Statement of
Dr. Mary Ellen Miller
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Before the Committee on
Energy and Natural Resources
U.S. Senate
August 3, 2017
Full Committee hearing to examine federal and nonfederal collaboration, including through the use of technology, to reduce wildland fire risk to communities and enhance firefighting safety and effectiveness.

Good morning Chairwoman Murkowski, Ranking Member Cantwell, and Members of the Committee. Thank you for inviting me here today to share my NASA applied science work in post-fire remediation. My name is Dr. Mary Ellen Miller and I am a research engineer at Michigan Tech Research Institute. I have a Master's degree in Imaging Science and a PhD in Environmental Engineering.

Post-fire flooding and erosion can pose a serious threat to life, property, and natural resources. As part of my PhD I worked on a large scale EPA project designed to help prioritize fuel reduction treatments in order to help protect water resources in the Western US from post-fire sedimentation. When this project ended I used the datasets and modeling techniques I had developed to rapidly model post-fire erosion for Forest Service BAER Teams in Colorado. BAER or Burned Area Emergency Response Teams are under tight time schedules; they usually have just one week to assess burned areas and make remediation plans with or without good information. Earth observations of burn severity are an integral component in their remediation planning, but I was surprised to learn from Forest Service Colleagues that BAER Teams were not utilizing spatial process based models in conjunction with satellite data. In 2011, I was invited by the National Park Service to model a small watershed (536 acres, Hospital Canyon) that burned within the Rock House Fire, Texas. I had one week – I thought it would be NO problem! However, it was a problem as Texas was not part of the original fuels project and I could not assemble the soil input data fast enough for the results to be included in the BAER analysis. One year later I was able to model over 80,000 acres of the 2012 High Park fire in Colorado – because I had base data layers consisting of soils, vegetation and terrain formatted so that I could easily join the data with Landsat derived burn severity maps. The difference between success and failure was simply preparation.

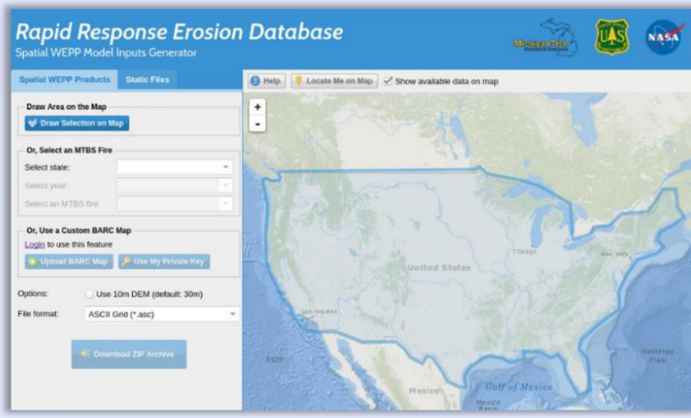
I am proud to introduce a new online Rapid Response Erosion Database (RRED, [http://rred.mtri.org/rred/](http://rred.mtri.org/rred/)) to support post fire remediation using NASA satellite imagery and process based hydrological models. RRED was created through a joint collaboration between Michigan Tech, the NASA Applied Sciences Program and the USDA Forest Service Rocky Mountain Research Station.

1) Data preparation that used to take a week can now be done in moments, making it feasible and much faster for BAER Teams to utilize NASA earth observations and spatially explicit process-based models.
2) Spatial predictions of runoff and erosion allow for the rapid spatial prioritization of costly post-fire remediation treatments. The database has been used to support BAER teams on several major fires in the Western US including the King Fire where modeling results were used to spatially prioritize a million dollars' worth of mulch and to plan 3 million dollars' worth of wood shreds for the Butte fire. RRED has also supported four fuel's projects including one in the Mokelumne Basin.
3) Future goals include expanding spatial coverage to include Alaska and Hawaii as well to improve RRED's capabilities for supporting fuel's planning projects designed to reduce the risk of high severity fires on valuable water reservoirs. This can be accomplished by expanding support to additional models.

