El Niño, Ice Storms, and the Market for Residential Fuelwood in Eastern Canada and the Northeastern U.S.

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Abstract

Extreme weather events such as the ice storm that affected eastern Canada and the Northeastern US in January of 1998 have significant impacts on both human populations and forests. One of the questions currently facing climate scientists is whether or not better forecasting of such events would lessen the economic impacts borne by households, industry, agricultural producers and the public sector when such weather events occur. This case study examines the economic impacts of the ice storm on the residential market for fuelwood. It is hypothesized that demand for fuelwood will increase due to the failure of non-wood heating sources during the ice storm. In addition, damage to trees in the region should increase the supply of fuelwood; the net effect of these outward shifts of supply and demand on price is not known. A household level survey administered to over one thousand households indicates that less than half of the households in the affected region currently rely on wood burning technologies as a source of heat for their homes. However, those households with wood burning technologies were better able to manage during the ice storm. The main policy implication of better forecasting of extreme weather events is the ability of households to alter or substitute home heating strategies and technologies in addition to other mitigative strategies such as storing food etc. In addition, forest managers or forest product producers who have information regarding extreme weather events have the option to undertake various management strategies to lessen the economic and biophysical impacts of ice storms on forests. Forest managers and woodlot owners may also enter or expand into the market for residential fuelwood when the production of other forest produce such as maple syrup and veneer are hindered by ice storm damage.

Key Words: fuelwood, El Niño, ice storm, forest management, extreme weather event, climate forecasting, forest policy

JEL Classification Numbers: D1, D13, Q2, Q21, Q23, Q42

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I. INTRODUCTION

Extreme weather events such as the ice storm that affected Eastern Canada and the Northeastern US in January of 1998 are known to have effects on both human populations and forests. Human populations are faced with challenges such as downed power lines and other inconveniences such as limited access to transportation routes for periods of up to several weeks. During ice storms households must often rely on alternative or secondary fuel sources to heat their homes; in many cases fuelwood is the alternative fuel chosen. During events such as ice storms, fuelwood becomes not only the main heating source, but also a main source of light and heat for cooking. It is hypothesized that increased reliance on fuelwood during ice storms will affect both demand and supply in the residential market for fuelwood. This has implications for local woodlot and forest management, and also for the importance of the ability to forecast extreme weather events such that households and forest managers might undertake various mitigative strategies to lessen the stresses and economic impacts associated with extreme weather events such as ice storms.

When considering ice storms, their impacts on both human populations and forests, and forecasting extreme weather events, it is useful to consider the potential causes of such storms. Ice storms are hypothesized to have some relationship to both El Niño weather patterns and global warming.[1] Although no clear scientific evidence exists to link ice storms to El Niño, it is possible that trends in global warming increase the probability of ice storms in some areas. Strong sub-tropical jet streams that flow from the Pacific Ocean across the southern US are common during the mature phase of an El Niño. This phenomenon when combined with shallow layers of cold air in valleys such as the St. Lawrence, in southeastern Canada, set the stage for prolonged periods of freezing rain. In addition, it is well

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[1] Ice storms are generally characterized by hot air masses from the south trapping cold Arctic air from the north. The result is often freezing rain characterized by "supercooled" raindrops, meaning they are already colder that 0 degrees Celsius but have not yet turned to ice. The mechanical shock of striking a hard surface causes instantaneous formation of ice crystals, which rapidly build up a mass of ice (Geotechnical Science Laboratories, 1998). Often these weather systems get trapped in one location exacerbating the effects of the storm.

documented that winters are becoming warmer, and warmer temperatures, especially those around 0° Celsius, increase the probability of ice storms in the forests of Canada and the northeastern U.S. (Environment Canada, 1998).

