PERCEPTIONS OF MAPLE PRODUCERS TOWARDS CLIMATE CHANGE

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Abstract

The Northern Forest (NF) region of Vermont and New York is home to over 1,000 commercial maple producers who rely on maple production as a source of income and as the basis for longstanding family and community traditions. Changes in maple production are projected in some studies due to climate change and its potential impacts on forest type (i.e., from maple to oak-hickory-pine; Perkins, 2007), tree health and vigor (Wilmot, 2012), and timing of sap flow (Skinner et al., 2010), although predictions vary. Because maple producers depend on the health of sugar maples for their livelihood and cultural traditions, adapting to changes in maple production will likely be necessary in the future and will require planning. The goal of this study is to engage maple producers in the development of strategies that help them plan for and adapt to the potential impacts of climate change. The research approach for this study includes interviews and a survey of maple producers in the Northern Forest region of NY and VT. Interviews were used to obtain information about producers' knowledge and perceptions of climate change. A mail survey of producers was then used to assess their ability to adapt to change and to identify the factors that influence this adaptability. Results indicate that more than half of the maple producers who responded to the survey expressed concerns about climate change, and more than two-thirds had already made or were planning to make modifications to their business. The two factors that were identified as most important to respondents when assessing adaptability to climate change are resiliency of the maple producers' sugar bush and the producers' ability to adopt new technologies. Despite the uncertainty with the climate, maple producers are highly optimistic about the future, with 90% planning to continue or expand their business within the next five years.

Introduction

Maple syrup production is an important tradition and source of income for family-based businesses in the Northeast. Vermont and New York are the two highest maple-producing states in the US (USDA NASS, 2014). The Northern Forest (NF) region of these states is home to over 1,000 commercial maple producers. Due to climate change, however, changes in maple production are projected. Predictions vary regarding levels of sap production, with some models suggesting that the season will be shorter in the Northeastern US, and others that the season will start significantly earlier (Skinner et al., 2010). Skinner, DeGaetano, and Chabot (2010, p. 685) indicate that the number of sapflow days will not change through 2100; however, producers will need to collect sap earlier in the season to "maximize the number of sapflow days." Climate data for the northeast indicate that the sugaring season has shortened by about 10% in the past 40 years. Changes in precipitation and temperature are forecasted to create shifts in forest type from sugar maple to oak-hickory-pine in the next 50 to 100 years (Perkins, 2007). Maples stressed by climate change may be more likely to be harmed by invasive pests, further reducing their vigor (Wilmot, 2012).

Because maple producers depend on the health of sugar maples for their economic well-being and as the foundation of family traditions and community life, adapting to changes in maple production will likely be necessary in the future and will require planning. Understanding all factors that affect the ability of producers' to adapt to change is essential, including perceptions of climate change. Research indicates that the US population has a range of views on climate change, from those who are concerned about it and believe action must be taken, to those who do not believe it is occurring and do not wish to initiate actions meant to deal with it. Over two-thirds of the U.S. population believes that climate change is occurring, with the remaining one-third primarily comprised of people who are not sure what to believe. Ten percent of the general public does not believe the climate is changing and is opposed to actions that address climate change through adaptation or mitigation (Leiserowitz, Maibach, Roser-Renouf, & Hmielowski, 2012; Chase and Grubinger, 2014). A survey of farmers in Iowa found similar results, with 5% of the respondents indicating that they do not believe in climate change and do not wish to engage in actions to address climate change (Arbuckle, 2011). To date, no studies have assessed maple producers' beliefs about climate change, their ability to adapt to change, or the mechanisms in place within their families, communities, and industry to plan for change.

The goal of this study is to develop strategies that help maple producers (i.e., sugar makers) plan for and adapt to potential impacts from climate change in the Northern Forest region. In order to accomplish this goal, several objectives were set for this study:

1. To identify the perceptions of maple producers in the Northern Forest region of New York and Vermont concerning: (i) climate change; (ii) the potential impacts of climate change on maple syrup production; (iii) the connection of maple syrup production to family, community, and industry networks and traditions; and (iv) their economic, recreational and social dependence on maple syrup production (Fig. 1).
2. To identify the elements affecting the ability of businesses to adapt to the potential impacts of climate change.
3. To identify strategies that enhance the ability of businesses to adapt to the potential impacts of climate change.

"Adaptability" is a business's ability to technologically respond to change, to be flexible in terms of its customer base (i.e., its market focus), and to have a management structure that can easily respond to change (Tuominen, et al., 2004). According to Walker and Ruckert (1987), a high degree of adaptability

in a business is essential since firms unable to adapt and innovate often fail — an unacceptable outcome for businesses as important to the traditions and economy of the Northern Forest as maple producers. This study examines how four main aspects of adaptability pertinent to maple producers (i.e., technology, customer base, management, and sugar bush resiliency) may be related to their potential adaptability to climate change.

In addition to understanding business adaptability, characteristics related to demographics (e.g., age, level of education), business size and management, and social setting (i.e., connections between individual businesses and family, community, and maple producers' associations) are also considered. Previous studies have shown that the owners of family-based businesses, such as maple production businesses, need to understand more than basic management and marketing to be successful. Eberle et al. (2004) found (for the dairy industry) that understanding family and community relationships is critical for successful transitions in times of uncertainty. Bjornberg and Nicholson (2007) found that family businesses are dependent upon the ability of the family running the business to effectively work together and to adapt to change. Because of the importance of family dynamics to business success, it is essential that these elements be considered for maple producers. The success of businesses has also been linked to managers' knowledge of and perceptions of new technologies, demographics (education and age), business characteristics (firm size; Peltier et al., 2012), business-related experience (Richbell et al., 2006), and the existence of a written business plan (Rue & Ibrahim, 1998). In order to provide a comprehensive understanding of business adaptability, this study examines these factors as well as business adaptability (Fig. 1).

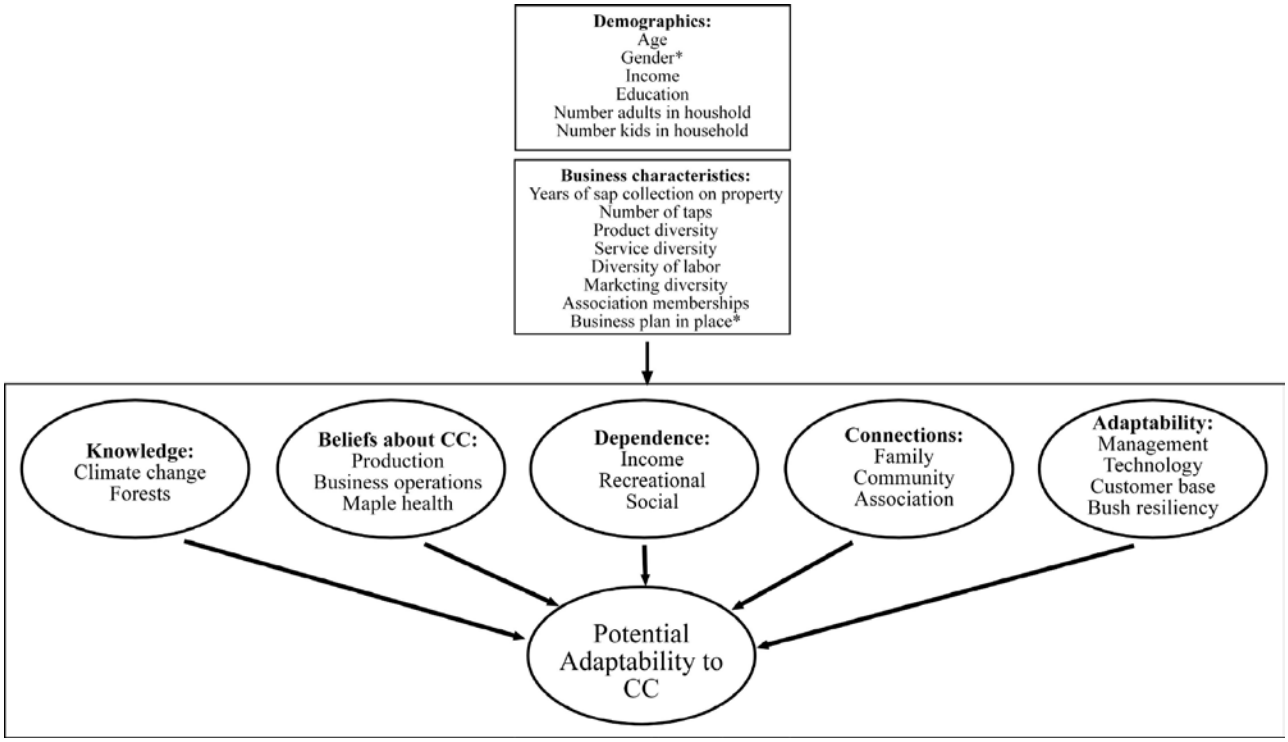

Figure 1. Proposed business adaptability model related to the potential impacts of climate change (CC). Concepts with an asterisk (*) could not be included in the final analysis due to low representation among respondents (i.e., only 6% are female, and only 9% have a written business plan).

