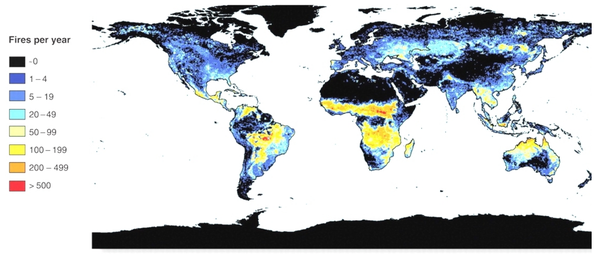
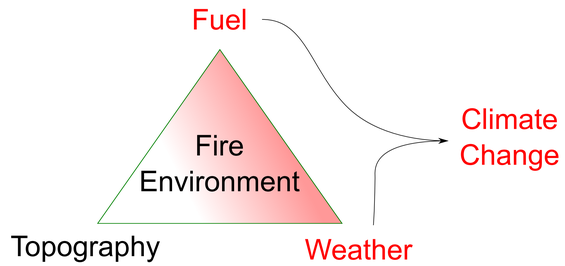
Understanding Fire and Climate in Mediterranean Ecosystems: an Integrated Approach

Adam Wilson[1], John A. Silander[1], Alan Gelfand[2]
[1]University of Connecticut, [2]Duke University



Average annual number of fires observed by satellite (Bowman, *et al.*, 2009). The fire regime (frequency, intensity, and seasonality) is an important component of many ecosystems. It also affects human social and economic systems (Shlisky, *et al.*, 2007).



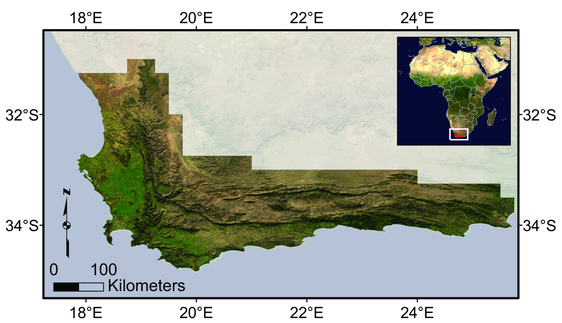
Climate change may influence biomass accumulation (and fuel load) by altering productivity of the vegetation, but more research is needed to quantify and predict the changes

High risk weather can enhance the fire regime, with more fires occurring during hotter, drier seasons

NASA's Earth Observing System provides an unparalleled perspective of ecosystem dynamics at regional to global scales, but the data are difficult to interpret in the absence of surface-based measurements that relate reflectance to vegetative status for specific ecosystems.

Regional Focus - South Africa

Wildfires drive many vegetation patterns and processes in Mediterranean climate ecosystems, including survival, reproduction, recruitment, and dispersal. Understanding how biomass accumulation and fire probability is affected by weather is vital to the management and conservation of these areas.



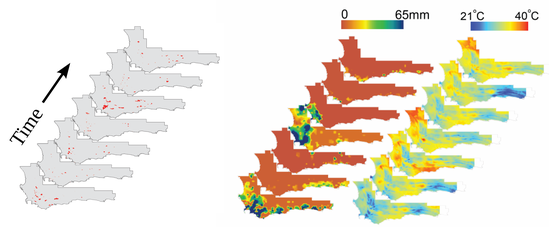
The Cape Floristic Region (CFR) of South Africa is a threatened, fire-dependent biodiversity hotspot:

Pre-development ecosystem area: 78,555 km²
Area Remaining: 20%
Endemic Plant Species: 6,210

Objectives

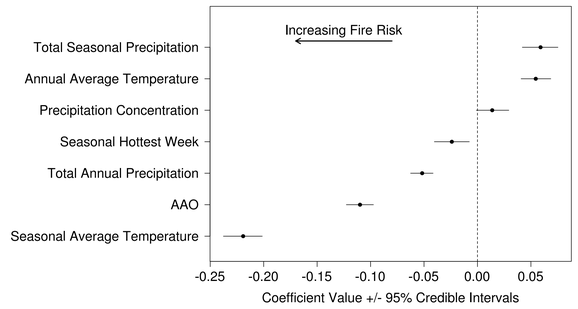
- Understand how historical weather has influenced the fire regime in the CFR
- Use field data and remotely sensed vegetation indices to estimate biomass across the region
- Build predictive models of biomass accumulation (using the historical satellite record) as a function of weather
- Use the predictive model to simulate the effects of climate change on the fire regime