When the existing data on the incidence of moderate and extreme El Niño episodes over the period 1945 to 1997 are compared with data that indicate moderate and heavy freezing rain or drizzle there is some indication that ice storms may be correlated to El Niño.[2] During the 52 years for which data are available, moderate or strong El Niños occurred in 23 percent of the years, whereas moderate to heavy freezing rain or drizzle was observed in 34 of the 52 years (65 percent). In 66 percent of the years that moderate and heavy freezing rain occurred in the Northeastern US a moderate or strong El Niño was observed. However, the frequency of freezing rain or drizzle episodes in non- El Niño years indicates that correlation between the El Niño and freezing rain may be weak. This research question requires further study by climatic scientists before the true value of predicting El Niño weather episodes with respect to potential ice storm damage mitigation strategies is known.

Historical data indicate that ice storms occur in regions such as the northern New England States and southeastern Canada as frequently as every 10 years. Although ice storms occur with greater frequency than other climate related stressors such as high winds and fire (Irland, 1998), the severity of ice storms is highly variable depending upon the accumulation of ice, the duration of the event, and the size and population density of the geographic region that the storm affects (Environment Canada, 1998b). The ice storm of January 1998 stands out as the worst storm to hit Canada in recent memory; similar sentiment was expressed with respect to the impact of the 1998 ice storm on both human populations and forests in the NE United States. The storm had its greatest impact in southern Quebec in the region between Montreal and Ottawa, but eastern Ontario, Maine, New Hampshire, and parts of Vermont and upstate New York were also seriously affected. Federal disaster areas were declared in 37 counties in 4 Northeastern US States (USDA, 1998).

Human populations are widely affected by severe ice storms and the 1998 ice storm was particularly debilitating as it affected a heavily populated urban area. Particularly in harsh winter climates, such as those experienced in Eastern Canada and the Northeastern US, downed power lines can cause several days, or weeks without electricity for heating, light and cooking causing major stress to households. In addition, impassable roads and retail store closures limit access to necessities such as food, water and fuel. Table 1 provides a summary of the estimates of damages and impacts by region. Estimates suggest that the January 1998 ice storm was partially responsible for a 0.7 percent decline in Canada's GDP, mainly due to a 14.2 percent fall in utility output and related effects on retail sales and manufacturing (Irland, 1998). The agricultural sector was also widely affected.

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[2] Data with respect to years in which moderate to strong El Niño were observed in the study region are courtesy of Environment Canada (1997). "Green Lane: Comparing El Ninos," web site accessed 1999 (available at `http://www1.tor.ec.gc.ca/elnino/comparing/index_e.cfm`). Data regarding moderate and heavy freezing rain and drizzle episodes are courtesy of USDA Forest Service Northern Central Research Station.

Approximately 5,500 dairy producers in Ontario and Quebec dumped an estimated 13.5 million litres of milk, valued at approximately $7.8 million Canadian dollars. In addition to disrupting regional economic activity several thousand households were displaced and had to seek shelter in hospitals and schools that were set up to accommodate people that had left their homes. The Red Cross and various local agencies provided emergency supplies.

Table 1: Regional Impacts of the January 1998 Ice Storm

	Households without electricity	Hydro towers toppled, hydro poles downed	State of emergency declared
Quebec	1,393,000	1,000; 24,000	14,000 troops deployed between Quebec and Ontario
Ontario	232,000	300	
Maine	315,000	N/A	Whole state
New Hampshire	67,586	N/A	9 of 10 counties
Vermont	33,200	N/A	6 of 14 counties

Source: Canadian Geographic (1998).

Forests also experienced significant damage and economic impacts as a result of the 1998 ice storm. Trees were seriously damaged in both rural and urban environments. Heavily forested landscapes in the region such as those in Maine experienced extensive damage to almost all forests (USDA, 1998). Generally hardwood species suffered much greater damage than conifer species. Aspen, poplar, birch, beech and both red maple and sugar maple generally suffered the greatest crown damage. In the majority of regions affected by the ice storm, 10-15 percent of trees were damaged so severely that they likely have not survived (Brunette, 1998). Ice storms cause tree branches and limbs to become weighted down with ice. Under such weight limbs often break off causing substantial stress to the tree. Depending on the extent of injury to the tree's crown cover, the tree may die, or be damaged to the point that it is unsatisfactory for sale as timber, wood veneer etc.