Methods

This study was comprised of two components: interviews with maple producers and a survey of all identified maple producers in the Northern Forest region of New York and Vermont (Figure 2). Online information from the New York State Maple Producers' Association (NYSMPA), the Vermont Maple Sugar Makers' Association (VMSMA), and from the University of Vermont Extension was used to identify maple producers in the Northern Forest Region of NY and Vermont.

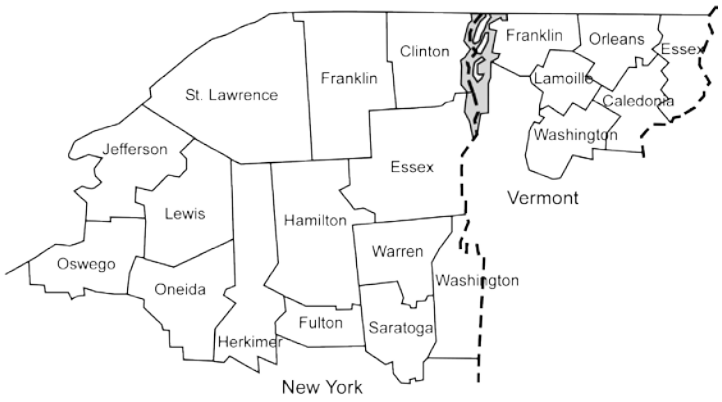

Figure 2. Northern Forest Region of NY and Vermont (based on a Northern Forest and Counties map by Conservation Advisory Services, 1994).

Telephone Interviews were conducted with 14 maple producers in the Northern Forest region of New York and Vermont in 2014 and 2015. Lists of key contacts, provided by University of Vermont Extension and the NYSMPA, were used to request the initial interviews; additional interviews were scheduled by sending out e-mail requests for interviews to roughly 200 maple producers. Interviews were recorded (with interviewee permission) with an Olympus DS-5000 digital voice recorder and transcribed using Dragon Dictate 4.0 software (Nuance Communications, 2014). Interviews ranged in length from 16 to 45 minutes. The list of interview questions included ones about maple producers' perceptions of climate change, business characteristics and structure, products and services, use of up-to-date technology, and resiliency of their sugar bush. Some questions in the interview guide were derived from an interview guide provided by Dr. Brenda Murphy of Wilfred Laurier University, Ontario, Canada. Interview questions concerning business adaptability were adapted from concepts presented in Bjornberg & Nicholson, 2007, Tuominen, et al., 2004, Peltier, Zhao, & Schibrowsky, 2012, and Walker & Brown, 2004. The interviews were structured so that the most contentious subjects (i.e., perceptions of climate change and how maple producers deal with change) were addressed only after rapport had been built between the interviewer and interviewee. Comments expressed by those interviewed were transcribed (typed) verbatim. These transcriptions were then used to identify concepts relevant to maple producers' perceptions of climate change and the ability of their business to adapt to change. Interview data were analyzed for reoccurring statements (concepts) related to adaptability and climate change. The number of respondents indicating each concept was identified.

The concepts identified in the interviews were then used to write a questionnaire. Through a mail survey, maple producers were asked to respond to numerous questions related to the characteristics of their business; their demographic characteristics; their knowledge of climate change and northeastern forests; climate change-related beliefs; their dependence on their business for economic, recreational,

and social reasons; the connection of their business to their family, community, and maple producers' association(s); and the current adaptability of their business concerning business management, adoption of technology, geographic distribution of customer base, and sugar bush resiliency (Figure 3). Questions were in multiple choice, fill-in-the-blank, and scale formats. For questions related to the perceptions of maple producers, a scale ranging from -2 (strongly disagree) to 0 (neutral) to 2 (strongly agree) was used.

Following the completion of the full survey, a short, one-page survey was mailed to all of the maple producers who did not respond to the full survey. Comparisons were made between the respondents to the full and short surveys to identify any significant differences ($p \leq 0.05$) in a few important variables. Finding a significant difference between the two groups could indicate that the entire population of maple producers in the Northern Forest Region is somehow different than the group of individuals who responded to the full survey.

Following data entry, "factors" were calculated from the survey questions by averaging together several similar questions. Factors are used because they simplify discussion about the results (i.e., rather than discussing each question separately, one factor that represents several questions is discussed). These factors are also necessary for completing the main statistical analysis — a path analysis (discussed below). Two statistical tests (i.e., Cronbach's alpha, confirmatory factor analysis) were used to determine if statements could be combined together into factors. Following these tests, the data for some questions were "reverse coded" before they were averaged together into the factors. Reverse coding involves reversing the "sign" for each response to a question. For example, a response of -1 would be reversed to 1 in the database. Because the reverse-coded statement was written on the survey "in the negative" or opposite of how the other variable statements were written, this sign change in the database is necessary so that the item could be correctly averaged together with the other variables listed for the factor. The variable average for reverse-coded questions shown in Table 13 and 14 do not show the reverse coding (i.e., averages of the actual responses are included in the table); however, the factor averages shown in these tables were calculated using the reverse-coded responses.

These factor averages were used to conduct a path analysis — a statistical analysis that identifies significant relationships ($p \leq 0.05$) among the factors (the relationships identified are indicated with arrows in Figure 1). This path analysis also included variables related to demographics (e.g., age, years of education) and business characteristics (e.g., number of taps). In Figure 3 (the results of the path analysis), the strength of the relationships among these factors and variables is indicated by the thickness of the lines; thicker lines indicate stronger relationships. A negative sign near a line indicates an inverse relationship (i.e., as one factor increases in value, the other factor it is related to decreases); no sign near a line indicates a positive relationship between the two factors (i.e., as one increases in value, the other also increases in value). A one-way arrow indicates that one variable is influencing the variable to which the arrow points. A two-way arrow indicates that both variables are influencing each other.

The study results were presented at two maple conferences in January, 2016 (one in Vermont and one in New York). Attendees were asked for input regarding the current technologies, adaptations, or strategies they are using to adapt to climate change; the technologies, adaptations, or strategies they plan on implementing in the next five years; and the technologies, adaptations, or strategies they think they may need to implement 20 years from now. Written and oral comments were collected and summarized.

Results

Interviews

In-depth interviews were conducted on the telephone (with interviewee permission) with 14 maple producers in New York and Vermont (eight interviewees were from New York and six were from Vermont). Seventy-two percent of the interviewees thought climate change was occurring, but differences in how they defined climate change were found. Half of the interviewees indicated that climate change involves extreme or odd weather patterns, 36% (five interviewees) indicated that it is the slow warming of the world, and 29% thought that it will cause warmer weather, less snow, and an early spring. Two respondents indicated that climate change has been accelerated by humans, two had no clear idea about climate change, and one considered it to be a political and marketing ploy (Sharkey, Kuehn, & Chase, in review). The detailed results of the interviews can be found at http://www.esf.edu/for/kuehn/reports.htm.

Mail Survey

Response rate

The full survey was mailed to a total of 1,322 individuals in the Northern Forest Region of Vermont and New York. A qualified sample of 1,011 maple producers was identified, after undeliverable addresses, deceased individuals, and non-commercial maple producers were removed from the contact list. Of this qualified sample, 269 maple producers returned their completed questionnaire for a response rate of 27%; 264 of these questionnaires were usable. Of these 264 questionnaires, 86 were completed by producers in New York and 178 by producers in Vermont. A short survey was sent to the 742 individuals who did not respond to the full survey; 70 maple producers returned this short survey.

Comparisons between respondents to the full and short surveys revealed no significant differences ($p < 0.05$) between the two groups of respondents to questions concerning number of taps, willingness to make business changes, having the financial resources necessary to adopt new technologies, catering to diverse clientele, and having back-up strategies in place to deal with sugar bush damage. The age and years of education of respondents were also compared; no significant differences were found.

Demographics

Respondents ranged in age from 18 to 88, with the average respondent being 61 years of age (n = 261). The average years of education of respondents was 14.5 years (includes 12 years for high school; n = 249). Ninety-four percent were male (n = 261). Nearly half of the respondents had an annual household income between $26,000 and $75,999 (n = 241). Most of the respondents' households were home to two or more adults (87%); 19% of households had at least one child (n = 261).

