Assessing the growth potential of the maple syrup industry in the United States:
A multi-disciplinary approach based on ecologic, socio-economic, and public policy factors

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ASSESSING THE GROWTH POTENTIAL OF THE MAPLE INDUSTRY IN NORTH AMERICA: A MULTI-DISCIPLANRY APPROACH BASED ON ECOLOGIC, SOCIO-ECONOMIC, AND PUBLIC POLICY FACTORS

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Abstract

This dissertation examines the growth potential of the U.S. maple syrup industry from a variety of ecologic, socio-economic, and public policy perspectives. It outlines the number of tappable trees by state, taking into account the species- sugar maple (*Acer saccharum*) and red maple (*Acer rubrum*)- ownership category, and the density and accessibility of the trees. Vermont taps the highest percentage of its available trees (3%) and thus leads the nation in syrup production. States with the most significant growth potential include Michigan, New York, and Pennsylvania. Production could also expand to fill local markets for syrup in states such as Illinois and Missouri. The extent to which the industry develops is based largely on landowner attitudes, socio-economic factors, and supply/demand dynamics that dictate profitability. I performed multinomial logistic regression using survey data to explain the characteristics that influence a landowners' desire to utilize their maple trees for syrup production- these include residing in New England, gender, and education. Since many large landowners are concerned about the effect of tapping maple trees on sawtimber value, I developed a Net Present Value (NPV) calculator that allows foresters and landowners to determine if it is more profitable to utilize maple trees for syrup or sawtimber production. The main determinants include tree size and growth, stumpage payments, lease payments, property taxes, discount rate, and the time horizon of the investment period. Our changing climate has caused much speculation that maples will migrate northward and be replaced with oaks and hickories by the end of the century. Thus, I utilized FIA data to explore recent trends in maple and oak/hickory abundance for 26 states over the past several decades and found that shade-tolerant sugar and red maples have been

infiltrating the understories of oak/hickory forests throughout the eastern U.S. Finally, I examine the role of public policies in the development of the U.S. maple industry. In particular, I discuss differences in policies for tapping on public land, property taxation, government resources devoted to the maple industry in research, extension, and promotion, and the effect of the Quebec Federation's quota and pricing system on market expansion.

BIOGRAPHICAL SKETCH

Michael Lynch Farrell was born and raised in Albany, NY. He attended Hamilton College in Clinton, NY, graduating cum laude with a major in economics and minor in environmental studies in 2000. After a year of spent teaching at environmental education centers in Maine and California, he attended graduate school at the State University of New York- College of Environmental Science and Forestry in Syracuse, NY. Following completion of a Masters of Professional Studies in Forest & Natural Resource Management in 2003, he worked for a year as a Public Service Forester for the New York State Department of Environmental Conservation in Potsdam, NY. In January 2005 Michael took a position with Cornell University as Director of The Uihlein Forest in Lake Placid, NY. There he manages a 5,000 tap maple sugaring research and extension field station spread over 200 acres in the center of the Adirondacks. Michael began his Ph.D. through the employee degree program in the Fall of 2007 in the Department of Natural Resources. Over the past five years, Michael has worked towards growing the maple industry in New York and beyond through dedicated research and extension efforts. The focus of his dissertation is fully in line with the scope of his responsibilities as Director of The Uihlein Forest, which has allowed him to serve the maple industry in many capacities. He resides in Lake Placid, NY with his wife Andrea and their dog Becket.

This dissertation is dedicated to Grammy.

Sugar maples have always been her favorite tree and maple her favorite flavor.

Thank you for being such an incredible inspiration for my work.

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My family has been instrumental to my personal and academic development over the years; my parents Marty and Kathy were tremendous role models and taught me the value of hard work and dedication. My siblings- Joshua, Katie, and Jeremy- have always provided encouragement and support. In particular, Jeremy taught me how to use the finer points of Excel for many aspects of data analysis.

I have learned a lot about maple syrup production and the maple industry from sugarmakers throughout New York State and beyond. In particular, I would like to recognize those whose input directly helped me in completing my dissertation- Chuck Winship, Bruce Bascom, Helen Thomas, and Mike Hill. I would also like to thank all of the landowners and maple producers for taking the time to respond to my mail-based surveys. My colleagues at Cornell, Steve Childs and Peter Smallidge, and all of the extension educators throughout the state that form the Cornell Maple Program, have offered valuable insights and collegiality through the years. Timothy Perkins, Director of UVM's Proctor Maple Research Center, has also provided constructive feedback on much of my research. Several anonymous peer reviewers provided comments and feedback on the individual chapters within this dissertation; it is greatly improved as a result of their efforts.

By endowing my position as Director of the Uihlein Forest, The Henry II and Mildred A. Uihlein Foundation has provided the financial resources and funding to allow me to pursue my Ph.D. at Cornell. I also received funding from the Northeastern States Research Council, the Cornell University Agriculture Experiment Station, and the College of Agriculture and Life Sciences for various aspects of this dissertation. I am very grateful for all of the financial support over the years.

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Finally, I would like to thank my wife Andrea for providing tremendous love and support over the past few years, allowing me to spend countless hours on my research and finish writing my dissertation. I couldn’t have done it without you.

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Introduction

The process of extracting sap from maple (*Acer spp*.) trees and processing that sap into syrup and sugar has been an important part of the North American landscape for centuries. The Native Americans relied on maple trees as their primary source of sugar and the early settlers learned the process when they immigrated to North America and settled the countryside (Nearing and Nearing 2000). The process has improved greatly over the years as a result of technological improvements that make it more cost-effective and efficient to collect sap from trees and process that sap into finished products. Even with primitive technology, maple sugaring was a much larger component of the rural economy in the 1800s. The U.S. produced a record equivalent of 6,613,000 gallons of maple syrup in 1860, although most of this was actually boiled down further into granulated sugar (US Census 1860). Beginning in the late 19^{th} and early 20^{th} century, imported cane sugar became less expensive than maple sugar and there was not as much resistance in the North towards using 'slave sugar' from the South (Whitney and Upmeyer 2004). As a result, maple sugar production dropped off rapidly and those who continued to tap maple trees started primarily making maple syrup. Rather than serving as one of the primary sweeteners, maple syrup became more of a luxury item to fill niche markets.

The maple syrup industry has undergone transformative changes in recent years. The transformation has been driven by technology, demographic, and economic factors coupled with organizational changes in the industry. With the advent of vacuum-assisted tubing to collect sap and reverse osmosis and efficient evaporators to process sap into syrup in a cost-effective and timely manner, large-scale sugaring operations started to emerge in the 1980s. In the past, many small family farms in the eastern U.S. produced maple syrup to supplement their income during the winter months. Although fewer family farms are producing maple syrup, there are now several thousand maple producers throughout eastern North America that make a substantial amount of syrup on a commercial scale. Whereas 2,000-3,000 taps used to be considered a large operation, individual operations with 50,000-100,000 taps are now possible and becoming more common on the landscape. Larger size operations are able to gain economies of scale in sap collection and processing, thereby encouraging different types of investors and businesses to come into the industry. Finally, more people are entering the market on a small scale in recent years due in large part to the interest in local food production and consumption.

In the Fall of 2007 I started to pursue my Ph.D. through the employee degree program. As Director of The Uihlein Forest, Cornell University's Sugar Maple Research & Extension Field Station in Lake Placid, NY, I was in a unique position to focus my research on the maple syrup industry. Within the first year of starting my degree program, there was a significant supply shortage and corresponding price increase of maple syrup in North America. Quebec, where approximately 80% of the world's maple syrup is produced, experienced three consecutive poor crops from 2006-2008 while simultaneously implementing a quota system to limit expansion of new taps (Gagne 2008). Their goal was to sell off the existing surplus in order to raise prices and make syrup production profitable. However, as their marketing efforts were expanding sales of syrup worldwide, the production fell much more than planned due to poor weather conditions. Thus, a situation developed in 2008 where there was simply not enough syrup to meet market demand. Bulk syrup prices had been steadily hovering around $2.20-$2.40/lb, yet they rapidly rose to $4/lb or higher as bulk buyers sought to secure as much syrup as possible. The *Maple News*, a trade publication for the industry, featured several articles addressing the need for expansion in order to fill the growing markets for pure maple products (Dravis 2008, Dravis 2009).

Given these circumstances, it was clear that a pressing and important topic in need of further research was determining the growth potential of the maple industry in the United States. Not only would it be important to determine the factors that have impacted development up to the present time, it was also necessary to assess how and where the industry may develop in the future. Due to limitations in time and resources, I could not address all possible aspects of this broad topic. After reviewing the literature and current state of knowledge in the industry, the main research questions that I decided to address include the following:

1. What is the current resource of tappable trees in the U.S. and what percentage of those trees are utilized for syrup production?
2. What is the current demand for maple products in the U.S. and how could production and consumption grow together on a local basis?
3. What are the main barriers that prevent landowners from wanting to utilize their maple trees for syrup production?
4. Is it more profitable to utilize maple trees for syrup or sawtimber production?
5. Will maple trees be a prominent tree on the landscape for the foreseeable future, or will they be replaced by oaks and hickories as some researchers have predicted?
6. How have public policies influenced development of the maple industry in the United States?

The remainder of this introductory chapter provides more context for each of these questions, explains why they are an important component of the research, and discusses the approaches I will use to address them.

1. **What is the current resource of tappable trees in the United States and what percentage of those trees are utilized for syrup production?**

In order to determine the growth potential of any natural resource-based industry, it is important to know the overall size and current utilization of the resource in question. Maple syrup production is unique as an agricultural crop since the immediate production capacity is limited by the number of tappable-size trees. If a farmer or landowner would like to start producing syrup, he or she would either have to plant trees and wait 20-30 years *or* find an established grove of maples that are already suitable for tapping. Thus, the immediate potential for syrup production is based on the existing resource of maple trees $\geq$ 10" dbh (diameter at breast height). Establishing baseline information on the number of tappable trees, where those trees exist, and what percentage of them are currently being tapped, is a necessary first-step in determining the growth potential of the industry.

Previous efforts to quantify the tapping potential in the U.S. have fallen short of providing realistic estimates. The first attempt was part of a Ph.D. thesis at Penn State in the 1960s (Taylor 1965). It was not an in-depth analysis, but did provide a general outline of the syrup production potential during that time period. More recently, Collins (2001) used U.S. Forest Service Forest Inventory & Analysis (FIA) data to estimate the syrup production potential in the U.S., but there were several shortcomings in this analysis. Most notably, it failed to include any data for red maples, public lands or corporate-owned private lands. Collins only performed the analysis for 12 states, even though there are 25 states in the eastern half of the country with a sizeable number of sugar and red maples. The tapping guidelines she used were a bit more aggressive than the currently accepted "conservative tapping guidelines". Finally, her analysis did not make any allowances for the density of maples within a stand or the distance of that stand to an access road. Additional research is warranted to develop a realistic estimate of the maple resource in the U.S.

In order to determine the utilization of the maple resource for syrup production, the National Agricultural Statistics Service (NASS) provides the most comprehensive source of the number of taps for the ten producing states. I will utilize the NASS data to calculate the percentage of tappable trees that are actually utilized for syrup production. Although fourteen additional states have a substantial number of maple trees, we lack any information on their number of taps and corresponding utilization rates. Syrup production levels are currently so low in these states that it is not feasible for NASS to gather these data. Nevertheless, using the NASS data will help gauge the current utilization for the ten states with the highest levels of syrup production. Conducting this research will provide baseline information on how the maple resource is utilized and what the overall capacity is for future growth.

2. **What is the current demand for maple products and how might production and consumption grow together?**

When exploring the growth potential of any natural resource or agricultural product, one cannot just examine the production potential, but also the current and projected demand for a given product. After all, if supply grows at a faster pace than demand, then a surplus will develop and prices will fall. With lower prices, syrup production may no longer be profitable and many sugarmakers could go out of business. Thus, the production potential is not limited solely by the number of tappable trees, but also by the ability to sell the finished products at profitable levels. Given the growing market for 'local food', I will examine the potential for production and consumption of maple syrup on a 'local' basis. The interest in locally produced food has been growing tremendously over the past decade as people wish to reduce their reliance on imported goods and support their local farmers while eating healthy, seasonal food. Maple syrup sales have benefited from this trend, so conducting this type of analysis is appropriate and timely.

I will consider two scenarios for how each state could grow their maple syrup industries: (1) if each state tapped 3% of their available trees (the percentage achieved in Vermont) and consumed all of the syrup locally among their residents, and (2) the amount of taps needed in each state to provide 2.6 oz/person from 'local' sources. Since Vermont leads the country in the amount of syrup produced and taps the highest percentage of their trees, the first scenario presents a target for other states to achieve. The second scenario is meant to gauge how many taps are needed to supply the current average annual consumption (2.6 oz/person) from local sources within any given state. Although there are practical limitations to these scenarios, this type of analysis will be useful at identifying the states with the greatest potential for growth.

3. **What are the barriers that prevent landowners from wanting to utilize their maple trees for syrup production?**

The first two research questions focus on determining the number of potentially tappable trees, the current utilization of these trees for syrup production, and the consumption levels necessary to increase production at varying levels. Since one cannot produce maple syrup without maple trees and few people would want to do it on a commercial scale if it wasn't profitable to do so, these are necessary and important considerations. However, one must also consider the role of landowner attitudes towards sugaring and the entire range of barriers or incentives that influence their land-use decisions. Even with a large resource of maple trees and a market that could absorb additional production, if landowners are not interested in sugaring, then the industry cannot grow. Since over 80% of the forestland in the eastern U.S. is privately owned (Nelson et al. 2010), further research on family forest owners' attitudes towards maple syrup production is warranted.

The objective of this chapter is to identify the landowner attributes that make them more or less likely to want to utilize their maple trees for syrup production. I aim to gain a greater understanding of the barriers and obstacles that may prevent landowners from tapping their trees themselves or leasing their woodland to another sugarmaker. To achieve this goal, I will survey landowners in the Northern Forest region that includes parts of Maine, New Hampshire, New York, and Vermont. The survey results will be used to construct a model of landowner characteristics that guide their attitudes towards how the maple trees on their land should be utilized. Understanding what drives landowner attitudes towards maple sugaring and the barriers that may have prevented them from utilizing their maples for syrup production will help formulate a better understanding of the true growth potential of the maple industry in the United States.

4. Is it more profitable to utilize maple trees for syrup or sawtimber production?

Maple trees, in particular sugar maples and red maples, are prized for both the quality of their lumber and the syrup produced from their sap. Most people consider these uses to be mutually exclusive since trees that are being used for syrup production cannot be harvested for lumber, and if they are eventually harvested, the previous tapping reduces the commercial value of the lumber in the first log. Landowners often have competing demands from loggers who want to harvest trees and maple syrup producers who wish to lease them for tapping. Determining the most profitable option is a critical component to address the future growth potential of the maple industry. Anecdotal evidence suggests that one of the main reasons large landowners have not utilized their trees for syrup production is concern over the potential loss of sawtimber value that occurs when maple trees are tapped. Whereas this may be a valid concern for some landowners and certain trees, there is no definitive answer about whether using maple trees for syrup production is more profitable than managing them for sawtimber.

The objective of this chapter is to explore the major factors that determine whether a landowner could earn greater profits by leasing maple trees for syrup production or managing them for sawtimber production. The variables in question include the initial tree size and growth rate, species (sugar or red maple), lease payments, stumpage rates, property taxes, discount rates, and the time horizon of the investment period. It will be necessary to incorporate all of these variables into a long-term financial decision making model that allows foresters and landowners to determine how to best manage an individual or stand of trees. Thus, I will develop a Net Present Value (NPV) calculator that determines the present values of all costs and revenues associated with leasing a tree to a maple producer and/or receiving stumpage payments for harvesting. This will allow foresters and landowners to evaluate the characteristics of an individual or stand of trees to decide what the most profitable management decision would be over the life of the investment period.

5. Are maple trees expected to be a prominent tree on the landscape for the foreseeable future, or will they be replaced by oaks and hickories as some researchers have predicted?

Although an abundant resource of tappable maple trees currently exists in the U.S., there are questions and concerns about whether maples will continue to persist in future forests. Prasad and Iverson (1999) first reported on the potential shifts in species distributions through the Climate Change Atlas. Their original work was intended to show where the climate would be most suitable for many species, not necessarily where trees will be found in the future. However, many people ignored the "Word of Caution" statements describing this nuance and assumed that the Climate Change Atlas predicted where species will be found (or not found) by 2100 given a particular climate model. This caused much speculation that sugar maples would largely disappear from the United States and become restricted to Canada by the end of the century.

The New England Regional Assessment Group (Lauten at al. 2001) and the Union of Concerned Scientists (Frumhoff et. al. 2007) both conveyed serious concern about the future of maples in the northeastern U.S. and the negative effect climate change would have on industries that rely on sugar maples, including maple syrup, fall foliage tourism, and timber products. These reports predicted that the Northern Hardwood forests of New England and New York, currently dominated by sugar maples, red maples, and beech (*Fagus grandifolia*), will be replaced by oaks (*Quercus spp*.) and hickories (*Carya spp*.) by the end of the century. The popular media ran with this storyline and its premise has become widely accepted by the general public and many scientists. However, oaks and hickories have had trouble regenerating in existing forests for several decades, raising concerns about the sustainability of these species in future forests

(Woodall 2008). Furthermore, there is already evidence that many oak-hickory stands are shifting to maple dominated stands in the central hardwood region (Fralish and McArdle 2009, Martin et al. 2011).

In this chapter, I will use FIA data over the past several decades to explore recent trends in sugar maple, red maple, beech, oak, and hickory distribution throughout the eastern U.S. If oaks and hickories will replace maples in northeastern forests, then there should be some evidence that this is already occurring. Similarly, if beech trees are forming dense thickets in the understory of many stands, then the number of beech saplings should also be on the rise. A close examination of abundance and distribution for these major species, stratified according to diameter class and forest type, is useful for identifying trends in forest composition over time. Although it is impossible to predict what the forest composition will be at the end of the century, examining what has been occurring over the past several decades should provide a useful preview of what to expect in future years.

6. How have public policies influenced development of the maple industry in North America?

My initial research into the tapping potential for the U.S. revealed wide differences in the percentage of available trees tapped for syrup production in each state. It became clear that Vermont dominates the industry not because they have the most maple trees, but rather because they utilize a much higher percentage of their trees than any other state (3%). Conducting research on Canada's maple industry revealed an even greater disparity in utilization rates, as producers in Quebec tap approximately 40 million of their 110 million total potential taps. In order for such wide disparities in syrup production to exist, public policies may have played a vital role in affecting the growth and development of syrup production in various states and provinces over time.

Although I am still conducting research and collecting data for a peer-review journal article, I have amassed enough information to merit inclusion of a chapter on this topic for my dissertation. I will explore various aspects of how government policies affect maple production in different states and provinces, in particular New York, Vermont, Maine, Michigan, and Quebec. I explore differences in policies for tapping on public land, government resources devoted to the maple industry in research, extension, and promotion, and differences in property taxation that may encourage (or discourage) syrup production. Although I do not discuss the Quebec situation in great detail, I will examine how its policies are currently helping to expand the maple industry in the U.S.

This dissertation is the first comprehensive report to examine the future growth potential of the U.S. maple industry from a variety of socio-economic and ecological factors. As with all agricultural crops, there are likely to be ups and downs in production levels and profitability over the years due to the vagaries of weather and market forces. Although forecasting future development patterns is difficult, it is important to examine the key factors that may affect how and where the industry develops in future years. Having a greater understanding of fundamental issues will help industry leaders and government officials develop policies and strategies to address long-term sustainability of the industry.

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Chapter 1: Assessing the growth potential and economic impact of the U.S. maple syrup industry[1]

Abstract

This paper addresses the growth potential of the U.S. maple syrup industry. It outlines the number of potentially tappable maple trees and the economic impact of utilizing more of these trees for syrup production. U.S. producers currently tap 0.4% of all potentially tappable maple trees, with the highest percentage tapped in Vermont, at 2.94%. Two scenarios are analyzed for how production and consumption could grow together: (1) if each state tapped 2.94% of its available trees and consumed all of the syrup locally among its residents; and (2) the number of taps needed in each state to provide 2.6 ounces (76.9 ml) per person from "local" sources. Based on these analyses, states with the greatest potential to increase local production and consumption of pure maple syrup include Connecticut, Michigan, New York, Ohio, and Pennsylvania. Strategic marketing efforts are necessary to help maple producers take advantage of the growing demand for local, healthy, and organic food.

Introduction

Maple syrup was once a much larger component of the rural economy in both the U.S. and Canada. The United States produced a record equivalent of 6,613,000 gallons (25,032,928 liters) of maple syrup in 1860, with most of the syrup actually boiled down further to produce granulated maple sugar (U.S. Census Office, 1860). As seen in Figure 1.1, maple production in

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the U.S. peaked in the 1800s, steadily declined throughout the twentieth century, and is experiencing a rebirth in the twenty-first century. Maple production was always a small component of the agricultural sector in Canada, but spiked dramatically in Quebec in the early 1980s. Producers installed vacuum tubing systems and reverse osmosis units that allowed them to significantly expand their operations while saving time and using less fuel. Production in Canada leveled off in recent years due to implementation of a quota system in Quebec in 2005 aimed at stabilizing prices and reducing surplus inventory (Gagné, 2008). Once the inventory was exhausted in 2008, prices rose to record levels, the quota restrictions were eased, and production levels surged once again.

Maple syrup is a luxury item consumed around the world, yet the greatest market for syrup still lies within the United States. The U.S. currently imports nearly four times as much syrup from Canada as it produces (Agriculture and Agri-Food Canada, 2006), so there is a tremendous opportunity for U.S. producers to expand production and fill domestic markets with “local” syrup. Maple syrup production is growing rapidly in the U.S., as a shortage of syrup and corresponding price increases led many sugarmakers to expand production and others to get started in recent years (Dravis, 2008; Dravis, 2009). Some politicians even seized on the opportunity to spur rural economic development through enhanced syrup production. Senator Charles Schumer (D-NY) introduced legislation in April 2008 that would provide grants and incentives to states in order to increase the number of trees being tapped on private lands (Churchill, 2008, Schwaner-Albright, 2009). This legislation was reintroduced in both the House and the Senate several times but has yet to pass in any form. Even without federal support, states including Connecticut, Maine, Michigan, New York, and Vermont have all moved forward with efforts to increase syrup production (Hoyum, 2010; Karkos, 2011; Litten, 2011; Wanamaker, 2009; Whitcomb, 2009).

Maple syrup consumption in the U.S. is only 2.6 oz. (76.9 ml)/person, yet this has grown tremendously over the past 35 years. Figure 1.2 tracks U.S. and Canadian syrup production, as well as U.S. imports and exports of maple syrup, from 1975 to 2009. Per capita consumption levels were determined by summing the amount of syrup produced by U.S. sugarmakers and the amount of syrup imported from Canada, subtracting the amount of syrup exported from the U.S., and then dividing by the population in a given year.

Per capita consumption of maple syrup in the U.S. has grown by 155% over the past 35 years, rising from 1.03 oz. (30.5 ml)/person in 1975 to 2.63 oz. (77.8 ml)/person in 2009. Although the increase in U.S. consumption has been made possible by large increases in Canadian production, future levels of syrup production and consumption might not follow the same trends. Questions remain about where the additional syrup will be produced and consumed and the impact of future development on prices and profitability.

Methods

In order to determine the tapping potential in the U.S., analyses were performed using the latest U.S. Forest Service Forest Inventory & Analysis (FIA) data (Bechtold & Patterson, 2005) from 24 states that contain a significant number of sugar (*Acer saccharum*) and/or red maples (*Acer rubrum*). The number of potential taps was estimated by summing all of the sugar and red maple trees greater than 10" (25.4 cm) diameter at breast height (dbh) and applying conservative tapping guidelines of one tap for a 10"–17" (25.4– 43.2 cm) tree and 2 taps for trees 18" (45.7 cm) and greater. The FIA data are classified by ownership category (private, U.S. Forest Service, other federal land, and state and local government). They are also divided between the tappable (nonreserved) and nontappable (reserved) trees, as the reserved forestlands where timber production is legally prohibited are also likely to have restrictions on tapping.

To determine the percentage of potential taps that are actually utilized for syrup production, these figures were compared with the number of taps reported for each state in the 2010 National Agricultural Statistics Service (USDA NASS) Maple Syrup Crop Report. NASS only tracks maple syrup production for 10 states. Thus, although 14 additional states have a substantial number of maple trees, we lack any information on their number of taps and corresponding utilization rates. Syrup production levels in these states are currently so low that it is not feasible for NASS to gather these data.

Given the strong growth in the local food sector and the niche that maple syrup occupies as the local, minimally processed sugar alternative for the eastern U.S., analyses were performed to determine the market potential for maple syrup production and consumption on a "local" basis. For these analyses, local syrup is defined as being produced and consumed within the same state. Based on local production for local consumption, two scenarios are posed for how the maple industry could expand:

1. If each state tapped the same percentage of its trees that Vermont does and all of the syrup was consumed locally by the residents of the state, how much syrup must each person in that state consume on an annual basis?

2. Given that the average American consumes 2.6 oz. (76.9 ml) of pure maple syrup annually, what percentage of the maple trees in each state would need to be tapped in order to fill the existing demand for syrup in a state from its own trees?

The final component of this paper is determining the economic impact for each of these two scenarios. For each state, average annual syrup production was estimated based on the average yield per tap in 2007–2009 for that state. For the states that do not have any production data, the lowest figure of all states, 22 oz. (651 ml)/tap for Pennsylvania, was assumed for the average production. A dollar figure was estimated by multiplying the possible production figures for each state by the average price that producers received in that state from retail, wholesale, and bulk syrup sales over the period 2007–2009. For states that do not have any data available, the average figure of USD37.10 per gallon for the entire U.S. was used.

Results and Discussion

As an agricultural crop, maple syrup production is unique since it is produced from large trees that are at least 30–40 years old. If a farmer or landowner would like to start producing syrup, he or she would either have to plant trees and wait a long time or find an established grove of maples that are already suitable for tapping. Thus, the immediate potential for syrup production is based on the existing resource of large maple trees. Although sugar maples are the preferred species for tapping due to the high sugar concentration in their sap, red maples are also suitable for syrup production, but usually exhibit slightly lower sap sugar production than sugar maples (Chapeskie, Wilmot, Chabot, & Perkins, 2006). The number of potential sugar maple taps is displayed in figure 3, while the number of potential red maple taps can be seen in figure 4. Figure 5 presents the total number of combined sugar and red maple taps for 24 states.

Michigan contains the greatest number of potential sugar maple taps, whereas Pennsylvania leads in red maples. When considering sugar and red maples combined, New York has the most potentially tappable trees of any state. The more southern and western states tend to have more red maple than sugar maple potential taps, though there are exceptions to this rule. For instance, Connecticut, Maine, Massachusetts, and Pennsylvania all have significantly more red maples than sugar maples, whereas Illinois, Indiana and Kentucky all have more sugar than red maple potential taps. Although Vermont dominates in syrup production, it ranks fifth in the number of potential sugar maple taps and seventh in the combined total number of sugar and red maple potential taps. Producers in Vermont make up for this apparent shortfall by tapping a much larger percentage of their trees than any other state.

It is important to realize that the figures presented here overestimate the realistic tapping potential for several reasons. In order to economically tap maples, the trees must be located close enough to an access road and the density of trees must be high enough to justify installing a tubing or road system to collect the sap. Although the FIA data includes all sugar and red maple trees growing on nonreserved forestland (land that is not restricted from management), many of these trees are growing in locations that are not suitable for tapping. Some of them are in stands that have a low density of maples, are too far from an access road, or are otherwise inaccessible due to topographic constraints. Further research is in process to obtain a more realistic estimate of the tapping potential for several states based on these considerations.

Finally, it is important to note that the FIA program only deals with forestland, and therefore does not account for a significant percentage of the trees that are actually tapped. Maples growing in yards, parks, and along roads are favored by producers who collect with buckets due to the easy access and large volumes of sweet sap they generate. In order to quantify these potential taps, much more detailed inventory data must be collected and analyzed through urban and community forestry research initiatives.

Utilization of the Maple Resource for Syrup Production

Significant differences exist in the utilization of the maple resource for syrup production, as seen in figure 6. Vermont clearly dominates the industry due to its relatively high utilization rate of 2.94%, whereas states such as Michigan (0.15%), New York (0.45%), and Pennsylvania (0.17%) have tremendous potential for expansion. Although these three states have the largest maple resource, they tap a much lower percentage of their trees than Vermont does.

The discrepancies in utilization rates can largely be explained by cultural traditions (Hinrichs, 1998). When there are strong cultural norms to produce maple syrup in a certain area, farmers and landowners are more likely to do so. However, even when there is a robust maple resource, if nobody is already producing syrup, then it is much less likely that landowners start production. Thus, even though Michigan contains the most tappable sugar maples of any state, the logging industry has dominated the landscape and only 0.15% of the maples are used for syrup production. Similarly, West Virginia has more tappable maple trees than Vermont, yet the culture for syrup production does not exist in most of the state. Even though Vermont ranks seventh in the number of potential taps, it ranks first in syrup production due in large part to the strong cultural traditions and superior branding and marketing of its product over the last century.

Among the more southerly states, such as Kentucky and Tennessee, even though maples grow abundantly, the climate is not thought to be as suitable for commercial syrup production. The climate may play a critical role in explaining why more syrup is not currently produced in these states and what the potential for increasing production is. Sugaring used to be more commonplace in the mid-Atlantic region during the 1800s (U.S. Census, 1860), but that tradition has been lost over time. In these states, the limited number of freezing nights and the spells of very warm weather can cause tapholes to "dry up" prematurely, especially when using buckets or gravity-based tubing to collect the sap. However, with new technologies and techniques, such as high-vacuum tubing, check-valve spout adapters, and replacement of droplines and spouts every year, there may be opportunities to achieve economic returns from syrup production even when the weather is not favorable. More research is needed to determine the potential yields in warmer climates using modern sap-collection technologies. This could provide immediate economic development in these states, while providing a preview for what the Northeast can expect in a future climate that is predicted to be similar to the mid-Atlantic region (Skinner, DeGaetano, & Chabot, 2010).

Finally, it should be noted that the NASS estimates are based on voluntary reporting of producers. Many sugarmakers are opposed to a government agency knowing about their activities and therefore do not provide NASS with accurate (or any) information on their production levels. Thus, even though NASS provides the most comprehensive database on syrup production in the U.S., using these figures likely underestimates the actual production in many states. Furthermore, since NASS only tracks syrup production in 10 states, there is no data on the limited amount of sugaring that takes place in the other states.

Economic Impact of Increased Syrup Production: Two Scenarios for Local Consumption

This section presents the results of two scenarios for increasing the production of maple syrup through local consumption within the state in which it is produced. The first scenario examines what could happen if each state tapped the same percentage of its trees as Vermont does, while the second scenario estimates the number of taps needed to provide each resident with 2.6 oz. (76.9 ml) of locally produced syrup.

Scenario 1: What if Each State Tapped the Same Percentage of Its Trees as Vermont

The first scenario provides a theoretical upper limit for what is possible to achieve in each state. Although no other state will likely ever tap the same percentage of its trees as Vermont does, this analysis presents the economic impact and per capita consumption levels necessary to consume all of the syrup locally if it did.

There are interesting observations when examining the per capita consumption necessary to sell all of the syrup produced in a state among the residents of that state. While most states have low "necessary" consumption levels, below 3 oz./person, the residents of Vermont and Maine would need to consume significantly more syrup, at 180.9 oz. (5,349.9 ml) per person and 26.6 oz. (786.7 ml) per person, respectively, in order to utilize all of the syrup they produce themselves. These extremely high values result from the combination of extensive syrup production and relatively low populations. Although it is likely that many producers of maple syrup consume at least 180 ounces themselves in a given year, it would take enormous marketing efforts and a tremendous reduction in prices to encourage all citizens to consume this much pure maple syrup annually.

Given this reality, Vermont and Maine have not limited their markets to the residents of their own state, but strategically looked elsewhere to sell most of their syrup. Vermont made wise decisions throughout the twentieth century in branding itself as the maple state in order to export this high-value crop throughout the U.S. and now to the world. Similarly, Canada purposefully built a worldwide image as the maple syrup nation and now exports over 80% of its production (Agriculture and Agri-Food Canada, 2006). It's commonly known within the maple industry that the vast majority of syrup production in Maine is carried out by Canadian citizens on former paper company land along the Quebec border. Since this region has few people to sell to locally, nearly all of the syrup is sold in bulk to the major packaging and distribution companies in the U.S. and Canada.

Although exports will continue to be important for agricultural commodities, the local food sector is currently experiencing rapid growth. It is now even being embraced by Walmart, which plans to source a larger percentage of the produce sold in its stores from farmers located in that state (Clifford, 2010). In order to examine the potential for local syrup consumption on a statewide basis, table 1 presents two figures:

1. The per capita syrup consumption necessary to consume all of the syrup currently produced in a state locally, and

2. The syrup consumption levels necessary if a state tapped the same percentage of its trees as Vermont does.

There are states such as Illinois, Missouri, and New Jersey that have high populations and relatively few tappable maple trees. Sugarmakers in these states do not produce enough syrup to be counted by NASS, but if they tapped 2.94% of their trees (as Vermont does), the average person would only have to consume less than 2 oz. (59 ml) annually to exhaust the supply. Therefore, these states could aggressively grow their maple industries and market exclusively through local outlets without trying to compete in the greater marketplace. As evidence, researchers in Illinois have examined the economic feasibility of expanding syrup production in their state and found promising results (Buchheit, Carver, Zaczek, Crum, Mangun, Williard, & Preece, 2004). States with high populations and a slightly greater number of tappable trees, such as Indiana, Kentucky, Massachusetts, Ohio, Tennessee, and Virginia could also expand production aggressively. The per capita consumption levels necessary in these states range from 4.5 oz. (133.1 ml) to 6.6 oz. (195.2 ml) per person, which are certainly achievable levels, especially if any efforts are put into marketing local syrup to each state's citizens and businesses.

There are other states that have large populations and a much greater resource of tappable maple trees, such as Michigan, New York, Pennsylvania, and Wisconsin. If these states were to expand to the same levels as Vermont, the consumption levels needed to sell all the syrup locally would be much higher, between 14 oz. (414 ml) and 25 oz. (739 ml) per person. Since it would be more difficult to sell all of the additional syrup locally, producers in these states would have to sell some of their syrup in barrels to large packaging companies. Bulk prices are strongly tied to global supply and demand, which is out of the control of individual producers. Therefore these states may not be able to expand as aggressively if global demand does not keep pace with supply, and prices fall to unprofitable levels.

Finally, states such as Vermont and Maine already produce much more syrup than can realistically be consumed locally. The majority of their syrup is already sold in bulk to large bottling companies, whose success is highly dependent on the national and global markets for maple syrup. Whereas the local food movement will help some of these producers sell their syrup to nearby residents and visitors, the dominant outlets for most of the syrup produced will continue to be elsewhere. Thus, expansion in these states will likely be curtailed if production outpaces consumption and bulk syrup prices fall.

Under the hypothetical scenario in which each state taps the same percentage of its trees as Vermont currently does, the U.S. maple industry could grow from approximately USD81 million to over USD500 million annually. It is important to realize that only 24% of total U.S. residents live in the 11 major maple producing states, while 52% live in the 25 states that contain a significant number of sugar and red maple trees. Thus, roughly half of U.S. citizens will not have access to local syrup and must purchase it from other states or Canada. At current production levels, if U.S. residents only consumed maple syrup produced within the U.S., the average per capita consumption would be 0.7 oz. (20.7 ml), much less than the current figure of 2.6 oz. (76.9

ml). If the U.S. were to develop its maple industry in every state the way Vermont has, did not import any syrup from Canada nor export any throughout the world, the average consumption would have to increase to 5.1 oz. (150.8 ml) per person. Given that this figure is less than the per capita consumption in Quebec, it is not an unreasonable proposition. However, as previously stated, it is highly unlikely that any state could achieve the same levels of production as Vermont, let alone every state. Furthermore, barring any unforeseen and extraordinary political tensions or drastic fluctuations in the exchange rate with Canada, the U.S. will continue to import the majority of its syrup from Quebec. Thus, although the U.S. will likely increase its production and consumption of pure maple syrup, it will probably never achieve the levels as conjectured in table 1.

Scenario 2: What if Each State Produced All the Syrup its Residents Consume Locally

Whereas scenario 1 examines the increased consumption necessary for each state to tap the same percentage of its trees that Vermont does, scenario 2 assumes that per capita consumption levels will stay the same, yet all of the syrup will come from local sources. This scenario provides a more realistic target for many states to achieve. It calculates the number of taps necessary, the corresponding utilization rate, and economic impact for each state to provide 2.6 oz. (76.9 ml) of maple syrup to each of its residents (see Table 2). The same assumptions on production per tap and price per gallon of syrup are used for this analysis.

Vermont and Maine would only need 45,996 and 123,962 taps, respectively, to supply all of their citizens with 2.6 oz. (76.9 ml) of syrup. Since there are many large producers and such low populations in these states, most of the syrup in Vermont and Maine is sold in bulk to large bottling companies and shipped out of state. Thus, the average price per gallon received by producers is the lowest in Vermont and Maine, at USD34.57 and USD33.27, respectively. New Hampshire, New York, and Wisconsin are the only other states that currently have more taps than needed to provide their residents with 2.6 oz. (76.9 ml) of syrup each year.

On the opposite end of the spectrum, there are states with large populations and a limited maple resource that would have a difficult time trying to provide each of their residents with 2.6 oz. (76.9 ml) of syrup. The necessary utilization rates in New Jersey and Missouri at 6.1% and Illinois at 11.9% are beyond the levels that could reasonably be expected to be achieved. Thus these states must continue to rely on imported syrup to meet consumer demand. Individual producers in these states would have a difficult time just supplying their own customer base with syrup and therefore would have to purchase bulk syrup from other states in order to meet local market demand. This strategy is already practiced throughout the maple industry, creating better synergy between the large sugarmakers who are focused on production and the smaller sugarmakers who concentrate on the marketing of finished products.

There are several states that could easily develop their maple industries further by supplying the local markets for pure maple products. Connecticut, Massachusetts, Michigan, Ohio, and Pennsylvania all have existing maple industries and the infrastructure in place to spur additional development. With existing utilization rates ranging between 0.15% and 0.45%, these states would only need to tap at most 1.2% of their trees to supply 2.6 oz. (76. 9 ml) of local syrup to their residents. Particularly desirable places for expansion are states such as Connecticut that have an affluent population with a strong desire to purchase local food. Expanding production in these regions is one of the best ways to assure profitability for producers. As evidence, producers in Connecticut sell most of their syrup retail and therefore command the highest average price of any state at USD59.23/gallon.

New York has the greatest number of potential taps, the largest population of any maple-producing state, and an extensive educational infrastructure already in place to enhance development. The industry has been growing in recent years and is poised for further expansion. Its utilization rate of 0.62% just barely allows the state to supply all residents with 2.6 oz. (76.9 ml) of syrup. However, previous studies have found that most of the syrup consumed in New York is purchased at grocery stores and comes from out of state (for example, see Chamberlin, 2008). New York is also a net importer of bulk maple syrup, as more bulk syrup is bought in and repackaged by individual producers than is sold out of state (Farrell & Stedman, 2009). Thus, per capita consumption in New York is already well above 2.6 oz. (76.9 ml) per person, but much more research is needed to determine the actual figure. New York state government officials have recognized the opportunity to increase maple production and have made several investments to help expand the industry, including creating a Maple Task Force in 2009 to explore the ways in which the state can assist in developing the maple industry (Wanamaker, 2009).

Generally speaking, most states would only have to tap a small percentage of their trees in order to supply their residents with local maple syrup. Eight states would have rates below 1% and another 8 states would have rates between 1% and 2%. Although these are feasible goals, it will be more difficult to establish maple production in regions that do not currently have a significant maple industry. For instance, although states such as Kentucky, Virginia, and West Virginia have a robust maple resource and some syrup producers already exist, the educational and cultural infrastructure simply does not exist to adequately develop the maple industry at this time. Since the climate is also much warmer in these states than in the traditional producing regions, there will be skeptics who believe that syrup production is only supposed to occur in northern states. Much more research is necessary to determine what yields one could expect utilizing various sap collection technologies along the southern and western edges of red and sugar maples' ranges. If some producers adopt the latest technologies and are able to achieve economic yields of at least 32 oz. (946 ml) of syrup per tap, these success stories could entice others to get started.

As a nation, the U.S. only taps 0.39% of all sugar and red maples growing in the eastern half of the country. In order to supply the average citizen with 2.6 oz. (76.9 ml) of "locally produced" U.S. syrup, it would have to add roughly 23 million taps, thereby increasing the utilization rate to 1.52%. The economic impact of doing so would be USD167 million, increasing the size of the maple industry from USD81 million to USD 248 million. However, to facilitate this growth, the U.S. would have to either stop importing syrup from Canada and/or increase average syrup consumption. It is highly unlikely that Americans will stop buying Canadian syrup, especially if it is relatively inexpensive and readily available in grocery stores. Thus, in order to increase consumption of locally produced maple syrup, U.S. producers should invest in strategic marketing campaigns that capitalize on the increasing interest in local, healthy food.

Limitations and Drawbacks of These Analyses

It is important to understand the limitations of these analyses and why both are unrealistic scenarios. For the first question, it is highly unlikely that any state will build its maple industry to the same status that Vermont has. Maple production is strongly tied to cultural heritage and Vermont has made a dedicated effort over the last century to build its reputation and brand itself as "the place for maple" in the U.S. So while Vermont presents an upper limit for what is possible to achieve in other states, it is highly unlikely that any other state will ever tap the same percentage of its trees as Vermont does.

It is also impractical to assume that the maple syrup produced within a state’s borders is the only maple syrup residents of that state will consume. Since most people buy their food at grocery stores and it is difficult for small, local producers to gain access to these markets, many residents will continue to buy imported syrup. Thus, the average syrup consumption in each state must be higher than the national average of 2.6 oz. (76.9 ml) per person in order to account for the additional syrup coming from out of state. On the other hand, not all the syrup that sugarmakers produce is sold to residents of their state. Many producers have extensive mail-order businesses, sell directly to tourists, or sell to restaurants and gift shops that cater to out-of-state tourists. Furthermore, the commercial-grade syrup that is produced at the end of the season is almost always sold to large bottling and distribution companies in Vermont and New Hampshire. Since a portion of the syrup produced in any state would be sold and consumed elsewhere, the per capita consumption among residents of that state could be lowered. Without knowing the magnitude of these variables, it is not possible to know the effect on necessary per capita consumption levels.

Furthermore, having a target consumption level of only 2.6 oz. (76.9 ml) per person is likely to underestimate the actual syrup consumption levels in states that produce maple syrup. Many producers are happy to share their products with friends, family members, and neighbors at a reduced price or free of charge, so naturally these people consume more syrup than they otherwise would. Even for people with no relation to a sugarmaker, there is still a more readily accessible supply of pure maple. The prevalence of maple products being sold through sugarhouses, roadside stands, farmers’ markets, community supported agriculture operations (CSAs), producer-operated pancake houses, and other venues for local food tends to increase the average per capita consumption of pure maple in regions where it is produced.

In fact, historical research by the U.S. Forest Service found that only 1.9% of households outside the maple-producing region had purchased pure maple syrup over a 12-month time frame versus 11.2% of households within maple producing states (Sendak, 1978). Therefore, the 2.6 oz. (76.9 ml) per person average consumption likely presents a minimum level that each producing state could easily achieve by supplying syrup from its own trees. Perhaps a more realistic estimate of syrup consumption in maple-producing states is 6 oz. (177 ml) per person, the level currently achieved in Quebec (Agriculture and Agri-Food Canada, 2006). However, since many residents will continue to purchase syrup from grocery stores that has been imported from outside the state or country, a 2.6 oz. (76.9 ml) per capita consumption of maple syrup produced within a state's borders may be a realistic target for many states.

