Adapting to climate change: Perceptions of maple producers in New York and Vermont

Diane Kuehn [a] *
State University of New York College of Environmental Science and Forestry

Lisa Chase [b]
University of Vermont Extension
Vermont Tourism Research Center

Thomas Sharkey [c]
State University of New York College of Environmental Science and Forestry

Abstract

Maple production is an important part of local food systems in the Northeastern U.S. and Canada, where producers rely on maple as a source of income and as the basis for longstanding family and community traditions. Like many other sectors of the food system, maple production is vulnerable to climate change because of its potential impacts on forest type, tree health and vigor, and timing of sap flow. Since 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 assess the perceptions of maple producers and engage them in the development of strategies for adapting to the potential impacts of climate

[a] * *Corresponding author:* Diane Kuehn, Associate Professor, Department of Forest and Natural Resources Management, State University of New York College of Environmental Science and Forestry; 1 Forestry Drive, 320 Bray Hall; Syracuse, NY 13210 USA; +1-315-470-6561; dmkuehn@esf.edu

[b] Lisa Chase, University of Vermont Extension, Vermont Tourism Research Center

[c] Thomas Sharkey, Department of Forest and Natural Resources Management, State University of New York College of Environmental Science and Forestry

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Authors' Notes

change. The mixed methods research approach for this study included interviews and a survey of maple producers in the Northern Forest region of New York and Vermont. 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 businesses. 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. These findings are not just relevant for maple production; they have important implications for climate change adaptation of food systems.

Keywords
Adaptability; Climate Change; Demographics; Business Characteristics; Maple Production

Introduction
Maple production is an important part of local food systems in the Northeastern United States and Canada, where it is a longstanding cultural tradition as well as a source of income for family-based businesses. Vermont and New York are the two highest maple-producing states in the U.S. (U.S. Department of Agriculture, National Agriculture Statistics Service [USDA NASS], 2017). The Northern Forest (NF) region of these states (Figure 1) is home to over 1,000 commercial maple production operations, primarily small businesses that depend on maple products (e.g., maple syrup and sugar) as a source of revenue. Many of these businesses have been in operation for decades (even generations), and there is substantial potential to expand maple production in several states in the Northeast and Midwest in the future (Farrell & Chabot, 2012).

Climate change is expected to impact the entire food system (Miller et al., 2013), and maple production is no exception. Predictions of climate change impacts regarding levels of sap production from maple trees vary, with some models suggesting that the season will be shorter in the Northeastern U.S., and others that the season will start significantly earlier (Skinner, DeGaetano, & Chabot, 2010). Skinner et al. indicate that the number of days on which sap flows from maples will not change through 2100; however, maple production business owners will need to collect sap earlier in the season to "maximize the number of sapflow days" (2010, p. 685). Climate data for the northeast indicate that the sugaring season has shortened by about 10% over the past 40 years (*Global Warming Mountaintop "Summit,"* 2007). 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 (*Global Warming Mountaintop "Summit,"* 2007). Maples stressed by climate change may be more susceptible to invasive pests and diseases, 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 and community traditions, adapting to and planning for changes in maple production will likely be necessary in the

Figure 1. Northern Forest Region of NY and Vermont
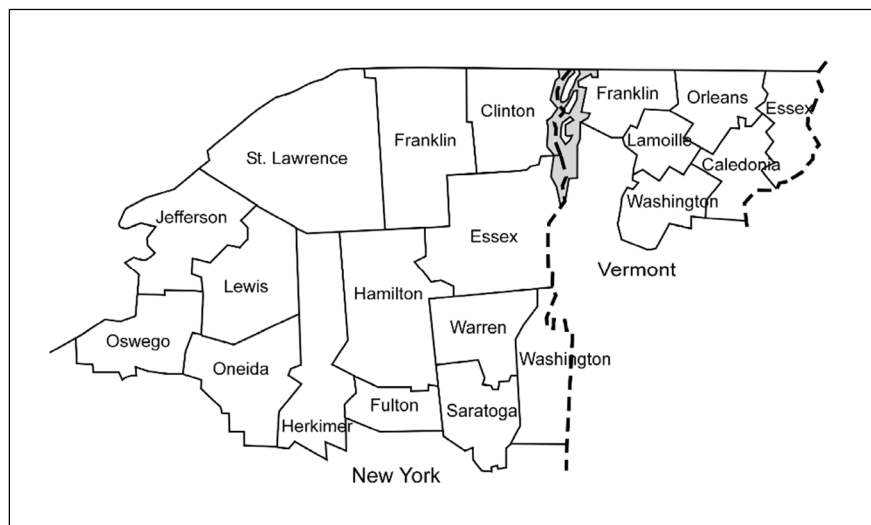
Map based on a Northern Forest and Counties Map by Conservation Advisory Services, 1994.

future. Past research indicates that understanding the factors, including perceptions of climate change, that affect the ability of producers to adapt to change is essential (Jemison, Hall, Welcomer, & Haskell, 2014; Ogalleh, Vogl, & Hauser, 2013). A range of views exist on climate change in the United States, from those who believe action must be taken to reduce carbon emissions, to those who do not believe climate change is occurring. 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 (Chase & Grubinger, 2014; Leiserowitz, Maibach, Roser-Renouf, & Hmielowski, 2012). A survey of farmers in Iowa found similar results: 5% of the respondents did not believe in climate change and did not wish 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. This study seeks to provide a better understanding of these beliefs for maple producers in the Northern Forest Region of New York and Vermont.

The goal of this study is to identify strategies that help maple producers plan for and adapt to the potential impacts from climate change. In order to accomplish this goal, the objective is to identify the elements influencing the ability of businesses to adapt to climate change. We hypothesize that there will be significant relationships among business characteristics, demographics, perceptions concerning climate change, and producers' perceptions of their ability to adapt to climate change; we use a path analysis to identify significant relationships. While this research focuses on maple production, the methods and results have broad implications for other sectors of agriculture and food systems.

Literature Review

Adaptability is a business's ability to respond technologically to change, to be flexible in terms of its customer base (i.e., its market focus), and to have a management structure that can respond to change (Tuominen, Rajala, & Möller, 2004). According to Walker and Ruekert (1987), a high degree of adaptability in a business is essential since firms

unable to adapt and innovate often fail. Resiliency (i.e., "the capacity of a system to absorb disturbance and reorganize while retaining essentially the same function" [Folke, Carpenter, Walker, Scheffer, Chapin, & Rockström, 2010, p. 3]) is important to business adaptability since it can determine how quickly businesses "bounce back" from catastrophic events such as severe weather. Research on small-business resilience during an economic downturn suggests that firms with high levels of adaptability and flexibility are more likely to be successful (Smallbone, Deakins, Battisti, & Kitching, 2012). For maple producers, resource-base resiliency (i.e., how quickly a maple forest or "sugar bush" can recover from catastrophic events) and flexibility in management and customer base are likely crucial to the long-term success of the business.

Adapting to the changing climate is a challenge for small businesses, particularly those as important to the traditions and economy of the Northern Forest Region as maple producers. Previous studies have used "adaptability scales" to measure (on a five-point scale) business owners' perceptions of their businesses' level of adaptability (Lansberg & Astrachan, 1994; Tuominen et al., 2004). This study uses this type of scale to study maple producers' perceptions concerning adaptability to climate change. Four components of adaptability are considered: customer base, management, technology, and resource base.

