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Understanding and quantifying fire-vegetation interactions through integrating satellite observation data with the Dynamic Land Ecosystem Model (DLEM)

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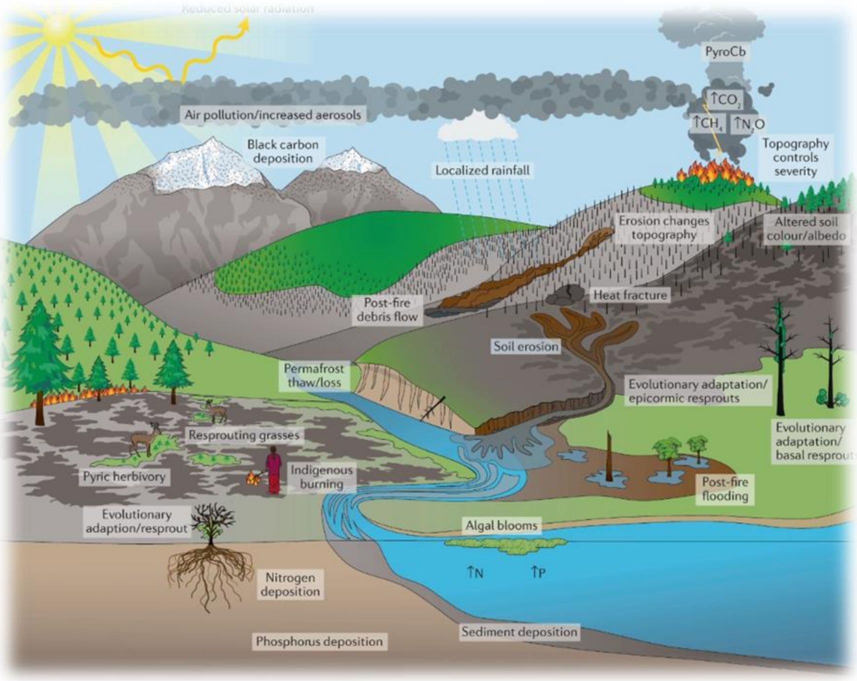
Background and Objectives



Bowman et al., 2020. *Nat. Rev. Earth Environ.*

Background

- Vegetation fires are an essential component of the Earth system but can also cause substantial environmental consequences.
- Satellites have detected a global decline in the burned area, but the forest fire emissions increased.
- Large fires showed growing importance in the conterminous United States (CONUS).

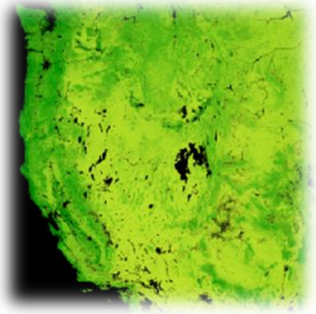
Objectives

- Analyze the spatial and temporal pattern of fires in the CONUS
- Quantifying the impact of fire on vegetation using satellite observation data and a process-based ecosystem model

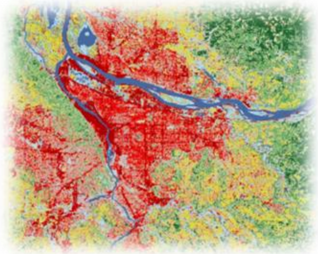
Data and Model

MTBS

Monitoring Trends in Burn Severity
(1984-2020)



MODIS and Landsat vegetation indices
(EVI, LAI, GPP, NPP)

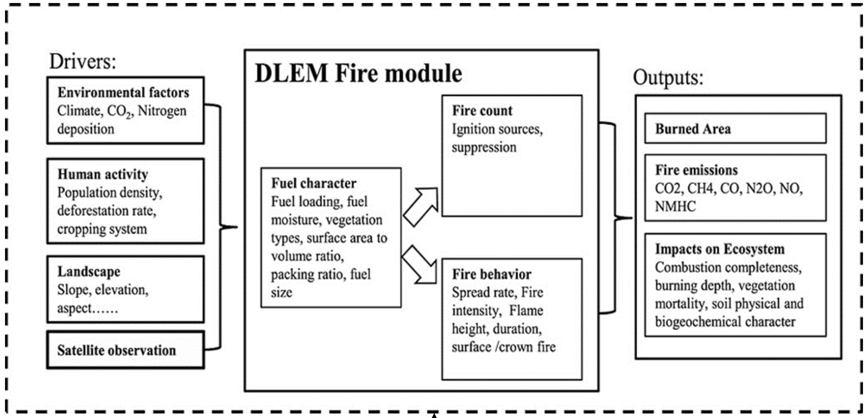


LandTrendr PySTEM Landcover
CONUS (1990-2017)