It is also important to consider the impact of yield per tap in conducting these analyses. The volume of syrup produced varies greatly from year to year, depending primarily upon the weather patterns and sap collection technologies that are used. New vacuum tubing systems can result in yields as high as 0.5 gallons of syrup per tap (64 oz. or 1,893 ml), whereas traditional bucket systems may only yield 0.1 gallons per tap (12.8 oz. or 379 ml). It is possible that average yields per tap could increase as more producers adapt the latest technologies with vacuum tubing. If this were to happen, either fewer taps would be needed to produce the same amount of syrup, or consumption would have to rise in order to keep pace with the additional syrup output.

Finally, the economic impact figures presented here only account for the farm-gate syrup sales of individual producers. They do not include the economic activities of bottling companies who purchase bulk syrup, package it into retail-size containers, and market it throughout the U.S. and beyond. Nor do they factor in the economic impacts of building sugarhouses and manufacturing and selling all the equipment necessary to produce maple syrup. Given all the additional economic activity that is involved with maple production, the economic impact figures provided in these tables grossly underestimate the true impact of expanding the maple industry. Determining the full economic impact of syrup production would require significant additional research and is outside the scope of this paper.

Conclusion: Marketing Efforts Must Keep Pace with Production

The fate of the global economy, coupled with the marketing efforts of the maple industry, will have a strong influence on the overall production and consumption of pure maple syrup. Production has spiked in recent years and is likely to continue to grow, so the maple industry will have to be more aggressive in its marketing and promotion efforts in order to keep demand in line with supply and prices stable. Per capita consumption of pure maple syrup in the U.S. is currently very low, so there is tremendous room for expansion, especially in the growing niche markets for local and healthy foods. The average American consumes about 2.6 ounces (76.9 ml) of syrup in one pancake breakfast, so clearly there is room for growth. One of the keys will be educating consumers about the differences between pure maple syrup its artificial and less sustainable competitors and convincing them that pure maple syrup is worth the extra cost.

Maple syrup is produced commercially only in the eastern U.S. and Canada, yet there is a growing worldwide demand for pure maple products, especially once people are exposed to them. Marketing efforts have been extremely successful in other countries, as Canadian exports to Japan rose by 252% between 2000 and 2005 once the Federation of Maple Producers in Quebec initiated a marketing campaign there (Agriculture and Agri-Food Canada, 2006). Markets have also been growing steadily in western Europe, as Canadian exports to Denmark and Switzerland each grew by more than 100% over the same time period. Even in the U.S., where most people should already know about pure maple syrup, marketing efforts often lead to dramatic increases in sales. For instance, the New York State Maple Producers Association initiated Maple Weekend, a statewide event where sugarmakers open their doors during the last two weekends in March every year. This event has grown steadily since it began in the 1990s and now accounts for over USD750,000 in sales among the over 100 participating producers during a four-day period (H. Thomas, personal communication, January 21, 2011). Vermont, Maine, Pennsylvania, and others have since adopted similar campaigns for their states. Despite these successes, only a small fraction of maple producers in the U.S. currently participate in this type of event.

If the maple industry continues to expand and supply outpaces demand, it should not be viewed as an overproduction problem, but rather an undermarketing problem. There is overwhelming evidence that investments in marketing pay off in terms of increased consumption of pure maple products. Per capita consumption has nearly tripled in the U.S. over the past 35 years, yet it is still quite low at less than 3 oz. (89 ml) per person, so more efforts should be put into marketing pure maple syrup as the local, healthy sugar in the regions where it is produced. Moreover, since maple syrup is only produced in eastern North America and yet has a growing worldwide demand, there is a tremendous opportunity to supply this high-value crop to international markets. It is up to the entire maple industry to work together — as they have in Quebec (Gagné, 2008), New York, Vermont, and elsewhere — to move the industry forward in a positive direction. In particular, further consumer research is necessary to determine the current and potential demand for maple syrup on a state-level basis throughout the U.S. Increasing both production and marketing efforts will provide more people locally and throughout the world with pure maple products while maintaining profitable prices for producers.

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Table 1.1 The economic impact of increasing syrup production levels to those achieved in Vermont (all prices in USD).

	Population (2010 Census Data)	Number of Potential Taps[1]	Number of Actual Taps[2]	Number of Taps When Achieving Vermont's Utilization Rate[3]	Syrup Production Efficiency (oz/tap)[4]	Local per-Capita Consumption at current utilization rates (oz./person)	Local per-capita consumption at Vermont utilization rates (oz./person)	Average Price per Gallon[5]	Current Value of Syrup Production	Potential Value of Syrup Production at Vermont's Utilization Rates	Economic Impact of Increasing Syrup Production to Vermont's Level
Arkansas	2,915,918	8,293,520	–	243,745	22.4	0.0	1.9	$37.80	–	$1,612,373	$1,612,373
Connecticut	3,574,097	32,702,898	75,000	961,132	23.7	0.5	6.4	$59.23	$823,343	$10,551,221	$9,727,878
Georgia	9,687,653	38,954,859	–	1,144,876	22.4	0.0	2.6	$37.80	–	$7,573,354	$7,573,354
Illinois	12,830,632	12,527,570	–	368,183	22.4	0.0	0.6	$37.80	–	$2,435,530	$2,435,530
Indiana	6,483,802	43,971,137	–	1,292,303	22.4	0.0	4.5	$37.80	–	$8,548,587	$8,548,587
Kentucky	4,339,367	75,286,754	–	2,212,663	22.4	0.0	11.4	$37.80	–	$14,636,768	$14,636,768
Maine	1,328,361	148,404,616	1,430,000	4,361,583	27.9	30.0	91.5	$33.27	$10,354,694	$31,582,419	$21,227,726
Maryland	5,773,552	24,643,818	–	724,277	22.4	0.0	2.8	$37.80	–	$4,791,093	$4,791,093
Massachusetts	6,547,629	55,928,669	250,000	1,643,733	24.6	0.9	6.2	$48.73	$2,339,200	$15,380,080	$13,040,880
Michigan	9,883,640	277,960,651	490,000	8,169,211	29.1	1.4	24.1	$42.53	$4,737,930	$78,990,094	$74,252,164
Minnesota	5,303,925	39,181,626	–	1,151,541	22.4	0.0	4.9	$37.80	–	$7,617,440	$7,617,440
Missouri	5,988,927	11,322,763	–	332,774	22.4	0.0	1.2	$37.80	–	$2,201,299	$2,201,299
New Hampshire	1,316,470	77,720,574	420,000	2,284,193	29.5	9.4	51.2	$50.40	$4,882,752	$26,555,112	$21,672,360
New Jersey	8,791,894	16,806,386	–	493,936	22.4	0.0	1.3	$37.80	–	$3,267,390	$3,267,390
New York	19,378,102	305,685,731	1,903,000	8,984,045	26.9	2.6	12.5	$38.83	$15,543,598	$73,381,184	$57,837,585
North Carolina	9,535,483	84,977,529	–	2,497,473	22.4	0.0	5.9	$37.80	–	$16,520,786	$16,520,786
Ohio	11,536,504	87,616,491	385,000	2,575,032	29.7	1.0	6.6	$39.07	$3,484,421	$23,305,184	$19,820,763
Pennsylvania	12,702,379	278,622,099	465,000	8,188,650	22.4	0.8	14.4	$36.00	$2,929,500	$51,588,498	$48,658,998
Rhode Island	1,052,567	6,019,295	–	176,906	22.4	0.0	3.8	$37.80	–	$1,170,233	$1,170,233
Tennessee	6,346,105	65,814,848	–	1,934,286	22.4	0.0	6.8	$37.80	–	$12,795,301	$12,795,301
Vermont	625,741	108,881,278	3,200,000	3,200,000	35.4	180.9	180.9	$34.57	$30,566,151	$30,566,151	–
Virginia	8,001,024	71,216,930	–	2,093,052	22.4	0.0	5.9	$37.80	–	$13,845,539	$13,845,539
West Virginia	1,852,994	125,961,220	–	3,701,976	22.4	0.0	44.8	$37.80	–	$24,488,573	$24,488,573
Wisconsin	5,686,986	154,493,465	650,000	4,540,533	30.8	3.5	24.6	$37.17	$5,806,053	$40,557,811	$34,751,758
United States	308,745,538	2,152,994,723	9,268,000	63,276,105	24.7	0.7	5.1	$39.54	$81,467,642	$503,962,019	$422,494,377

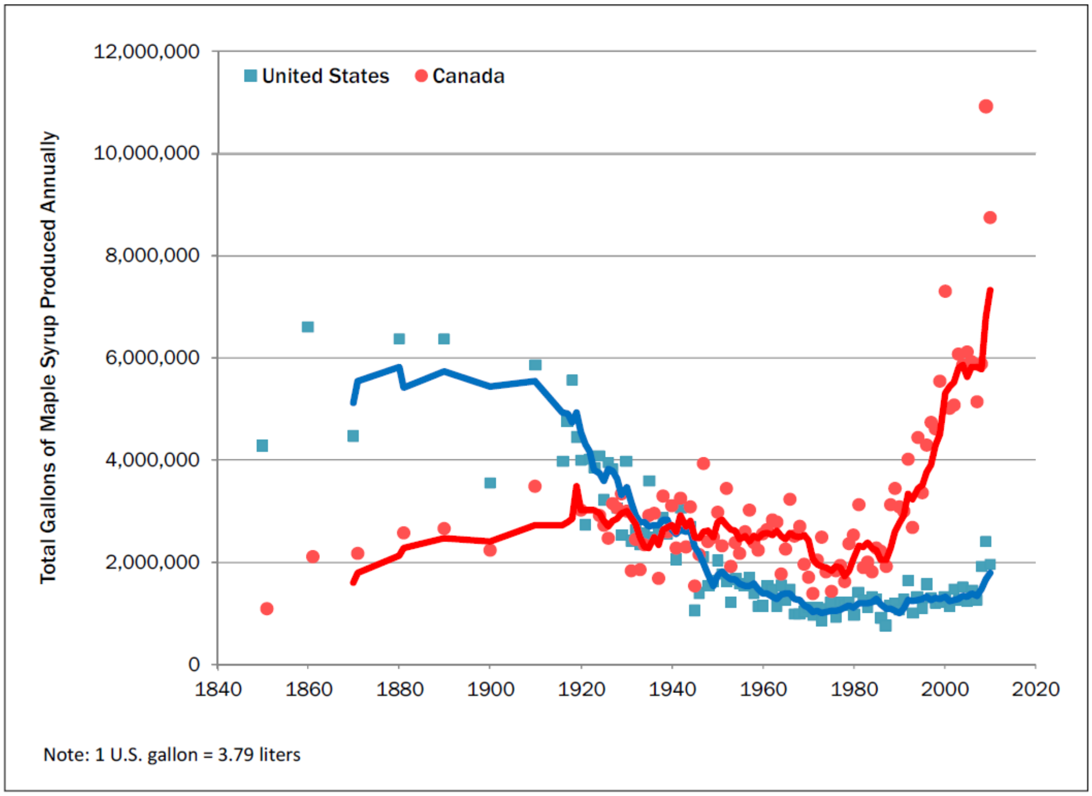
[1] These are calculated only for nonreserved forestlands, i.e., those that are NOT legally prohibited from timber harvesting or management.
[2] Based on USDA NASS 2010 Maple Syrup Crop Report.
[3] These figures are calculated by multiplying the number of potential taps by 2.94%, the utilization rate achieved in Vermont.
[4] Based on the average production per tap for each state for 2007–2009 as seen in the 2010 NASS Maple Syrup Crop Report.
[5] Based on the average price received for all retail, wholesale, and bulk syrup sales for each state for 2007–2009 as seen in the 2010 NASS Maple Syrup Crop Report.

Table 1.2 The economic impact of producing all of the maple syrup consumed in a state locally (all prices in USD).

	Population (2010 Census Data)	Number of Potential Taps	Number of Actual Taps	Number of Taps Necessary To Provide 2.6 oz/ Resident of Each State[1]	Current Utilization Rate[2]	Utilization Rate Necessary to provide 2.6 oz/resident of each state[3]	Syrup Production Efficiency (oz/tap)	Average Price per Gallon	Current Value of Syrup Production	Potential Value of Syrup Production to Supply 2.6 oz for Each State Resident	Economic Impact of Supplying 2.6 oz/Resident for Each State
Arkansas	2,915,918	8,293,520	–	338,455	–	4.08%	22.4	$37.80	–	$2,238,878	$2,238,878
Connecticut	3,574,097	32,702,898	75,000	391,720	0.23%	1.20	23.7	$59.23	$823,343	$4,300,272	$3,476,928
Georgia	9,687,653	38,954,859	–	1,124,460	–	2.89	22.4	$37.80	–	$7,438,301	$7,438,301
Illinois	12,830,632	12,527,570	–	1,489,270	–	11.89	22.4	$37.80	–	$9,851,520	$9,851,520
Indiana	6,483,802	43,971,137	–	752,584	–	1.71	22.4	$37.80	–	$4,978,344	$4,978,344
Kentucky	4,339,367	75,286,754	–	503,677	–	0.67	22.4	$37.80	–	$3,331,820	$3,331,820
Maine	1,328,361	148,404,616	1,430,000	123,962	0.96%	0.08	27.9	$33.27	$10,354,694	$897,612	$(9,457,081)
Maryland	5,773,552	24,643,818	–	670,144	–	2.72	22.4	$37.80	–	$4,433,005	$4,433,005
Massachusetts	6,547,629	55,928,669	250,000	692,702	0.45%	1.24	24.6	$48.73	$2,339,200	$6,481,471	$4,142,271
Michigan	9,883,640	277,960,651	490,000	883,115	0.18%	0.32	29.1	$42.53	$4,737,930	$8,539,053	$3,801,123
Minnesota	5,303,925	39,181,626	–	615,634	–	1.57	22.4	$37.80	–	$4,072,420	$4,072,420
Missouri	5,988,927	11,322,763	–	695,143	–	6.14	22.4	$37.80	–	$4,598,373	$4,598,373
New Hampshire	1,316,470	77,720,574	420,000	115,928	0.54%	0.15	29.5	$50.40	$4,882,752	$1,347,736	$(3,535,016)
New Jersey	8,791,894	16,806,386	–	1,020,488	–	6.07	22.4	$37.80	–	$6,750,526	$6,750,526
New York	19,378,102	305,685,731	1,903,000	1,871,400	0.62%	0.61	26.9	$38.83	$15,543,598	$15,285,487	$(258,111)
North Carolina	9,535,483	84,977,529	–	1,106,797	–	1.30	22.4	$37.80	–	$7,321,463	$7,321,463
Ohio	11,536,504	87,616,491	385,000	1,011,519	0.44%	1.15	29.7	$39.07	$3,484,421	$9,154,697	$5,670,276
Pennsylvania	12,702,379	278,622,099	465,000	1,474,383	0.17%	0.53	22.4	$36.00	$2,929,500	$9,288,615	$6,359,115
Rhode Island	1,052,567	6,019,295	–	122,173	–	2.03	22.4	$37.80	–	$808,174	$808,174
Tennessee	6,346,105	65,814,848	–	736,601	–	1.12	22.4	$37.80	–	$4,872,619	$4,872,619
Vermont	625,741	108,881,278	3,200,000	45,996	2.94%	0.04	35.4	$34.57	$30,566,151	$439,355	$(30,126,796)
Virginia	8,001,024	71,216,930	–	928,690	–	1.30	22.4	$37.80	–	$6,143,286	$6,143,286
West Virginia	1,852,994	125,961,220	–	215,080	–	0.17	22.4	$37.80	–	$1,422,752	$1,422,752
Wisconsin	5,686,986	154,493,465	650,000	480,653	0.42%	0.31	30.8	$37.17	$5,806,053	$4,293,378	$(1,512,675)
United States	308,745,538	2,152,994,723	9,268,000	32,460,105	0.43%	1.52	24.7	$39.54	$81,467,642	$247,981,361	$166,513,719

[1] This is determined by first multiplying the population by 2.3 (oz) to determine the total syrup consumption and then dividing this figure by the average production per tap for that state.
[2] These figures are determined by dividing the number of taps reported for each state in the 2010 NASS Maple Syrup Crop Report by the number of potential taps based on the FIA data.
[3] These figures are determined by dividing the column "Number of Taps Needed to Supply 2.3 oz per Resident" by the column "Number of Potential Taps."

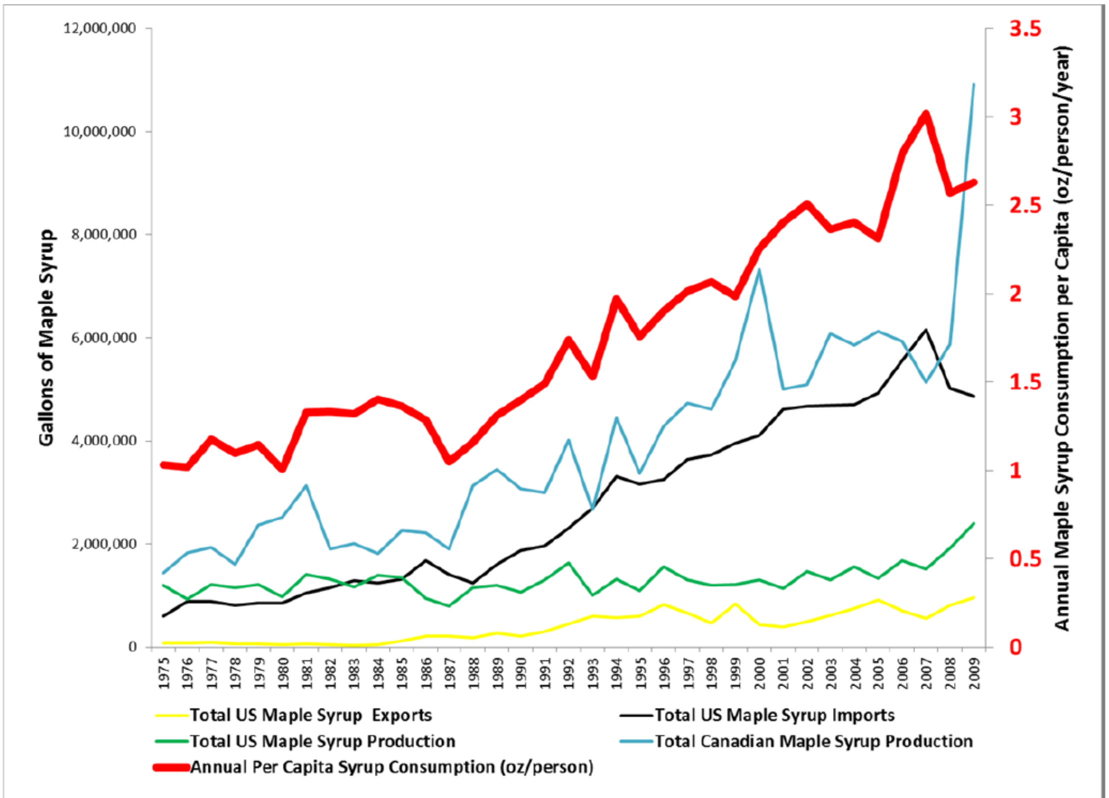
Figure 1.1 Maple Syrup Production in the United States & Canada 1860-2010



Sources: Statistics Canada. (2011, Dec. 14). Table 001-0008 – Production and farm value of maple products, annual (table). CANSIM (database) . Retrieved from http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=0010008&pattern=maple&tabMode=dataTable&srchLan=-1&p1=1&p2=-1

U.S. Department of Agriculture, Economic Research Service. (2011, June 10). *Table 43–U.S. maple syrup production, imports, exports, and prices, by calendar year* [Excel spreadsheet]. Retrieved from http://www.ers.usda.gov/briefing/sugar/data/table43.xls

Figure 1.2 Maple syrup production, imports, and exports in the United States and Canada, and per capita annual maple syrup consumption in the U.S., 1975-2009

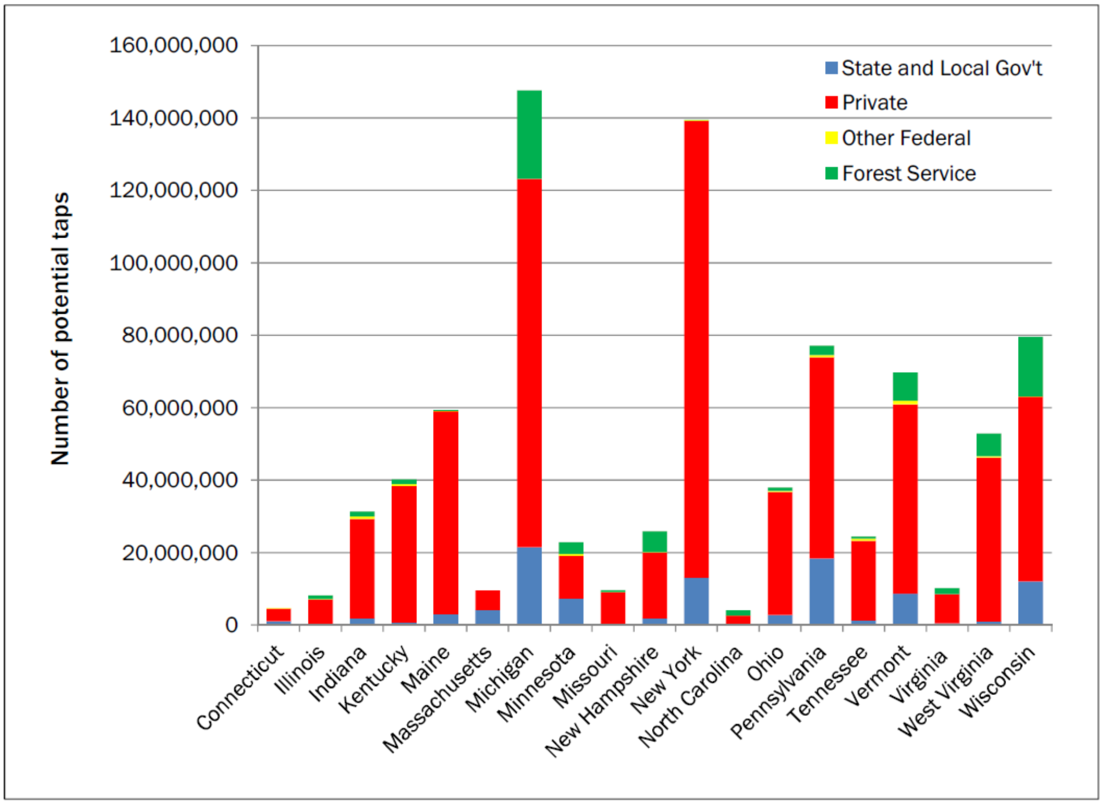


Sources: Statistics Canada. (2011, Dec. 14). Table 001-0008 – Production and farm value of maple products, annual (table). CANSIM (database) . Retrieved from http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=0010008&pattern=maple&tabMode=dataTable&srchLan=-1&p1=1&p2=-1

U.S. Department of Agriculture, Economic Research Service. (2011, June 10). *Table 43—U.S. maple syrup production, imports, exports, and prices, by calendar year* [Excel spreadsheet]. Retrieved from http://www.ers.usda.gov/briefing/sugar/data/table43.xls

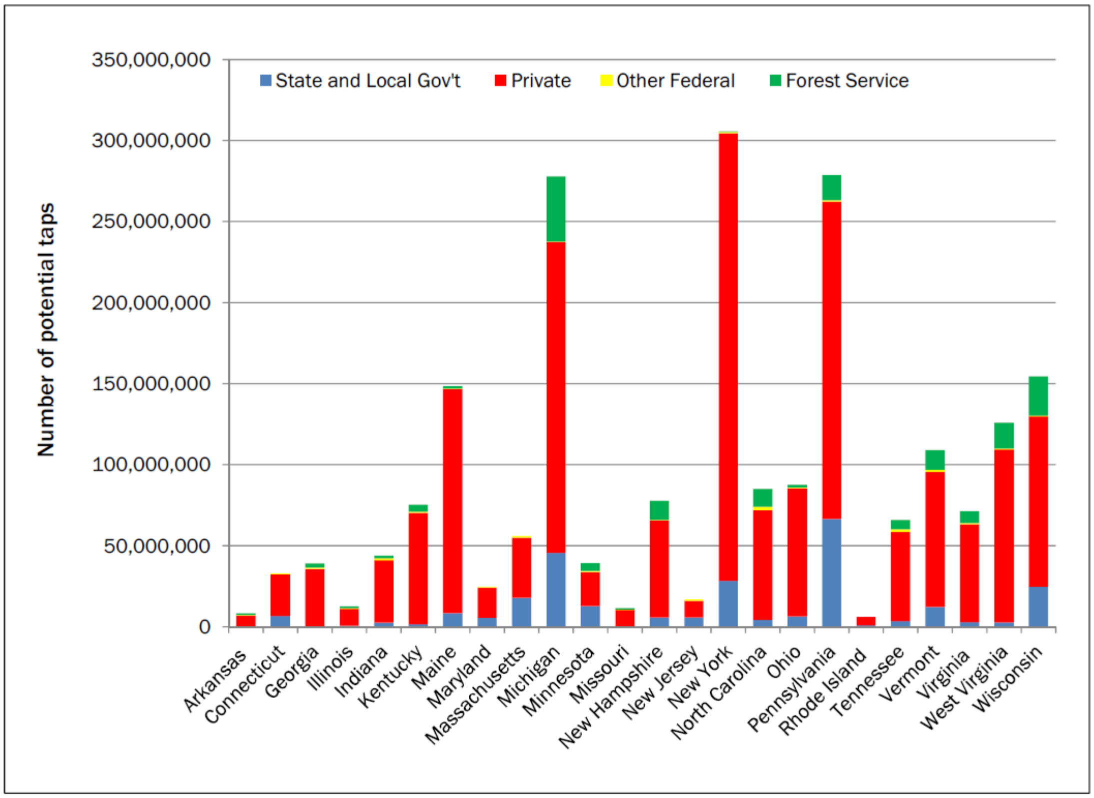
U.S. Census Bureau. (2011, Dec. 21). *Population estimates: State totals: Vintage 2011*. Retrieved from http://www.census.gov/popest/data/state/totals/2011/index.html

Figure 1.3 Number of potential sugar maple taps for 19 states by ownership status, 2010.



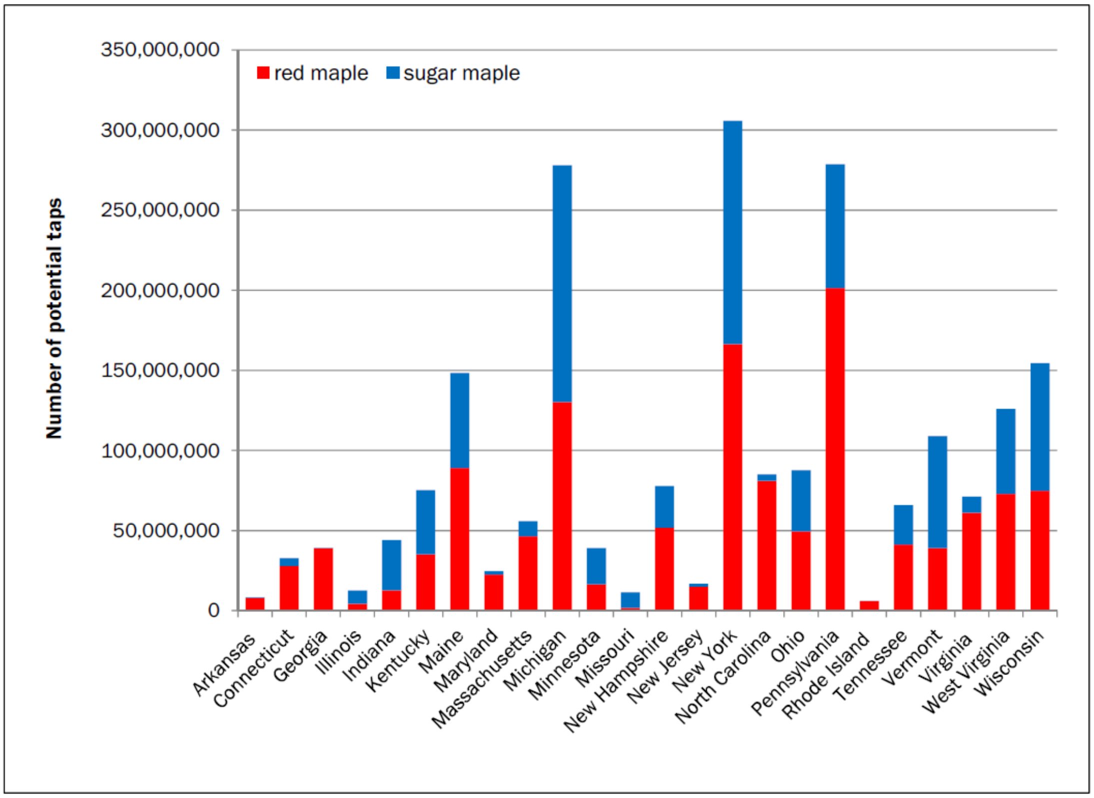
Source: U.S. Department of Agriculture, Forest Service. (2010)..

Figure 1.4 Number of potential red maple taps for 19 states by ownership status, 2010.



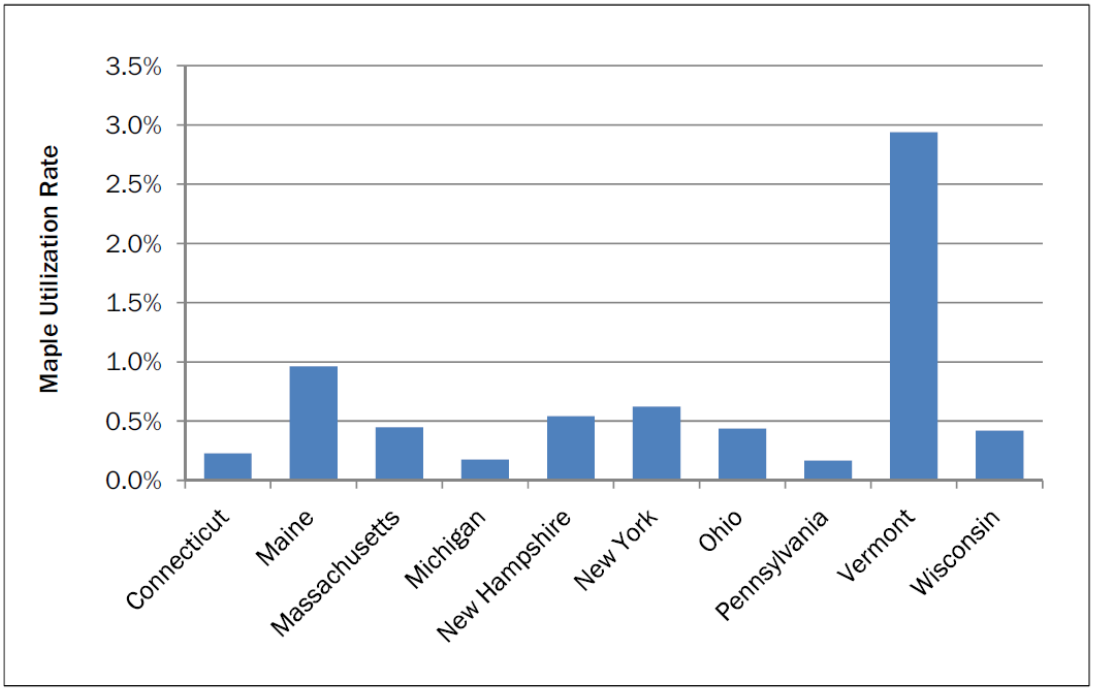
Source: U.S. Department of Agriculture, Forest Service. (2010).

Figure 1.5 Number of potential sugar and red maple taps for 24 states, 2010.



Source: U.S. Department of Agriculture, Forest Service. (2010).

Figure 1.6 Utilization of the maple resource for syrup production, 2011.



Note: Results based on NASS Maple Syrup Crop Report (2010) and U.S. Foresty Service FIA data (2010) on the number of tappable sugar and red maple trees.

Chapter 2: Estimating the maple syrup production potential of American forests: An enhanced estimate that accounts for density and accessibility of tappable maple trees[2]

Abstract

This paper examines the maple syrup production potential of American forests by analyzing Forest Inventory & Analysis (FIA) data provided by the U.S. Forest Service on the resource of sugar maple (*Acer saccharum*) and red maple (*Acer rubrum*) trees in twenty states. The analysis is based on tree species and size (diameter at breast height, or dbh), ownership category, jurisdiction, the density of maple trees in a stand, and the distance of the stand to an access road. Although there are over 2 billion sugar and red maple trees of tappable size growing in U.S. forests, when narrowed down according to the attributes of an optimal 'sugarbush', there are 100 million potential taps from sugar maples alone and 286 million potential taps with sugar and red maples combined. Overall, 45% of the tappable-size maple trees are found in stands whose density is not high enough to support commercial sap extraction whereas only 6% are found in stands that are at least 1.6 km from an access road. The ten states with commercial maple syrup industries have a much higher percentage of their maple trees occurring in stands of optimal density and also contain a higher percentage of sugar maple than red maple trees. States that are utilizing the highest percentage of their potential sugarbushes include Vermont and Maine, whereas states that have significant room for expansion include Michigan, New York, and Pennsylvania.

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[2] This paper has been published in Agroforestry Systems with the advanced online citation as: Farrell, M. 2012. Estimating the maple syrup production potential of American forests: An enhanced estimate that accounts for density and accessibility of tappable maple trees. *Agroforestry Syst 86(3)* DOI 10.1007/s10457-012-9584-7

Introduction

Maple sugaring is one of the oldest agroforestry practices in eastern North America. Native Americans had been gathering sweet sap from maple trees and boiling it down into granulated sugar for centuries before Europeans arrived (Nearing and Nearing 2000). The settlers were able to incorporate new equipment and technologies to improve the process, and by the mid-1800s maple syrup and sugar production peaked in the U.S. (U.S. Census 1860, Whitney and Upmeyer 2004). Although it is seldom mentioned in discussions of forest farming, tapping sugar maple (*Acer saccharum* Marsh.) and red maple (*Acer rubrum* L.) trees to harvest sap is the largest industry involved in producing food from deciduous forests. There are more than 100 species of maple occurring in temperate regions throughout the world, yet Canada and the United States are the only two countries that produce maple syrup on a commercial scale.

As seen in Figure 1, the production of maple syrup in the United States has approximately doubled over the past decade while Canadian output has been climbing at an even faster rate over the past 35 years (Statistics Canada 2011, USDA 2011). Although there are year-to-year variations in output based upon weather conditions, the increasing trend results from more trees being tapped, greater use of vacuum-assisted tubing systems, and the recent adoption of improved spout and tubing technologies that boost yields per taphole. Prices for maple syrup spiked in 2008 and have remained relatively high by historical standards over the past several years, thereby creating additional incentive for market expansion (Dravis 2008).

Although maple trees can be planted in agroforestry systems for future sap collection efforts, the immediate production capacity is based upon the resource of tappable trees that currently exist.

Thus, to determine the growth potential of the maple industry in North America, it is essential to quantify the number of tappable maple trees in various states and provinces. Canada does not have a national forest inventory system comparable to that of the U.S., so an assessment of the tapping potential for all of Canada is not possible. However, a report by the Ministry of Natural Resources in Quebec (where the vast majority of production occurs) estimated that there are a total of 110 million potential taps within the province (MRN-MAPAQ Rapport 2000). This estimate is based on forest inventory data that defines a sugarbush as:

"A grouping of leafy hardwood plants of at least eight hectares, with at least 60% of the surface area composed of maple, of which the actual number of potential tap holes per hectare is greater than or equal to one hundred and fifty. It should be noted that biophysical and socio-economic criteria could eventually narrow this definition (accessibility, area, aspect, etc.)"

Previous efforts to quantify the U.S. tapping potential have fallen short of providing realistic estimates. The first attempt was part of a Ph.D. thesis at Penn State in the 1960s (Taylor 1965). It was not an in-depth analysis, but did provide a general outline of the syrup production potential during that time period. More recently, Collins (2001) utilized U.S. Forest Service Forest Inventory & Analysis (FIA) data to estimate the syrup production potential for 12 states, but there were several shortcomings in this analysis. Most notably, it failed to include any data for red maples, public lands or corporate-owned private lands. The tapping guidelines were a bit more aggressive than the currently accepted "conservative tapping guidelines" (Heiligmann et al. 2006), as this paper assumed 3 taps for trees 53 cm and larger, whereas conservative tapping guidelines recommend only 2 taps for trees larger than 46 cm. Collins (2001) estimated a total of 260 million potential taps for 12 states utilizing the FIA data that existed in 2000. A decade later, I calculated a total of 550 million potential taps from sugar maples on private land for the same 12 states, using the same basic methodology (Farrell 2009). Part of this difference is that Collins (2001) omitted corporate ownership whereas I included all privately owned land. My analysis also used more recent data, so there was some ingrowth of smaller trees into tappable sizes between survey intervals in the FIA program. However, these two factors alone cannot account for the large discrepancy in the two estimates. Thus, more investigation is necessary to develop a reliable estimate of the maple syrup production capacity in the U.S.

To be fair, both of the previous analyses by Farrell (2009) and Collins (2001) overestimated the realistic tapping potential for several reasons. In order to economically tap maple trees, they must be growing in a stand of sufficient density to install a tubing or trail system to collect the sap. Furthermore, the stand of trees must be located close enough to a road to gain access. Some maples occur in stands that have a low density of tappable trees, are too far from an access road, or are otherwise inaccessible. Other topographic features that can affect accessibility include slope, aspect, drainage, or waterways. However, these features are not nearly as important and would be difficult to model with the FIA data. In reality, the density of maple trees in a stand and the proximity of that stand to a road are the major factors influencing whether or not trees can be economically tapped, so this paper focuses on incorporating these two features into an enhanced estimate of the tapping potential in U.S. forests.

Methods

The U.S. Forest Service Forest Inventory & Analysis (FIA) Program has provided a comprehensive database of the distribution and abundance of tree species and forest composition in the United States since the 1950s. The protocols and methods for conducting forest inventories have been modified in the past decade, making the data set even more robust and timely (Bechtold and Patterson 2005). Field crews measure the same permanent fixed radius plots on a periodic basis to assess the growth and health of forests throughout the U.S. Each plot has been randomly chosen within a 2,430 hectare grid pattern spanning the entire country. The plots are concealed to the greatest extent possible in order to prevent tampering and provide an unbiased assessment of the forest resources. An entire division of the U.S. Forest Service is dedicated towards collecting and analyzing these data on a periodic basis.

With the assistance of Charles Barnett and Richard McCullough from the U.S. Forest Service, we utilized the latest FIA data as of October 2011 to determine the tapping potential for twenty states that contain a sizeable maple resource, defined here as at least ten million sugar and/or red maple trees of tappable size. Only non-reserved forestlands were used for this analysis, as the reserved forestlands that are legally restricted from timber harvesting are also likely to be prohibited from tapping. The number of potential taps for each state is based on "conservative tapping guidelines" that suggest 1 tap for trees 25-45 cm (10-17.9") dbh and 2 taps for trees 46cm (18") dbh and larger (Heiligmann et al. 2006), as seen in the following formula:

Number of potential taps =

$$\sum \text{\# of live trees 25-45 cm dbh} + \left(\sum \text{\# of live trees} \geq \text{46 cm dbh} * 2 \right)$$

Note that these tapping guidelines are more conservative than those used to estimate the number of potential taps in Quebec; their guidelines include 1 tap for trees 20-39 cm (8-15.9") dbh, 2 taps for trees 40-59 cm (16-23.9") dbh, and 3 taps for trees 60 cm (24") dbh and greater.

Whereas my previous efforts (Farrell 2009) included all live trees growing on U.S. forestland, this revised analysis is based on an algorithm that determines the total number of tappable maple trees according to two additional key variables:

(1) the density of maple trees in a stand
(2) the distance from the plot center to the nearest access road

To account for density measurements, we developed four categories of sugarbushes based on the number of potential taps per acre:

(1) <74 taps/hectare (<30 taps/acre): not commercially feasible to collect sap from
(2) 74-146 taps/hectare (30-59 taps/acre): acceptable sugarbush but not optimal
(3) 147-220 taps/hectare (60-89 taps/hectare): excellent sugarbush potential
(4) 221+ taps/hectare (90+ taps/acre): an ideal sugarbush that is likely overstocked and would benefit from thinning

When conducting an inventory, the FIA field crew determines the distance from the plot center to the nearest improved road, which is defined as "a road of any width that is maintained as evidenced by pavement, gravel, grading, ditching, and/or other improvements". We grouped the 'distance to road' figures for each plot into four categories:

(1) ≤ 91 meters (≤ 300 ft)
(2) 92 meters – 0.8 km (301ft- ½ mile)
(3) 0.8 km-1.6 km (½ mile- 1 mile)
(4) >1.6 km (> 1 mile)

Although any maple tree can be tapped for syrup production, we only completed the analyses for sugar maple and red maple, as these are the two most commonly tapped trees in eastern North America. Many sugarmakers will tap red maples as long as they are readily available and accessible. Although their sugar content is a bit lower and they tend to bud out earlier in the spring, red maples are certainly capable of producing quality maple syrup (Wilmot 2011). However, some producers will only tap sugar maples, so one must also examine the two species individually.   Given this reality, all of our analyses were conducted in two ways:

(1) sugar and red maples were examined as distinct, independent species of differing value for tapping

(2) sugar and red maples were considered together, as if they were of equal value for tapping

Based on differing levels of density, distance to road, and species, we created the following categories of potential sugarbushes:

(1) Optimal sugarbushes that contain at least 147 taps/hectare of sugar maples on private land within 0.8 km of an access road
(2) Optimal sugarbushes that contain at least 147 taps/hectare of sugar and red maples on private land within 0.8 km meters of an access road
(3) Feasible sugarbushes that contain at least 74 taps/hectare of sugar maples on private land within 1.6 km of an access road
(4) Feasible sugarbushes that contain at least 74 taps/hectare of sugar and red maples on private land within 1.6 km meters of an access road

The number of potential taps should be greater for each successive category as the restrictions on species, density, and accessibility are loosened. Category 1 would be considered ideal for tapping since it contains a dense stand of sugar maples located close to an access road. Category 2 would also be considered an excellent sugarbush, but not as desirable since it contains red maples in addition to sugar maples. Categories 3 and 4 allow for lower densities of tappable maple trees that can be located further from an access road. Although it would be feasible to tap these types of sugarbushes, they are not as economical or productive as the first two categories.

We have previously explored the percentage of tappable trees that are utilized for syrup production (Farrell and Chabot 2012). This was determined by dividing the number of taps reported in the National Agricultural Statistics Service (NASS) surveys by the total number of potential taps, as estimated by the FIA data. By refining the potential tap estimates, new utilization rates are calculated based on factors dealing with the density of maples in a stand and the distance of that stand to an access road.

Results

Estimating the number of potential taps according to the density of maple trees in a stand and the distance of that stand to a road provides many interesting findings. The results based on density were much more significant and noteworthy than distance to road and therefore receive the most attention in this analysis. Table 1 presents the total number of sugar and red maple potential taps for 20 states, stratified according to the density of tappable trees within a stand. The table is divided among the ten states whose syrup production is large enough to be tracked by NASS (hereafter referred to as the 'NASS states') and ten other states where some syrup production occurs, but the industry is not large enough for the government to keep records of it.

