Climate Change Negatively Impacts Maple Syrup Yields in Nova Scotia, Canada



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Introduction

Maple syrup yields in Nova Scotia (NS) have gradually been declining, a major concern to maple syrup producers. A contributing factor to this decline is hypothesised to be climate change. Climate change is suspected to affect tree growth and physiology, as well as contribute to fluctuations in syrup production. Research was initiated to (i) assess the climate change scenario in NS, (ii) evaluated link(s) between the climatic factors and syrup production, and (iii) model the relationships to predict syrup yield and the start date of sap flow.

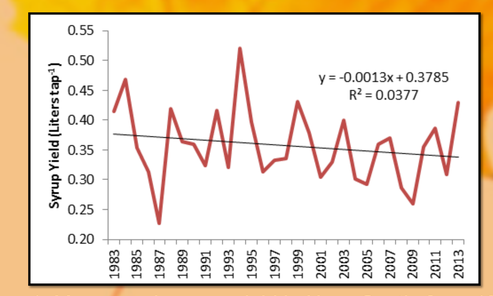

Figure 1. Mean maple syrup yield in Nova Scotia from 1983-2013

Methodology

Maple syrup production data was collected from ten (*n=10*) producers across Nova Scotia. Data included information on annual syrup production and sap yield (Liters), number of taps, sap brix content, timing of tapping, date of first boil, and date of last boil, as well as any comments or notes regarding weather if available. Not all parameters were available from the producers due to the gaps in their records.

Historical weather data (1978-2013) from stations in close proximity to the production locations were collected from Environment Canada.

To analyze the effect of climate change on growth of the maple trees, a preliminary investigation on the tree rings was performed. Four increment cores were collected from four selected sites (*n=4*). Tree ring analysis using Leica M80 boom microscope with camera and analyzed tree ring widths with LAS image analysis.

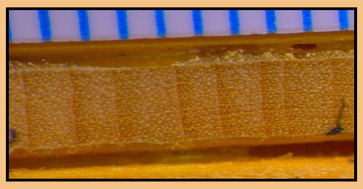

Figure 2. Tree ring analysis using Leica M80 boom microscope with camera and analyzed tree ring widths with LAS image analysis.

Regression analysis was performed in MS Excel application to identify the trend line, strength and nature of the relationship. The polynomial functions and R^2 values were obtained from Excel. SAS 9.3 application was used to conduct the correlation analysis and to screen the various input parameters. P-values less than 0.05 were considered to be statistically significant for regression and correlation analyses.

Results

Mean annual winter temperature has increased by ~1°C in the last 15 years. This has translated into an increased effective growing degree days (EGDD) of at least 100-125 days on an annual basis resulting in a 40-50% drop in sap yield during this period.

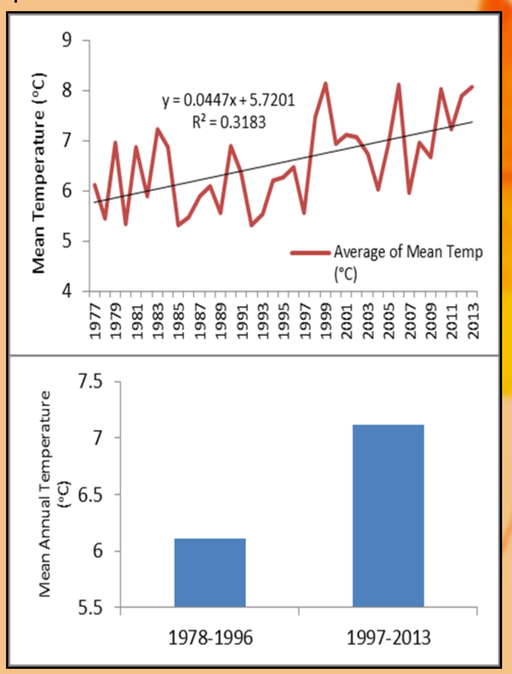

Figure 3. Annual mean temperature for five weather station sites (n=5) within Nova Scotia with linear regression (above) and the mean annual temperature increase pre and post 1997 (below).

Historical syrup yields and EGDD were regressed, it was evident that the decline in syrup yields (0.65 to 0.33 L/tap/yr) significantly correlated with the increase in the EGDD.

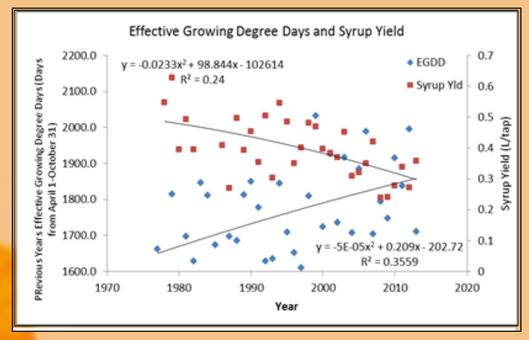

Figure 4. The previous year's effective growing degree days (EGDD) calculated from April 1 to October 31 plotted against the Nova Scotia maple syrup yield (L/tap) from 1977 to 2013.

There was a significantly negative amount of precipitation occurring during the winter months (Jan-Mar) (p=0.000; R^2= 0.3160), however we could not discriminate between a snow or rain event from the data available.

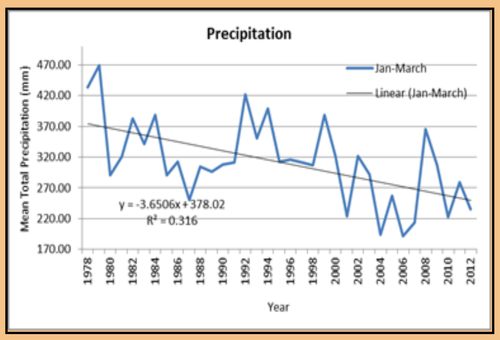

Figure 5. Regression analysis of the mean total precipitation (mm) between January and March from 1978-2012 for five weather station sites (n=5).

Results Cont'd

The start date for the sap flow has moved ahead by five days. However, the length of tapping season was found to remain unchanged.

Over 108 weather parameters were screened for their relationship with syrup yields, only six of the weather parameters strongly correlated with syrup yields (Table 1) and three weather parameters (Temperature difference in January; Number of freeze-thaw events in April, May and October; Total precipitation in January and July) correlated with the start date of the sap flow.

Table 1. Step wise regression analyses results for various weather parameters and syrup yields.

Step	Variable Entered	Number Vars In	Partial R-Square	Model R-Square	F	Pr > F
1	Total precipitation in January	1	0.3597	0.3597	16.29	0.0004
2	Freeze-thaw events in October	2	0.1051	0.4648	5.50	0.0263
3	Total precipitation in July	3	0.0877	0.5525	5.29	0.0294
4	Differential temperature in January	4	0.1205	0.6729	9.58	0.0047
5	Freeze-thaw events in May	5	0.0712	0.7441	6.95	0.0142
6	Freeze-thaw events in April	6	0.0612	0.8053	7.55	0.0112

Conclusions

Initial investigation identified that the Nova Scotia climate has been changing, with trends indicating a negative effect on Nova Scotia maple syrup production.

The weather factors in combination have negatively affected the sap yield and shifted the sap flow season earlier.

The multiple regression syrup yield model constructed with these parameters exhibited strong potential to predict the syrup yields and start date; however, its ability is limited owing to the small size of training data currently available.

Preliminary tree ring analysis showed a moderately consistent growth pattern among the different sites with maple trees in Nova Scotia growing slowly despite the increases in EGDD. Further intensive sampling is required to gain a solid understanding.

Acknowledgements

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