US Forest Service estimates indicate that in the Northeastern States, Maine, Vermont, New Hampshire and northern New York 18 million acres of forestland were damaged by ice. Estimates of damaged timber range from $650 million to $1.4 billion USD, which equates to approximately 25 million cords of wood, or more than 3 billion board feet of timber lost. In addition forest dependent communities throughout the Northeastern US have and will continue to experience significant economic losses. Timber producers, wood manufacturers, sugar maple producers and those who depend on outdoor recreation and tourism are estimated to suffer long term economic losses of $1-2 billion USD (USDA, 1998).

The significant number of partially and totally damaged trees in regions hardest hit by the ice storm may have implications with respect to the supply of fuelwood for residential use, and the price charged for that fuelwood. Damaged trees and salvage, although not merchantable for most industrial wood purposes with the exception of pulp, do have significant potential for use as fuelwood. This increased availability of fuelwood, combined with increased demand anticipated in regions that were isolated from electricity during and after the storm is anticipated to influence both demand and supply side factors in the residential fuelwood market both in the short and medium term.

II. THE MARKET FOR RESIDENTIAL FUELWOOD

The ice storm could potentially affect both demand from households and supply from traditional suppliers and new entrants in the market for residential fuelwood. Demand for fuelwood may increase as households become more aware of wood as an alternate source of heat during a power outage, and as households realize that their supply or stock may not be adequate to serve them during long power disruptions. Increased demand may come from new users and from existing users of fuelwood. The implication of the hypothesized increase in demand is that price will also increase, however, simultaneous changes in the supply side of the market may offset price increases resulting in no net change in price, or possibly decreasing price.

The number and extent of trees downed and damaged during the ice storm may have created a windfall of fuelwood availability, allowing households to purchase or gather wood from sources other than regular suppliers. Irland (1998) predicted that local fuelwood markets would likely be glutted during the fall of 1999 due to households with wood burning technologies gathering wood from their own yards. The limiting factor of this new source of fuelwood would be the ability of residents to buck and stack the downed materials. Lack of access to chainsaws, lack of confidence in using a chainsaw and possibly the hazards associated with salvaging damaged trees may have prevented people from taking advantage of damaged and downed wood. Traditional suppliers of fuelwood would also see an increase in supply of their product. Downed trees in woodlots may increase the inventory of suppliers beyond anticipated levels causing a potential glut in the market. Further supplies could be obtained by cleaning up downed trees in other areas outside of the land base that fuelwood is generally sourced from. It is unclear what affect these events may have on price. As was noted above, we hypothesize that increased supply will, to some degree, counteract price increases that might occur, as a result of changes in the demand for fuelwood, making the net effect on prices uncertain.

How the supply and demand of fuelwood are influenced by events such as the 1998 ice storm has implications for public policy, particularly with respect to allowing human populations and forest managers to prepare for extreme weather events. Climate forecasting, particularly forecasting of extreme weather events such as ice storms, is far from an exact science and offers limited potential for mitigating the total impact of ice storms. It is acknowledged that better forecasting will not necessarily benefit all groups within the affected society (Pfaff et al., 1999), thus policy makers are faced with how to disseminate forecasts for maximum economic and social benefit. Indeed even the dissemination of climate forecasting information such as the prediction of an El Niño brings to the fore questions regarding the benefits of complete information and the distortion of climate forecasting information, and also whose welfare among labor, industry and consumers; different regions; and the present and future counts as a benefit (Pfaff et al., 1999).[3]

If households in Eastern Canada and the Northeastern U.S. had been better informed regarding the timing and severity of the ice storm, especially with respect to the potential for electrical services to be interrupted for long periods of time, and transportation networks to have limited access, mitigative strategies may have been taken that could have lessened the economic and emotional impact of the storm. It is clear that households could benefit from better forecasting in that various mitigative strategies such as the storing of food, water and blankets or the purchase of an electric generator would be undertaken in advance of the onset of storms. Likely more significant in economic terms is the value of such forecasts to agriculture and forestry producers such as dairy farmers, hardwood producers and maple sugar farmers. With respect to forest produce, silvicultural considerations such as stocking, inventory levels and pest control etc. may be implemented to lessen the impacts of ice storms and other extreme weather events on forests (USDA, 1998).

