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RESEARCH PAPER

Perceptions of Small Private Forest Owner's Vulnerability and Adaptive Capacity to Environmental Disturbances and Climate Change: Views from a Heterogeneous Population in Southern Quebec, Canada

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Abstract A study on the perception of vulnerability and adaptive capacity to climate change (CC) was realised among 27 small private forest owners (SPFOs) of a region in southern Quebec. In-depth semi-structured interviews were conducted with SPFOs of diverse profiles to better understand their perception of environmental disturbances and their needs to improve forest management in relation to global change and more precisely to CC. The main purpose of the research was to better understand whether perceptions of vulnerability and adaptive capacity to CC can constitute a barrier to proactive actions toward adaptation. Qualitative data shows a spectrum of attitudes and perceptions which highlight how SPFOs identify different potential and actual disturbances and assess the risk they represent for their forest-based activities. It shows how place-based experiences of environmental disturbances shape perceptions of vulnerability and capacity to adapt to disturbances. Factors such as access to financial resources and perceived resilience of forest ecosystem influence perceived adaptive capacity. Most SPFOs who participated in the research do not perceive their forest or forest-based activities to be vulnerable to CC, which may constitute a barrier to proactive adaptation to CC. The awareness of CC as a general phenomenon does necessarily translate into adaptation in forestry practices. Yet, many participants expressed a need for better access to

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knowledge and financial support to improve adaptive capacities to CC and broader environmental or economic stressors.

Keywords Global change · Risk perception/tolerance · Resilience · Forest-based activities · Vulnerability · Adaptation

Introduction

Scientific evidence shows that forest ecosystems will be increasingly exposed to the effects of climate change (CC) in the twenty-first century (Stocker et al. 2013). In temperate regions, the rise in mean temperatures and in the number and length of droughts, increase the stress on forest ecosystems (Allen et al. 2010; Fu et al. 2013; Lindner et al. 2010). An increase in mortality rates among many tree species has been documented in parts of North America (Van Mantgem et al. 2009). Although the local consequences of CC remain difficult to predict accurately, the trend indicates a rise in mean temperatures and climate variability as well as increase in the number and range of meteorological extreme events (Desjarlais et al. 2010; Leclerc et al. 2015). Interacting with CC, biotic changes including migration of insect pests, pathogens and invasive plants are expected to further affect forest ecosystems (McKenny et al. 2007; Dukes et al. 2009a, b). This may impact economic activities, aesthetic characteristics and provision of ecological services (Anderegg et al. 2013).

With 761,100 km^2 of forested lands in Quebec (45% of total land), the forestry sector plays a crucial economic role in many communities, while providing essential ecosystem services. However, the way these communities will be affected by CC and other environmental disturbances varies greatly according to regions and sub-sectors (Johnston and Williamson 2007; Le Goff and Bergeron 2014). For most small private forest owners (SPFOs), the small scale of their operations and low intensity of their practices influence their level of vulnerability, or their susceptibility to be adversely impacted by environmental disturbances. For instance, SPFOs' access to financial resources and technologies, which can significantly reduce their vulnerability to environmental stressors, differs widely (Grotta et al. 2012). For forests under public tenure, an action plan has been developed by the Ministry of Sustainable Development and Environment to mainstream adaptation to CC in forest management (MDDEP 2012). However, there is no action plan for small private forest owners (SPFO) of southern Quebec, who manage 16% of productive forests, and face conditions that differ from those of large-scale industrials (Fédération des producteurs forestiers du Québec 2013). Moreover, SPFOs form a heterogeneous population with a broad range of values, which influence attitudes towards environmental risks, including CC (Eriksson 2014; Côté et al. 2015).

Efforts have been made to better understand the perception of CC in forest communities of Canada (Davidson et al. 2003; Williamson et al. 2005, 2009; Spittlehouse and Stewart 2003). Manifestations of CC are often location- and community-specific, and decisions regarding environmental risks are largely made

at the local scale by individual SPFOs (Keskitalo 2008). SPFOs being the main actors of forest management in southern Quebec, further research is required to better understand their perceptions and responses to CC. Despite the sustained interest of policy makers for the small-scale forestry sector, knowledge gaps persist, especially regarding SPFOs' perception of vulnerability and adaptive capacity to CC and other global environmental changes. In fact, how SPFOs integrate knowledge on CC in forest management may be determinant in shaping their capacity to respond to environmental disturbances and avoid or mitigate impacts, what we refer to as adaptive capacity (Grotta et al. 2012). A better understanding of SPFOs' experience of disturbances and risk perception is important to identify possible knowledge transfers and improve policy responses (Füssel and Klein 2006). In this regard, this study addresses how SPFOs perceive adaptive capacities to environmental disturbances and CC in relation with past experiences in forest management.

The question addressed in this study is: Are SPFOs' perceptions of vulnerability and adaptive capacity to CC a barrier to proactive actions toward adaptation? To address this question, we attend to individual perceptions of adaptive capacity to CC and global change as influenced by local immediate and contextual frame of reference of each SPFO. More specifically, the objectives are: (1) to address perceptions of vulnerability and adaptive capacity as they are framed through risk assessment for forest ecosystems and forest based activities. Therefore, we attend to the way in which SPFOs appraise risk regarding environmental disturbances, including direct and indirect effect of CC and global change. (2) We investigate past experiences of forest disturbances and how they shape perceptions of vulnerability and adaptive capacities to CC; and (3) address perceptions of barriers to adapt to CC and global change and improve forest management.

Conceptual Framework

This study contributes to the vulnerability and adaptation approach to the human dimensions of CC (i.e. Füssel 2007). Our conceptual framework provides a review of vulnerability and adaptive capacity as framed by individual perceptions of SPFOs. We attend to these perceptions through the appraisal of risk in experiential knowledge—direct experience—of forest disturbances. We then turn to the relation between SPFOs' perceptions in relation with barriers to adaptation. Therefore, we focus more broadly on approaches which analyse individual and community perceptions in the face of CC (i.e. Grothmann and Pratt 2005; Wolf and Moser 2011; Granderson 2014).

Vulnerability and Adaptation

We define vulnerability as "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change […] it is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity." This definition is intended for

either socioeconomic and ecological systems, or socioecological systems (Ostrom 2009). In this perspective, vulnerability to climate change is determined, not only by exposure to environmental hazards, but by resource availability and their accessibility by individuals and groups (Kelly and Adger 2000; Turner et al. 2003; Gallopín 2006).

Furthermore, adaptation is defined as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2007). While adaptive capacity is "The ability of a system to adjust to climate change to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (IPCC 2007). Other definitions insist that high adaptive capacity, minimizes vulnerability of individuals or communities (Smit and Skinner 2002; Smith and Wandel 2006; Keskitalo 2008). Vulnerability and adaptive capacity are closely linked, so if the latter is enhanced, the former is reduced. Yet a conceptual distinction remains as vulnerability mainly refers to exposure to hazard, while adaptive capacity is about means of action (Brooks and Adger 2004).

