMRS-GTR-262.**

Figure 3 may help clarify the relationship between the fundamental components of risk embedded in the risk triangle concept, with the fundamental analytical steps of assessing risks. Again this is all premised on implementation in a spatial context, overlaying fire modeling outputs with mapped locations of assets and resources. **At present, the national-scale RBWFM analysis only directly incorporates a measure of wildfire likelihood, and it is therefore most appropriate to refer to RBWFM as exposure analysis.**

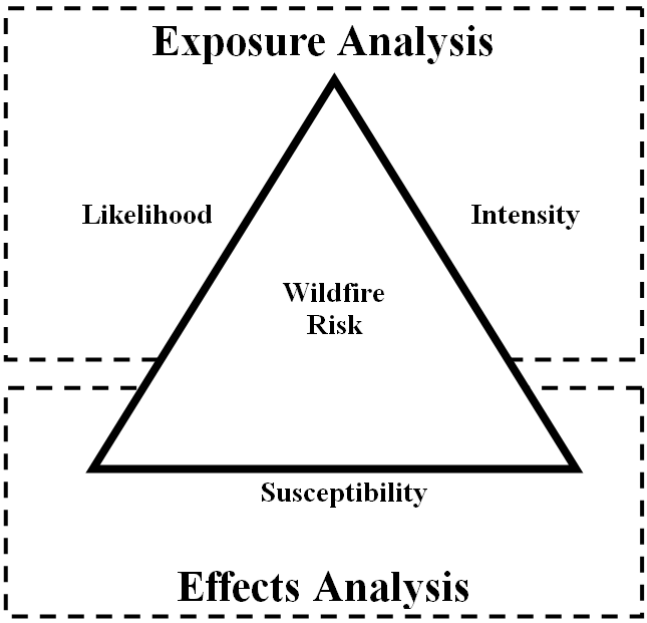


**Figure 3: Relationship between risk triangle and analysis of exposure and effects**

**Finding #3: Risk Concepts & Terminology – Effects Analysis and Risk Characterization would be inappropriate**

Three central tenets of risk assessment are worthy of mention:

1. Identification of assets and resources should be highly specific
2. The potential consequences to resources and assets given exposure should be highly specific
3. The relative importance of assets and resources should be articulated

Given that national life, property, and resource values as currently identified are very coarsely mapped and intended to be surrogates for other national, state, and local values, none of these three tenets can be met. It would therefore be inappropriate to attempt to perform an effects analysis or to characterize the relative importance of assets and resources. Strategic Business Plans at the bureau-level however should be able to better address each of these points in relation to relevant missions, mandates, GIS data, etc. **At present, it would be most appropriate to only perform a national-scale exposure analysis anyway.**

**Finding #4: Analytical Shortcomings**

Although (after reframing as exposure analysis) RBWFM is conceptually sound, there are several issues with how RBWFM is implemented within the spatial analysis process. These issues are fleshed out in more detail in the PowerPoint presentation.

1. Known issues with FSim, especially under-prediction of crown fire behavior
2. NLPR layers – Forest Areas, Sagebrush Steppe, and especially Drinking Water are driving the entire analysis

3. NLPR counting – only considering the presence/absence of NLPRs ignores variable densities of NLPRs, likely significantly underestimates exposure in some locations, and effectively turns the analysis into a hazard assessment of area burned by bureau
4. Evaluating DOI ignitions only could significantly underrepresent the exposure of certain NLPR values, and focusing fuel treatment investments on where exposure is located rather than where the source of exposure is located might be more sensible

In total, these analytical shortcomings could:

1. Misrepresent the size, shape, and location of simulated perimeters and cumulative fire activity associated with each bureau
2. Misrepresent or underrepresent exposure levels
3. **Go against the principle that every acre is not equal**

**Finding #5: Risk Mitigation Ignored**

Stated objectives for RBWFM include the ability to formulate budget requests and demonstrate return on investment. At present RBWFM has no components that address the costs, effectiveness, or efficiency of preparedness and hazardous fuel investments in reducing exposure levels, reducing effects, or reducing risks.