Analysis based on density requirements

As seen in Table 1, Michigan contains the most potential sugar maple taps, Pennsylvania leads in red maples, and New York has the largest resource of sugar and red maples combined. However, by only counting the trees that occur in feasible sugarbushes with at least 74 taps/hectare, Michigan would surpass New York as the state with the greatest resource of sugar and red maples combined. Furthermore, when only considering the most optimal sugarbushes with at least 147 or more taps per hectare of just sugar maples, Michigan's 51 million potential taps far exceed all other states. New York (23 million), Wisconsin (19 million), and Vermont (18 million) fall well behind Michigan in this regard whereas six states do not have any sugarbushes meeting these criteria. If one includes red maples in the optimal sugarbushes densities, Michigan still ranks first with 94 million potential taps, New York (70 million) remains in second place, and Pennsylvania climbs to third place with 62 million potential taps. Since Wisconsin and Vermont have mostly sugar maples and relatively fewer red maples, they remain far behind with 33 million and 27 million potential taps, respectively.

NASS states have a much higher percentage of their maple trees in the largest density categories and a greater percentage of their tappable trees are sugar maples (as opposed to red maples). The NASS states have roughly three times as many potential taps as the states with only limited syrup production, and there are even greater differences based upon density factors. In fact, the number of potential sugar and red maple taps in stands that have at least 147 taps/hectare is nearly eight times higher in NASS states compared to that of limited-production states. When considering just sugar maples in the optimal density categories, there are over fourteen times as many potential taps in the NASS states.

When evaluating the syrup production potential of a particular state or region, it is important to note the percentage of potential taps that are red maples versus sugar maples. Red maples have been expanding throughout the eastern U.S. over several decades (Fei and Steiner 2007) and now outnumber sugar maples in nearly every state. As calculated from Table 1, 59% of the potentially tappable trees in the U.S. are red maples and 41% are sugar maples. Although half of the NASS states have more sugar maples than red maples (Maine, Michigan, New

Hampshire, Vermont, and Wisconsin), Minnesota is the only limited-production state that has more sugar maples than red maples in the upper density categories (>147 taps/hectare).   Red maples are prevalent in warmer, southerly states whereas sugar maples are more common in northerly regions, as illustrated by the fact that all of the sugar maple-dominated states share a border with Canada.

There are noticeable differences in potential taps for the four density categories when examining sugar and red maples independently versus a combination of sugar and red maples (treated as if they were of equal value for tapping). When considering the latter, there are more tappable trees in the higher density categories and fewer in the lowest density category. To understand why, suppose that an FIA plot had 60 sugar maple and 40 red maple potential taps per hectare. When considering these species individually, both would be counted in the lowest density category of <74 potential taps/hectare.   However, when considering these two species together, there would be 100 potential taps, putting the plot into the next highest density category. Whereas stands with <74 taps/hectare are not considered economically viable to collect sap from, those with 74-146 taps are feasible sugarbushes.

Table 2 shows the advantages of tapping red maples in addition to sugar maples. It displays the total number of potential taps for the U.S. according to four density categories, as previously discussed. The third column provides the total number of sugar maples and red maples as if they were separate, independent species whereas the fourth column considers them together, as if they were of equal value for tapping. Based on this distinction, the fourth column has 172 million fewer potential taps in the lowest density category and 87 million more potential taps in the higher density categories than the third column. This makes intuitive sense given the fact that sugar maple and red maple often occur together in mixed stands. Thus, sugarmakers who are willing to tap red maples in addition to sugar maples have a larger resource of viable sugarbushes to select from.

Whereas Table 1 provides the total number of potential taps based on four density categories, Figure 2 displays the percentage of all tappable sugar and red maple trees for each state that occur within these same four density categories. The states are positioned in increasing order based on the percentage of all tappable trees occurring in stands whose density is not high enough to economically collect sap from (<74 taps/hectare). The five states furthest to the right (Illinois, Virginia, North Carolina, Tennessee, Kentucky), with over 70% of their trees occurring in stands of insufficient density, are all located along the southern end of sugar maple's range, illuminating the fact that maples usually occupy a smaller component of the canopy in the oak/hickory dominated regions. This helps to explain why southerly states with a seemingly large number of maple trees may not have developed their resource for syrup production in any meaningful way. For instance, West Virginia has 126 million potential taps, even more than Vermont's 112 million potential taps. However, 58% (73 million) of West Virginia's trees occur in stands of <74 taps/hectare whereas only 29% (33 million) of Vermont's trees fall within this lowest density category. Furthermore, even though sugar maple is the state tree of both Vermont and West Virginia, 72% of Vermont's feasible taps are sugar maples whereas only 40% of West Virginia's are sugar maples.

Overall, nearly half (45%) of all the potential sugar and red maple taps in the U.S. occur in stands where the density of maple trees is not high enough to economically collect sap from. However, this figure is much higher (66%) in the states with limited syrup production as opposed to only 38% in the NASS states. Likewise, 22% of the potential taps in NASS states occur in the optimal stands of ≥147 taps/hectare as opposed to only 7% in the limited- production states.

Analysis based on 'distance to road'

Our original hypothesis was that there would be a large percentage of trees that were too far from an access road to economically tap for syrup production. However, the results seen in Figure 3 prove the opposite. Only 6% of all tappable trees are 1.6km meters or further from an access road and 13% are located within 0.8-1.6 km of a road. Overall, 15% of the tappable trees fall within 91 meters of a road while the vast majority (66%) occur within 92-0.8 km. Densely populated states such as Connecticut, Maryland and New Jersey have the highest percentage of trees growing close to a road whereas Maine, Michigan, Minnesota, and Vermont are the only states that have at least 25% of their potential taps occurring 0.8 km or further from an access road. There are some discrepancies between the states, but road access appears to be a non-issue for the vast majority of tappable trees.

Utilization rates based on density and 'distance to road' requirements

Table 3 provides the utilization rates for ten states based on four categories of potential sugarbushes. There are broad differences among states in the percentage of available trees being used for syrup production. If one considers all of the feasible taps (Category 4), Vermont sugarmakers would be tapping 5.8% of their available trees. However, by only considering the most optimal sugarbushes in Category 1, the utilization rate would be over 50%. Since a large percentage of the optimal sugarbushes are already being utilized, for Vermont to increase its output of maple syrup, sugarmakers will have to tap trees that may not be the most economical to gather sap from. Maine and New York regularly trade places for the #2 ranking in syrup production for the U.S., although New York is utilizing a much lower percentage of its tapping potential than Maine. If all of the taps were located in optimal sugarbushes, Maine would be using 26% of its capacity whereas New York would be using far less (13%). Considering all of the feasible taps, Maine's utilization rate is 2.7% whereas New York's is 1.2%.

Michigan and Pennsylvania have the lowest utilization rates and greatest potential for growth among the NASS states. Only 2% and 7%, respectively, of their most optimal taps are used for syrup production and only 0.4% of all the feasible taps are utilized in each state. In particular, Michigan has the largest potential for growth, as it contains nearly 25 million potential taps in the optimal density category, much higher than any other state.

Overall, with 9.6 million taps spread out over the 10 NASS states, U.S. sugarmakers are utilizing 2.5% of all the potential taps in Category 2 and 0.8% of all the potential taps in Category 4 sugarbushes. To put this in perspective, Quebec puts out 40 million taps each year out of a total potential of 110 million potential taps in their Category 2 sugarbushes, resulting in a utilization rate of 36%. Thus, Quebec dominates the maple industry not because they have the largest resource of tappable trees, but rather because they use such a large percentage of their trees for syrup production.

Discussion

Even though our analysis focuses on the major producing NASS states, it also reveals a large resource of sugar and red maples in regions of the country not well known for producing maple syrup. There are many hobby producers and a limited number of commercial operations in the mid-Atlantic and central states, and there have been efforts to expand production in states such as Kentucky and Illinois (Hill 2010, Buchheit et al. 2004). However, the climate may not be as suitable to achieve economic yields of sap and the lower density of trees in these regions may preclude any significant expansion of the industry. Although shade-tolerant sugar and red maples have been increasing in abundance over time, oaks and hickories still mostly dominate these states, so it is more difficult to find an optimum sugarbush in these regions (Farrell and Chabot unpublished data). Furthermore, the majority of potentially tappable trees in the southerly states are red maples, whereas maple syrup producers prefer to tap sugar maples due to the greater abundance and higher sugar content of the sap. Skinner et al. (2010) found that the number of sap flows days and the timing of sap flow in the northeast will likely be similar to that of the mid-Atlantic states by the end of the century if the climate continues to warm. Thus, conducting research in these states on the timing of sap flow, yields/tap using various collection practices, and other key variables would be useful for forecasting what the maple syrup industry may be like in the northeast in future years.

Our analysis found that the vast majority of trees fall within 1.6 km of an access road. Given that tubing systems frequently span across 1.6 km and occasionally even further, it appears that the distance to a road is not a limiting factor for tapping maple trees. However, while distance to a road is a good indicator of accessibility, it is not a perfect metric for determining if a stand of maple trees is actually accessible. For instance, FIA data only provides the distance to a road, not whether that road is uphill or downhill from a stand of trees. To gather sap from trees that occur downhill of an access road, auxiliary roads can be built and/or sap can be pumped uphill, but this presents additional challenges and costs that may render sap collection efforts no longer desirable or cost-effective.

There are other aspects regarding terrain that could also limit accessibility of the trees. A large hill, waterway, wetland, or other natural feature between the sugarbush and an access road could make collecting sap a difficult process, and the FIA data cannot account for these types of topographic constraints. Another impediment for some sugarmakers may be the slope of a hillside, as some otherwise suitable sugarbushes may be too steep to work on. A large percentage of maple producers may not possess the athleticism or physical fitness to work on slopes in excess of 25^{O} or 30^{O}. However, steep hillsides may be ideal for maple producers who have the physical capability to work on them, as the steep slopes make sap collection with smaller diameter tubing much easier and productive, even without a vacuum pump (Wilmot 2011). Finally, in regards to aspect, some producers prefer to tap trees on southerly or eastern aspects, whereas others may be content with northerly facing sugarbushes, especially in warmer regions. On the whole, because slope or aspect would not disqualify a sugarbush from being tapped by all producers, we did not include this information in our analysis.

It is important to realize that just because a dense stand of maple trees exists close to a road without any other topographic constraints, this does not necessarily mean it is available for tapping. The desires and preferences of the landowner is the ultimate determinant of whether or not a stand of trees could be tapped. We have conducted extensive survey research on landowners to determine their attitudes towards making syrup themselves or leasing their land to another sugarmaker for tapping (Farrell and Stedman 2011). Many landowners do not have the time, interest, financial means, or labor supply to tap the trees on their land. Other landowners will not lease their trees because they are concerned about reducing sawtimber value and the negative impact of tubing on the aesthetics and recreational opportunities. Our research only focused on the northeastern states of Maine, New Hampshire, New York, and Vermont, where syrup production is a strong part of the cultural fabric in rural communities (Hinrichs 1998). It is likely that landowners in other states, especially those without established maple syrup industries, would not be as interested in tapping trees themselves or leasing their land to another sugarmaker. Given this scenario, the true tapping potential outside of the major producing NASS states may be significantly less than the figures seen here.

Finally, although many of the figures presented in this analysis include non-reserved public land, the publically owned trees may be considered off-limits for tapping in any given state. Many government agencies do not allow tapping on state or federal forestland, and those that do may place restrictions that render the stands inoperable for maple producers. Vermont recently revised its policies to open up several sugarbushes for tapping and has allowed tubing to be installed on a year-round basis, but the stands made available represent only a small fraction of the total tapping potential on state forestland. New York has restricted its leasing to buckets on selected parcels of state forestland in the past, but is currently developing a pilot project that would allow tubing to be installed for five year leases. Further research on the policies for tapping on public land, and the factors that affect public agencies' willingness to lease taps, is necessary to gain further understanding on the true tapping potential of U.S. forests.

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Table 2.1 Number of potential taps on private and public non-reserved forestland based on the density of the stand in which they occur, provided here as the number of potential taps per hectare.

States Without Commercial Maple Syrup Production				States With Commercial Syrup Production (NASS States)			
	Thousands of Potential Taps				*Thousands of Potential Taps*		
	sugar maple	red maple	sugar & red maple		sugar maple	red maple	sugar & red maple
Illinois	8,724	5,560	14,283	**Connecticut**	5,056	28,777	33,832
<74 potential taps/ha	7,334	2,464	9,692		3,259	10,756	12,169
74-146 potential taps/ha	1,389	2,688	4,078		1,797	9,206	11,839
147-220 potential taps/ha	-	407	513		-	5,885	6,894
221+ potential taps/ha	-	-	-		-	2,930	2,930
Indiana	31,909	13,491	45,400	**Massachusetts**	9,383	46,973	56,356
<74 potential taps/ha	19,406	8,407	26,733		5,796	19,476	21,243
74-146 potential taps/ha	11,036	2,841	14,924		2,603	17,318	22,334
147-220 potential taps/ha	1,468	1,866	3,366		984	5,210	6,364
221+ potential taps/ha	-	378	378		-	4,968	6,415
Kentucky	41,572	37,558	79,130	**Maine**	58,826	89,983	148,809
<74 potential taps/ha	33,712	30,435	60,457		26,171	67,218	82,249
74-146 potential taps/ha	7,509	6,036	17,217		21,730	20,203	48,098
147-220 potential taps/ha	351	1,087	1,455		7,951	1,983	14,393
221+ potential taps/ha	-	-	-		2,974	578	4,069
Maryland	1,978	22,309	24,287	**Michigan**	150,698	134,112	284,810
<74 potential taps/ha	1,031	12,216	13,114		41,623	70,304	82,526
74-146 potential taps/ha	947	7,302	8,381		57,956	45,523	108,301
147-220 potential taps/ha	-	1,617	1,617		40,625	13,016	67,731
221+ potential taps/ha	-	1,175	1,175		10,493	5,268	26,252
Minnesota	22,795	16,598	39,393	**New**	26,572	52,363	78,935
<74 potential taps/ha	10,557	14,319	23,024	**Hampshire**	12,977	30,179	36,026
74-146 potential taps/ha	7,094	2,019	10,106		8,850	20,153	32,604
147-220 potential taps/ha	3,941	259	5,059		2,686	2,031	8,246
221+ potential taps/ha	1,204	-	1,204		2,059	-	2,059
North Carolina	4,167	82,435	86,602	**New York**	141,740	163,939	305,679
<74 potential taps/ha	2,247	60,055	61,686		66,523	74,543	104,502
74-146 potential taps/ha	1,920	18,213	19,064		52,041	60,891	130,758
147-220 potential taps/ha	-	2,072	3,757		17,793	24,297	55,074
221+ potential taps/ha	-	2,095	2,095		5,384	4,208	15,344
New Jersey	1,842	14,043	15,885	**Ohio**	38,171	50,387	88,558
<74 potential taps/ha	1,621	6,598	8,146		25,076	29,229	49,188
74-146 potential taps/ha	221	5,793	5,701		11,805	14,797	29,190
147-220 potential taps/ha	-	1,652	2,038		1,290	5,268	9,088
221+ potential taps/ha	-	-	-		-	1,093	1,093
Tennessee	24,737	42,441	67,178	**Pennsylvania**	77,968	204,775	282,743
<74 potential taps/ha	20,090	31,536	50,200		37,347	95,478	106,516
74-146 potential taps/ha	4,646	9,083	14,814		27,439	70,399	113,951
147-220 potential taps/ha	-	1,823	2,165		10,818	27,323	45,029
221+ potential taps/ha	-	-	-		2,364	11,575	17,247
Virginia	11,524	63,790	75,314	**Vermont**	71,395	40,517	111,912
<74 potential taps/ha	8,492	47,602	52,670		23,105	21,689	32,933
74-146 potential taps/ha	2,481	12,495	17,960		30,281	13,728	51,789
147-220 potential taps/ha	-	2,460	2,901		11,820	3,949	17,524
221+ potential taps/ha	551	1,232	1,783		6,190	1,151	9,665
West Virginia	52,936	73,614	126,550	**Wisconsin**	82,096	77,841	159,937
<74 potential taps/ha	37,048	49,238	72,991		30,967	49,132	67,048
74-146 potential taps/ha	13,424	20,141	42,851		31,920	22,384	59,690
147-220 potential taps/ha	2,464	3,651	10,125		13,726	5,015	24,592
221+ potential taps/ha	-	583	583		5,482	1,309	8,607
Totals:	202,184	371,841	574,023	**Totals:**	661,906	889,666	1,551,570
<74 potential taps/ha	141,539	262,871	378,712		272,845	468,003	594,399
74-146 potential taps/ha	50,667	86,611	155,097		246,421	294,605	608,554
147-220 potential taps/ha	8,224	16,895	32,995		107,693	93,978	254,934
221+ potential taps/ha	1,754	5,464	7,218		34,947	33,079	93,683

Table 2.2 Number of potential taps in the United States based on different density categories and species groupings.

Density Category	sugar maple	red maple	sugar and red maple (independent)[1]	sugar and red maple (combined)[2]
	Thousands of Potential Taps			
<30 potential taps/ha	414,384	730,875	1,145,258	973,111
30-59 potential taps/ha	297,088	381,216	678,304	763,651
60-89 potential taps/ha	115,917	110,873	226,790	287,929
90+ potential taps/ha	36,701	38,543	75,245	100,901
Total	864,090	1,261,507	2,125,597	2,125,592

1: this column is simply the sum of the first two columns, treating sugar and red maples as independent species of differing value for tapping

2: this columns considers sugar and red maples of equal value for tapping

Table 2.3 Utilization rates (percentage of tappable trees on private land that are utilized for syrup production) for 10 states based on four categories of potential sugarbushes.

		Category 1 sugar maples on private land stands with 147+ taps/hectare within 805 meters of access road		Category 2 sugar+red maples on private land stands with 147+ taps/hectare within 805 meters of access road		Category 3 sugar maples on private land stands with 74+ taps/hectare within 1.6 km of access road		Category 4 sugar+red maples on private land stands with 74+ taps/hectare within 1.6 km mile of access road	
State	**Number of taps in 2011**	**number of potential taps**	**utilization rate**	**number of potential taps**	**utilization rate**	**number of potential taps**	**utilization rate**	**number of potential taps**	**utilization rate**
Connecticut	71,000	-		7,550,000	0.9%	1,029,000	6.9%	17,613,000	0.4%
Maine	1,470,000	5,572,000	26.4%	10,548,000	13.9%	26,519,000	5.5%	55,334,000	2.7%
Massachusetts	245,000	-		5,718,000	4.3%	1,314,000	18.7%	19,989,000	1.2%
Michigan	495,000	24,786,000	2.0%	44,103,000	1.1%	66,258,000	0.7%	128,251,000	0.4%
New Hampshire	420,000	3,370,000	12.5%	6,566,000	6.4%	9,316,000	4.5%	30,634,000	1.4%
New York	2,011,000	15,126,000	13.3%	48,429,000	4.2%	63,486,000	3.2%	171,361,000	1.2%
Ohio	405,000	1,290,000	31.4%	8,589,000	4.7%	11,830,000	3.4%	35,717,000	1.1%
Pennsylvania	503,000	7,195,000	7.0%	32,033,000	1.6%	26,902,000	1.9%	116,446,000	0.4%
Vermont	3,300,000	6,360,000	51.9%	12,100,000	27.3%	32,375,000	10.2%	56,493,000	5.8%
Wisconsin	660,000	6,487,000	10.2%	13,537,000	4.9%	28,546,000	2.3%	55,969,000	1.2%
Grand Total	**9,580,000**	**70,187,000**	**13.6%**	**189,174,000**	**5.1%**	**267,574,000**	**3.6%**	**687,808,000**	**1.4%**

Figure 2.1 Maple syrup production in the United States and Canada, 1975-2011. Data based on USDA National Agricultural Statistics Service (NASS) and Statistics Canada.

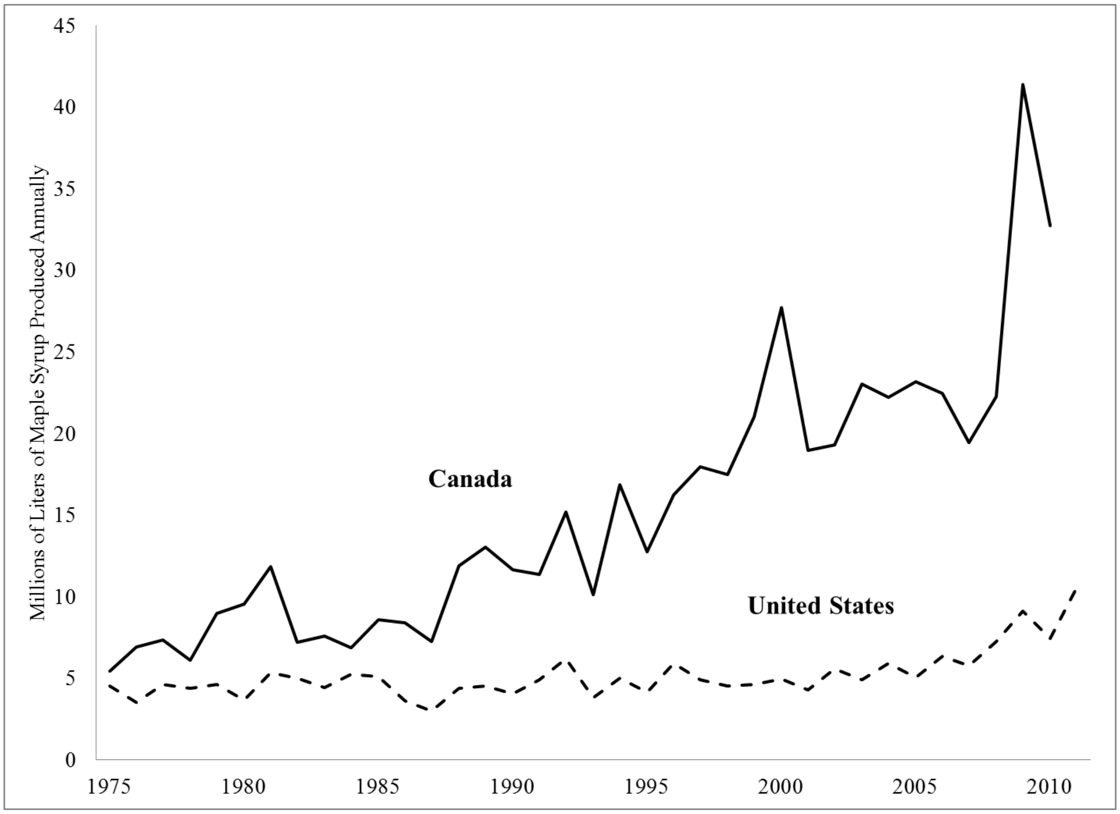


Figure 2.2 Percentage of all tappable trees that occur within stands of varying densities for each state. States without commercial syrup industries appear on the left and major producing states whose syrup output is tracked by NASS appear predominantly on the right.

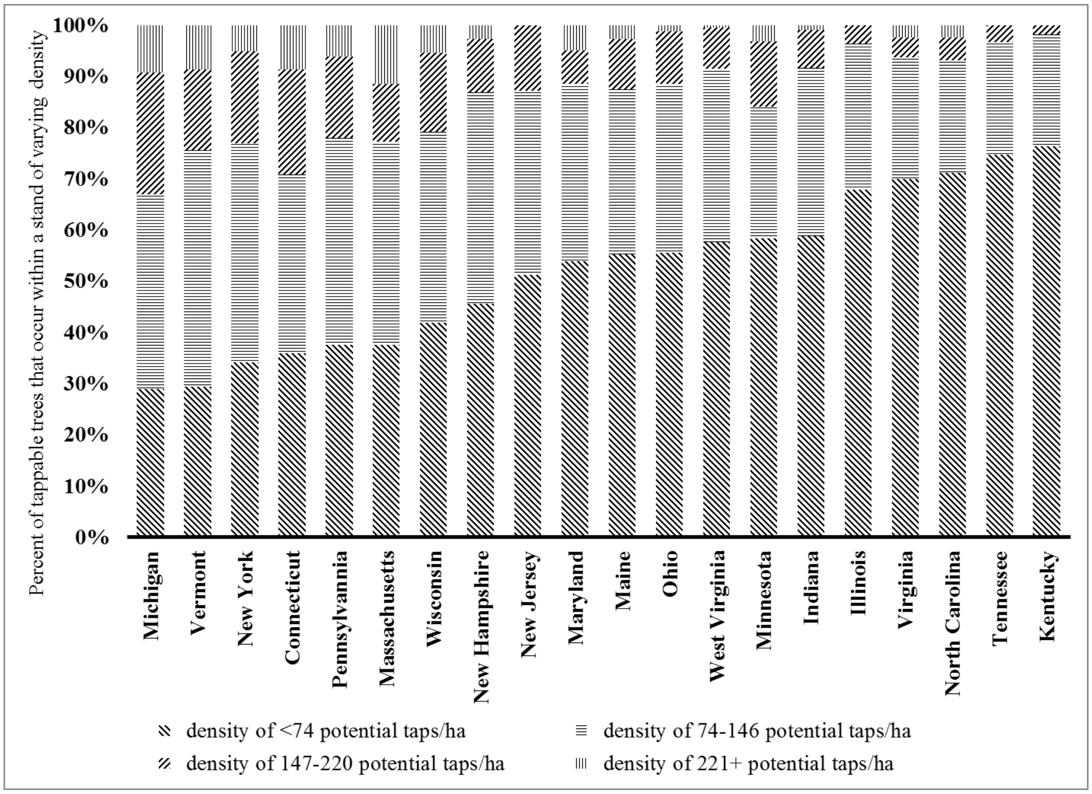
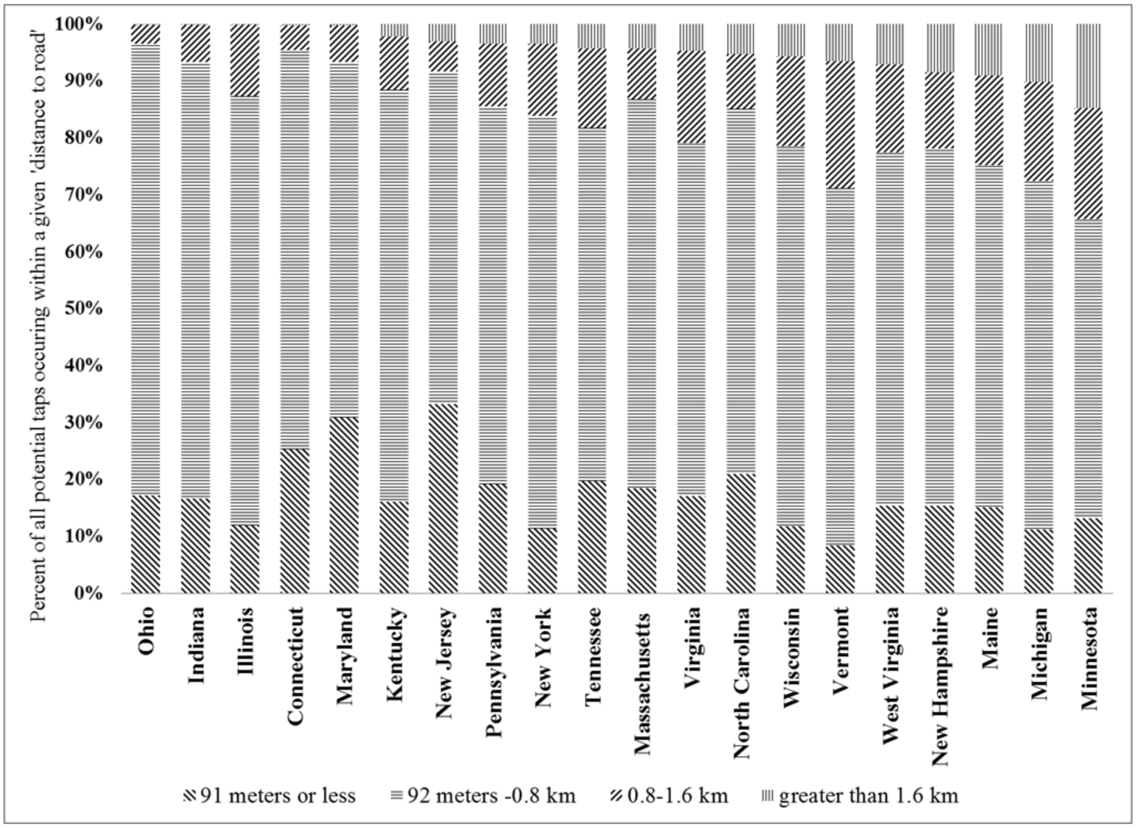


Figure 2.3 Percentage of all sugar and red maple potential taps for 20 states that occur within varying distances to the nearest road. States are displayed in increasing order based on the percentage of trees occurring at least ½ mile from an access road.



Chapter 3. Landowner attitudes towards maple syrup production in the Northern Forest[3]

Abstract

The Northern Forest region, including the states of Maine, New Hampshire, New York, and Vermont, accounts for over 75% of the maple syrup produced in the U.S. annually. Although syrup output has been growing at a rapid pace over the past decade, only a small fraction of the maple resource is currently tapped for syrup production. In order to determine the future growth potential of the maple industry, this paper explores landowner attitudes towards utilizing their maple trees for syrup production based on a mail-survey of 2,400 landowners carried out in October 2009. A multinomial logit model was developed using the survey results to examine the main barriers landowners perceive for producing maple syrup themselves or leasing their woodland to another sugarmaker for tapping. We found that landowners in New England had much more favorable attitudes towards sugaring than those in New York and that highly-educated landowners and females were the most likely to want to lease their land for tapping. Significant barriers identified by landowners include concern over the possible loss in sawtimber value from tapping, lack of personal interest and knowledge in the sugaring process, time and labor constraints, and not having enough accessible maple trees.

[3] This paper is currently in review at the *Northern Journal of Applied Forestry* with authors M Farrell & R Stedman

Introduction

Maple syrup production is an important part of the northeastern heritage and an increasingly valuable component of the rural economy. Sugar maples (*Acer saccharum*) and red maples (*Acer rubrum*) are tapped in the spring for their sweet sap, which is then boiled down into pure maple syrup (Heiligmann et al. 2006). Syrup production in the U.S. peaked in 1860, declined throughout the 20th century, and has experienced a period of rapid growth over the past decade (U.S. Census 1860, USDA NASS 2012). More people are now getting started with syrup production and existing sugarmakers are expanding their operations, yet the maple resource is underutilized in comparison to historical standards in the U.S. and the current situation in Quebec. In fact, with approximately 10 million taps put out on an annual basis, less than 1% of the nearly two billion potentially tappable maple trees are currently used for syrup production in the U.S. (Farrell and Chabot 2012). This pales in comparison to the situation in Quebec, where sugarmakers are utilizing approximately 40 million of the 110 million potentially tappable trees for syrup production, a utilization rate of 36% (MRN-MAPAQ Rapport 2000). Consequently, roughly 80% of the maple syrup produced in the world comes from Quebec in a typical year (USDA NASS 2012).

Although the U.S. produces much less syrup than Canada, it contains a significantly larger resource of maple trees (Farrell and Chabot 2012). The Northern Forest region (including parts of Maine, New Hampshire, New York, and Vermont) accounts for 75% of all the syrup production in the U.S. and contains a vast maple resource that could be utilized to expand syrup production. In fact, sugar and red maples are the top two species by volume in New York (Widmann 2012) and Vermont (Morin et al. 2011), and in the top six species by volume for

Maine (McCaskill and McWilliams 2012) and New Hampshire (Morin and Woodall 2012). Although there are over 300 million maple trees growing in stands of sufficient density and accessibility within the Northern Forest region (Farrell 2012 in press), currently only seven million of those trees are tapped on an annual basis. Whether more are utilized for syrup production is dependent on many other factors, most notably the attitudes and desires of millions of family forest owners in the eastern U.S.

Private landowners control approximately 80% of all of the forestland in the eastern United States (Nelson et al. 2010). They also produce nearly all of the maple syrup, as there are not any forest product companies or government agencies engaged in syrup production directly (though some do lease land for sugaring to private individuals and businesses). Since private landowners exert the greatest influence on overall production levels, it is important to understand their attitudes towards maple sugaring in order to determine how the industry might evolve over time.

Literature Review

There is significant literature focusing on the psychological, social, biologic, economic, and public policy factors that influence how landowners utilize their woodland for other activities. These studies have addressed timber production, wildlife habitat, recreational and hunting access, conservation easements, cross-boundary cooperation for forest management activities, carbon markets, and other non-timber amenities (Belin et al. 2005, Finley et al. 2006, Finley and Kittredge 2006, Kauneckis and York 2009, Jacobson et al. 2000, Kilgore et al. 2008, Markowski-Lindsay et al. 2011). Despite a breadth of knowledge on landowner behavior dealing with a variety of issues, no study has evaluated landowners' beliefs, attitudes, and barriers for utilizing their maple trees for syrup production.

Butler and Leatherberry (2004) found that scenic amenities, privacy, recreational opportunities, and passing land down to their heirs were the main reasons people own woodland. Maple syrup production is strongly tied to these *other reasons* for owning land, yet there has been very little research examining the factors that guide landowners' decision making in whether or not to utilize their maple trees for syrup production.

Hinrichs (1998) found that cultural influences and the desire to make maple syrup are major motivators for landowners to tap their trees for syrup production. Similarly, O'Brien (2007) found that maple sugaring was strongly associated with Vermonters' overall perceptions of well-being, quality of life, and cultural identity. Although economic issues may drive syrup production activities on a large scale, earning money may not be the primary reason most landowners engage in syrup production. Indeed, many natural resource and land use decisions, especially those made by landowners who do not generate their livelihood from their land, are not based primarily on financial outcomes (Koontz 2001). Whereas financial circumstances often dictate when timber is harvested (Brubaker et al. 2006), maple sugaring is often done more for recreational and other purposes. In fact, a large equipment distributor and buyer of maple syrup in the United States estimated that approximately 75% of his customers have sugaring operations that are not profitable (Bruce Bascom, pers. comm, Jan 7, 2012).

Previous studies suggest that time constraints, not having the right equipment, and high costs were the main reasons why landowners do not actively manage their land (Connelly and Smallidge 2007). In this vein, the process of making maple syrup requires a large investment in time and money, especially in comparison to other forest management activities. Hiring a forester or logger to conduct a timber harvest involves minimal time commitment while potentially providing immediate income for a landowner. In comparison, maple sugaring can be a very time and/or resource intensive activity, and any financial benefits may not be realized for many years. Thus, the motivations for undertaking this activity and the barriers for doing so are likely to be different than timber harvesting or other activities a landowner could pursue on his or her property. Accordingly, our research explores the factors that motivate landowners to utilize their maple trees for syrup production and the barriers that inhibit them from doing so.

Research Methods

Landowner Survey

Our research utilizes a mail survey of 2,400 landowners in Maine, New Hampshire, New York, and Vermont, where approximately 75% of all of the maple syrup is made in the U.S. (USDA NASS 2012). We initiated the survey in October 2009 according to standard practices as outlined by Dillman (2000). This procedure included an initial letter with the questionnaire, a reminder letter sent a week later, another questionnaire and letter sent after three weeks, and a final reminder letter sent on the fourth week. The questionnaire was based upon a similar survey that had been sent to 1,600 landowners and members of the New York Forest Owners Association in 2008 (Farrell & Stedman 2009). That survey had been carried out in order to determine barriers and incentives among a targeted sample of New York landowners to supply maple syrup to a proposed new bottling facility.

Our questionnaire was sent to random samples of 600 landowners in each of the four states who owned at least 100 acres. Although most of the landowners in the northeast own less than 10 acres, those who own at least 100 acres make up more than half of the total forestland ownership in the U.S. (Butler 2008). Small sugaring operations of less than 2,000 taps are rarely profitable (Boulet and Deschenes 2005), so we chose 100 acres of total land ownership as a likely minimum for a landowner to have enough tappable maple trees to develop a commercially viable sugaring operation.

The Maine sample was drawn from the Land Use Regulation Commission (LURC) database that includes all of the Unorganized Territories in the Counties of the State of Maine. Because a state database for all landowners does not exist in New Hampshire, we sampled from landowners enrolled in a state program that provides property tax relief for open land that has not been developed. This database was provided by the Statewide Program of Action to Conserve our Environment (SPACE). The New York sample was derived from a database of all landowners provided by the Real Property Tax Service Agency and the Vermont sample was drawn from a listing of all property owners provided by the state Department of Taxes.

Of the 2,400 questionnaires that were mailed, we received 1,100 completed questionnaires with 163 undeliverable and 7 not usable, resulting in a total adjusted response rate of 49% (Table 1). Although we did not conduct non-respondent interviews, we compared early and late respondents under the theory that late respondents behave similarly to non-respondents (Armstrong and Overton 1977). We did not find any significant differences in regards to all of the variables in the model. The only finding that came close to being significant was that early respondents had less personal interest and knowledge of maple sugaring than later respondents. This finding, although not statistically significant, contradicts our original assumption that respondents would be more interested in maple sugaring than non-respondents. Since this was not the case, we are confident that our findings can be extrapolated to the greater population.

We only included responses from those who identified themselves as ‘private non-industrial’ (also commonly referred to as ‘family forest owners’). We had 152 respondents (14.7% of our database) identify themselves as private hunting clubs, corporations, or not-for-profit organizations, yet we could not include them since our sample size was not large enough to produce statistically significant results. We also eliminated as outliers six respondents who claimed to own more than 10,000 acres, as these respondents were anomalies that do not represent a typical family forest landowner. Thirteen percent (n = 135) of our completed questionnaires came from current sugarmakers, but their responses to an abbreviated survey were not included in our analyses due to the nature of our study. Our final sample resulted in 645 useable responses.

Model Development

We measured landowner willingness to engage in maple syrup production with the following variable: “Do you feel that at least some of the trees on your property should be tapped for syrup production, either by yourself or someone else?” Respondents were given four choices for how to answer this question (yes- by me, yes-by somebody else, no, not sure). We developed a multinomial logit model since these are commonly used when the dependent variable is categorical and has more than two outcomes (Zhang and Mehmood 2001, Vokoun et al. 2006, Kaetzel et al. 2011, Snyder et al. 2008, Nagubadi and Zhang 2010). We originally ran some models with the “not sure” responses included, but the results were inconclusive and did not offer any meaningful results. Thus, we set “no” as the reference category and discarded the “not sure” responses based on other studies that have done the same (Kilgore et al. 2008, Kniivilä

2006). This allowed us to focus on the differences between those landowners who had definitive feelings on whether their land should be utilized for syrup production.

Our independent variables (Table 2) were chosen based on existing literature about what drives landowner behavior. We originally included many variables that are commonly used in landowner studies, including number of acres owned and absentee vs. resident status. We also asked about membership in a woodland owner association and whether a landowner is managing his or her land. Following Connelly and Smallidge (2007), management was defined in our questionnaire as "taking deliberate actions to influence the value of the land. Some examples of management activities are harvesting firewood, marking a trail, tapping maple trees, or improving habitat for wildlife". Demographic variables included age, gender, and education. Because maple sugaring is considered a New England tradition, we thought that owning woodland in one of these states may influence landowners' attitudes and behaviors towards sugaring, so we combined residents of Maine, New Hampshire, and Vermont together as a 'New England' variable. We included a variable that addresses whether or not a landowner was involved with maple sugaring as a youth, since childhood experiences could influence attitudes and behavior as an adult.

Potential barriers are also important to consider. Since maple lumber is highly valued and tapping reduces the commercial value of sawlogs, the reduction in sawtimber value caused by tapping may be a main obstacle preventing landowners from utilizing their trees for syrup production (Fast and Roberge 2010). We grouped 14 other potential barriers into five distinct categories and created continuous variables based on the number of options selected within a given category, ranging from 0-3. InterestKnowledge included having never thought about it, having no interest in the process and not knowing how to get started. Time and labor constraints were not having enough time, not having enough helpers, and living too far from the land. The land constraints were not having enough maple trees, not being able to access the trees for sap collection, and having land regulations that prohibit tapping. Economic constraints included sugaring not being profitable enough and the initial cost of equipment being too high. Tubing concerns involved the aesthetics of plastic tubing to collect sap and the possible impact of the tubing on wildlife, though this was eventually dropped from the model.

Results

Table 3 provides descriptive statistics of all the variables we included in our model plus some that were removed from the final analysis. Since we purposefully sampled landowners who owned at least 100 acres of total land, the mean (279) and median (150) number of woodland acres owned was much larger than the average landowner in the eastern U.S. We were surprised to find that 35% of respondents were involved with syrup production in their childhood, significantly higher than the overall population. The average age was 63 years, 77% of the respondents were males, and 51% had earned at least a bachelor's degree. The greatest potential barriers selected were time and labor constraints, with 74% of respondents choosing one of the barriers in this category. Land constraints (69%) and a lack of personal interest and knowledge (56%) were the two other most significant barriers chosen. Seventy-one percent of landowners indicated that they currently manage their land and 12% belonged to a forest landowner association.

In response to our main research question regarding whether a landowner believes the maple trees on their property should be tapped for syrup production, 69 (11%) responded with "yes, by me", 61 (9%) selected "yes, by somebody else", 296 (46%) selected "no", and 218 (34%) selected "not sure". Predictors of responses to the variables are displayed in Table 4. For multinomial logit models, it is important to examine both sets of coefficients for the two models. The data on the left-hand side of the table represent those would like to produce syrup themselves whereas the data on the right-hand side depicts those who would like to lease their land for tapping. Both sets of data are in comparison to those landowners who do not feel their woodland should be used for syrup production.

Owning land in one of the New England states (Maine, New Hampshire, Vermont), as opposed to New York, had a significant impact on a landowner's feelings towards using their trees for syrup production. Net of all other variables, the odds that New England landowners wanted to tap their trees were 3.3 times higher than landowners in New York. In regards to leasing their trees for tapping, the odds were 1.7 times higher for New England landowners. There has been some speculation that this may be based on the density and accessibility of the maple trees, yet recent research has found that New York has comparable sugarbush characteristics to those in the New England states (Farrell 2012 in press).

Although only 12% of respondents selected "concern about sawtimber value" as a potential barrier, this figure was much higher (60%) for landowners who own at least 2,000 acres. Controlling for acres of woodland in our model, we determined that the odds that landowners would want to tap their trees were 55% lower for those who are concerned about reducing sawtimber value. Similarly, the odds of wanting to lease their trees were 58% lower for these landowners.

There were three possible barriers that landowners could select concerning personal interest and knowledge in the sugaring process. These barriers included having never thought of it, having no interest in the process, and not knowing how to get started. For each one selected, there was a 37% reduction in the odds that a landowner would want to produce maple syrup themselves, yet there was no statistical relationship among the desire for others to tap their trees. This makes intuitive sense since leasing one's land to another person requires little effort from the landowner whereas actually partaking in maple sugaring requires a significant landowner interest and involvement.

Three of the potential barriers had to do with not having enough time or labor to get involved with sugaring. For each additional option selected in this category, the odds that landowners wanted to produce maple syrup themselves increased by 1.6 times and nearly doubled when considering leasing their land for sugaring. Thus, if landowners simply had more time or assistance from others, it is likely than many more would become involved with sugaring.

Landowners were presented with three possible land constraints- not having enough tappable maple trees, and not having their trees accessible, and having land regulations in place that prohibit tapping. Although no one selected land regulations as a barrier, for each of the other choices selected the odds that a landowner would want to use his or her land for sugaring themselves fell by 90% and leasing it out to others fell by 70%. Simply put, landowners who do not think they have enough accessible maple trees are not at all likely to consider attempting to use their land for syrup production. However, given the fact that sugar and red maples are so prevalent in this region, it is likely that many landowners who claimed to not have enough accessible maple trees on their property actually do have a viable sugarbush. There are many landowners who are not aware of the resources on their property and/or do not know what is required to produce maple syrup.

Economic constraints, defined here as the cost of equipment being too high and syrup production not being profitable enough, proved to be a significant barrier for landowners to produce syrup themselves. The odds of a landowner wanting to tap his or her maple trees nearly doubled when selecting one of these barriers, yet there was no effect on the desire to allow others to tap their trees. This is likely due to the fact that leasing trees for someone else to tap actually generates revenue, whereas producing syrup oneself requires substantial investments that may not be profitable for many years (if ever).