This concludes my prepared statement. I am happy to take any questions you may have.

# NASA **RRED:** ***Rapid Response Erosion Database***

Created by a collaboration between **NASA**, **Michigan Tech Research Institute**, and the **USDA Forest Service**, the **Rapid Response Erosion Database** (**RRED**) is an interactive web application designed to support process-based hydrological modeling for **post-fire remediation** efforts. **RRED** supports this modeling by using **NASA** satellite data to rapidly create the required geospatial model inputs, expediting the process so that the spatially explicit erosion and run-off prediction outputs are more readily available for use in assessing and prioritizing post-fire remediation.

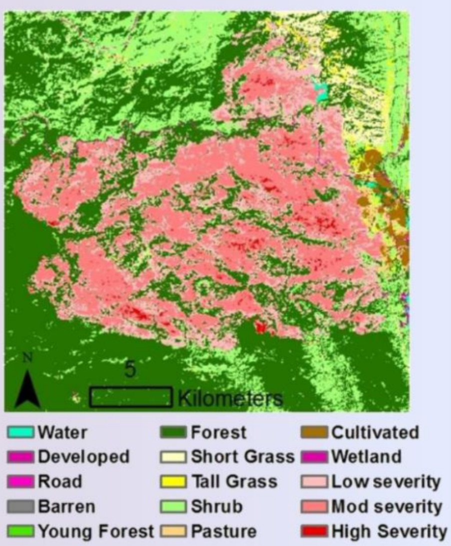



**Prior to RRED, assembling and formatting these geospatial model inputs would have taken *several days*; RRED delivers these inputs in mere *seconds*.**

Modeling database:

rred.mtri.org/rred

Data can be delivered in both burned and not burned formats, providing flexibility for other applications such as **agriculture**, **construction** and for **fuels planning** projects seeking to **protect water resources**.




## Why RRED matters

**Post-fire flooding** and **erosion** can pose a serious **threat to life**, **property** and **municipal water supplies**. To respond to this threat, interdisciplinary **Burned Area Emergency Response** (**BAER**) teams are formed to assess potential erosion and flood risks. BAER teams must quickly determine if expensive remediation treatments are needed and how to prioritize their spatial application. One of the primary sources of information for making these decisions is a burn severity map that reflects fire-induced changes in vegetation and soil properties. Slope, soils, land cover and climate are all important parameters in assessing risk. Process-based hydrological models, such as the **Water Erosion Prediction Project** (**WEPP**), are needed to estimate the effects of these parameters.

*(left) a disturbed land cover map created by RRED from an uploaded a Landsat burn severity map of the 2012 High Park Fire, Fort Collins, CO. Spatial soils and DEM layers are also generated.*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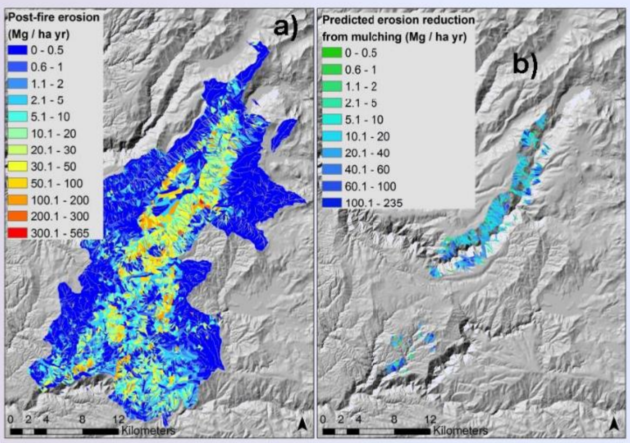
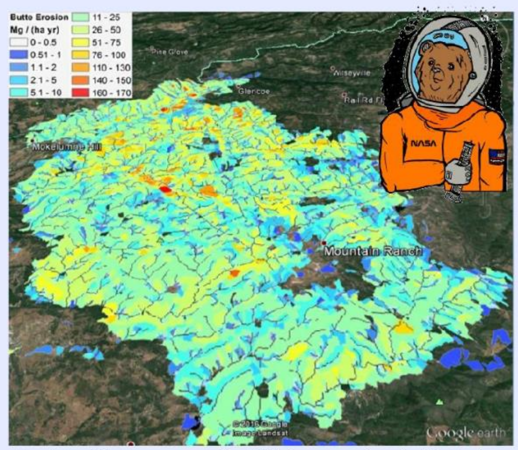
# RRED in action