III. THE SURVEY

In order to estimate the influence that the 1998 ice storm had on households and the supply and demand for residential fuelwood, a telephone survey was administered to 1011 households in Ontario, Quebec and the US in February and March of 1999 in regions where damage from the 1998 ice storm was known to be significant.[4] Regionally the response rates for the telephone survey were 48 percent, 42 percent and 39 percent for Ontario, Quebec and the U.S. respectively with an overall response rate of 42 percent. The questionnaire was divided into four main sections; the first was a series of screening questions designed to determine who had the potential to alter their home heating technologies. The second and third sections dealt with fuelwood use and fuelwood sales respectively. Questions regarding home heating, wood burning and patterns of fuelwood acquisition during the past four winter seasons, and wood selling trends over the same time period were asked of respondents. The final section dealt with perceptions about the cause or causes of ice storms, information regarding mitigative strategies households are currently undertaking to prepare for future storms and a variety of demographic variables intended for use in assessing whether or not factors such as income level, education and household size have any influence on household behavior with respect to home heating, fuelwood use and mitigative strategies.

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[3] For example, successful forecasting of the 1986-87 El Niño allowed the Ethiopian government to advise farmers accordingly and reduce the amount of food relief required. However, not all forecasts are successful as was the case in Zimbabwe in 1997 where forecasts suggested a more severe drought than occurred, resulting in reduced planting and subsequent agricultural output (Pfaff et al., 1999).

[4] The sample was broken down as follows: 258, 251, 171, 151, 180 households in Ontario, Quebec, Vermont, New Hampshire and Maine respectively.

IV. RESULTS

In this section the survey results are presented in chronological order. Household behavior with respect to fuelwood use, household heating and ice storm mitigation strategies from their state before the ice storm through behavior during the ice storm, and following the ice storm are outlined.

Home Heating and Fuelwood Use Prior to the Ice Storm

The ability to alter home heating systems was one of the main screening criteria used in the study. This was important to us for two reasons. First we wanted to know if households had decision-making power regarding home heating technologies and the mix of technologies that they utilized over time. Secondly, households that went without heat for an extended period of time might seek to upgrade or introduce new technologies, wood burning or otherwise in their households. Table 2 provides summary statistics by province or state for the questions used to determine whether or not respondent households were able to alter their home heating systems.

Table 2: Ability to Alter Home Heating Systems, by Province and State, Percent

	Ontario	Quebec	Vermont	New Hampshire	Maine	Total
Current residence same as ice storm residence	91	90	94	93	94	92
Owns home (vs. rent)	80	68	86	86	89	81
Dwelling type that generally allows for heating system changes[a]	76	83	80	82	84	81
Independent heating system[b]	79	98	84	85	87	87

[a] Includes single detached homes, semi-detached houses or duplexes, townhouse or townhouse condominiums and manufactured or modular homes.

[b] Heating systems are not common with other neighboring units, for example a townhouse condominium with its own furnace system.

The table clearly indicates that the majority of respondents have remained in the dwellings that they were residing in during the ice storm of 1998. This information was important with respect to being able to compare household home heating behavior both before and after the storm. In the study area owning a home is much more common than renting, however, this trend is not as apparent in Quebec as Ontario and the three states evaluated. We assumed that owning implied some ability to make autonomous decisions regarding home heating technologies. Among the four dwelling types represented in the above statistic 81 percent of the total sample were residing in dwelling types that would likely allow for alterations to home heating technologies versus an apartment which would be more likely to have a shared heating system. Further, 87 percent of households identified their home heating systems as independent of neighboring households. These numbers show that most of the households surveyed had some level of autonomous choice over their home heating technologies. Most would have the option of upgrading or adding wood-burning technologies to their household's home heating system after the ice storm if they chose to.