Fire burned area

Burn severity

- Unburn to low
- Low
- Moderate
- High



Vegetation mortality

Vegetation age disturbance

Model out

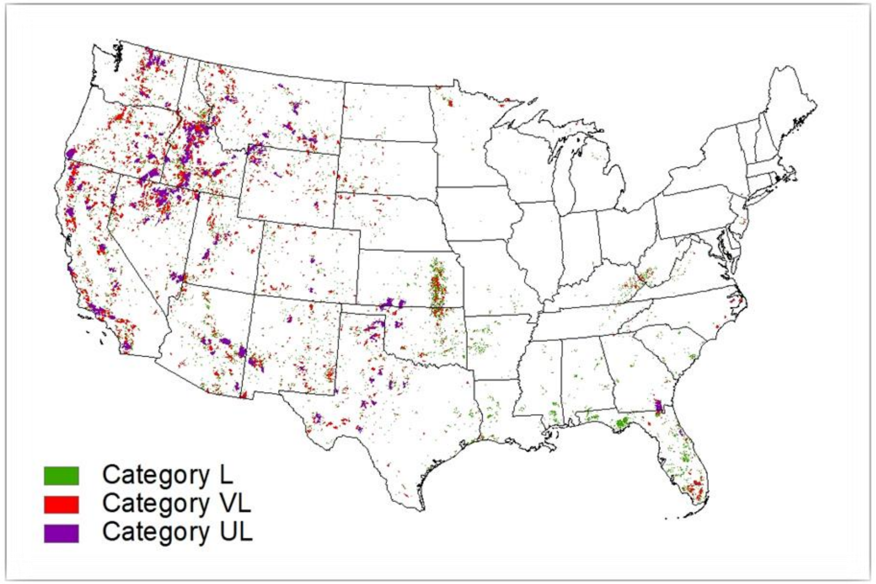
Carbon fluxes: GPP

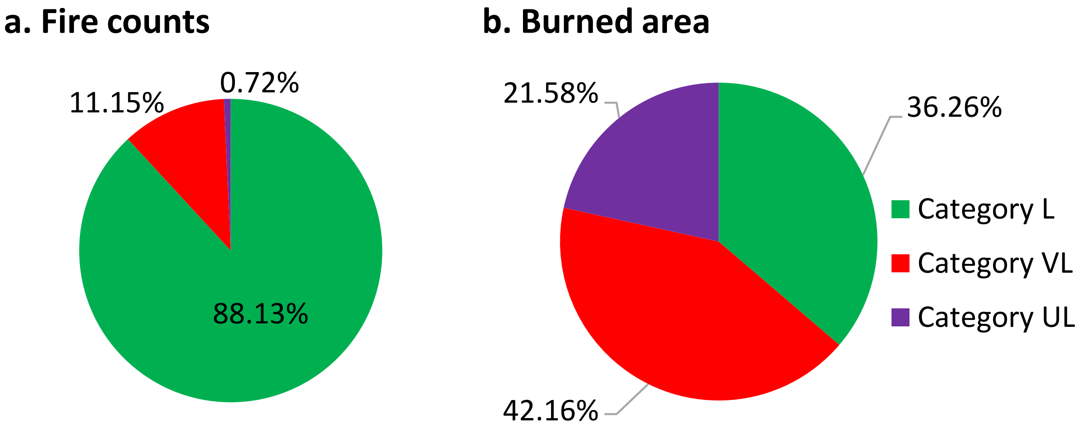
NPP, MR, GR, Rh…

Carbon pools: VegC, SoilC, LitterC…

Yang et al., 2014. *JGR: Biogeosciences*

Results – Fire changes in the CONUS



