Controls on Tree-Ring Growth in an Age-Sequence of Planted White Pine Forests

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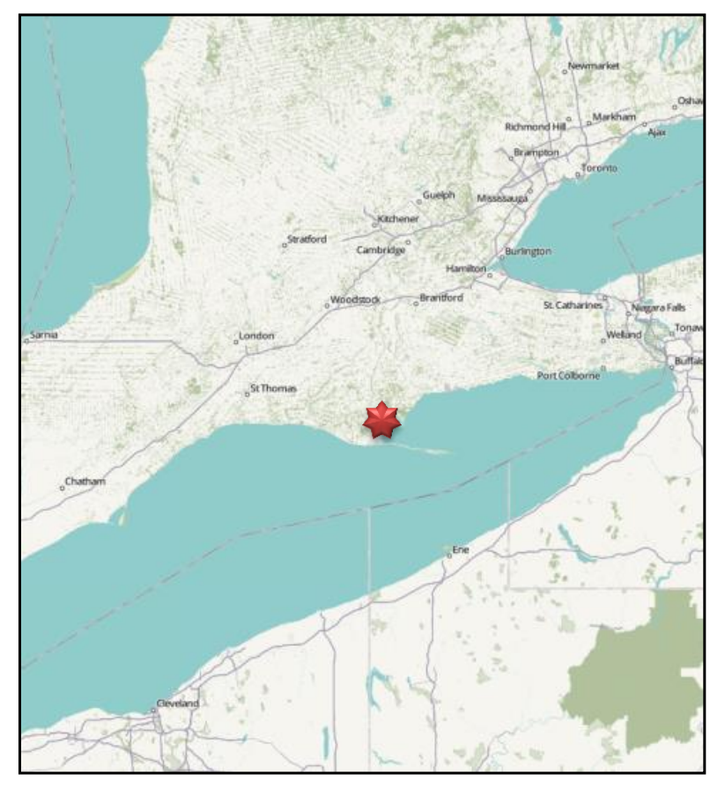
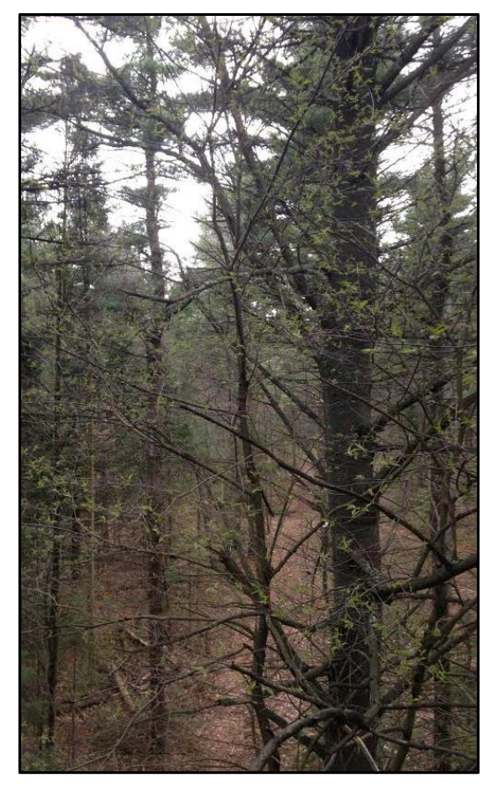
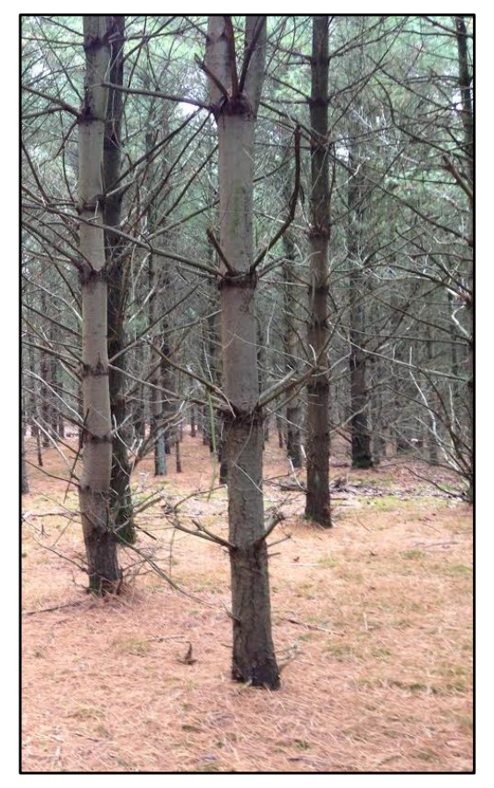
Introduction