The survey addressed home heating technologies, with specific emphasis on patterns of fuelwood use both before and after the ice storm. The primary source of heat for the home varied by region. In Ontario, natural gas (53 percent) was the primary heating source while electricity dominated in Quebec (63 percent) and oil in the United States (57 percent). Table 3 summarizes trends in home heating technologies, how many people made alterations in home heating technologies and how reliant households in the study area are on wood as a source of heating and as a primary source of heating. We also include statistics regarding the percentage of households in each region that ran out of fuelwood during the 1998 ice storm. As Table 3 indicates, very few households adopted new non-wood burning technologies after the ice storm. This is likely due to the significant capital costs associated with altering home heating systems.

Table 3: Household Heating by Province and State, Percent

	Ontario	Quebec	Vermont	New Hampshire	Maine	Total
Purchased new non-wood heating source after the ice storm	4	3	5	3	6	4
Households that burn wood	35	39	50	48	49	43
Households that burn wood as a main source of heat	8	5	14	9	9	9
Households that ran out of fuelwood during the ice storm	<1	3	1	<1	2	2

Approximately one third of the Canadian households surveyed, and 50 percent of households in the U.S. burned wood for either heat, recreation or both. The number of households that rely on wood as their main source of heating is much lower and follows the trend observed in the preceding statistic. Canadian households are less reliant upon fuelwood as a main source of heating, this is likely partially attributable to the urban characteristic of the Canadian sample.[5] Five percent of respondents heated their homes exclusively with wood, while 9 percent used wood as a primary source of heat. These data indicate that in general

[5] Of the Canadian households surveyed 90 percent identified themselves as residing in a community of more than 5,000 households, which we defined as "urban" for the purposes of this study, whereas 55 percent of US households surveyed identified themselves as urban.

wood is not a major source of home heating in the region affected by the ice storm. However, many households used wood as a secondary source of home heating.

Forty-three percent of households surveyed burned wood in their homes and 58 percent of those who burned wood relied on wood burning as a source of heat. Wood was more important as a source of heat for those who burned wood in the United States (63 percent) compared to Ontario (51 percent) and Quebec (51 percent). Again, as with the general wood burning statistics this result is likely affected by the rural versus urban character of the Canadian and U.S. populations surveyed.[6] Respondents that did not cite wood burning as a source of heat utilized wood for "recreation," for example, burning wood purely for the aesthetic value of having a fire burning in a living room fireplace. However, it should be noted that a recreational fire in a fireplace might be an important source of heat in an emergency. Wood burning stoves were the most common wood burning technology observed. This is especially the case in the United States where two-thirds of respondents used a wood stove as their main wood burning technology compared to just over one half in Ontario and Quebec. Fireplaces are the more common wood burning technology observed among the Canadian respondents.

Respondents who relied on wood for home heating prior to the ice storm, or the combination of home heating and recreational wood burning use were asked a series of questions relating to the fuelwood market in their region during the three years leading up to the ice storm. Wood purchased from local fuelwood suppliers was the most important source of wood for home heating. In 1995 and 1996 this was the sole source of fuel for over 40 percent of respondents. Quebec respondents had a far greater propensity to purchase rather than gather wood than the other regions being studied. The amount of wood burned and the prices paid for wood remained relatively stable during the two winters preceding the ice storm. Prices paid per cord of fuelwood were higher in the United States than in Canada.