Business Characteristics

Maple syrup was produced on the respondents' land for an average of 82 years for respondents of both NY and VT combined (51 years on average in NY and 97 years in Vermont; n = 256). In 2014, NY producers had an average of 2,576 taps (the median was 1,350 taps, indicating that most businesses had a moderate number of taps (n = 86); see also Table 1). Vermont producers averaged 4,876 taps (the median was 2,000; n = 175). The maximum number of taps reported was 10,500 in New York and 70,000 in Vermont. In the five-year period from 2010 to 2014, NY and Vermont producers in the Northern Forest Region had added an average of 681 and 1,470 taps, respectively (n = 86 and n = 175). The breakdown of respondents by number of taps (NY and VT respondents combined) is given in Table 1.

The average maple producer made 1,337 gallons of syrup in 2014 (n = 248); the maximum number of gallons produced by a single producer was 32,500. The average respondent sold 46% of their product in bulk, 12% wholesale, and 42% as retail (n = 248). As the number of taps increased, the percentage of syrup sold in bulk significantly increased and the amount sold via retail significantly decreased (significance level: $p \leq 0.05$). For example, businesses with under 500 taps sold 71% of their maple products by retail, while businesses with over 10,000 taps sold 72% in bulk; wholesale sales did not significantly vary according to the number of taps.

Producers were asked if they purchased sap and/or syrup from other operations; 20% said they did, 73% did not, and 7% said they did only when their production was low (n = 260). Fifty-three percent of the respondents indicated that they use reverse osmosis (n = 256). Sixteen percent of respondents collected sap with buckets, 1% with bags, 21% with tubing with no vacuum (i.e., 3/16" or 5/16" tubing, gravity flow), and 62% with tubing with a mechanical vacuum (n = 258); most respondents (62%) used only one of these collection methods. Ninety-one percent of respondents did not have a written business plan in place, though 5% indicated that they were in the process of writing one (n = 255).

Table 1. Number of maple producers according to categories for number of taps (n = 261).

Category of number of taps	Percent of producers in category
< 500 taps	20 %
501-1,000	17 %
1,001-2,000	14 %
2,001-3,000	14 %
3,001-5,000	13 %
5,001-10,000	14 %
10,001 or more	8 %

Products Offered

Although all maple producers provide maple syrup, 36% of producers provide other products as well. Maple cream, maple candy, and maple granulated sugar are the most commonly sold products by respondents (Table 2). Twelve percent of the respondents sell two different types of maple products, 10% three different maple products, and 14% four or more different types of maple products. In addition, non-maple products are sold by 19% of the respondents, farm produce and farm-raised meats being the most commonly sold non-maple products (Table 2). For overall product diversity, 81% of respondents sell only maple products, 13% sell maple products plus one other type of non-maple product, and 6% sell maple products plus two or more non-maple products.

Table 2. Percentage of responding maple producers providing various products (n = 258).

Maple products	Percent of producers providing product
Maple syrup	100 %
Maple cream (not containing butter)	27 %
Maple candy	25 %
Maple sugar (granulated)	18 %
Maple-covered nuts	5 %
Maple butter (containing butter)	2 %
Maple fudge	2 %
Other maple products (maple jelly, seasonings, condiments, BBQ sauce, kettle corn, ice cream, cotton candy)	5 %

Non-maple products	Percent of producers providing product
Farm produce	8 %
Farm-raised meats	7 %
Other non-maple products (hay, eggs, dairy, farm animals, mushrooms, wood products, honey)	10 %

Services Offered

With regard to customer services, 39% of respondents do not offer any tours or demonstrations. The remaining 61% of maple producers offer at least one type of service, the most common being tours of their maple production facility and/or maple bush, hosting an "open house" during Maple Weekend, and offering programs for school groups (Table 3). Twenty-four percent of respondents offer one type of service, 11% offer two different services, 15% offer three to four services, and 11% offer five or more different types of services.

Table 3. Percentage of responding maple producers providing various services (n = 254).

Service	Percent of producers providing service
None	39 %
Tours of maple production facility	36 %
Tours of maple bush	27 %
Participates in Maple Open House Weekend	21 %
Programs for school groups	21 %
Tours of farm	15 %
Farm store or farm stand	14 %
Exhibits on maple production	13 %
Demonstrations for the public	8 %
Educational workshops	4 %
Other (speaking at workshops, giving scout group tours, developing educational materials, selling at farmers markets, delivering product to local businesses)	5 %

Advertising and Marketing

Twenty-six percent of businesses did not use any form of advertising (Table 4); the remaining 74% of respondents use a diversity of advertising approaches, including word-of-mouth, a sign outside their business, business cards, promoting their business through the website of a maple producers' association, their own business website, and Facebook®. Of those respondents who did use some type of advertising, 39% used only one form, 20% used two forms, 14% used three forms, and the remaining 27% used four or more forms of advertising. Results indicate that word-of-mouth in particular is very important to maple production businesses.

Table 4. Types of advertising used according to percentage of respondents (n = 256).

Type of advertising	Percent of producers using technique
None	26 %
Word-of-mouth	64 %
Sign for business	26 %
Business cards	25 %
Association website	21 %
Business' website	20 %
Facebook®	16 %
Brochure for business	11 %
Ads in tourism guidebooks	7 %
E-mail advertising blasts	5 %
County government website	4 %
State government website	2 %
Radio ads	2 %
Magazine ads	2 %
Internet pay-per-click ads	1 %
Twitter	1 %
Merchandise Catalog	<1 %
Other (newspapers, yellow pages, Craig's list)	4 %

Associations and Information Sources

Information was collected concerning organization memberships and where respondents obtain up-to-date information about the maple production industry. Most respondents were members of the maple producers' association for their state (96% in NY and 90% in Vermont); many respondents in both states were also members of a county or regional maple producers' association, and of the Farm Bureau (Table 5). Twelve percent of the respondents from NY were members of their local chamber of commerce; 7% of those from Vermont were chamber of commerce members. Most respondents indicated that their primary sources of up-to-date information were their maple producers' association(s), the Cooperative Extension, and other business owners (Table 6).

Table 5. Organizational membership (n = 242).

Organization	Percent of respondents in organization
New York Respondents (n = 82):	
NYS Maple Producers Association	96%
County or Regional Maple Producers' Association	43%
Farm Bureau	35%
Chamber of Commerce	12%
International Maple Syrup Institute	6%
North American Maple Syrup Council	5%
Vermont Maple Sugar Makers' Association	2%
Other	4%
Vermont respondents (n = 160):	
Vermont Maple Sugar Makers' Association	90%
County or Regional Maple Producers' Association	33%
Farm Bureau	24%
Chamber of Commerce	7%
International Maple Syrup Institute	3%
North American Maple Syrup Council	2%
NYS Maple Producers Association	0%
Other	4%

Table 6. Primary sources of up-to-date information for respondents of both states (n = 255).

Organization	Percent of respondents in organization
New York Respondents (n = 85)	
Maple Producers Association	88%
Cooperative Extension	57%
Another business owner	37%
National Agricultural Statistics Service (NASS)	13%
Farm Bureau	11%
Other	17%
Vermont respondents (n = 170)	
Maple Producers Association	84%
Cooperative Extension	28%
Another business owner	23%
National Agricultural Statistics Service (NASS)	10%
Farm Bureau	9%
Other	17%

Labor and Employment

Having help during the maple production season is crucial to responding maple producers, especially since 59% are employed outside of their maple production business; 12% do not have outside employment and 29% are retired (n = 255). Most respondents (92%) indicated that other people help them with maple production. By far, the most often mentioned assistants were the respondent's spouse (mentioned by 62% of all respondents) and children (56%); grandchildren (17% of respondents) and other relatives (31%) were also indicated (n = 260). Thirty-five percent of respondents had friends volunteer their time to help with maple collection and 17% paid their friends to help; 19% hired other employees to help. Table 7 provides the breakdown of assistants according to the size of the business.

Table 7. Respondents' assistants (n = 260).