In addition to the components of adaptability, an understanding is needed of demographic, business, and social system (i.e., connections between individual businesses and family, community, and industry) characteristics. Previous studies have shown that the owners of small, family-based businesses, such as maple production businesses, need more than basic management and marketing skills to be successful. Eberle, Milliman, Peterson, and Rendleman (2004) found (for the dairy industry) that understanding family and community relationships is critical for successful transitions in times of uncertainty. Davis and Stearn (1981) emphasize the importance of being able to differentiate between business operations and family dynamics, since the two are often closely integrated in family-based businesses. Björnberg

and Nicholson (2007) found that family businesses are dependent upon the ability of the family running the business to work effectively together and to adapt to change.

Because of the importance of family dynamics to business success, it is essential that these elements also be considered for maple producers. In addition, business success has been linked to managers' knowledge and perceptions of new technologies, demographics (education and age), business characteristics (e.g., firm size [Peltier, Zhao, & Schibrowsky, 2012]), business-related experience (Richbell, Watts, & Wardle, 2006), and the existence of a written business plan (Rue & Ibrahim, 1998). In order to provide a comprehensive understanding of business adaptability, this study integrates these elements as well as measures of adaptability in its theoretical framework (Figure 2).

Applied Research Methods
This study was composed of two components:

interviews with a sample of maple producers, and a survey of all identified maple producers in the Northern Forest region of New York and Vermont (Figure 1). Information from online sources (e.g., New York State Maple Producers Association (NYSMPA), the Vermont Maple Sugar Makers Association (VMSMA), and business websites) and from the University of Vermont Extension program was used to create a contact list for all known maple producers in the Northern Forest Region of New York and Vermont.

Fourteen telephone interviews were conducted with 15 maple producers in the Northern Forest region of New York and Vermont in 2014 and 2015 (one interview was conducted with two business partners). The list of key contacts was used to randomly select producers for interviews. Interviews were scheduled by sending out e-mail requests. Interviews were recorded (with interviewee permission) with an Olympus DS-5000 digital voice recorder and transcribed using Dragon

Figure 2. Business Adaptability Model Related to the Potential Impacts of Climate Change (CC) on Maple Production Businesses
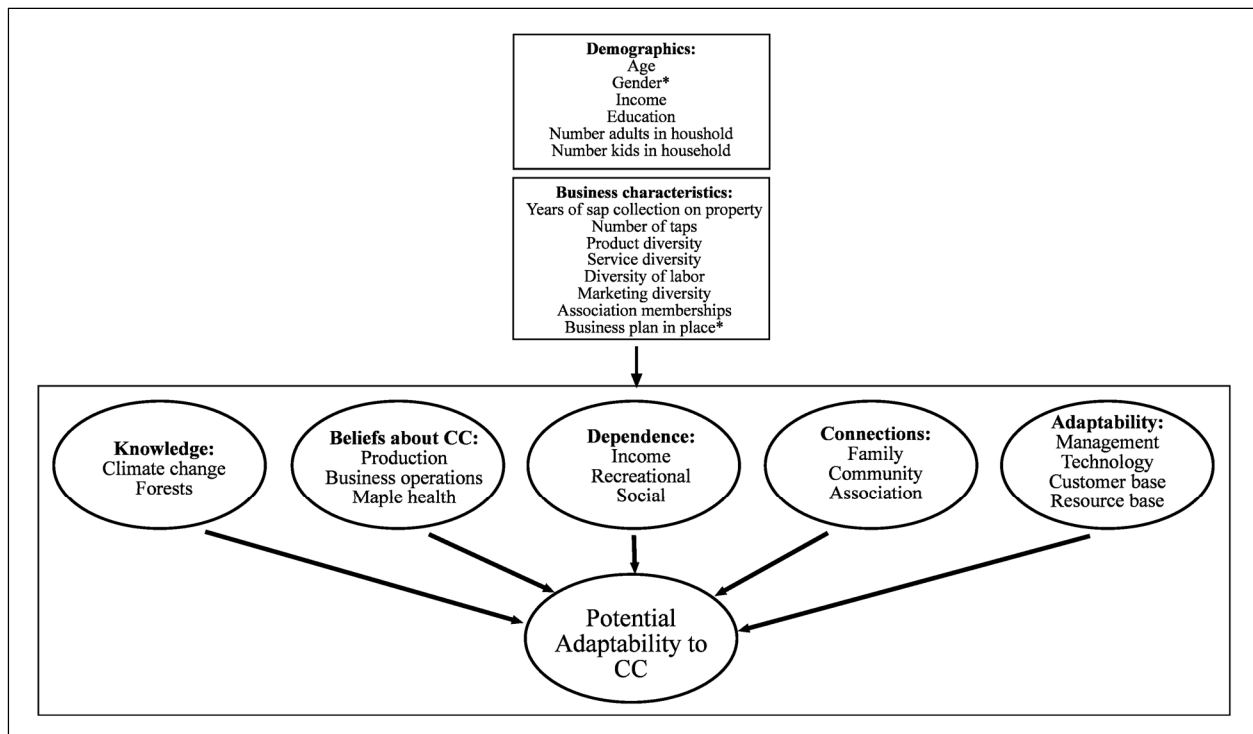
Note: An asterisk indicates that the item was not included in the final analysis.
Source: Kuehn, Chase, Sharkey, & Powers, 2016.

Dictate 4.0 software (Nuance Communications, 2014). Interviews ranged in length from 16 to 45 minutes.

The interview guide included questions about maple producers' perceptions of climate change, the characteristics and structure of their businesses, their businesses' products and services, the use of up-to-date technology, and the adaptability (i.e., resiliency) of their sugar bush. Interview questions related to adaptability, dependence, and connections (Table 1) were identified from Bélanger, Vanasse, Parent, Allard, & Pellerin (2015); Björnberg and Nicholson (2007); Eberle et al. (2004); Peltier et al. (2012); Tuominen et al. (2004); and Walker and Brown (2004). Questions regarding business characteristics and maple production were derived from an interview guide provided by Dr. Brenda Murphy of Wilfred Laurier University, Ontario, Canada. 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 interviewees were transcribed verbatim. These transcriptions were then used to identify concepts relevant to interviewees' perceptions of climate change and the elements influencing their business' ability to adapt to change (Figure 2).

Interview data were analyzed by the first and third authors for reoccurring concepts related to the themes identified through literature review (Table 1). In addition, grounded theory techniques (Creswell, 2009) were used to identify themes previously unidentified for business owners' perceptions of climate change (e.g., beliefs concerning climate change, knowledge of climate change and of forests, and adaptability of the resource base (i.e., sugar bush resiliency; see Table 1). We identified the number of respondents indicating each concept within each theme. Intercoder agreement (i.e., cross-checking concepts identified by two different researchers [Creswell, 2009]) was calculated for each concept using ReCal online software (http://dfreelon.org/utils/recalfront/) (Freelon, 2010). An intercoder agreement percentage of 80% is usually considered an adequate indication of consistency of the data (Miles & Huberman, 1994);

however, since the closest percentage to 80% that could be obtained mathematically based on the number of interviews in this study was 79%, this percentage was considered an adequate indication of intercoder agreement.