Fuelwood Use and Events during the Ice Storm

During the course of the ice storm, several households were forced to seek shelter away from their primary residence. Seventy-four percent of respondents remained in their homes while of the 26 percent who left, most went to the home of a nearby friend or relative. Those households with wood burning technologies were less likely to leave their homes during the ice storm. Only 11 percent of those who used wood exclusively to heat their homes, 13 percent of those for whom wood was the primary source of heat and 21 percent of those who burned wood as a secondary heat source or for recreation went elsewhere for shelter from the storm. Those for whom the primary source of heat was electricity were most likely to leave their household and seek shelter elsewhere. Although intuitively one would expect that large households would be more likely to seek alternative shelter during

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[6] Cross-tabulations of households that burn wood and various demographic variables such as level of income, education and family size did not indicate any socioeconomic trends in households that burn wood.

an ice storm due to constraints on available food, water, etc., family size was not an important factor in the decision to stay or leave.

There was a marked increase in wood burned during the ice storm but it is not clear that respondents interpreted the survey questions with respect to time periods of wood burning as they were intended. Our objective was to have respondents break the 1997-98 season into before, during, and after the ice storm. The very large numbers of cords of wood burned reported after the storm appear to show that many people may have interpreted the question to mean, "How much wood did you burn in the entire season?" A conservative but more realistic total for the 1997-98 season maybe obtained by aggregating consumption during the autumn of 1997 and during the ice storm (Table 4). By applying the value of 1 to those who burned less than 2 cords, 4 for those who burned more than 2 but less than 6 cords, and 7 for those who burned more than 6 cords, we can estimate the amount of wood burned in each season for the total sample to be as follows: 781 cords during the 1995/1996 winter season, 786 cords during the 1996/1997 winter season and 817 cords during the fall of 1997 and during the ice storm in January of 1998. Wood burned during the ice storm period alone (368 cords) was just less than half of the wood burned in each of the previous two complete seasons.

Table 4: Wood Burning by Season, Number of Households

	None	<2 Cords	> 2 < 6 Cords	> 6 Cords
1995-96	31	91	92	46
1996-97	30	94	89	48
1997 Fall	35	160	53	11
1998 During	25	192	30	8
1998 Post	45	157	53	5

Respondents were asked where they obtained wood during the storm. While a comparable number of people gathered wood from their own land, or obtained it from someone else's land, fewer people purchased all their wood and more people relied on their own stockpiles than during previous seasons or during the fall preceding the ice storm. The decrease in purchases was particularly noticeable in Quebec. This result is not unexpected due to the difficulty associated with purchasing wood during the storm, but it is somewhat surprising that more people did not gather wood from their own property. Many trees and large branches fell during the storm. People may not have gathered wood because they did not have chainsaws to harvest with or because the wood may have been too green for immediate use. For those who purchased wood during the ice storm a small increase, approximately 5 percent in price was estimated from the survey data.

Finally, the percentage of households that ran out of fuelwood during the ice storm was unexpectedly very low, particularly when taken in the context of the media coverage during the ice storm indicating that running out of wood was a major issue in several of the hardest hit regions in both Canada and the United States. The data indicate that most households had enough wood stockpiled to get them through the storm. Only 7 percent of those who used wood for heat ran out of wood, approximately half of those households were in Quebec. Data are not available on those who used wood for recreation only.

After the Ice Storm

While it is not entirely clear whether or not people built up their wood supplies after the storm, it is clear that people are not making capital investments to obtain wood burning technologies. Only about 3 percent of respondents indicated that they would be purchasing new wood burning equipment. Wood stoves were the dominant choice for a new wood burning technology. About 4 percent of respondents are planning to purchase a new non-wood burning technology with American respondents favoring propane while natural gas was the preferred choice of respondents from Ontario and Quebec. These findings are consistent with a survey conducted by *La Presse* newspaper in Montreal in early 1999 (*La Presse*, 1999).

Following the ice storm fuelwood prices per cord remained consistent with those observed during the ice storm. In the months immediately following the ice storm there was no marked increase in people gathering or purchasing wood to increase their stockpiles in the event of another ice storm. We were unable to obtain data regarding whether or not households made an effort to build up their wood supplies during the summer and fall of 1998.

