**CASE STUDY 2**

## The Maple Sugar Industry

*by Barrett Rock and Shannon Spencer*

The maple sugar industry represents an important component of both New England and New York's character and economy. The U.S. maple syrup production presently accounts for approximately 20% of the worldwide production. Prior to the 1950s, the U.S. accounted for 80% of the worldwide maple syrup production. The New England/ New York region represents roughly 75% of the total U.S. production and the average value of the New England/New York syrup production was $25 million for 1997-1999 (Figure 5.4). In Vermont, the highest volume maple syrup producing state in the region, the multiplier affect of the industry to related equipment, manufacturing, packaging, and retail sectors equals $105 million annually and represents approximately 4000 seasonal jobs. The maple syrup industry also contributes significantly to the tourism industry and other service sectors within the region.

The sugar maple tree *(Acer saccharum)* produces sap flows during late February to early March depending on geographic location and diurnal (day/night) temperature differences. This occurs due to physiological changes resulting in the conversion of stored starch to transportable sugar (sucrose). Sucrose is required for bud and leaf expansion and prolonged cold periods below 25ºF (cold recharge periods) are required for the enzymatic conversion of starch to sucrose, resulting in high sugar content (3-5%) in the sap. The occurrence of diurnal alternating freeze-thaw conditions causes positive stem pressures, resulting in sap flow. Amino acids found in the sap, microbial action, and thermal carmelization are responsible for giving maple syrup its distinctive color and taste.

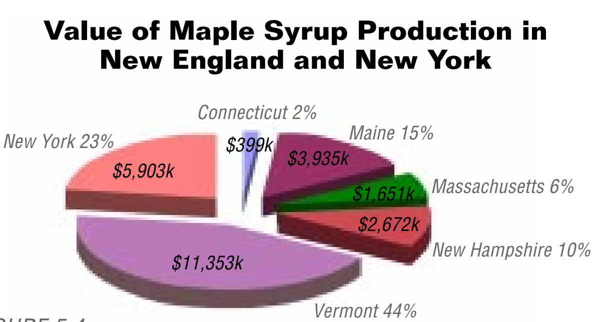


*FIGURE 5.4*
*Average production value for New England states and New York between 1997-2000.*

The successful maple syrup season in New England depends on the proper combination of freezing nights and warm daytime temperatures greater than 40° F. Once a string of days occurs where nighttime temperatures no longer fall below freezing, sap flow stops. The first sap flow of the season generally has the highest sugar content and the lowest nitrogen content, resulting in the highest quality syrup of a given season. Therefore, the maple industry in New England depends to a large extent on the timing of these critical climate events. For Vermont this has typically been between the middle of March and the middle of April. Yet, for the last several years the sugaring season and first sap flow have occurred as early as the beginning of February. Warmer seasonal temperatures result in reduced sap flow, a shorter tapping season, and a lower grade product. The question that concerns New England regional maple syrup producers in the NERA region is: How will a changing climate affect sap flow and quality?

### Current Stresses on the Syrup Industry

Tree health issues dominate the concern for most maple syrup producers in the region. In 1987 the North American Sugar Maple Decline Project, now named the North American Maple Project (NAMP), was formed out of concern for an apparent regional decline in sugar maple health. A number of biotic (pests, pathogens) and abiotic (acid rain, soil depletion) stresses are of concern. The primary biotic stressors include Pear Thrips, which had a significant outbreak in 1988, and

**Early initial flows and warmer nighttime temperatures…have resulted in a shift in syrup production to the Gaspe Peninsula of Quebec.**

the Forest Tent Caterpillar. These two insects affect the leaves of sugar maple during the spring and early summer which, when the outbreak is severe, can affect photosynthesis and the amount of stored stem and root sugars. Abiotic impacts to sugar maple include air pollution, atmospheric deposition, drought, and damage to stems and roots by humans. A bad drought year in 1988 significantly affected tree health for two years. Wet deposition of high levels of both sulfate and nitrate had significant impacts on maple health. Freeze injury to roots during periods of little to no snow cover may also be detrimental to tree health.