Although our sample size of women was relatively small (n = 96), gender played an important role in our analysis, as the odds that males would lease their trees for tapping were only 46% of that of females. Educational background was also important, as the odds of those with a 4-year degree were nearly double those without the same educational background to want others to tap their trees. However, for both of these variables, there was no difference on the effect of wanting to produce syrup directly. Older people were less likely to want to produce syrup themselves, as the odds of wanting to tap one's trees fell by 3.5% as a person's age increased by one year. It is worth noting that the mean and median age for our sample was 63 years, so this outcome was likely influenced by the older nature of the respondents. If the age of the respondents was much younger, being older may have had a positive effect on wanting to produce maple syrup.

We had originally included several variables in our model that we thought would be important, yet our research found that these were not statistically significant determinants of a landowner's attitudes towards sugaring. For instance, we believed that landowners who manage their property would be more likely to want to engage in syrup production, yet that was not the case. Similarly, whether or not someone belonged to a forest landowner association did not have a discernible effect on their attitudes towards sugaring. We hypothesized that absentee landowners would be more interested in leasing their woodland for tapping to other sugarmakers, yet the data on this point were inconclusive. Whereas there are many anecdotal reports of landowners objecting to plastic tubing systems being installed on their land, only 8% of respondents indicated that this was a concern. Finally, having participated in maple sugaring activities as a child had no significant impact on landowners' attitudes towards sugaring.

Discussion

This study has strengthened our understanding of the factors that drive landowner behavior towards maple sugaring and their perceived barriers for utilizing their maples for syrup production. Our results showed that New England landowners have more favorable attitudes towards sugaring than those in New York, yet we do not know exactly why this phenomenon occurs. Since maple syrup production is often considered a "New England" or "Vermont" tradition that most people look favorably upon, perhaps simply living in one of these states positively influences a person's attitudes towards sugaring. Landowners are more likely to see and meet other people who are producing syrup, so just being exposed to the industry might make more people want to get involved. Nearly all of the major manufacturers of sugaring equipment and buyers of bulk syrup are located in New England, so having ready access to supplies and markets may also play a vital role. There may be additional institutional factors that drive more landowners towards utilizing their woodland for maple sugaring, thus further research is necessary to determine the main factors underlying the 'New England effect'.

Given that New York is close to New England and also has a substantial maple industry, we may have found an even greater effect if we compared New England states to the rest of the U.S. Even though many other states have a substantial resource of tappable maple trees, the utilization for syrup production is even less than that of New York (Farrell and Chabot 2012). For instance, Michigan and Pennsylvania have the 2nd and 3rd largest number of tappable trees, yet only 0.2% of all potentially tappable trees are actually used for syrup production. For comparison purposes, New York producers tap 0.6% of all available trees and Vermont leads the nation with a 3% utilization rate. Future research will expand on this work to survey landowners in other states as a means of gauging the full impact of the 'New England effect'.

This study illustrates the relative importance of perceived sawtimber value reduction on landowners' attitudes towards utilizing their maple trees for syrup production. We found that roughly half of the landowners who would otherwise want to use their trees for sugaring have not done so in part because of concerns about the reduction in sawtimber value. However, there is no clear answer as to whether a landowner would earn greater revenues from managing their maple trees for syrup or sawtimber production. A Net Present Value (NPV) calculator was recently developed that allows foresters to input values for 36 variables pertaining to an individual maple tree to determine if a landowner would earn greater revenues from leasing a tree for tapping or selling the stumpage rights for harvesting (Farrell 2012 in press). With the exception of large, high quality sugar maples and short investment periods, leasing taps for many years before harvesting often results in greater returns than traditional sawtimber management. Since we discovered that concern over sawtimber value is an important barrier, it is possible that more landowners would utilize their maples for syrup production if they better understood the economics of this decision.

We found that landowners with larger acreages were much more concerned about reducing the value of their maple logs by tapping them for syrup production. Thus, in contrast with Quebec, the opportunities for developing very large scale sugaring operations in the U.S. are currently limited. One of the few places where very large sugaring operations ($\geq$ 50,000 taps) exist in the U.S. is northern Maine, where Timber Investment Management Operations (TIMOs) lease out nearly 1.5 million taps each year to sugarmakers who predominantly come from Quebec (Theriault 2007). This tradition has been carried on for decades when the land had previously been owned and managed by paper companies. Since the forests were being managed primarily for pulp production, and tapping has little effect on pulp quality, leasing taps made economic sense. The new owners have honored the existing leases and even developed new ones in order to secure additional annual revenues. However, whether this type of industrial leasing happens in other places will depend largely on whether the land managers perceive they can earn greater revenues from timber management or leasing taps.

Although our sample size for this category was limited, women were much more likely than men to want to lease their woodland for sugaring purposes. Furthermore, having at least a bachelor's degree also led to favorable attitudes towards sugaring. Women generally like the idea of sugaring and are willing to let others tap their trees, yet most of them do not have much interest in producing syrup themselves. Although an increasing number of women are attending beginners' workshops and engaging the maple industry (Childs, pers. comm, July 22, 2012), the vast majority of sugarmakers are still men. An important finding for maple producers interested in expanding their operations is that they should reach out to female and/or highly educated landowners for the best chances of securing a lease.

It is possible that we could have had different results if we included landowners with significantly smaller acreages in our survey. We had focused on relatively large landowners with ≥100 acres because of the minimum number of taps needed to support a sugaring operation that is capable of producing an annual profit (Boulet and Deschenes 2005). The motivations to produce syrup, and the barriers and incentives to getting started, may be much different for those who consider it a "hobby" versus those who do it as part of their livelihood. There are thousands of landowners in the U.S. who produce maple syrup from a few hundred trees or less growing in backyards and small woodlots. Future research will examine landowners with much smaller acreages in order to help determine the overall growth potential of the maple industry.

Conclusion

This research provides greater insight into the growth potential of the maple syrup industry in the Northern Forest region. It appears that at least 20% of the landowners would like to utilize their maples for syrup production, yet there are many barriers that prevent them from doing so. Even though sugar and red maples are the dominant species in the region, not all landowners have a dense stand of suitable maples available for tapping. Since time and labor constraints was the #1 barrier identified by landowners who would like to utilize their maples for syrup production, leasing trees to other sugarmakers may be a viable option for many landowners. The main barrier we identified that could stifle these arrangements is the concern over reduced sawtimber value from tapping. It is possible that maple sugaring activities in the Northern Forest could increase rapidly if more landowners believed that they could earn greater revenues by managing their maple trees for syrup rather than sawtimber production.

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Table 3.1 Response rate for survey by state (600 mailed out per state).

State	Usable Returns	Undeliverable	Not Usable	Response Rate
Maine	268	55	0	49%
New Hampshire	268	34	4	51%
New York	265	44	2	48%
Vermont	279	40	1	49%
Total	1100	163	7	49%

Table 3.2 Definition and description of model variables.

Name	Definiton
NewEng	a binary variable equal to 1 if the respondent owns land in Maine, New Hampshire, or Vermont
TimberValue	a binary variable equal to 1 if the respondent indicated concern about reducing sawtimber value as a reason for not tapping maple trees
InterestKnowledge	a continuous variable from 0-3 based on the number of constraints selected from the following: “I have never thought about it as an option”, “I have no interest in the process”, and "I don't know how to get started"
TimeLabor	a continuous variable from 0-3 based on the number of constraints selected from the following: I don't have enough time, "I don’t have access to family, friends, or neighbors who could help me", and "I don’t live close enough to my forestland"
LandConstraints	a continuous variable from 0-3 based on the number of constraints selected from the following: "I do not have enough tappable maple trees", "Land regulations do not allow me to make syrup", and "My trees are not easily accessible"
EconConstraints	a continuous variable from 0-2 based on the number of constraints selected from the following: "The initial cost of buying equipment is too high", "Syrup production is not profitable enough"
4yrCollege	a binary variable equal to 1 if the respondent has a 4 year college degree
Gender	a binary variable equal to 1 if the respondent is male
Age	a continuous variable indicating the age of the respondent

Table 3.3 Selected descriptive statistics of model variables.

Name	Mean	Std Deviati	Median	Min	Max
NewEng	0.76				
TimberValue	0.12				
InterestKnowledge	0.56	0.75	0	0	3
TimeLabor	0.74	0.87	1	0	3
LandConstraints	0.69	0.72	1	0	3
EconConstraints	0.31	0.6	0	0	2
4yrCollege	0.51				
Gender	0.77				
Age	64	12.8	63	30	99

Table 3.4 Multinomial logistic regression asking landowners if they feel the maple trees on their property should be tapped for syrup production.

	landowners who want to produce maple syrup versus those who do not want their land used for sugaring				landowners who want to lease their woods for tapping versus those who do not want their land used for sugaring			
	Estimate	**Std Error**	**Prob>ChiSq**	**Odds Ratio**	**Estimate**	**Std Error**	**Prob>ChiSq**	**Odds Ratio**
intercept	0.38	0.987	0.6974		-3.06	0.996	0.0021	
NewEng	0.98	0.276	0.0004	2.67	0.53	0.226	0.0182	1.70
TimberValue	-0.61	0.270	0.0250	0.55	-0.54	0.288	0.0603	0.58
InterestKnowledge	-1.00	0.308	0.0011	0.37	-0.29	0.235	0.2191	0.75
TimeLabor	0.49	0.232	0.0357	1.63	0.67	0.199	0.0007	1.96
LandConstraints	-2.25	0.335	<.0001	0.11	-1.31	0.262	<.0001	0.27
EconConstraints	0.68	0.285	0.0170	1.97	0.25	0.296	0.3911	1.29
4yrCollege	-0.22	0.178	0.2122	0.80	0.62	0.184	0.0007	1.87
Age	-0.03	0.014	0.0157	0.97	0.01	0.013	0.5008	1.01
Gender	-0.16	0.212	0.4507	0.85	-0.77	0.244	0.0017	0.46

Chapter 4: Economic analysis of leasing an individual maple tree for syrup production or managing for sawtimber production[4]

Abstract

It is often debated whether using maple trees for syrup production is more profitable than managing them for sawtimber. This paper utilizes a Net Present Value (NPV) calculator to determine whether a landowner would earn greater profits by leasing an individual maple tree for syrup production or managing it for sawtimber production. Three scenarios are analyzed with the NPV calculator to demonstrate the instances when the choice is clear and when the decision-making process is more difficult. This paper explores the variables that have the greatest influence on the results, including the initial tree size and growth rate, species (sugar or red maple), lease payments, stumpage rates, property taxes, discount rates, and the time horizon of the investment period. The primary attributes that favor leasing taps include small, slow-growing red maples, high lease rates ($\geq$ \$0.50/tap/yr), low stumpage payments, property tax reductions for maple sugaring, low discount rates, and long-term planning horizons. Attributes that favor timber management include large, fast-growing sugar maples, low lease rates (<\$0.50/tap/yr), high stumpage payments, property tax reductions for forest management, high discount rates, and short-term planning horizons.

[4] This paper has been accepted to the *Northern Journal of Applied Forestry* with sole author Farrell

Introduction

Maple trees, in particular sugar maples (*Acer saccharum*) and red maples (*Acer rubrum*), are prized for both the quality of their lumber and the syrup produced from their sap. Most people consider these uses to be mutually exclusive since trees that are being used for syrup production cannot be harvested for lumber, and if they are eventually harvested, the previous tapping reduces the commercial value of the lumber in the first log. Landowners often have competing demands from loggers who want to harvest trees and maple syrup producers who wish to lease them for tapping. Determining the most profitable option must consider all of the immediate and long-term costs and revenues. This is not an easy decision to make and the answer will depend on many attributes of the individual trees and the stand in which they occur.

In order to assist foresters and landowners in evaluating their options, an Excel-based *Net Present Value (NPV) Calculator* was developed so that one could enter values for up to 36 variables specific to an individual maple tree. The spreadsheet determines the present values of all costs and revenues associated with leasing a tree to a maple producer and/or receiving stumpage payments for harvesting. Users can then compare the NPVs of four distinct management options:

(1) leasing the tree for tapping and eventually harvesting it

(2) continually leasing the tree for tapping without ever harvesting it

(3) letting the tree grow freely (no tapping) and harvesting it in the future

(4) harvesting the tree immediately without any tapping

Although this analysis is presented on an individual tree basis, foresters and landowners are usually concerned about management options for a stand of trees or an entire forest. The *NPV Calculator* was designed specifically to examine the major factors affecting the economics of leasing taps versus sawtimber management for individual trees. It is up to the forester to consider the specific attributes of all trees that make up a particular stand in order to make the final decision on how to manage it. It is possible (and occasionally practiced) to not tap certain trees in a stand that is managed for syrup production, and the astute forester will be able to recognize which trees are appropriate for tapping, which should be harvested immediately, and which ones should be managed for long-term sawtimber production. The *NPV Calculator* aids in this type of analysis by providing financial information to support management decisions.

Since this analysis focuses on stumpage versus lease payments, it assumes that landowners are taking a passive approach in managing their property. Although landowners could potentially earn more revenue by tapping or harvesting/milling trees themselves, there are many other economic factors that would complicate this analysis. By assuming that the landowner will only be paid for the opportunity for someone else to tap their trees or cut them down, it allows for a more just comparison between maple sugaring and timber harvesting.

Background

The logging community is often at odds with maple producers when it comes to tapping maple trees, as seen in the recent debate over whether to allow tapping on state forestland in Vermont (Vermont Public Radio 2009). Also, the possible loss in sawtimber value is the primary concern among *large* landowners for why they have not tapped their trees. According to a survey of

1,100 landowners in Maine, New Hampshire, New York, and Vermont, 60% of respondents who own at least 2,000 acres indicated that "concern over the loss of timber value" was the primary reason why they have not leased their trees to a maple producer (Farrell & Stedman 2011). The situation is much different among *small* landowners, as only 12% of those with less than 200 acres indicated reduced sawtimber value as a reason for not tapping.

The interest among maple producers to lease trees for tapping is high and growing. A 2009 survey of 2,400 maple producers in New York revealed that 61% of their planned expansion over the next 5-10 years was to take place on leased land while 25% indicated that not being able to tap on state land would impede the growth of their business (Farrell & Stedman 2009). However, agencies such as the New York State Department of Environmental Conservation (NYSDEC) and Vermont Department of Forestry have been reluctant to lease forestland for tapping due in large part to the perceived loss of timber value. Vermont began implementing limited tapping leases in 2009, focusing primarily on stands that have been tapped historically (Whitcomb 2009). New York has yet to allow commercial tapping, citing as one barrier that it must yield the greatest economic returns from forestland with all transactions (NYSDEC 2010). Clearly there are strong opinions in these two agencies that timber management is more lucrative than leasing taps.

The experiences in Vermont and New York are in direct contrast with the situation in Quebec, where approximately 80% of the world's maple syrup is produced. Since it also has a thriving hardwood lumber industry, government officials have often debated whether to utilize their maple-dominated forests for syrup or timber production. In the 1980s a graduate student at Laval University developed an economic model for the allocation of public forests, utilizing maple syrup and timber production as his case study (Pare 1985). Additional studies were commissioned to examine the socio-economic costs and benefits of managing Crown land for timber production or leasing for syrup production (TECSULT 1998, Ministry of Natural Resources 1998, Ministry of Natural Resources 1999). Each study concluded that leasing taps was more beneficial than managing for sawtimber production. They focused not only on direct lease and stumpage payments to the government, but also took into account other factors such as overall employment and wages for rural citizens. As a result, the government of Quebec decided to allocate additional Crown land for tapping with the goal of doubling production between 1998-2003 (MRN-MAPAQ Rapport 2000).

The only previous research examining the effects of maple sugaring on lumber value was conducted by the US Forest Service approximately 30 years ago (Sendak et al. 1982). The authors examined the lumber value loss associated with tapping wounds on graded maple lumber from 90 trees spanning 4 sugarbushes in northern Vermont. They found an average loss in lumber value of < 5% due to grade defects caused by tapholes and staining. Their paper indicated that the value loss could be used as a way of calculating the annual lease payment for sugaring rights, but it did not go so far as to present an economic analysis to compare tapping versus sawtimber production. Since this study took place over 30 years ago, when most taps were put in low on the tree with buckets, it is possible that the damage could be more extensive today, as many sugarmakers use plastic tubing systems that result in taps being placed higher on the stem. Moreover, log buyers typically offer landowners much less for tapped trees, even if there is little value loss due to the tapholes.

Methods

In order to determine when it makes more economic sense for a landowner to lease a maple tree for syrup production or manage it for sawtimber production, a spreadsheet was developed where users can enter values for 36 variables pertaining to tree size and growth, stumpage payments, lease payments, property taxes, and financial determinants. Due to space constraints, this paper cannot describe the model in detail. However, a *User's Guide* was developed that describes the 36 user-controlled variables while providing the possible range and suggested default value for each variable. Readers are encouraged to download the *User's Guide*, *Formula Descriptions*, and the actual *NPV Calculator* from http://maple.dnr.cornell.edu/produc/tvs/index.htm Reviewing these documents and experimenting with the *NPV Calculator* will greatly assist readers in understanding how the model works.

Three hypothetical maple trees were chosen to evaluate the *NPV Calculator* under different scenarios. Table 4.1 contains all of the variables that are held constant whereas Table 4.2 contains values for the variables that may differ across the scenarios. The first example presents a "best-case" scenario for leasing taps, the second example shows when timber management is the obvious choice, and the third option presents a situation where the decision-making process is difficult and the outcome can easily change depending on key variables. Although this paper only describes three examples, there are numerous scenarios that could be analyzed. Thus, readers are encouraged to download the *NPV Calculator*, enter in values appropriate to different situations, and examine the results.

Results

Figures 4.1-4.5 contain NPV data for three hypothetical scenarios of individual maple trees. Two graphs are displayed for scenarios 2 and 3, one depicting the results for a sugar maple and the other for a red maple, all else being equal. Each graph presents NPV figures, at annual intervals depending on the time horizon of the investment period, of four different options a forester/landowner has for utilizing an individual maple tree. This analysis is carried out over a 40 year time horizon and does not account for replacement of a tree if it is harvested.

The graphs show what the NPV for a particular management strategy would be if the time horizon for the investment period was a specific number of years. For example, consider a situation where someone planned on owning a parcel of land for 10 years before selling it, or was planning on conducting a timber harvest in 10 years. The forester would want to know what the NPV of various management options would be, given that 10 year planning horizon. The NPVs are displayed for a 40 year time frame in order to show how NPVs, and thus the management decision, can change based on how long someone plans on owning a parcel of land or conducting a timber harvest. What might be the most profitable option for a 10 year planning horizon may not be the same for a 3 year or a 40 year planning horizon.

Scenario #1- Small tree with variables favorable to leasing

This scenario presents a "best-case" for continuous leasing of taps in comparison to timber management. As seen in Figure 4.1, the NPV was only positive for the management options that included leasing. This is due in large part to the fact that (1) there was no loss in sawtimber value since the small, slow-growing tree never developed a merchantable sawlog within the 40 year time horizon, and (2) there were large savings on property taxes by using the tree for syrup production. When a tree can only be harvested for cordwood, this revenue often falls short of the regular annual property tax payments, so managing for long-term timber production can actually yield negative returns. In fact, a recent study of Massachusetts family forest owners found that long-term timber management will produce negative returns for many landowners in that state (D'Amato et al. 2010).

It is worth noting that even if the tree was growing rapidly, the lease payment was lower, or a tax break for leasing did not exist, the NPV would still be positive for leasing taps and negative for timber management. When starting with small trees that are decades away from producing a sawlog, the fact that they can generate revenue each year until they are ready to be harvested will almost always favor leasing taps over timber production. Finally, Figure 4.1 displays the same information for sugar and red maples in this scenario because the lease payments and stumpage rates for cordwood are typically the same for both species.

Scenario #2- Large veneer tree with variables favorable to harvesting

In contrast with Scenario #1, this scenario presents a clear picture of when timber harvesting is much more lucrative than leasing taps. With a veneer-quality tree, the dilemma is not whether to lease taps or harvest timber, rather the only question is when the tree should be cut. It becomes a matter of financial maturity depending upon the rate at which the tree is increasing in value (due to tree growth and the rise in stumpage prices) vs. the alternative rate of return (the discount rate) that the landowner could earn in other investments of comparable duration, risk, liquidity, etc.

(Bullard et al 2002). In this example, the discount rate is 6% whereas stumpage rates are increasing at 4.6% annually and the tree only has a moderate growth rate of .12 inches/year. Thus, it would make sense to harvest the tree immediately or within a few years, as seen in Figure 4.2. However, if the tree was growing at a much faster rate, if the discount rate was lower than 4.6%, or if stumpage rates were increasing at more than 6% annually, then it could make sense to let the tree grow for a longer time period in order to achieve the greatest revenues.

When considering large, merchantable trees, in order for leasing to compete with timber management, there must either be a substantial tax savings for leasing and/or a lucrative market for taphole maple lumber. Even when these conditions are met, any sugar maples that may produce veneer should be identified before a lease goes into effect and either harvested immediately or prohibited from tapping. If there is a large percentage of veneer trees in a given stand, that entire stand may be prohibited from tapping.

Since red maples are rarely used for veneer, the tree is likely to be sold for sawtimber when it is harvested, making the difference in NPVs between tapping and timber production much lower. As seen in Figure 4.3, a red maple would become financially mature in approximately 20 years, at which point it would have made much less difference if the tree had been tapped (as compared to sugar maples).

Scenario # 3- Small sawtimber tree with variable outcomes

Whereas the first two scenarios have clear directives on which management strategy is more profitable, when considering a small sawtimber tree the decision is much more difficult to make, especially for sugar maples. The time horizon of the investment period should have a particularly significant impact on a landowners' decision. For sugar maples in this scenario (Figure 4.4), if a landowner's planning horizon is 8 years or less, the greatest returns would be from cutting immediately. However, if the landowner wants to hold on to the tree for at least 10 years, then he or she would be better off leasing taps and then harvesting a tapped tree after a minimum of 10 years. The lowest returns come from continuous leasing without ever harvesting, as the annual lease payments will never compensate for the lost stumpage value from not harvesting the mature tree.

The outcomes for this scenario are much different when considering red maples (Figure 4.5). Because of the lower stumpage values, leasing and then harvesting will become the most profitable option when considering a planning horizon of at least 3 years. The financial returns for this management option continue to increase as the time horizon of the investment period increases, reaching a maximum after 32 years before starting to decline. Continuous leasing of red maples will actually become more profitable than long-term timber management when considering a time horizon of 23 years or greater, though it never quite reaches the value that could have been achieved with immediate timber harvesting.

For sugar and red maples, note the stark jump in NPVs once the tree reaches 14" dbh after a planning horizon of ~10 years. At this size, log prices move up a grade and the rise in NPVs reflect this jump in stumpage prices. When considering sawtimber production, the year at which this happens often coincides with maximum financial maturity. After this time period, the property taxes that must be paid are greater than the accrued stumpage value from tree growth and price increases, so the NPV for timber management continually falls as the time horizon increases beyond 10 years. Finally, it is worth noting that this scenario did not include any property tax savings for leasing taps. If it did, the property tax savings would likely result in leasing being the most profitable option in most cases.

Discussion

As seen from the three scenarios discussed above, the most profitable option for managing a maple tree is not always clear. Table 4.3 provides guidelines that can assist foresters and landowners in assessing a particular tree or stand of trees. It outlines the attributes of each variable that dictate whether an individual tree would yield greater profits through leasing taps, immediate timber production, or long-term timber management. However, just because a variable has an attribute that lends itself towards a particular management strategy does not necessarily mean that using the tree for that purpose will yield the greatest profits. Rather, it is the combination of many variables- *and their weight in a particular situation*- that determines the best choice for an individual tree. The many variables involved require careful analysis each time a forester decides how to manage each individual tree within a stand. The most important variables and how they affect the outcome are discussed below.

<u>Species</u>

Since the stumpage prices for red maple are much lower than those for sugar maple, landowners are better off leasing stands with a large component of red maples. The lease payments tend to be the same for sugarbushes that contain a high percentage of red maples, yet the reduction in sawtimber value is much less when tapping red maples. Although sugarmakers prefer to tap sugar maples because of the higher sugar content in the sap, many will tap red maples if they are readily available and accessible. This is especially true among large sugarmakers with reverse osmosis systems that remove ~80% of the water from the sap before boiling.

Tree Diameter

The smaller the initial diameter of the tree, the greater the likelihood that leasing taps will be more profitable than sawtimber management. Small diameter trees have low stumpage values and are able to generate lease payments each year as they mature into sawtimber size. Landowners are usually paid the same lease rate whether a tree is 10”, 14”, or 16” dbh, so it makes more sense to lease smaller trees, capturing an annual payment without worrying as much about reducing sawtimber value.

Extent of Tapping Zone

The lower the height of the taps, the less impact on lumber value loss and stumpage payments one can expect. Landowners may request that a maple producer tap as low as possible, although in some years the snow depth may necessitate high tapping.

Growth Rates

A landowner receives the same lease payment no matter how fast the tree is growing whereas future sawtimber value is highly dependent on the size (and therefore the growth rate) of the tree. Thus, the slower a tree grows, the more likely it is that leasing taps will be more profitable than managing for sawtimber production.

Stumpage Rates

The current and future stumpage rates for maple are highly volatile and largely unpredictable. In these analyses, the real annual percentage change varies between 3 and 5%, based on historical records between 1961-2002 (Wagner and Sendak 2005). Price fluctuations have a strong impact on the timing and level of timber harvest, but it is very difficult to know what will happen to prices over time. Factors that would favor leasing include low current stumpage rates for maple logs and low expectations on future stumpage rate increases.

Log Scale

The three commonly used log scales are Doyle, Scribner, and International ¼”.
Since International ¼” estimates much higher volumes than Doyle or Scribner, using International ¼” favors immediate timber cutting over long term leasing. The Doyle scale is much more likely to favor leasing taps while Scribner also has a slight advantage for leasing versus International ¼”.

Log Quality

The more defects that exist in a tree, in particular the butt log, the more likely that leasing will be a better option. If a tree has veneer potential, the tremendous value of these logs should preclude any landowner from leasing these trees for tapping. However, not all maples will produce high quality sawlogs and often times poorly formed maples with many lower branches yield the greatest amount of sap.

Lease Payments

The higher the lease payment, the greater the likelihood that maple sugaring will be more lucrative than timber management. Also, the rate at which the payment changes over time will affect profitability. Often times the rate is set at ~ $0.50/tap/yr and does not vary over time, but if there is positive inflation, then the real value of the lease payment would fall. There is a greater chance that sawtimber management would be the most profitable option under these circumstances.

Tapping Guidelines

In order to maximize long-term sap production, conservative tapping guidelines suggest 1 tap for a 10-17” tree and 2 taps for trees ≥18” dbh. However, many maple producers will start tapping trees when they are only 6-8”, place a second tap once the trees are 12-14” and put in 3-4 taps on trees that are 18” or greater. Smaller trees will not yield as much sap as larger ones and overtapping will result in long-term declines in sap yield per taphole, but overtapping is unlikely to kill a tree. Thus, from a strictly financial perspective, a landowner should allow a maple producer to be aggressive in their tapping practices. Moreover, since a landowner is usually paid according to the number of taps put in rather than the amount of sap collected, it does not matter as much (to the landowner) how much sap the tree actually produces.

Time Horizon of the Investment Period

The length of time before a landowner plans on harvesting trees and/or selling a piece of property has a profound impact on whether or not it is more profitable to manage for syrup or timber production. If a landowner desires immediate revenues, timber harvesting will almost always be more lucrative, especially when considering trees that could produce high-quality sawlogs or veneer. Because the commercial stumpage value falls as soon as the first tap is placed, a landowner must lease for many years in order to recoup the lost timber value caused by tapping. The longer a landowner is planning on owning a property or waiting until harvesting timber, the more likely it will be that leasing taps will make economic sense.

Discount Rate

The rate used to discount future cash flows to their present values is a key variable of any NPV analysis. Discounting future values is necessary to equalize the revenue streams of leasing taps (a smaller annual payment) versus managing for sawtimber production (a larger one-time payment) over time. Generally speaking, the lower the discount rate, the more profitable leasing will be whereas high discount rates will result in immediate timber harvesting generating the highest returns. The three scenarios discussed in this paper assume that the rate at which future costs and revenues are discounted is the same rate as which current revenues are reinvested, but if these two rates differed the results of any analysis could be drastically altered. Wagner et al. (2003) provide an excellent discussion of the impact of the discount rate versus the reinvestment rate when considering diameter limit cutting. When contemplating tapping or timber production, if reinvestment rates were higher than discount rates, it would make more sense to harvest large trees containing marketable sawlogs immediately. However, for smaller trees that do not yet contain marketable sawlogs, higher reinvestment rates would make leasing of taps more profitable, as the annual lease payments would grow at a faster rate than they were being discounted at.

Property Taxes

In some states, such as New York and Wisconsin, landowners can qualify for reduced property tax payments by producing syrup themselves or leasing taps to another producer. The amount of tax savings will vary greatly depending on the assessed value of the land without agricultural assessment and the tax rate for that municipality. The greater the difference between the regular and reduced tax payments, the more profitable leasing will be. In deciding between leasing taps or timber management, landowners should first check to see if there is a tax advantage in their state for utilizing their maples for syrup production.

Number of Trees per Acre

Conducting the NPV analysis on an individual-tree basis complicates the effect of property taxes, since those are usually calculated on a per-acre or total property basis. Although the number of trees growing on an acre has little to no effect on the overall taxes that are paid on that acre, the density of trees is directly correlated to the taxes paid *on an individual tree*. This has the potential to skew the results when there is a substantial tax savings from utilizing maple trees for syrup production. In these situations, fewer trees per acre result in more drastic differences in property taxes paid on a per-tree basis. However, a landowner will usually pay the same in property taxes for an acre of land whether 100 or 500 trees are growing on that acre. One must realize this limitation, be particularly careful when estimating the number of trees per acre, and adjust the interpretation of results accordingly.

Value of Tapped Logs as a Percentage of Untapped Logs

The value of tapped logs varies considerably in geography and time based on the current markets for standard maple lumber and the niche markets for taphole maple lumber that a particular landowner or sawmill may have. The value could also be influenced by the history of tapping and the knowledge of tapping history that the log buyer possesses. Trees that have only been tapped recently with all plastic spouts are much more desirable than older trees that were tapped with metal spouts and/or used nails to support tubing. It is dangerous and costly for commercial sawmills to process logs that may contain hardware whereas portable bandmills can usually afford to hit metal components on an occasional basis. Due to the large variation in prices that are possible, it is worth the time of landowners to explore all market options for tapped logs before they are sold.

Whether or not the timber versus tapping debate even makes sense is contingent on the assumption that a landowner is giving up significant sawtimber value in the first butt log by tapping. However, the market for taphole maple lumber is growing due to the interesting character and story behind the wood (Figure 4.6), so occasionally market conditions dictate that the price for tapped logs is the same as untapped logs. In these instances "you can have your cake and eat it too", generating annual income from leasing taps while eventually earning the same (or similar) stumpage prices when the trees are harvested. If this were always the case, it would not make sense to compare the two options, as leasing would always generate additional revenue for the landowner without risking a significant loss in stumpage prices.

Conclusion

Rather than providing a definitive answer to the question of whether a landowner will generate greater revenues from leasing taps or harvesting logs, this paper reveals a myriad of factors that influence the outcome for any given tree. The initial tree size and growth rate, species, lease payments, stumpage rates, property taxes, discount rates, and the time horizon of the investment period can all greatly impact the outcome of different management options. Although financial returns are important, there are many other factors that may influence a landowner's decision on what to do with his or her property (Butler 2008). Leasing trees allows a landowner to generate annual income without having to harvest trees and could be a desirable option for landowners that do not want any logging on their property. On the other hand, many landowners place tremendous value on the privacy and aesthetics of their woodlots. They might consider having people hanging tubing and collecting sap in their woodlot as an infringement on their privacy and aesthetically unpleasing. Ultimately it is up to the landowner, under guidance from a forester, to decide what is most desirable for their property. The NPV analysis discussed in this paper provides a mechanism for foresters and landowners to focus on the financial aspects of the decision to utilize maple trees for syrup or sawtimber production.

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Table 4.1 Values for the variables held constant of three hypothetical maple trees used to evaluate the *NPV Calculator*. Note that the delivered log prices shown here are for the top grade log in each size category.

Miscellaneous variables

Effect of tapping on height growth rate (ft/year)[1]	10%
Percent reduction in annual height growth rate[2]	1%
Percent reduction in annual dbh growth rate[2]	1%
Effect of tapping on diameter growth rate[1]	10%
Stumpage rate for cordwood ($/MBF)	20
Payment method ("scaled" or "contract")	scaled
Cost of timber harvesting ($/MBF)	150
Time horizon of investment period (years)	40
Real annual tax payment % increase/decrease	2%
Height of tree affected by tapping (ft)	8

Sawtimber Delivered Log Prices

DBH Range	Untapped Sugar Maple	Untapped Red Maple
less than 10" dbh	80	80
between 10 and 12" dbh	325	160
between 12 and 14" dbh	450	160
between 14 and 16" dbh	550	250
greater than 16" dbh	800	300

Veneer Delivered Log Prices

DBH Range	Untapped Sugar Maple
between 14 and 15"	3100
between 15 and 16"	3600
between 16 and 18"	4600
between 18 and 20"	5600
greater than 20"	6100

1: Based on personal communication with Brian Chabot, February 10, 2011.
2: Adapted from Teck and Hilt (1991)

Table 4.2 Values for the 23 variables that may differ for the three hypothetical maple trees used to evaluate the *NPV Calculator*.

	Scenario 1	**Scenario 2**	**Scenario 3**
Tree Size and Growth			
Initial tree diameter at breast height (inches)	10	18	13
dbh growth rate (inches/year)	0.1	0.15	0.12
Initial merchantable height (ft)	24	32	28
Merchantable height growth of an untapped tree (ft)	0.4	0.25	0.5
Stumpage Payments			
Log scale utilized (Doyle, Scribner, Int'l 1/4")	Doyle	Int'l 1/4"	Int'l 1/4"
Number of grades reduced by defects in butt log	2	0	1
Number of grades reduced by defects in upper logs	2	0	1
Real Annual % increase/decrease in stumpage rate	5%	5%	3%
% of delivered log price the landowner receives	50%	67%	50%
Value of tapped Logs as a % of untapped logs	50%	10%	50%
Butt log market	sawlog	veneer	sawlog
Lease Payments			
Initial annual lease payment ($/tap/year)	$0.50	$0.50	$0.60
Real annual lease payment % increase/decrease	0%	-2%	0%
dbh at which to add the first tap (inches)	10	12	12
dbh at which to add a second tap (inches)	16	18	18
Property Taxes			
Number of trees per acre	250	150	175
Current assessment of forestland ($/acre)	$2,000.00	$1,200.00	$1,000.00
Agricultural assessment for forestland ($/acre)	$278.00	$1,200.00	$1,200.00
Uniform percentage	62%	48%	100%
Property tax payment rate	5%	5%	3%
Financial Variables			
Tapping lease income tax rate	28%	33%	28%
Timber income tax rate	28%	15%	28%
Discount rate	4%	6%	4%

Table 4.3 Attributes of an individual maple tree that make it more conducive for leasing taps, immediate cutting, or long-term sawtimber production.

Variables	Conditions that favor leasing taps	Conditions that favor immediate cutting	Conditions that favor long term timber production
Tree size and quality	small tree (<12" dbh) defects in main stem many lower branches tree has been peviously tapped tree is a red maple	large tree (≥18" dbh) no defects in trunk some dieback visible in top tree has never been tapped tree is a sugar maple	medium size tree (13-16" dbh) no defects in trunk tall straight tree tree has never been tapped tree is a sugar maple
Forest attributes	dense stand of accessible maples large percentage of red maples	maples are widely scattered & not easily accessible	maples are widely scattered & not easily accessible
Tapping method	low height of tapping zone no metal objects used in collection log buyer is familiar with tappers	large height of tapholes/staining metal objects used in collection no knowledge of past practices	large height of tapholes/staining metal objects used in collection no knowledge of past practices
Growth rate	slow growth rate	slow growth rate	fast growth rate
Log scale	Doyle or Scribner	International 1/4"	International 1/4"
Stumpage rates	low current prices for maple low future prices predicted low price difference for tapped logs	high current prices for maple uncertainty on future prices high price difference for tapped logs	low current prices for maple high future prices predicted low price difference for tapped logs
Lease rates	high lease rates above $.50/tap includes annual fee increases	low lease rate no annual increase in lease fees	low lease rate no annual increase in lease fees
Property taxes	tax breaks available for leasing high initial assessment high tax rate	tax breaks available for forestry low initial assessment low tax rate	tax breaks available for forestry low initial assessment low tax rate
Discount rate	low discount rate landowner wants long-term profits	high discount rate landowner needs immediate cash	low discount rate landowner wants long-term profits
Planning horizon	long time horizon	short time horizon	medium time horizon

Figure 4.1 Net present values of four strategies for managing a sugar or red maple tree under Scenario 1.

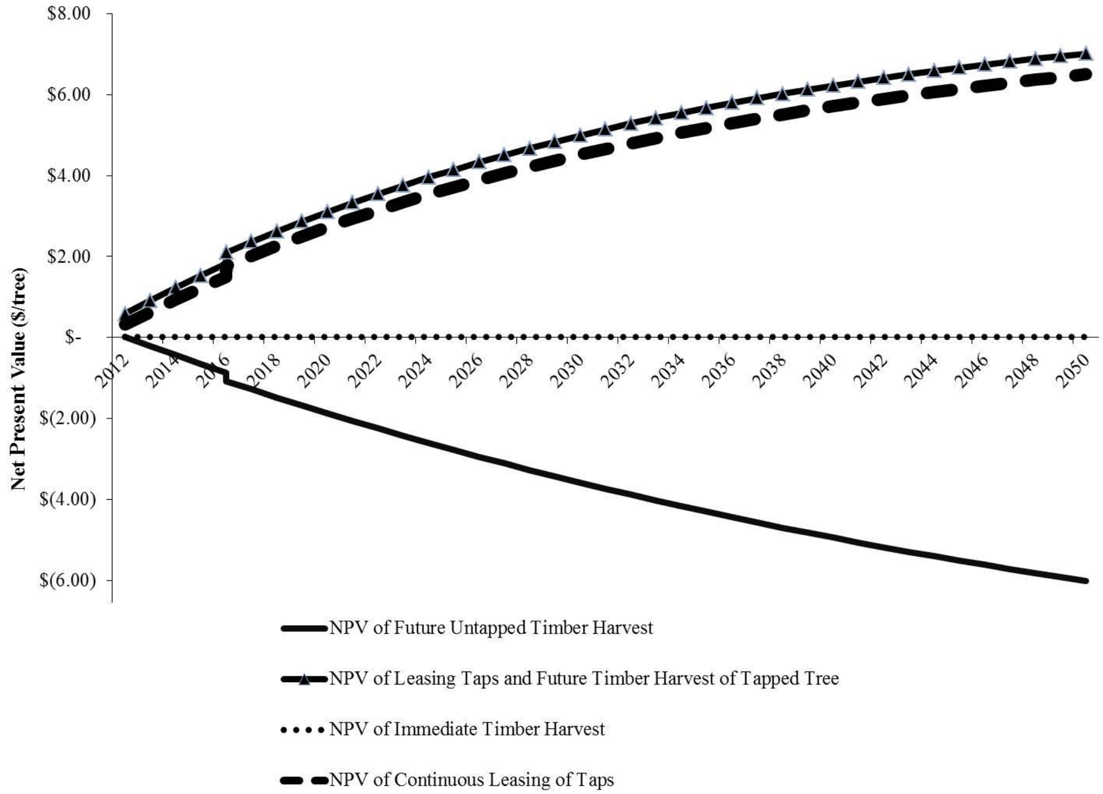

Figure 4.2 Net present values of four strategies for managing a sugar maple tree under Scenario 2.

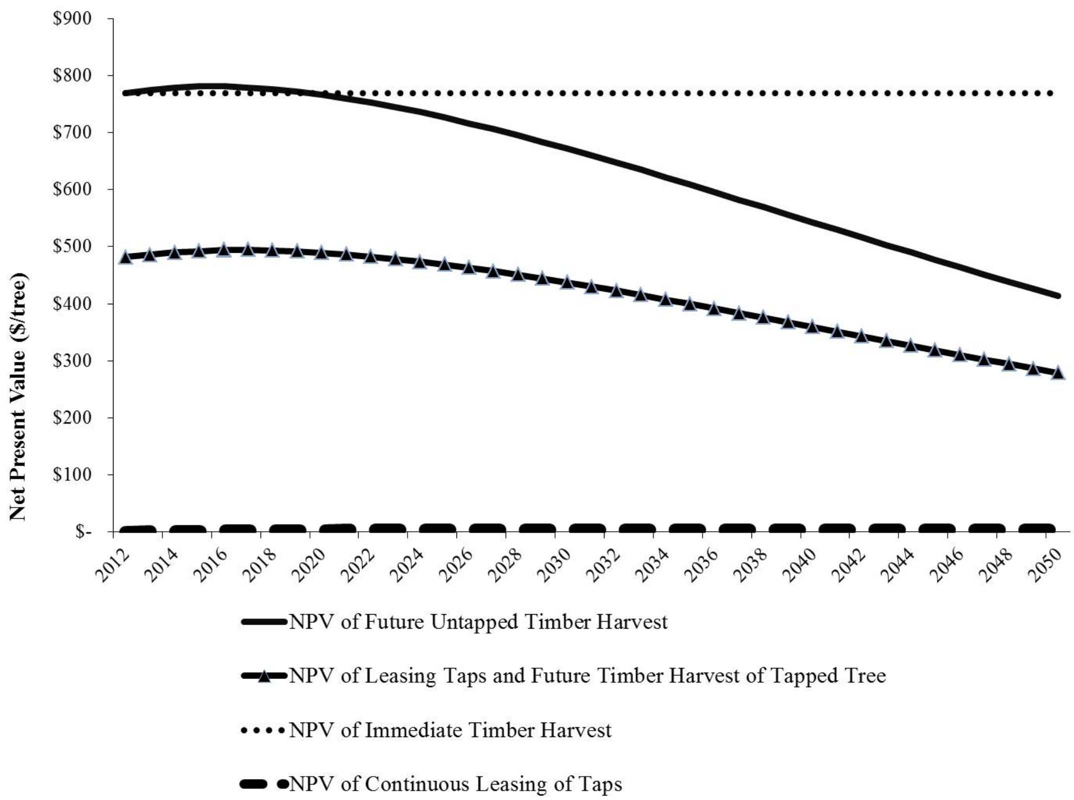

Figure 4.3 Net present values of four strategies for managing a red maple tree under Scenario 2.