## Recommendations

1. Wait until 2015 FSim results come online
    a. Crown fire issue addressed
    b. Improved spatial representation of fire activity within forested areas
    c. Improved calibration on basis of more relevant spatial analysis units
2. NLPR Layers
    a. Count the number of NLPR values in each burned cell, not just the presence/absence – this gives a true representation of "value acres burned"
    b. Only include Drinking Water above a threshold – importance values are directly provided by the Forests-to-Faucets data
    c. Examine the sensitivities of how individual layers are driving results and ensure that is commensurate with importance to national-scale priorities
3. Consider including all ignitions for fuels investments
    a. Focusing only on DOI ignitions has great potential utility for understanding where to position preparedness resources but less utility for fuels decisions.
    b. Off-site ignitions could still affect NLPR values on DOI lands, and treatments to reduce intensity could address these issues
    c. This actually makes the analysis process much simpler, and enables the direct incorporation of fire intensity
4. Consider risk mitigation opportunities and how they may vary across NLPRs and bureaus. This could include a number of other factors including:
    a. Workload and complexity
    b. Suitability and duration of vegetation to fuel treatment
    c. Past accomplishments

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# Response to technical and management questions:

## Management Questions:

**1. Does DOI's approach address the three fundamental questions?**

Yes, but with limitations

- Analysis does not measure risk but exposure, and there are limitations to the exposure analysis
- No consideration of risk mitigation opportunities
- Unclear path forward for performance measurement

**2. Does the RBWFM approach align with the principles and goals?**

Yes, and the clear definition of principles and goals is a great strength of this approach

**3. Are there biases (e.g., ecological, social, or economic) in the approach?**

Yes, primarily the issues with how NLPRs are identified and counted, but also through ignoring variation in risk mitigation opportunities

**4. Does the approach inadvertently create barriers to success, i.e., the more successful you are the less risk there is and the less money you get?**

This is a possibility (how far the needle will actually move in a 5-10 year period is unknown but likely small), but can be addressed directly

- Consider maintenance needs, temporal look-ahead of treatment durability
- Consider external drivers influencing risk
- Consider past performance

**5. Can the approach be used to demonstrate the value of investing in fuels and preparedness and the expected return?**

Limited ability to do so

- Requires assumptions about treatment location, durability, effectiveness
- Reliant on uncertain process to demonstrate success
- Return only measured in reduced exposure, not avoided loss or enhanced resilience

**6. Do the values reasonably represent DOI and bureau missions?**

Unclear – what these layers are surrogates for is never made known

- What about fire-adapted ecosystems and ecologically beneficial fire?

- What does “Forests” represent? What does “Riparian” represent? Are the underlying concerns forest values, habitat, soil and water quality, etc.? I think the specifics of these management concerns drive the bus and ultimately should dictate which values are represented in the model
- Drinking Water is mapped nearly exhaustively and includes areas Forests-to-Faucets identifies as very low importance to drinking water – does not seem nearly commensurate with other life and property values

**Technical Questions:**

1. **Is the Risk Triangle Concept (intensity, susceptibility and likelihood) consistent with the best available science?**

Yes, the risk triangle is very sound and consistent with the best science. However, this analysis has not fully implemented the triangle.

2. **Is the analytical handling of FSim consistent with its intended use?**

Mostly; intended use is largely for burn probabilities and fire intensity levels, and there has been limited calibration on actual perimeters. However, applications increasingly use perimeters with some degree of confidence. It is worth double checking that FSim outputs are well understood – specifically that perimeters contain no intensity information. Note that there are significant issues with FSim outputs relating to crown fire prediction that could bias results, although 2015 results should have that bug fixed.

