

Large-scale climatic controls of fire activity in red pine forests point to the role of winter/spring conditions since 1675 AD and generally less fire prone weather since the mid-20th century

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Main goal and Hypothesis

Aim: examine the effect of large-scale modes of climate variability on the regional history of red pine forests

Hypotheses:

- 1. There are states of atmospheric circulation, captured by climate oscillation indices, that are consistently associated with increased fire activity over the distribution range of mixed pine forests in eastern North America.
- 2. These states mark periods of increased climatological fire hazard over the study area.



Main findings

- Years with increased fire activity in the reconstructed record fire records were associated with:
 - El Niño
 - Positive NAO
 - The combination La Niña/PDO neutral
- Only La Niña/PDO neutral in the modern record
- Warmer winters/springs might lead to higher fire activity
 - Formation of thinner snowpack that melts quicker => drier fuels
- Frequency of fire-prone climate states decreased in the mid 20th cent.



Methods

	FIRE DATA	CLIMATE INDICES
HISTORICAL RECORD (1675-1900)	Synthesis of dendro-resolved fire reconstructions from red pine forests	ENSO PDO
MODERN RECORD (1959-2020)	Area burned from observation data from the Canadian government	
MODERN RECORD (1950-2020)	Fire relevant monthly weather data (mid-troposphere SLP and temperature)	NAO

- Identify associations between climate indices and fire activity in the reconstructed record
- Use a modern-day analog to develop mechanistic explanations of the associations we observed





Positive NAO

Reconstructed record (1675-1900)

NAO mean value per bin



Positive NAO





-0.6 -0.3 -0.4 -0.3 -0.2 0.2 0.3 0.4 0.5 0.6 cerr Mar NAC-Gibraltar with Mar NCFP/NCAR 500mb height (ciff, detrend) 1951:2020 p<10%



3.6 -0.5 -0.4 -0.3 -0.2 0.2 0.3 0.4 0.5 0.6

Temperature



93w 50w 97w 84w 81w 78w 75w 72w 69w 66w

-0.8 -0.8 -0.4 -0.3 -0.2 0.2 0.3 0.4 0.5 0.6 corr Mar NAO-Gibraltar with Mar CRU TS4.04 temperature (diff, detrend) 1951:2019 p<10%



-0.6 -0.5 -0.4 -0.3 -0.2 0.2 0.3 0.4 0.5 0.6





El Niño

Reconstructed record (1675-1900)



La Niña/PDO neutral

2 GN

44N

41N

39N 38N





February

March

36N



-24 -21 -18 -12 -9 -8 composite Mar ENSO1PD02 index, 0.5 < index < 1.5 of War NCFP/NCAR 500mb height 1959:2019 p<10% 49N 153 4.4N -47N 46N 44N -43N 42N-41N 40N -

35 40

Temperature

composite Jan ENSO'PDO2 incex, 0.5 < incex < 1.5 of Jan CRU TS4.04 temperature 1959:2019 p<10%



0.35 0.45 0.85 0.65 0.75 0.83 1.05 1.16 1.28 1.35 composite Fea ENSO1FD02 index, 0.5 < index < 1.5 of Feb CRU TS4.04 temperature 1959:2019 a< 0%





Reconstructed record (1675-1900)

ENSO	PDO	N	Observed	Expected	Significance percentile
La Niña	PDO neutral	23	0.217	0.0877	0.979

Modern record (1959-2020)



Nonlinear weather responses to ENSO



-06 -05 -04 -03 -02 02 03 04 05 06

81W

Temperature



-66 -65 -64 -63 -62 62 63 64 65 66 corr Feb NINC3.4 rel with Feb CRU TS4.C4 temperature (diff, detrend) 1951:2019 p<10%



-0.6 -0.5 -0.4 -0.3 -0.2 0.2 0.3 0.4 0.5 0.6 corr Mar NINO.3.4 rel with Mar CRU TS4.04 temperature (diff, detrend) 1951:2019 p<10%



-0.6 -0.5 -0.4 -0.3 -0.2 0.2 0.3 0.4 0.5 0.6







In general, less fire-prone weather in eastern North America since the mid 20th cent.