Perceptions of Vulnerability and Adaptive Capacity

Studies on adaptation have been assessing the capacity of groups, individuals and ecological systems to adapt to CC by looking at forest ecosystem resilience—along with socioeconomic and biophysical factors which render adaptation possible (Lindner et al. 2010). However, in the context of CC, given the localised experience of impacts, perceptions of vulnerability and adaptive capacity may be different from actual ones (Brody et al. 2008). Moreover, perceptions influence the willingness and capacity to undertake adaptive actions (Adger et al. 2009).

Perceptions underlying decision making regarding CC are key to better understand the actions and attitudes of SPFOs in forest management. Studies on CC in other contexts demonstrated how perceptions, not only as a cognitive process, but as affect, negative or positive feelings about object or ideas, may prove key to understand attitudes and responses to CC action (Leiserowitz 2006). As Grothmann and Patt (2005, 202) assert: "the objective ability or capacity of a human actor (…) only partly determines if an adaptive response is taken". In other words, the subjective or perceived ability of human actors, mediated through affect and feelings, is at least as important as the objective ability. In the model proposed by Grothmann and Patt (2005), the interplay between perceived adaptive capacity and objective adaptive capacity is key to understanding actual responses to expected environmental change related to CC.

Risk Perception: Appraisal and Response

Because trees are long-lived organisms exposed to hazards throughout their development, forestry involves risks which can be related to CC or not. Risk defined as "probability times magnitude of a hazard" can influence adaptive responses and vulnerability (Blennow and Sallnäs 2002, 472). Most SPFOs perform risk appraisals which include the likelihood of being affected and the severity of the threat (Birot

and Gollier 2001). Based on risk appraisal, SPFOs deploy a range of adaptive responses to stressors that can be proactive or reactive to hazards that already occurred (Reser and Swim 2011).

Responses to perceived risks can manifest in different forms, as a cognitive process through which perception is altered, or as a behavioural process that involves actions (Eriksson 2014, 485). More importantly, responses to perceived risks are not always analytical or rational, but also experiential as they manifest intuitively through feelings (Slovic et al. 2004; Viscusi and Zeckhauser 2006). Risk appraisals may be biased, overly optimistic, or unrealistic, especially in the context of high levels of uncertainty as it is the case with CC (Costa-Font et al. 2009). Knowledge and beliefs influence risk perception in forestry, these perceptions are contextual and change with factors such as age, main occupation, forest composition and level of economic dependence to forest resources (Lönnstedt and Svensson 2000).

Experiential Knowledge

A number of studies emphasise that perceptions of vulnerability and adaptive capacity along with actual willingness of SPFOs to engage in proactive adaptation measures are shaped primarily by direct experiences of forest disturbances associated with climate change. In this regard, a survey by Blennow et al. (2012) among forest owners in Europe demonstrates that factors determining adaptive capacity are (1) the belief in the existence of CC locally, and (2) previous observations of their effects. Beliefs, experiences and interpretations would have more influence than socioeconomic or political factors in explaining behavioural differences towards CC among SPFOs in Europe (Blennow and Sallnäs 2002; Blennow and Persson 2009; Blennow et al. 2012). This confirms the importance of experiential and contextual knowledge in shaping SPFO's attitudes and responses to CC. As stated by Adger et al. (2009, 346), "historic and current adaptation is and continues to be informed by perceptions and local knowledge based on previous experience of weather and climate."

For SPFOs, the meaning of information on CC impacts or environmental disturbances would be understood through localized experience, as meaning is grounded in a sense of place. In the field of small-scale forestry, risk perception largely rests on place-based experiences of biophysical conditions and environmental stressors, which is often key in forest management. Moreover, stakeholders tend to rely on ways of knowing that are particularistic and draw on personal experiences and specific place features (Cheng and Daniels 2003). These experiences, embedded in a sociocultural and ecological context, shape to a large extent perceived control of actual and future environmental hazards (McGee et al. 2009; Adger 2010; Eriksson 2014). As such, the study of Grotta et al. (2012, 6) shows that "information sources that reflect an individual's cultural context or sense of place are influential in shaping perceptions of CC." Moreover, SPFOs' perceptions are largely tied to their relationship with a particular landscape or forest ecosystem (Grotta et al. 2012). This body of literature clearly shows the limits of scientific knowledge on CC in forestry, and point toward more nuanced and place specific perceptions of vulnerability and adaptive capacity to CC effects (i.e. Engle 2011).

Barriers to Adaptation

SPFO's adaptation to CC remains constrained by numerous factors, and depend on socioecological relations in which small-scale forestry takes place (Genin et al. 2013). This is often referred to as barriers to adaptation in the literature on CC adaptation (Moser and Ekstrom 2010). A growing field is now concerned with barriers which constrain effective adaptation and it increasingly takes into account the challenges of understanding actors' perceptions and non-causal relationships in adaptation variables (Adger 2001; Adger et al. 2003; Folke 2006; Biesbroek et al. 2015). Adger et al. (2009) have argued that values and context-specific objectives, which are closely related to perceptions, can constitute barriers to adaptation. Whether certain hazards related to CC or not are perceived as a risk which require effective adaptation largely depends on cultural values (Leiserowitz 2006).

Barriers can appear at all phases of adaptation processes and are related to spatial and temporal frameworks. Beyond forestry, many studies have documented the barriers preventing more engagement from the general public in actions to mitigate or adapt to CC. The barriers most commonly cited are part of three categories: cognitive, affective and behavioural (Lorenzoni et al. 2007). In fact, some studies have found that general awareness about CC in the U.S. for example, does not allow adequate grasp of causes, consequences and solutions to CC, which prevents behavioural transformation (Kempton 1997). Moreover, "any limits to adaptation depend on the goals of adaptation, which are themselves dependent on diverse values" (Adger et al. 2009, 338). In this regard, goals of adaptation vary widely and are subject to change, while some measures can prove maladaptive in a certain spatial–temporal scale. Many informational, financial, and institutional barriers can prevent effective adaptation (Charnley et al. 2010; Moser and Ekstrom 2010). Adaptation in forestry is a dynamic and ongoing socioecological process that rests on some level of collective action, which depends also on perceived need and capacity to engage in such actions. Therefore, adaptive solution must be acceptable and feasible within a given society to minimize barriers (Adger et al. 2003).

Study Area

Small private forest owners (SPFOs) number 130,000 in southern Quebec, and control 16% of the province's productive forests, or 7 million hectares (Côté et al. 2015). Because these lands are located in the southern part of Quebec, mainly at low elevations near densely populated areas, they sustain important economic activities while providing essential ecosystem services (Dupras et al. 2015a; Dupras and Alam 2015). Since the 1970s, many exhaustive surveys have documented forest owners' profile and activities, the most recent was released in 2012 (Côté et al. 2015). The surveys conducted by Côté et al. (2015, 2016) show that the increase prevalence of some sociological characteristics among SPFOs—aging population increasingly living off the forest site—correlate with the decreasing rate or harvesting and forest management activities.