3. **Do values represented in the model statistically skew the modeled outputs, i.e., are they the right values?**

Unclear if “values” here is referring to FSim outputs or NLPR values. Both could skew model outputs, for different reasons already articulated: FSim outputs have biases from crown fire, NLPR values have biases based upon coarse mapping and single counting.

4. **Do the data sets used reasonably represent the values listed above?**

Again the issue that NLPR values as identified as surrogates makes this a difficult question to answer. Certainly forests, riparian, and drinking water layers cause the greatest concern. I think a major concern is mapping every single acre where Forests-to-Faucets has a value, even if the importance to drinking water is very, very, very low. As described above I would recommend identifying some threshold and only including watersheds above that threshold. Barring that, I would recommend stating explicitly that you used all watersheds and didn’t use the importance values to filter out watersheds, and that this analysis therefore explicitly ignores any information on the variable importance of watersheds to drinking water.

Greg Dillon mentioned that he found the WFDSS communication sites layer to be much more comprehensive than the HSIP Gold layer, and similarly that HSIP data on campgrounds was lacking relative to WFDSS or perhaps bureau-specific data for campgrounds.

As for the riparian layer, Greg stated it might be possible to get a better representation of riparian habitat by selecting all riparian types out of the LANDFIRE Existing Vegetation Type layer. LANDFIRE used the NHD as a starting point, but also modeled riparian settings using a valley bottom zone algorithm based on topography. Along these same lines, why are riparian areas that are associated with larger water bodies like lakes not accounted for in the data (only NHD flowlines were used)?

T&E Species: When we considered using these data in the national risk assessment for the Forest Service, we were advised by Susan Goodman with OWF that these data were inconsistent and unreliable and we would be better off not incorporating T&E in a national-scale risk assessment.

**5. Do modeled outputs (Expected Value Acres Burned) reasonably represent a national risk profile across the DOI lands?**

No. The modeled outputs reflect exposure, which is a component of risk but does not describe risk. The exclusion of susceptibility to loss/benefit and relative importance weights are significant limitations. The exposure analysis itself has limitations as described above (NLPR counting, only focusing on DOI ignitions, etc.). But, it could be argues that (after issues are addressed) EVAB reasonably represents a national *risk-based exposure* profile.

**6. How might ongoing maintenance of mitigated risk be represented already in the profile?**

There are a number of possible metrics to consider

- Capacity
- Acres treated, type, and assumed durability
- Fraction of treated acres that interacted with fire (needs monitoring)
- Fraction of treated acres that met stated objectives when tested by fir (needs monitoring)
- More than just IA rates, but proportion that met strategic objectives

**7. What strengths and weaknesses do you see in the analysis based on the RBWFM approach?**

Many of these are addressed above and in the PowerPoint presentation, with a few additional concerns listed here. Are there plans to maintain/update geospatial data as it changes over time? The team might consider streamlining the geospatial processing to facilitate annual updates by exploiting functionality in the RMRS Raster Utility toolbar. This is based on Function Modeling concepts that can profoundly improve raster processing operations

http://www.fs.fed.us/rm/raster-utility/ (e.g. processes that used to take days can take hours or minutes)

**8. Are there any fatal flaws in the analysis?**

No, but there are a number of recommended improvements prior to basing decisions on analysis results.

**9. What types of performance metrics should be considered when evaluating implementation of a risk based approach (e.g., treatment effectiveness, reducing the effects of wildland fire and avoided costs)?**

This is the million dollar question. A clear difficulty is using outputs (e.g., acres treated) as a proxy for outcomes. I think outputs will inevitably be a part of performance measurement for some time, but we can and should invest more in monitoring outcomes. For the fuels perspective this begins with GIS data on the size, type, age, and location of every treatment, and then periodically assessing whether these treatments are tested by fire. This can help answer questions like are doing better or worse than random?

Coarse-scale

- Capacity
- % of treatments that interact with fire
- % of those treatments that achieved objectives

Fine-scale

- Capacity
- Post-fire reports
- Post-fire analyses analyzing avoided losses and costs (modeling and data intensive)