Size of business (number of taps)	Type of assistant	Percent of respondents having assistant
1000 or fewer taps (n = 96)	Spouse	51 %
	Respondent's children	44 %
	Respondent's grandchildren	16 %
	Other relatives	24 %
	Friends who volunteer	42 %
	Friends who are paid	6 %
	Other paid employees	2 %
	No one	12 %
	Other	3 %
1001 to 3000 taps (n = 72)	Spouse	61 %
	Respondent's children	64 %
	Respondent's grandchildren	22 %
	Other relatives	29 %
	Friends who volunteer	40 %
	Friends who are paid	11 %
	Other paid employees	14 %
	No one	8 %
	Other	1 %
3001 or more taps (n = 90)	Spouse	72 %
	Respondent's children	63 %
	Respondent's grandchildren	13 %
	Other relatives	40 %
	Friends who volunteer	26 %
	Friends who are paid	33 %
	Other paid employees	41 %
	No one	3 %
	Other	1 %

Factors recently affecting business

Respondents were asked to indicate which elements (from the list in Table 8) have affected their maple production business in the last five years (2010 through 2014). The items receiving over one-quarter of the responses in New York were: it's harder to predict when to tap, tapping earlier than usual, changes in snow cover, and increased wind damage to trees. In Vermont, the responses given by over one-quarter of respondents were: increased wind damage to trees, tapping earlier than usual, it's harder to predict when to tap, and ice damage to trees. Only 13% and 10% of respondents in New York and Vermont, respectively, have had none of the items listed affect their business over the past five years.

Table 8. Recent elements affecting businesses in NY and VT (2010-2014; n = 252).

New York respondents (n = 85)		Vermont respondents (n = 167)	
Type of affect	**Percent of respondents Indicating affect**	**Type of affect**	**Percent of respondents Indicating affect**
Harder to predict when to tap	42%	Increased wind damage to trees	44%
Tapping earlier than usual	35%	Tapping earlier than usual	39%
Changes in snow cover	35%	Harder to predict when to tap	37%
Increased wind damage to trees	28%	Ice damage to trees	37%
A decline in the health of their maples	22%	Changes in snow cover	22%
New or increased presence of ticks	15%	A decline in the health of their maples	21%
Low production over several years	15%	Low production over several years	16%
Decrease in sugar content of sap	14%	Decrease in sugar content of sap	13%
Ice damage to trees	14%	Flavor of some syrup is "off"	11%
Increase in maple diseases or pests	8%	Needed to tap red maples	9%
Flavor of some syrup is "off"	7%	An improvement in the health of their maples	7%
New or increased invasive plants	6%	Increased flooding of maple bush/roads	4%
An improvement in the health of their maples	6%	Increase in sugar content of sap	4%
Needed to tap red maples	6%	New or increased presence of ticks	3%
Increase in sugar content of sap	5%	New or increased invasive plants	2%
Increased flooding of maple bush/roads	1%	Increase in maple diseases or pests	2%
Other	7%	Other	5%
None of the above	13%	None of the above	10%

Future plans of maple producers

Maple producers were asked what their plans are for the next five years. The one item mentioned by half of the producers in both states is to increase the number of taps (Table 9). Both states were also similar in that 42% of respondents plan to keep their business as is. In New York and Vermont, respectively, 21% and 16% of respondents plan to expand their product line. With regard to the future existence of their business, 17% and 19% in New York and Vermont, respectively, plan to give their business to their children; 9% and 6% plan to retire, 5% and 4% to sell their business, and 1% in both states to close their business.

Table 9. Plans of maple producers over the next five years (2015-2019).

New York respondents (n = 86)		Vermont respondents[1] (n= 172)	
Future plans	**Percent of respondents Indicating item**	**Future Plans**	**Percent of respondents Indicating item**
To increase the number of taps I have	50 %	To increase the number of taps I have	48 %
To keep my business as is	42 %	To keep my business as is	42 %
To expand the products I sell	21 %	To give my business to my children	19 %
To give my business to my children	17 %	To expand the products I sell	16 %
To write a business plan	11 %	To retire	6 %
To retire	9 %	To write a business plan	6 %
To offer new services to my customers	7 %	To offer new services to my customers	4 %
To sell my business	5 %	To sell my business	4 %
To close my business	1 %	To close my business	1 %
Other	11 %	Other	14 %

Perceptions towards Climate Change

Maple producers were asked three open-ended questions with regard to their perceptions of climate change and how it is currently affecting their business. The first question was:

"In your own words, please write in your personal definition of "climate change." (NOTE: Including a definition does not indicate to the researchers that you think climate change will occur.)"

Seventeen different concepts related to climate change were identified by respondents. The most frequently mentioned concept was that climate change involves a change in weather patterns (27% of respondents; Table 10), severe or unusual weather events or storms (26%), and increasing temperatures (23%), all of which are likely to affect maple production. Three percent of respondents indicated that climate change is a political ploy or hype.

Table 10. Respondents' definitions of climate change (n = 219).

Concept included in definition	Percent of respondents indicating concept
A change in weather patterns	27 %
Severe or unusual weather events and storms	26 %
Increasing temperatures	23 %
A natural process, not human-caused	15 %
Deviation in weather patterns from the past norm	14 %
A human-caused problem	11 %
Warm winters	11 %
Earlier sap collection	11 %
A change in precipitation levels	7 %
Increased greenhouse gases in atmosphere	6 %
Global warming	6 %
A change in species composition of forest	5 %
Shorter tapping season	4 %
Hype; political ploy	3 %
Does not have a definition	3 %
Increase in insect pests and diseases of trees	1 %
Warming of ocean waters	1 %

The second question was:

"Do you have any concerns related to climate change and its potential impact on your business in the future? If so, what are your concerns? If you don't have any concerns, write in "none"."

Forty-two percent of respondents indicated that they do not have any concerns related to climate change, some of whom indicated that they had no concern since their business would adapt to any potential impacts from climate change as needed. Damage to their maple bush from weather extremes was the most commonly mentioned concern (14% of respondents overall), followed by a concern for either an earlier tapping season or a change in timing for sap collection (13%). Larger businesses (with 3001 or more taps) had more concerns about climate change, than did respondents from smaller businesses with 3000 or less taps (Table 11). Concerns such as forest regeneration in the future and fluctuating precipitation levels stressing the trees were only mentioned by a few respondents and are not included in Table 11.

Table 11. Respondents' concerns with regard to climate change (n = 234).

Size of business (number of taps)	Concerns	Percent of respondents Indicating concern
1000 or fewer taps (n = 97)	No concerns	38 %
	Weather extremes causing damage to sugar bush (ice damage, flood damage, frost damage)	8 %
	Earlier season or change in timing of season	13 %
	Maintaining tree health	10 %
	Having a shorter season	11 %
	Having a reduction in future sap flow	10 %
	Invasive pests and diseases	5 %
	Knowing when to tap	2 %
	Maintaining forest health	2 %
	Flavor of syrup	1 %
	Concern over stress on trees from use of vacuum system	0 %
1001 to 3000 taps (n = 75)	No concerns	43 %
	Weather extremes causing damage to sugar bush (ice damage, flood damage, frost damage)	13 %
	Earlier season or change in timing of season	11 %
	Maintaining tree health	12 %
	Having a shorter season	7 %
	Having a reduction in future sap flow	5 %
	Invasive pests and diseases	4 %
	Knowing when to tap	7 %
	Maintaining forest health	1 %
	Flavor of syrup	0 %
	Concern over stress on trees from use of vacuum system	0 %
3001 or more taps (n = 90)	No concerns	33 %
	Weather extremes causing damage to sugar bush (ice damage, flood damage, frost damage)	16 %
	Earlier season or change in timing of season	11 %
	Maintaining tree health	7 %
	Having a shorter season	8 %
	Having a reduction in future sap flow	10 %
	Invasive pests and diseases	9 %
	Knowing when to tap	9 %
	Maintaining forest health	1 %
	Flavor of syrup	4 %
	Concern over stress on trees from use of vacuum system	2 %

The third question was:

"What types of changes to your maple production business do you think might be needed in the future in response to climate change? Include any specific changes related to either management or technology. If you have already made some changes, write in what you have done so far. If no changes are predicted, indicate that as well."

Twenty-nine percent of respondents indicated that they are not currently making and have no plans to make adaptations to their business with regard to climate change (Table 12). The majority of respondents, however, are either already making modifications to their maple production business or planning these changes. Nearly one-quarter of respondents overall indicated that they are tapping earlier than in the past. In particular, 31% of businesses with 3001 or more taps, 19% of those with 1001 to 3000 taps, and 10% with fewer than 1000 taps indicated that they are tapping earlier. Fourteen percent of respondents indicated that they have added a vacuum tubing system to increase production; 5% of businesses with 3000 or fewer taps indicated that they would like to install a vacuum system in the future (0% of respondents having 3001 or more taps indicated this as a future plan, likely because they already have a vacuum system in place). Three percent of all respondents have installed check leader spout adapters. Other respondents are considering installing new technologies in the future, or taking measures to improve tree health (e.g., using conservative tapping methods, thinning their maple forest to encourage tree crown development).

Table 12. How respondents are adapting to the potential impacts from climate change (n = 221).

