Fire as a Driver of Increases in Photosynthesis in Boreal Forest Ecosystems of North America

Jinhyuk E. Kim[1], Jonathan A. Wang[1,2], Claudia I. Czimczik[1], James T. Randerson[1]

[1]Department of Earth System Science, University of California Irvine
[2]School of Biological Sciences, University of Utah

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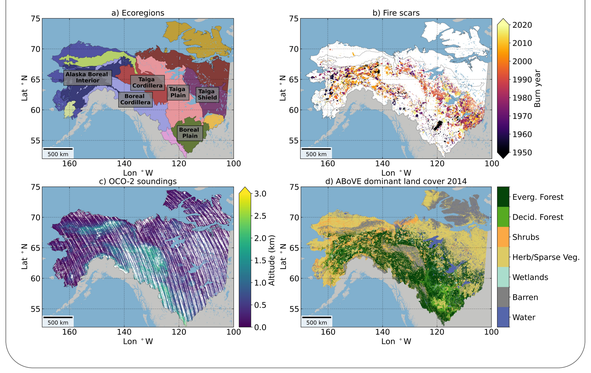
Motivation and Background

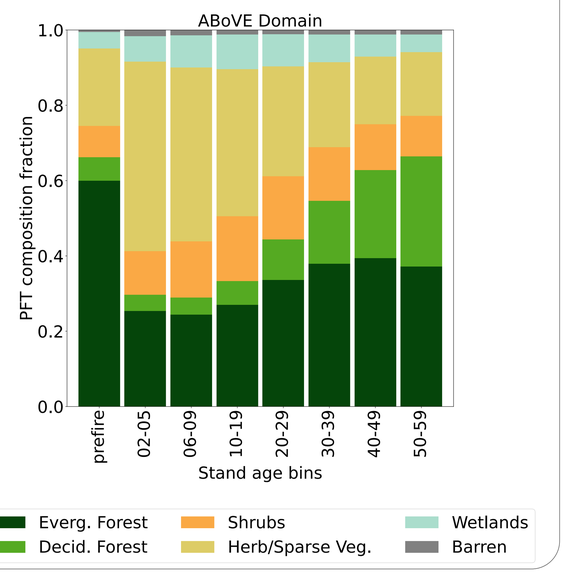
The resilience of North American boreal forests is declining [1]. Increasing burn area per year is putting additional pressure on these ecosystems. After fires, changes to the plant functional type (**PFT**) composition occur through succession. Different PFTs have different photosynthetic rates that can influence carbon fluxes [2,3,4]. Solar-induced fluorescence (**SIF**) can be used to observe photosynthetic activity, particularly in regions like boreal forests where traditional vegetation indices are less reliable [5]. Here we want to understand the consequences of increasing fire for land cover and photosynthesis as measured by SIF.

Datasets and Methods

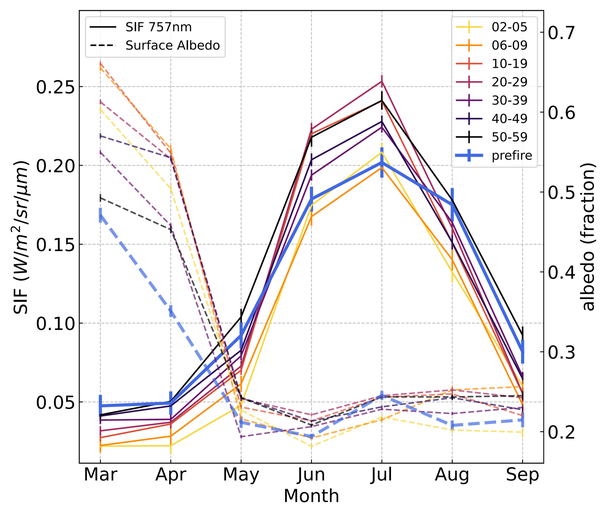
We used the ABoVE domain and the Level-2 Ecoregions from the EPA as our study regions. We used fire perimeters (1950-2021) from the Alaska Large Fire Database [6], Canadian National Fire Database [7], and NBAC [8]. We analyzed the OCO-2 SIF signal [9] and the ABoVE dominant land cover [10] within the domain and the fire perimeters.



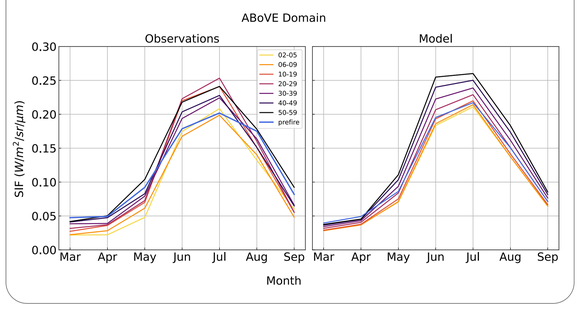
Early successional plant functional types dominated by deciduous vegetation



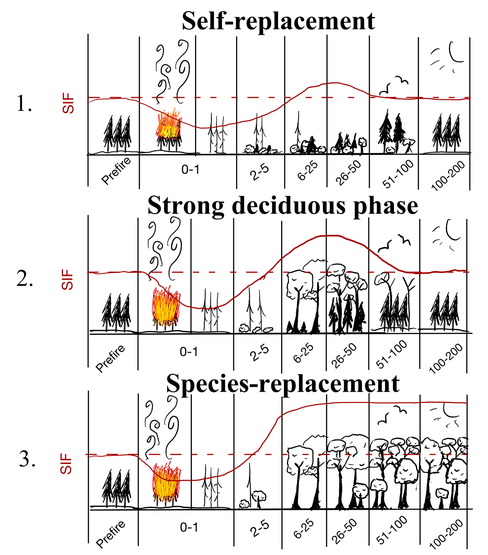
Post-fire SIF is enhanced during summer and reduced during spring and fall