The themes confirmed and/or identified through analysis of the interview data were used to write a questionnaire for the mail and online survey (Table 1). The questionnaire included questions related to the characteristics of respondents' businesses; respondents' demographic characteristics; their knowledge of climate change and northeastern forests; their beliefs related climate change; their dependence on their business for economic, recreational, and social reasons; the connection of their business to family, community, and the maple production industry; perceived adaptability of their business with regard to management, technology, customer base, and resource base (i.e., sugar bush resiliency); and potential adaptability to climate change (Figure 2). Questions were in multiple choice, fill-in-the-blank, and five-point scale formats. For questions related to the perceptions of maple producers, the questionnaire used a scale ranging from –2 (strongly disagree) to 0 (neutral) to 2 (strongly agree). Lists of services and marketing and promotion techniques were also included on the questionnaire. "Diversity of services provided" was calculated as the sum of all services identified on the questionnaire; "diversity of marketing" was calculated as the sum of all marketing and/or promotion techniques implemented by the respondent.

The survey was conducted by mail and online in the fall of 2015 using a modified tailored design method (Dillman, 2007). We distributed four mailings of the questionnaire to the 1,322 maple producers identified in the Northern Forest Region of New York and Vermont via first-class mail. The first and third mailings contained a cover letter, full questionnaire, and postage-paid return envelope; the second and fourth mailings were reminder postcards. An identical online version of the questionnaire was provided using SurveyMonkey (San Mateo, CA) for those respondents who prefer submitting responses via the Internet. A link for the online survey was included in the questionnaire mailings; respondents were required to enter a

number from the back of their mailed question-naire to participate in the online version.

Following 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 to the 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 population of maple producers is somehow different than the group of individuals who responded to the full survey.

Data were entered into PASW Statistics version 18.0 (SPSS, Inc.). Following data entry, a confirmatory factor analysis was conducted using EQS 6.1 software (Bentler, 2010) to confirm the arrangement of variables into factors (Hair, Anderson, Tatham, & Black, 1998). Because some variables were written on the survey "in the negative" or opposite of how other variable statements were written, these variables were reverse coded before the factor analysis was conducted. The variable means for the reverse-coded questions shown in the tables in Appendices A and B do not show the reverse coding (i.e., the means of the actual responses are included in each table); however, the factor means shown in these tables were calculated using the reverse-coded data. For the confirmatory factor analyses, a root mean square error of approximation (RMSEA) of less than 0.05 (Byrne, 2006, p. 100) and a comparative fit index (CFI) of "close to 0.95" (Byrne, 2006, p. 97) were used to identify adequate fit of the variables into factors. The reliability of factors was checked by calculating the Cronbach's alpha. Alphas above 0.7 are considered to have good consistency and can be used for statistical analyses such as path analysis (Hair et al., 1998). Following these tests, the responses for the questions composing each factor were averaged together for each respondent, creating the summated scales used in the path analysis (Hair et al., 1998). The summated scales for all respondents were then averaged to identify the overall factor means for all respondents reported in tables in Appendices A through D.

A path analysis was used to identify significant relationships ($p \leq 0.05$) among the factors (the relationships tested are indicated with arrows in Figure 2). Variables related to demographics (e.g., age, years of education) and business characteristics (e.g., number of taps or holes put in the trees to extract the sap) were also included. The path analysis utilized robust methods as suggested by Byrne (2006); good fit was attained when the CFI was near 0.95, the RMSEA was less than 0.05, and the Satorra-Bentler chi square reached a p-value of greater than 0.05 (Byrne, 2006).

Results

Interviews
Fourteen in-depth telephone interviews were conducted with maple producers after obtaining interviewee permission. Eight interviews were with New York producers and six were with Vermont producers; one interview included both owners of the business. Seventy-two percent of the interviewees thought climate change was occurring; 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, 2015).

Themes related to business management and climate change were identified from previous literature and from the interviews. "Knowledge of climate change" and "knowledge of forests in the northeast" were two of the constructs identified from interview results (Table 1). Knowledge of climate change was indicated by interviewees' comments concerning the "slow global warming of the world" (indicated by 36% of respondents; intercoder reliability (ICR)=93%), "extreme or odd weather patterns" (50%; ICR=86%), and "warmer weather, less snow, early spring" (29%; ICR=86%).

> Interviewee #8 (male, in business 5 years): "The ocean temperatures are changing, and the ocean temperatures and the currents are actually what dictates weather patterns everywhere else. So as the ice caps melt, the water gets warmer, which is what creates the wind, and the wind actually dictates how the whole atmosphere revolves and conducts itself. So yes, the climate is changing."

Table 1. Themes Used to Write the Mail and Online Survey

Themes	Source
Knowledge of climate change	Interview results
Knowledge of forests	Interview results
Beliefs about impacts of climate change on production	Interview results
Beliefs about impacts of climate change on business operations	Interview results
Beliefs about impacts of climate change on maple health	Interview results
Dependence on maple production for income	Walker & Brown, 2004; Interview results
Dependence on maple production for recreational purposes	Interview results
Dependence on maple production for social purposes	Bélanger et al., 2015; Walker & Brown, 2004; Interview results
Connections of business to family	Eberle et al., 2004; Interview results
Connections of business to community	Eberle et al., 2004; Interview results
Connections of business to industry	Eberle et al., 2004; Interview results
Adaptability of business in management	Björnberg & Nicholson, 2007; Tuominen, et al., 2004; Interview results
Adaptability of business in technology	Peltier, Zhao, & Schibrowsky, 2012; Tuominen, et al., 2004; Interview results
Adaptability of business in customer base	Tuominen, et al., 2004; Interview results
Adaptability of resource base (i.e., sugar bush resiliency)	Interview results
Ability of business to adapt to climate change	Interview results

Knowledge of forests was indicated by interviewees discussing the potential reduction of maples in forests in the southern portion of the sugar maple range (21% of interviewees; ICR= 93%), as well as the observation that maples on north-facing slopes might do better as temperatures increase (14%; ICR=86%).

> Interviewee #14 (male, in business 10 years): "I think that some producers may see an effect if they have a southerly aspect slope on their sugar bush. But if they have a northerly aspect slope, like I do, it may take longer for those effects to impact their business."

Three belief-related themes concerning climate change were identified from the interviews: production, business operations, and maple health. Fifty percent of interviewees indicated beliefs concerning production by indicating that there would be an impact on production levels in the future due to climate change (ICR=86%); 57% believed that this impact would not occur in their lifetime (ICR=86%).

> Interviewee #14 (male, in business 25 years): "Looking forward 100 years, if the temperatures are steadily increasing, we will see declines in maple syrup production."

Beliefs concerning business operations were mainly related to changes made to operations such as tapping trees earlier (43% of interviewees; ICR= 79%) and being flexible about when tapping begins (21%; ICR=79%).

> Interviewee #13 (male, in business 4 years): "The big things are in terms of when to tap the trees.…When the season begins to how the sap is flowing. I think that's being affected by changing temperatures in the climate."