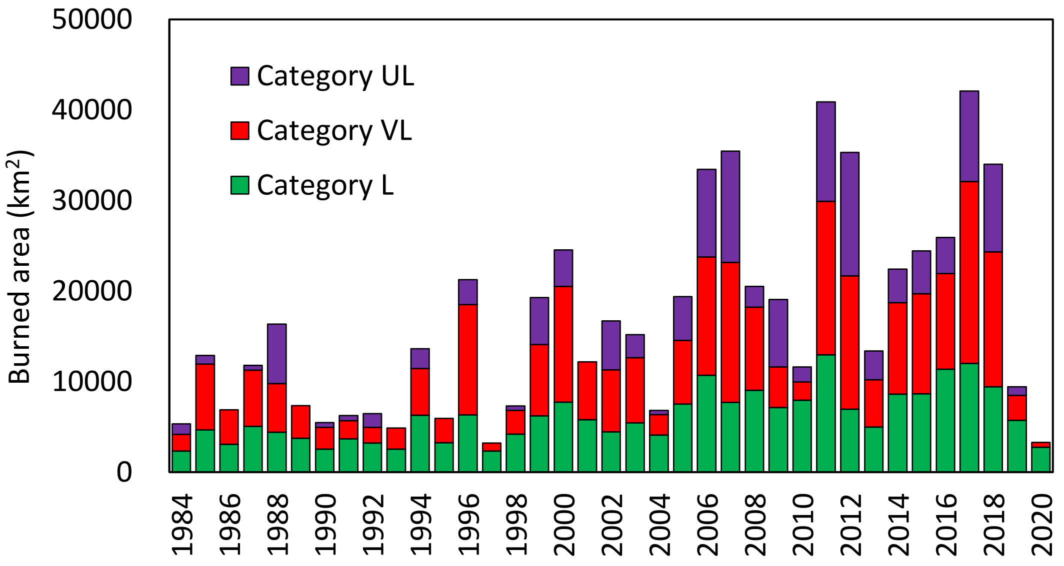


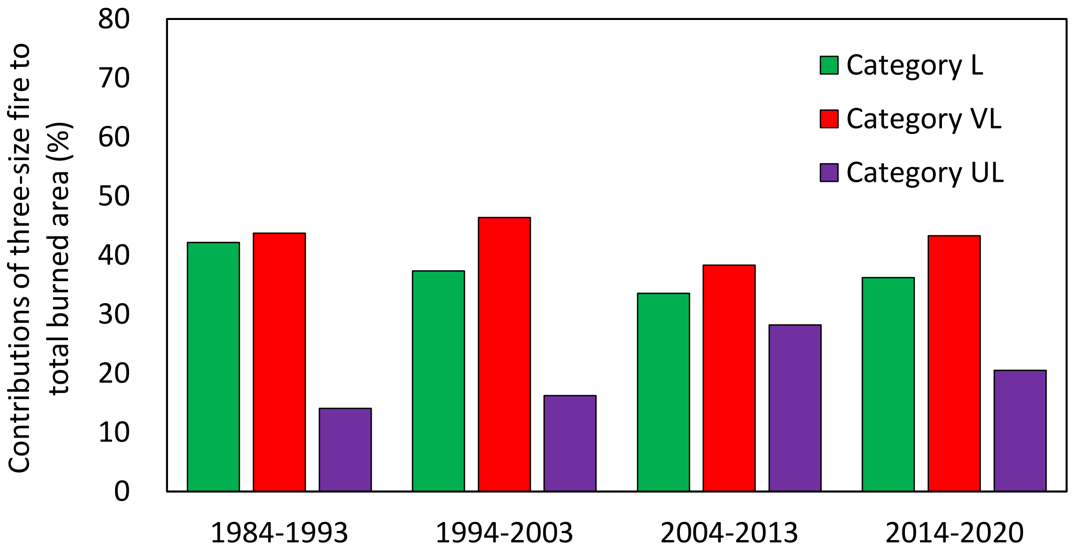
Category L (large): $3 \leq \log_{10}(\text{fire size}) < 4$
Category VL (very large): $4 \leq \log_{10}(\text{fire size}) < 5$
Category UL (ultra-large): $\log_{10}(\text{fire size}) > 5$

The UL fires were only 0.72% of total fire counts but accounted for 21.58% of the total burned area in CONUS.