*RRED in action on 11 wildfires that burned in the Western US in 2012-2016 and on two fuels projects in the Mokelumne watershed and Flagstaff, Arizona.*

RRED has been used to support multiple BAER teams and fuels projects. The **French** (5,600 ha) and **Silverado** (390 ha) fires were relatively small, and predictions of post-fire erosion and runoff were generated within hours of receiving soil burn severity maps. For the **Butte** (8,700 ha) and **Valley** (30,800 ha) fires, BAER teams were interested in modeling a wet climate due to El Ninõ concerns. BAER teams on the **King** (39,500 ha) and **Happy Camp** (54,200 ha) fires modeled predictions of average first year post-fire erosion and erosion from a single storm event. On the King and Silverado fires, multiple modeling runs were used to estimate impacts of proposed mulching treatments. Modeling work on the King fire was used to justify and target more than $1 million in mulching treatments, which the Sacramento Municipal Utility District helped pay to protect a hydroelectric and water supply reservoir downstream of the fire. Hillslope scale predictions **save money** by allowing for the spatial prioritization of costly post-fire remediation treatments.




*Predicted first-year post-fire hillslope erosion a) for the King fire and b) expected reduction in erosion due to proposed mulching treatments.*




*Predicted first-year post-fire hill slope erosion for Butte fire, CA using a "wet" climate to address El Ninõ concerns.*

# Future vision

Our vision is for advanced GIS surface erosion and mass failure prediction tools that use Earth Observations data to be easily applied to post-fire analysis using readily available spatial information from a single online site. RRED currently covers the contiguous US and we are seeking support to expand coverage (Alaska, Hawaii, internationally). Future goals also include supporting additional post-fire debris flow models, a dry ravel model, and models for predicting erosion impacts on reservoirs. We are also developing a new open-source interface for WEPP that will work seamlessly with RRED and can be customized for multiple applications including trafficability of unpaved roads, agriculture, and construction. Our goal is to make the latest technology and satellite data easily accessible to the land managers tasked with protecting lives, property and natural resources.

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USDA Forest Service Rocky Mountain Research Station Forestry Sciences Laboratory, Moscow, ID

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For more information, visit: http://appliedsciences.nasa.gov.

Michigan Tech Research Institute

Background

Forests protect watersheds and reservoirs because their canopy and surface cover protect forest soils from runoff and erosion (Robichaud 2000; Moody and Martin 2001). After a wildfire, this protective cover is removed and the resulting flooding and erosion can threaten lives, property and natural resources. Flooding after the 1996 Buffalo Creek Fire in Colorado resulted in the deaths of two people, and sediment from this fire reduced Denver's municipal reservoir capacity by roughly a third (Agnew *et al.* 1997). The hazards of flooding due to increased runoff and mass movement events are of special concern near the wildland urban interface, cultural sites, municipal water sources, and sensitive habitats (Robichaud and Brown 2000; Moody and Martin 2001; Cannon *et al.* 2010; Moody *et al.* 2013).

Planning the mitigation of post-fire threats is undertaken by state or federal agencies. On a federal level, interdisciplinary Forest Service BAER and Department of Interior Emergency Stabilization and Rehabilitation (ESR) Teams work diligently to estimate erosion and flood risk. Their assessments are used to develop recommendations to mitigate increases in runoff and erosion (US Department of Agriculture and Forest Service 2004; US Department of the Interior 2006).