Historical Trends Wilson, *et al.* 2010

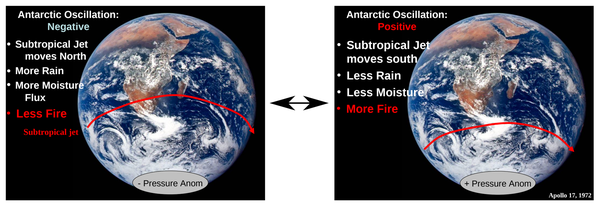


$$P(\text{no Fire}_{t,s} \mid \text{no Fire}_{t-1,s}, \text{Precipitation}_{ts}, \text{Temperature}_{ts}, \text{AAO}_t, \varepsilon_{ts})$$

The 20 year record of wildfire in the region was modeled with a Hierarchical Bayesian survival model to identify the effects of weather on fire probability.

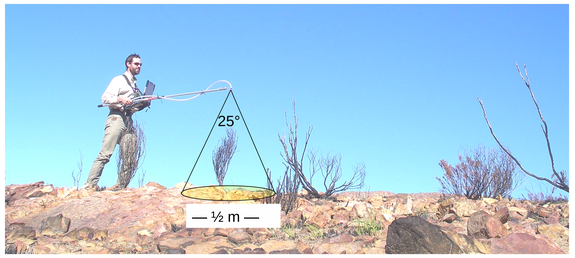


Fire occurrence in the CFR is strongly affected by climatic variability at both local and global scales, and thus likely to respond sensitively to future climate change.

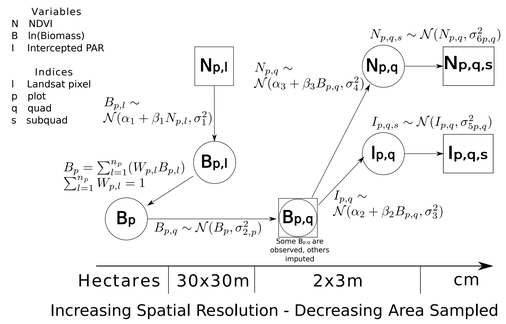


The Antarctic Ocean Oscillation is also significantly correlated with fire probability through its control on the subtropical jet stream. Comparison of the modeled fire probability between two periods (1951–1975 and 1976–2000) revealed a 4-year decrease in an average fire return time.

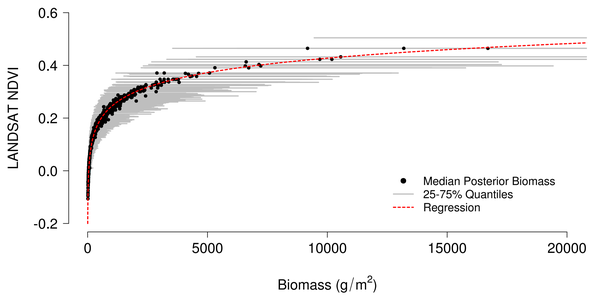
Ground-truthing Wilson, *et al.*, in review



In the field I collected reflectance and biomass data with scales spanning from centimeters to hectares



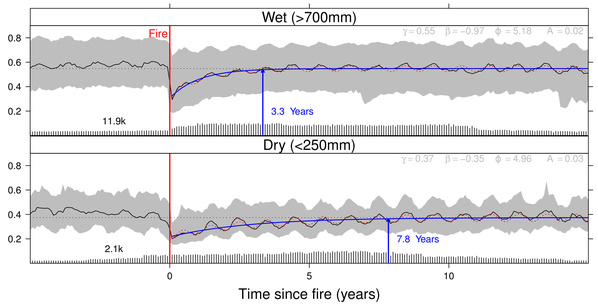
A Bayesian model was used to assess the relationship between field and satellite measurements.



There is a strong correlation between NDVI and biomass, which supports the use of NDVI in spatio-temporal analysis of vegetation dynamics in this mediterranean shrubland ecosystem.

Vegetation Dynamics from Space

By combining the fire data with satellite NDVI, it is possible to develop spatial explicit post-fire biomass accumulation curves and study the response of the vegetation across climate gradients.



$$\gamma - exp^{\beta * age} + sin(\phi + \omega * age) * A$$

Summary

- Increased probability of wildfire in abnormally hot, dry seasons
- Wildfire probabilities sensitive to large scale climate variability (AAO)
- Post-fire biomass accumulation is also sensitive to climate

Understanding the net effects of climate change will require integrating the different effects of climate on biomass accumulation and high risk weather.

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