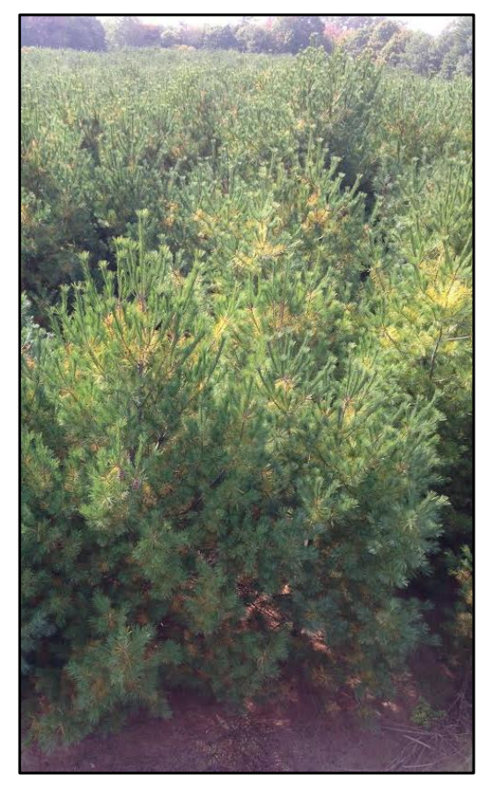
Historical information on forest growth is essential to evaluate and predict the effects of climate change and anthropogenic management strategies in temperate ecosystems. These factors also impact the carbon sequestration and carbon sink capacity in these stands on an annual basis. One efficient way to investigate changing environmental factors is considering the dimension of time through tree ring studies (dendrochronology). *Pinus strobus* L. (eastern white pine) is one of the most used afforestation species in southern Ontario, Canada, where plantation stands have been established in 1939, 1974, and 1989 at Turkey Point. These stands are a part of the Turkey Point Flux Station and global Fluxnet.

This study explores controlling aspects on forest growth rate: 1) how a chronosequence of white pine react to annual- and multi-decadal scale climate events in the study area, and 2) the effect of land use history and forestry practice on the growth rate and carbon allocation over the chronosequence.


