Using MODIS ET to Evaluate Wildfire Intensity in the RECOVER Project

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Abstract

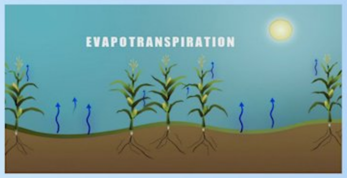
Using Moderate Resolution Imaging Spectroradiometer (MODIS) evapotranspiration (ET) products from 2000 to 2011, we assessed ET across the Big Desert study area of southeast Idaho. ArcMap 10.1 Zonal Statistics were used to derive total ET estimates throughout the growing season (April 1 to September 30) for the entire dataset. Growing season ET was used as part of the GIS TReC/NASA Rehabilitation Capability Convergence for Ecosystem Recovery project (RECOVER), to evaluate the influence of ET on fire rehabilitation planning realtive to fire intensity.

This research focuses on the Big Desert study area of southeast Idaho, a semiarid savanna (figure 1).

Figure 1. Idaho and the study site (shown by the red box) for an evaluation of evapotranspiration's (ET) relationship with fire intensity.

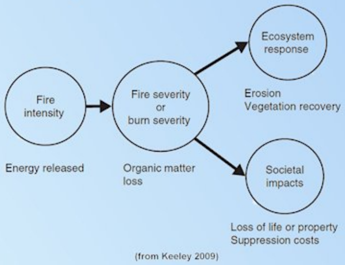
Many factors influence the characteristics of a wildfire

- Precipitation
- Temperature
- Soil moisture
- Evapotranspiration (ET)
- Fuel load, etc.



Watch a video to understand evapotranspiration: Scan Here!

- Fire characteristics can be described using fire severity and **fire intensity**



(from Keeley 2009)

- While fire severity indices exist (e.g., Normalized Burn Ratio [NBR]) few geospatial **fire intensity** models have been developed.
- Fire rehabilitation planning is highly influenced by **fire intensity,** as seed bank mortality is dependent on the depth to which heat from the wildfire penetrates.

- ET and soil moisture are interrelated, forming an important parameter influencing wildfire characteristics. Soil moisture exhibits a positive relationship with **fire intensity.**

↑ET ⟷ ↓Soil Moisture ≈ ↓Fire Intensity$_{(potential)}$

- Understanding the interaction between precipitation and temperature (expressed using growing degree days (GDD)) can be a useful tool for understanding the environmental conditions affecting soil moisture (figure 2).

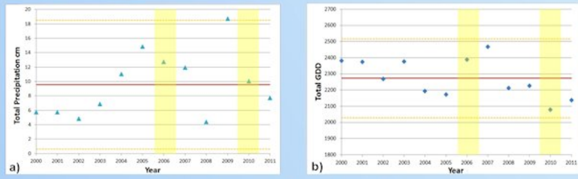


Figure 2. Total a) precipitation and b) GDD for the Big Desert study area throughout the 2000-2011 growing seasons (April 1- September 30)[1]. This study focuses on two specific fire years, 2006 and 2010 which are highlighted in yellow. The 12-year mean is represented by the red line with +/- 95% CI shown by the orange dashed line.

1. Environmental data extrapolated across the Big Desert using the USBOR weather station at Aberdeen Idaho.

- The cumulative and interactive effects of precipitation, temperature, and ET on soil moisture may be described using drought observations (figure 3). However, current drought maps are non-empirical and cannot be derived directly from satellite imagery.

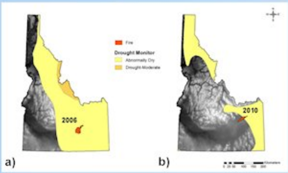


Figure 3. Drought conditions in a) 2006 and b) 2010 and the extent of two prominent wildfires; the Crystal Fire (2006) and Jefferson Fire (2010).