Results – Fire changes in the CONUS

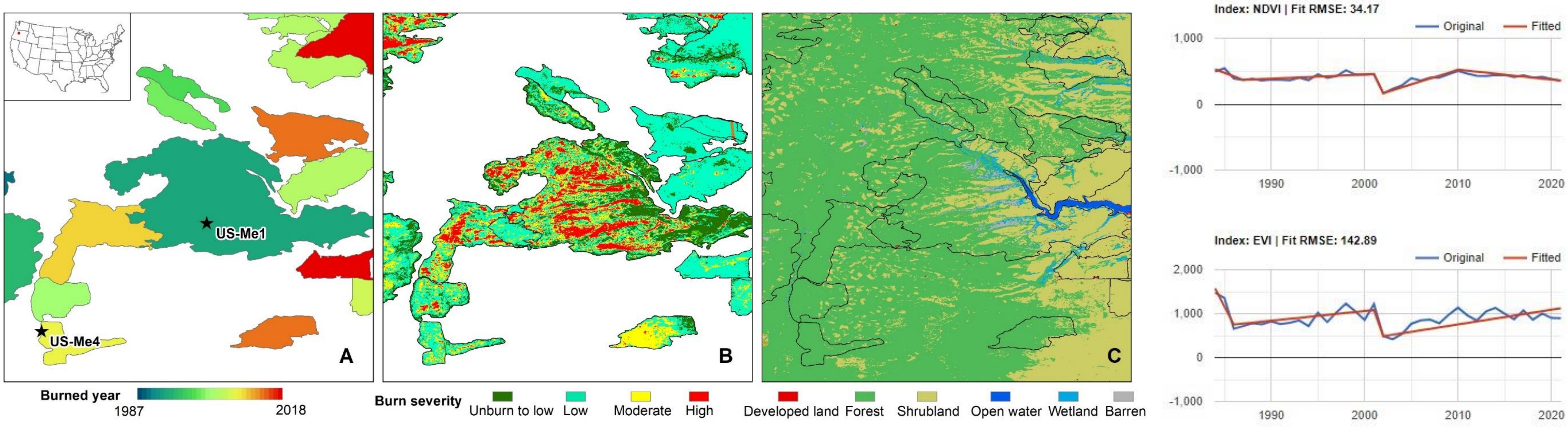
- During 1984-2020, the annual burned area derived from all the large fires was 16771.89 $km^2\ yr^{-1}$ with a significant upward trend at the rate of 557.02 $km^2\ yr^{-1}$.
- Compared with 1984–1993, the annual burned area of all the large fires increased by 176.02% during 2014–2020, while the area burned by fires in category UL increased by 301.31%.
- The percent of the area burned by category UL fires increased from 14.08% to 20.47%, while the percent of the area burned by fires in category L decreased from 42.19% to 36.23%.