Turkey Point Flux Station

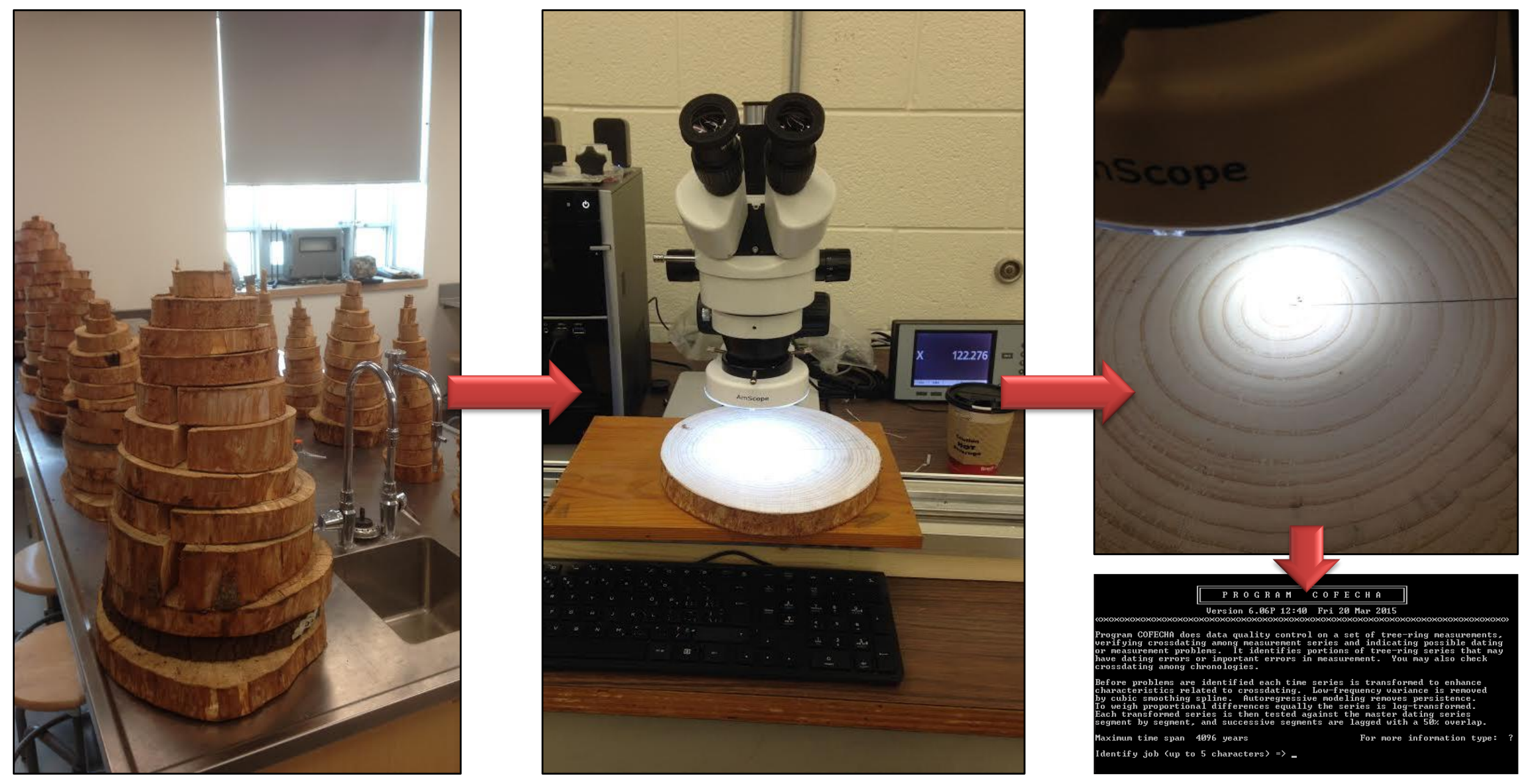

65-year


30-year


14-year

Methods

Opportunistic sampling was carried out in 2004 at the site. Five samples of tree cross sections (discus) from each of the three stands were sanded. Two transects on each disk were measured using a Velmex measuring table. All measurement data was quality checked using COFECHA.



Results

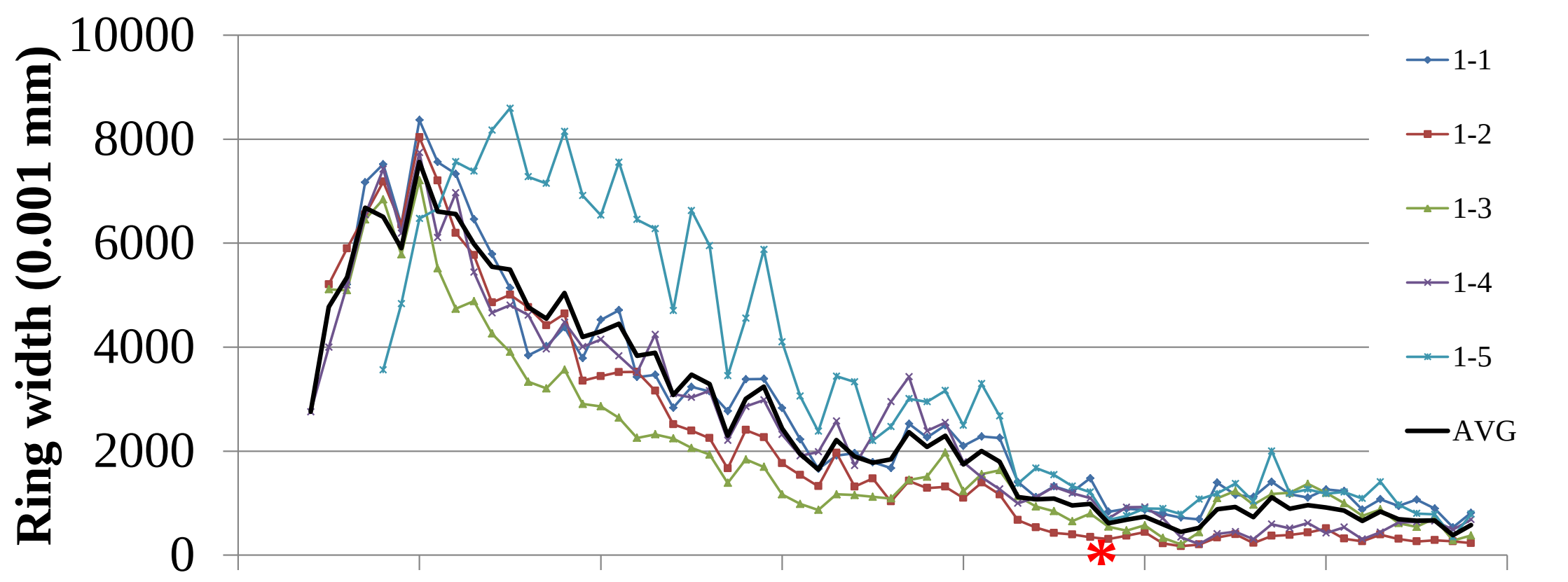


Fig. 1: Results in unstandardized measured ring width for the 65-year stand show an age-dependent trend. The 1983 thinning event is marked *.