Type of adaptation made or planned	Percent of respondents indicating adaptation
None	29 %
Tap earlier	24 %
Have already added a vacuum system	14 %
Be prepared to tap as soon as the season starts	9 %
Don't know	5 %
Focus on tree health	5 %
Get a vacuum system in the future	4 %
Use conservative tapping methods	4 %
Increase number of taps	3 %
Use reverse osmosis	3 %
Use spout adapters	3 %
Thin forests to encourage crown development	2 %
Utilize new technology as it becomes available	2 %
Improve fuel efficiency to reduce carbon emissions	2 %
Fertilize/Lime sugar bush	1 %
Sell or close business if low production occurs	1 %
Carry-over inventory from previous year	<1 %
Tap other maple species	<1 %

Maple producers' perceptions

Respondents were asked to rate their knowledge, beliefs, and perceptions of climate change and of forests in the northeast on a scale of -2 (strongly disagree) to 0 (neutral) to 2 (strongly agree). The averages for these factors are discussed below.

Knowledge of climate change and forests. With regard to knowledge of climate change, the average respondent perceived his or her knowledge of climate change as a 0.3 on a scale of -2 to 2, a score that indicates weak agreement with statements related to respondents' perceived knowledge of climate change (Table 13). The average respondent perceived his or her knowledge of forests as slightly higher (Average = 0.43).

Beliefs concerning potential impacts from climate change. The averages for three different belief factors were calculated from respondents' responses. The first, beliefs concerning production, was negative and moderately strong (Average = -0.62; Table 13), indicating that the average respondent believes that climate change may cause a decrease in sap production in the future. The second belief factor (i.e., concerning business operations) had a moderately strong average of -0.7, indicating that the average respondent believes that maple producers will need to make changes to adapt to climate change in the future. The third belief (i.e., beliefs concerning maple health) had a strong, negative average (Average = -0.9), indicating that the average respondent believes that climate change will have an impact on maple health in the future.

Dependence of maple producers on their business. The averages for three different factors were calculated concerning the dependence of maple producers on their business. The first, dependence on the income from maple production, had a moderately weak average of -0.46 (Table 14), indicating that the average respondent likely has other sources of income besides maple production. The second factor, recreational dependence, had a moderately high average of 1.0, indicating that the average respondent does rely on maple production for getting outdoors and for physical exercise. The third factor, social dependence, had a moderate average of 0.46, indicating that the average respondent does rely on maple production to a small extent for the social aspects of the business (e.g., interacting with friends and family, social events, traditions). However, one statement on the questionnaire that was included in this social dependence factor (i.e., "Maple production is important because it is part of my heritage and/or family traditions") had a higher average (0.87), indicating that the average respondent does have a strong connection to his/her business because of heritage and traditions.

Connections of maple production businesses with family, community, and business associations. The averages for three different factors were calculated concerning the social connections of responding maple production businesses (Table 15). The first, connections between the business and the maple producer's family, had an average of 0.4, indicating that the average respondent perceives a moderate connection between his/her business and family. The second factor, connections of business with community, had a moderate and negative average of -0.6, indicating that the average respondent does not rely on his/her connections with the community for organizing events, networking, and promotions. The third factor was connections between the business and maple producers' association(s). This factor had a moderate and positive average (Average = 0.4), indicating that the average respondent has a moderate connection with his/her association for promotions and networking overall. However, the questionnaire statement "I greatly depend on a maple producers' association for up-to-date information about maple production" had a strong average (0.85), indicating that this one specific aspect of associations is particularly important to the average maple producer.

Table 13. Averages for questionnaire statements related to maple producers' beliefs and knowledge of climate, forests, and maple production[1].

Factor	Statement on questionnaire	Statement average	Factor average
Knowledge of climate change	I know a great deal about the potential impacts of climate change on forests in the northeast.	0.32	0.30
	I know a great deal about the potential impacts of climate change on the health and vigor of sugar maple trees.	0.28	
	I know a great deal about the potential impacts of climate change on maple production.	0.32	
	I know a great deal about climate change in general.[2]	0.29	--
Knowledge of forests in the northeast	I know a great deal about forests in the northeastern United States in general.	0.34	0.43
	I know a great deal specifically about maple forests in the northeast.	0.45	
	I know a great deal about the factors that influence maple forest health in the northeast.	0.49	
	I know a great deal about the ecology of maple forests in the northeast.[2]	0.27	--
Beliefs concerning production	I believe climate change will generally **increase** the amount of maple sap produced in the future.	-0.76	-0.62
	I believe climate change will generally decrease the amount of maple sap produced in the future.	0.58[3]	
	I believe climate change will **not affect** the amount of maple sap produced in the future.	-0.52	
Beliefs concerning business operations	**I believe that maple production businesses will need to change their operations in the future to adapt to climate change.**	0.75[3]	-0.70
	I believe that maple producers will **not** need to make any changes to adapt to climate change in the future.	-0.75	
	I believe that maple production businesses will need to adopt new technologies to adapt to climate change in the future.	0.61[3]	
Beliefs concerning maple health	**I believe climate change will influence where maple trees are able to thrive in the northeast in the future.**	0.76[3]	-0.90
	I believe climate change will make it easier for insect pests and diseases to spread through forests.	0.81[3]	
	I believe that climate change will have **no** impact on the health and vigor of maple trees in the future.	-0.85	
	I believe that climate change will affect when tapping begins and/or ends each year in the future.	1.17[3]	

[1] The scale used for these statements was: -2 = strongly disagree, -1 = disagree, 0 = neither agree nor disagree, 1 = agree, 2 = strongly agree.

[2] This statement was removed from the factor due to the results of the confirmatory factor analysis. Although the statement was not used to calculate the factor mean, the average for the statement is provided.

[3] The statement (in bold) was "reverse coded" prior to calculating the factor average; the actual statement average is shown (i.e., rather than the reverse-coded average). The factor average includes the statement after it was reverse-coded.

Table 14. Averages for questionnaire statements related to the dependence of maple producers on their business[1].

Factor	Statement on questionnaire	Statement average	Factor average
Income dependence	Maple production is a primary source of income for my household.	-0.37	-0.46
	Maple production provides only a small proportion of my household's income.	0.36[3]	
	My household has other sources of income besides maple production.	1.40[3]	
	I greatly rely on maple production as a supplemental source of income.	0.29	
	I greatly rely on maple production to provide maple products for myself, my family, and my friends. [2]	1.03	--
Recreational dependence	Maple production is important to me for the physical exercise it provides.	0.93	1.00
	Maple production is important to me because it gets me outdoors.	1.08	
	Maple production is important to me more as a hobby than as work. [2]	0.21	--
	Maple production is important to me because of the enjoyment it provides.[2]	1.41	--
Social dependence	Maple production is important to me because of the social events and activities it gets me involved in.	0.14	0.46
	Maple production is important because it is part of my heritage and/or family traditions.	0.87	
	Maple production is important to me because it makes it possible for me to spend more time with family and/or friends.	0.52	
	Maple production is important to me because it makes it possible for me to meet new people (e.g., customers).	0.33	
	Maple production is "in my blood." [2]	1.26	--

[1] The scale used for these statements was: -2 = strongly disagree, -1 = disagree, 0 = neither agree nor disagree, 1 = agree, 2 = strongly agree.

[2] This statement was removed from the factor due to the results of the confirmatory factor analysis. Although the statement was not used to calculate the factor average, the average for the statement is provided.

[3] The statement (in bold) was "reverse coded" prior to calculating the factor average; the actual statement average is shown (i.e., rather than the reverse-coded average). The factor average includes the statement after it was reverse-coded.

Table 15. Averages for questionnaire statements related to the connections of maple production businesses with family, community, and business associations[1].

Factor	Statement on questionnaire	Statement average	Factor average
Connection of business with family	My family is extensively involved in the day-to-day operations of maple production.	0.36	0.40
	I depend a great deal on family members to help run my maple production operation.	0.50	
	The profitability of my maple production operation is greatly due to the help I get from family members.	0.35	
	My family's traditions and/or heritage are greatly dependent upon maple production.[2]	0.12	--
Connection of business with community	My community greatly supports my business by organizing events that include and/or showcase maple producers.	-0.36	-0.60
	I greatly depend on my community to create promotional materials (e.g., brochures, websites) that promote my maple production business.	-0.75	
	I greatly depend on my community to provide me with opportunities to network with other business owners (e.g., Facebook, meetings).	-0.69	
	I am frequently involved in events hosted by my community (e.g., farmers' markets, festivals) at which maple products are sold.	-0.54	
Connection of business with associations	I frequently attend events and/or workshops organized by a maple producers' association in my state, region, or county.	0.45	0.41
	I greatly depend on a maple producers' association to promote my business.	-0.09	
	I greatly depend on a maple producers' association for up-to-date information about maple production.	0.85	
	I network a great deal with other maple producers, whether through an association or on my own.	0.44	

[1] The scale used for these statements was: -2 = strongly disagree, -1 = disagree, 0 = neither agree nor disagree, 1 = agree, 2 = strongly agree.