The present study was conducted in Montérégie, an administrative region located in southern Quebec (Fig. 1). For this region, CC models predict for the period 2041–2070

compared with 1971–2000, warmer mean temperatures and increased occurrence of extreme events such as heavy rainfalls, droughts, gusts of wind and hailstorms (DesJarlais et al. 2010; Michaud et al. 2012). Forest ecosystems are dominated by temperate deciduous forest and are among the most biodiverse and productive in Quebec (Meilleur et al. 1994; Doyon et al. 1998). Studies using historical documents have shown that the forest in West Montérégie have been highly transformed by land-use changes and past forest practices during the last two centuries (Bouchard et al. 1989a, b; Simard and Bouchard 1996; Pan et al. 1999; Domon and Bouchard 2007). Transformations such as agriculture and maple tapping, had a tremendous impact on the natural resources of the region and on landscape structure (Bouchard and Domon 1997a, b; Brisson and Bouchard 2003; Provost et al. 2006; Schmucki et al. 2002; Kandyba et al. 2011).

The region under study partly falls within the Metropolitan area of Montreal, and is particularly exposed to the combined effects of urban sprawl, intensive agriculture and invasive species (Dupras et al. 2015b). Consequently, the forest is highly fragmented, covering 26% of a landscape dominated by agricultural lands (Brisson et al. 1988; Meilleur et al. 1994; Doyon et al. 1998). As a result, CC effects would add to the high level of fragmentation and degradation and would increase the stress on forest ecosystems (Gagné and Gravel 2010, xxxii).

In Montérégie, according to Quebec official figures, 10500 SPFOs owning tracts over 4 ha control nearly all forest resources (AFM cited by Goulet et al. 2013, 18). Most data gathered in this study derives from interviews conducted more precisely in West Montérégie, in the Regional County Municipalities (*Municipalité régionale de comté*—MRC) of Vaudreuil-Soulanges and Haut-Saint-Laurent. These two MRCs harbour a population of 2800 SPFOs among which a majority is not actively involved in commercial forestry activities (Côté et al. 2016; Goulet et al. 2013). A large share of SPFOs in the region are maple syrup producers, more than a third of forest resources are allocated to this activity (MAPAQ 2012).

In the past 5 years, in the region of Montérégie as a whole, 48% of SPFOs have benefited from the regional program that provides technical and financial support for forestry work (Goulet et al. 2013, 28). Under this program, forest management plans are provided to woodlot owners by the Montérégie Forest Agency, a regional subsidiary responsible of administering the provincial program (Agence forestière de la Montérégie 2015). The prescriptions realized by accredited forestry professionals as part of management plans detail the works to be done over a period of 5 years. If the SPFO completes the prescription within the time allowed, the program refunds 80% of technical and execution costs of forestry works recognised by the agency (Agence forestière de Montérégie 2015).

Methodology

Methods and Analysis

To address whether perceptions of vulnerability and adaptive capacity to CC represent a barrier to proactive actions toward adaptation for SPFOs, we have relied

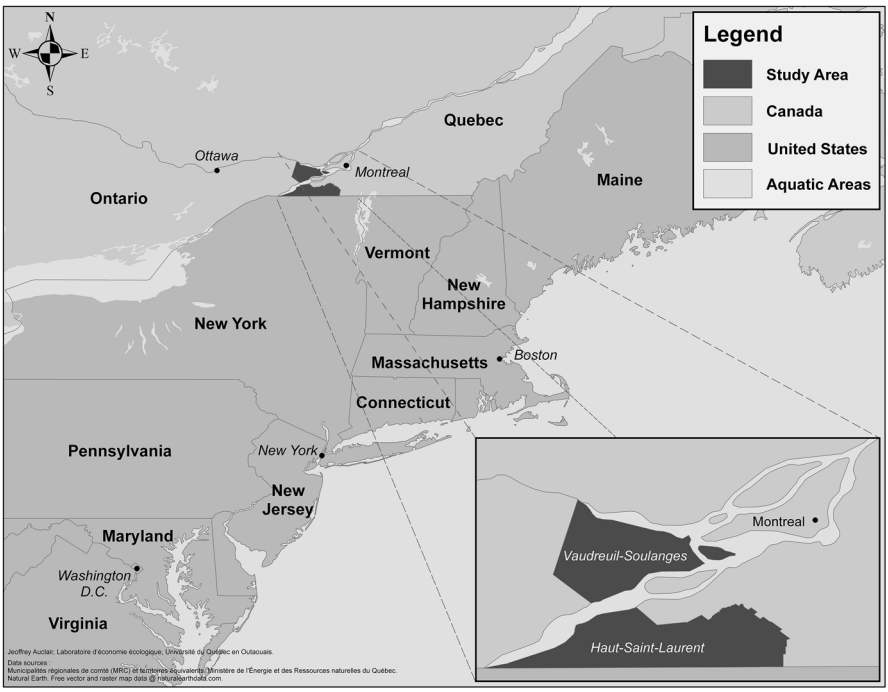

Fig. 1 Location of the study area, West-Montérégie, Quebec

on qualitative methods. The main method used for data acquisition was individual face-to-face interviewing in both French and English according to the main language spoken by participants. Interviews with SPFOs were based on a short questionnaire and a set of open-ended questions. The method of in-depth semi-structured interview based on open-ended questions was considered the most relevant to perform an exploratory research based on inductive analysis of perceptions unique to each SPFO (Bliss and Martin 1989; Creswell 2013). Semi-structured interviews were used to understand a range of risk perceptions based on the experiences, knowledge, and frame of reference of individual participants (Smith 2000). Moreover, the researchers asked probing questions during interviews to go further in-depth and capture perceptions in relation with specific characteristics of SPFOs, such as their main forest-based activities or type of management. Most questions allowed for free spontaneous responses and the development of a conversation around the themes identified (Patton 2002). Participant observation on forest sites with their owners was also used to complement data gathering. Participant observation is part of methods of encounter and engagement with research participants to further understand lived experience and the meanings associated with private forests (Smith 2000). Data gathered from participant observation increases the level of comfort between researcher and participant, and allows participants to exemplify certain statements (Musante and DeWalt 2010, 41–47), although it is not analysed per se in this study.