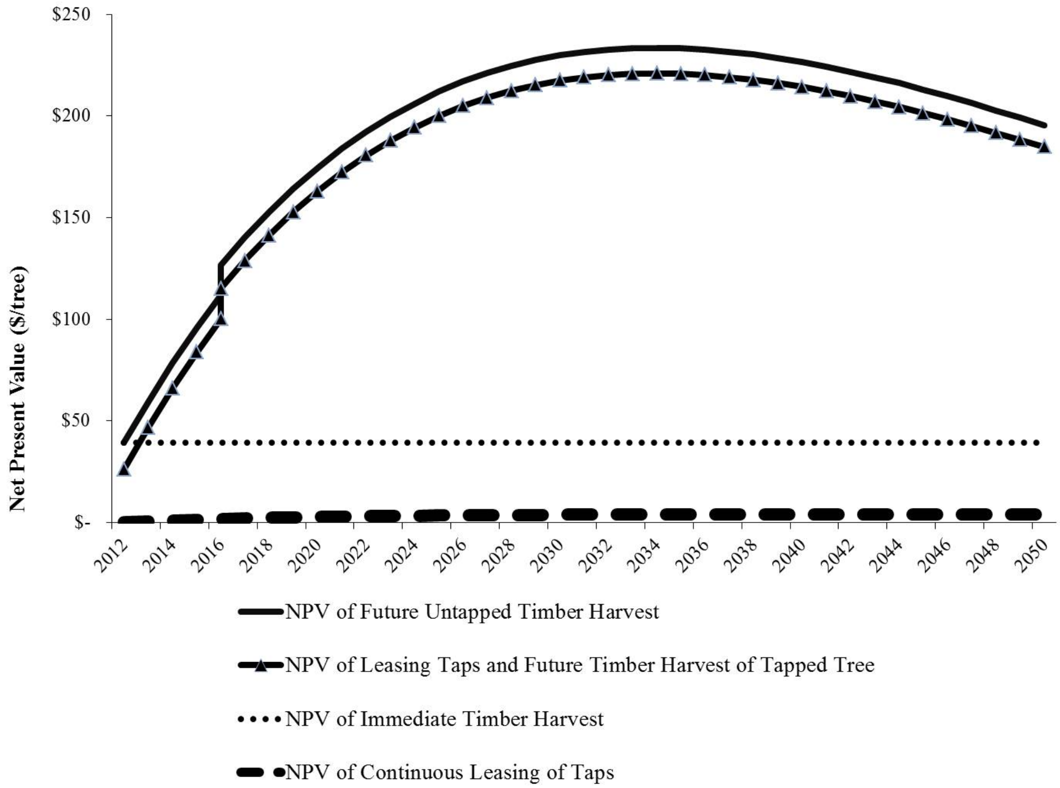

Figure 4.4 Net present values of four strategies for managing a sugar maple tree under Scenario 3.

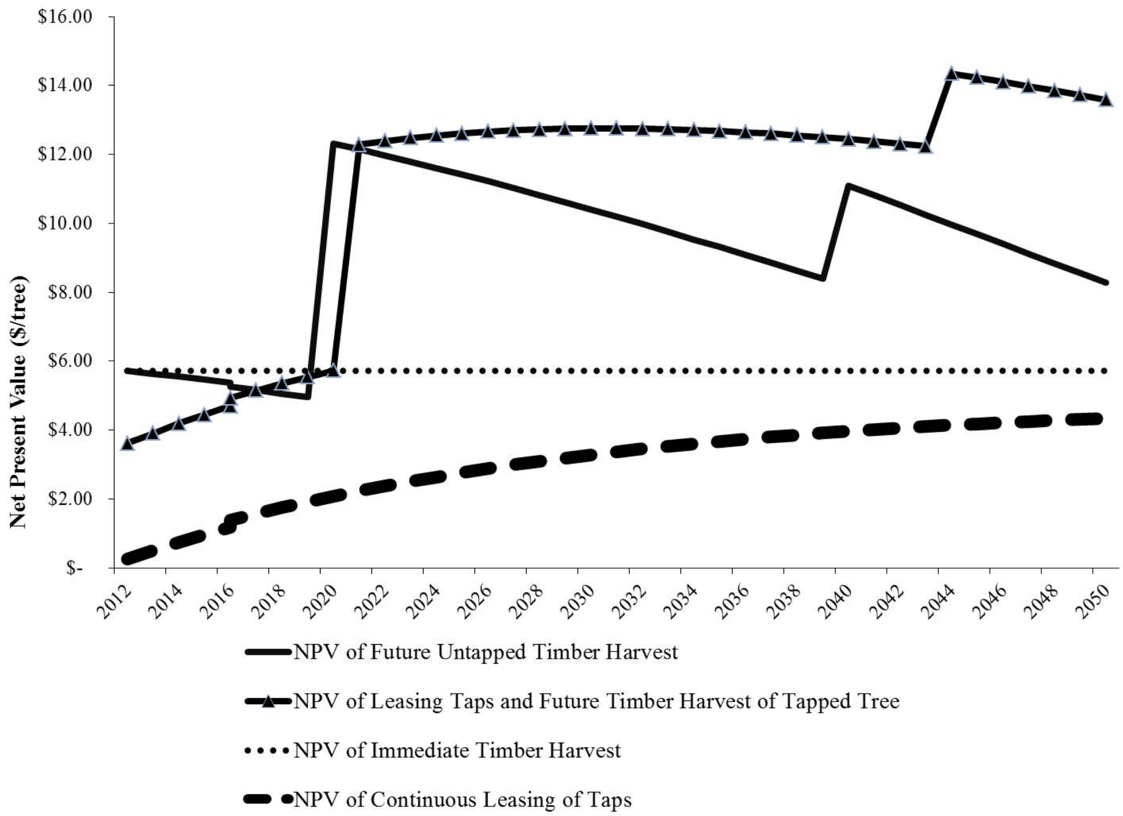

Figure 4.5 Net present values of four strategies for managing a red maple tree under Scenario 3.

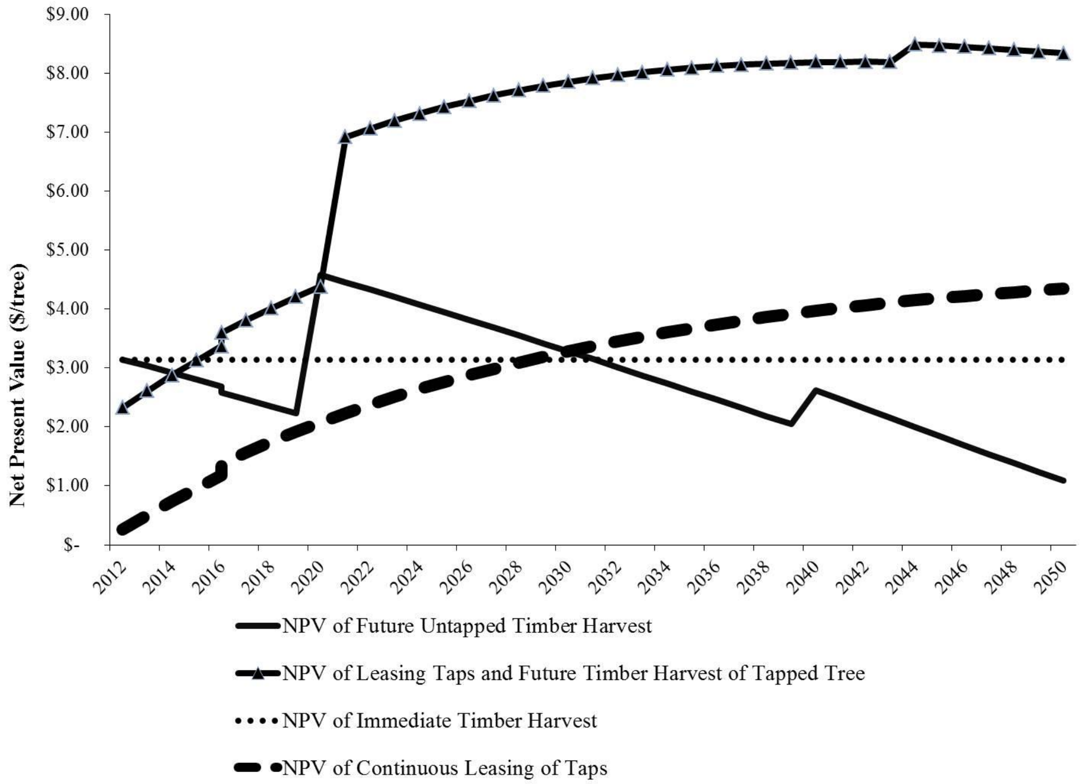

Figure 4.6 A tapped maple log being sawn into boards with a portable bandmill- note the prevalence of old tapholes and the associated stained columns.

Chapter 5: "Are recent trends in maple, beech, oak and hickory abundance in the eastern United States consistent with climate change projections?" [5]

Introduction

As an iconic symbol of the northeast forest, sugar maples (*Acer saccharum*) have long been studied and monitored to assess their status and condition across the landscape. In the 1990s the North American Maple Decline Project was initiated to examine the health of sugar maples and the possible causes of decline and death in certain regions (Allen et al. 1999, Horsley et al. 2002). Extensive research has been conducted in recent decades regarding acid rain, nutrient availability, and other factors that have negatively affected sugar maple health and regeneration (Houle 1990, Payette et al. 1996, Duchesne et al. 2005, St. Clair et al. 2008, Long et al. 2009). Whitney and Upmeyer (2004) chronicled the history of maple sugaring in North America and expressed serious concern about the sustainability of the industry, especially in the wake of global warming. Even though sugar maples have exhibited symptoms of decline and have had trouble regenerating in some regions, red maples (*Acer rubrum*) have proliferated in a wide variety of forest types and are now one of the dominant tree species in the eastern U.S. (Lorimer 1984, Abrams 1998, Alderman 2005, Fei and Steiner 2007).

There has been significant research examining the impacts of climate change on the abundance and distribution of tree species in the U.S. Iverson and Prasad (2002) first reported on the potential shifts in species distributions through their Climate Change Atlas (Prasad and Iverson 1999). Their original work was intended to show where the climate would be most suitable for many species, not necessarily where trees will be found in the future. However, many people

[5] This paper is currently in review at the *Journal of Forestry* with authors M Farrell & B Chabot

ignored the “Word of Caution” statements and assumed that the Climate Change Atlas predicted where species will be found (or not found) by 2100 given a particular climate model. This caused much speculation that sugar maples would largely disappear from the United States and become restricted to Canada by the end of the century.

The New England Regional Assessment Group (Lauten at al. 2001) and the Union of Concerned Scientists (Frumhoff et. al. 2007) both conveyed serious concern about the future of maples in the Northeast and the negative effect climate change would have on industries that rely on sugar maples, including maple syrup, fall foliage tourism, and timber products. These reports predicted that the Northern Hardwood forests of New England and New York, dominated by sugar maples, red maples, and beech (*Fagus grandifolia*), will be replaced by oaks (*Quercus spp*.) and hickories (*Carya spp*.) by the end of the century. The popular media ran with this storyline and its premise has become widely accepted by the general public and many scientists. However, oaks and hickories have had trouble regenerating in existing forests for several decades, raising concerns about the sustainability of these species in future forests (Loftis and McGee 1993, Gribko et al. 2002, Woodall et al. 2008). Furthermore, there is already evidence that many oak-hickory stands are shifting to maple dominated stands in the central hardwood region (Fralish and McArdle 2009, Martin et al. 2011).

Although climatic variables certainly influence the vegetation of a region, there are many other factors besides climate that dictate species abundance and distribution. The most recent work by Iverson et al. (2011) and Matthews et al. (2011) factors in other variables besides climate that can influence species abundance and distribution. The new models include nine biological characteristics and twelve traits relating to disturbances that are expected to increase in a changing climate. With the new models, it appears less likely that maple-dominated forests will be replaced by oaks and hickories at any point in the foreseeable future. Rather than losing suitable habitat, red maples are expected to flourish and expand throughout the northeast. The new and improved model has allowed Iverson et al. (2011) to state that it now "seems plausible that the maple-beech-birch type will persist". Furthermore, by merely adjusting their models to focus on abundance vs. presence/absence data, Iverson et al. (2009) reduced the predicted habitat loss of sugar maples from 90% to 36%.

Beech bark disease (BBD) has been spreading throughout eastern North America over the past century, causing significant changes in forest composition in its wake (Busby and Canham 2011). The ability of beech to tolerate dense shade and reproduce vegetatively through stump sprouting and root suckering has allowed this species to dominate the understory in many stands affected by BBD (Nyland et al. 2006). These traits, combined with the limited browsing of beech by deer and the ability of beech to withstand soils with severe base cation depletion (Duchesne and Ouimet 2009) has caused great alarm that many hardwood forests will convert to "beech thickets" in the future without proper management. Whereas large beech trees are an essential food source for many species of wildlife, dense groves of young beech stems are a serious threat to the ecological health of eastern forests (Nyland 2011).

This paper utilizes U.S. Forest Service FIA (Forest Inventory & Analysis) data to explore recent trends in maple, beech, and oak/hickory distribution throughout the eastern U.S. over the past three decades. If oaks and hickories will replace maples in northeastern forests, then there should be some evidence that this is already occurring. Similarly, if beech trees are forming dense thickets in the understory of many stands, then the number of beech saplings should also be on the rise. A close examination of abundance and distribution for these major species, stratified according to diameter class and forest type, is useful for identifying trends in forest composition over time.

Although there are many tree species growing in eastern forests besides maples, beech, oaks, and hickories, our analyses focus solely on these dominant species for the following reasons. In setting out to do this research, our main objective was to examine the hypothesis that maples will be replaced by oaks and hickories in the northeastern U.S. Thus, we distinguished between sugar and red maple while including all oak and hickory species together. Oak-hickory forest types include a wide variety of species, yet the *Quercus* and *Carya* genera were chosen due to their ecologic and economic significance within this forest-type. Sugar and red maples were analyzed separately because they differ in their economic importance and have different life-history characteristics. We included beech since it is an important species found in both oak/hickory and maple/beech/birch forest types. Although it would have been useful to include other species found within these forest types (*Betula, Prunus, Fraxinus, Populus,* etc.), this was ancillary to our main research objective and not included due to space restraints.

Methods

In order to examine trends in maple, beech, oak, and hickory abundance, we analyzed FIA data for twenty-six eastern states where these species occur in large numbers. The FIA program utilizes a series of fixed plots throughout the U.S. to gather information on various forest attributes (Smith 2002, Bechtold & Patterson 2005). The intensive sampling program first relies on aerial photography and satellite imagery to help determine forest cover. In order for land to be identified as forest, it must be at least 10% stocked with trees, 0.4 ha in size and 36 m wide. In the second phase, over 125,000 permanent fixed area plots, located within a 2,428 ha grid pattern, are sampled annually. Field crews collect a great of information at each plot; for this analysis we utilized the number of live stems by species and 2” diameter class, stratified according to forest type. The field crews identify the forest type based on ocular estimation on site and their values are then checked by program staff at regional offices during data analysis based on species abundance (Woudenberg et al. 2010).

Although the data collection methods do not permit significant analysis on small, localized scales, it is useful in examining larger trends on a landscape scale (Moser et al. 2010). The first inventories took place in the mid-20th century, yet detailed historical data are only available in an electronic form for inventories starting in the 1970s, 80s, or 90s, depending on the state. For this study, we utilized the oldest and most current inventories available electronically for 26 states in the eastern U.S (Table 1) as of March 2012. The average time-frame between surveys is 22 years, a relatively short period in terms of forest succession but long enough to identify trends in species abundance.

Population level estimates were provided by the U.S. Forest Service for the total number of live trees, grouped according to 2” diameter classes, for the most recent survey and oldest survey data for which electronic data was available (USDA Forest Service 2012). Data were aggregated by state, species group, and forest type group (maple/beech/birch and oak/hickory). We tallied population estimates of the number of live trees, grouped according to 2” diameter classes, for sugar maples, red maples, beech, and all oak and hickory species for the initial survey year and the most recent inventory data. In order to analyze trends and relationships between these species, we calculated the change over time in the total number of live trees and the percent change of live trees by diameter class for each species from the oldest to the most recent survey. Due to the way in which the data was tabulated across different states and time periods, it was not possible to calculate whether the changes were statistically significant. However, the standard error for the estimates presented here were very low (Table 2), so one can be confident in the results.

It is important to examine the absolute and percent changes due to the differences in the number of stems for each species and diameter class. Smaller diameter classes have significantly more stems than larger diameter classes, so a change of 1,000,000 live trees may not be at all important in a sapling size class whereas it would be a substantial change in one of the larger sawtimber size classes. Furthermore, there are many more maple stems than oaks and hickories in the maple/beech/birch forest types, and the reverse is also true for oak/hickory forest types. Thus, by examining percent changes, we can gauge how individual species groups are performing in relative terms, as the absolute numbers may not be indicative of meaningful trends.

The forest type groupings we focused on included oak/hickory and maple/beech/birch. There are nine other forest type groups where maples, oaks, hickories, and beech may be found, but they are minor components of these forest types. The maple/beech/birch forest type group includes four forest types that contain a significant percentage of these species whereas the oak/hickory forest type group contains nineteen forest types that include oaks and/or hickories as dominant species. For the purposes of our analyses, we grouped all nine of the other forest type groups in to the "other forest type" category. The stems occurring in these "other forest types" were included when we conducted our analysis for all non-reserved forestland.

Results

Figure 1 displays the percentage of maple/beech/birch, oak/hickory, and all other forest types for twenty-four states in the eastern U.S. With 15% identified as maple/beech/birch and 37% as oak/hickory, more than half of the eastern temperate forest is comprised of these two major forest type groups (thirteen other forest types make up the remaining 47%). Maine, Michigan, New Hampshire, New York, and Vermont are the only states that have more maple/beech/birch than oak/hickory forest types. Although maples, beech, oaks, and hickories are also found in other forest types, the vast majority of the live stems for these species are found within these two major forest types. Our interest is in the success of certain species rather than forest type, but there are significant differences in how species are performing between forest types, so we also stratified the data by forest type.

Rather than providing evidence that oaks and hickories are likely to replace maples in northeastern forests, the data reveal a nuanced and complicated story that seems to disprove this hypothesis. Since this paper only considers sugar and red maples, beech, oaks, and hickories, it cannot explain what is happening for all species across the landscape. However, the data do show interesting changes in the relative abundance of dominant tree species in the landscape. As seen in Figure 1, most states in the eastern U.S. are dominated by oaks and hickories, especially those in the mid-Atlantic and central regions. However, even though oaks and hickories are increasing in sawtimber size trees, their presence in the understory has been falling over time (Tables 2 and 3). Whereas shade-tolerant sugar and red maples are a small part of the overstory in oak/hickory forest types, they make up an increasingly larger portion of the understory. In fact, sugar and red maples appear to be increasing in abundance in oak/hickory forest types even as they are decreasing in abundance within the smallest size classes of maple/beech/birch forest types. For oak/hickory forest types, although the number of oak and hickory saplings has fallen significantly, sugar maples have actually been increasing in all size classes. Of the species we explored, red maples have experienced the greatest overall gains in the sapling size classes and the largest percentage increases in the poletimber and small sawtimber size classes across all forest types in the region. These trends point to increased red maple abundance in coming years, especially within oak/hickory dominated forests. Beech also is expected to play a larger role in the understory as it has undergone the greatest percentage increases in the sapling size classes throughout the region. Beech has been fairly stable in the larger size classes, with the exception of significant decreases in the larger size classes (primarily as a result of BBD in the Northeastern states).

The situation is quite different in the maple/beech/birch forest types. These forest types have experienced significant declines in sugar maple, red maple, and oak/hickory regeneration. Beech trees, not oaks or hickories, are replacing sugar maples in the understory, as there are now over 700 million additional beech trees and nearly 800 million less sugar maples in the 1-2.9" diameter class for these forest types over the past ~22 years. In fact, beech is the only species that has actually increased in abundance within the first four size classes. The opposite trend is seen in the larger size classes, as sugar and red maples are expanding whereas BBD continues to decimate large beech trees in northeastern states. Sugar maple is the only species that has been increasing in every size class above 9" dbh. Red maples have undergone the greatest percentage increases in the small and medium size sawtimber classes, but have fallen in the largest size classes above 21" dbh. Oaks and hickories have experienced the greatest percentage declines in nearly all size classes, with the exception of increases in some of the larger sawtimber size classes.

We also completed these analyses on a state-level basis, but have only been able to present regional analyses in this paper due to space constraints. For a detailed analysis of how maples, oaks, hickories, and beech have fared in 26 states, readers can refer to the appendix for figures depicting the absolute and percent change in number of live trees by diameter class for each state.

Discussion

Trends in species abundance over time

The data presented in this paper seriously challenge the predictions that oaks and hickories will replace maples in northeastern forests within the next century. Although there are some concerns of sugar maple health in certain regions, the larger size classes of sugar maples are currently increasing throughout the eastern U.S. Sugar maple seems to be doing comparatively better in oak-hickory dominated stands along the southern and western edges of its natural range than it is in the sugar maple dominated stands of the Northeast. There are some states that are showing declining sugar maple regeneration, but the pattern seems less related to climate warming than to deer browsing and acid precipitation. Red maple is showing the largest increases across the region, though not everywhere. Larger sized oaks and hickories are increasing as a result of growth of established trees, yet the regeneration of these species has been falling for several decades. Thus the likelihood of maple-dominated forests being replaced by oaks and hickories seems very low.

The fact that sugar maple regeneration has been increasing in the more southerly states currently dominated by oaks and hickories indicates that the problems associated with maple regeneration in the northern states may have little to do with climate change. Since there has been increased sugar maple regeneration in the southern climates and forest types that have been predicted to shift into the northeastern states, climate change in itself should not be the primary concern for the possible loss of sugar maple in the northeast. Rather, there must be other, more important factors that have hindered sugar maple regeneration in the northeast and assisted sugar maple advancement in the oak/hickory forests of mid-Atlantic and central states. Deer browsing is a known problem that may be adversely impacting oaks and hickories more so than maples (Kittredge and Ashton 1995, Long et al. 2007). Acid precipitation has negatively affected sugar maples in many northeastern forests with limited buffering capacity (Juice et al. 2006, Thornton et al. 1986). Better seed dispersal, persistent seedling banks (Marks and Gardescu 1998), and rapid growth rates when light is available (Canham 1985) give maples inherent advantages over oaks and hickories in established forests. Additional research is necessary to determine why sugar maples have performed better in states and forest types where the climate is considered to be not as favorable for its growth. At the interface with spruce-fir forests maples have been expanding their range as climate warming predicts (Beckage et al. 2008). Thus we appear to have a landscape where maples are becoming more abundant.

Since we only analyzed FIA data on non-reserved forestland, all of it has been subject to possible management over the years; it is and will remain an anthropogenic biome (Ellis and Ramankutty 2008). Most forests in the eastern U.S. originated after clearcutting, fire, and agricultural abandonment in the 1800s and early 1900s. Since these practices are uncommon today, regenerating oaks and hickories has become more difficult. There has been considerable research exploring the decline of oak in eastern forests in modern times (Abrams 2003, McWilliams et al. 2002, Fei et al. 2011) and management strategies to increase oak and hickory regeneration (Steiner et al. 2008, Steen et al. 2011). Our analysis does not separate oaks (or hickories) by species, but rather combines all species within the *Quercus* and *Carya* genera. We found that oaks and hickories have seen declining populations of saplings and poletimber in almost every state whereas the population of sawtimber size trees has been increasing throughout the eastern U.S. In comparison to maples, oaks and hickories have experienced more dramatic declines in the sapling size classes and greater increases in the sawtimber size classes. Thus, the immediate outlook for oaks and hickories is positive whereas the long-term trends point to lower populations of these species on the landscape. These circumstances conflict with predictions that maple/beech/birch forests will be overtaken by oaks and hickories in future forests. Although the climate may continue to become more favorable to the growth of established oak and hickory, the ecology of these species, in particular their limited seed dispersal mechanisms and requirement for high light environments for establishment and growth, may prevent their natural spread across a landscape where fire, agricultural abandonment, and clearcutting are much less prevalent (Hart and Buchanan 2012).

Although red maple regeneration is down in maple/beech/birch stands, it has been expanding in the larger size classes and is also quickly becoming one of the dominant species in oak/hickory forest types. Lorimer (1984) first examined the influx of red maple in oak dominated stands in New York and Massachusetts in the 1980s. The trends identified then have continued throughout oak/hickory forest types in the eastern U.S. over the past 30 years. Red maple has experienced the highest percent increase in number of stems across the poletimber and sawtimber size classes and the greatest overall increase in number of stems in the sapling classes. Red maple is an opportunistic, generalist species that is a heavy seeder, prolific stump sprouter, and can perform reasonably well in early successional and late successional stages across a wide variety of environments (Abrams 1998). Fire suppression in eastern forests starting in the 20th century has hastened the presence of red maples in oak/hickory forests. Without any changes in land use, timber harvesting, and fire management practices, it is highly likely that red maple will assume an even more dominant role in future forests.

As our forests have matured and there is less early successional habitat, many states have experienced large declines in saplings of maples, oaks, and hickories (in addition to other species). Large, forested states, such as Michigan, New York, and Pennsylvania, have experienced some of the most dramatic declines in this regard. This is part of a larger trend of regeneration problems in forests throughout eastern North America resulting from the overabundance of deer, invasive species, the lack of proper silvicultural management, and other factors unique to certain species (Loftis and McGee 1993, Matonis et al. 2011, Didier and Porter 2003). If these trends continue, it is unclear what the future composition of forests will be. This paper only examines maples, beech, oaks, and hickories, and, with continued depression of smaller size classes, it is certainly possible that other species could replace these species in eastern forests. However, this is likely to be hundreds of years in the future. The long life span of maples, oaks, and hickories, combined with the existing populations of smaller trees beyond deer browse height suggest the continuing presence of these species for several hundred years. The rapid removal of ash (*Fraxinus spp*.) by the emerald ash borer (*Agrilus planipennis*) is creating an opportunity for increases of the species studied here, or possibly non-native invasive species (Knight et al. 2011). Given the ever-changing nature of forest ecosystems, we recommend that these analyses be carried out again in 5-10 years once more data is available. Future research should also carry out these same analyses for all tree species.

Implications for forest management in the eastern U.S.

Iverson et al.'s (2011) revised models and our analyses suggest that sugar and red maples will continue to occupy an important role in eastern forests for the foreseeable future. However, the reduced number of sugar maple saplings in maple/beech/birch forest types is a cause for concern. Given the promising results of liming on sugar maple growth and regeneration, forest managers should seriously consider making this investment in stands located on acidic and base-poor soils that are subject to acid precipitation (Long et al. 2011, Moore et al. 2012)

Given the increasing abundance of sugar and red maples in the mid-Atlantic and central regions, it would be worthwhile to evaluate the potential for maple syrup production in these states. The data show that maple trees can thrive in southerly states, yet we do not know if the climate is suitable to yield economically viable levels of sap flow. Since the Northeast is expected to inherit a climate similar to that of Kentucky or West Virginia by the end of the century, conducting research in these states could help forecast what the Northeastern maple syrup industry will be like in the future.

Oaks and hickories are still the dominant species throughout much of the eastern deciduous forest, yet there are long-term concerns about their persistence and viability on the landscape. Without deliberate management to encourage regeneration of oaks and hickories, this paper reinforces the concern that their presence will be severely diminished in future forests. With increased attention on this problem and established solutions that are silviculturally appropriate (Steiner et al. 2008, Brose et al. 2008, Steen at al. 2011), foresters and landowners who wish to regenerate oak can do so. However, more foresters and landowners must implement these principles in order to keep oaks and hickories as dominant in future forests as they are today. Although beech is rapidly expanding in understories of eastern forests that have been impacted by BBD, there are remedies that foresters and landowners can take to halt its spread. Conventional cutting, especially during the dormant season, usually exacerbates the problem as sprouting from stumps and root systems results in many more stems than were present before cutting (Nyland et al. 2006, Wagner et al. 2010). However, extensive research starting in the 1980s has shown that applying herbicides to stumps when harvesting can be a cost-effective way to reduce the abundance of beech in a stand (Wendel and Kochenderfer 1982, Horsley and Bjorkbom 1983, Kochenderfer et al. 2004). For situations where chemical treatment is not an option, there a variety of mechanical controls that may work, including flame weeding (Ostrofsky 2004), girdling (Nyland 2004), and goat browsing (Smallidge 2003), and repeated cutting (Smallidge and Nyland 2009). Given the multitude of options available, foresters must be proactive and utilize the appropriate treatment in order to control beech saplings and enhance the regeneration of desirable species.

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Table 5.1 Date of the initial (Ti) and most recent (Tr) FIA survey for each state.

State	Initital Survey (Ti)	Recent Survey (Tr)	Years between surveys
Arkansas	1988	2009	21
Connecticut	1985	2008	23
Delaware	1986	2008	22
Georgia	1982	2009	27
Illinois	1985	2008	23
Indiana	1986	2009	23
Iowa	1990	2008	18
Kentucky	1988	2008	20
Maine	1995	2008	13
Maryland	1986	2008	22
Massachusetts	1985	2008	23
Michigan	1980	2009	29
Minnesota	1977	2009	32
Missouri	1989	2009	20
New Hampshire	1983	2008	25
New Jersey	1987	2008	21
New York	1993	2008	15
North Carolina	1984	2007	23
Ohio	1991	2008	17
Pennsylvania	1989	2008	19
Rhode Island	1985	2008	23
Tennessee	1980	2009	29
Vermont	1983	2008	25
Virginia	1985	2008	23
West Virginia	1989	2008	19
Wisconsin	1983	2008	25

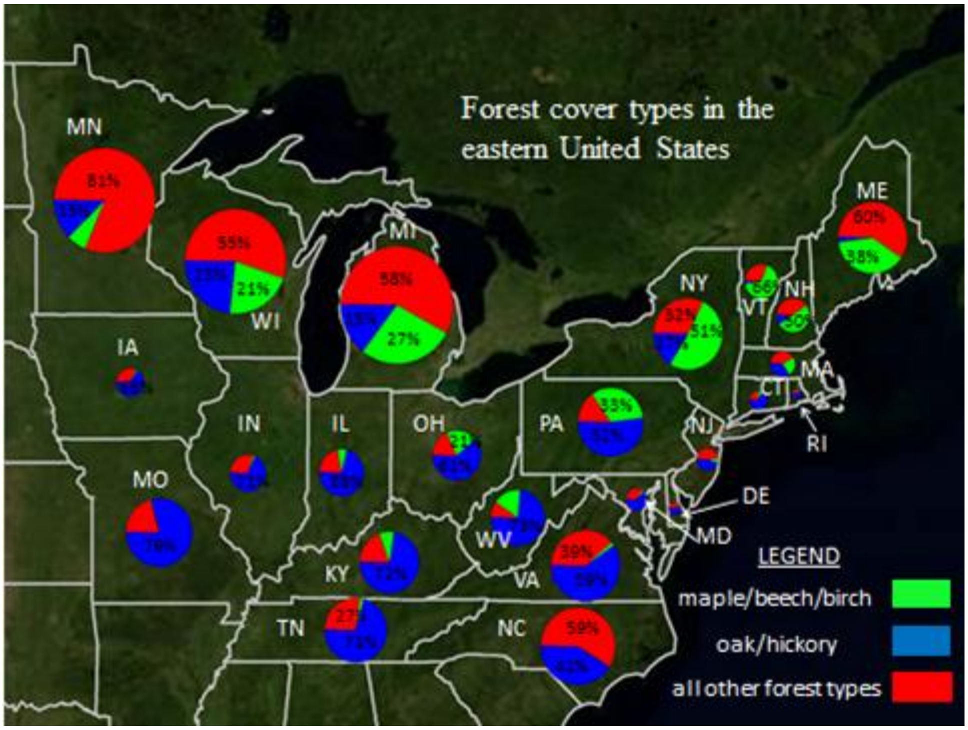
Table 5.2 Number of lives trees (in millions) and standard errors for these estimates by diameter class for the initital (Ti) and most recent (Tr) survey periods. Data is aggregated for 26 eastern states and is stratified according to species and forest type.

			diameter at breast height (dbh) category											
Forest Type	Survey Period	Species	1-2.9"	3-4.9"	5-6.9"	7-8.9"	9-10.9"	11-12.9"	13-14.9"	15-16.9"	17-18.9"	19-20.9"	21-28.9"	29.0+"
			number of live trees (in millions) with standards errors to the right											
all non-reserved forestland	Initial (Ti)	beech	2,531.1 2.9%	630.0 4.0%	305.8 2.8%	183.2 2.8%	119.9 2.8%	76.4 2.9%	50.8 3.0%	31.7 3.3%	21.8 3.5%	13.6 4.0%	18.6 3.5%	3.0 6.9%
	Recent (Tr)		3,729.4 2.1%	834.9 2.9%	326.9 2.0%	192.8 2.3%	116.2 2.5%	71.3 3.0%	48.5 3.3%	30.3 4.0%	19.3 4.8%	11.9 5.8%	17.4 5.0%	2.2 12.8%
	Initial (Ti)	oak/hickory	10,431.1 1.1%	4,363.4 1.3%	3,027.4 0.9%	2,132.4 0.8%	1,472.7 0.8%	973.2 0.8%	627.5 0.8%	390.7 0.9%	221.6 1.1%	119.4 1.2%	141.1 1.2%	18.5 2.5%
	Recent (Tr)		10,186.3 1.3%	3,602.8 1.4%	2,158.2 0.8%	1,691.1 0.8%	1,351.5 0.8%	1,032.0 0.8%	763.3 0.9%	514.8 1.0%	319.6 1.2%	189.8 1.6%	231.8 1.5%	31.8 3.5%
	Initial (Ti)	red maple	10,678.4 1.3%	3,321.3 1.7%	1,614.1 1.2%	914.4 1.3%	492.0 1.4%	269.0 1.6%	142.9 1.8%	73.8 2.1%	37.3 2.6%	19.6 3.3%	21.8 3.2%	2.8 7.1%
	Recent (Tr)		11,848.6 1.3%	3,441.4 1.6%	1,674.1 0.9%	1,064.0 1.0%	661.8 1.1%	395.7 1.3%	225.4 1.6%	119.5 2.1%	62.0 2.8%	32.4 3.7%	31.5 3.8%	2.9 11.6%
	Initial (Ti)	sugar maple	5,239.1 1.8%	1,694.6 2.1%	824.2 1.5%	506.0 1.6%	301.8 1.7%	180.0 1.9%	109.2 2.0%	64.8 2.3%	35.4 2.6%	20.0 3.4%	24.1 3.4%	4.2 7.6%
	Recent (Tr)		5,121.7 1.6%	1,609.1 1.9%	796.3 1.2%	552.2 1.3%	390.1 1.4%	247.7 1.6%	152.0 2.0%	87.4 2.4%	45.5 3.0%	23.9 4.1%	28.7 4.0%	4.6 9.6%
maple/beech/birch	Initial (Ti)	beech	1,629.5 3.8%	431.5 5.0%	211.8 3.5%	129.2 3.5%	83.5 3.5%	51.3 3.7%	32.5 3.9%	19.6 4.4%	12.2 4.9%	7.2 5.5%	8.0 5.5%	1.0 12.6%
	Recent (Tr)		2,346.9 2.9%	541.2 3.8%	214.7 2.6%	132.8 2.9%	79.1 3.2%	48.2 3.8%	29.7 4.4%	18.1 5.4%	10.4 6.5%	5.7 8.4%	7.1 8.1%	1.0 19.1%
	Initial (Ti)	oak/hickory	365.6 5.3%	130.4 6.8%	91.9 4.1%	74.0 3.5%	54.0 3.3%	40.6 3.1%	27.3 3.3%	17.9 3.6%	10.9 4.0%	6.2 4.6%	7.6 4.1%	1.3 7.4%
	Recent (Tr)		267.5 5.8%	86.6 7.7%	60.8 4.0%	45.8 4.0%	41.7 3.9%	37.2 4.0%	29.5 4.1%	20.7 4.5%	13.8 5.7%	8.3 7.2%	8.8 7.0%	1.5 16.7%
	Initial (Ti)	red maple	1,962.9 3.7%	850.3 3.6%	497.2 2.5%	348.0 2.4%	206.6 2.5%	116.3 2.6%	64.8 2.9%	32.6 3.5%	16.3 4.2%	8.8 5.1%	9.9 5.3%	1.4 10.6%
	Recent (Tr)		2,147.8 3.6%	809.4 3.7%	435.5 2.1%	329.6 2.0%	229.4 2.0%	151.5 2.3%	88.6 2.8%	45.4 3.5%	23.6 4.7%	11.3 6.3%	9.3 7.1%	1.0 20.1%
	Initial (Ti)	sugar maple	3,117.5 2.3%	1,147.8 2.5%	591.5 1.8%	389.6 1.9%	237.5 2.0%	145.4 2.2%	89.6 2.3%	53.0 2.6%	29.1 3.0%	16.5 3.9%	20.1 3.9%	3.5 8.7%
	Recent (Tr)		2,724.8 2.4%	964.2 2.6%	526.0 1.6%	402.2 1.6%	299.9 1.7%	198.4 1.9%	123.4 2.3%	71.1 2.7%	37.5 3.3%	19.7 4.5%	24.1 4.4%	4.0 10.3%
oak/hickory	Initial (Ti)	beech	674.2 5.1%	161.4 7.9%	73.2 5.3%	42.1 5.4%	28.7 5.1%	20.3 5.1%	15.6 5.0%	10.5 5.4%	8.5 5.4%	5.7 6.2%	9.5 4.8%	1.9 8.6%
	Recent (Tr)		992.1 3.5%	223.4 5.3%	86.8 3.3%	48.1 4.0%	30.9 4.7%	19.2 5.2%	16.4 5.4%	10.9 6.5%	8.0 7.4%	5.8 8.3%	9.3 6.7%	1.0 18.6%
	Initial (Ti)	oak/hickory	6,378.4 1.5%	3,093.3 1.6%	2,270.0 1.1%	1,666.7 1.0%	1,182.1 1.0%	792.1 0.9%	514.6 1.0%	320.2 1.1%	179.1 1.3%	95.9 1.4%	110.5 1.4%	13.5 3.0%
	Recent (Tr)		5,896.5 1.7%	2,479.7 1.8%	1,616.9 1.0%	1,357.0 1.0%	1,118.0 1.0%	866.1 1.0%	648.2 1.0%	438.8 1.2%	272.5 1.4%	160.8 1.7%	193.7 1.6%	25.0 4.0%
	Initial (Ti)	red maple	4,071.4 2.2%	1,229.5 2.8%	544.4 2.2%	268.6 2.3%	140.9 2.6%	80.6 2.8%	41.2 3.2%	20.7 3.7%	10.9 4.6%	5.7 5.7%	6.0 5.4%	0.6 12.0%
	Recent (Tr)		4,541.8 2.0%	1,469.3 2.3%	697.2 1.4%	427.0 1.6%	253.6 1.8%	146.2 2.1%	85.6 2.7%	46.2 3.3%	24.1 4.4%	13.3 5.7%	13.9 5.7%	1.4 17.0%
	Initial (Ti)	sugar maple	1,520.1 3.4%	375.7 5.1%	158.1 3.3%	82.4 3.6%	46.0 3.8%	25.2 4.1%	15.4 4.6%	8.8 5.1%	4.7 6.1%	2.8 7.4%	3.0 6.6%	0.4 13.0%
	Recent (Tr)		1,830.3 2.5%	511.0 3.5%	215.4 2.2%	121.1 2.4%	72.9 2.8%	40.2 3.5%	23.6 4.4%	13.6 5.5%	6.5 7.4%	3.3 10.5%	3.6 10.6%	0.4 30.9%

Table 5.3 Absolute and percent difference in the number of lives trees (in millions) by diameter class for the initital (Ti) and most recent (Tr) survey periods. Data is aggregated for 26 eastern states and is stratified according to species and forest type.

		diameter at breast height (dbh) category																							
Forest Type	Species	1-2.9"		3-4.9"		5-6.9"		7-8.9"		9-10.9"		11-12.9"		13-14.9"		15-16.9"		17-18.9"		19-20.9"		21-28.9"		29.0+"	
		absolute and % difference in the number of live trees (in millions) from initial (Ti) to most recent (Tr) survey period																							
all non-reserved	beech	1,198.3	47%	204.9	33%	21.1	7%	9.5	5%	(3.8)	-3%	(5.1)	-7%	(2.3)	-5%	(1.4)	-5%	(2.6)	-12%	(1.7)	-13%	(1.1)	-6%	(0.8)	-27%
forestland	oak/hickory	(244.8)	-2%	(760.6)	-17%	(869.2)	-29%	(441.3)	-21%	(121.2)	-8%	58.8	6%	135.9	22%	124.1	32%	97.9	44%	70.4	59%	90.6	64%	13.3	72%
	red maple	1,170.3	11%	120.1	4%	59.9	4%	149.6	16%	169.8	35%	126.7	47%	82.5	58%	45.6	62%	24.8	66%	12.8	66%	9.7	44%	0.03	1%
	sugar maple	(117.4)	-2%	(85.5)	-5%	(27.8)	-3%	46.2	9%	88.3	29%	67.7	38%	42.8	39%	22.6	35%	10.1	28%	3.9	19%	4.6	19%	0.4	8%
maple/beech/birch	beech	717.4	44%	109.7	25%	2.9	1%	3.5	3%	(4.5)	-5%	(3.1)	-6%	(2.7)	-8%	(1.6)	-8%	(1.8)	-15%	(1.5)	-21%	(0.9)	-11%	0.02	2%
	oak/hickory	(98.1)	-27%	(43.8)	-34%	(31.1)	-34%	(28.2)	-38%	(12.3)	-23%	(3.4)	-8%	2.3	8%	2.8	16%	2.9	26%	2.0	33%	1.2	16%	0.2	12%
	red maple	184.9	9%	(41.0)	-5%	(61.8)	-12%	(18.3)	-5%	22.8	11%	35.2	30%	23.9	37%	12.7	39%	7.3	45%	2.5	29%	(0.5)	-5%	(0.4)	-29%
	sugar maple	(392.7)	-13%	(183.5)	-16%	(65.5)	-11%	12.6	3%	62.4	26%	53.1	37%	33.9	38%	18.0	34%	8.4	29%	3.2	20%	4.1	20%	0.5	13%
oak/hickory	beech	317.9	47%	62.0	38%	13.6	19%	6.0	14%	2.1	7%	(1.0)	-5%	0.8	5%	0.5	4%	(0.6)	-6%	0.1	2%	(0.2)	-2%	(0.9)	-46%
	oak/hickory	(481.8)	-8%	(613.6)	-20%	(653.1)	-29%	(309.7)	-19%	(64.0)	-5%	74.0	9%	133.7	26%	118.6	37%	93.4	52%	64.9	68%	83.2	75%	11.6	86%
	red maple	470.3	12%	239.8	20%	152.8	28%	158.4	59%	112.7	80%	65.7	81%	44.4	108%	25.5	123%	13.1	120%	7.6	133%	7.9	133%	0.8	132%
	sugar maple	310.2	20%	135.3	36%	57.3	36%	38.8	47%	26.9	59%	15.0	60%	8.3	54%	4.8	54%	1.8	38%	0.5	18%	0.6	19%	(0.04)	-10%

Figure 5.1 Forest cover types in the eastern United States



Chapter 6: The impact of public policies on the U.S. maple industry

My research into the tapping potential for the U.S. revealed wide differences in the percentage of available trees tapped for syrup production in each state. Remarkably, with only 5% of the potentially tappable trees, Vermont is able to produce 40% of all the maple syrup in the U.S. (USDA NASS 2012). Michigan, New York, and Pennsylvania all have close to 300 million potential taps, much more than Vermont's ~100 million. However, the utilization rate in Vermont is roughly 3%, well above any other state. New York's utilization rate of 0.6% is nearly three times the rate in Michigan and Pennsylvania, each at 0.2%. Consequently, New York usually places second in syrup production whereas Michigan and Pennsylvania are often ranked between 6^{th} - 8^{th} in total syrup output. Conducting research on Canada's maple industry revealed even greater differences in utilization of the maple resource, as producers in Quebec utilize approximately 35% of their potential sugarbushes (MRN Rapport 2000). Even though they have far fewer maples trees than the U.S., Quebec produces roughly 80% of all the syrup each year. Quebec and Vermont dominate the maple industry not because they have the most maple trees, but rather because they have been able to utilize a much greater percentage of their trees for syrup production. Thus, in order to determine why utilization rates differ so much between various states and provinces, this chapter examines differences in public policies and their effects on the development of the maple industry.