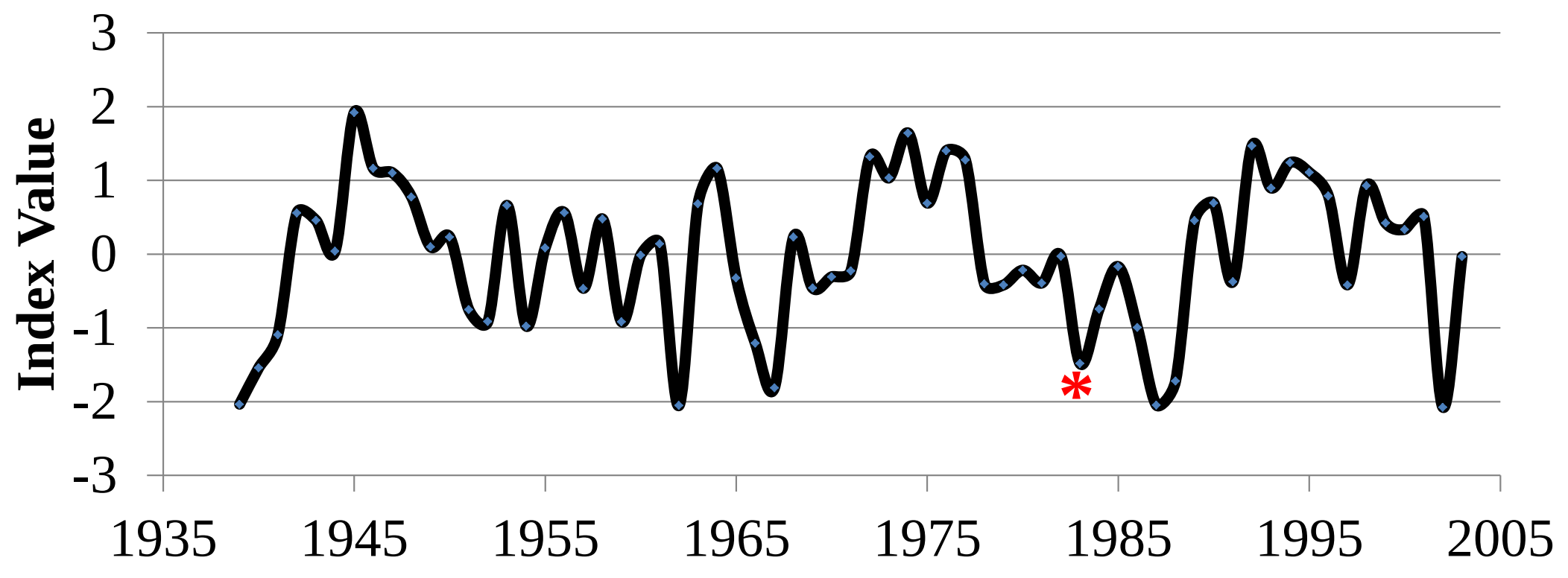


Fig. 2: 65-yr stand: mean index outputs using Cofecha. Mean index outputs display environmental variability on tree-ring growth. Annual and multi-decadal (~20-year) trends are visible.