To operationalise the research question raised, we examined SPFO responses in forest management in relation to actual or potential environmental disturbances. Interviews attended to general perceptions on vulnerability and adaptive capacity to actual or potential threats, with a focus on CC and global change. To analyse whether perceptions constitute a barrier to proactive adaptation, our study looks at narratives of past experiences, and expression of future actions. The questionnaire and set of open-ended questions used for the research was partly based on the material developed to assess the vulnerabilities and adaptive capacities to CC in the forestry sector (Doyon et al. 2012). The questionnaire included closed questions which allowed gathering background information on SPFO profile, forest utilisation and management practices. The set of open-ended questions meant to stimulate conversation around two main themes: (1) experiences of forest disturbances and perception of vulnerability and adaptive capacity as SPFO; and (2) perception of adaptive capacity to CC and its direct and indirect effects, along with barriers to adaptation. The focus on CC in open-ended questions had heuristic value, designed as an approach for learning and reflecting, for it allowed SPFOs to express themselves in relation to a high-profile global phenomenon with long-term impacts and high level uncertainty (Leiserowitz 2006; Tschakert and Dietrich 2010).

Participants in the research were selected according to their availability and willingness to take part in the study within a specific population, which amounts to purposeful sampling (Patton 2005). The strategy used to select the 27 SPFOs who participated in the research was the following. All participants in the study were part of a population of 900 SPFOs of West Montérégie registered as forest owners with the Ministry of Agriculture, Fisheries and Food of Quebec (*Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec*—MAPAQ). These 900 SPFOs had previously been contacted by the MAPAQ in the name of a local organization to attend a meeting on the creation of a forestry cooperative. Those who attended the meeting were invited to provide their contact details for further communication by the local organization. Having established a long-term partnership with this organization, we were granted access to the contact details provided by 55 SPFOs who attended the meeting. We then contacted all 55 SPFOs by phone and managed to set appointments with 24 who agreed to participate in the study. Remaining participants were selected through snowball sampling method as some SPFOs met were then requested to provide the name of another SPFO whom they knew, often in the area where they lived (Patton 2002).

Interviews were carried out during the months of May and June 2015. Interviews lasted from 30 min to over 2 h, for a total of 30 h of recorded material, on average 67 min each. The interviews were recorded while the researcher was taking notes to keep track of the discussion and follow the themes that had been addressed. Further notes were taken about participant observation and the discussions that were not recorded. All interviews were transcribed as verbatim.

The type of content analysis used corresponds to what Hsieh and Shannon (2005) call directed content analysis, as we used categories derived from the conceptual framework for data coding, while allowing for the emergence of new codes to provide further nuance. Saldaña (2015, 3) defines a code in qualitative research as a word or short sentence which refers to an important feature summing up a portion of

text. It is a construction generated by the researcher which attributes a meaning to data (sentence, paragraph, etc.) so that it can be used to identify patterns and create categories or other analytical processes (*Ibid.*). To do the hand coding, we listened to the recordings of 10 interviews selected randomly and read the verbatim in a process called open coding (Esterberg 2002). The coding allowed to organize the data in order to better understand the important themes according to the research question and objectives. The rest of interview data was coded according to the codes (themes) previously identified. This has allowed to organize all 25 codes into the three main themes related to the conceptual framework to understand perception of vulnerability and adaptive capacity: (1) risk perceptions regarding forest and forest related activities as they shed light on 1.1) perception of vulnerability, and 1.2) adaptive capacity, (2) experiences of environmental disturbances and (3) perceptions of barriers to adaptation. To refer to interview data, each respondent was assigned a random number, i.e. Respondent, R.1–R.27.

The methodology chosen has limitations such as the way in which participants were selected from a specific group of people willing to engage in forestry activities. Moreover, as participants were only met once, their responses have been expressed during a limited time period, and this has lessened the level of engagement and trust between participant and researchers. Also, the participants who accepted to meet with the researchers at the time of the study had schedules that allowed them to do so. Most participants expressed an interest in forestry research, which may have introduced a bias in the participant sampling.

Description of Respondents' Profile

A majority of SPFOs who participated in the research (74%) are over 54 years old, a proportion somewhat similar to the SPFO population in Quebec (65%) (Côté et al. 2012). More than half of SPFOs interviewed (55%), had owned their forest land for over 20 years at the moment of interview. A majority of respondents (78%) have their main residence within a 1 km radius from their forest. For nearly half (48%) of them, the main occupation is agriculture, while others are mainly involved in the service sector as blue/white collar, or retired. The size of forest woodlot of respondents range from 4 to 410 ha, with a majority (86%) of SPFOs owning tracts smaller than 100 ha. According to forest areas declared by respondents, the median size of forest owned is 25 ha (Table 1).

Most respondents describe that the primary function of their forest is recreational activities or leisure (48%). A share of respondents (15%) consider that the primary function of their forest is conservation, before recreational activities. The majority of respondents declare not deriving any income from their forest, besides the benefits related to fuelwood access. Only about 19% of SPFOs declared deriving more than 25% of their income from forest-based activities, mainly from maple syrup production. Nevertheless, for 26% of them, forest-based activities represent 5–15% of their total revenues.

A majority of respondents (59%) have a valid forest management plan which grants them access to the financial assistance program for forestry activities. However, whether they participate in the program or not, the vast majority of

Table 1 Comparison of respondent SPFOs' characteristics with Quebec SPFOs (2012) *Source* Côté et al. (2012)

	Age > 54 (%)	Period of ownership > 20 years (%)
Mean respondents	74	55
Quebec SPFOs	65	51
	Distance between main residence and forest <1 km (%)	Agriculture as main occupation (%)
Mean Respondents	78	48
Quebec SPFOs	50	15
	SPFOs with a management plan under the provincial program (%)	
Mean Respondents	59	
Quebec SPFOs	55	
	Distribution of SPFOs according to size of forest land (%)	
	Montérégie respondents (%)	Quebec SPFOs (%)
4–20 ha	30	30
21–40 ha	26	22
41–100 ha	30	28
Over 100 ha	11	14
	Income derived from forest-based activities (%)	
	Montérégie respondents (%)	Quebec SPFOs (%)
0–25%	75	95
26–50%	15	3
51–75%	0	1
76–100%	4	1

respondents (96%) perform some form of management activities in their forest. Most engage in thinning practices on some areas, usually to harvest unhealthy or dead trees for firewood. The same proportion also reported maintaining forest trails for economic or leisure activities. In this regard, the main activity of respondents, practiced by 85%, is timber harvesting for firewood.

Different silvicultural practices can be inferred from the qualitative data gathered. A first type of practices would be related to stand management for timber production, performed with variable degrees of intensity by 48% of respondents. It would include silvicultural treatments for speeding up succession processes by cutting down pioneer species such as white poplar (*Populus tremuloides*) or paper birch (*Betula papyrifera*) as well as general thinning practices and selection cutting of different hardwood species. The second type of practices reported concerns maple syrup production, which is practiced on part of SPFO's land or a portion of it, by 30% of respondents. This type of management involves intensive selective

logging and thinning to create optimal conditions for the development of sugar maple (*Acer saccharum*) or to a lesser extent, red maple (*Acer rubrum*). The third type, practiced by 26% of respondents, involves planting trees on idle pastures or degraded habitat for restoring forest ecosystems and reinitiating forest production. The last type of management practiced by 19% of respondents is performed to enhance wildlife habitat. This type of management depends on the species privileged for hunting and/or conservation purposes. Only one respondent declared not practicing any type of these management practices.