Beliefs concerning maple health were indicated by comments about the future health and vigor of maple trees due to potential impacts from climate change. Thirty-six percent of interviewees discussed changes they thought would occur in maple forests due to climate change. Five (36%) indicated that maples would no longer be able to thrive due to the warmer weather conditions (ICR=79%).

> Interviewee #1 (male, in business 1 year): "If it gets hotter and drier it will affect species that can't adjust to the extreme conditions. And I don't know enough about our species to know which ones will be affected most, but obviously maple is the one that is closest to home and the species that we will watch the most."

Four interviewees (29%) indicated that the changing temperatures could encourage the spread of invasive species and tree diseases (ICR=86%).

> Interviewee #13 (male, in business 4 years): "As for the health of the maple trees, I do worry about changing temperatures and how that'll affect the winters here, and potentially new invasives that are going to affect my maple trees and new diseases."

Three themes were identified concerning the interviewees' "dependence" on their business for financial, recreational, and social purposes. All interviewees indicated that they use their syrup within their family and to give to friends (ICR=100%); 79% use their maple business as a supplemental source of income (ICR=79%).

> Interviewee #2 (male, in business 17 years): "It's a nice additional source of income. It helps us pay our taxes, and also gives us a bit of spending money."

"Recreational dependence" was indicated when interviewees mentioned that they liked being outdoors (21% of interviewees; ICR=93%), the physical exercise involved with being out in their maple forest or "sugar bush" (29%; ICR=86%), that maple production was a hobby for them (36%;

ICR=79%), and/or that they "love" or enjoy making syrup (43%; ICR=79%).

> Interview #10 (male, in business 4 years): "It's a healthy activity to produce it, and we enjoy it because of that. I think that's the simplest answer."

"Social dependence" was shown when interviewees discussed socializing with other business owners or with customers (14%; ICR=100%), and that maple production was "in their blood" or an important part of their heritage (36%; ICR=93%).

> Interviewee #8 (male, in business 5 years): "Well, of course you've got to make money, but I'm not really doing it for the money, because I'm never going to get rich doing this. I guess it's just one of those things that you have in your blood."

Three themes related to "connections" of the interviewee and his or her business to family, community, and the maple industry were identified in the literature and confirmed through the interviews. "Connections to family" were shown by the integration of family members into the production process. Seventy-nine percent of interviewees indicated that their spouse or significant other was either an employee or partner in their production business (ICR=100%); 21% indicated that their children or grandchildren help during sugaring season (ICR=86%). Five businesses (41%; ICR=86%) indicated that their business has been passed down through the generations.

"Connections to community" were identified by the interviewees' involvement in community-based events, farmers markets, and open houses (64% of interviewees; ICR=93%); 29% indicated that they did not have a strong connection to their community for business purposes (ICR=100%).

> Interviewee #4 (female, 20 years in business): "It's really made us be more active in the local community as a small business. We're part of the chamber of commerce and actively involved in the local community thanks in large part to our maple business."

"Connections to the maple industry" were primarily shown by involvement in maple producers associations; 93% of interviewees indicated that they are members of a maple producers association (ICR=93%).

Interviewee #9 (male, in business 30 years): "I do a lot of work with the state association working with government officials and things like that."

Interviewees felt that association involvement was important because it kept them up-to-date on the industry (36%; ICR=86%), provided opportunities for networking with other producers at conferences and association meetings (50%; ICR= 79%), and provided important promotional tools (36%; ICR=79%).

Three themes identified through literature review were confirmed through the interviews in relation to "adaptability" in management, technology, and customer base; a fourth theme, "adaptability of the resource base," was identified through analysis of the interview data (Table 1). "Adaptability in management" was shown through the flexibility of maple producers with regard to decision-making. Seventy-nine percent of the interviewees had businesses that were adaptable with regard to management because all decision-making was done either by themselves or in conjunction with their spouse (ICR=79%). Decisions were also made by 29% of interviewees based on input from professionals such as accountants, Cooperative Extension agents, and foresters (ICR=93%). The family-based system used by most producers seemed to provide further adaptability in that if an employee quit or was unavailable during sugaring season, family members or the owner would complete the needed tasks (86%; ICR=86%).

Interviewee #4 (male, lifelong involvement in business): "That actually did happen a few years back. My wife's father was really sick and she had to fly out to take care of him during production season. When that happened, my parents came to the farm and helped pick up some slack."

"Adaptability in technology" was expressed by interviewees when they discussed the adoption of new sugaring technology. Thirty-six percent of interviewees indicated that they have already installed new technologies to adapt to climate change (ICR=93%), while 29% indicated that they plan to do so in the future (ICR=86%). The majority of owners (79%) indicated that the financial expenses associated with adopting new technologies influences their adoption to some degree (ICR=79%); 29% indicated that they need to see a relatively quick return on investment to make the adoption of new technologies feasible (ICR=86%). Only two interviewees indicated that nothing stops them from adopting new technologies; both were the owners of larger businesses with high profit margins (ICR=100%).

Interviewee #4 (male, lifelong involvement in business): "It's really all about the numbers and how fast it will get a return on our investment. So we just sit down with a calculator and crunch the numbers. If we think we can make our money back say, in five years, then we might move forward with buying new equipment or something like that."

"Adaptability in customer base" was related to the diversity of visitor markets served by interviewees, and the geographic breadth of the customer base. Thirty-six percent of interviewees served local customers only (i.e., customers within the immediate geographic region of the maple production business; ICR=100%); 57% served local customers as well as customers from elsewhere in the state and out-of-state (ICR=93%). Only one interviewee sold products via the Internet.

Finally, "adaptability of the resource base" was identified through the interviewees' perspectives on how they would react if severe damage to their sugar bush occurred due to a catastrophic event. Twenty-nine percent indicated that they would harvest timber if needed to generate income (ICR= 93%), 21% would replace sap lines as quickly as possible (ICR=79%), and 36% would buy sap from other producers (ICR=86%). Many of the actions indicated by interviewees indicated the limited resiliency of the sugar bush itself.

Interviewee #2 (male, in business 17 years): "There was a bad windstorm back in '98, and it put us out of business for a year. We lost a lot of customers during that year, but we bought more sap and tried to keep as many customers as possible."

Mail Survey

Response Rate
The full survey was mailed to 1,322 businesses in the Northern Forest Region of Vermont and New York. Undeliverable addresses, deceased individuals, and noncommercial maple producers were removed from the contact list, leaving a qualified sample of 1,011 maple producers. Of this qualified sample, 269 maple producers returned a completed questionnaire for a response rate of 27%. Of the usable questionnaires (N=264), 86 were completed by New York producers and 178 by Vermont producers (Kuehn et al., 2016).

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 responses to the full and short surveys revealed no significant differences ($p \leq 0.05$) between full survey and short survey responses 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 (i.e., resource base) damage. The age and years of education of respondents were also compared; no significant differences were found, indicating that the respondents to the full survey are likely representative of maple producers in the Northern Forest region (Kuehn et al., 2016).

Demographics
The age of respondents ranged from 18 to 88, and the average respondent was 61 years of age (n=261). The average respondent had 14.5 years of education (includes 12 years for high school; n=249). Most (94%) were male (n=261). Nearly half of the respondents had an annual household income between US$26,000 and US$75,999. Eighty-seven percent of respondent households

were home to two or more adults; 19% of households had at least one child (n=261; Kuehn et al., 2016).