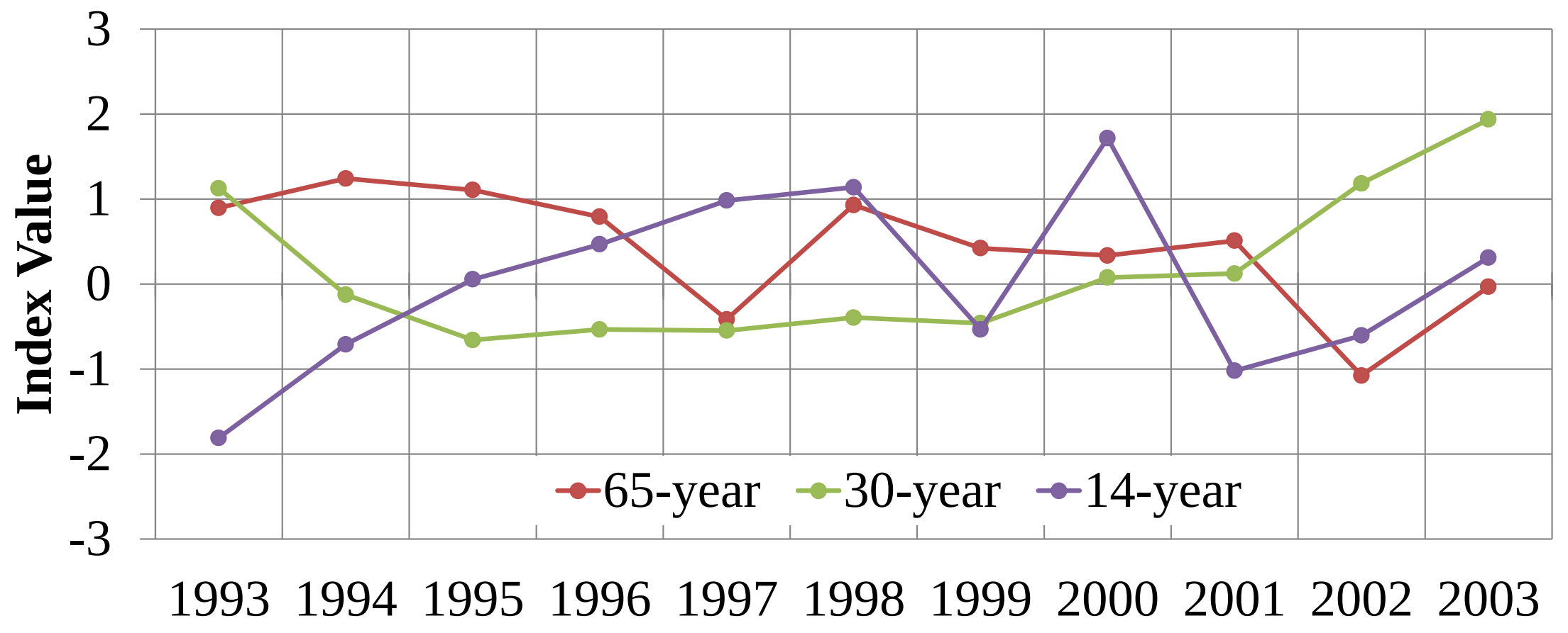


Fig. 3: Similarity between all three stands 1993-2003.

Cross stand comparisons do not reveal common annual scale environmental trends. The comparatively high water table present in the 14-year stand suppressed variability and reduced sensitivity association between growth and monthly precipitation.