Burn severity maps derived from satellite data reflect fire-induced changes in vegetative cover and soil properties. Slope, soils, land cover, and climate are also important factors that require consideration. Many modeling tools and datasets have been developed to assist remediation teams, but process-based and spatially explicit models are under-utilized compared to simpler models because they are difficult to setup and require properly formatted spatial inputs. To facilitate the operational use of models in conjunction with NASA earth observations my research team and I have developed an online spatial database (http://rred.mtri.org/rred/; Miller et al. 2016a) to rapidly generate properly formatted modeling datasets modified by user-supplied soil burn severity maps. Automating the creation of model inputs facilitates the wider use of more accurate, process-based models for spatially explicit predictions of post-fire erosion and runoff.

Rapid Response Erosion Database (RRED)

RRED was created through a joint collaboration between Michigan Tech, NASA applied sciences and the Forest Service Rocky Mountain Research Station to facilitate the operational use of spatially explicit and process-based models (Miller et al., 2016a). Our online database delivers model inputs in mere seconds, replacing days of assembling and formatting spatial data and model parameters. Users may select a historical fire, upload a new burn severity map, or upload a prediction of future burn severity. Once uploaded, the burn severity map is combined with vegetation and soils datasets and delivered to the user pre-formatted for modeling. Vegetation datasets are derived from the Landfire Existing Vegetation Type (Rollins 2009; LANDFIRE 2011) and the soil layer was created using the SSURGO or STATSGO (STATe Soil GeOgraphic) NRCS (Natural Resources Conservation Service) soil databases (US Department of

Agriculture 1991; Soil Survey Staff 2014). Digital elevation model (DEM) data is acquired from the USGS national elevation dataset (Gesch et al. 2002; Gesch 2007).

For added flexibility, users can also select an area of interest with a drawing tool and download inputs formatted for agricultural or rangeland applications. Model inputs produced by the web database application are designed to be used by spatial Water Erosion Prediction Project (WEPP) models including GeoWEPP (Renschler, 2003) and a brand new open source interface QWEPP (Miller et al.,2016b) being developed specifically for use with the database. Support for additional models is provided by flexibility in the format of the model inputs. Early applications of the database included creating inputs for fuels planning projects using predictions of burn severity (Elliot et al.,2016; Elliot and Miller, 2017). The RRED site also provides modeling support for historical fires with the inclusion of fires from the Monitoring Trends in Burn Severity (MTBS) project (USDA, Department of the Interior 2009). The MTBS database enables researchers and land managers to model cumulative watershed effects and compare the watershed impacts of proposed land management practices to erosion following historic fires.