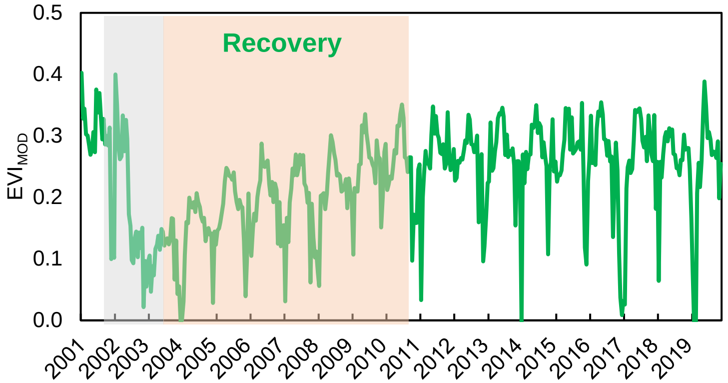
Results – Site information

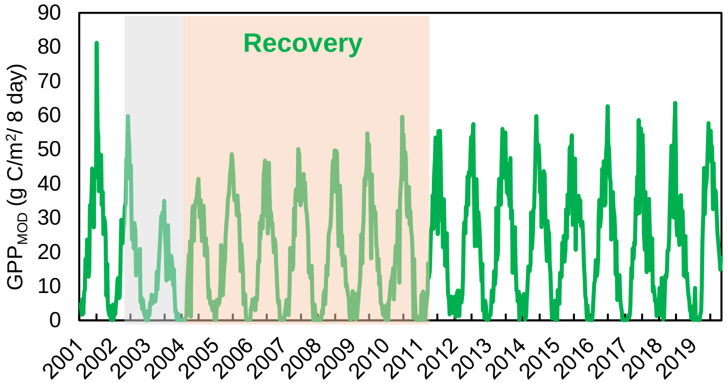
US-Me1: Evergreen Needleleaf Forests (ENF)

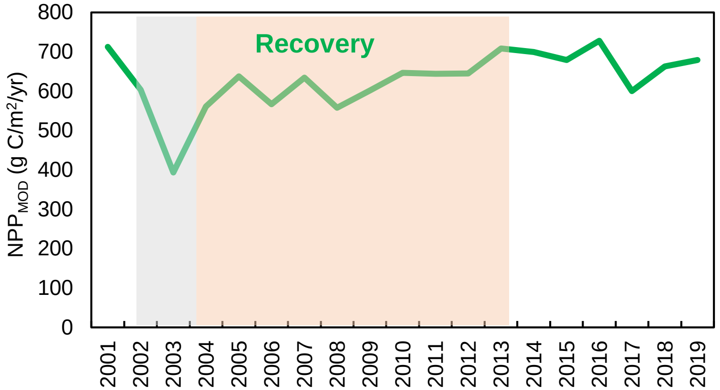


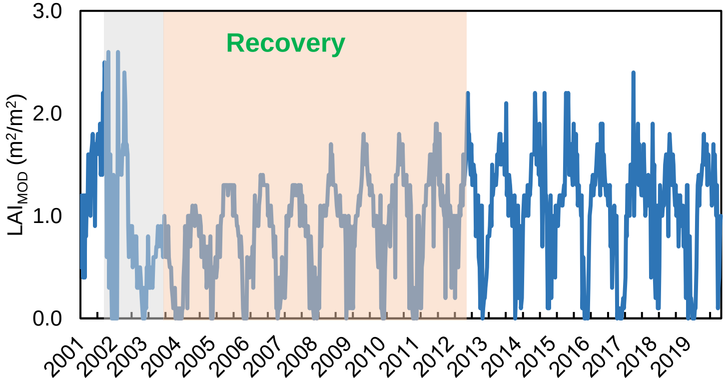
Results – Satellite observed vegetation dynamics

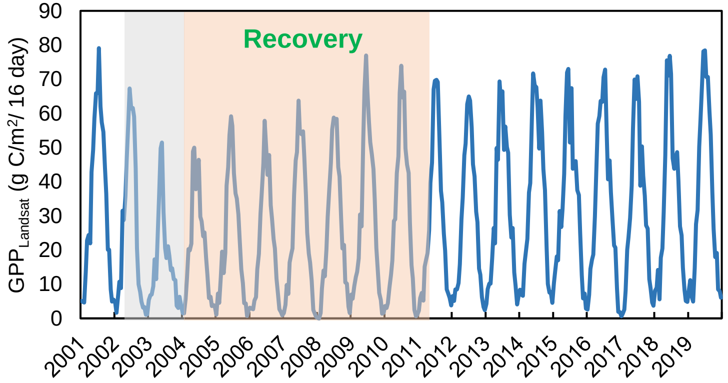
- Satellite observed EVI, LAI, GPP, and NPP decreased in 2002-2003.
- The post-fire vegetation recovery time is about 8-10 years.
- The vegetation greenness indices (EVI and LAI) capture the post-fire recovery better.