Discussion

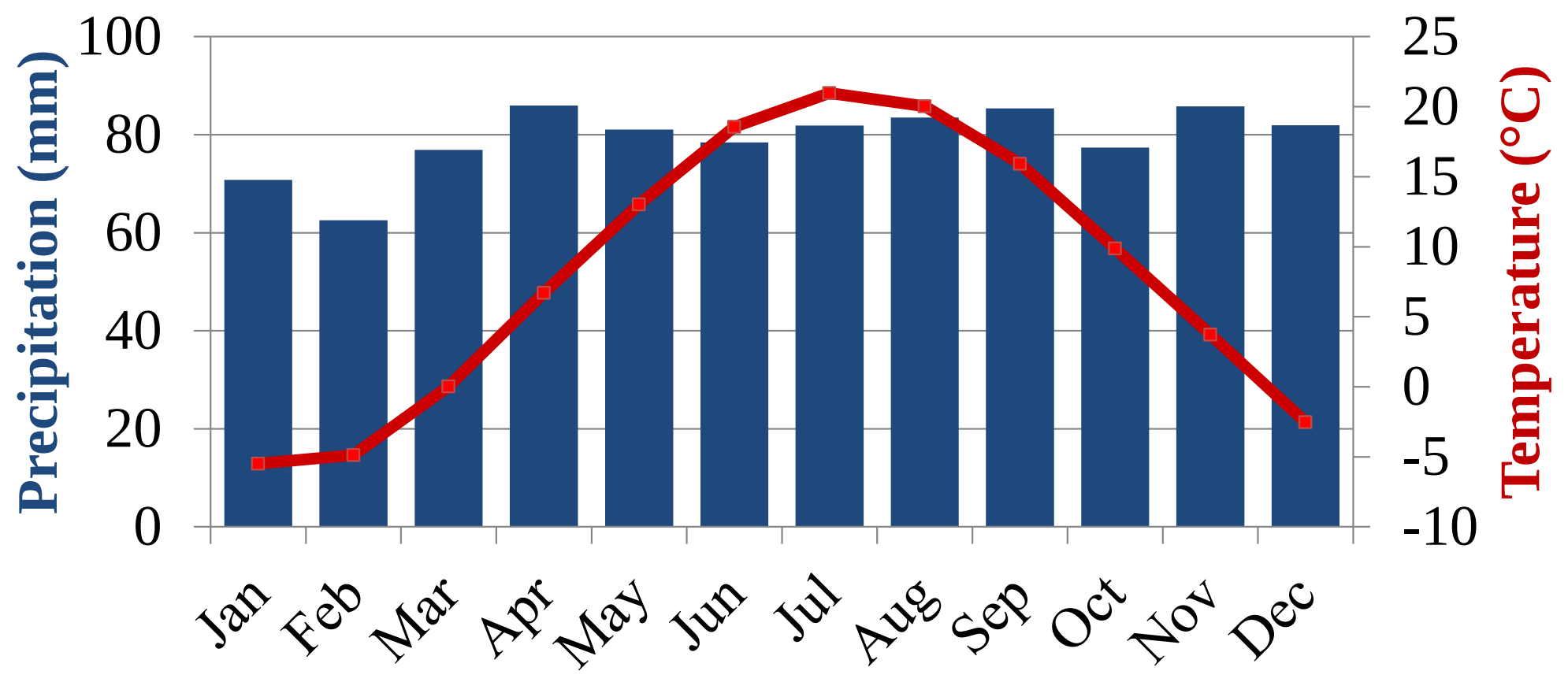


Fig. 4: Average monthly historic climate data from 1935 – 2006 obtained from Environment Canada's Delhi station.

Tab. 1, 2: Data association of mean growth index to Environmental Canada historical monthly parameters reveal growth sensitivity to climate conditions early in the year, in particular March.

Tab. 1: Growth/monthly precipitation association.

	65-yr: full seq.	65-yr: Pre-thin	65-yr: Post-thin	30-yr: full seq.	14-yr: full seq.
Jan	0.188	0.707	**0.038**	**0.050**	0.677
Feb	0.520	0.538	0.510	0.197	0.922
Mar	**0.039**	**0.010**	0.678	0.695	0.480
Apr	0.788	0.693	0.888	0.493	0.521
May	0.176	**0.038**	0.432	0.793	0.345
Jun	0.108	0.390	0.115	0.889	0.335
Jul	0.445	0.166	0.857	0.837	0.177
Aug	0.744	0.788	**0.050**	0.319	0.317
Sep	0.545	0.598	0.745	0.208	0.729
Oct	0.442	0.315	0.973	0.739	0.138
Nov	0.957	0.985	0.585	0.759	0.659
Dec	0.297	0.417	0.650	0.760	0.654

Tab. 2: Growth/monthly temperature association.

	65-yr: full seq.	65-yr: Pre-thin	65-yr: Post-thin	30-yr: full seq.	14-yr: full seq.
Jan	0.996	0.930	0.767	0.337	0.855
Feb	0.660	0.950	0.422	0.466	0.268
Mar	**0.051**	**0.007**	0.694	0.330	**0.052**
Apr	0.803	0.552	0.367	0.091	0.204
May	0.875	0.509	0.629	0.282	0.634
Jun	0.052	0.056	0.414	0.092	0.871
Jul	0.235	0.784	**0.036**	0.966	0.070
Aug	0.798	0.983	0.258	0.558	0.456
Sep	0.739	0.815	0.149	0.940	0.356
Oct	0.369	0.990	0.123	**0.048**	0.072
Nov	0.181	0.176	0.940	0.778	0.272
Dec	0.354	0.086	0.602	0.333	0.387