[2] This statement was removed from the factor due to the results of the confirmatory factor analysis. Although the statement was not used to calculate the factor average, the average of the statement is provided.

Perceptions concerning business adaptability in general. Four factors were calculated concerning business adaptability in general (Table 16). The "adaptability of management" factor was used to identify the average respondent's perceptions concerning the willingness and ability of themselves and their employees to plan ahead and quickly make decisions. The average for this factor was 0.81, indicating that the average respondent perceived their management adaptability to be strong. Of the statements included in this factor, "I plan ahead for any major issues or concerns identified for the maple production industry" had a moderate average of 0.57.

The second factor, "adaptability of technology," had a relatively weak factor average of 0.23, indicating that the average respondent may not always have the finances and ability to keep up-to-date with new technologies related to maple production.

The third factor, "adaptability of customer base," had a moderate average of 0.40, indicating that the average respondent is catering to a clientele base that is only moderately diverse with regard to customer type (e.g., retail, individuals, families), and customer interest in diverse products and services. The statement "My customers reside in diverse locations both within and outside my state" included in this factor had a relatively strong average (0.84), indicating that the customers of the average respondent do reside in diverse locations.

The fourth factor, "adaptability of the sugar bush," examines the ability of maple producers to have back-up options for periods of low production or catastrophic events affecting their maple bush. The average for this factor was -0.56, indicating that the average maple producer does not have back-up options in place for these types of events.

Potential adaptability to climate change. One factor focused on maple producers' perceptions of the potential ability of their business to adapt to climate change (Table 16). The average for this factor was -0.22, indicating that the average respondent does not perceive his/her business to be able to adapt to climate change at this point in time. In particular, the average respondent moderately disagreed (Average = -0.49) with the statement "If any severe damage to my sugar bush occurred due to climate change, my business could quickly change how it collects and/or obtains sap," indicating that sugar bush resiliency may be of particular concern to respondents. Results from respondent interviews suggests that some respondents think that climate change is not something that will greatly impact their business in their lifetime, which may reduce the concern of maple producers at this point in time for making changes to their business relative to climate change.

Table 16. Averages for questionnaire statements related to the adaptability of maple production businesses[1].

Factor	Statement on questionnaire	Statement average	Factor average
Adaptability of management	I **plan ahead** for any major issues or concerns identified for the maple production industry.	0.57	0.81
	My employees (if any) and I always **work quickly** to resolve maple production problems.	0.89	
	I am always **willing** to make changes to my business to resolve any maple production problems.	0.98	
Adaptability of technology	My business has the financial resources necessary to quickly adopt new maple production technologies.	0.19	0.23
	I am always able to keep my business up-to-date with new maple production technologies.	0.11	
	I always invest in new technologies when I know I will get a return on the investment.	0.39	
Adaptability of customer base	My maple production business caters to a diverse clientele such as retailers, individuals, and families.	0.47	0.40
	My customers reside in diverse locations both within and outside my state.	0.84	
	My customers are attracted to the diversity of products and services (e.g., tours, demonstrations) my business offers.	-0.11	
Adaptability (resiliency) of sugar bush	I have several back-up options for obtaining sap/syrup when maple production is low.	-0.49	-0.56
	I have several back-up strategies to keep my business running if my sugar bush is damaged by storms, disease, insects, or other	-0.55	
	I can quickly adapt how and/or where I collect sap if my sugar bush is damaged by storms, disease, insects, or other	-0.64	
Potential adaptability of business to climate change	If any changes in **labor** (number of workers, and/or hours worked) are needed due to climate change, my business could quickly get the help it needs to operate.	-0.06	-0.22
	If any changes in maple production **technologies** are needed due to climate change, my business could afford to quickly adopt the new technologies.	-0.08	
	If any changes in **customer base** are needed due to climate change, my business could quickly find and attract new customers.	-0.24	
	If any **severe damage to my sugar bush** occurred due to climate change, my business could quickly change how it collects and/or obtains sap.	-0.49	

[1] The scale used for these variable statements was: -2 = strongly disagree, -1 = disagree, 0 = neither agree nor disagree, 1 = agree, 2 = strongly agree.

Relationships among factors

A statistical analysis technique called a path analysis was used to identify the significant ($p \leq 0.05$) relationships among the factors shown in Tables 13 through 16, and with demographic and business characteristics as well. This analysis was done step-by-step, first testing the relationships between the factors and responding maple producers' perceptions of adaptability to climate change; demographic and business characteristics were later added in to test for additional relationships. Thirty-seven separate models were run during the analysis; during each step in the process, factors and questionnaire statements that were not significant were removed from the analysis. The final model (Figure 3) identifies factors using rectangles, and relationships between the factors using arrows; thicker arrows indicate stronger relationships.

Four factors were identified as "directly" influencing respondents' perceptions of their businesses' adaptability to climate change (i.e., there is an arrow pointing directly from these four factors to the "perceptions of adaptability to climate change" factor in Figure 3):

1. Knowledge of northeastern forests. The results indicate that those who perceive their understanding and knowledge of forests in the northeast as high, also perceive the adaptability of their business to climate change as high. Knowledge about forests could enhance producers' understanding of the potential impacts of climate change on forests and, consequently, the business adaptations that may be needed to adapt to these forest impacts.

2. Adaptability in technology. It is likely that respondents' perceptions concerning their ability to adapt to climate change is influenced by their ability to adopt new technologies. Results indicate that adaptability in technology is influenced by the number of taps used by a business. Since adopting some new technologies may depend on the profitability of the business, businesses with a larger number of taps may be more likely to have the profits needed to adopt new technologies quickly (Figure 3).

Figure 3 also shows that adaptability in technology may be influenced by the ability of a business' owner(s) and employees to adapt to change in general (i.e., "adaptability in management"). "Adaptability in management" may be influenced by both number of taps and age of the responding maple producer. Larger production businesses with more taps may have more flexibility with regard to how quickly they can respond to problems and concerns, possibly due to a greater number of assistants and adequate profits. The negative relationship between age and adaptability in management suggests that younger producers may perceive themselves as responding more quickly to needed business changes and concerns than do older respondents.

3. Beliefs concerning impacts on production. This third factor focuses on respondents' beliefs concerning the impacts of climate change on production. The positive relationship between it and "perceived adaptability to climate change" suggests that respondents who believe that climate change is a potential threat to their business are more likely to consider adapting to climate change in the future.

4. Resiliency of the sugar bush. Respondents were asked to indicate how quickly their business could adapt with back-up strategies or options if their sugar bush was damaged by a catastrophic event. This resiliency factor is perceived by respondents as a strong influence on their perceived ability to adapt to climate change. Sugar bush resiliency is also likely to be the weakest component of maple production

businesses since producers do not have control over catastrophic events. A respondent's perceptions of the resiliency of his/her sugar bush is related to his/her perceived knowledge of the northeastern forest.