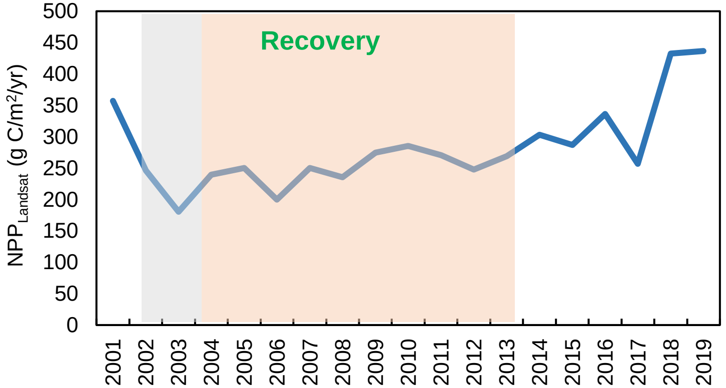








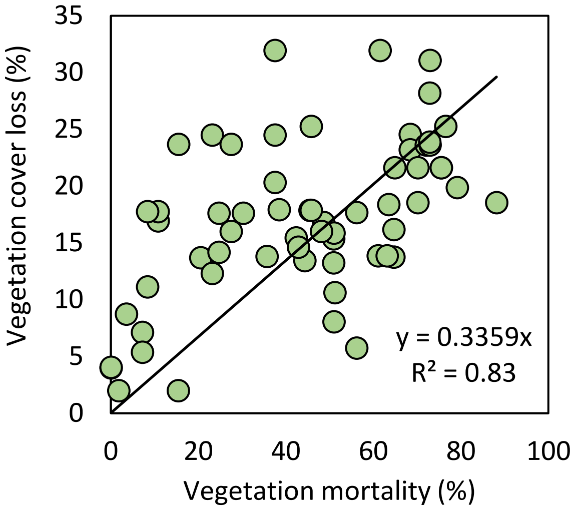


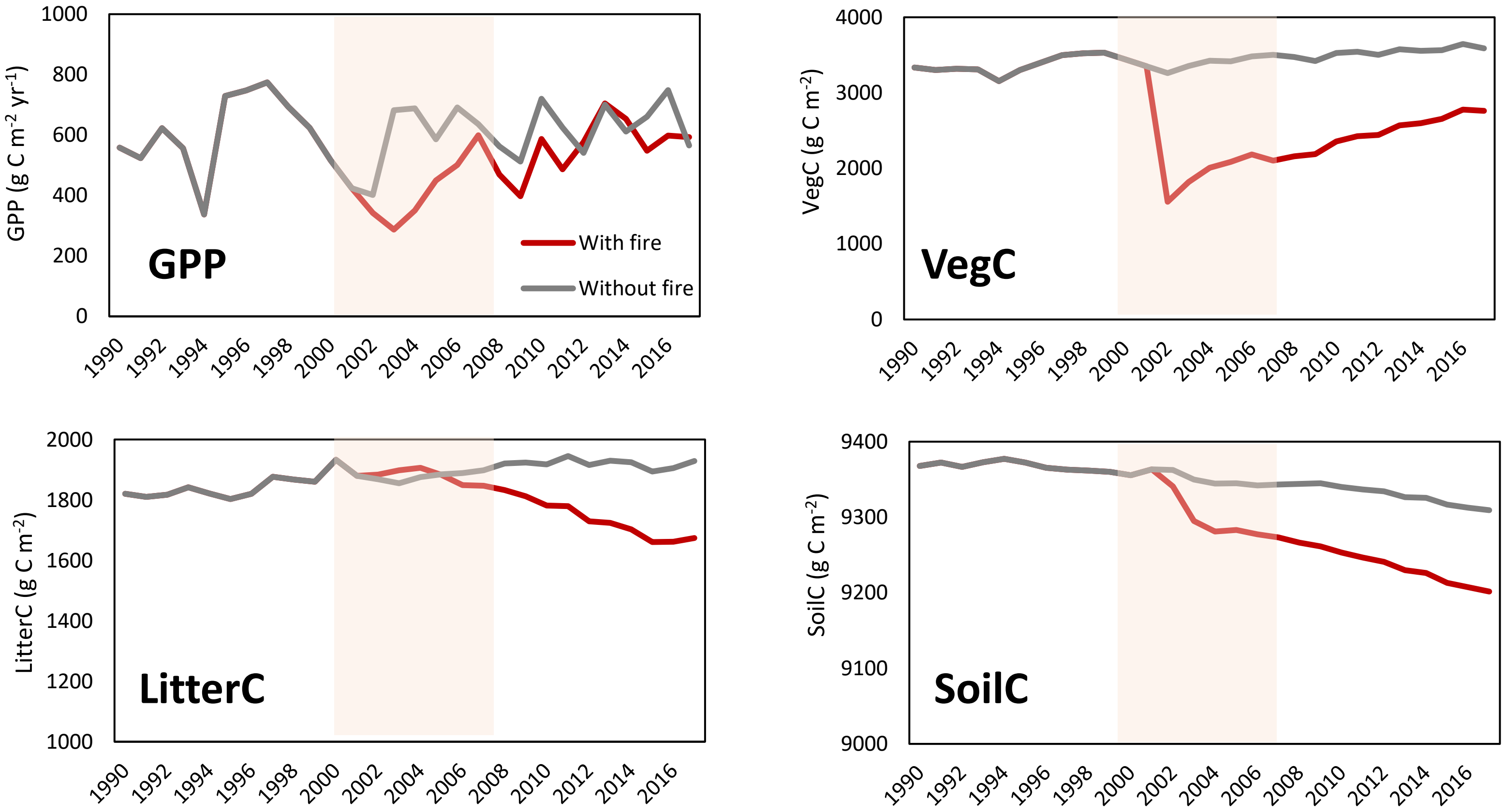


EVI_{MOD} & LAI_{MOD} **GPP_{MOD} & $GPP_{Landsat}$** **NPP_{MOD} & $NPP_{Landsat}$**

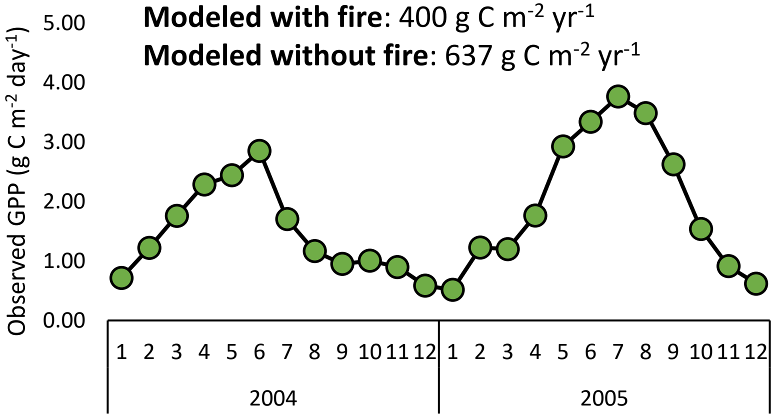
Results – Model validation and Output

- The vegetation cover loss is positively correlated with vegetation mortality.
- The modeled GPP, vegetation carbon (VegC), and soil carbon (SoilC) significantly decreased in 2002-2003. GPP and VegC recovered gradually after the fire.





Observation: 633 g C m^{-2} yr^{-1}
Modeled with fire: 400 g C m^{-2} yr^{-1}
Modeled without fire: 637 g C m^{-2} yr^{-1}



Take home messages

Summary

- Large fires increased rapidly in the CONUS during 1984-2020, and the burned area of ultra-large fires accounted for more than 21%.
- Satellited observed vegetation indices (EVI, LAI, and GPP) can capture the fire disturbance and post-fire recovery.
- By integrating remote sensing-based fire datasets, DLEM can accurately simulate the impact of fire on GPP, vegetation carbon, and soil carbon.

Future work

- Optimize mortality parameters and improve the vegetation recovery process in the DLEM model, and quantify the impact of fire on the carbon cycle at the regional scale.

Thank you!