Results and Discussion

Risk Perception

A broad range of risks were identified by participating SPFOs, according to probability and magnitude of a disturbance, as well as its consequences for forest uses. More importantly, risks were identified were not always in relation with climate change, although climate change may have been discussed in relation to a specific risk. Risk assessment is based on both past experiences and considerations of knowledge acquired from different sources. The most cited risk was insect pests and pathogens, which are risks concerning specific tree species. This was followed by the effects of temperature variations and rainfall patterns (Fig. 2). However, for insect pests, during interviews, the main researchers did not make any explicit relationship to CC, which some respondents did as they discussed these issues, some wondering about the existence of such link.

Many insect pests were perceived as risks. The Emerald ash borer (*Agrilus planipennis*), a beetle which causes the death of ash trees, affects Montérégie SPFOs, as the region falls within the natural range for three ash species (*Fraxinus americana, F. nigra, F. pensylvanica*). This risk was minimized by many

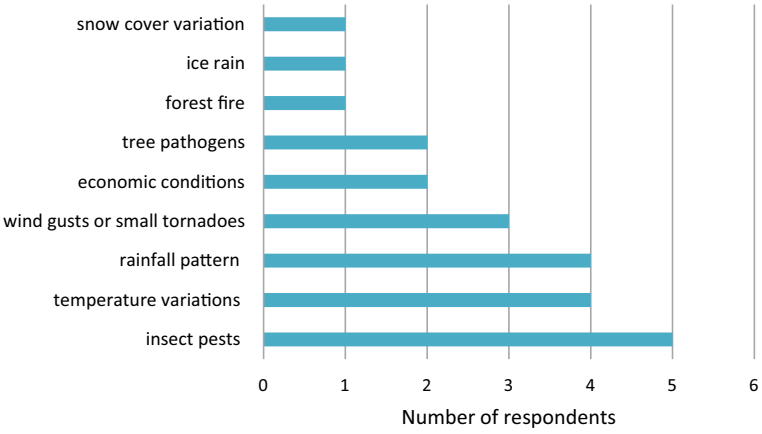

Fig. 2 Main forest disturbances mentioned by respondents

respondents given the limited importance of ash tree species in their forest, however it was magnified by those for whom it covers a significant share of forest. Some considered it to be an important loss in the landscape, and as economic asset, for it is a hardwood widely used in furniture and flooring (Respondent 22, R.23). However, most envisioned that the probability to lose the majority of ash trees over the medium term. The Asian longhorn beetle (*Anoplophora glabripennis*), although it has not been reported in the region so far, was cited as potentially the most acute threat to the suger maple (*Acer saccharum*) (R.3, R.16). This was considered a serious potential disturbance for maple syrup producers, and many mentioned following the situation closely. However, this risk was minimized as Montérégie remains outside the geographical range of the insect, although the magnitude of such hazard could be considerable.

Many tree pathogens were mentioned as actual or potential risks to forests and related economic activities. Most notably, the Dutch elm disease and the beech bark disease affect respectively the American elm (*Ulmus americana*) and North American beech (*Fagus grandifolia*). These tree diseases are now well known in some areas of Montérégie. Although the threat posed by these pathogens is considered less acute than pest insects, SPFOs met mentioned having observed high mortality rates among affected species (R.22). Longer established SPFOs were able to observe that for instance Dutch elm disease would affect Elm trees only periodically. The probability for forests to be affected and the magnitude of hazard was considered particularly acute for those mainly composed of species affected by both insect and pathogens pests. The combined impact of insect and disease poses serious risks for some forest ecosystems. As exemplified in the following quote from a middle age male resident whose main activity is farming, SPFOs deploy important grounded knowledge to identify risks and assess their magnitude of disturbance in order to determine management:

> *R.21* We had about 15–20% Elm tree, but we cut down most of them. There are two stages: if it survives over 4–6 inches in diameter, it will make it to 12 inches, otherwise they die and dry up quickly… Elm trees do not grow over 14 inches (in diameter), after that they start declining, we know they're going to die, so we harvest them before that…
> *Researcher* And you said there was also some Ash tree?
> *R.21* About 40–50%, and we'll lose it all… so we might be losing most of our trees on that parcel. There will only be a 15% of Red Maple left… Luckily we have another parcel where there's a bit of everything…

Other potential disturbances related to climate variability include temperature and rainfall pattern variations which have occurred over the last 20 years. This manifested through important drought that affected tree planting, when all new planted coniferous perished (R.5). It also manifested through ice rain, heavy wet snow which can break resinous tree branches, or intense and sudden freeze–thaw cycles during the winter which can cause damage to sugar maple bark (R.19; R.20; R.22). Moreover, variations in snow cover was mentioned as a potential disturbance, lack of snow in case of sudden freeze can also damage tree roots (R.23). Wind gusts or small tornadoes have also been mentioned, along with forest

fires (R.9, R.20). According to SPFOs, the risks posed by these disturbances are minimized by their limited frequency or their probability of occurrence. These potential disturbances appear localised in space and time, or concern specific species, which limits their gravity (Weber 2006). Even for insect pests, the main risk identified, their magnitude and importance are relativized due to the limited economic importance of the trees affected for SPFOs, and due to the relatively limited spread of those trees, in most forests. Those who depend most on the forest economically, among which many maple grove owners (26% of respondents), minimize the risk of occurrence of major disturbances which would disrupt their activities.

Perceptions of Vulnerability

Perceptions of vulnerability, which is the degree of susceptibility to particular adverse effects of CC or other disturbances, were analysed through concrete disturbance and long-term change. Moreover, data shows that SPFOs have a broad range of reactions to environmental stressors, but that they perceive their level of vulnerability to be generally low. When SPFOs were asked about the issue of CC and global change, the level of preoccupation was irregular. More importantly, CC remains seen as an abstract phenomenon that does not provide one significant experience of reference such as specific disturbances like the ice rain of 1998 or a major wind gust. Most agreed that CC induced by anthropogenic activities exist, and it is probably irreversible, but that it does not increase the vulnerability of their forest or forest-based activities. A majority of respondents (74%) consider risks posed by this phenomenon for forest ecosystems on the short or medium-term as nonexistent or limited. However, the perceptions of SPFOs are nuanced and change according to spatial and temporal scales. In this regard, most respondents distinguished between CC as a general phenomenon and CC effects as a phenomenon which increase their degree of vulnerability of their private forest's ecosystems. As such, a respondent stated: "for my social conscience, CC is urgent, but for my forest, it's not obvious" (R.25). In this regard, a large majority (85%) considers to be well or very well informed about CC, and an even greater proportion (89%) thinks that information on the topic is accessible or very accessible in the media or in specialised forestry documents.