Business Characteristics
Maple syrup had been produced on the land of respondents for an average of 82 years in NY and VT combined (an average of 51 years in NY and 97 years in Vermont; n=256). Producers in NY had an average of 2,576 taps in 2014, and had added an average of 681 taps between 2010 and 2014 (n=86); Vermont producers averaged 4,876 taps, adding an average of 1,470 taps in the same five-year period (n=175). The average producer made 1,337 gallons (5,062 liters) of syrup in 2014 (n=248); the maximum amount produced by a single producer was 32,500 gallons (123,026 liters). Most respondents (91%) did not have a written business plan in place, although 5% indicated that they were currently writing one (n=255; Kuehn et al., 2016).

Diversity in Products, Services, and Marketing and Promotions
Although all the maple producers surveyed provide maple syrup, 36% of respondents provide other products as well. Maple cream, maple candy, and maple granulated sugar were the products most commonly mentioned by respondents. Eighty-one percent of respondents sell only maple products; 13% sell maple products plus one non-maple product, and 6% sell maple products plus two or more non-maple products (n=258; Kuehn et al., 2016).

Sixty-one percent of maple producers offer at least one type of service, the most common being tours of their maple production facility and/or sugar bush, an "open house" during Maple Weekend (state-sponsored events used to promote maple production businesses in both states), and programs for school groups. 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 services. The mean number of services offered by respondents was 1.6, with a median of 1.0 (n=254; Kuehn et al., 2016).

About one-quarter of businesses do not use any form of marketing or promotion; the

remaining 74% of respondents use diverse promo-
tional approaches, including word-of-mouth, a
sign outside their business, business cards, listings
on maple producers association websites, their
own business website, and Facebook. Of those
respondents who promote their business, 39% use
only one form of promotion, 20% use two forms,
14% use three forms, and the remaining 27% use
four or more forms. The mean number of
promotional approaches implemented by
respondents was 2.1, with a median of 1.0 (*n*=256;
Kuehn et al., 2016).

Factors Related to Perceptions of Climate Change

Knowledge of climate change and forests
Respondents were asked to rate their knowledge of
climate change and of forests in the northeast on a
scale of –2 (strongly disagree) to 0 (neutral) to 2
(strongly agree). For "knowledge of climate
change," the average respondent had a mean of
0.3, indicating weak agreement with statements
related to perceived knowledge of climate change
(Appendix A). The mean for "knowledge of
forests" was slightly higher (*M*=0.43; Kuehn et al.,
2016).

Beliefs concerning potential impacts from climate change
Three beliefs concerning the potential impacts of
climate change on maple production, business
operations, and maple tree health were examined.
The first, "beliefs concerning impacts on produc-
tion," had a negative and moderately strong mean
(*M*=–0.62; Appendix A), indicating that the
average respondent believes that climate change
may cause a reduction in sap production in the
future. The second belief factor concerning
impacts on business operations had a moderately
strong and negative mean of –0.7, indicating that
respondents (on average) believe that maple
producers may need to change how they operate in
the future because of climate change. The third
belief concerning impacts on maple health also had
a strong, negative mean (*M*=–0.9), suggesting that
respondents (on average) believe that climate
change will harm maple health in the future
(Kuehn et al., 2016).

Dependence of maple producers on their business
Three different factors were calculated concerning
the dependence of maple producers on their
business. The first, dependence on the income
from maple production (i.e., "income depend-
ence"), had a moderately weak mean of –0.46
(Appendix B). This result suggests that the average
respondent likely has sources of income other than
maple production. The second factor, "recreational
dependence," had a moderately high mean of 1.0;
the average respondent may rely on maple produc-
tion for getting them outdoors and for physical
exercise. The third factor, "social dependence,"
had a moderate mean of 0.46; the average respond-
ent does appear to rely on maple production to a
small extent for social reasons such as interacting
with friends and family, attending social events,
and carrying on cultural traditions. The mean for
one variable included in this social dependence
factor was high (i.e., "Maple production is impor-
tant because it is part of my heritage and/or family
traditions;" *M*=0.87), indicating a strong heritage-
based connection between the average respondent
and their production business (Kuehn et al., 2016).

Connections of maple production businesses with family, community, and business associations
Three factors were calculated concerning the con-
nections of maple production businesses (Appen-
dix C). The first, "connections between business
and family," had a mean of 0.4, suggesting that the
average respondent perceives a moderate connec-
tion between their business and family. The second
factor, "connections of business with community,"
had a moderate and negative mean of –0.6; the
average respondent does not appear to rely on their
community for organizing events, networking
opportunities, and promotions. The third factor,
"connections between business and associations,"
focused on relationships between respondents and
industry-based organizations such as maple produ-
cer associations. This factor had a moderate and
positive mean (*M*=0.4), indicating that the average
maple producer has a moderate connection with
his or her association for promotions and
networking overall. However, the variable "I
greatly depend on a maple producers association

for up-to-date information about maple produc-
tion" had a strong mean (0.85); this information-
providing aspect of associations appears to be
important to the average producer (Kuehn et al.,
2016).

Business adaptability
Four factors were related to business adaptability
(Appendix D). "Adaptability of management"
concerned the perceived willingness and ability of
respondents and their employees to plan ahead and
quickly make decisions. The mean for this factor
was 0.81, indicating that the average respondent
had a strong and positive perception of their man-
agement adaptability. The second factor, "adapta-
bility of technology," had a relatively weak mean of
0.23; the average respondent may not always have
the finances and ability to keep up-to-date with
new maple production technologies. The third
factor, "adaptability of customer base," had a
moderate mean of 0.40. Although the clientele base
of the average respondent is perceived as only
moderately diverse with regard to selling to retail,
individuals, and families (*M*=0.47), respondents
perceived the diversity of locations where
customers reside (i.e., in-state and out-of-state) as
high (*M*=0.84; Kuehn et al., 2016). The fourth
factor, "adaptability of the resource base," had a
negative and moderate mean (–0.56), suggesting
that the average maple producer does not have
back-up options in place for periods of low
production or catastrophic events affecting their
sugar bush (Kuehn et al., 2016).

Potential adaptability to climate change
This factor focused on producers' perceptions of
their business to potentially adapt to climate
change in the future with regard to labor, technol-
ogy, customer base, and resource base (i.e., sugar
bush; Appendix D). The slightly negative mean
(*M*=–0.22) suggests that the average respondent
does not perceive (at this time) that their business
will be able to easily adapt to climate change.
Adaptability of the resource base may be of
particular concern to respondents since the average
respondent most strongly disagreed (*M*=–0.49)
with the variable "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."

Path Model
A path analysis using robust techniques was con-
ducted to identify the significant ($p \leq 0.05$) relation-
ships among the factors shown in the tables in
Appendices A through D, as well as demographic
and business characteristics (Figure 3). Prior to the
path analysis, respondents missing data for any of
the independent or dependent variables were
removed from the database, leaving a sample of
n=170. Thirty-seven separate models were run
during the analysis; during each step in the process,
factors and variables that were not significant were
removed from the model.