- Fire severity maps (figure 4) for the Crystal Fire (2006) and Jefferson Fire 2010 were used for initial investigation into the relationship between ET (figure 5) and **fire intensity.**

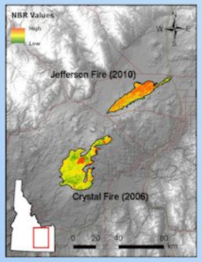


Figure 4. The Normalized Burn Ratio (NBR) for the Crystal and Jefferson Fires. NBR was calculated with atmospherically corrected Landsat 5 TM imagery using:

NBR= (Band 4 - Band 7) / (Band 4 + Band 7)

Band 4 = Near-infrared (830 nm band center)
Band 7 = Shortwave infrared (2215 nm band center)

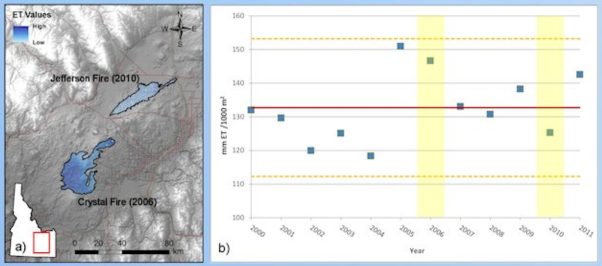


Figure 5. MODIS ET layers were used to calculate a) total annual ET (April 1- date of the respective fire) for the Crystal and Jefferson Fires and b) total ET for the 2000-2011 growing seasons (April 1 - September 30). The years of the Crystal and Jefferson Fires are highlighted in yellow. The 12-year mean is represented by the red line with +/- 95% CI shown by the orange dashed line. Note ET is higher than the mean in 2006 (suggesting lower fire intensities) in contrast to 2010.

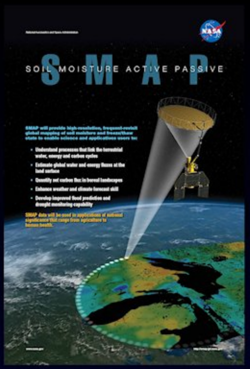
Conclusions

- The Crystal Fire exhibited higher ET values and corresponding lower fire severity (NBR) while the Jefferson Fire had lower ET values and higher fire severity.
- Our results suggest that a quantifiable relationship may exist between soil moisture with fire severity and consequently **fire intensity**.

Direction: What's Next?

- Further exploration using MODIS ET to better understand the relationship between ET and fire intensity
- Implement SMAP products (cf. sidebar) to more directly assess soil moisture.

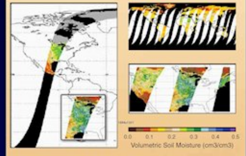
To learn more, visit the RECOVER website at http://giscenter.isu.edu/research/Techpg/nasa_RECOVER



SMAP?

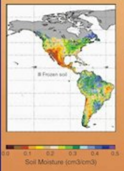
- **Soil Moisture Active Passive (SMAP) will provide more direct quantification of soil moisture.**
- **SMAP Level 2, 3 and 4 products may replace MODIS ET in this research.**

Level 2 and 3 Soil Moisture Active/Passive



- Merges active (radar HH and VV) with passive (radiometer H and V) channels using a time-series algorithm and spatial heterogeneity of L1C radar products to retrieve ~9 km soil moisture product over land with 0.04 cm^3 cm^{-3} accuracy for low-to-moderately vegetated areas (VWC ≤ 5 kg/m²)
- Depends on transient water body and freeze-thaw state retrievals from HiRes radar
- Level 3 daily composite made from Level 2 half-orbits
- Provides global coverage in 3 days

Level 4 Surface and Root Zone Soil Moisture (L4_SM)



- Merges SMAP observations with soil moisture estimates from a land surface model in a land data assimilation system, yielding a product that is superior to satellite or land model estimates alone
- Provides global surface (top 5 cm) and root zone (top 1 m) soil moisture estimates at ~9 km and 3-hourly resolution that are spatially and temporally complete and consistent with SMAP observations
- Includes surface meteorological forcing fields, land surface fluxes, soil temperature and snow states, runoff, and error estimates as research output (validated on a best effort basis)

- **Projected launch date Dec. 2014**