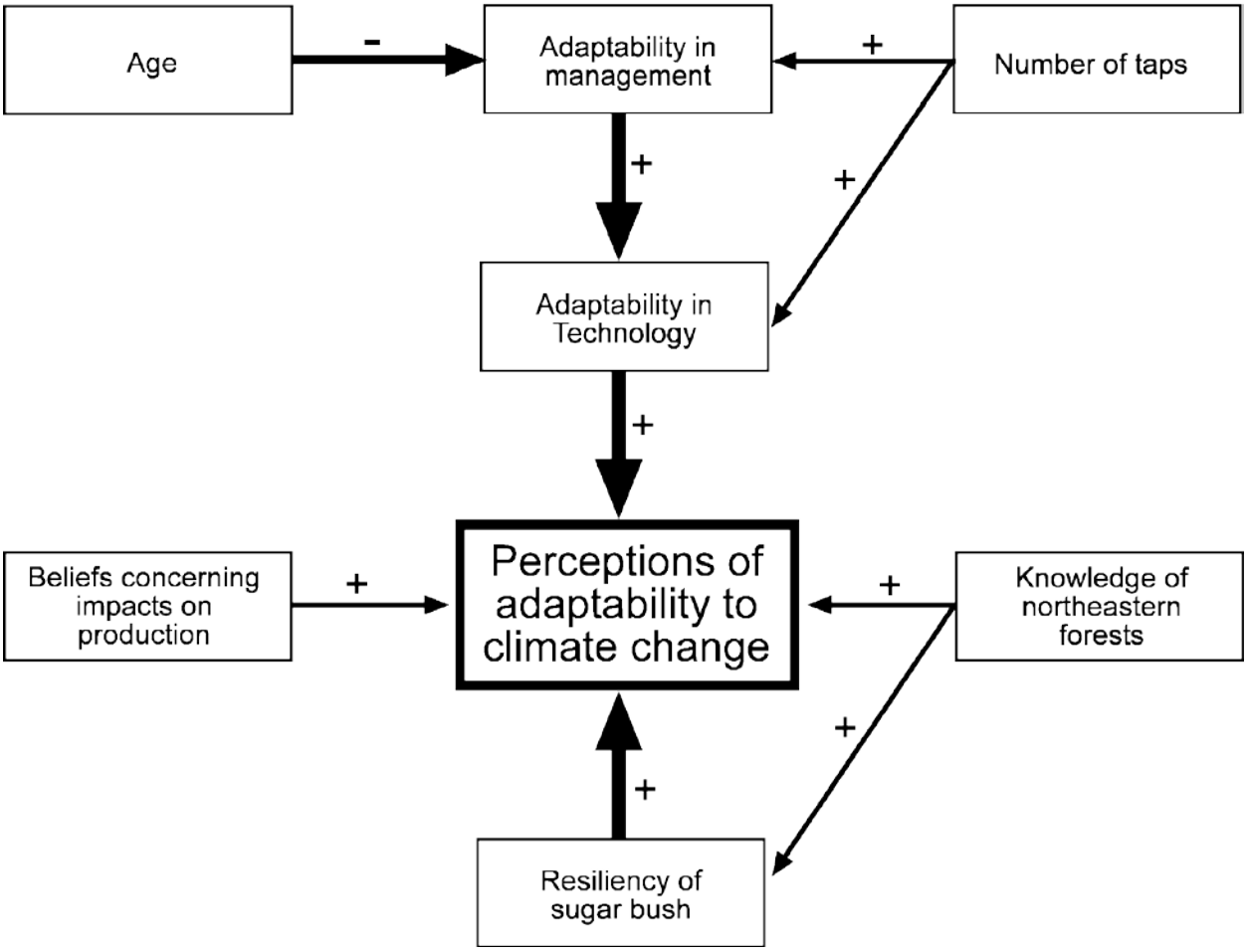

Figure 3. Path analysis model. One-way arrows indicate that one factor influences the other; stronger relationships are indicated by thicker lines. A "minus sign" above an arrow indicates that as one factor increases, the one it is related to decreases; a "plus sign" indicates a positive relationship (as one factor increases, so does the other).

Workshop Discussions

Study results were presented to 69 maple producers at maple conferences in NY (33 from New York, Ontario, and Quebec) and Vermont (36 producers from VT, NH, and Quebec) in January, 2016. Feedback from attendees was compiled by the researchers who took notes during the discussion portion of the workshops. In addition, attendees were asked to complete the open-ended questions on an input form that was collected at the end of each workshop session. Twenty-eight attendees completed the form.

The first question included on the workshop input form was: "Have you made any changes to your maple production business to deal with climate change?" Eleven of the 28 attendees who completed the form indicated that they had already implemented changes to their business. During the workshop discussions, many attendees commented that they had made changes, such as tapping earlier and using vacuum systems. Some indicated that these changes were motivated by climate change, while others indicated that they made these changes for other reasons. In the words of one Vermont attendee, "I have made changes but it's hard to say whether they were because of climate change."

Next, attendees were asked to write in their response on the input form to the question: "What technologies, adaptations, or strategies are you currently using in response to the potential impacts from climate change? Consider products and services, your customer base, the staffing and organization of your business, production-related technologies, and techniques used to maintain the health of your trees." For the 28 attendees who responded to this question, using good forest management practices to enhance tree health and tapping earlier were the most commonly indicated strategies (Table 17).

Discussions at both workshops often focused on tapping earlier. Of particular interest was tapping during the fall season. Those who had experimented with tapping in the fall found that the sap typically was lower in quality (i.e., had a lower sugar content). Vermont maple producers indicated that tapping in the fall made sense only for a sugar bush that was difficult to access in the winter and spring. For attendees from both states, many were tapping in early winter during the first thaw in January or even December. Some Vermont attendees indicated that they were keeping their taps open through the winter using vacuum systems and check valves.

Workshop sessions revealed that adopting new technologies, particularly vacuum systems and check valves, has helped attendees deal with the changing climate. Many producers (two-thirds of Vermont survey respondents and about half of those in New York) no longer use buckets because of the labor required and concerns over the sap freezing with variations in the weather. Good sanitation of tap holes is another concern since bacteria can thrive in the warming climate. Some producers from both states are looking to the future by diversifying the species of trees in their sugar bush to help protect against threats from insects and weather-related events. Some attendees from New York are practicing sugar bush management techniques such as conservative tapping, thinning, fertilizing, planting windbreaks, and planting saplings to maintain the health of their sugar bushes. One New York attendee mentioned his use of careful annual monitoring of his sugar bush, by taking both notes and photographs, to catch any potential problems quickly. One producer from Vermont commented that he is keeping his operation small because he doesn't know what the future holds.

Table 17. Current methods of responding to the effects of climate change as indicated through written comments (n = 28).

Method	Number of attendees indicating item
Using good forest management practices to enhance tree health	29%
Tapping earlier	25%
Using vacuum system	21%
Diversifying plant species in maple bush	14%
Using good sanitation practices for taps/drilling holes	14%
Energy efficient equipment	14%
Conservative tapping techniques	14%
Reverse osmosis	14%
Installed tubing	14%
Implementing new technology as it becomes available	11%
Thinning non-maple species	11%
Networking	11%
Planting more maple trees	7%
Re-using water from Reverse Osmosis to clean equipment	7%
Fertilizing sugar bush (wood ash, lime dust, other fertilizers)	7%
Less aggressive thinning	4%
Using glass instead of plastic	4%
Using recycle bins	4%
Creating wind breaks to protect from high wind storm events	4%
Not tapping during drought	4%
Implementing educational program for visitors	4%

Attendees were also asked: "What technologies, adaptations, or strategies do you plan on implementing **within the next five years** in response to the potential impacts from climate change? Consider products and services, your customer base, the staffing and organization of your business, production-related technologies, and techniques used to maintain the health of your trees." For the 14 attendees who responded to this question on the input form, monitoring their sugar bush and adapting their management techniques as needed was the most frequently mentioned strategy (Table 18).

At both workshops, discussions centered on tapping earlier, with the possibility of tapping in the fall and keeping taps open through the winter. Concerns were raised about increased damage to maple trees from insects, wildlife such as deer, and weather events. Concerns about Lyme disease and the increasing numbers of ticks were also discussed. Maple producers are paying attention to new technologies such as the maple plantations that the Proctor Maple Research Center at the University of Vermont is studying. Thinking long-term, producers are looking into energy conservation alternatives, planting trees, and managing their sugar bush so it will be "resilient and healthy in 100 years."

Some producers have plans to diversify their income through agritourism. One producer mentioned upgrading his sugarhouse to manage larger crowds and another mentioned plans to create a website for

his sugarhouse to increase visitation. A third is in the process of creating a non-profit sugarhouse called North Roads Sugar Works in Vershire, VT to serve as a demonstration site and venue for conversations about climate change.

Table 18. Strategies to be implemented in response to the potential impacts of climate change within the next 5 years (n = 14).

Method	Number of attendees indicating item
Monitor maple bush and adapt management as needed	29%
Use good forestry practices	21%
Keep track of new research about maple production	21%
Add energy efficient equipment	21%
Add new technology if recommended by the Cooperative Extension	14%
Annually document changes in the maple bush (photos, notes, etc.)	14%
Create new internet site	14%
Add solar power	7%
Practice good water conservation	7%
Participate more in open space programs	7%
Expand sales at farmers markets	7%
Add vacuum pumps	7%
Tap in spring and fall	7%
Tap earlier	7%

Lastly, attendees were asked: "What technologies, adaptations, or strategies do you think will be implemented at your business **20 years from now** in response to the potential impacts from climate change? Consider products and services, your customer base, the staffing and organization of your business, production-related technologies, and techniques used to maintain the health of your trees." Thirty-six percent of the 14 attendees who responded to this question indicated that business decisions would be made by their children or grandchildren 20 years in the future (Table 19). Other attendees indicated that applying new research findings to their business and tapping earlier would be important.