In the first step of analysis (Figure 3), one
factor (knowledge of forests) was identified as
significantly related to perceptions of adaptability
of business to climate change (i.e., dependent
variable; $S\text{-}Bx^2$ (1)=60.043, p<.001, CFI=.337,
RMSEA=.591). In step two, relationships between
belief-related factors and the dependent variable
were added; only one belief factor was significant
(i.e., beliefs concerning the impacts of climate
change on production; $S\text{-}Bx^2$ (6)=142.167, p<.001,
CFI=.162, RMSEA=.366). In step three, factors
related to the "dependence" of the producer on
maple production for income, recreation, and
social purposes were added. Both the income
dependence and social dependence factors were
identified as significant, and model fit improved ($S\text{-}Bx^2$ (10)=18.627, p=0.045, CFI=.764, RMSEA=
.071). In step 4, the factors related to "connec-
tions" of the business to family, community, and
association were included; only connections with
the community were found to be significant ($S\text{-}Bx^2$
(21)=117.982, p<0.001, CFI=.249, RMSEA=.165).
In step 5, the "adaptability" factors were added
(Figure 4). Although the factors of adaptability of
management, technology, and resource base were
found to be significant, several factors (income
dependence, social dependence, and connections
to community) were identified as no longer signifi-
cant and were removed from the model ($S\text{-}Bx^2$
(28)=148.621, p<0.001, CFI=.519, RMSEA=.160).

Demographic and experiential characteristics
were tested for both direct relationships with the

Figure 3. Step-by-Step Process Used to Conduct the Path Analysis
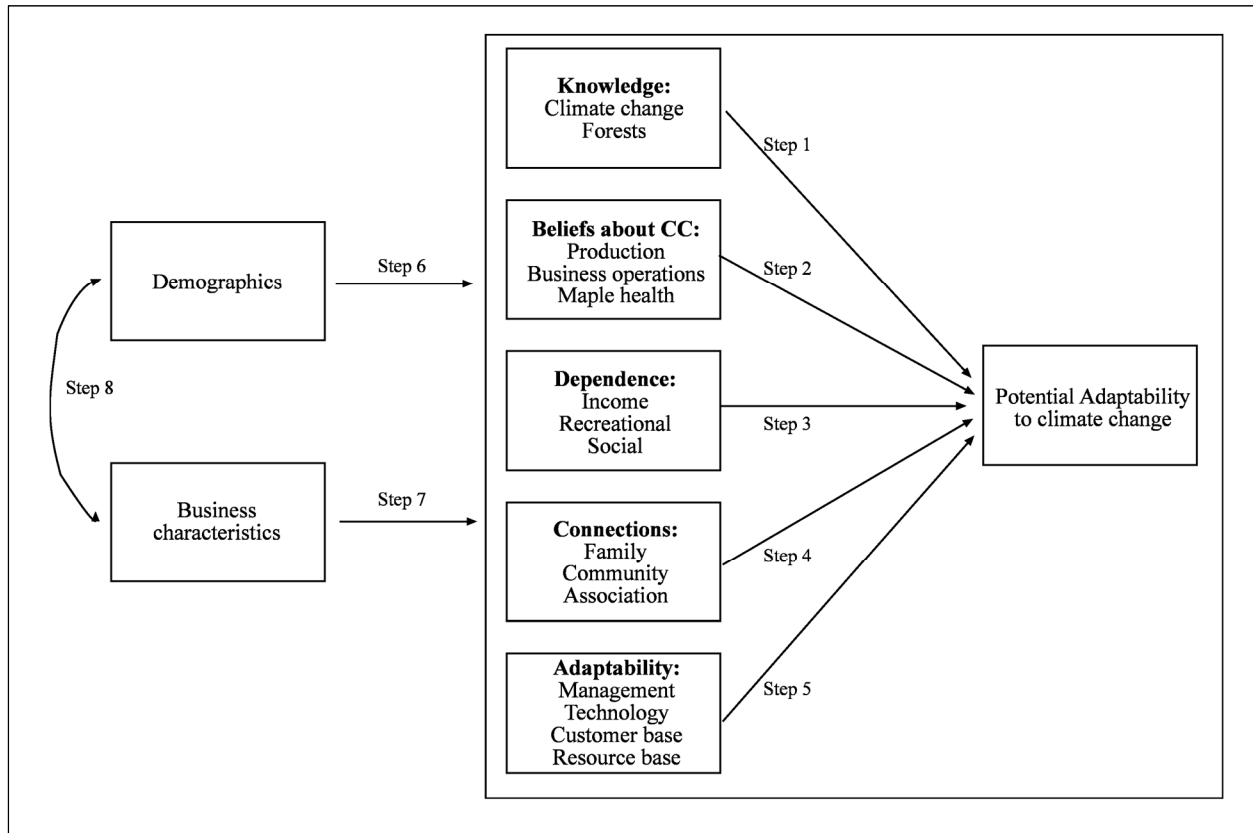
dependent variable and indirect relationships mediated by the significant factors identified in steps 1 through 5; none had significant direct relationships with perceived ability to adapt to climate change, but seven did have significant indirect relationships (i.e., education, number of children in household, diversity of services, age, income, number of taps, and diversity of marketing; $S-Bx^2$ (61)=249.449, p<0.001, CFI=.555, RMSEA=.135). Results of a LaGrange Multiplier test revealed potential relationships among the mediating factors; these relationships were added to the model ($S-Bx^2$ (58)=196.380, p<0.001, CFI=.673, RMSEA=.119). Relationships between exogenous variables were added in step 8; model fit improved significantly ($S-Bx^2$ (54)=73.369, p=0.041, CFI=.954, RMSEA=.0046). Because the Satorra-Bentler chi square results were not yet showing adequate fit, additional analyses were run to test for improvement in model fit upon removal of each exogenous variable. Model fit was shown to

improve when "income" was removed (S-Bx^2 (47)=58.676, p=.118, CFI=.970, RMSEA=.038). Although Wald test results indicated that no parameters needed to be dropped from the model, LaGrange multiplier test results indicated the existence of a significant relationship between beliefs concerning production and adaptability in technology. The addition of this relationship resulted in the final model (Figure 4; $S-Bx^2$ (46)=54.832, p=.174, CFI=.977, RMSEA=.034).