There are limits to the effects of public policies (Brooks 2010) and likely a wide array of social, cultural, and economic factors that affect development of the maple industry. Private producers and organizations have also played a key role in shaping the maple industry throughout North America. Nevertheless, public policies have also helped create the disparities in tree utilization and syrup production between different states and provinces. There are many ways that the public sector can support or discourage development in the private sector. This chapter explores various aspects of how government policies have influenced maple production in selected states and provinces. In particular, I discuss differences in government resources devoted to the maple industry in research, extension, and promotion, policies for tapping on public land, cost-sharing programs, grants, and property tax programs that encourage syrup production. Much of the chapter is focused on New York, Vermont, Maine, and Quebec, since this is where the vast majority of syrup is produced. There is also some discussion of the U.S. Federal Government and other states that have devoted public resources towards maple production . Finally, I provide a brief overview of the policies that have helped propel Quebec to the forefront of the maple industry and are now encouraging expansion of the industry elsewhere.

It is worth noting that this is an initial, incomplete assessment of the effect of public policies on the North American maple industry. The purpose of this chapter is to document some of the types of public interventions that have been intended to support maple sugar production. Future research will provide a more systematic comparison among the many states and provinces that have significant maple industries and will examine how impacts might be assessed.

Methods

My research for this chapter consisted primarily of literature review and interviews with leaders in the maple industry. The literature review consisted of historical texts, state and federal policy documents, and other articles containing information on public policies relevant to the maple syrup industry. Interviews were conducted with a wide array of industry leaders, including state officials, officers of maple producer organizations, business owners, and research and extension personnel. Findings were organized according to the state, province, or federal government in which the policies originated. The remainder of this chapter outlines the major policy initiatives and actions on a state, federal, and provincial basis.

New York

As the land grant university responsible for agricultural research and extension, Cornell University has made significant investments in the maple industry over the years. In the early 1900s, professors in the College of Agriculture and Life Sciences started conducting applied research and extension for the maple industry (Rasmussen et al. 1928). Professors Robert Morrow and Fred Winch were most active during the 1950s-1970s and both earned places in the North American Maple Hall of Fame for their work in helping the maple industry develop. Their efforts played a critical role in making NY the leader in maple production in New York in the 1960s (Bill Clark, pers. comm, October 29, 2012). Although some research had been carried out at Cornell's Arnot Forest for many years, in 1965 Cornell enhanced its maple program with the development of a 200-acre property in Lake Placid, NY devoted entirely towards research and extension for the maple industry. The land was donated by Henry Uihlein II, and ever since Cornell has maintained the Uihlein Sugar Maple Research & Extension Field Station. As one of only two dedicated maple research centers in the U.S., many developments in the industry were tested and evaluated at this facility over the years. Research efforts also expanded at the Arnot Forest in recent years with the appointment of Steve Childs as the NYS Maple Specialist in Ithaca. The research and extension activities originating from the Uihlein and Arnot Forests have benefitted maple producers not only in New York, but throughout the eastern U.S. and Canada.

Following the retirement of long-time Director Lew Staats in 2001, the Uihlein Forest and the entire Cornell Maple Program was almost shut down as part of restructuring within the Department of Natural Resources. However, based on the appeals from maple producers to Dean Susan Henry, the College changed course and decided to make significant investments in the maple industry. In 2004, Dean Henry recruited Brian Chabot, an experienced professor and administrator in the College to serve as Director of the Cornell Maple Program. Dr. Chabot became responsible for overseeing all maple related research and extension efforts for Cornell throughout the state. He organized an advisory group made up of prominent maple producers and worked with them to develop a strategic plan to guide the re-development of a research and extension program in the college. In October 2004, Steve Childs was hired as the New York State Maple Specialist based out of Ithaca and, in 2005, Michael Farrell was hired as Director of The Uihlein Forest in Lake Placid. Peter Smallidge, the New York State Extension Forester for Cornell, was also recruited to focus 20% of his efforts on research and extension for the maple industry. The Cornell Maple Program was re-invigorated and has helped drive the increased production and sales of maple products in New York State ever since. With the assistance of extension educators in various counties, the Cornell Maple Program now sponsors dozens of workshops, webinars, maple schools and other educational programs throughout the state each year. As a testament to its importance for the maple industry, the Cornell Maple Program received the Richard G. Haas Distinguished Service Award from the North American Maple Syrup Council in 2011 "in recognition and gratitude for outstanding contributions in the advancement of the industry through many years of research and education in the maple syrup industry".

Although government officials have generally been supportive of the maple industry in New York, they started taking more initiative to enhance production and sales over the past 7 years. Since 2005, the state legislature appropriated between $100,000-$150,000 as a line-item in the state budget in order to assist with organizational and market development. The New York State Maple Producers Association (NYSMPA), a trade group for the industry comprising approximately 500 producers, receives the funding each year. Among other things, the money has been used to hire a full time Executive Director to manage the organization and oversee all aspects of maple syrup promotion and marketing for the state, including the signature Maple Weekend activities every March. Prior to receiving this funding, the NYSMPA had relied on all volunteer labor and thus had not been nearly as active or influential.

In 2006 the NYSMPA also received $275,000 in state funding to renovate their booth at the State Fairgrounds in Syracuse. Since the renovations, sales of maple products during the fair have nearly doubled (Helen Thomas, pers. comm, Oct 1, 2012). As a result, residents and visitors to New York have been exposed to a greater variety of maple products, including maple cream, maple candies, maple cotton candy, maple soda, and maple ice cream. Producers now have an excellent venue to sell their products and the revenue generated helps support the promotional activities of the NYSMPA. This investment will pay large dividends for many years to come.

In 2009 The NYS Department of Agriculture & Markets (DAM) created a Maple Task Force to explore ways that the state government could assist in developing the maple industry (Campbell 2009). A dozen sugarmakers and representatives from the NYSMPA met on a quarterly basis to share ideas with state officials. The final report highlighted several areas that have been addressed in recent years with the most important ones described as follows:

(1) Developing a brand for pure New York maple syrup

With funding from DAM, NYSMPA was able to partner with a marketing firm to develop the "Taste the Tradition: New York Maple" brand and associated logos. This process has helped build the image of maple production in New York and has facilitated entry of NYS maple syrup into large grocery chains such as Wegmans.

(2) Developing and implementing new policies for tapping on state forestland

DAM helped facilitate conversations between the NYS Department of Environmental Conservation (which manages state forestland) and the Governor's office to overcome previous obstacles for the DEC to lease forestland for tapping. The DEC has developed new guidelines and has recently sent out a public bid notice for leasing taps on selected parcels of state forestland in Dutchess County (NYS DEC 2012). This is a pilot project that could expand to many others parcels if deemed successful.

(3) Revising building codes for sugarhouses

There has been ambiguity on building codes for sugarhouse, as these are usually considered agricultural buildings but are sometimes viewed as manufacturing or commercial structures. Under the existing law, agricultural buildings cannot allow for public visitation or processing, causing potential issues for sugarmakers. As one of the Task Force outcomes, NYSMPA leadership worked with state officials to revise the building codes to allow for agritourism activities at sugarhouses and to clearly define sugarhouses as agricultural buildings with their own set of standards (Mike Hill, pers. comm. October 16, 2012).

Although the DEC is just starting to implement tapping leases on limited parcels of state forestland, it is important to realize that approximately 25% (75 million) of all the potentially tappable maple trees growing in New York are legally prohibited from tapping. The Adirondack and Catskill Forest Preserves are guided by the "forever wild" clause of the New York State Constitution which prohibits any tapping of maple trees on these lands. Since it would require a constitutional amendment to open the Forest Preserve lands to tapping, this seems highly unlikely within the foreseeable future. Thus, as a matter of public policy, New York State has effectively reduced its syrup production potential by 25%. For the state with the largest resource of tappable maple trees, this is a significant policy directive.

Even though the state has historically discouraged syrup production on public lands, it has greatly encouraged maple sugaring activities on private lands through the agricultural assessment program. Wisconsin and Minnesota are the only other states that specifically provide tax breaks to landowners who utilize their woodland for syrup production. Property taxes are particularly high in many places within New York, yet if a landowner produces maple syrup or leases their woodland to another sugarmaker, they may be able to qualify for an agricultural assessment that significantly reduces their annual tax burden. Our survey research of New York landowners found that 24% would be very likely and 33% somewhat likely to utilize their woodland for syrup production if they could receive a tax break for doing so (Farrell and Stedman 2009). Although we have not yet conducted any formal research on the percentage of landowners who are aware of the agricultural assessment program, my experiences in working with landowners and maple producers suggests that this number is very low. When landowners do find out about agricultural assessment, they are often eager to start producing maple syrup themselves or lease their sugarbush to another producer. In fact, agricultural assessment provided the impetus for one of the largest sugaring operations to be recently developed in New York. Agricultural assessment also presents a large incentive for landowners to lease their properties for tapping, as the savings on property taxes are usually much higher than the lease payment given by the maple producer. Further research is necessary to quantify the potential impact of the agricultural assessment program on maple syrup production in New York.

Educational institutions can have a large impact on private industry, even outside of the university system, as evidenced by the programs at the Vernon-Verona-Sherrill (VVS) High School. Under the leadership of their FFA advisor Keith Schiebel, they have developed their own innovative maple sugaring program that not only educates their own students about sugaring, but also the greater maple community. Their signature NYS Maple Conference now draws in nearly 1,000 people each January and serves as the premier educational event for the maple industry. Keith and FFA students organize conference logistics and Steve Childs organizes the educational programs. Dozens of speakers and vendors come to share the latest in maple syrup production technologies and ideas with producers throughout the eastern U.S. Although there are other smaller maple schools throughout the state and other FFA programs that focus on maple production, nothing compares to the size and scope of the VVS program.

With assistance from Bill Magee (Agriculture Committee Chair for the NYS Legislature), the VVS FFA also developed a mobile maple sugarhouse in 2007 to be able to take their educational programming on the road. The students have traveled with their mobile sugarhouse throughout the state (focusing primarily on New York City) and even to Washington D.C. to teach students and others about how maple syrup is produced. In recognition of this exceptional program and the extraordinary efforts of its director, Keith Schiebel was named Outstanding Teacher of the

Year by the National Association of Agricultural Educators in 2010 (http://www.naae.org/awards/pastawardwinners/2010awards/ot.html#6).

Vermont

When most people in the U.S. think about maple syrup, they think about Vermont. This is not an accident, as the state has taken concerted efforts to brand itself as 'the place for maple syrup' over the past century. Although private producers and business are responsible for most of the industry's success, state and federal agencies have also supplied vital resources. This section highlights some of the main initiatives and influential programs in Vermont since the early 1900s.

University sponsored research has played a major role in the development of the Vermont maple industry over the past century. The first professors to delve into maple research were W.W. Cooke, J.L. Hills, and C.H. Jones (Lockhart 2008). Some of their earliest works included the *Vermont State Agriculture Bulletin Number 26- Maple Sugar, The Maple Sap Flow, and The Carbohydrate Contents of the Maple Tree*. Research was conducted in primitive facilities for many years until 1946 when the Governor of Vermont, Mortimer Proctor, approached the state legislature to request funding to start a maple syrup research center for the University of Vermont. The legislature was not willing to fund it, so the Governor spent his own personal money on a tract of forestland in Underhill Center and donated it to the University for the purposes of maple syrup research and extension. The Proctor Maple Research Center has flourished ever since, conducting basic and applied research on all aspects of maple syrup production (Perkins 2006). Although the Proctor Center receives some support from the

University, it has also benefitted greatly from Federal funding. Dr. Mariafranca Morselli, a prominent scientist at the Proctor Center, convinced Senator Patrick Leahy (D-VT) to earmark funds for the facility for many years. Starting in 1992, the Proctor Center received between $80,000-$130,000 as part of a special grant through the USDA (pers. comm., Dr. Timothy Perkins, October 22, 2012). Since earmarks are no longer popular, the Proctor staff has managed to support their research and extension efforts through varied sources of external grants.

Vermont is very proud of its maple syrup and has developed strict laws and regulations on what it requires to label a product as Vermont Maple Syrup. It is not just protective of the Vermont name, but also the maple name as well. Their regulations state that "it shall be unlawful to use the term maple syrup or maple sugar, however modified, to describe any product, flavoring, sweetener or food additive unless the product, flavoring, sweetener, or food additive so described meets the statutory definition of maple syrup or maple sugar" (Vermont Maple Products Laws & Regulations 2006). They are serious about enforcing this law as well, as seen in the objections to McDonald's new line of "Fruit & Maple Oatmeal" (Fromson 2011). Vermont is the only state that labels its lightest grade of syrup as 'fancy' and it requires a minimum sugar content of 66.9 brix whereas all other states and provinces require 66 brix minimum (Sendak and Jenkins 1982). According to surveys of industry leaders and government officials, grading standards benefit the industry by promoting quality syrup, helping producers market their syrup, and increasing wholesale buyer confidence (Drake and James 1992). In particular, the strict grading standards and the ability of state agencies to enforce these standards through adequate staffing has helped Vermont build its reputation as the superior maple producing state. Given that Vermont sugarmakers are so proud of their syrup and grading standards, state officials have encountered significant resistance in adopting the new proposed international grading standards (Rathke

2012).

According to Bill Clark (pers. comm., October 29, 2012) and Jacques Couture (pers. comm., October 30, 2012), prominent figures in the Vermont maple industry, the Agency of Agriculture has been a driving force in helping the industry prosper. Although the Agency has a regulatory mission to enforce the grading and quality standards, they do so in a way that is helpful, rather than detrimental to producers. The Agency also assists with production of 20,000 grading kits each year and tests hydrometers for accuracy at multiple locations each year. Their current director, Henry Marckres, is well respected and maintains a positive relationship between his agency and the producers. The Agency was instrumental in helping to eliminate lead from maple syrup in the 1990s and is currently leading the initiative in Vermont to adopt the new international grading standards. In the 1970s and 80s, when it was called the Department of Agriculture, they had two full time staff people devoted entirely towards education and promotion for the maple industry. Everett Willard and Bruce Martell served the industry for many years before budget cuts and restructuring within the department ended their positions. One of their lasting achievements was the creation of the Vermont Maple Promotion Board, an institution which has helped build the Vermont brand and promote Vermont syrup throughout the world.

The Department of Tourism & Marketing has also assisted with promoting maple syrup and the Vermont brand for decades. Vermont maple products are often featured whenever state agencies hold out-of-state events or are welcoming others to Vermont. They were instrumental in getting the Vermont Ski & Maple map into the hands of tourists and always making maple syrup a prominent attraction for visitors to the state. Having the two major state agencies in charge of agriculture and tourism promoting the maple industry has certainly helped the producers of Vermont market their products and build their brand over the years.

Although state land had been leased for maple sugaring in the past, very little of this activity had been happening in recent years. However, based on substantial input and pressure from the Vermont Maple Sugarmakers Association, the state opened up several large sugarbushes for tapping in 2009. Even with significant resistance from the logging community (Vermont Public Radio 2009), the Agency of Natural Resources developed an extensive set of guidelines for tapping of state land (Appendix D). Seven parcels were identified by the Agency for a competitive bidding process for maple sap production, and since then more parcels have been targeted for possible leasing. Vermont led the way in developing standards for modern leasing of state forestland for tapping, providing additional impetus and rationale for New York to reconsider its policies for tapping on state land.

Maine

As clearly described in Veronique Theriault's (2007) thesis, Maine has a tremendous potential to expand production. The state is benefitting from its close proximity to Quebec and the Federation's policies that have increased and stabilized prices for maple syrup while encouraging expansion in places like Maine. Furthermore, a large percentage of the syrup produced in Maine occurs on the former paper company land in northern Maine that is now primarily owned by Timberland Investment Management Organizations (TIMOs). Producers who live just across the border in Quebec handle the vast majority of these leases and therefore produce the majority of Maine maple syrup. Maine officials now recognize the opportunities for state residents to expand syrup output and are taking initiatives to grow the industry even further.

Building on the successes and example set by New York, Maine established its own Maple Task Force in 2010 to "study the promotion and expansion of the Maine maple sugar industry" (Whitcomb 2011). The 13 member panel consisted of small and large maple producers from throughout the state, an extension educator, forest industry representatives, and state officials. Among other things, one of their missions was to explore various "investments or actions that could be taken by the State that would produce tangible economic returns". The report offers several recommendations for how the government could assist the industry, including the following:

- Establishment of a permanent Maine Maple Commission to continually assess the status of the industry
- Creation of a ½ time position within the Department of Agriculture, Food, and Rural Resources (Market and Production Development) to support the maple industry and assist with regulations and inspections
- Creation of a "Certified Maple Producer" program that would recognize sugarmakers who followed certain guidelines in the production of maple syrup
- Creation of high school and/or community college curriculum that would educate and train workers for the maple industry
- Creation of a full time position within the University of Maine Cooperative Extension to assist with education and development of the maple industry
- Further develop the process for leasing taps on forestland managed by the Maine Bureau of Parks and Lands

These are also worthy objectives, yet the fact that they remain as recommendations within this report shows that the state has not done much to advance the industry to date. Kathryn Hopkins with University of Maine Cooperative Extension is the sole extension educator for the maple industry, and her appointment only allows her to spend 20% of her time assisting with maple production. If the State of Maine follows through with these recommendations, the impact could be tremendous, but that is yet to be seen.

Miscellaneous State Programs

Although Vermont and New York have devoted the most government resources towards developing their maple industries, other states have also implemented various programs to boost syrup production in recent years.

Michigan contains the largest maple resource of any state, yet its production of maple syrup has been relatively low. The timber industry has long dominated the maple rich forests of the Upper Peninsula and maple sugaring was never widely adopted among the residents. With encouragement from the Michigan Maple Producers Association, the state has recently changed their property taxation policies to provide reduced assessments for landowners who utilize their woodland for syrup production (David Polk, pers. comm., March 26, 2012). Given the success of the agricultural assessment program for maple production in New York, this policy has the potential to drastically increase the number of landowners getting into sugaring in Michigan. Further research is necessary to fully understand why maple sugaring has never been a major industry in Michigan and what actions could be taken to bolster syrup production in this state.

Ohio was a leader in maple production in the 1800s. Although they have been surpassed by other states over the past century, there is still a substantial maple industry. Les Ober and Gary

Graham currently coordinate all maple extension and educational programming within the state through their appointments with Ohio State Extension. Ohio State also publishes the North American Maple Syrup Producers Manual, the definitive resource for all aspects of maple syrup production.

Being located so close to Vermont, New Hampshire producers have been able to take advantage of all the educational opportunities happening across the state line. New Hampshire once had an active extension educator devoted to the maple industry, but when Sumner Dole retired in 2008, his position was left vacant and little activity has taken place in recent years. However, a partnership of UNH Cooperative Extension, NH Maple Producers Association, and the NH Timberland Owners Association hosted their first maple school in New Hampshire this October (Fosters Daily Democrat 2012). It is unlikely that New Hampshire will ever devote the kinds of resources towards maple that neighboring Vermont has, but this upcoming maple school is a step in the right direction.

Iowa and Kentucky are two states not known for maple sugaring, but that may be changing in the future. In 2009 Iowa State University hired Jesse Randall, an extension forester who comes from a prominent maple sugaring family in New York. Jesse started conducting maple education workshops and secured funding to construct a small mobile sugarhouse. Even though Iowa is known much more for growing corn than producing maple syrup, Randall has helped well over one hundred people get started with their own sugaring operations over a three year time frame. Similarly, in Kentucky, an extension forester named Deborah Hill has encouraged many people to get started with maple sugaring. She authored a fact sheet on sugaring in Kentucky (Hill 2010) and has hosted several workshops for landowners to learn the art and science of sugaring.

As seen with these two examples, having extension educators with a strong personal interest in maple is key to developing the industry, even in unlikely places.

New Jersey is another state not known for maple sugaring, yet it has an extensive state park system with a strong focus on education for its dense population. There are at least five (and possibly more) state parks and nature centers that offer maple education and demonstration workshops in February and early March. Although maple sugaring will never be a major industry in New Jersey, the demonstration programs held in many of the state parks provide an opportunity to teach residents about sugaring while also providing the inspiration for countless backyard sugarmakers to get started. If the maple industry is to develop in states such as New Jersey, Iowa, and Kentucky, it will require these type of educational programs to make residents aware of the opportunities to use their land for syrup production.

United States Federal Government

Although Canada put the maple leaf on its flag and is known for maple syrup throughout the world, the U.S. Government has also devoted substantial resources to help support the maple industry over the past 100 years.

One of the first actions the U.S. Government took to encourage maple production was the establishment of the sugar bounty in 1890 with the passage of the McKinley Bill (Lockhart 2008). It provided a financial incentive of $0.02/lb for sugarmakers who applied for the license and produced at least 500 lbs. of maple sugar. The program included all forms of sugar, including cane and beet, but only lasted for a few years. Many independent farmers opted out of the bounty program in order to avoid any government intervention, but in Vermont alone, applications for ~ 3,500 licenses were filed to receive the maple sugar bounty in 1893-1894. Although the sugar bounty never led to a spike in maple sugar production, it did provide extra money to the farmers at the time. Its lasting legacy consists of "ornately decorated licenses, preserved in family records or framed on sugarhouse walls, treasured by generations that came after" (Lockhart 2008).

After the sugar bounty program ended, in 1909 the U.S. Government instituted a tariff on maple sugar and syrup imported from Canada as another means of protecting the maple industry from foreign competition (Sendak 1972). The tariff was a significant component of maple prices during its early years, averaging about \$0.04/lb between the 1920s and 1940s. As seen in figure 6.1, taken from Sendak (1972), the tariff was approximately 33% of the price of maple syrup between 1925-1945 and 5% of the price between 1946-1971. Sendak claimed that since the maple supply curve was inelastic, the tariff could never work very well. However, Canadian imports as a percentage of U.S. consumption were much lower in the early 1900s when tariffs were high and continued to climb throughout the 1900s as the tariff became obsolete (Fig 6.2 from Sendak 1972). By the time it was abolished through the Kennedy Rounds of tariff negotiations under the General Agreement on Tariffs and Trades (GATT) in 1964, the tariff was already insignificant. However, if the U.S. government had continued its protectionist efforts with the maple industry, it may have limited the decline of maple production in the U.S. throughout the 20th century.

Through the efforts of the U.S. Forest Service, the federal government devoted significant resources towards maple syrup research, especially in the 1960s-70s. For many years they sponsored a Sugar Maple Laboratory as part of the Northeastern Forest Experiment Station in South Burlington, VT and conducted significant research out of their laboratory in Philadelphia, PA. During this time period, several USFS research scientists concentrated their efforts on improving all aspects of maple syrup production and marketing. Their publications range across the spectrum from an analysis of pure maple syrup consumers (Sendak 1974) and their preferences for graded maple syrup (Sendak 1978), to cost analyses for producing maple syrup (Huyler and Garrett 1979, Sendak and Bennink 1985, Huyler 2000), the effects of plastic tubing on syrup quality (Walters and Yawney 1978) and vacuum pumping on sap yields (Smith and Gibbs 1970). The USFS has also hosted symposiums covering all aspects of maple syrup production and marketing and sugar maple ecology and health (Northeastern Forest Experiment Station 1982, Horsley and Long 1998). Finally, the USFS initiated the Sugar Maple Tree Improvement Program to identify and propagate sugar maples trees that contained significantly higher levels of sucrose in their sap, a program that continues on today (Koelling and Gabriel 1965).

More recently, one of the biggest investments that the Federal Government made in the maple industry has been through Renewable Energy Assistance Program (REAP). With REAP, the USDA provides cost sharing to assist maple producers in upgrading and purchasing new equipment in order to make their operations more energy efficient. Maple producers in New York and Vermont have benefitted the most through this program, as the state associations have promoted it among members and facilitated the application process. According to Scott Collins, Energy Coordinator for the USDA Rural Development Office (pers. comm., Oct 1, 2012), since 2009 there have been 78 projects totaling $656,291 awarded to maple producers in New York (even more funds have been awarded to Vermont producers). This combination of a government program and a private organization capable of disseminating information and assisting with the application process has allowed dozens of maple producers to install reverse osmosis units and more energy efficient evaporators. With the new equipment, producers have not only been able to reduce their energy costs and therefore increase their profitability, many have also been able to expand their operations by adding new taps or buying and processing sap from neighboring farms.

Another way the Federal Government has helped the maple industry has been through record keeping of annual maple syrup production and sales data. The USDA National Agricultural Statistics Service (NASS) started keeping track of maple syrup production in the ten largest producing states every year since 1917. Before that the Census Bureau tracked production every 10 years starting in 1850, and all of the records were recently amassed together in one publication (Graham 2012). The effort of NASS has been an invaluable service to the industry, allowing for a wide variety of research, education, and promotion efforts over the years.

Through the leadership of Senator Charles Schumer (D-NY), Congress has recently taken actions to help boost maple syrup production in the U.S. In 2008, one of Schumer's staffers, Katie Kulpa, read an article in *The Saratogian* highlighting my research on the growth potential of the maple industry in New York (Post 2008). Given the vast number of untapped trees in New York, Schumer's office introduced a bill called the Maple Tapping Access Program Act (TAP Act) that would provide incentives to landowners who made their sugarbushes available for tapping to private producers. However, this bill had very little support within the maple industry and went nowhere in Congress. Maple producers wanted to see a bill that did not just offer grants to private landowners, but rather offered funding for a variety of means of growing the industry. Representative Peter Welch (D-VT) introduced a different version in 2011 that included funding for competitive grants that could be used for research, education, and promotion/marketing efforts. By 2012, the House and Senate bills were exactly the same, and at the time of publication, the TAP Act has passed through both version of the 2012 Farm Bill (Appendix E). If the Farm Bill passes in its current state, the Maple TAP Act will be a major step forward for the maple industry and will allow for much greater development of the maple resource within the U.S. Although there are some other federal programs for which maple syrup producers can apply, this would be the only dedicated funding stream for the maple industry and would thus guarantee funds towards further development of the maple resource in the U.S.

Since introducing the TAP Act, Senator Schumer has gone to great lengths to promote the maple industry in New York and beyond. After the *New York Times* featured an article about an IHOP offering pure maple syrup at its one location in Vermont (Zezima 2009), Schumer sent a letter to IHOP CEO Julia Stewart stating that… "an arrangement with IHOP, modeled after the Vermont restaurants, could be the perfect way to introduce New Yorkers to their own appetizing product, while also opening a new market to New York tappers." (Schumer press release) Although Stewart never replied to the Senator (at least publically) and IHOP still does not offer pure maple syrup on its menu, the letter did create publicity for the maple industry and made some people aware of the differences between pure maple and artificial syrup. In another promotional effort for New York maple syrup, Senator Schumer placed a public bet on the Yankees-Tigers series in 2010, offering to give Senator Debbie Stabenow (D-MI) pure maple syrup from New York if the Tigers beat the Yankees (Miller 2011). Senator Schumer has only recently started to promote the maple industry in New York, but if New York always had elected officials exhibit the same passion for pure maple, it could have a lasting impact on the industry.

Along with co-sponsors Kirsten Gillibrand of New York, Vermont's Patrick Leahy and Bernie Sanders, and Susan Collins of Maine, Senator Schumer introduced another bill in 2011 aimed at protecting the maple industry in the U.S. (Selier 2011). Following a report about a Rhode Island man alleged to have sold cane syrup labeled as maple syrup, they developed the Maple Agriculture Protection and Law Enforcement (MAPLE) Act that would increase the penalty for selling counterfeit maple syrup from a misdemeanor up to a felony capable of a maximum sentence of five years in prison. This law has yet to pass, but it was championed by the maple industry in the U.S. and Canada, so it may just be a matter of time before it becomes law.

Quebec

Although my dissertation has focused primarily on the U.S. maple industry, Canada (in particular Quebec) became the leader in maple syrup production due in part to significant provincial and federal leadership. An entire dissertation could (and should) be written on the public policies that have affected the maple industry in Quebec over time. For the purposes of this chapter, I will highlight the major effects that Quebec's recent policies are having on syrup production in and outside of Quebec's borders.

Since the 1970s most states and provinces showed lackluster growth while syrup production in Quebec soared. The industry was more technologically advanced in Quebec in terms of sap collection and processing capabilities, government policies were geared towards stimulating rural development through enhanced syrup production, and for many years there was a currency advantage for selling Canadian syrup into U.S. markets. The large bottling facilities could secure vast amounts of syrup at low prices and sell their syrup in grocery stores below the prices being charged by American producers. Consequently, there was little incentive for producers in the U.S. to expand and the industry was mostly stagnant outside of Quebec. The situation today is quite different, due in large part to unintended consequences of the activities of the Federation of Maple Producers in Quebec (FPAQ).

As with many of the agricultural commodities in Quebec, all producers must belong to the Federation. The Federation is one faction of the Union of Agricultural Producers in Quebec and has done much to advance the industry since it was created under the professional union law in 1966 (Theriault 2007). There are nearly 7,000 members that elect a 12 member panel to serve on the Board of Directors, overseeing all aspects of bulk maple syrup production and marketing. By joining forces and putting adequate funds towards promotion and market development, the producers of Quebec have worked within this government sponsored framework to advance the entire industry (Gagne 2008). The Federation has facilitated development of markets for maple syrup outside of North America through strategic marketing initiatives in Japan, Western Europe, and elsewhere. By implementing a quota system for the amount of syrup individual producers are allowed to sell in drums and setting the minimum prices for maple syrup sold in drums, the Federation has stabilized bulk syrup prices throughout the entire industry. The Federation purchases excess syrup on the market in order to maintain a strategic reserve of maple syrup. This allows the Federation to balance the good years with the bad ones and supply markets even when the weather causes a poor yield of syrup in any given year. Although the Federation has helped the industry progress in many ways, some of their policies have been highly controversial and have led to internal strife within the industry (Bolduc 2004).

In order to understand how the Federation has impacted the maple industry, it is important to first describe some of the Federations' policies. All bulk maple syrup produced and sold in Quebec must go through authorized buyers for the Federation. Since the adoption of the Joint Plan in 2004, the Federation receives a certain amount of money (it is now $0.12/lb) for all of the syrup and sets the minimum prices for bulk syrup that must be paid by authorized buyers in Quebec. This price is based on what the producers would like to receive for their output, not necessarily what the market should bear. The current prices ($2.80/lb for the top grades) are currently higher than they would be if left to the free market forces of supply and demand. As a matter of policy, producers receive 75% of the bulk syrup price when they first sell their syrup to the Federation and are paid the remainder once all of the syrup is sold. However, for the past three years, supply has vastly exceeded demand and thus the Federation has been amassing a surplus of syrup that it is putting in to the Strategic Reserve. Producers in Quebec have not been getting paid the full price for their syrup, rather their effective take has been about $2.10/lb. The discrepancy in the set price of $2.80/lb and the effective price of $2.10/lb has led to unintended consequences in the rest of the maple industry, most notably the expansion of syrup production in the U.S. and other Canadian provinces.

By setting the minimum price that must be paid for bulk syrup in Quebec, the Federation has effectively created a floor for syrup prices throughout North America. The large bottling companies must pay producers close to the Federation minimum price, otherwise another buyer would offer a slightly greater price to secure the syrup. Because producers everywhere are now getting paid relatively high prices for their bulk syrup (due in large part to the Federation policies), they have had a strong financial incentive to expand output (Theriault 2007). The Federation has been restricting output in Quebec through their quota system and is now encouraging expansion throughout the rest of North America by artificially inflating bulk syrup prices. It is only a matter of time before the producers in Quebec revolt and/or the Federation leadership changes course on its own volition.

The Federation can only regulate prices and supply when Quebec is the sole dominant player in the industry. In their assessment of the syrup surplus, Fortin and Van Audenrode (2005) warned of the dangers to the Quebec industry of encouraging expansion outside of the province. Since their report was published seven years ago, production has steadily climbed in the U.S. and other Canadian provinces as the Federation continues to institute a quota system within Quebec. If the current production trends in the U.S. and other Canadian provinces continue, within a few years Quebec will not control enough market share for the Federation to be able to set pricing. As long as producers are willing and able to expand production outside of Quebec, the Federation's quota system could soon become irrelevant. Should this happen, the maple industry may once again enter a period of massive supply imbalances and price fluctuations.

The Federation isn't the only major player in the Quebec maple industry. For more than 50 years, the provincial government provided significant research and extension services for the maple industry through two departments. The Ministry of Agriculture, Fisheries, and Food (MAPAQ) handled issues related to harvesting and processing of maple sap and the marketing maple products. The Ministry of Natural Resources and Wildlife (MRNF) focused on all aspects of sugarbush management and forest health. In 1996, plans were developed to combine the resources of these agencies with key partners in the private sector to create a new state of the art research center for the maple industry. By 1998, a new organization was created under name of the Center for Research, Development, and Transfer of Maple Technology, Inc. (Centre ACER).

Although Centre ACER receives some industry support, it has benefitted greatly from the provincial government funding to become a world-class maple research center (http://www.centreacer.qc.ca).

Not only has Centre ACER received provincial support, it has also received tremendous support from the federal government of Canada. For instance, the federal government recently granted $1.7 million for research funds devoted entirely to the maple industry, with the vast majority of funding headed to Centre ACER (CBC News 2012). Researchers will be developing testing tools to determine if any adulterants have been added to pure maple syrup. They will also be developing new maple products and examining the health benefits of pure maple sap and its derivative products. This type of research support benefits the entire maple industry and is indicative of the level of importance placed on maple production in Canada.

Although Centre ACER does carry out some education and technology transfer as part of its mission, there is a separate extension system for the maple industry in Quebec that operates quite differently than the U.S. system. There are currently seven maple extension agents that provide direct, personalized educational services for the maple industry as their primary duty (http://www.agriconseils.qc.ca/site/doc/250/acericulture_07.pdf). The Ministry of Agriculture pays for 55% of their salary and the individual producers that they work with make up the remainder of their compensation. Maple producers are willing to pay for a portion of these agents time because of the large benefits they receive by having experts in the maple industry work directly with them on an individual basis at their operations.

The provincial government has also positively impacted maple production through leasing of

Crown land for tapping. In stark contrast with the U.S., large acreages of Crown land have been leased for many years at rates well below those seen in the private sector. For instance, in the early 1980s land could be leased for $2.50/ha regardless of the productivity or location of the sugarbush (Pare 1982). The Ministry of Natural Resources advocated for increased leasing of Crown land in 1998, and though the rental rate was raised considerably, it still provided an extremely cost-effective means for producers to install large scale sugaring operations up to 100,000 taps (MRN Rapport 2000). Although there are many sugaring operations on private land in Quebec, the MRN has allowed for the rapid development of the industry through strategic leasing of Crown land. Without this government support, the industry could not have grown nearly as fast over the past several decades. Given that a large percentage of the available taps occur on Crown land, their leasing policies will continue to affect growth of the industry over time.

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Figure 6.1 Maple syrup and sugar tariff as a percentage of the value of the product (taken from Sendak 1972)

Figure 4.—Maple Syrup and Sugar Tariff expressed as a percentage of the value of the product.

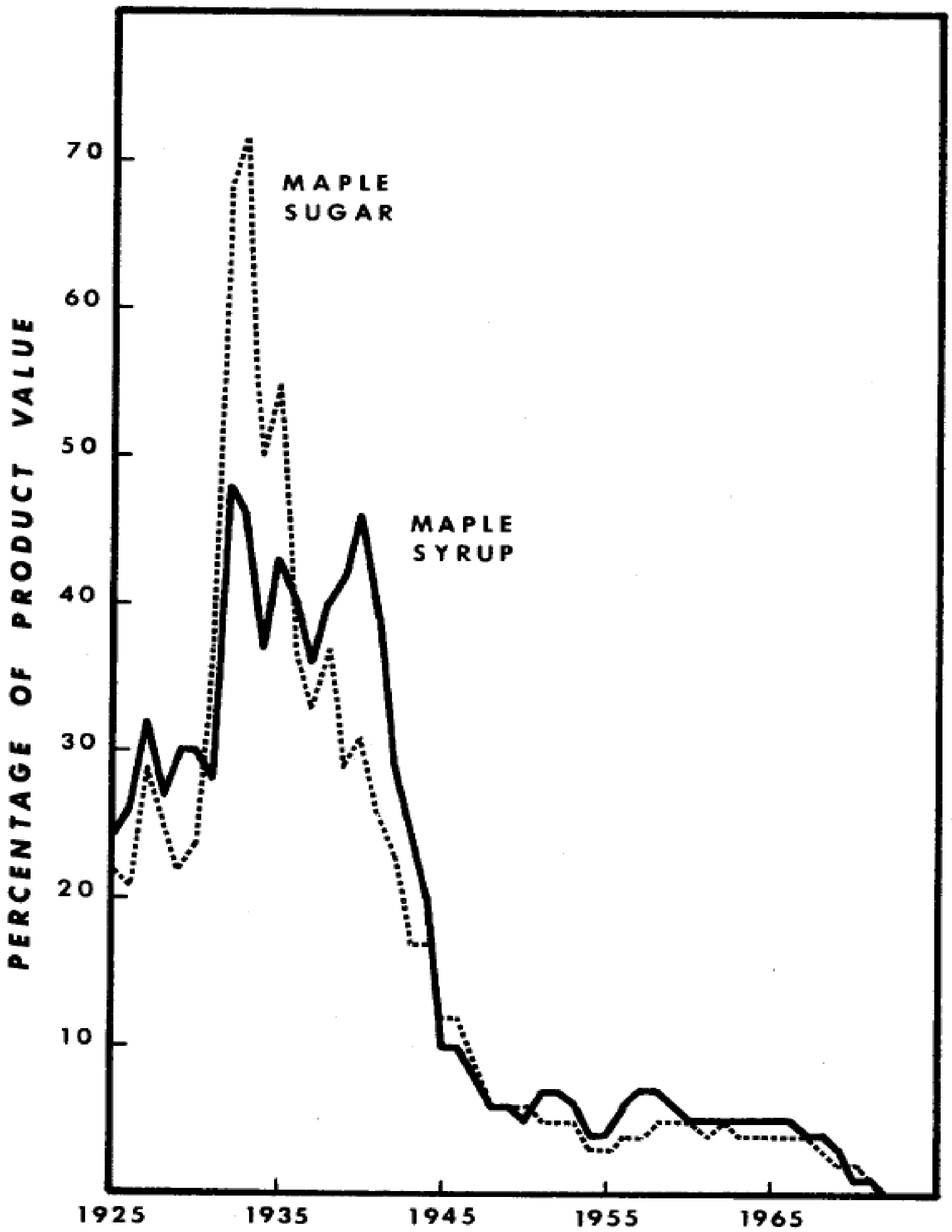
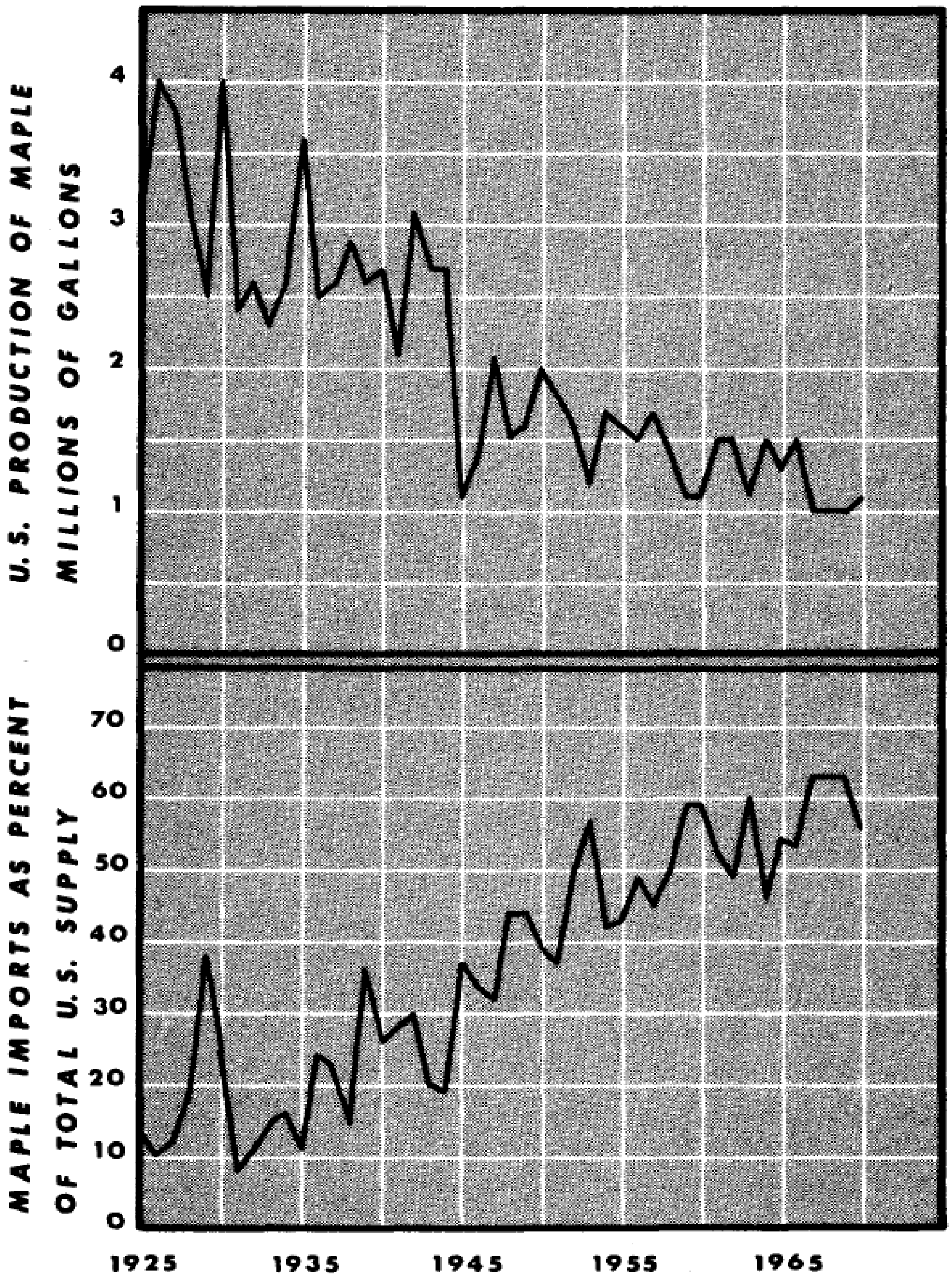


Figure 6.2 U.S. production of maple syrup from 1925-1970 and imports as a percent of total supply for the same time period (take from Sendak 1972)

Figure 1.—Trends in maple production and imports in the United States from 1925 to 1970.



Overall Conclusions

My dissertation research has explored various aspects of the ecologic, socio-economic, and public policy factors that have influenced the maple syrup industry in the United States thus far and could play a critical role in future development. This final chapter synthesizes my major findings and offers recommendations for how the maple industry can ensure a sustainable future during an era of global change. Although there are some areas of concern, the overall prospects are very promising for the foreseeable future. The U.S. contains a vast resource of untapped trees and has the educational, manufacturing, and organizational infrastructure in place to rapidly expand production. American sugarmakers have benefitted from price stabilization and market expansion carried out by the Federation of Maple Producers in Quebec, yet there are no production quotas limiting the ability of sugarmakers to expand in the U.S. Although international markets are growing, the U.S. is still by far the largest market for pure maple syrup, the currency exchange between the U.S. and Canada is relatively stable, and there is a growing trend towards consuming 'locally produced', American-made products within the U.S. While I am optimistic about the future for syrup production in Canada, the prospects for the U.S. are even better.