At both workshops, the discussions continued to center on tapping even earlier, with a likelihood of tapping in the fall and keeping taps open through the winter. In the Vermont workshop, there was speculation that the fall and spring tapping seasons may merge into one long season, bridging the two separate seasons we have now. There was also speculation around growing conditions for sugar maples, with some optimism that trees may grow better in a warmer climate, although damage from insects and wildlife may continue to worsen. Attendees at both workshops indicated that they will be looking at new technologies in the future and enhancing the energy efficiency of their operations. One attendee at the New York workshop indicated that property tax policies in the future might determine whether maple producers are able to stay in business or not. One New York attendee is currently expanding windbreaks

around his sugar bush so that in twenty years, his sugar bush will be better protected from storm events. A few maple producers at the New York session also discussed the north-facing aspect of sections of their maple bush and how this location might help the maples survive the warming temperatures associated with climate change. While some producers are planning for the future and actively planting trees with a 100-year timeline in mind, others are not at this point in time. One producer from Vermont said, “Don’t ask me -- ask my kids and grandkids!"

Table 19. Strategies to be implemented 20 years in the future in response to the potential impacts of climate change (n = 14).

Method	**Number of attendees indicating item**
Pass on business to children/grandchildren	36%
Apply new research	21%
Tap earlier	21%
Add new technology if recommended	14%
Continue tree planting efforts	14%
Become more energy efficient or energy independent	14%
Continue to educate myself about maple production	7%
Practice good water conservation	7%
Support open space programs	7%
Expand production to newly thinned areas	7%
Have windbreaks in place	7%
Support reasonable property tax policies	7%
Tap in spring and fall	7%

Discussion

Overall, the results provide some important concepts for maple producers to consider with regard to the potential impacts of climate change. First, the two factors that most influence if a respondent perceives their business as adaptable to climate change are his/her perceived ability to adopt new technology and his/her perceptions concerning the resiliency of their sugar bush. Respondents' perceptions concerning the ability to adopt new technology appear to be closely linked to the size (i.e., number of taps) of the business. Those businesses with more taps are likely to be receiving more income from maple production, influencing their ability to invest in new technology. Similarly, the resiliency of a business's sugar bush is likely dependent on the size of the sugar bush (acreage) as well as its geographic location (latitude, elevation, spread across a region, aspect (i.e., north or south-facing slopes)). Interviewees mentioned that their sugar bush may be more resilient to climate change since portions of it are on north-facing slopes which tend to be cooler. Many interviewees in the northern portion of Vermont also indicated that their northern latitude would protect their business, to a certain extent, from the warmer weather associated with climate change. Having a sugar bush that is spread out over a large geographic area might also limit the portions of the bush affected by localized storm events.

Second, both "diversity of services" and "diversity in marketing" may be important to consider with regard to adapting to climate change in the future (both were identified as indirectly influencing "perceived adaptability to climate change," but were omitted from Figure 3 in order to highlight the factors found to be direct influences). Sixty-one percent of respondents offered one or more customer services, and 76% used at least one type of marketing technique. Diversity of services and in marketing approaches may be particularly important during years of low maple production. Unique services offered by businesses may help maple producers maintain some level of income, even when production is low. Similarly, diverse marketing strategies may help maintain customer interest in a business, helping the maple producer weather periods of low production. It is important to note that "diversity of products" was not identified as a significant factor in the model, likely due to the fact that 81% of the respondents offer only maple products. It is likely that producers who do have a diverse line of maple and non-maple products will maintain a higher income during times of low maple production. Having a diverse product line may be particularly important in years when syrup production is low since many value-added maple products can be made using smaller amounts of maple. It is also important to realize that the income from maple production may not be a large part of the household income for many maple producers, since 88% are either employed outside the maple production business or receive retirement income.

Third, "adaptability in management" appears to indirectly influence the average producers' perceived ability to adapt to climate change. The flexibility of the management of a respondent's business appears to be somewhat influenced by the age of the respondent (i.e., younger respondents perceived themselves as more flexible in their business management) and the number of taps of the business (i.e., owners of larger businesses perceived themselves as having more flexibility in management, possibly due to a greater profit margin).

Fourth, although "connections of business with family" was not identified as significant in influencing potential adaptability to climate change, it should not be overlooked as an essential component of the current maple industry, since 92% of respondents receive assistance from family and friends during the tapping season. Furthermore, with 57% of maple producers being 60 years or older and 18% of producers planning to pass their business on to their children, the future of the industry relies on these connections between family and friends. The heritage and traditions involved in this industry are

especially important to note, with high averages for the variables "maple production is in my blood" and "maple production is important because it is part of my heritage and/or family traditions."

Fifth, though "connection of business with associations" was not identified as a significant influence on potential adaptability to climate change, associations were identified as an important source of information for maple producers. Associations are likely to be extremely important to maple producers in the future should impacts from climate change occur, primarily because of their ability to provide maple producers with up-to-date information on production technologies. The Cooperative Extension was another extremely important source of up-to-date information for respondents from both NY and Vermont.

Sixth, although the dependence of maple producers on their business for recreational purposes was not identified as a significant influence on potential adaptability to climate change, this factor had the highest average (1.00) of all factors, indicating that the recreational aspects of maple production are very important to the average respondent. Similarly, the variable "maple production is important to me because of the enjoyment it provides" had the highest average (1.41) of all variables included on the survey. Thus, though the recreational aspect of maple production is not likely to affect a business's adaptability to climate change, it is likely to affect whether a business owner wishes to remain in the maple production business, whether impacts from climate change occur or not.

It is important to note the limitations of this study. First, the survey questions are designed to obtain the perceptions of respondents. As with any social science study, the perceptions of respondents may not always exactly reflect the situation as experienced by the respondent or as perceived by those not in the sample of respondents. Second, although efforts were made to obtain the most comprehensive list of maple producers in both New York and Vermont, producers who do not advertise on the internet or who do not advertise online through an association may have not been included in the sample. Third, response bias is possible, as with any survey. Although the non-respondent follow-up survey did not reveal differences between respondents and non-respondents, both surveys used the term “climate change” and it is possible that some maple producers chose not to answer the survey for that reason. Fourth, only maple producers in the Northern Forest Region of NY and Vermont were included in this study; maple producers in more southerly regions (more likely to be affected by climate change) have not been included. These results should not be generalized to producers in regions south of the Northern Forest Region. Fifth, the mail survey instrument did not specify a time horizon for impacts of climate change, leaving interpretation open to respondents. Future research is needed to better understand maple producers’ perceptions of adaptability to climate change over different time horizons. Finally, the workshop sessions comprised attendees who voluntarily chose to participate. Most attendees appeared to believe that climate change is occurring. Different workshop results might have been obtained from a randomly selected sample of maple producers. Workshop results should be used to help identify potential strategies that can be implemented by businesses, and should not be interpreted as results representative of all maple producers in the Northern Forest Region.

Conclusion

More than half of the maple producers who responded to the survey expressed concerns about climate change, and more than two-thirds had already made or were planning to make modifications to their business. According to the path analysis, the ability to adopt new technologies and the resiliency of the sugar bush are the two factors that most influence maple producers' perceptions of their ability to adapt to climate change in the future. With regard to technology, the responses of maple producers suggest that many have implemented (or plan to implement) technological innovations that allow increases in sap yields, regardless of weather fluctuations. Many have also started collecting sap earlier in the season than in the past, some in early winter, and others are looking at a fall season for sap collection. Business adaptations such as these may minimize many of the potential negative impacts from climate change in the foreseeable future. Strategies for enhancing sugar bush resiliency need to be considered as well. Some maple producers are preparing for the future by planting diverse, resilient tree species in their sugar bush. Maple producers will likely need to adopt new technologies in the future in order to adapt to changes in the production season and remain competitive in a growing market.

As the climate continues to change and new technologies are developed, a variety of questions are raised requiring further research. One of the most urgent questions is "what happens to a business if it cannot afford to adopt new technologies?" The economics of the maple industry are complicated by the Federation of Quebec Maple Syrup Producers, which regulates the production and marketing of maple syrup in Quebec, the producer of three-quarters of the global supply. Competing in global, wholesale markets is an uncertain venture. Currently, maple producers can command higher prices by selling direct from their sugarhouses and providing complimentary products and services such as maple candies, pancake breakfasts, and educational tours. What will happen to these opportunities in the future? Furthermore, if small production businesses cannot afford to adopt new technologies, what will the structure of the maple production industry look like in the future? These questions require future research.

Despite the uncertainty of the future, the results of the survey suggest that maple producers are committed to their operations, with only 10% planning to retire, sell, or close their business over the next five years. The vast majority of maple producers are highly optimistic about the future of maple production, with 48% wanting to increase the number of taps over the next five years, 42% wishing to keep their business "as is", and 18% wanting to expand the services and products they offer. These committed maple producers are adept at adapting to changing conditions, and they are creating the foundation for a resilient maple industry into the future.

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