Discussion

This study employed a mixed-methods approach comprising interviews with maple producers and a mail/online survey to study the relationships affecting respondents' perceived adaptability to climate change in the maple production industry. The interviews revealed themes not previously identified in the literature, thus enabling a comprehensive examination of business adaptability for this specific industry, with general implications for

Figure 4. Path Analysis Model
Standardized parameter estimates are given above one-way arrows; correlations are given near two-way arrows.
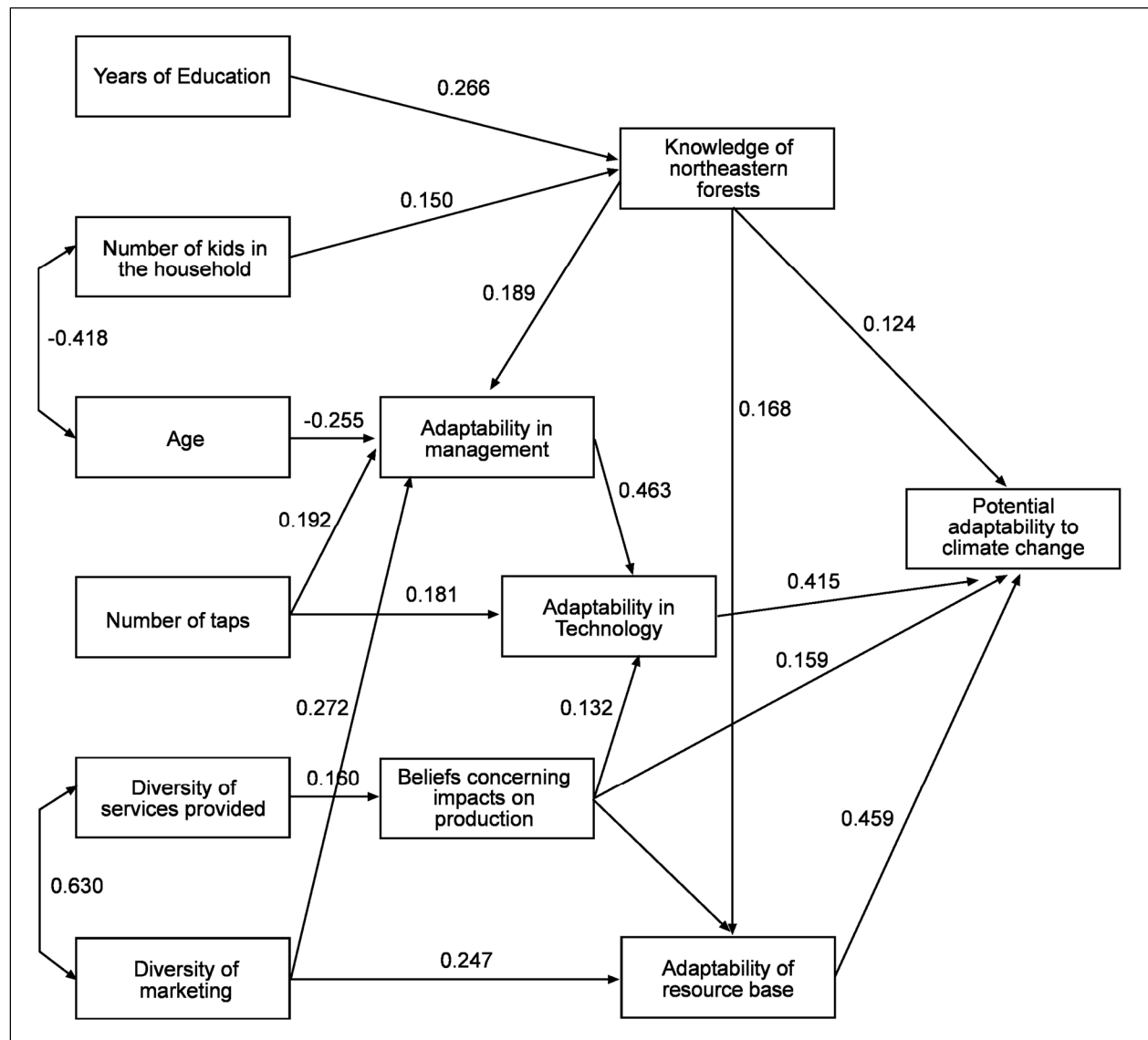
small business adaptability. Through path analysis, we were able to confirm that significant relationships in this new adaptability model do exist. Furthermore, the results provide some important concepts for maple producers and other small resource-based businesses to consider with regard to the potential impacts of climate change on their business and industry, and to other external factors that could affect productivity.

The four factors found to be directly associated with the dependent variable of "potential adaptability to climate change" are adaptability of the resource base (i.e., resiliency of the sugar bush), adaptability in technology, knowledge of northeastern forests, and beliefs concerning the impacts of climate change on production. Of these four factors, adaptability of the resource base and adaptability in technology had the strongest relationships (standardized parameter estimates=0.459 and 0.415, respectively). Based on these results, it appears that the perceptions of respondents regarding the environmental and/or economic

setting of their business can be particularly impor-
tant in their perceptions of the future viability of
their business. Furthermore, for some responding
business owners, perceptions regarding the ability
of their business to adapt to change may be greatly
influenced by their ability to obtain new technolo-
gies. Although adaptability in technology has been
identified as an important element influencing
business success by previous researchers (Peltier,
Zhao, & Schibrowsky, 2012; Tuominen et al.,
2004), adaptability of the resource base may be
unique to resource-based businesses such as those
involved in agriculture (Perks & Medway, 2012),
natural resources management, and the maple
production industry. Similarly, knowledge of the
northeastern forest and beliefs concerning maple
production are specific to the maple industry;
however, it is possible that knowledge and beliefs
specific to the business environment of other types
of businesses may affect business owner
perceptions as well.

Several of these factors found to directly influ-
ence "potential adaptability to climate change" also
served as mediating variables. Adaptability in
technology appears to be one of the most impor-
tant mediating variables in our model, as adapta-
bility in management, beliefs concerning produc-
tion, and number of taps are all directly related to
it. Furthermore, number of taps also directly
influences adaptability in management. These
results suggest that larger businesses (i.e., those
with a greater number of taps) may be able to more
easily handle management problems and afford
new technologies than smaller businesses, possibly
because of greater profit margins.

Other significant variables in the path model
include demographic characteristics, years of
education, number of children in the household,
and age. The relationship between years of educa-
tion and knowledge of northeastern forests sug-
gests that increased education levels could help
maple producers better understand the environ-
ment in which their business operates. Knowledge
of northeastern forests is also influenced by the
number of children in the household, indicating
that maple producers with children may be more
involved in learning about forests in general, per-
haps as a way of engaging their children in their

maple production business. Age seems to influence
adaptability in management; the older a respondent
was, the less likely they were to perceive them-
selves as flexible in responding to management
problems.

Diversity in services was found to influence
production beliefs, while diversity in marketing and
promotion influenced both adaptability in manage-
ment and adaptability of the resource base.
Respondents who offer diverse services and
implement diverse marketing and promotion
strategies are more likely to perceive their sugar
bush as resilient. These types of services 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 identi-
fied as a significant factor in the model, likely
because 81% of respondents offer only maple
products. It is possible that producers who do sell
a diversity of maple and non-maple products are
able to maintain a higher income during times of
low maple production. Having a diverse product
line may be particularly important in low produc-
tion years since value-added maple products can be
made using smaller amounts of syrup.

Several factors were not significant in the
model; even though they were scored highly by
respondents, these factors do not appear to
influence respondents' perceptions of potential
adaptability to climate change. First, "connections
of business with family" was not significant, even
though 92% of respondents receive assistance
from family and friends during the tapping season.
Furthermore, 18% of producers plan to pass their
business on to their children, indicating that these
family connections are important to respondents
and could influence the future of the industry. The
heritage and traditions involved in this industry
appear to be especially important to respondents,
with high averages for the variables "maple pro-
duction is in my blood" and "maple production is
important because it is part of my heritage and/or
family traditions."

Next, "connection of business with associa-
tions" was not identified as a significant influence

on potential adaptability to climate change, even though associations were identified by respondents as an important source of information. Associations are likely to remain important to maple producers in the future should impacts from climate change occur, primarily because they provide producers with up-to-date information on production technologies. In addition to associations, education programs such as the Cooperative Extension were another important source of up-to-date information for respondents.