Reconstructing SIF by stand age using SIF by PFT composition



Different successional trajectories can change the future of SIF/photosynthesis in an ecoregion

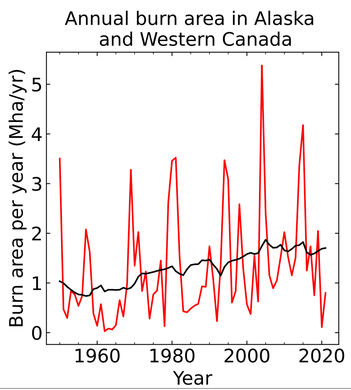


	Successional trajectory	References	Expression within ecoregions
1.	Self-replacement	Van Cleve and Viereck (1983) Johnstone et al. (2010)	Taiga Cordillera Taiga Shield Boreal Cordillera
2.	Strong deciduous phase	Chapin et al. (2004) Johnstone et al. (2010) Mack et al. (2021)	Alaska Boreal Interior
3.	Species-replacement	Chapin et al. (2004) Johnstone et al. (2010) Mekkonnen et al. (2019) Mack et al. (2021) Baltzer et al. (2021)	Boreal Plain Taiga Plain

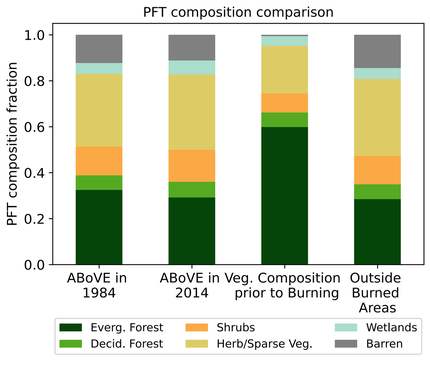
Successional trajectory varies by ecoregion

Deciduous broadleaf forests and shrubs show higher summer SIF relative to evergreen needleleaf forests

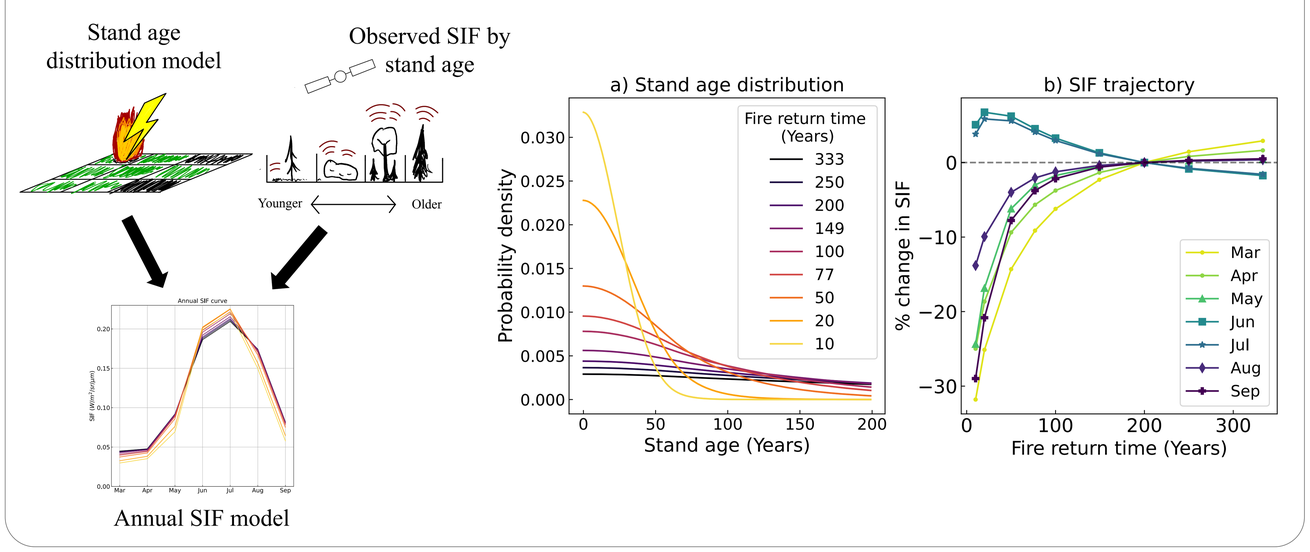
Burn area per year is increasing in the ABoVE domain



Fire occurrence is more prevalent in areas with evergreen needleleaf forest cover



Exploring the influence of a changing FRT on SIF using an idealized model



Conclusions

- Increasing annual burned area can shift the stand age distribution to younger ages which may enhance the summer SIF signal and decrease the shoulder season SIF.
- The successional trajectory varies by ecoregion. Species replacement of evergreen forests with deciduous forests in the Boreal and Taiga Plains
- Reducing stand age distributions at a regional scale may increase photosynthesis and SIF but reduce carbon storage. This is one of the few known mechanisms by which photosynthesis and carbon storage become decoupled.

References and Acknowledgements

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