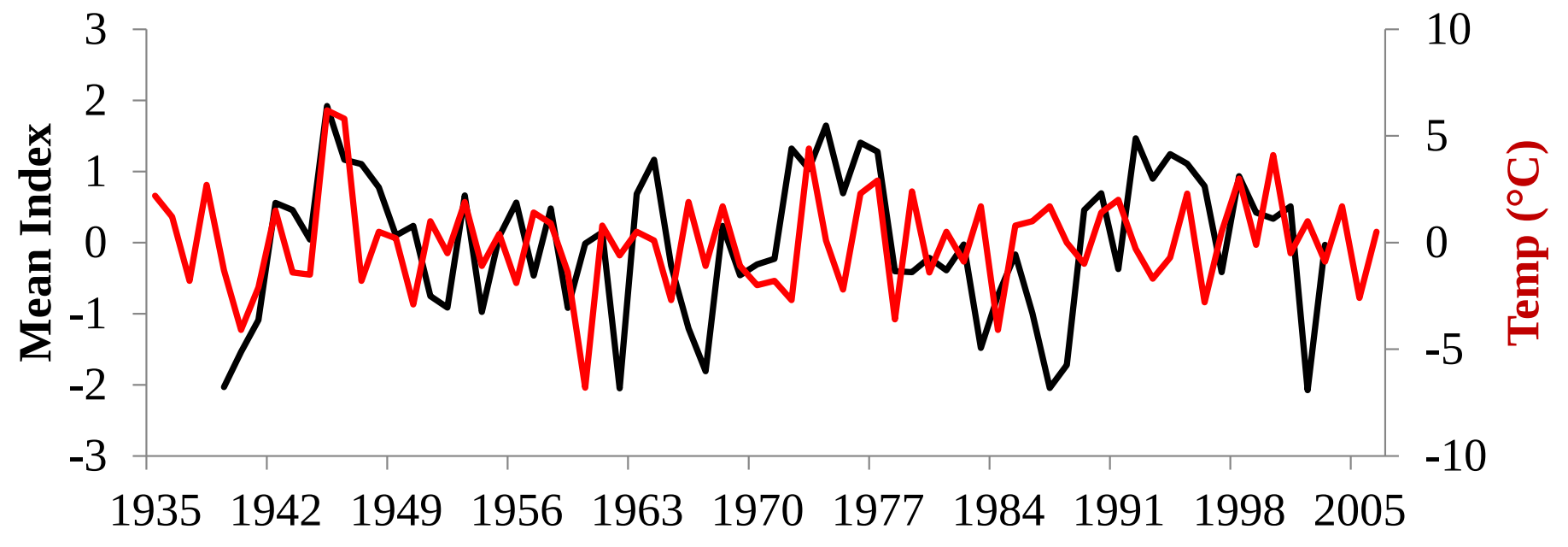


Fig. 5: Growth/T March relationships in the 65-yr stand. Increases in temperature appear to increase growth, revealing a positive association in growth.