Regarding vulnerability to CC, general attitudes towards CC range from scepticism to firm belief in the observation its effects. A significant part of respondents (59%) mentions being able to perceive some effects of anthropogenic CC. Perceived manifestations were highlighted, such as the increase in extreme events, rapid temperature variations, windier conditions, warmer annual temperature means, as well as change in rainfall patterns, characterised mainly by more heavy rains throughout the summer. However, these specific events were not perceived as increasing their level of vulnerability, regardless of their adaptive capacity. In this group, the apprehension of most concern long-term impacts of CC. However, an important share of respondents also doubted the capacity of human societies to evaluate the evolution of climate (R.9, R.11, R.14, R.20, R.24, R.27). For some, the issue of CC in forest management comes down to a general attitude regarding

uncertainties and management of fears and anxieties, as expressed by this SPFO, middle age man working in the tertiary sector:

> *R.14* I analyse that, when I cut a tree, I look at growth rings, some years they are close together, other years they are far apart, there have always been good years and bad years, it's not over, we'll have bad years and good years again. Listen, I don't know if you're aware, why this year is there so much caterpillar on some trees? Some are already dead, I've never seen so many caterpillars.
> *Researcher* Is that a threat for your activities?
> *R.14* A threat? We talk about emerald ash borer, climate change and this and that…there's a lot of tree species…some will survive, so…Am I afraid? The youngest continent has 65 M years, we live less than a 100 years…

As expressed in the previous citation, many respondents picture CC effects on a larger time frame, in part to minimize its impacts and their vulnerability. Moreover, many referred to their age during the interview to minimize the potential ecosystem changes they will have to face and adapt to. Some, insisting on their relatively advanced age, were of the opinion that CC, as presented by the media, was a long-term transformation, which main effects were not of their concern, even if they were able to identify some of its effects (R.20, R.27). Moreover, some suspected that mainstream information on the topic was not reliable. As we addressed this topic during the interview, many reasserted the value of their own experience in forest management (R.9).

Overall, regardless of their attitude toward CC, when they are questioned about potential impacts of CC on their forest, in the short and medium-term, most SPFOs (80%) foresee very little or none, and do not express any sense of vulnerability. On the contrary, 15% of SPFOs perceive higher mean temperatures as a positive change which is favourable to tree growth. Many maple syrup producers have mentioned an upward trend in yields since the past years, which they attribute to better forest management and warmer temperatures (R.3, R.16). Aware that maple syrup yields are higher in the United States, where the heat index is higher than in Quebec, these SPFOs welcome warmer temperatures. They also insist on the importance of new techniques due to which yields can be at least maintained from year to year, if not improved. The perceptions regarding vulnerability related by CC effects may constitute a barrier to proactive adaptation and means that SPFOs will rather react to future disturbances.

The degree of perceived vulnerability and capacity to respond or adapt to important environmental disturbances varies according to the level of economic dependence on forest and the resources available in terms of knowledge, economic or money. Many statements suggest that SPFOs perceive their level of vulnerability to major environmental disturbance is relatively limited, as the resilience of both forest ecosystem and adaptive capacity economic activities would be high. Perceived forest resilience which minimize SPFO vulnerability is confirmed by the narratives regarding droughts, or invasive caterpillars (R.12, R.13, 15, 25). However, others mentioned that some particular disturbances have had lasting impacts and that they lack the means or will to intensify management practices to respond to the impact of the ice rain or a wind gust (R.9, R.24). Perceived forest

resilience allows some SPFOs to downplay the consequences of some disturbances for the forest and for forest-based activities (R.3, R.5). Most SPFOs express having the capacity to cope with environmental disturbances, whether on their own or with different forms of support.

Perceptions of Adaptive Capacity

During the interviews, adaptive capacity was mainly perceived in relation to past experiences which also informed projections in the future, which may include information on CC. As it was expressed retrospectively, adaptation is largely represented by SPFOs as a long-term objective which is intertwined with management objectives for short or medium-term goals. Adaptive capacities are shaped as proactive or reactive actions. As data suggests, SPFOs deploy adaptive measures when they can clearly identify aspects of forest management or forest related activities requiring improvement. They also deploy experiential knowledge or new technologies to better adapt to extreme events and climate variability as lived experience, instead of responding to more abstract principals such as CC previsions. However, the data presented does not allow to identify whether those practices were intentionally deployed as forms of adaptation to CC or global change, or simply to improve forest based production and management.

Both to improve their economic performance and limit their vulnerability to climate variability, which is not necessarily perceived as an effect of CC, a majority of SPFOs involved in maple syrup production had adopted new technologies. Through conversation with the researcher, they came to see those practices as forms of adaptation.

Maple syrup producers assert that technologies currently used significantly improve maple syrup yields and minimize the impact of climate variations, as maple syrup production is dependent on specific patterns of weather conditions in the spring, namely freeze–thaw cycles over 24 h. One SPFO involved in this industry said: "low production years don't exist anymore thanks to the new equipment" (R 3). Most maple tree producers met who used current technologies mentioned having increasing yields, and being confident in their capacity to maintain high yields. These perceptions are similar to those recorded by Sharkey et al. (2015) who mention that for most sugar maple producers, climate change is real, but may only affect producers in the next generation. The utilisation of some technologies improve the collection of maple sap through the pipeline system as exemplified by this statement, from a SPFO who is a retired farmer:

> *R.8* Four years ago I installed a vacuum pump, the yields have gone up, just because of the pump. Because, before I used buckets, I didn't have good yields, they were getting lower every year. But with the vacuum pump, yields have doubled, and maybe more than doubled.
>
> *Researcher* Otherwise without the vacuum pump, the yields were decreasing?
>
> *R.8* Yeah, it looked like the yields were going down, with climate change…I think. Like last year I installed a few buckets on maple trees, but they almost didn't collect any maple sap, last year.

Researcher You think it's linked to climate change?

R.8 There were some freeze–thaw cycles that year but maple sap didn't run…but the vacuum pump changes the pressure in the maple tree, and the maple tree runs, so with the pump we can get the sap.

SPFOs practicing forest management for the purpose of environmental conservation on their property also demonstrated perceptions of adaptive capacity. These respondents were aware of the different threats represented by insect pests, especially the Emerald ash borer, and insisted on the need to diversify tree species on their land. They had been involved in replanting hardwood species such as Red oak (*Quercus rubra*), species that had become rare in the region (R.15, R.19). As one mentions, "The Emerald Ash borer, what it tells us, is that we have to diversify the species planted". Some were able to access trees to plant through the regional agency which reinforced their perceived capacity of adaptation (R.5, R.15). Many respondents (30%) mentioned taking into consideration tree species diversity in their forest management, especially because they are aware of threats such as insect pests. Moreover, a belief is shared among many respondents that forest in the region is resilient, has always adapted and will continue to adapt (R.11, R.14). In sum, actual reaction to environmental disturbances and adoption of new technologies and practices were interpreted through the interview as active adaptation to increased climate variability in Montérégie.