In order to forecast future growth and development, it is important to understand the historical context for the production and consumption of pure maple products. During the 19^{th} century, there were far fewer alternatives for sweeteners and the primary competitor (cane sugar) was relatively expensive (Whitney and Upmeyer 2004). Northerners also had strong personal motivations to produce their own maple sugar in lieu of buying "slave sugar" from the South. Thus, maple production peaked around 1860 even though there were far fewer maple trees on the landscape and it was much more difficult to produce maple syrup and sugar (US Census 1860). However, many people lived on small family farms and labor was relatively cheap, so sugaring in the early Spring was an annual ritual. The situation is much different today. There is now a plethora of natural and artificial sweeteners in the market, maple syrup is one of the most expensive options, and a very small percentage of Americans live on farms and earn their living from the land. Thus, we produce far less syrup today despite having an abundance of tappable maple trees and the technology to produce maple syrup in a much more cost and time effective manner.

The future development of the maple industry is mostly contingent upon people's desire to produce and consume pure maple syrup and the economic forces that drive those decisions. With less than 1% of the available trees tapped for syrup production in the U.S., the maple resource is not a key limiting factor to increasing production. Furthermore, given that consumption of pure maple syrup is less than 3 oz/capita in the U.S., 6 oz/capita in Canada, and barely even measureable throughout the rest of the world, there is a tremendous opportunity to increase consumption of pure maple products (Farrell and Chabot 2012). As long as demand stays high and prices remain at or near their current levels, syrup production is likely to continue to expand at a rapid rate. However, if supply outpaces demand and syrup prices fall, many sugarmakers could get out of the business and production levels may fall. As with many agricultural crops, the production potential is not necessarily limited by ecological parameters, but rather economic forces that dictate pricing and profitability. Given these circumstances, marketing and promotion efforts are essential to sustainability and growth across the entire maple industry.

The ability to produce bumper crops of syrup that flood the market is much greater than it used to be, making it even more important to invest in marketing and promotion efforts. Although the Federation has established a Strategic Reserve for maple syrup and can absorb some additional capacity, their resources to do so are limited. Even when the weather conditions are poor, sugarmakers who utilize the latest vacuum tubing technologies can still obtain decent yields. For instance, although the 2012 season was terrible for sugarmakers who rely on buckets and gravity tubing, most sugarmakers who tapped early with high vacuum tubing produced at least an average crop (USDA NASS 2012). Maple producers are still at the mercy of the weather to a certain degree, yet adopting the latest technologies for sap collection provides an excellent buffer against a changing climate. Sugarmakers can also collect sap from large acreages spread out over long distances and then transport the sap with piping and/or vehicles to a central processing facility, greatly increasing the production capacity for individual operations. Furthermore, modern evaporators and reserves osmosis units allow sap to be converted into syrup with significantly less time, labor, and energy expended.

Since it is much easier and less costly to produce maple syrup than it used to be, one would expect output to rise in modern times. Indeed, after a steady decline throughout the 20th century (before major technological advances took place), syrup production started to expand rapidly in Canada in the 1980s and has just recently started to accelerate in the U.S. The future growth of the industry will depend on a variety of factors, several of which I explored in this dissertation:

(1) The number of tappable maple trees growing in economically viable sugarbushes and the percentage that are currently utilized for syrup production

(2) Per capita consumption levels necessary to expand syrup production on a ‘local’ basis

(3) Landowner attitudes towards utilizing their maple trees for syrup production

(4) The economics of managing maple trees for syrup or sawtimber production

(5) The future distribution of maple trees in a changing climate

(6) The impact of public policies on the production and marketing of maple syrup

The following paragraphs highlight my major findings in regards to these core issues.

1. *The number of tappable maple trees and the percentage that are currently utilized for syrup production*

The FIA data reveals an abundant maple resource throughout the eastern United States that could be tapped to expand syrup production. There are over 2 billion sugar and red maple trees of tappable size growing in U.S. forests, though not all of these trees occur in locations where sap collection is economically feasible. My original analysis was based solely on tree species and size, ownership category, and jurisdiction, whereas the refined numbers also include the density of maple trees in a stand and the distance of that stand to an access road. I found that the density of maples is a much greater limiting factor that the distance of these trees to an access road. Overall, 45% of the tappable-size maple trees are found in stands whose density is not high enough to support commercial sap extraction (< 30 taps/acre) whereas only 6% are found in stands that are at least 1 mile from an access road. When narrowed down according to the attributes of an optimal 'sugarbush' (containing >60 taps/acre and within ½ mile of a road), there are 100 million potential taps from sugar maples alone and 286 million potential taps with sugar and red maples combined (Farrell 2012 in review).

Overall, with 9.6 million taps, sugarmakers are tapping less than 0.5% of all the sizeable maple trees in the eastern U.S. However, when considering only the maple trees occurring in optimal sugarbushes, the utilization rate is about 2.5%. For comparison purposes, sugarmakers in Quebec are tapping approximately 36% of their optimal sugarbushes (MRN-MAPAQ Rapport 2000).

The only state that rivals Quebec in this capacity is Vermont. At 27%, Vermont's utilization rate of optimal sugarbushes is over 10 times higher than the national average. Thus, even though Vermont contains only 5% of the potentially tappable maple trees, it accounts for roughly 40% of all U.S. syrup production (USDA NASS 2012). There are plenty of maple trees in other states, yet Vermont is the only state that utilizes their maple resource to such a large extent. Since Quebec has more than ten times as many tappable maples as Vermont (a relatively small state), it produces 80% of the world's supply of maple syrup. However, if every state utilized their maples to the same extent that sugarmakers in Vermont do, the U.S. would vastly outproduce Quebec. Whether or not the market could absorb that increased production is another question.

Given the relatively low utilization rates in the U.S. (especially in comparison with Quebec), it would appear that the maple resource is not a limiting factor to expanding production. However, there are places within Vermont, New York, New Hampshire, and other states where syrup production is a way of life and most of the available trees are tapped for syrup production. In these places, sugarmakers would expand if there were more maples readily available for tapping. Unfortunately there is a disconnect between where the majority of sugarmakers exist and where most of the maple trees are growing. Although a limited number of sugarmakers are willing to travel or relocate to gain access to large sugarbushes, many sugarmakers are limited by the immediate, nearby resource of tappable trees. If there were more sugarbushes readily available in the major producing regions, syrup production could rapidly expand. One of the biggest challenges and opportunities to increasing syrup production in the U.S. is encouraging landowners to produce syrup in areas where maple trees are plentiful yet sugaring is not a part of the social fabric of the community.

2. *Per capita consumption levels necessary to expand syrup production on a local basis*

It is important to remember that the production of maple syrup is not limited solely by the number of tappable trees, but also by the ability to sell the final product at economically viable prices. As with all agricultural crops, consumer demand plays an integral role in the overall growth projections for the industry. Given the increased importance and growth of the local food sector in today's marketplace, I explored the feasibility of expanding maple syrup production and consumption on a 'local' basis (Farrell and Chabot 2012). By defining local as being produced and consumed within the same state, I considered two possible scenarios:

1) if each state tapped ~3% of its available trees and consumed all of the syrup locally among its residents; this is the utilization rate in Vermont and thus presents an upper target for other states to achieve
2) the number of taps needed in each state to provide 2.6 ounces of maple syrup per person (the average consumption in the U.S.) from "local" sources

Although there are some limitations to these scenarios, conducting these analyses did provide interesting and useful findings on where syrup production and consumption could expand jointly.

There are places in the U.S. with a significant number of maple trees and high populations that could greatly expand production of maple syrup in order to supply local markets. Illinois, Missouri, and New Jersey are some of the states that fall in to this category- although there is limited syrup production currently taking place, they have an incredible capacity to expand production and sell all of their syrup locally. However, for the vast majority of states, in order for them to grow their maple industry in the same manner as Vermont, either per capita consumption of local maple syrup would have to drastically increase and/or producers would have to sell most of their syrup elsewhere. The places that produce the greatest amount of syrup, Quebec and

Vermont, have relatively low populations that couldn't possibly consume all of the syrup produced there. Given their predicament, Quebec and Vermont have both devoted tremendous resources towards marketing and promotion efforts to sell their maple products throughout the world. Although local markets are important, the growth of international markets has provided an outlet for much of the increased syrup output over the past decade. Thus, future growth must rely on a combination of local, national, and international markets to absorb excess supply and maintain stable prices.

3. *The attitudes of landowners towards utilizing their maple trees for syrup production and their perceived barriers for doing so*

Although it is often overlooked, the human dimensions of maple syrup production are a significant influence on the growth potential of the maple industry. Since the vast majority of tappable maples occur on privately owned land, the attitudes and goals of the landowners who control access to these trees is the ultimate deciding factor on whether they will be tapped for syrup production. In Fall 2009 we conducted survey research in the Northern Forest states of Maine, New Hampshire, New York, and Vermont in order to determine the perceived barriers that may deter landowners from wanting to produce maple syrup themselves or lease their land to another sugarmaker for tapping (Farrell and Stedman in review). The results were promising in that a high percentage of landowners, especially those from the New England states, had positive attitudes towards utilizing their land for syrup production. The 'New England effect' may have been even more significant had we surveyed landowners in other states where maple trees are present yet little sugaring takes place. Future research is necessary to explain why landowners in New England, and especially Vermont, are much more likely to want to utilize their maples for syrup production. Taking this knowledge and disseminating it to other states could give a significant boost to syrup production in the U.S.

Significant barriers identified by landowners for why they have not gotten into maple syrup production included concern over the possible loss in sawtimber value from tapping, lack of personal interest and knowledge in the sugaring process, time and labor constraints, and not having enough accessible maple trees. While some of these issues are major impediments towards getting more landowners involved in syrup production, others can be overcome with strategic outreach and extension activities. In particular, we found that highly educated females were the most likely to want to lease their land for tapping even though very few are interested in producing syrup themselves. Targeted messaging to these types of landowners highlighting the advantages of leasing taps is one way to open up more potential sugarbushes for syrup production. Furthermore, previous survey research of New York landowners (Farrell and Stedman 2009) also highlighted the extent to which property tax reductions provide incentive landowners to utilize their maples for tapping. Over half of the respondents stated that they would be likely to tap their trees or lease them to another sugarmaker if they could qualify for agricultural assessment as a result. Should more landowners actually become aware of this program, syrup production in New York will likely expand considerably.

4. The economics of managing maple trees for syrup or sawtimber production

My survey research highlighted the extent to which landowners are concerned that tapping will reduce the value of their sawtimber. Given the fact that large landowners who control significant acreages of sugarbush are the most concerned about sawtimber impact, this issue could severely limit the expansion of the maple syrup industry. Most foresters and loggers advise landowners against tapping, yet up until now there was no way of determining whether a landowner could earn greater revenues by managing a maple tree for syrup or sawtimber production. Thus, I developed a *Net Present Value (NPV) Calculator* to be able to evaluate the economics of leasing an individual maple tree for syrup production or harvesting it for the timber value. After running the model for a variety of trees, it became apparent that leasing taps for a minimum of five years and then eventually harvesting the tree is actually the most profitable management strategy over the long-term for most situations. The paper that I authored on this topic has been accepted to The *Northern Journal of Applied Forestry* and is scheduled to be published in 2013. In addition, the *NPV Calculator* has been posted on the Cornell Maple Program website and has been downloaded by over 100 professionals and students in the forestry sector. Several timber investment companies, large landowners, and state agencies have already used the *NPV Calculator* to determine that leasing taps makes economic sense for their situations. By developing the *NPV Calculator*, explaining all of the issues that affect the profitability of leasing taps versus harvesting trees, and making it possible for others to evaluate their own circumstances, this aspect of my dissertation research may have the most significant long-term impact on the maple syrup industry.

5. The future distribution of maple trees in a changing climate

Climate change is having a major impact on agriculture throughout the world and the North American maple industry is certainly no exception. Several reports have made alarming predictions about the sustainability of the maple industry as a result of global warming (Frumhoff et al. 2007, Lauten at al. 2001), yet these fears may be unfounded. Although climate change has been and will continue to impact maple syrup production, there are approaches sugarmakers can take to adapt to a changing climate (Chabot 2011). The two main ways that climate change could affect the maple industry include:

(1) altering the timing of sap flow and the number of sap flow days, and

(2) impacting the distribution and health of maple trees.

I did not address the timing of sap flow in my dissertation research because other studies have found that this should not be a major concern within the next 100 years. Skinner et al. (2009) modeled sap flow conditions in 2100 for the northeastern U.S. and found that the season will shift earlier in to the winter months. Whereas some of the southerly areas will wind up having less sap flow days, more northerly regions (where the majority of syrup is produced) will actually have more sap flow days. Sugarmakers can adapt by simply tapping earlier to take advantage of the increasing number of sap flow days in January and February. Furthermore, by utilizing new spouts and relatively clean tubing under high vacuum, one can tap early to take advantage of winter sap flows without worrying about tapholes "drying up" during the course of the traditional sugaring season (Wilmot 2008).

The other major impact that climate change could have is on the distribution and health of maple trees. Upon release of the Prasad and Iverson (1999) Climate Change Atlas, some people misinterpreted this work and predicted that sugar maples would become nearly extinct from the U.S. by the end of the 21st century. In reality, the Climate Change Atlas only predicted where the climate would be most suitable for various species by 2100, not necessarily where they will be found by then. It is difficult to know what will happen to forests in 50-100 years, yet the current trends are positive for maples. I analyzed FIA data over the past 30 years to examine the number of trees by diameter class for sugar maple, red maple, oaks, hickories, and beech (Farrell and Chabot in review). My results showed that sugar and red maples are expanding their range further south and west into oak-hickory dominated forests, completely contradicting the predictions from the original Climate Change Atlas.

Most of the logging that occurs today is ‘selective harvesting’ and diameter limit cutting that provides a filtered light environment for shade-tolerant maples to thrive. This type of management, coupled with a lack of fire, is allowing sugar and red maples to infiltrate oak/hickory forests through the Appalachians and Midwest. Although persistent droughts and extreme heat events could hamper tree growth on local and/or regional scales, the long-term prospects for sugar and red maples appear favorable throughout the eastern U.S. Whereas climate change will have some influence on species abundance and distribution, our management of forests is likely to have a much greater impact on stand dynamics. Given the positive bias many landowners and foresters have towards sugar maples and the fact that red maples proliferate even without preferential treatment, there is likely to be an abundant supply of maples to tap for the foreseeable future.

6. *The impact of public policies on production and marketing of maple syrup*

My research found vast differences in the percentage of available trees tapped and the amount of syrup produced between different states and provinces. Although I still have more research to do on this topic, it is clear that public policies have played a vital role in how the industry has developed over time. There are significant differences between states and provinces in policies for tapping on public land, government resources devoted to the maple industry in research, extension, and promotion, cost-sharing programs, and property tax programs that encourage syrup production.

Although Maine, New York, Vermont, and other states have taken various measures to boost the maple industry, the most significant public policy impact on production levels in the U.S. actually comes from Quebec. By stabilizing prices at relatively high levels and limiting production within Quebec, the Federation has encouraged maple producers to expand throughout the U.S. and other Canadian provinces. How long this can continue to occur remains to be seen. Part of the Federation's mission is to store surplus syrup in its Strategic Reserve in order to supply markets during poor crop years and allow for market expansion. However, their current surplus of 47 million pounds is much greater than the target amount. If supply continues to outpace demand and expansion outside of Quebec limits the ability of the Federation to set target prices and enforce quotas, the maple syrup industry could once again enter a period of price instability. Should this happen, expansion will likely be curtailed, some producers may drop out of the business, and the Federation will lose its control over the industry. There will likely be additional public policies enacted to try to maintain stability and sustainability in the maple industry.

Conclusion: Marketing efforts will determine industry's future

After studying many aspects of the maple industry, I believe that future growth will be limited primarily by investments in marketing that will allow sugarmakers to sell pure maple products at profitable levels. There is an abundant resource of maple trees that could be utilized to expand syrup production, but this will only happen if the market can absorb the additional output. Landowners generally have favorable attitudes towards sugaring, yet fewer will start their own operations and some will drop out if a surplus develops and prices fall. Although landowners are often concerned about the effect of tapping on sawtimber value, utilizing maple trees for syrup production is actually more profitable than managing them for sawtimber production in most situations, but only if prices for syrup remain relatively stable. Government programs have generally encouraged maple production over time, but public policies are unlikely to support continued expansion if there is already more syrup being produced than the market can reasonably handle. Finally, despite some alarmist predictions about the impact of climate change on the maple industry, sugar and red maples are thriving in warmer regions and minor adaptations will allow sugarmakers to continue to obtain viable yields of syrup despite warming temperatures.

There have been several supply and demand imbalances over time that have wreaked havoc with syrup prices, marketing efforts, and the overall expansion of the industry. However, by instituting the Strategic Reserve in 2005, the Federation of Maple Producers of Quebec is now able to absorb excess capacity in good years and supply the market with surplus syrup in poor years (Gagne 2008). Their system has added stability to pricing and has eased market pressures, but it is not perfect and can only withstand limited volatility in pricing and supply issues. Furthermore, producers in Quebec do not get paid fully for their syrup and may wait long periods to realize their total income in any given year. The Federation cannot be solely responsible for stabilizing prices over time and their quota system will have little effect on supply levels if syrup production continues to expand rapidly outside of Quebec. There must be greater cooperation and coordination among industry leaders to expand the market for pure maple products in order to facilitate growth throughout eastern North America.

Although expanding sales of maple products throughout the world may seem like a challenging proposition, per-capita consumption levels are so low that there is a tremendous opportunity to increase the demand for pure maple products. The industry should invest in marketing and promotion campaigns to take advantage of the increased focus on natural, healthy, and organic foods. This type of marketing strategy would appeal to the rapidly growing local food markets in the U.S. and Canada. Furthermore, since maple syrup is only produced on a commercial scale in eastern North America yet has worldwide appeal, further investments should be made to promote maple syrup in world markets. As long as demand can keep up with supply and prices remain near their current levels, the industry is poised to expand for the foreseeable future.

Expanding production in regions where there is a robust maple resource, yet little sugaring taking place, would be one of the best ways to grow the industry. If a 5,000 tap sugaring operation got started in Vermont or Quebec, the impact on consumption would be negligible. There is already an abundant supply of maple products in the major producing regions, so nearly all of the additional output would need to be marketed elsewhere. However, if a large sugaring operation got started in Illinois, Kentucky, Missouri, New Jersey, or Virginia, the marketing situation would be entirely different. In these places, a local supply of maple syrup would be unique and thus very popular in the local food marketplace. People are much more likely to consume maple syrup when it is locally produced and readily available, so expanding production in these regions would allow production and consumption to rise together. As evidence, one study found that 18% of residents in the maple producing regions used pure maple syrup whereas only 4% outside of the major producing states did (Sendak 1974).

Furthermore, producing syrup along the southern and western edge of sugar maple’s range would help provide a preview for what sugaring may be like in the northeast and Canada by the end of the century as a result of climate change. The current tapping season of January-early March in states such as Kentucky and Virginia is what Skinner et al. (2009) forecasted for the northeast by

2100. By conducting applied research on potential yields using various sap collection technologies over a period of many years, we will be better able to predict how the northeast maple industry will be able to respond to a changing climate in the future.

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Appendix A: Survey instrument used for research discussed in Chapter 3.

A SURVEY OF LANDOWNERS IN THE NORTHERN FOREST

Cornell University
Human Dimensions Research Unit

Cornell Maple Program

A Survey of Landowners in the Northern Forest

Research conducted by the
Human Dimensions Research Unit and Cornell Maple Program
Department of Natural Resources
Cornell University

The purpose of this survey is to learn more about the thoughts and attitudes of landowners towards maple syrup production in the Northern Forest region of Maine, New Hampshire, New York, and Vermont. We developed a series of questions that will provide us with a better understanding of why you own your forestland and how maple syrup production may fit in your long term plans.

Your name was randomly selected from landowners who owned potentially wooded land. If you do not own wooded property in Maine, New Hampshire, New York, or Vermont, please answer just the first question and return the survey to us, so that we do not bother you with reminder mailings.

Please complete this questionnaire at your earliest convenience, seal it with the white resealable label provided, and drop it in any mailbox; return postage has been provided. Your participation in this survey is voluntary, but we sincerely hope you will take just a few minutes to answer our questions. All of the data will be summarized to provide a general overview of forest owners in the Northern Forest region. **Your identity will be kept confidential and the information you give us will never be associated with your name.**

1. **Do you own wooded land in the Northern Forest region?**

   ☐ No → Thank you for your time. Please seal this questionnaire and return it to us, so we don't bother you with unnecessary reminder letters.

   ☐ Yes → I own land in (check all that apply):

   ☐ Maine ☐ New Hampshire ☐ New York ☐ Vermont

2. **Approximately how much land do you own in these state(s)?**

   ________ total acres of land owned (even if it is multiple parcels)

   ________ acres of **wooded** land

   _______ acres of wooded land that you think may contain enough accessible maple trees to be tapped for syrup production

3. **How long have you owned your wooded land?** _______ **years**

4. **How far do you live from your closest forested property?**

   ☐ I live on or within 1 mile of my forested property

   ☐ I live ________ miles from my forested property

5. **What is the ownership category for your land?**

   ☐ privately owned non-industrial ☐ private business/corporation

☐ private recreational/hunting club ☐ non-profit organization

☐ other ____

6. **Do you feel that your wooded property should be managed in some way by you or others?** *(By "manage" we mean take deliberate actions to influence the value of the land. Some examples of management activities are harvesting firewood, marking a trail, tapping maple trees, or improving habitat for wildlife.)*

☐ Definitely Yes ☐ Yes ☐ Not Sure ☐ No ☐ Definitely No

7. **Do you manage (or have others manage) your wooded property?** *Please check one.*

☐ Yes ☐ No ☐ Not Sure

8. **Do you belong to one or more of the following organizations?** *Please check all that apply.*

☐ Small Woodland Owners of Maine ☐ NH Timberland Owners Assn ☐ NY Forest Owners Association ☐ Vermont Woodland Owners Assn

9. **Do you currently produce maple syrup on your property?**

☐ No → **Please skip ahead to Question 12 below**

☐ Yes → **Please answer questions 10 and 11 that relate to your maple sugaring operation.**

10. **How many taps do you put out in a typical year?** __________

11. **What year did you start producing syrup ?** ________

Questions 12-18 are directed towards landowners who do not currently produce syrup, so if you are a maple producer, please skip Questions 12-18 and continue on to Questions 19-27.

12. **Do you feel that at least some of the maple trees on your property should be tapped for syrup production, either by yourself or someone else?**

☐ Yes, by me ☐ Yes, by someone else ☐ No ☐ Not Sure

13. **Below is a list of possible reasons why you may not be producing maple syrup.** *Please check all that apply.*

☐ I have never thought about it as an option

☐ I have no interest in the process

☐ I do not have enough tappable maple trees

☐ Land regulations do not allow me to make syrup

☐ I don't know how to get started

☐ My trees are not easily accessible

☐ I do not have enough time

☐ I don't have access to family, friends or neighbors who could help me

☐ The initial cost of buying equipment is too high

☐ Syrup production is not profitable enough

☐ I don’t live close enough to my forestland

☐ Tapping would interfere with other forest uses

☐ I’m concerned about reducing sawtimber value

☐ I think the tubing used to collect sap would look bad

☐ I’m concerned that tubing would interfere with recreation and trails

☐ Other____

14. How likely would you be to start producing syrup if….?

(check one box per line)	Very Unlikely	Somewhat Unlikely	Somewhat Likely	Very Likely
Syrup production was more profitable	☐	☐	☐	☐
There was more education and training opportunities for learning how to do it	☐	☐	☐	☐
You had more trees available for tapping	☐	☐	☐	☐
You lived closer to your forested property	☐	☐	☐	☐
You were able to qualify for reduced property taxes by using your land for syrup production	☐	☐	☐	☐
Easy financing was available for purchasing equipment	☐	☐	☐	☐
You had more people available to assist	☐	☐	☐	☐
Other______________________________	☐	☐	☐	☐

15. Have you ever been approached by a maple producer asking permission to tap the maple trees on your property?

☐ No ☐ Yes, I accepted the request ☐ Yes, I declined the request

16. If you lease or have leased your forestland to a maple producer, please answer the following questions below, otherwise skip ahead to question 17 on the next page:

16a. About how many taps are/were put out each year ? _______

16b. Did/do you have a written contract with the maple producer?

☐ No ☐ Yes → what is the length of the contract ________ years

16c. How satisfied are/were you with this arrangement? *Please circle one.*

Very Dissatisfied Dissatisfied Satisfied Very Satisfied

17. If you do not lease your forestland for tapping to a nearby maple producer, please tell us the reasons why. *Check all that apply.*

☐ I have never been approached by someone asking permission

☐ I do not have enough maple trees on my property

☐ I am concerned about reducing sawtimber value

☐ I think the tubing used to collect sap would look bad

☐ I'm concerned the tubing would interfere with recreation/trails

☐ The revenues gained from leasing are not worth the trouble

☐ I am concerned that tapping would harm or kill my trees

☐ Other ____

18. Some landowners tap the trees on their property and sell the sap to a nearby maple producer, typically receiving half of the value of the syrup produced from the sap as compensation. If you knew a nearby maple producer that wanted to boil your sap, how likely are you to enter into this type of arrangement? *Please circle one.*

Not at all likely   Somewhat likely   Likely   Very likely

The following questions are aimed at learning about your current and previous background with syrup production and consumption.

19. Where do you get the syrup you use at home? *Please check one.*

- ☐ I make it myself.
- ☐ I usually get it from friends/family that make syrup.
- ☐ I usually buy pure maple syrup from a local producer
- ☐ I usually buy pure maple syrup from the grocery store.
- ☐ I usually buy artificial pancake syrup.
- ☐ I usually don't buy any type of syrup.

20. How many people do you know that produce maple syrup? ____

21. As a child were you ever involved with maple syrup production? *Please check all that apply.*

- ☐ I had no involvement with maple production as a child.
- ☐ I recall visiting sugarhouses, tasting pure maple syrup, etc.
- ☐ I used to help family/neighbors that produced maple syrup.
- ☐ Other:____

BACKGROUND INFORMATION

Please tell us about your background so we can better understand your responses. Your information is never associated with your name. —

22. Are you male or female? *(Check one.)*

☐ Male   ☐ Female

23. In what year were you born? 19_____

24. What is your main occupation (if retired, what was your main occupation)?

____

25. Are you retired? ☐ Yes ☐ No

26. What is the highest level of formal education you have completed? *(Check one.)*

- ☐ Less than high school
- ☐ High school diploma / G.E.D.
- ☐ Some college or technical school
- ☐ Associate's Degree
- ☐ College undergraduate degree (e.g., B.A., B.S.)
- ☐ Graduate degree (e.g., M.S., Ph.D., M.D.)

27. Normally, Cornell University never associates your name with the information you provide. However, it would be extremely valuable to the Cornell Maple Program to be able to contact a sample of forest owners for further analysis based on the responses to this survey. Would you be willing to be contacted by researchers with the Cornell Maple Program if selected? (Background information such as age and education would still never be associated with your name.)

☐Yes ☐ No

Please use the space below for any comments you wish to make.

Thank you for your time and effort!

To return this questionnaire, simply seal it with the white removable seal, and drop it in the mail (return postage has been provided)

Appendix B: Users Guide to the Net Present Value (NPV) Calculator for Leasing Taps vs. Managing for Sawtimber Production

Please read the following document before operating the Net Present Value (NPV) calculator. This document describes the key variables in the decision of whether or not to lease a maple tree for tapping, harvest the tree immediately, or manage the tree for long-term commercial sawtimber production. There are 26 variables that a user must input values for in order to conduct the analysis. The website defaults to a typical value one might expect to find in an average maple tree. What makes this spreadsheet useful is that a user can change the value of any of the variables and then immediately see how the NPV analysis changes. The possible ranges for each of the variables is presented in red next to the name of the variable (with the default value appearing in parentheses).

Tree Diameter, Height and Growth Rate

Initial tree diameter (ITD) 6 – 36 (12) inches (dbh)

A user can enter any value for the diameter of the tree at breast height (inches). At very small sizes (<6" dbh) the analysis will not make much sense, so it is best to consider trees than are ≥ 6" dbh.

Initial Diameter Growth Rate Untapped (DGRU) 0 – 1 (.15) inches/year to dbh

Individual tree growth rates will vary based on many factors, including soils, genetics, age, crown position. etc. Typical growth rates range anywhere from .02-.08 in/yr for a slow growing tree vs. .25-.50 for a very fast growing tree. An average tree growing in a northeastern forest would grow at about .15 in/yr. The following table is taken from Richard M. Teck and Donald Hilt. 1991. Individual-Tree Diameter Growth Model for the Northeastern United States. USFS Northeastern Forest Experiment Station Research Paper NE-649. It shows the average potential growth rate for a sugar maple tree based on tree diameter and site index (a measure of site quality). Given that the average potential growth rate is .15 in/yr, this is set as the default growth rate.

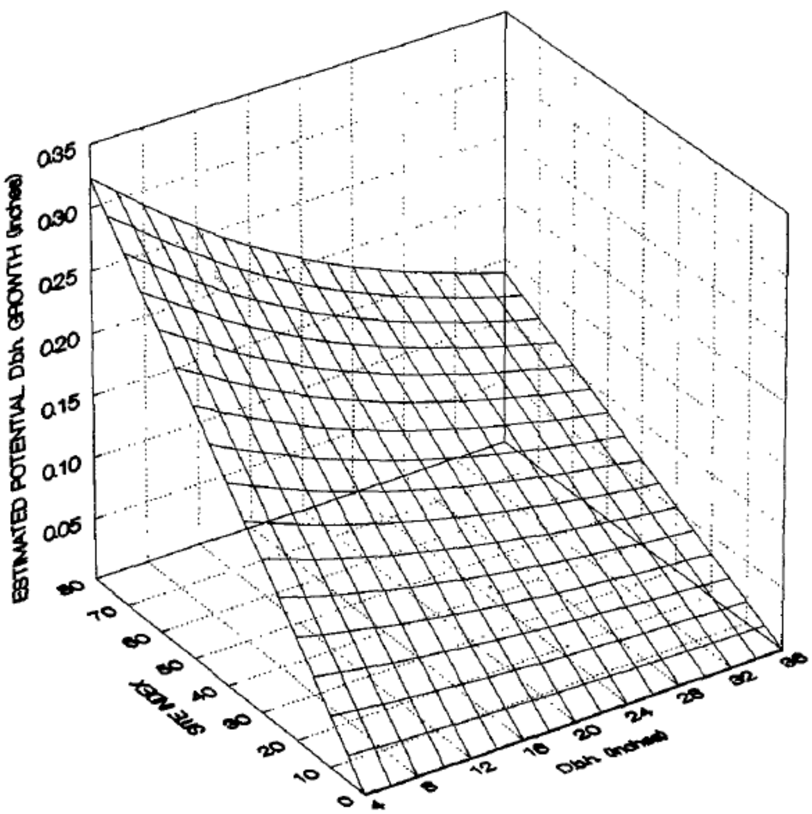


Figure 6.—Predicted potential diameter growth (in inches) for sugar maple.

Initial Merchantable Height Untapped (IMHU) 0 – 3 (.5) ft/year

Enter the height at which the bole of the tree reaches a point where it can no longer be used for a sawlog. This generally occurs where the diameter of the tree inside the bark equals 8". It can also be to the point where there are many large branches spreading out in to the crown of the tree or where a serious defect occurs that would negate any potential sawlog value.

Initial Merchantable Height Growth Rate Untapped (IMHGU) 0 – 3 (.5) ft/year

Users can enter the rate at which the height of the bole that could be sold for sawtimber is increasing at an annual rate (in feet). This could be 0 if the tree form and quality is such that it can no longer add additional height in merchantable logs. This could be the case for trees with serious defects, crotches, or large limbs that occur at a certain height in the tree. For tall straight trees that can still add merchantable height growth, the growth rate may vary anywhere from 0- 3 ft/yr, with the default value set to .5 ft/yr.

Reduction in diameter growth due to tapping (%ΔDGT) 0-50 (10) %

A user can enter the expected % reduction in diameter growth rate if the tree was to be tapped.

This can range anywhere from 0-50%, depending on the assumptions of the user. Based on personal communication with Brian Chabot, who has done research on the effect of tapping on diameter growth rate, the default setting has been set to 10%.

<u>Reduction in height growth due to tapping (%ΔHGT)</u> 0-50 (10) %

A user can enter the expected % reduction in height growth rate if the tree was to be tapped. This can range anywhere from 0-50%, depending on the assumptions of the user. Since merchantable height is strongly correlated with diameter growth of the upper logs, one can assume the same reduction in height growth due to tapping as diameter growth. However, no formal research has ever been done on this subject, so a user can input whatever value he/she feels is appropriate.

<u>% Decline in annual diameter growth rate (%ΔADGR)</u> 0-5 (1) %

Unless trees are growing at an increasing rate, the amount of annual diameter growth will decline as trees get larger. This is due to the fact that if a tree puts on the same amount of wood volume, by having to distribute that same volume over a larger surface area, the annual diameter growth will be reduced by a certain amount. The percentage reduction is what the user must input for this variable, and the default setting is 1%. This figure was devised according to the following graph, taken from Richard M. Teck and Donald Hilt. 1991. Individual-Tree Diameter Growth Model for the Northeastern United States. USFS Northeastern Forest Experiment Station Research Paper NE-649. This shows the potential diameter growth for five species (sugar maple is the 2nd one from the bottom) as a function of tree diameter. The authors develop a series of complicated formulas to derive this graph, but they require information on basal area and relative density that would be difficult and time consuming for a user to obtain. Thus, for the purposes of this analysis, a user can assume that a 1% reduction in annual growth rate for maples, which closely approximates the following graph.

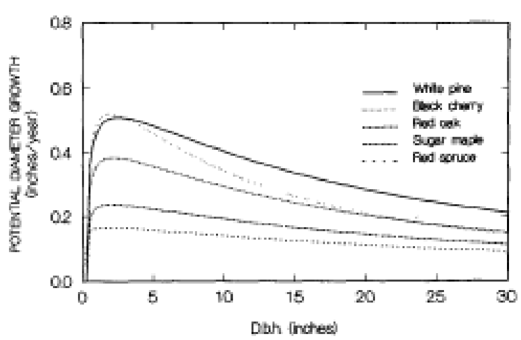


Figure 3.—Predicted potential diameter growth rates for several important species groups (species specific site index equivalent to SI = 50 for red spruce).

<u>% Decline in annual height growth rate (%ΔAHGR)</u> 0-5 (1) %

Given that merchantable height growth is strongly correlated with annual diameter growth, the default setting for this variable is also set to 1.

Stumpage Rates

<u>Species (Sp)</u>   sugar or red maple

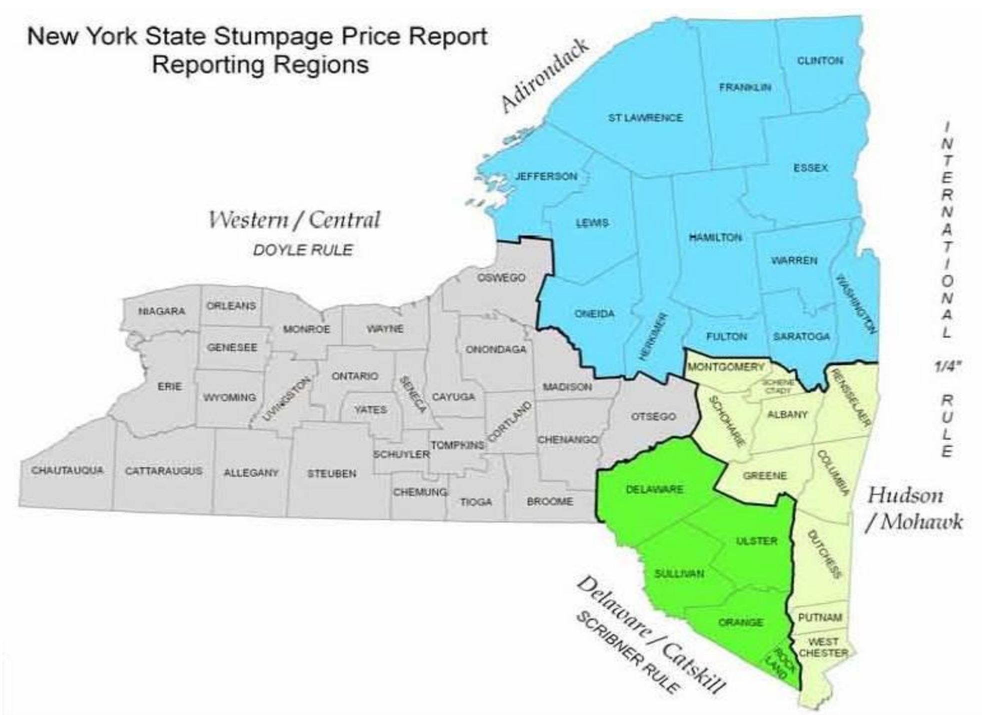
A user can type in 'sugar' or 'red'. The only difference this will make is in the stumpage prices, although since sugar maple sells for much more than red maple the change in NPV will be quite significant.

<u>Height of Tree Affected by Tapping (HTTap)</u>   3-12 (8) ft

Enter in the height at which the butt log would be affected by tapping (in feet). The default value is set to 8, as one can reasonably predict that the first 8 ft butt log will contain all of the tapholes and staining. This is due to tapping higher in years of heavy snow depth with tubing systems. Also, with a typical lateral line height of 4 ft and a 30" dropline extended to maximum capacity, most of the holes wind up being approximately 5-6 ft above the ground. However, if a sugaring operation only used buckets in an area without excessive snow depths, it is possible that only the bottom 3-5 ft would contain tapholes and staining.

<u>Log Scale (LS)</u>   Doyle or Scribner or International scale

The three commonly used log scales in North America are Doyle, Scribner, and International. For New York, Doyle is used primarily in central and western regions, Scribner is used in a small portion of the Catskill region, and International is used in the Adirondacks and Hudson Valley regions. If you live in New York, please refer to the following map, taken from the NYSDEC Stumpage Price Reports, to determine the log scale appropriate for your region. For other states or provinces, consult your local sawmills or state forestry organizations to determine the log scale appropriate for you.



Sawtimber Delivered Log Prices (SDLP) 0-2,000 $/MBF

The user can obtain a price sheet from a local sawmill to input the delivered log prices for sugar and red maples of a given size (assuming no grade defects). The spreadsheet is set up such that users can enter prices for sugar and red maple logs with a diameter inside bark at the small end of 10-11.9”, 12-13.9”,14-15.9”,and ≥ 16”.

Sawtimber Delivered Log Prices (SDLP)

DBH Range	Untapped Sugar Maple (SDLPUSM)	Untapped Red Maple (SDLPURM)
less than 10" dbh	SRC	SRC
Between 10 and 12" dbh	0-2,000 (325) $/MBF	0-2,000 (160) $/MBF
Between 12 and 14" dbh	0-2,000 (400) $/MBF	0-2,000 (160) $/MBF
Between 14 and 16" dbh	0-2,000 (475) $/MBF	0-2,000 (250) $/MBF
greater than 16" dbh	0-2,000 (625) $/MBF	0-2,000 (300) $/MBF

Veneer Delivered Log Prices (VP) 1,000-12,000 $/MBF

The user can obtain a price sheet from a local sawmill to input the delivered log prices for veneer sugar maples of a given size. The spreadsheet is set up such that users can enter prices for sugar maple veneer logs with a diameter inside bark at the small end of 14,15,16,18, and 20”.

Veneer Prices (VP)

DBH Range	Untapped Sugar Maple Veneer (USMV)
between 14 and 15"	1,000-12,000 (3,100) $/MBF
between 15 and 16"	1,000-12,000 (3,600) $/MBF
between 16 and 18"	1,000-12,000 (4,600) $/MBF
between 18 and 20"	1,000-12,000 (5,600) $/MBF
greater than 20"	1,000-12,000 (6,100) $/MBF

Real Annual % Increase/Decrease in Stumpage Rate (%ΔSR) -10 to 10 (4.5) %

Users can estimate the annual percent increase in the real (nominal - inflation) stumpage prices for maple sawtimber. In *Northeastern Regional Timber Stumpage Prices: 1961-1991*, USDA Forest Service Research Paper NE-683, Sendak (1994) estimated over a 30 year period (1961-1991) that real hardwood stumpage prices in the northeast increased at an annual rate of 4.5%. Based on this analysis, the default value is set to 4.5, however users can change this to whatever value they feel anticipate for the future.

Lease Payments

Initial Annual Lease Payment (ALP) 0 – 2 (.50) $/tap/year

The user can enter the annual payment he/she expects to receive per tap. This usually varies anywhere from $.25 to $1 per tap. If the compensation is in syrup rather than a direct cash payment, the user can determine the cash equivalent according to the following formula.

$$\text{Lease Payment} = \frac{\text{Gallons received * \$/Gallon (if landowner had to purchase the syrup)}}{\text{\# of taps leased}}$$

Real Annual % Increase/Decrease in Lease Payment (%ΔLP) -10 to 10 (0) %

This can range anywhere from -10 to 10%, depending on the level of inflation and terms of the lease contract. It is determined according to the following formula:

(%ΔLP) = % annual increase in lease payment (nominal value) – annual rate of inflation.

For example, lease contracts are often developed such that the lease payment is set at a determined rate such as $.50/year for a certain time period. Given that there is no annual increase in the lease payment, if inflation was 3% and then the real annual decrease in lease payment would be -3%. Now imagine another common scenario in which the contract provides an initial lease payment of $.50 with a $.01 (2%) increase each year. If inflation was still at 3%, then the real annual decrease would be 2 – 3 = -1%.
If a contract is written such that the annual lease payment increases at the rate of inflation each year, then the %ΔLP would be 0. Since this is a recommended practice, the default value for this variable is set to 0.

Diameter at which the tree can be tapped (D1T) 6-12 (10) inches (dbh)

The spreadsheet is currently set at 10" but in reality, this could range anywhere from 6-12", depending on the mutually agreed upon desires of the maple producer and landowner. It should be noted that conservative tapping guidelines do not permit the tapping of a tree until it reaches 10 or 12" dbh. However, it is common practice for maple producers to tap trees much smaller than 10" dbh, especially if the stand is crowded and a silvicultural thinning is not scheduled to take place.

Diameter at which to add a second tap (D2T) 12-36 (18) inches (dbh)

Following conservative tapping guidelines, the spreadsheet defaults to 2 taps being placed in a tree once it reaches 18"dbh. However, many maple producers will put a second tap in before the tree reaches 18". The spreadsheet is not set up to include more than 2 taps in a tree, as this is not an acceptable practice according to conservative tapping guidelines. If a user would like to explore the financial implications of adding a 3rd tap, then he/she could simply increase the lease payment by 50%. For a 4th tap, the use can increase the lease payment by 100%.

Tapping Lease Income Tax Rate (TLITR) 0-60 (15) %

Income from leasing trees should be reported as ordinary income. The tax rate a landowner will pay on this revenue is based on the landowners' overall income bracket.

Stumpage Payments

Number of Grades reduced by defects in butt log (#GRBL) 0 – 4 (1) grades

A user should assess the condition of the butt log (on the standing tree) and grade it according to the following specifications, taken from the A. Johnson Company's spec sheet acquired in December 2009. Note that the size and extent of the heartwood has a significant impact on grade, yet this cannot be determined until the tree has been cut down. Therefore, the amount of heartwood must be estimated by examining the outer features of the tree and making an educated guess based on previous experience.

HARDWOOD LOG GRADE SPECS

Prime	16" & up, 1 defect/13 ft of length
Clear	14" & up, 1 defect /10 ft of length
Select	12" & up, 1 defect /4 ft of length
#1	10" & up, 1 defect/3 ft of length 9" butt logs, 1 defect - HM & RO
#2	10" & up, 1 defect/2ft length
Cord Wood	Maximum 20" dia, 20' length

ACCEPTABLE LENGTHS: 8' 4" -16' 4" ft.
Odd lengths are accepted in hardwood.
Pine & Spruce even lengths only
Please mark length on the small end of the log.
Please keep 8' logs to a minimum.

