National analysis of interactions between compounded forest disturbances from tornado and fire over 30 years (1984-2014)

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Introduction

- Natural disturbances impact forest vegetation through a number of mechanisms, including differential mortality among trees.
- Wind disturbance is extremely common in the USA with approximately 1.65 million ha of forest impacted from wind damage every year.
- Tornados affect approximately 450,000 ha.
- Tornados can alter fuel accumulation leading to synergies or antagonism with future fire.

Synergistic interaction

Increase severity or intensity of future fire

-Increase surface fuel loads

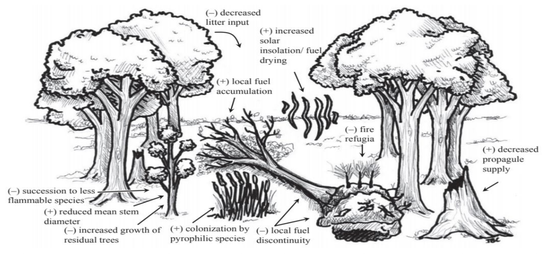
-Decrease seed availability

Antagonistic interaction

Decrease severity or intensity of future fire

-Disrupt fuel connectivity

-Advanced regeneration

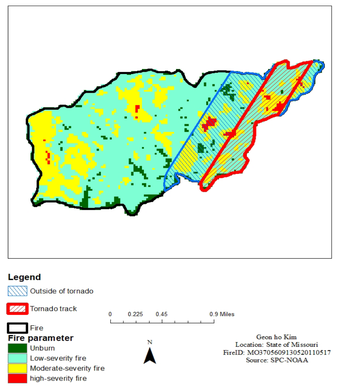


Schematic diagram of potential mechanisms of interaction between forest wind damage and fire. Cannon et al, 2017, *Forest Ecology & Management*

Research questions

- **How does forest disturbance from tornados change severity of a subsequent fires?**
- **What factors influence interaction direction as synergism (+) or antagonism (-).**

Methods



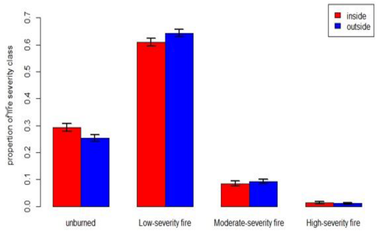
Overlap of tornado track from NOAA severe weather database and subsequent fire severity from MTBS. We compared fire severity within tornado tracks (red) and just outside tracks (blue). Example from Kansas City, 2007.

Methods

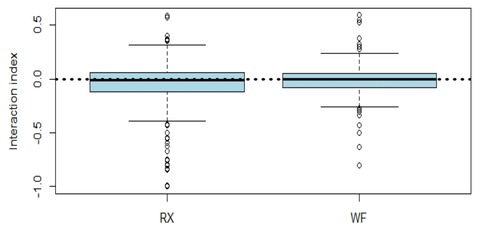
- To estimate differences in fire severity, we used Monitoring Trends in Burn Severity classified fire severity data (MTBS) which classifies fire severity at 30 m resolution.
- We compiled tornado track data in the U.S. from 1950–2010 from the National Oceanic and Atmospheric Administration (NOAA) Storm Prediction Center.
- To estimate changes in fire severity due to tornados, we compared fire severity inside (left, red hatching) and outside (blue hatching) of tornado tracks
- To estimate interaction direction, we found the sumproduct of the proportions of unburned, low, medium, and high severity fire and 0,1,2, and 3 respectively inside and outside tornado tracks. We found the difference between sumproducts inside and outside of tracks to obtain an interaction index (+ for synergic interactions and – for antagonistic interactions)

We examined how differences in disturbance severity within and outside tracks (interaction index) correlated with fire type, time between disturbances, fire regime group and average temperature.

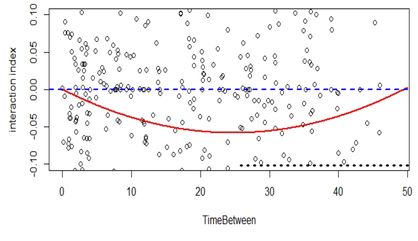
Results



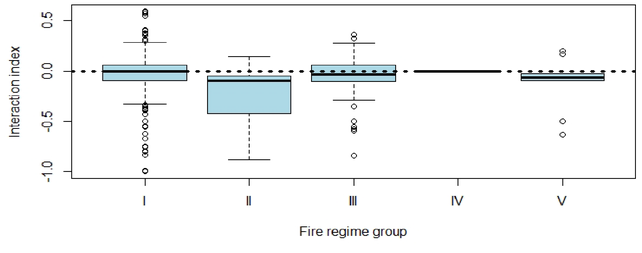
Mean proportion of each fire severity class inside and outside of tornado tracks. Error bars represent ± 1 standard deviation of the mean fire severity.



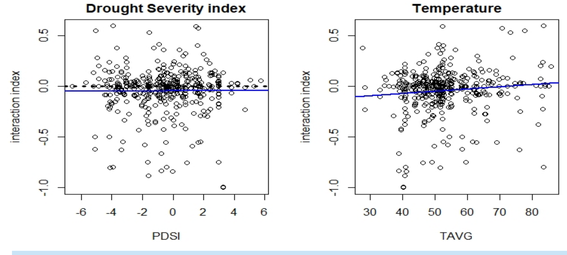
We found a marginal difference between interaction index among prescribed fires (RX) and wildfires (WF; P = 0.08).



Interaction indexes and time between disturbances were non-linearly related with moderate time periods showing more antagonistic interactions (P < 0.001).



Fire regime groups generally had differences in interaction index (P = 0.03), with Fire regime group II (frequent, replacement severity fire) generally exhibited antagonistic interactions.



We found no relationship between drought severity index (PDSI, P = 0.80) and interaction index. However, higher pre-fire temperatures (TAVG) were more likely to exhibit synergies (P = 0.03).

Discussion

Tornadoes damage in Alabama pine forest. Photo Credit: B. Shields, 2013, ESRI

- **Tornado decreases the severity of subsequent when fire severity is relatively low.**
- Prescribed fire and fires in Fire Regime Group II resulted in more antagonistic interactions between the tornado and subsequent fire.
- Wildfire and higher pre-fire average temperature led to more synergic interactions between tornado and subsequent fire.
- Precipitation and wildfire led to synergic interaction between tornados and subsequent fires.
- Harvey et al found that interaction fires may have a buffering effect on subsequent fire, especially when severity of second fire is low. Similarly, tornado disturbances may also have a similar interaction with subsequent fire.
- **Buffering interactions may be more common than synergistic interactions between wind and fire.**

Future research

- Further research may investigate interactions between fire and other types of wind disturbance with other types of cyclones (e.g., hurricanes)
- Future work will examine the effect that various forest types have on disturbance interactions