Climatic impacts, such as drought (mentioned above) and ice storms, can cause significant local and regional-scale maple tree damage, which can influence sap flow and syrup production. The Ice Storms of 1998 appear to have had significant impacts on maple syrup production and tree health in the New England/New York region (see Ice Storm Damage Case Study). In areas where maple stands were affected by the ice storms, moderate to severe damage occurred on 22% of the trees. Northern New York was severely affected by the ice storms and an average of 26% of the trees within damaged sugarbushes were severely damaged (80-100% crown loss). The Cornell Cooperative Extension Agency estimated the initial economic impact of the ice storms on syrup production in Clinton County, NY to be $4.5 million. The estimated 1998 syrup production loss for NY counties ranged from 20-100%. The damage caused by the storms includes direct structural damage to trees (broken limbs/trunks), damage to sap collection equipment, and a lost opportunity to tap trees where access to the sugarbushes was impeded by downed debris. The full impact of these ice storms will not be known for several years until tree recovery and sap production impacts can be fully assessed.

A recent study of two Vermont maple stands assessed the relative impacts of two growing seasons (1998 and 1999) on the root and stem carbohydrate reserves in sugar maple. Precipitation in 1998 was normal, while 1999 was a significant drought year. Year-to-year variations in precipitation between the two growing seasons resulted in greater difference in root and stem starch when compared with the effects of the ice storm damage. There was approximately 70% less root starch in 1999 (the drought year) when compared with 1998, and stem starch was 50% less in 1999 than in 1998. These results call into question the significance of severe weather events (the ice storms) and highlight the importance of inter-annual climate variation in terms of their impact on stored energy reserves in sugar maple.

Another current stress to the New England and New York syrup industry is market competition. Canadian production of maple syrup has tripled since the 1970s (figure 5.5) due to several factors, one of which is aggressive marketing. In addition the Canadian government now offers subsidies for Canadian syrup production. At the same time U.S. production has been constant. Market forces are making maple sugaring in New England more and more marginal, especially for small producers.

Finally, the advent of tubing-based methods of sap collection has also played a significant role in the Canadian dominance in the world maple sugar production. In the past, the success of the maple syrup industry in Canada was limited by deep snow cover (limiting access to individual trees) and fewer freeze/thaw cycles due to prolonged periods of low nighttime and daytime temperatures. The development of tubing-based sap collection methods that provide easier access to trees and early initial flows and warmer nighttime temperatures (fewer freeze/thaw cycles and reduced cold recharge periods) across New England over the past two decades, have resulted in a shift in syrup production to the Gaspe Peninsula of Quebec.

### Current and Historic Syrup Production Trends

Syrup production for both the New England/New York region and other U.S. syrup producing states show a long-term trend in decreased production and more recent short-term variability (Figure 5.5). There are a number of factors that can account for these short and long-term trends in maple syrup production; some are climate related while others are socially or economically related.

From a climate perspective, there are two primary questions the industry needs answered regarding the impacts of a changing or variable climate in the future:

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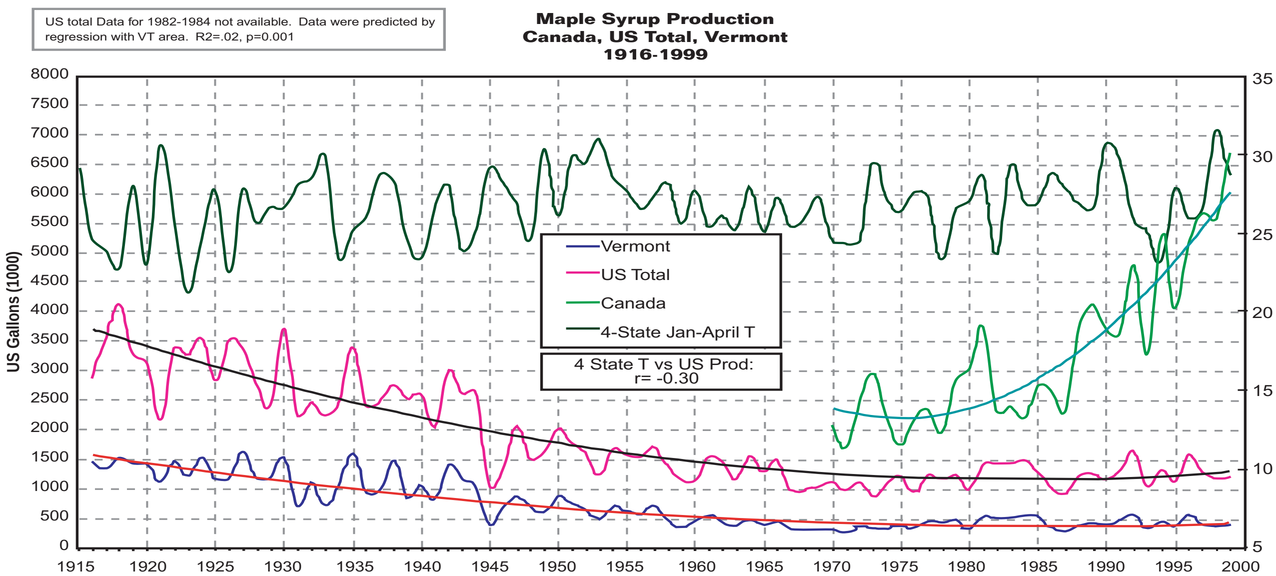


FIGURE 5.5 Maple syrup production: Canada, U.S. Total, Vermont 1916-1999.

1. What direct affect would a change in climate have on sap production?
2. What affect would climate change have on the health of maple trees in the region?

To address these concerns we must consider the various factors that affect maple sap flow and factors that affect syrup production. Poor climatic conditions may reduce sap flow, while a good sap flow year could occur but the number of trees tapped could be reduced for any number of reasons.

Figure 5.5 shows that U.S. syrup production has decreased dramatically since the early 1900s and has stayed fairly level over the last 30 years. Vermont, the largest U.S. producer, has also seen a decrease but this has been less dramatic than the U.S. total production. Since January to April is the timing for maple tree tapping and sap flow, mean temperature for this 4-month period for the four top producing states in the region (VT, NY, ME, NH in descending order) is plotted in comparison to syrup production. Interesting patterns are seen between the mean temperature data and Vermont, total U.S., and Canadian maple syrup production: In general, years with lower temperatures (e.g. 1998) exhibit an increase in syrup production. A moderate inversely related correlation (r = - 0.30) between the mean temperature and total U.S. syrup production means that approximately 30% of the variation in syrup production can be correlated with variations in January-April temperatures.

Figure 5.6 shows the syrup production and mean winter temperature trends over the last decade. Three different ways of characterizing temperature data are plotted for comparison. The VEMAP temperature curve (see Chapter 4 for a discussion of these data) shows the mean of the monthly temperature between January 1 and April 30. Additionally, daily temperature data were acquired from one first-order station from each state and the daily data averaged over two time periods: January 1 to March 15 and February 1 to March 15. Some years show a relationship