MAXIMUM DIAMETER Sawlogs: 30" - either end
Diameter includes sweep, crook & large knots and flare

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[1] **Hard Maple** - Logs with more than 1/3 diameter in heart are reduced 1 grade
Logs with more than 2/3 diameter in heart are reduced 2 grades.

LONG LOGS PAY A BONUS

[2] **HARD MAPLE, RED OAK, ASH & YELLOW BIRCH** earn a 7% price bonus for length.
Long logs are **13' 4"** & longer in the grades of Prime, Clear & Select.

FACTORS AFFECTING GRADE AND SCALE

Log diameter and length, size and location of defects. Defects include:

Sweep: 1" per 4' of length maximum. Rot, Crook, Heart size (Hard Maple only), Black heart, Mineral stain, Dry logs, Worm holes, Ingrown bark, Checking, Frost cracks, Shake, Cat faces, Knots (especially knots larger than 1/4 of log diameter), Seams (especially spiral seams). Excess gum in Cherry.

Hard Maple (or any other species) with signs of tapping may not be scaled.

Number of Grades reduced by defects in upper logs (#GRUL) 0 – 4 (1) grades

The same process that is undertaken to determine the number of grade reductions for the butt log must also be done to determine the amount of grade reductions in the upper logs. Often times there will be several logs in the upper portion of the stem, yet this analysis assumes that all of the logs have the same number of defects. Therefore, an overall average number of defects (and associated grade reductions) must be assumed for all of the upper logs in a given tree.

Butt Log Market (BLM) sawlog or cordwood or veneer

As seen in this specification sheet from A. Johnson Company, it clearly states that "hard maple (or any other species) with signs of tapping may not be scaled". However, it does not state that tapped logs *will* not be scaled, it only states that they *may* not be scaled. Different sawmills have different policies and guidelines for buying and scaling tapped logs and this will change based on the quality of the logs and market forces. If a tapped log will be bought as a sawlog, then the user should enter "sawlog". If not, then the tapped log will be used for either firewood or pulpwood, so the user should enter "cordwood". This variable also presents an opportunity for the user to enter "veneer" if the butt log is of sufficient size and quality to be sold to a veneer mill. This drastically increases the stumpage price for the log, though readers should note that only a small fraction of all sawlogs will be sold as veneer.

Percentage of Delivered Log Price that the landowner receives (%DLPLR) 10-100 (50) %

This will vary based on many factors, including but not limited to timber quality, volume to be harvested, terrain and accessibility, market demand, distance to market, season of year, costs of harvesting, landowner knowledge, and the terms of the contract.

Value of Tapped Logs as a % of Untapped Logs (TL%UT) 10-150 (33) %

If a tapped log is to be sold as a sawlog, this variable allows the user to specify the price that will be paid to the landowner as a fraction of the untapped price. The default price is set to 33%, meaning that a tapped log will sell at 33% of the price of an untapped log of the same size and number of defects. The figure may actually be much higher, depending on the buyer, market conditions, and other factors. Also note that by inserting a value above 100, the price for a tapped log can actually be higher than that of an untapped log. While this is rarely the case, there are situations where niche markets for taphole maple lumber will drive the prices up for relatively rare tapped logs.

Stumpage rate for Cordwood (SRC) 0-50 (20) $/MBF

Although cordwood stumpage is usually based on a per cord basis, the nature of this spreadsheet requires that stumpages prices for cordwood be described on a bd ft basis. If one assumes that there are 2 cords in 1,000 bd ft (MBF), and the stumpage rate for cordwood is $10/cord, then the user should input 2 * 10 = $20 for this variable.

Stumpage Payment Method (SPM) scaled or contract

Loggers sometimes pay landowners based on a percentage of the revenues from logs brought to a sawmill; in these cases a user should type in "scaled". Other times a logger may provide the landowner with the monies that are leftover once their costs for harvesting, skidding, and hauling have been covered. In these circumstances a user should type "contract".

Cost of timber harvesting (CTH) 0-500 (150) $/MBF

If the user enters "contract" in the Stumpage Payment Method, then this variable is used to calculate stumpage payments. In this case, the value entered for CTH is subtracted from the delivered log price to determine the stumpage price received by the landowner.

Timber Income Tax Rate (TITR) 0-60 (15) %

The rate a landowner pays on timber income will vary depending on whether it is classified as ordinary income or capital gains. A landowner should input the tax rate they expect to pay on the income from selling timber.

Property Tax Payments

Regular taxes per acre (RTPA) 0-1,000 (20) \$/acre/year

A user can look at his or her tax bill and assessment to determine the amount of taxes he/she is paying on a per acre basis for the forestland. The following equation is useful for determining this value:

$$RTPA = \frac{\text{Total Tax Payment} * (\text{Value in land/Total assessed value})}{\text{Acres in sugarbush/Total acres on property}}$$

Ag assessment taxes per acre (AgTPA) 0-1,000 (5) \$/acre/year

In New York State (and possibly others), landowners can receive an agricultural assessment, thereby reducing their property tax payments, by producing syrup themselves or leasing taps to another producer. For a brochure explaining the details of this program, please refer to the following website.
A user can determine what the annual taxes would be on a per acre basis if his or her land qualified for an agricultural assessment. This will be based on the assessed value of the land (as determined by the soil type provided from the Soil & Water Conservation District) as well as the tax rate for a given town.

Real Annual Property Tax Payment % increase/decrease (%ΔRAPTP) -10 to 10 (0) %

Property tax rates and payments are not static yet tend to fluctuate from year to year. A user can make a prediction on how tax payments will increase or decrease over time. Estimates are made as a percentage of the annual property tax payment per tree.

Property Tax Payment Rate (PTPR) 0-50 (5) %

The tax rate is determined by dividing the total amount of money that has to be raised from the property tax (the tax levy) by the taxable assessed value of taxable real property in a municipality. If, for example, a town levy is \$2,000,000, and the town has a taxable assessed value (the sum of the assessments of all taxable properties) of \$40,000,000, the tax rate would be \$50 for each \$1,000 of taxable assessed value, or 5%.

Uniform Percentage (UP) 0-100 (100) %

Once an assessor estimates the value of a property, its total assessment is calculated by multiplying the market value by the uniform percentage for the municipality. That percentage can be five percent, ten percent, 50 percent, or any other percentage not exceeding 100 percent. The percentage used does not matter, the only requirement is that all properties in the municipality use the same value. For example, if an assessor assesses property at 15 percent of value, forestland with a market value of $100,000 would have an assessment of $15,000.

Number of trees per acre (TPA) 30-500 (100) # trees/acre

This variable is used to determine the amount of taxes per tree that a landowner must pay each year. Although taxes are paid on a per acre basis, in order to conduct the analysis on an individual tree basis, on must divide the total taxes per acre by the number of trees per acre. A young, dense sugarbush could have upwards of 400-500 trees per acre whereas an older, established sugarbush that has been managed may only have 30-50 trees per acre. This is one of the most difficult and time consuming variables to determine the value for, especially if the data is collected scientifically and systematically (which it should be). Furthermore, assessing taxes on a per tree basis is not a fair assessment of real-world conditions, as landowners will pay the same amount of taxes no matter how many trees are growing on a specific acre. The exception to this is where assessors utilize a "tree tax", essentially taxing landowners at a higher rate based on the quality and quantity of timber present.

Financial Variables

Discount Rate (DR) 0-16 (4) %

This is one of the most important variables, especially when comparing future revenues for leasing and/or timber harvesting vs. harvesting a tree immediately. As seen in 'Discount rate for long-term Forest Service investments', *Journal of Forestry*, 79(6): 367-369,376., Row, C., Kaiser, H.F. and Sessions, J. (1981) explain how the US Forest Service used a discount rate of 4% to evaluate long term investments. Therefore, based on the USFS guidelines, 4% is the default discount rate used in the spreadsheet. However, the discount rate can vary greatly based on the desires of the landowner, so user can change it to reflect their own situation. In order to set a discount rate, one should first ask themselves "What is the annual rate of return (interest payment) that I could expect to get over the long-term if I invested the money that I would receive by harvesting the tree immediately?"

Time Horizon of the Investment Period (THIP) 2-40 (10) years

A user can enter between 2 and 40, depending on either (1) the number of years the user is planning to own a particular piece of land, or (2) the number of years until which the landowner is planning on harvesting the tree in question.

Appendix C: Formula Descriptions for NPV Calculator

This document shows all of the variables that are used in the Net Present Value analysis of managing an individual maple tree for sawtimber production or leasing it for syrup production. The first section shows all of the variables that are directly controlled by the user, the second section displays the intermediate formulas that are used in the analysis, while the third section outlines all of the formulas that are used in the final analysis.

Section 1. User Controlled Variables

All of the variables in this section are directly controlled by the user. The possible inputs/ranges for each of the variables are displayed in red with recommended values for some of the variables placed in parentheses.

Tree Diameter and Growth
Initial tree diameter (ITD) 6 - 36 inches (dbh)
Initial Diameter Growth Rate Untapped (DGRU) 0 – 1 (.15) inches/year to dbh
Reduction in diameter growth due to tapping (%ΔDGT) 0-50 (10) %
% Decline in annual diameter growth rate 0-5 (1) % (%ΔADGR)

Merchantable Height and Growth
Initial merchantable height (IMH) 8- 48 (32) ft
Initial Merchantable height growth rate Untapped (IMHGU) 0 – 3 (.5) ft/year
Reduction in height growth due to tapping (%ΔHGT) 0-50 (10) %
% Decline in annual height growth rate 0-5 (1) % (%ΔAHGR)

Stumpage Variables
Species sugar or red maple (Sp)
Height of tree affected by tapping (HTTap) 3-12 (8) ft
Real Annual % increase/decrease in stumpage rate (%ΔSR) -10 to 10 (4.5) %
Log Scale (LS) Doyle or Scribner or International scale
Butt Log Market (BLM) sawlog or cordwood or veneer
Number of Grades reduced by defects in butt log (#GRBL) 0 – 4 (1) grades
Number of Grades reduced by defects in upper logs (#GRUL) 0 – 4 (1) grades
Stumpage Payment Method (SPM) scaled or contract
Cost of timber harvesting (CTH) 0-500 (150) $/MBF
Percentage of Delivered Log Price that the landowner receives (%DLPLR) 10-100 (50) %
Value of Tapped Logs as a % of Untapped Logs (TL%UT) 10-150 (33) %
Stumpage rate for Cordwood (SRC) 0-50 (20) $/MBF
Timber Income Tax Rate (TITR) 0-60 (15) %

Lease Payments
Annual Lease Payment (ALP) 0 – 2 (.50) $/tap/year
Real Annual % Increase/Decrease in Lease Payment (%ΔLP) -10 to 10 (0) %
Diameter at which the tree can be tapped (D1T) 6-12 (10) inches (dbh)
Diameter at which to add a second tap (D2T) 12-36 (18) inches (dbh)
Tapping Lease Income Tax Rate (TLITR) 0-60 (15) %

Property Taxes
Number of trees per acre (TPA) 30-500 (100) # trees/acre
Current assessment of forestland per acre (CAFPA) 0-10,000 (800) $/acre/year
Ag assessment of forestland per acre (AgFPA) 0-600 (200) $/acre/year
Real Annual Property Tax Payment % increase/decrease (%ΔRAPTP) -10 to 10 (0) %
Property Tax Payment Rate (PTPR) 0-50 (5) %
Uniform Percentage (UP) 0-100 (100) %

Financial Variables
Discount rate (DR) 0-16 (4) %
Time horizon of investment period (THIP) 2-40 years

Delivered Log Prices

Sawtimber Delivered Log Prices (SDLP)

DBH Range	Untapped Sugar Maple (SDLPUSM)	Untapped Red Maple (SDLPURM)
less than 10" dbh	SRC	SRC
Between 10 and 12" dbh	0-2,000 $/MBF	0-2,000 $/MBF
Between 12 and 14" dbh	0-2,000 $/MBF	0-2,000 $/MBF
Between 14 and 16" dbh	0-2,000 $/MBF	0-2,000 $/MBF
greater than 16" dbh	0-2,000 $/MBF	0-2,000 $/MBF

Veneer Prices (VP)

DBH Range	Untapped Sugar Maple Veneer (USMV)
Between 14 and 15"	1,000-12,000 $/MBF
Between 15 and 16"	1,000-12,000 $/MBF
Between 16 and 18"	1,000-12,000 $/MBF
Between 18 and 20"	1,000-12,000 $/MBF
greater than 20"	1,000-12,000 $/MBF

Section 2. Intermediate Formulas
The following formulas are based on the variables presented above. They do not appear directly in the final spreadsheet, rather they are used in the final derivations.

Tree Growth

Diameter Growth Rate Tapped (DGRT)
= Diameter Growth Rate Untapped (DGRU) * % Reduction in Diameter Growth Rate due to Tapping (%ΔDGT) = ________ inches/year to dbh

Merchantable Height Growth Rate Tapped (HGRT)
= Merchantable Height Growth Rate Untapped (HGRU) * % Reduction in Merchantable Height Growth Rate due to Tapping (%ΔHGT) = _______ ft/year to merchantable height

Stumpage Payments: This section contains intermediate formulas that are used to calculate stumpage rates.

Initial Stumpage Table (IST)
The following table shows how stumpage rates are derived based on the user controlled variables provided above. The numbers in each cells are explained in the paragraphs below.

DBH Range	Untapped Sugar Maple (SRUSM)	Untapped Red Maple (SRURM)	Tapped Sugar Maple (SRTSM)	Tapped Red Maple (SRTRM)
Less than 10" dbh	1	2	3	4
Between 10 and 12" dbh	5	6	7	8
between 12 and 14" dbh	9	10	11	12
between 14 and 16" dbh	13	14	15	16
Greater than 16" dbh	17	18	19	20

1,2,3,4 = Stumpage Rate for Cordwood (SRC)

5,9 = IF(SPM="contract", SDLPUSM – CTH, SDLPUSM * %DLPLR)

6,10,14,18 = IF(SPM="contract", SDLPURM – CTH, SDLPURM * %DLPLR)

13 = IF (Butt Log Market (BLM)="veneer", AVERAGE(USMV1:USMV2)*(%DLPLR), IF(SPM="contract", SDLPUSM – CTH, SDLPUSM * %DLPLR))

17 = IF (Butt Log Market (BLM)="veneer", AVERAGE(USMV3:USMV5)*(%DLPLR), IF(SPM="contract", SDLPUSM – CTH, SDLPUSM * %DLPLR))

7,11,15,19 =IF(BLM="cordwood",SRC, IF(SPM="contract",((SDLPUSM * TL%UT)-CTH),(SDLPUSM * TL%UT * %DLPLR)))

8,12,16,20 =IF(BLM="cordwood",SRC, IF(SPM="contract",((SDLPURM * TL%UT)-CTH),(SDLPURM * TL%UT * %DLPLR)))

# of 16 ft logs affected by tapping (#16LABT)
= Height of the tree affected by tapping (HTTap) / 16 = _________ # of 16 ft logs

Untapped stumpage rate increase/decrease of butt log ($ΔUSRBL)
= Initial Stumpage Rate of Untapped Butt Log (ISRUBL) * Real Annual % Increase/Decrease in Stumpage Rates (%ΔSR) = ______ $/MBF/year

Tapped stumpage rate increase/decrease of butt log ($ΔTSRBL)
= Initial Stumpage Rate of Tapped Butt Log (ISRTBL) * Real Annual % Increase/Decrease in Stumpage Rates (%ΔSR) = _______ $/MBF/year

Stumpage rate increase of upper logs ($ΔSRUL)
= Initial Stumpage Rate of Upper Logs (ISRUL) * Real Annual % Increase/Decrease in Stumpage Rates (%ΔSR) = _______ $/MBF/year

Initial Untapped Stumpage Rate Butt Log (IUSRBL)
= IF (Species = "red", VLOOKUP ((ITD-(#GRBL*2)),IST,SRURM), VLOOKUP((ITD-(#GRBL*2)),IST,SRUSM)) = ________ $/MBF

Initial Tapped Stumpage Rate Butt Log (ITSRBL)
= IF (Species = "red", VLOOKUP ((ITD-(#GRBL*2)),IST,SRTRM), VLOOKUP((ITD-(#GRBL*2)),IST,SRTSM)) = _______ $/MBF

Initial Stumpage Rate Upper Logs (ISRUL)
= IF (Species = "red", VLOOKUP ((ITD-((#GRUL*2)+2)),IST,SRURM), VLOOKUP((ITD-((#GRUL*2)+2)),IST,SRUSM)) = ________ $/MBF

Lease Payments

Monetary value of increase in lease payment ($ΔALP) = Annual Lease Payment (LP) * Annual % Increase/Decrease in Lease Payment (%ΔLP) = _____ $/tap/year

Property Taxes

Regular taxes per acre (RTPA)
Current assessment of forestland per acre (CAFPA) * Uniform Percentage (UP) * Property Tax Payment Rate (PTPR)

Ag assessment taxes per acre (AgTPA)
Agricultural assessment of forestland per acre (AgFPA) * Uniform Percentage (UP) * Property Tax Payment Rate (PTPR)

Regular taxes per tree (RTPT)
= Regular Taxes per Acre (RTPA) / Trees per Acre (TPA) = ________ $/tree/year

Ag assessment taxes per tree (AgTPT)
= Ag Assessment Taxes per Acre (AgTPA)/ Trees per Acre (TPA) = _____ $/tree/year

Monetary value of increase/decrease in regular tax payment ($ΔRTP)
= Regular taxes per tree (RTPT) * Real Annual Property Tax Payment % increase/decrease (%ΔRAPTP)

Monetary value of increase/decrease in ag assessment tax payment ($ΔAgTP)
= Ag assessment taxes per tree (AgTPT) * Real Annual Property Tax Payment % increase/decrease (%ΔRAPTP)

Section 3. Spreadsheet Formulas

This section used the variables above and intermediate formulas to conduct the final NPV analyses over a 40 year time horizon. This section only uses acronyms in the formulas, so the user must refer back to the previous pages to find descriptions of the acronyms. Using the "Control-F" function on your keyboard will make this process easier.

Untapped Tree Diameter Year 1 (UTD1)
= ITD

Untapped Tree Diameter Year 2 (UTD2)
= UTD1 + (DRGU * (1-(%ΔADGR))^(Current Year-Year 1))

Tapped Tree Diameter Year 1 (TTD1)
= ITD

Tapped Tree Diameter Year 2 (TTD2)
= TTD1 + (DRGT * (1-(%ΔADGR))^(Current Year-Year 1))

Number of 16 Foot Logs Untapped (#16LU)
= (IMH/16) +((IMHGU/16)*(1-%ΔAHGR)^(Current Year-Year 1))

Number of 16 Foot Logs Tapped (#16LT)
= (IMH/16) +((MHGT/16)*(1-%ΔAHGR)^(Current Year-Year 1))

Board Foot Volume Equations: The following three formulas utilize the same two variables (#16LU and UTD), their only difference is in the coefficients for the volume equation.

Board Ft Volume of the Entire Tree Untapped; Scribner Scale (BFVETUSS)
=((17.53508*(#16LU))+(0.59242*(#16LU ^2))-22.50365)+(((3.02988-(0.02302*(#16LU ^2))-(4.34391*#16LU))*UTD))+((((0.51593*#16LU)-(0.02035*(#16LU ^2))-(0.01969))*(UTD^2)))

Board Ft Volume of the Entire Tree Untapped; International Scale (BFVETUIS)
=((1.52968*(#16LU ^2))+(9.58615*E156)-13.35212)+(((1.7962-(0.27465*(E156^2))-(2.59995*E156))*$C156))+(((0.04482-(0.00961*(E156^2))+(0.45997*E156))*($C156^2)))

Board Ft Volume of the Entire Tree Untapped; Doyle Scale (BFVETUDS)
=((0.55743*(#16LU ^2))+(41.51275*#16LU)-29.37337)+(((2.78043-(0.04516*(#16LU ^2)) -(8.77272*#16LU))*UTD))+(((0.04177-(0.01578*(#16LU ^2)) +(0.59042*#16LU))*(UTD^2)))

The Bd Ft Volume equations for an entire untapped tree have been presented above using all 3 log scales. However, in the interest of time and space, I have only presented the Doyle scale equations for the bd ft volumes equations for an entire tapped tree, the butt log of tapped and untapped trees, and above the butt log for tapped and untapped trees. The only aspect that would change for these equations using the Scribner and International scales is the coefficients in the equations, so I did not feel it was necessary to include all of them in this document.

Board Ft Volume of the Entire Tree Tapped; Doyle Scale (BFVETTDS)

=((0.55743*(#16LT ^2))+(41.51275*#16LT)-29.37337)+(((2.78043-(0.04516*(#16LT ^2)) - (8.77272*#16LT))*TTD))+(((0.04177-(0.01578*(#16LT ^2)) +(0.59042*#16LT))*(TTD^2)))

Board Ft Volume of the Butt Log Untapped; Doyle Scale (BFVBLUDS)
=((0.55743*(#16LABT ^2))+(41.51275*#16LABT)-29.37337)+(((2.78043-(0.04516*(#16LABT ^2)) - (8.77272*#16LABT))*UTD))+(((0.04177-(0.01578*(#16LABT ^2)) +(0.59042*#16LABT))*(UTD^2)))

Board Ft Volume of the Butt Log Tapped; Doyle Scale (BFVBLTDS)
=((0.55743*(#16LABT ^2))+(41.51275*#16LABT)-29.37337)+(((2.78043-(0.04516*(#16LABT ^2)) - (8.77272*#16LABT))*TTD))+(((0.04177-(0.01578*(#16LABT ^2)) +(0.59042*#16LABT))*(TTD^2)))

Board Ft Volume above the Butt Log Untapped; Doyle Scale (BFVABLTDS)
= (BFVETUDS) - (BFVBLUDS)

Board Ft Volume above the Butt Log Tapped; Doyle Scale (BFVABLTDS)
= (BFVETTDS) - (BFVBLTDS)

Untapped Stumpage Rate Butt Log (USRBL)
=IF(Sp="red",((VLOOKUP((UTD-(#GRBL *2)),IST, SRURM))+((Current Year-Year 1)* $ΔUSRBL)), ((VLOOKUP((UTD-(#GRBL *2)),IST, SRUSM))+((Current Year-Year 1)* $ΔUSRBL))

Untapped Stumpage Rate Above the Butt Log (USRABL)
=IF(Sp="red",((VLOOKUP((UTD-((#GRUL *2)+2)),IST, SRURM))+((Current Year-Year 1)* $ΔUSRUL)), ((VLOOKUP((UTD-((#GRBL *2)+2)),IST, SRUSM))+((Current Year-Year 1)* $ΔUSRUL))

Untapped Stumpage Payment Butt Log (USPBL)
= BFVBLUDS * (USRBL/1000)

Untapped Stumpage Payment Above the Butt Log (USPABL)
= BFVABLUDS * (USRABL/1000)

Tax Payment for Untapped Stumpage Revenue (TPUSR)
= - (USPBL + USPABL) * TITR

Tapped Stumpage Rate Butt Log (TSRBL)
=IF(Sp="red",((VLOOKUP((TTD-(#GRBL *2)),IST, SRTRM))+((Current Year-Year 1)* $ΔTSRBL)), ((VLOOKUP((TTD-(#GRBL *2)),IST, SRTSM))+((Current Year-Year 1)* $ΔTSRBL))

Tapped Stumpage Rate Above the Butt Log (TSRABL)
=IF(Sp="red",((VLOOKUP((TTD-((#GRUL *2)+2)),IST, SRURM))+((Current Year-Year 1)* $ΔTSRUL)), ((VLOOKUP((TTD-((#GRBL *2)+2)),IST, SRUSM))+((Current Year-Year 1)* $ΔTSRUL))

Tapped Stumpage Payment Butt Log (TSPBL)
= BFVBLTDS * (TSRBL/1000)

Tapped Stumpage Payment Above the Butt Log (TSPABL)
= BFVABLTDS * (TSRABL/1000)

Tax Payment for Tapped Stumpage Revenue (TPTSR)
= - (TSPBL + TSPABL) * TITR

Untapped Stumpage Payment Present Value (USPPV)
=(USPBL + USPABL + TPUSR)/((1+DR)^(Current Year-Year 1))

Tapped Stumpage Payment Present Value (TSPPV)
=(TSPBL + TSPABL + TPTSR)/((1+DR)^(Current Year-Year 1))

Annual Lease Payment Spreadsheet Calculation (ALPSC)
=IF(TTD < D2T,(ALP+((Current Year - Year 1)* $ΔALP)),(2*ALP)+(Current Year - Year 1)*(2*$ΔALP)))

Tax Payment for Lease Revenue (TPLR)
= - (ALPSC * TLITR)

Annual Lease Payment Present Value (ALPPV)
= (ALPSC + TPLR) /((1+DR)^(Current Year-Year 1))

Cumulative Annual Lease Payment Present Value (CALPPV)
In Year 1
= ALPPV (Year 1) + CALPPV (Year 0)

Regular Taxes per Tree Present Value (RTPTPV)
= - ((RTPT+((Current Year-Year 1)* $ΔRTP)) / ((1+DR)^(Current Year-Year 1)))

Cumulative Regular Taxes per Tree Present Value (CRTPTPV)
In Year 1
= RTPTPV (Year 1) + CRTPTPV (Year 0)

Ag Assessment Taxes per Tree Present Value (AgTPTPV)
= - ((AgTPT+((Current Year-Year 1)* $ΔAgTP)) / ((1+DR)^(Current Year-Year 1)))

Cumulative Ag Assessment Taxes per Tree Present Value (CAgTPTPV)
In Year 1
= AgTPTPV (Year 1) + CAgTPTPV (Year 0)

Net Present Value (tapping/cutting vs. delayed harvest)
= (TSPPV + CALPPV + CAgTPTPV) – (USPPV + CRTPTPV)

Net Present Value (tapping/cutting vs. immediate harvest)
= (TSPPV + CALPPV + CAgTPTPV) – (USPPV in Year 1 + RTPTPV in Year 1)

Net Present Value (continuous tapping vs. delayed harvest)
= (CALPPV + CAgTPTPV) – (USPPV + CRTPTPV)

Net Present Value (continuous tapping vs. immediate harvest)
= (CALPPV + CAgTPTPV) – (USPPV in Year 1 + RTPTPV in Year 1)

Appendix D: Guidelines for leasing taps on state forestland in Vermont

Guidelines and Licensing Requirements for Tapping and Collecting Sap from Maple Trees on Department of Forests, Parks and Recreation Lands

The purpose of this document is to provide guidelines for the production of maple sap as part of a long-term sustainable forest management practice on lands owned by the Department of Forests, Parks and Recreation ("Department" or "FPR").

It is recognized that monocultures can increase susceptibility to insect and/or disease damage and should be discouraged. It is also recognized that the risk of infrastructure damage by squirrels increases with the percentage of conifers in a stand and that an ideal stand for maple sap production is a mix of hardwood species with maple as the dominant component.

Site specific guidelines will be developed on a case-by-case basis for each license area to identify trees that the Department wishes to have reserved from tapping or otherwise protected for reasons including, but not limited to, protection of potential veneer quality trees[1] or for tree health protection. These trees will be marked by or under the direction of a Department forester as determined by the Department on a case-by-case basis by painting or any other non-removable method indicated by the State.

Tapping Guidelines

Sugar or hard maple (*Acer saccharum*) and red maple (*Acer rubrum*) shall both be considered tappable species. The Department may review and approve all trees to be tapped prior to tapping in any year.

The health of individual tappable trees must be assessed and the allowable taps reduced or deferred where a tree shows signs of stress.

Tappable trees shall have a healthy crown and show minimal sign of dieback. Tree health may be evaluated by the Department, and at risk trees may be reserved from tapping at the Department's discretion. Indicators of tree risk include, but are not limited to, poor crown condition, slow taphole closure, predicted or prior defoliation, weather damage, visible damage due to disease, fungus, insect infestation, drought or physical trauma. Trees that are not at risk may be tapped according to the following standards:

[1] For these purposes, "potential veneer quality tree" shall mean a sugar maple that has no visible defect on any side for the first 12 feet of log height and no visible rot at the stump.

12-20” DBH 1 Tap
20”+ Larger DBH 2 Taps

Diameter at breast height (DBH) means tree diameter measured outside the bark at a level 54 inches above the ground on the highest side of the tree when the tree is on a slope, and measured from between any root buttresses. DBH shall be measured with a diameter tape as used in the forestry profession and not with calipers, a Biltmore stick or its equivalent, or any other means than a diameter tape. Where a swell, abnormality, deformity or other protuberance occurs at the prescribed height of measurement, the measurement shall be taken immediately above the swell, abnormality, deformity or other protuberance. All doubts as to whether a tree is of sufficient DBH to qualify for tapping shall be resolved in favor of not tapping.

No tree shall contain more than two taps and tap holes should be placed as far apart as possible. In an ideal situation, tap holes should not be placed closer than three inches horizontally and twelve inches vertically from an open tap hole. Holes should not be placed closer than three inches horizontally from a visible dead seam if possible. Tap holes shall not exceed 5/16” in diameter and shall be drilled no deeper than 1.5” total depth into the tree’s white wood. Trees shall be tapped only once per year. Taps must be removed from each tree at the end of each sugaring season.

For multi-stem trees that separate within 4.5 feet from the ground each stem shall be considered one tree, for trees that fork higher than 4.5 feet from the ground, the stems shall be collectively considered a single tree.

Tree and Forest Health Issues

As stated above, no tree shall have more than two taps, and no tree less than 12” DBH will be tapped. No sanitizing materials may be used in tap holes. The Licensee must take precautions to avoid tree wounding such as vehicle and other mechanical damage during operations and maintenance activities. Soil compaction by vehicles must be minimized.

Any proposed vegetation management must be approved in writing in advance by the Department in a document setting forth the approved activity and any requirements and/or limitations associated therewith. This includes, but is not limited to fertilization, thinning, treatment of invasive or native species, and any use of a pesticide. The Licensee will encourage regeneration of appropriate species in the understory. Chainsaws may be used to remove downed limbs that are in the way of or have damaged tubing systems. Felling of trees of any size (live or dead) without prior approval of the Department is prohibited.

Sap may be collected using either buckets or tubing. All tubing systems shall be installed and managed according to best management practices as outlined in "North American Maple Syrup Producers Manual 2nd Edition" or approved successor document(s). Tubing systems may be left in place during the off-season if they do not interfere with trail-related activities as determined by the Department and as specified in individual license agreements. Vacuum pumps may be used for sap collection and the noise from these vacuum pumps kept to a minimum.

The end of mainlines may be anchored into trees using lag bolts or sleeved wires. The use of nails to support tubing, either main lines or laterals is prohibited. Where wires or cables come into contact with a tree, either blocking or sleeves shall be used to prevent the wire or cable from becoming imbedded into the tree.
The use of an ATV or snowmobile may be allowed for the installation and maintenance of tapping systems. The use of these vehicles shall be restricted to the areas specifically identified for each licensed site and shall be restricted to the Licensee or those working for the Licensee for the installation and maintenance of tapping systems only. The Licensee will report any unauthorized use of motorized vehicles that occurs on the site in any season to Department staff.

The Department may, on a case-by-case basis for extensive tapping installations, authorize the seasonal use of larger equipment to transport main lines for installation and removal. The Department must approve the use of larger motor vehicles in advance, in writing in the license agreement or in a separate document. Such written approval or license shall contain conditions and limitations on use including, but not limited to the following: 1) the equipment shall be used only under dry or frozen conditions and may be further limited by the Department based on the season and on-site conditions; 2) identification of authorized vehicle access route(s); 3) entry shall be as minimal as possible; 4) requirements to install and replace or repair any gates, barricades or berms as soon as the work using the vehicles is completed; 5) all access roads must be built and maintained according to guidelines provided by the Department. Any road, ditch or crossing device that is installed for maple production must be maintained and repaired at the sole expense of the Licensee to a condition satisfactory to the Department.
All access trails and/or roads shall be routinely maintained by the Licensee and all culverts, crossings, and/or water bars must be kept in good working condition. Where a motorized vehicle must cross a permanent stream, a temporary bridge shall be constructed and utilized and the Department notified. Licensees must comply with applicable guidelines contained within the "Acceptable Management Practices For Maintaining Water Quality On Logging Jobs In Vermont" **and all specific requirements in their license agreements related to the** use of all existing or constructed roads. The Acceptable Management Practices (or AMP's) will also be used to guide design and spacing for drainage devices, protective strips or other water protection items not specifically detailed here or spelled out

in the license agreement. If snow plowing of a forest highway is required for operations and approved by the Department, the Licensee shall be responsible for such plowing and any associated costs and shall be responsible for any damage to the roadway or ditches resulting from this activity. Designated snowmobile trails may not be blocked or plowed by Licensees without prior written permission of the Department.

Practices to Be Applied During Maple Sugaring Operations to Protect Soil and Water Resources

The Licensee is responsible for installing and maintaining all erosion control and water quality protection measures during and after the sugaring season. Licensees shall submit plans and maps that show the expected road and access trail usage and construction as well as main lines and the approximate number of taps that will be served by them.

Licensees may make arrangements for the use of private access points and existing graveled forest highways to access sugar license areas and sap collection stations. Any road construction on state land is limited to short spurs or landings to access sap collection stations. Licensee will be required to repair any damage to forest highways and other roads on state land that their use may cause, as well as to maintain such roads as may be associated with normal wear and tear related to their use of them.

1. Snowplowing of forest highways to access sugaring operations will be of the shortest distance possible and on gravel surfaces for sap collection and related purposes only. The state lands forester in charge will be notified before snowplowing operations are to begin.
2. All temporary access construction will be done to standards and approved by the state lands forester in charge.
3. Roads will be gated or blocked at the Licensee's expense when not in active use for sugaring or line maintenance as per the direction of the state lands forester in charge. Licensee will be provided with any necessary gate keys or lock combinations to state-owned gates so that they can access the licensed sugarbush.
4. Road surfaces will be adequately drained. Ditches will be constructed to divert water from road surfaces if needed. Culverts will be placed if needed to the specifications of the state lands forester. Ditches and culverts will be kept free of debris in all seasons. Silt fencing, diversions, hay bales and other erosion check devices may be required during construction or during use in the spring sap collection. These shall follow the standards outlined in the AMP's.

5. Weight limits will be established on state forest highways by the state lands forester in charge if necessary during sap hauling. To minimize road damage, Licensee will make every attempt to haul large sap loads out during early morning hours or at other times when the road bed is frozen.
6. Maintenance of roads will be as needed. Prompt attention will be made to ruts or other surface issues related to spring usage. Grading, graveling and ditch maintenance will be done annually when the road dries out following sugaring.
7. Vehicles will not ford streams or wet areas. Temporary bridges designed for the weight of the vehicle will be required. The State does not design temporary bridges or recommend load weights and does not accept liability for any bridge failure or problem.

Access Trails

1. Constructed trails will be allowed for use by tractor or ATV for spring sap collection activities or for work on lines in frozen conditions or dry weather. Vehicle size or tire type may be restricted during spring collection.
2. Access trail construction will be of the shortest length possible and will be approved by the state lands forester. Trail construction and maintenance will take place in dry weather prior to spring sap run.
3. Pitches of 20% grade on trails will not exceed 300 feet. Trails will not be built that exceed 20% grade.
4. Trails will not ford streams or wetlands. Temporary bridges will be required if needed. No brushing in of streams will be allowed. Culverts for trail crossings will be discouraged in favor of bridges. No slash or other debris shall be allowed in streams.
5. Buffer strips along access trails and roads will be in place along streams and wetlands in accord with the AMP's.
6. Trails will not be built on existing hiking, skiing, biking or snowmobile trails without Department approval. Crossing of these trails shall be avoided.
7. Licensee will be required to fill and smooth trails that develop ruts and may be required to armor some stretches with gravel or rocks. Water bars will be installed at the direction of the state forester.
8. Roads, trails and turnoffs will be required to be seeded and mulched after construction.

9. Trails may need to be blocked or gated to prevent inappropriate recreational vehicle passage when not in active use for management activities.

Guidelines for Buildings and Equipment Needed for Tapping and Sap Collection on Public Lands

Temporary buildings, power lines or other structures needed for pumps, reverse osmosis systems (R/O's), storage tanks and/or generators associated with a tapping operation may be authorized by the Department in a license agreement. Structures such as sugar houses and gift shops are considered permanent structures and are not allowed. The Licensee shall be responsible for obtaining and complying with any and all permits that may be required. Any structures so authorized shall be considered property of the Licensee and all property taxes associated with these structures shall be paid to the town by the Licensee. Structures may be built on either a concrete slab or wooden floor with prior written approval. At the termination of the license agreement the Licensee must remove all equipment, utility lines and structures including concrete slabs or wooden floors unless otherwise authorized in writing by the Department. The ground must be smoothed, grass seed spread and mulched.

Fuel tanks for generators and/or pumps are allowed but must be installed and maintained under all local, state and federal regulations, including but not limited to the Environmental Protection Agency's "Spill Prevention, Control and Countermeasure Rule" and Licensee is responsible for obtaining all requisite permits. Tanks must be sited with Department consultation and approval. Tanks must be inspected no less than every five years and prior to any license renewal request. Licensee shall immediately report any fuel spills or leaks shall to the State's Emergency Hazardous Spills Hotline (1-800-641-5005).
A Security Bond or letter of credit in the amount of $3.00 (three dollars) per tap must be issued for the benefit of the Department by Licensee authorizing the Department to call in the security bond or letter of credit to restore any and all damages to the license area and/or removal of materials Licensee may leave behind at the termination of a license. The security bond or letter of credit must be issued for the term of the license plus an additional 3 months.

Advisory Board:
An Advisory Board will be established. It will consist of a total of eight members; three representatives from the Vermont Department of Forests, Parks and Recreation, three sugar makers, at least one of which is an independent sugar maker unaffiliated with an association, one representative from either the Proctor Maple Research Center or UVM Extension, and one representative from the Vermont Forests Products Industry.

The mission of this group is to advise the Department on this program. The Advisory Board will recommend program guidelines and advise the Commissioner of the Department in the selection of candidates for certain parcels of land whenever needed. The Advisory Board shall meet at least once each year during the month of May to advise the Department, and on an as needed basis as may be requested by the Commissioner.
The Department will coordinate closely with the Advisory Board but assumes ultimate responsibility for administration of this program.

Guidelines, Criteria, and Process for Awarding Sugaring Licenses

Periodically, interested parties will be invited to submit an application to the Department for a sugaring license. The applications will include a detailed description of the proposal including approximate number of taps proposed, equipment to be used, access to be used, roads to be built, structures/power lines to be erected/installed, identification of site-specific constraints and how these will be addressed by the applicant, financial business plan and other elements of their proposal as well as a description of the applicant's sugaring expertise, knowledge, experience, and commitment to sound resource management and stewardship. Sugaring licenses will not be bid out to the highest bidder as license fees will be pre-determined (see below). Instead, awarding of sugaring licenses will be based on the following criteria:

1. Sugarbush Management and Operations: Compliance with current sugarbush management and operations standards, guidelines, and recommendations as contained within the "North American Maple Syrup Producers Manual 2nd Edition", or other sources approved by the Commissioner. (In instances where such sources contain standards or guidelines that differ from those outlined within this document, then the guidelines contained within this document shall be followed). Demonstrated commitment to sound resource stewardship and management as articulated in the application.
2. Expertise, Ability, and Capacity of Applicant: Prior sugaring experience, ability to move forward in timely manner, demonstrated financial capacity to undertake the proposed work, etc.
3. Miscellaneous: Location of applicant to licensed area, level of necessary supporting infrastructure (power, storage building(s), road and trail network), completeness/quality of application, educational values of proposal, applicants' financial/legal standing with the State, etc.

In the event that more than one applicant for a sugaring parcel is qualified, submits their application on time, meets all necessary requirements, and if the Commissioner believes there is no obvious benefit to the State in awarding the sugaring license to a particular party, then the successful applicant will be determined by lottery. In no event shall a current member of the Advisory Committee apply for or be awarded a sugaring license.

License Fee and Payment Process

The payment formula described below will be used each year to determine the fee per tap assessed as the annual Licensee fee. The standard base administrative fee for all ANR licenses of $50 will be assessed. In addition, the Advisory Board will estimate by May 1st of each calendar year the average current price being paid per pound for bulk Vermont Fancy Grade maple syrup and Vermont Commercial Grade. Once these prices have been set then the average between to two prices will be calculated. Twenty five percent (25%) of this average will be the amount charged as rent per tap for the following year by the Department. The Department will provide this information to each Licensee on or before December 1 of each year along with an invoice for the coming year's license fee which must be paid by January 1. The first year's per tap fee will be based on the Licensee's estimated number of taps. Subsequent annual license fees may be adjusted to reflect the actual number of taps

License agreement terms will be for five years with the potential for two additional renewable five year terms. Each new renewal will be signed by the Licensee and the Department two-years prior to end of the current five year term. The Department will not approve a renewal unless the Licensee has actively sugared the site for at least two years during the preceding five year term. If the Licensee has complied with all license terms and condition and has demonstrated responsible stewardship and care of the licensed parcel, the succeeding five year renewal period cannot be unreasonably withheld. This represents a possible total of up to 15-years (three consecutive five year terms) under a single license agreement. Two years prior to the end of the maximum 15-year term, the Licensee may indicate their intent to apply for a new license which may be approved at the discretion of the Department. Upon the written approval of the Department, license agreements may be assigned to another member of the Licensee's immediate family.

At each five year renewal, the license may be revised to align with current research and accepted practices regarding tapping technology. At the end of the license period and upon the termination of a sugaring license, the State reserves the right to delay or deny the issuance of a new sugaring license for forest management or other resource management purposes.

Appendix E: Amendment to the 2012 Farm Bill including the Maple Tapping Access Program Act

SIL12492

S.L.C.

AMENDMENT NO.________ Calendar No.______

Purpose: To support State and tribal government efforts to promote research and education related to maple syrup production, natural resource sustainability in the maple syrup industry, market promotion of maple products, and greater access to lands containing maple trees for maple-sugaring activities, and for other purposes.

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Stabenow for AMENDMENT № 2427

By Schumer

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S. 3240

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3 Page(s)

GPO: 2010 63-070 (mac)

AMENDMENT intended to be proposed by Mr. SCHUMER

Viz:

On page 1009, after line 11, add the following:

SEC. 12207. ACER ACCESS AND DEVELOPMENT PROGRAM.

(a) GRANTS AUTHORIZED; AUTHORIZED ACTIVITIES.—The Secretary of Agriculture may make grants to States and tribal governments to support their efforts to promote the domestic maple syrup industry through the following activities:

(1) Promotion of research and education related to maple syrup production.

(2) Promotion of natural resource sustainability in the maple syrup industry.

(3) Market promotion for maple syrup and maple-sap products.

(4) Encouragement of owners and operators of privately held land containing species of tree in the genus Acer—

(A) to initiate or expand maple-sugaring activities on the land; or

(B) to voluntarily make the land available, including by lease or other means, for access by the public for maple-sugaring activities.

(b) APPLICATIONS.—In submitting an application for a grant under this section, a State or tribal government shall include—

(1) a description of the activities to be supported using the grant funds;

(2) a description of the benefits that the State or tribal government intends to achieve as a result of engaging in such activities; and

(3) an estimate of the increase in maple-sugaring activities or maple syrup production that the State or tribal government anticipates will occur as a result of engaging in such activities.

(c) RELATIONSHIP TO OTHER LAWS.—Nothing in this section preempts a State or tribal government law, including any State or tribal government liability law.

(d) DEFINITION OF MAPLE SUGARING.—In this section, the term "maple-sugaring" means the collection of sap from any species of tree in the genus Acer for the purpose of boiling to produce food.

(e) REGULATIONS.—The Secretary of Agriculture shall promulgate such regulations as are necessary to carry out this section.

(f) AUTHORIZATION OF APPROPRIATIONS.—There is authorized to be appropriated to carry out this section $20,000,000 for each of fiscal years 2012 through 2015.