Regarding CC as a general phenomenon, many proved cautious regarding adaptation measures that would be implemented for short-term response to CC and that might not be best suited in the long-term (R.23). A majority of respondents (70%) consider that it is not or really not urgent to adopt adaptation measures in their forestry practices. Among those who consider it is urgent or very urgent to adapt, they mainly stress the importance to pursue the diversification of tree species in forest management. Overall, for forest management, CC in itself remains a secondary issue for a majority of SPFOs.

Direct Experiences of Environmental Disturbances

Most SPFO met had already some direct experience of environmental disturbances to which they referred to in order to express perceptions of vulnerability and adaptive capacity, in relation to broader phenomenon such as CC. The main environmental disturbance in Montérégie was the ice storm of January 1998, as the freezing rain caused widespread heavy forest damage over the whole region (Irland 1998; Miller-Weeks et al. 1999). It was experienced directly and recalled particularly by SPFOs who have been owned their forests during the event. Such event had major consequences on forest ecosystem dynamics (Hooper et al. 2001; Rhoads et al. 2002; Beaudet et al. 2007; Weeks et al. 2009) and forest-related activities (DeGaetano 2000).

The 1998 ice storm as experienced by SPFOs provides access to a broad range of perceptions regarding vulnerability and adaptive capacity. The ice rain contributed to shape SPFO's perceptions of forest ecosystem resilience and their adaptive

capacity in the medium-term and long-term. When reflecting on those events, almost 20 years later, one maple syrup producer even declared that the ice rain had "cleaned up" his forest by destroying older trees, and less valuable species, leaving more room for regrowth which was now ready to be tapped. He also reflected saying: "in the first place, many panicked because of the magnitude of devastation, but on the longer term, they realised it was also part of a natural process" (R.3). Although the ice rain impacts differed from one locality to the other, some who had had a forest with diverse tree species on which they did not depend economically, expressed that the impact of ice rain was marginal (R.10; R.20). Overall, time elapsed since the event changed perception of what appeared at first a major environmental disturbance, and was reinterpreted as an extreme event with low occurrence, to which forest and economic activities could adapt.

The 1998 ice storm provides examples of how direct experience of disturbances, and the actions undertaken at this time shaped perceptions SPFOs. This is particularly clear in attitudes toward the government funded program offered to SPFOs after the ice rain. The program included management advices by forestry professionals in tandem with subsidised labour for timber salvaging. Some maple syrup producers and loggers expressed that without the program, they would be out of business (R.16, R.8). However, others expressed issues of trust regarding state foresters, considering that they had very limited experience with disturbances of that magnitude, and that their silvicultural prescriptions were questionable (R.3, R.11). They perceived their forest related activities would be more vulnerable if they accepted standard technical solutions. Some refused to comply with the advices of state foresters, and mobilised their own knowledge and labour for timber salvaging and forest cleaning. Lack of trust in government experts has been correlated with low belief in climate change (Mase et al. 2015). Nevertheless, access to knowledge in tandem with high level of perceived control and perceived adaptive capacity are exemplified by the statement of this men of over 65 years old, whose main activity is farming:

> *R.11* They came here during the ice rain, they wanted me to cut down at least 50% of trees, they wanted me to cut down almost everything. I refused, I said no. The government provided men (labour)…I don't know if you heard about that?
>
> *Researcher* Yeah I've heard of it. The government had recruited the labour, largely unemployed people…
>
> *R.11* Yes…My forest, I take care of it, I saved it a few times, but they wanted me to work with people who didn't know trees…a plumber, an electrician… They'll just cut down the tree. When it's a maple tree, you have to try to save it, sometimes you have to climb in the tree to do that. I didn't accept anything, I didn't get any subsidy, I preferred to work with people I know around here, who know the forest, they helped me to clear that.

Regarding the ice storm of 1998, whether SPFOs accepted government support or not, the prevailing perception is that reactions that followed were largely appropriate and constitute effective measures of adaptation. Reflecting on its own experience, one SPFO expressed that "the ice storm led SPFOs to better manage

their maple grove" (R.6). This is echoed by another SPFO who says that "the ice storm changed my perception, now when I cut down trees I'm less hasty, I take my time, I make sure to keep the healthiest tree" (R.3). Moreover, the ice storm encouraged some to improve their forest management by seeking expert knowledge on the issue. A maple syrup producer stated that, after these events, he registered to obtain a forest management plan as provided by the provincial program (R.16). Others mentioned that they changed their thinning practices, without requesting expert advice, notably by leaving more maple regrowth and by reducing the space they used to leave between trees so that branches of multiple trees can support themselves, and become less likely to break under the weight of ice (R.3, R.23). A few SPFOs not involved in important forest-based economic activities mentioned nevertheless that following the ice storm they questioned the usefulness of forest management, perceiving at first that the forest was too exposed to major disturbances (R.22). This data speaks to the key role of direct experience in shaping perceptions of vulnerability and adaptive capacity, while also motivating concrete actions.

Perception of Barriers to Adaptation

Respondents identified barriers to improve forest management and maximise their level of adaptive capacity, whether it is in relation to a particular potential disturbance or not. CC raises questions and concerns among SPFOs regarding their forest management. All respondents expressed forest management goals and some stressed the constraints to achieve them. The goals pursued through forest management include the improvement of the landscape's aesthetic quality, improvement of accessibility for leisure, attraction of desired game species, biodiversity conservation or enhancement, better productivity of economically valuable hardwood species, and better maple sap productivity.

Perceptions of needs for adequate adaptation to CC reveal a high level of uncertainty regarding the impacts. Many respondents expressed need for more knowledge in order to better understand the specific threats posed to their forest and adaptation actions proposed. As such, many (70%) mentioned being disposed to invest time to learn more about the impacts of CC, for instance, through workshops for knowledge transfer. Regarding CC, one maple grove owner mentioned: "there are perhaps things that we don't know, we'd like to have more time to take interest in that" (R.6). A respondent without a valid management plan said regarding environmental changes he had observed: "I want to talk to a professional about my thinning practices, in case I should change anything" (R.26). Moreover, better knowledge on the tree species that will be best suited to changing climatic conditions was also expressed: "for my forest, I would like to know what species will stay in place, if it's necessary to plant other species" (R.19). This concern points to the importance of maintaining the subsidised distribution of trees for planting, an important program that has been mismanaged according to some, but remains crucial to promote tree species diversity and reinforce adaptive capacities (R.22). However, only a minority of research participants can project themselves in the future, beyond their direct experience of climatic conditions.

In the context of Montérégie, access to scientific knowledge on forest management is largely determined by the participation in the regional program for forest development. A maple syrup producer with a valid management plan said that if he ever noticed high mortality among maple trees, he would immediately contact the forester (R.16). Others rather expressed distrust toward foresters who did not understand their particular vision of forest management (R.20, R.24). Many respondents, who are not economically dependent on forest, rather rely on their own experiential knowledge for forest management. However, the lack of access to the forest management program can be considered as a barrier to improvement of management practices and ultimately to adaptation to effects of CC and global change.