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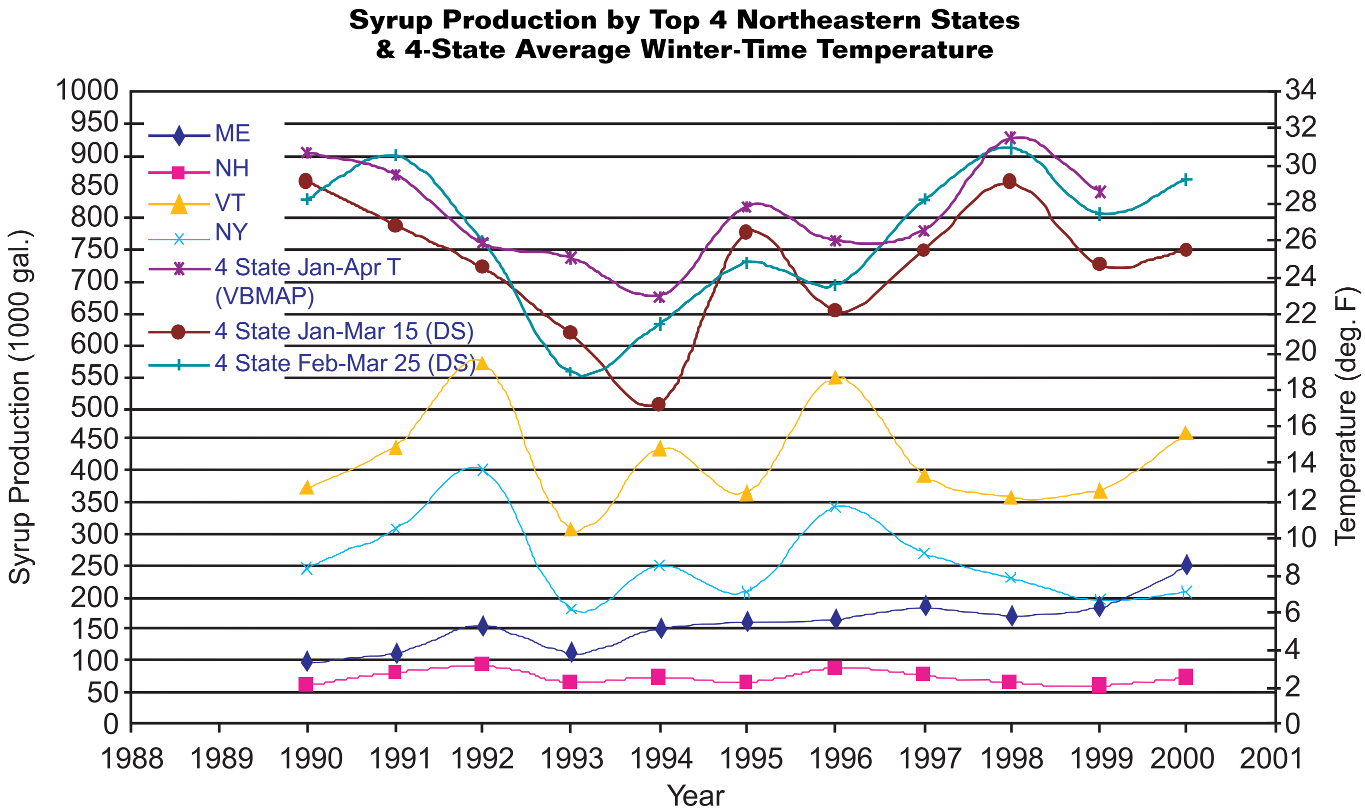


*FIGURE 5.6 Recent syrup production and winter temperature trends in ME, NH, VT and NY.*

with syrup production, with 1994 and 1996 "good" years corresponding to low temperature years. However, 1992 was a "good" year and 1995 and 1997 were poor years, yet all three exhibiting very similar temperature regimes.While ice storm damage may account for 1999 being a poor producion year in all states, both Vermont and Maine appear to have recovered in 2000 (unlike New York and New Hampshire.)

To accurately assess the impact of climate on syrup production, syrup production per number of trees tapped is needed. Additionally, precipitation and the previous summer's growing conditions are likely to have important implications for sap flow and syrup production during the late winter and early spring. The temporal analysis of climate data should be investigated further to better understand how climate variables and tree physiology control sap flow and quantity.

### Conclusions

The maple syrup industry in the US has exhibited a dramatic decline since early in the 20th century. This decline is due to many factors, including climate. Over the past thirty years, the Canadian Maple industry has shown a dramatic increase also due to many factors, including climate. Most disturbing are the results of ecological modeling efforts that show the changes in climate could potentially extirpate the sugar maple within New England. The maple syrup industry is an important part of New England character, way-of-life, and economy that, because it is highly dependent upon prevailing climatic conditions, may be irreparably altered under a changing climate.