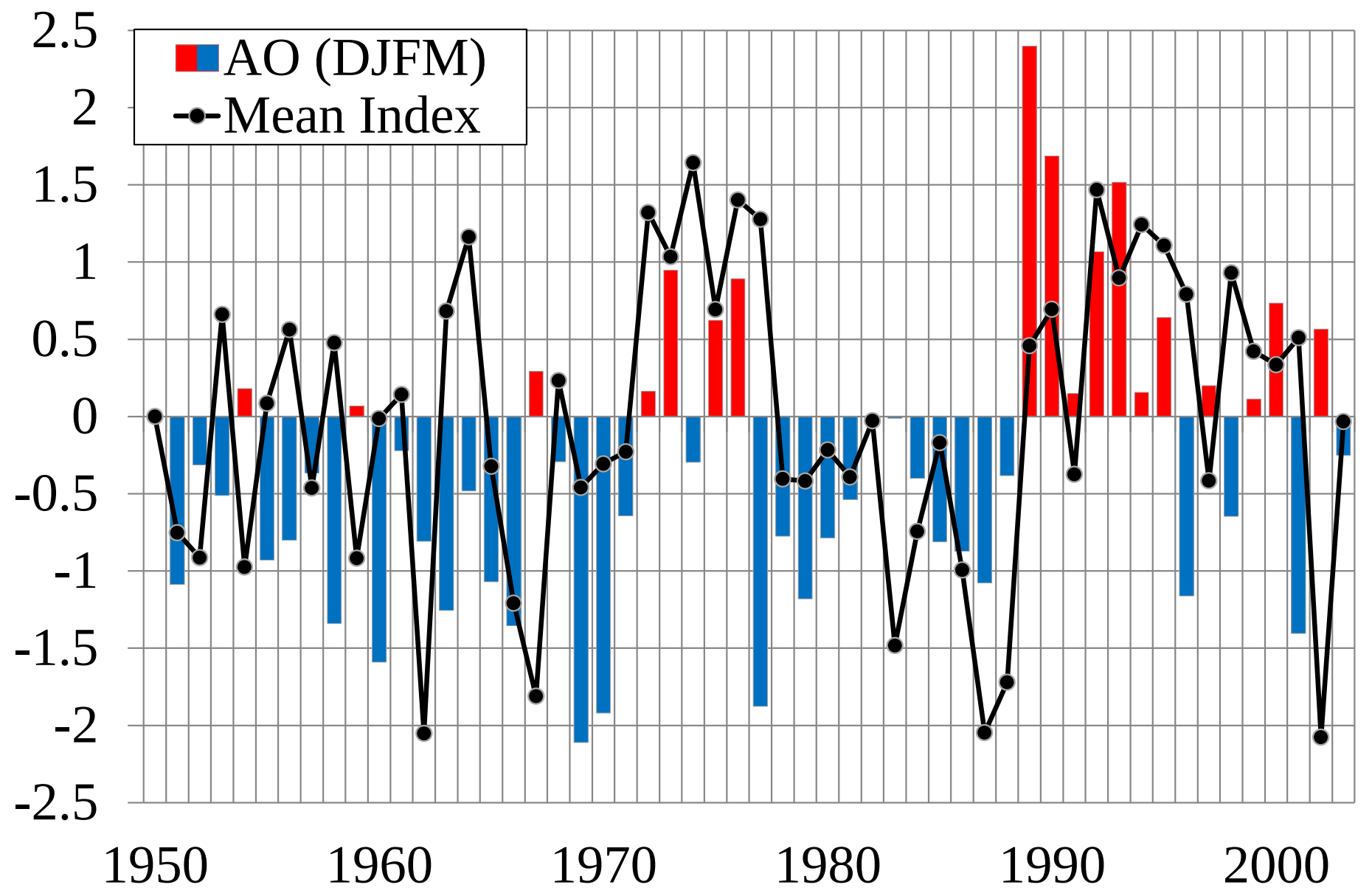


Fig. 6: Multi-decadal trends – Arctic Oscillation (AO) DJFM index and growth similarity 1951 – 2003. The Arctic Oscillation, with it's early spring climate variation, controls multi-decadal growth trends. This agrees well with monthly data association results.

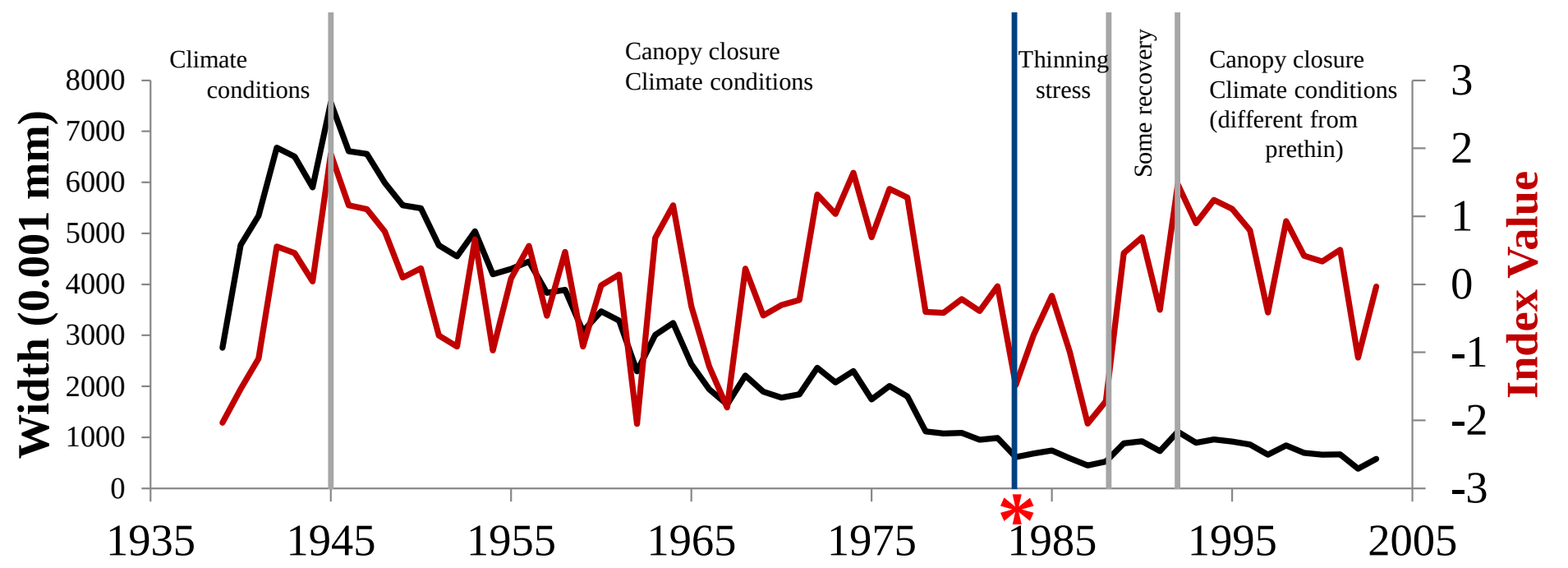


Fig. 7: Summary: Environmental controls 1939-2003. Thinning* at the site in 1983 overrode climate controls from 1983 – 1987. Additionally, climate association parameters changed at the thinning event from early spring (prior) to summer (after). The stand appears sensitive to characteristics of the AO, with positive AO index enhancing growth due to more moderate temperatures and more precipitation in DJFM.

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Further information

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Conclusions

Changing environmental conditions are reflected in chronosequence tree-ring width. Forest management strategies such as thinning override annual climate signals and become the defining factor on growth in older stands. When climate regimes are controlling growth, temperature and precipitation conditions in March appear to be most influential, with temperature as a slightly more dominant control. The Arctic Oscillation controls multi-decadal trends through early growing season variability.