Finally, "dependence on maple production for recreational purposes" was not identified as significant in the model, but had the highest average (M=1.00) of all factors, indicating that the recreational aspects of maple production are important to the average respondent. Similarly, the variable "maple production is important to me because of the enjoyment it provides" had the highest average (M=1.41) of all variables included on the survey. Thus, although the recreational aspect of maple production is not likely to affect a business's potential adaptability to climate change, it is likely to affect whether a business owner decides to continue with maple production.

This study has important implications for research regarding the adaptability of food systems to climate change and other stressors. Although the model shown in Figure 4 was developed specifically for maple producers in the Northern Forest Region of New York and Vermont, the constructs identified through a mixed-methods process can be adapted for research on other types of businesses. For example, the concepts of "knowledge of climate change" and "knowledge of northeastern forests" should be considered for future research in a broader light as "knowledge of business-related stressors" and "knowledge of business setting." Similarly, "adaptability of the resource base," though focused in this study on sugar-bush resiliency, could very well be relevant to other businesses, especially those related to agriculture and natural resources. The constructs of "beliefs" related to business production and operations, though operationalized according to their relevance to climate change in this study, could be refocused on different issues important to business owners. Other constructs such as "dependence,"

"connections," and "adaptability" are all important to other businesses and should be considered for inclusion in future business adaptability models as well.

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 nonrespondents, 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 New York and Vermont were included in this study; maple producers in more southerly regions, which are more likely to be affected sooner by climate change, were not included. Finally, the survey instrument did not specify a time horizon for impacts of climate change, leaving the interpretation open to respondents. Future research is needed to better understand maple producers' perceptions of adaptability to climate change over different time horizons.

Conclusion

This study sought to identify the elements facilitating and limiting the ability of maple production businesses to adapt to climate change. Specifically, the alternative hypothesis tested was that significant relationships exist among business characteristics, demographics, perceptions concerning climate change, and producers' perceptions of their ability to adapt to climate change. We found many significant relationships among the factors and variables studied, supporting the hypothesis. The two factors that seem most important to respondents when assessing adaptability to climate

change are resilience of the resource base (the sugar bush in this case) and ability to adopt new technologies. Other factors such as beliefs concerning impacts on production, adaptability in management, knowledge of northeastern forests, and size of the business (as based on the number of taps) also appear to be important influences on respondents' perceptions of their potential ability to adapt to climate change in the future. Although this study is specific to maple producers, the basic concepts included in the model can be adapted to other business types and considered for inclusion in future research on food system adaptability to climate change. These constructs include knowledge, beliefs, connectedness, and adaptability; demographic and business characteristics should be taken into account as well.

In New York and Vermont, the findings of this study are currently being used to help maple producers identify strategies for adapting to climate change. Specific strategies, such as tapping earlier in the maple season, updating sap collection technologies by installing vacuum systems, and expanding the number of taps, are being implemented or considered for future implementation by the majority of respondents. 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 optimistic about the future of maple production, with 48% wanting to increase their 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 managing to adapt to changing conditions, and they are attempting to create the foundation for a resilient maple industry into the future. This study highlights how one sector of the food system is adapting to climate change, with broad implications for adaptability of other sectors of the food system also affected by climate change.

Acknowledgements

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Appendices

Appendix A. Variable and Factor Means for Items Related to Maple Producers' Beliefs and Knowledge of Climate, Forests, and Maple Production [a]

Factor	Statement on questionnaire	Statement average	Factor Mean (Alpha)
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 (.927)
	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. [b]	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 (.930)
	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. [b]	0.27	--
Beliefs concerning impacts on production	I believe climate change will generally **increase** the amount of maple sap produced in the future.	–0.76	–0.62 (.746)
	I believe climate change will generally decrease the amount of maple sap produced in the future.	0.58 [c]	
	I believe climate change will **not affect** the amount of maple sap produced in the future.	–0.52	
Beliefs concerning impacts on business operations	**I believe that maple production businesses will need to change their operations in the future to adapt to climate change.**	0.75 [c]	–0.70 (.849)
	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 [c]	
Beliefs concerning impacts on maple health	**I believe climate change will influence where maple trees are able to thrive in the northeast in the future.**	0.76 [c]	–0.90 (.826)
	I believe climate change will make it easier for insect pests and diseases to spread through forests.	0.81 [c]	
	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 [c]	

Source: Kuehn, Chase, Sharkey, & Powers, 2016.

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

[b] This variable was removed from the factor due to the results of the confirmatory factor analysis. Although the variable was not used to calculate the factor mean, the mean of the variable is provided.

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

Appendix B. Variable and Factor Means for Items Related to the Dependence of Maple Producers on their Business[a]

Factor	Item	Variable Mean	Mean (Alpha)
Income dependence	Maple production is a primary source of income for my household.	−0.37	−0.46 (0.701)
	Maple production provides only a small proportion of my household's income.	0.36[c]	
	My household has other sources of income besides maple production.	1.40[c]	
	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.[b]	1.03	--
Recreational dependence	Maple production is important to me for the physical exercise it provides.	0.93	1.00 (.872)
	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.[b]	0.21	--
	Maple production is important to me because of the enjoyment it provides.[b]	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 (.728)
	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." [b]	1.26	--

Source: Kuehn, Chase, Sharkey, & Powers, 2016.

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

[b] This variable was removed from the factor due to the results of the confirmatory factor analysis. Although the variable was not used to calculate the factor mean, the mean of the variable is provided.

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

Appendix C. Variable and Factor Means for Items Related to the Connections of Maple Production Businesses with Family, Community, and Business Associations[a]

Factor	Item	Variable Mean	Mean (Alpha)
Connections of business with family	My family is extensively involved in the day-to-day operations of maple production.	0.36	0.40 (.929)
	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.[b]	0.12	--
Connections of business with community	My community greatly supports my business by organizing events that include and/or showcase maple producers.	−0.36	−0.60 (.880)
	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	
Connections 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 (.759)
	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	

Source: Kuehn, Chase, Sharkey, & Powers, 2016.

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

[b] This variable was removed from the factor due to the results of the confirmatory factor analysis. Although the variable was not used to calculate the factor mean, the mean of the variable is provided.

Appendix D. Variable and Factor Means for Items Related to the Adaptability of Maple Production Businesses [a]

Factor	Item	Variable Mean	Mean (Alpha)
Adaptability of management	I **plan ahead** for any major issues or concerns identified for the maple production industry.	0.57	0.81 (.756)
	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 (.864)
	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 (.711)
	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 of the resource base (i.e., sugar bush resiliency)	I have several back-up options for obtaining sap/syrup when maple production is low.	–0.49	–0.56 (.802)
	I have several back-up strategies to keep my business running if my sugar bush is damaged by storms, disease, insects, or other catastrophes.	–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 catastrophes.	–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 (.797)
	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	

Source: Kuehn, Chase, Sharkey, & Powers, 2016.
[a] The scale used for these variable statements was: –2=strongly disagree, –1=disagree, 0=neither agree nor disagree, 1=agree, 2=strongly agree.