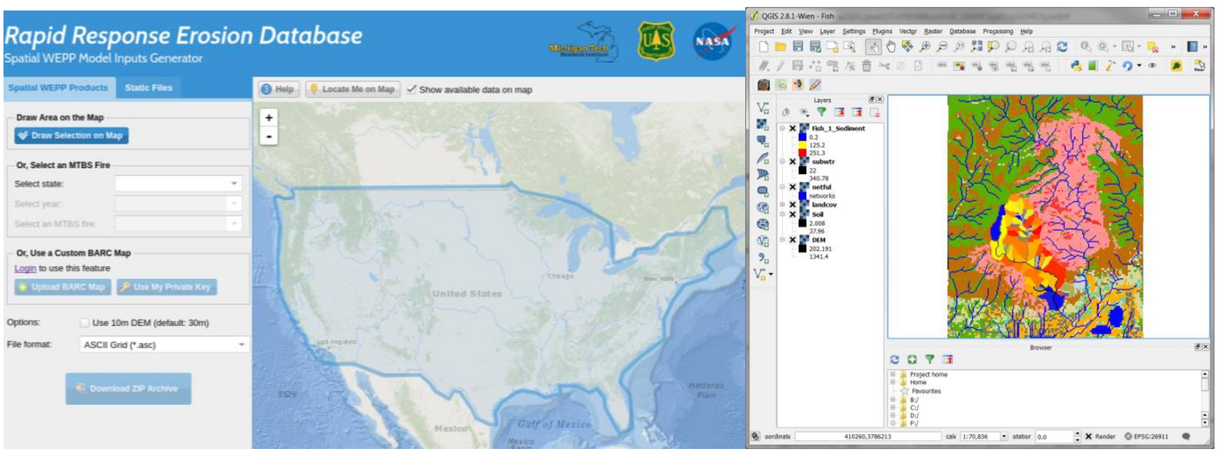


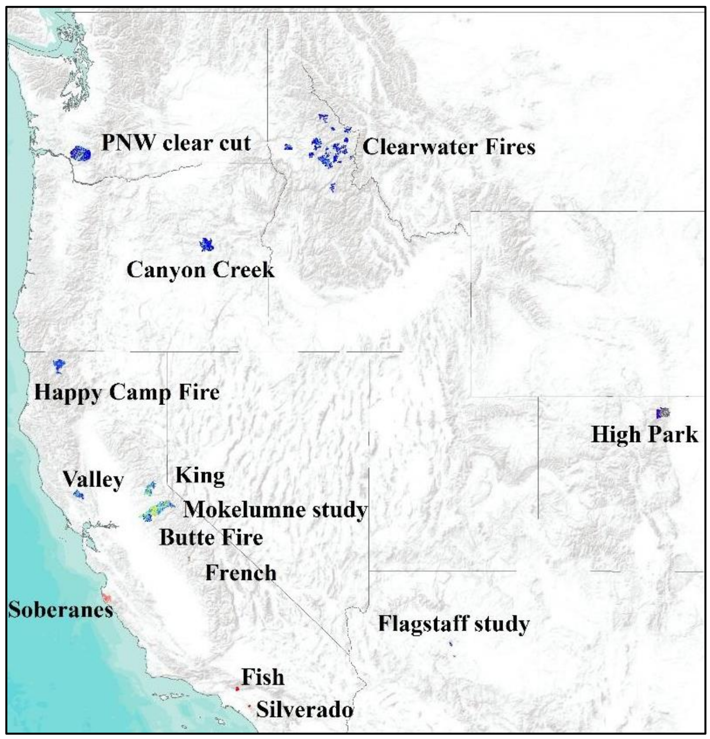

Figure 1. a) Rapid Response Erosion Database (RRED) for supporting erosion modeling and b) QWEPP, a new open source interface to the Water Erosion Prediction Project which works with data from RRED.

## The Water Erosion Prediction Project (WEPP)

RRED provides comprehensive support for WEPP, a physically-based hydrology and soil erosion model developed by an interagency team of scientists (Laflen et al. 1997). The surface hydrology component of WEPP utilizes climate, topography, soil, and vegetation properties to predict plant growth, residue decomposition and soil water balance on a daily time step and infiltration, runoff, and erosion on a storm-by-storm basis. WEPP then provides runoff, erosion and sediment delivery by event, month, year, or average annual values for time periods ranging from a single storm to 999 years for either an individual hillslope or a watershed containing many hillslopes, channels and impoundments. A key advantage of WEPP is that it is process based and unlike empirical models can be applied outside the region where it was developed (Elliot et al. 2010).

The newly developed Rapid Response Erosion Database makes use of WEPP soil and vegetation parameters developed by the Forest Service for managing disturbed forests. USDA Forest Service scientists have developed user-friendly online interfaces for the hillslope version of WEPP to model both unburned hillslopes and hillslopes following wildfire (Elliot et al. 1999; Elliot et al. 2006; Robichaud et al. 2007a). The two main hillslope tools available for post-fire analysis are Disturbed WEPP, which predicts average annual surface runoff and erosion values, and the Erosion Risk Management Tool (ERMiT) that predicts the probability associated with sediment delivery from a single runoff event (Elliot et al. 2006; Robichaud et al. 2007a). Both interfaces link land cover to vegetation and soil properties, so users need only select a land cover and soil texture. Disturbed WEPP has land cover for mature and young forests, skid trails, shrubs, grass communities, and low and high soil burn severity. In order to support BAER teams; spreadsheet tools for both ERMiT and Disturbed WEPP were created within Microsoft Excel to allow users to run multiple hillslopes (Elliot 2013).