More generally, many respondents insisted on the issue of financial and time constraints in relation to their capacity to modify or intensify forest management activities that would not be prescribed in the forest management plan. Even though the participation in the regional program for forest development provides access to financial support, many SPFOs raised limits about their capacity or willingness to participate in the program. For example, many respondents have expressed that trees marked to be culled in the forester's silvicultural prescription exceeded their capacity to do it on their own, without a recourse to hired labour, which cost would not be fully covered. Therefore, SPFOs unable to comply with the prescription within the time allowed, without incurring costs they deemed too high, decided not to renew their participation (R.24, R.26). One mentioned in this regard: "tree marking was such that I would not have been able to comply with the forester's prescription…and he doesn't even understand what I need… so I didn't renew my participation" (R.20).

Forest management capacity also depends on the economic profitability of forest based-activities. A respondent who owns a forest of less than 10 ha and performs low intensity management for leisure purposes, asserts: "I'm not willing to invest $CAN 2000 in my forest…the forest is simply not a priority" (R.18). However, maple syrup production is considered to be a lucrative forest-based activity in the region, which encourages intensive forest management. Many maple syrup producers highlighted the profitability of forest management: "…money is the bush, the best remedy for a maple grove, it's the chainsaw. You take out your chainsaw and you cut down adverse species, sick maple trees, you remove them" (R.3).

Barriers to adaptation manifest in economic factors, which are particularly important in the case of maple syrup producers (R.3, R.6). Marketing of maple syrup in Quebec is regulated by a supply management policy which restricts the amount of maple syrup that each producer can provide to the selling agency for retail distribution. Quotas regulate the amount of syrup marketed by the agency, however according to respondents these quotas poorly reflect the maple syrup yields in southern Quebec, which are superior to other regions. Moreover, respondents who seek to become maple syrup producers have not yet been granted quotas, as new quotas are distributed by lottery every year (R.3, R.6, R.16). Some SPFOs perceive that those restrictions affect maple syrup producers and restrict their capacity to intensify forest management, and to manage risks associated with this

activity. This situation leads a maple syrup producer to say: "I'm more afraid of economic conditions than climatic conditions, economy is based on 4–5 years plans, forestry is more based on 50–100 years planning" (R.6). This time scale mismatch expresses a perceived barrier to some activities of management.

Discussion and Conclusion

The study addressed whether perceptions of vulnerability and adaptive capacity can constitute barriers to proactive actions toward adaptation to CC. As shown by the data, adaptation among SPFOs is mainly perceived as an ongoing phenomenon occurring as a reaction to actual environmental disturbances, rather than as a response to knowledge on CC. The study shows how participants respond to factors affecting forest ecosystems and forest-based activities according to their own experience, belief and priorities in terms of forest utilisation. Moreover, our study emphasises that SPFOs do not necessarily perceive their vulnerability to CC as distinct from vulnerability to other stressors. Perception of vulnerability and adaptive capacity appears contextual and related to SPFO's forest based activities. The fact that owners generally perceive their adaptive capacity to CC in light of their adaptive capacity to current and past stressors may constitute a barrier to engage in long-term adaptation to future disturbances related to CC (Weber 2006).

The study shows that most West-Montérégie SPFOs interviewed do not generally perceive their forest or forest related activities to be vulnerable, despite the number of potential and actual disturbances that can be identified. Factors such as specific forest utilisation, knowledge in forestry, low level of economic dependence on forest, seem to lessen perception of vulnerability. As such, the fact that SPFOs who depend economically on forest related activities have been able to sustain their practices over the last decades, has been favourable to a good perception of adaptive capacity. Moreover, the magnitude of most actual and potential disturbance is minimized as their effects are circumscribed to specific tree species of limited economic value for them, and/or are perceived as stressors of low occurrence and/or of limited geographical spread. The good perception of adaptive capacity is reinforced by the perceived resilience of forest ecosystem following the last ice storm.

The general perception which minimize vulnerability may be considered as an impediment to proactive adaptation. As suggested by Adger et al. (2009), and as demonstrated in the present study, adaptation is less a response to expected impacts of CC, than a reaction to disturbances experienced directly within a specific geographical setting. The only proactive action that can be interpreted by SPFOs as a manifestation of adaptation to CC and global change are efforts to maintain or enhance the diversity of tree species as a general principle of forest management. Overall, the ability of SPFOs to undertake proactive adaptive actions is largely determined by subjective assessment of risk, which has a lot to do with previous experiences or knowledge acquired (Lönnstedt and Svensson 2000). It is also experiential knowledge that lead most SPFOs interviewed to express caution and

intention to observe forest changes to react only if needed, after consulting with experts, i.e. forest professionals.

SPFOs feel that the temporal scale of CC impacts differs from the temporal scale of their ownership/management horizon. Perceptions that influence adaptive actions appear intrinsically related to forest management goals over a certain time scale. In fact, we find that such management goals can be related to specific economic, recreational or conservation objectives which temporal scale is different from what they perceive as the temporal scale of CC. Following Blennow et al. (2012), the belief in CC and in the observation of its impacts might not automatically translate into adaptive actions. We have noticed cognitive, affective and behavioural barriers to CC adaptation, which appear based on past experience and management goals (Lorenzoni et al. 2007). Believing in CC and in having experienced their impact in the past are important conditions to engage in adaptation actions, but these sole beliefs remain insufficient to translate into actions. As the present study suggests, the high level of uncertainty surrounding CC and the lack of knowledge on specific future impacts and temporal scale locally appear as some of the main barriers to adaptation (Costa-Font et al. 2009). Moreover, as adaptive capacity is intertwined with the intensity and quality of management practices, lack in financial resources and time are potential barriers to forest management and adaptation.

Perceptions of adaptive capacity are also largely influenced by the feeling that no action is needed, or no action is worth the investment in time or money. Such affective barriers are also present in perceptions of limited vulnerability or lack of interest in CC impacts on forests. In this regard, it would be beneficial that knowledge on CC and global change be included in local strategies of knowledge transfer, notably through the regional program for forest management (Rodriguez-Franco and Haan 2015). Since only a fraction of SPFOs participate in the program, other mechanisms may be used to disseminate knowledge on CC, such as the formation local forestry clubs. Moreover, government funded programs following major environmental disturbances, such as the 1998 ice rain program, would benefit from being less reactive and further integrating scientific knowledge. Overall, the particular context of West Montérégie, where forest exploitation remains a marginal economic activity, also explains the limited interest and capacity to change or intensify management. A large part of adaptive capacity may depend on better knowledge of forest management that implies proactive actions toward adaptation. In this regard, future research will need to engage more clearly with specific impacts of forest management strategies used by SPFOs and their effective adaptation to potential CC effects.

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