The third section of the survey was designed to gather data regarding the supply side of the residential fuelwood market in the areas affected by the ice storm. We received an insufficient number of replies from woodlot owners to learn whether or not they would have a significant increase in supply from downed trees. Our hypothesis, that the ice storm would have caused salvage to occur and precipitate the harvest of damaged trees for fuelwood, rests on the assumption that households with wooded area would have taken advantage of increased demand in the fuelwood market and the opportunity to sell to households without access to fuelwood that had increased demand. Although a significant proportion of the respondents in our sample indicated that they had wooded area on their property, very few respondents verified that they had sold fuelwood at any time during the past four winter seasons including during and after the ice storm.[7] This finding was unexpected.

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[7] In Ontario and Quebec, 16 percent and 8 percent of households respectively indicated that they had wooded area on their property. The percentage of respondents that indicated they had wooded area on their property was much higher in the three US states that were surveyed, indicating clearly that the population in the region of the US that was impacted by the ice storm was much more rural than the population that was affected in Canada. In Vermont, New Hampshire and Maine respectively, 47 percent, 61 percent and 51 percent of respondents indicated that they had wooded area on their property. Of the total number of respondents with wooded area on their land approximately 6 percent indicated that they had sold wood from their property as fuelwood.

Households are undertaking mitigative strategies not related to home heating technologies to lessen the stress of future ice storms and other extreme weather events on human populations. Table 5 summarizes data regarding mitigative strategies undertaken during the winter of 1998/1999 by province and state. Household level mitigative strategies were not highly differentiated regionally although households in New Hampshire and Maine, perhaps due to their more rural characteristic, most often cited the storing of food, blankets and light sources as mitigative strategies for coping with future ice storms. Between 15 and 30 percent of respondents from Ontario and the United States stored or would store food, blankets or water while over 50 percent of those queried from those regions said they would purchase candles or other lighting sources. Respondents from Quebec were far less likely to undertake these measures with only 8 to 10 percent indicating they would store food, blankets or water and only 34 percent indicating they would buy candles or other light sources. A similar pattern was observed when people were asked whether they would be purchasing an electric generator. Twelve percent of Ontario and US respondents said they would be doing this while only 4 percent of Quebec respondents are planning to purchase a generator. However, Quebec respondents are taking steps to prepare other than those that were directly queried about. Sixty-nine percent (compared to 38 percent and 40 percent in Ontario and the United States respectively) responded that they have taken or will take "other" steps. These include(d) buying more fuelwood or purchasing kerosene lamps.

Demographic characteristics such as family size, education and income level do not appear to influence the mitigative strategies that households are currently undertaking to prepare for future ice storms. Family size made little difference in the decision to prepare, with the exception of households that are planning to buy a generator. Thirteen per cent of households with more than 4 people planned to buy a generator while only 8 percent of smaller households were planning such a purchase. Higher income level or higher education level did not imply that households would take greater steps to prepare. For most of the ice storm mitigation categories, households earning $50-70,000 were less likely to take mitigative steps to prepare for the next ice storm than those respondents in lower income groups were.

Finally of interest are which climatic variables respondents identified as being the potential cause or causes of ice storms. Table 6 summarizes respondent's views on the cause of ice storms by geographic region. Fifty-one per cent of respondents believe that the ice storm was caused by a combination of factors while 18 percent blamed El Niño, 16 percent felt that it was a function of normal weather patterns while only 6 percent cited global warming. The remaining 10 percent said "other" and when asked for specifics suggested that the ice storm was an "act of God." Results were not highly differentiated by region although people in the US were more likely to cite "normal weather patterns" as a potential ice storm cause. The majority of respondents felt that the ice storm was a result of some combination of factors, both El Niño and global warming, or global warming and normal weather patterns. Regionally, more people in Quebec cited global warming or "acts of God" as a cause of the ice storm while fewer cite El Niño.