<u>RRED in action</u>




RRED has supported BAER Teams on multiple fires that burned in California (CA), Idaho (ID), and Oregon (OR). The 2014 French (5,600 ha) and 2014 Silverado (390 ha) fires in California were relatively small; therefore, predictions of post-fire erosion and runoff could be generated within just a few hours. The larger 2014 King (39,500 ha), 2014 Happy Camp (54,200 ha), 2015 Valley (30,800 ha) and 2015 Butte (28,700 ha) fires in California required one to two days. RRED has also been used on at least four fuel's planning projects to protect water quality and reservoirs (Mokelumne, CA; Flagstaff, AZ; East Deer Creek, WA; and Clear Creek, ID) (Srivastava et al., 2015; Elliot et al.,2016; Elliot and Miller, 2017). Recent non fire applications for RRED include the use of the database to predict erosion from silver mining activities in Idaho (Martin Jacobson, personal communication, 9/9/2016) and utilizing the database to predict the long term effects of clear cutting in the Pacific Northwest (Banach 2017).

The 2014 King Fire BAER Team utilized several modeling scenarios including predictions of average first year post-fire erosion with 25 years of climate and post-fire erosion from a single 5-year storm event. Using our web application, spatial DEM, land cover and soils were created in seconds and modeling scenarios were completed within two days. For both climate scenarios the burned watersheds were modeled in both pre- and post-fire state in order to estimate additional erosion due to the fire. Once initial modeling was completed the BAER Team proposed several mulching treatments expected to increase ground cover to 72%. Effects of increased ground cover due to mulching were then modeled and results were used to target more than $1 million in mulching. Predictions also helped justify treatment costs, some of which was paid for by the Sacramento Municipal Utility District, to protect a hydroelectric and water supply reservoir downstream of the fire (Jeff Tenpas, USFS Region 5, Personal communication, 10 April 2015).

In 2015 spatially explicit predictions of post-fire erosion made possible by RRED were used by FEMA, BLM, BIA and Cal Fire on the Butte and Valley fires in California. The spatial application of at least $3 million dollars' worth of mulching were targeted using process-based hydrological data in conjunction with satellite observations of burn severity.

## Conclusion

Our vision is for advanced GIS surface erosion and mass failure prediction tools that use Earth Observations data to be easily applied to post-fire analysis using readily available spatial information from a single online site. RRED currently covers the contiguous US and we are seeking support to expand coverage (Alaska, Hawaii, and internationally). Future goals also include supporting post-fire debris flow models, a dry ravel model, and models for predicting erosion impacts on reservoirs. We are also developing a new open-source interface for WEPP that will work seamlessly with RRED and can be customized for multiple applications including trafficability of unpaved roads, agriculture, and construction. Our goal is to make the latest technology and satellite data easily accessible to the land managers tasked with protecting lives, property and natural resources.

RRED was made possible through funding from both the NASA Applied Sciences Program for Wildfires (Grant: #NNX12AQ89G; M.E. Miller, PI) and the USDA Forest Service. Forest Service funding for QWEPP and for utilizing RRED for fuel's planning projects was provided by USDA Forest Service Agreement Numbers: 12-JV-11221634-175 and 13-JV-11221634-175. The proposal for RRED was competitively selected by peer review from a solicitation of the scientific community. Our operational partners and Co-Investigators William Elliot, PhD, PE and Peter Robichaud, PhD, PE from the Rocky Mountain Research Station provided vital support for project success. I would also like to acknowledge Michigan Tech Research Institute's Michael Billmire who served as lead programmer as well as Nancy French, PhD, Robert Shuchman, PhD, William Breffle, PhD, David Banach, Michael Battaglia, Richard McClusky, PhD, K. Arthur Endsley, Anthony Russel, Anthony Chavez and Brent Palarz. Support in the form of a travel grant and educational outreach was provided by the Joint Fire Science Program. The program is also grateful for the support of the NASA Applied Science management team Lawrence Friedl, Amber Soja, and Vincent Ambrosia.

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