Table 5: Mitigative Strategies Observed in the Study Area, Percent[a]

	Ontario	Quebec	Vermont	New Hampshire	Maine	Total
Store food	28	10	23	32	29	24
Store water	16	8	21	23	21	17
Store blankets	22	12	23	23	27	21
Purchase/obtain electric Generator	12	4	8	8	20	10
Store lights/candles	54	34	48	56	58	49
Plan holiday	4	5	2	1	1	3
Other[b]	38	69	40	41	49	47

a Respondents were permitted to offer multiple responses for the set of questions regarding mitigative strategies that would lessen stresses/impacts to households.

b Where 'other' includes mitigative strategies such as storing wood, purchasing oil lamps and kerosene stoves etc.

Table 6: Perceived Cause of Ice Storm by Province and State, Percent[a]

	Ontario	Quebec	Vermont	New Hampshire	Maine	Total
Normal weather patterns	9	12	20	24	15	15
Global warming	4	10	3	4	6	6
El Niño	21	14	19	13	17	17
Combination of factors	52	44	45	48	53	48
Other[b]	9	17	8	8	4	56

[a] Categories may not sum to 100% due to non-responses by survey respondents.

[b] Where 'other' includes causes such as random occurrence, God, don't know/uncertain etc.

V. CONCLUSION

The survey results provide us with some policy relevant insights. The main policy implication of better forecasting of extreme weather events is the ability of households to alter or substitute home heating strategies and technologies in addition to other mitigative strategies such as storing food, purchasing electric generators etc. The survey results indicate several trends and with respect to home heating, the market for residential fuelwood and mitigative strategies that indicating household level mitigation strategies that are not related to home heating technologies are preferred in the study area.

More specifically we find several trends in the data we gathered for the regions most seriously impacted by the 1998 ice storm. First, regional differences in home heating technologies and differences in regional responses to the ice storm should be noted. Regions rely on different heating sources, have different attitudes towards preparing for extreme weather events, different propensity to purchase wood rather than gather it and so on. These differences need to be recognized and accounted for when suggesting possible mitigative strategies and also when determining which regions or sectors of the economy will benefit most from prior knowledge about events such as ice storms.

Secondly, and with specific reference to fuelwood users, there is a clear trend indicating that households with wood burning technology were less likely to leave their homes during the ice storm. In addition, wood burning households that used wood as a primary source of heat were the least likely to leave home. Encouraging households in regions prone to extreme weather events such as ice storms to adopt or enhance their wood burning technologies could result in significant saving in public dollars if people have the ability to stay in their households during similar storms rather than being moved to shelters or elsewhere. However, we found that few people are substituting away from non-wood fuels, or supplementing their home heating systems with wood burning technologies. Supplemental to this is our finding that although demand for fuelwood increased during and after the ice storm, there is little evidence to indicate that households experienced widespread fuelwood shortages.

With respect to the forest management implications of implementing a public policy that promotes the use of wood burning technologies there are several factors to be considered. Our data were insufficient to confirm our hypothesis that the supply of fuelwood due to downed and damaged trees in the regions affected by the ice storm increased the supply of fuelwood in the region. We however do not rule out our hypothesis as estimates of tree damage, particularly in the rural areas that the ice storm affected are very high. In addition to benefiting households, a policy that promotes the adoption of wood burning technologies would also benefit woodlot owners whose alternative forest produce (for example, maple syrup, hardwood veneer, lumber etc.) may be significantly damaged or destroyed by the ice storm. An alternative market for forest produce, namely fuelwood may lessen the economic impacts that forestland owners bear in both the short and medium term following an ice storm.

A third and final factor to consider with respect to our survey results is that most households perceived the 1998 ice storm as an event related to some sort of weather phenomenon such as El Niño or global warming rather than a random event. This finding combined with evidence that households have shown a willingness to prepare for future extreme weather events, points to the value of better weather forecasting. When households are provided with sufficient warning regarding impending events, they can prepare for them and once again potentially save public dollars required to assist people during these events. This finding extends to agricultural and forest producers who experienced considerable economic losses as a result of the ice storm that brought economic activity to a halt for a period of up to a month in some of the hardest hit regions of eastern Canada in January 1998.

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