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An enterprise-level economic analysis of losses and financial assistance for eastern Ontario maple syrup producers from the 1998 ice storm

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Abstract

This paper reports estimates of the costs of damage from the ice storm of 1998 for two producer size categories of maple syrup operation (1000 and 3000 tap) and three damage levels (light, moderate and severe) for eastern Ontario. These size categories represent approximately 500 and 1500 trees in production, respectively, given the general practice in the region of installing two taps per tree. Damage categories were defined on the basis of the proportion of average crown loss inflicted by the storm. Partial budget capital budgeting and stochastic simulation were used to generate interval estimates of damages. Sensitivity analysis was used to explore the robustness of the estimated damages. Estimated losses for 1000-tap operators with light, moderate and severe damage were $5385, $13 821 and $28 721, respectively. Losses for 3000-tap operators with light, moderate and severe damage were $14 160, $37 399 and $75 630, respectively. Average government financial assistance was found to be within 5–30% of the estimated losses. © 2002 Elsevier Science B.V. All rights reserved.

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1. Introduction

Between 4th and 10th of January 1998, freezing rain, ice pellets and snow fell on over 600 000 ha of land in eastern Ontario from the Quebec and United States borders west to Kingston (Lautenschlager and Nielsen, 1999). In general, the hardest hit area in Ontario was within a 20–50-km radius of the Kemptville–Winchester area, although damage was variable on a local scale (Irland, 1998). The freezing rain created an ice accumulation ranging from 40 to over 100 mm in the area affected in Ontario. The heavy ice accumulation caused branches and whole trees to snap and break under stress. This damage impacted a large number of maple bush owners in the area. Approximately 285 000 maple taps in Ontario were

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located in areas affected by the ice storm (Statistics Canada, 1998).

Little is known about tree recovery rates, tree mortality or the biological responses of maple trees to ice storms of this magnitude in Canada. Some studies have examined the impact of ice storm damage on tree diameter, stem density, canopy cover, basal area and forest community structure (Melacon and Lechowicz, 1986; De Stevens et al., 1991; Seischab et al., 1993), but none relate crown damage to maple syrup yield. Consequently, there is considerable uncertainty regarding the biological effects of the storm damage on syrup production in eastern Ontario. This paper quantifies the financial losses due to the ice storm for representative classes of maple syrup producers as a result of the storm. The amount of financial assistance available to individual maple producers is compared to the expected losses.

A partial capital budgeting approach was used. A partial capital budget involves the characterization of changes in costs and revenues attributable to the storm. These changes are subsequently discounted to a net present value. Price and yield risk was incorporated into the analysis using Palisade @Risk® in conjunction with a Microsoft Excel® spreadsheet. Sensitivity analyses were also conducted in order to examine the effects of some of the key assumptions.

The size of the tree crown and the foliage density are both believed to be positively related to syrup production (Moore et al., 1952; Blum, 1971). Therefore, loss of limbs caused by ice storm damage will likely contribute to a reduction in syrup production until the trees have recovered (Kerry et al., 1999). Production in the region for the 1998 season was approximately 25% less than the average for recent years (Harris, 1998). Along with a reduction in the trees' ability to produce sap, the plastic tubing that is often used to collect the sap from trees was damaged by ice accumulation. Because of safety concerns, many maple bushes were inaccessible when the sap began to flow in February of 1998. All of these factors significantly reduced maple syrup output in the spring of 1998, but the effects of the damaged trees will continue to be a factor in the future (Kerry et al., 1999).

In January 1998, soon after the storm, the Ontario Ministry of Agriculture Food and Rural Affairs co-ordinated a damage assessment program. Technicians estimated the average percentage of crown damage for maple bushes in the region (Lake, 1999). Most of the maple bushes that were assessed suffered at least 25% crown loss on average. These assessments were used to formulate post-storm management guidelines and to distribute government assistance. Guidelines for the tapping and pruning of ice-damaged trees were made available to landowners. These guidelines suggested conservative levels of tapping for different classes of damage (Ontario Ministry of Agriculture, Food and Rural Affairs, 1998). The biological recovery of the damaged trees, maple producers' management activities and future weather conditions during the production season will jointly determine the net revenues from maple production that producers in eastern Ontario will experience over the next few years.

Pure maple syrup is a unique product and can only be produced in specific climates. Syrup production is an important regional seasonal enterprise in the area affected by the ice storm, including parts of the northeastern United States and western Quebec, as well as eastern Ontario. Regional estimates of the value of the damage to the eastern Ontario maple syrup industry have been reported by Kidon et al. (2001). Annual regional gross revenue for the industry was generally approximately \$3 000 000 (Cdn) prior to the storm. Sugar maple (*Acer saccharum*) and black maple (*Acer nigrum*) are the preferred species for maple syrup production because they produce the sweetest sap, but sugar maples tend to be much more abundant (Chapeskie, 1997). Maple trees are tapped in late winter or early spring when temperatures fall at night, but increase significantly during the day (usually below and above freezing). The changes in temperature induce sap flow. Taps are inserted into trees to draw out the sap, which is collected either by buckets or by a tubing system. The tubing system collects sap through a series of plastic tubes, which connects all trees to a common line and brings the sap to the sugarhouse, where the sap is made into syrup. A tubing system may also include a vacuum to assist in collection of sap. Over 50% of maple producers in Canada use tubing and vacuum systems (Agriculture and Agri-Food Canada, 2000). Ultra-violet light or sap filters are often used to remove microorganisms from the sap before it is processed into syrup. Sap is heated in an evaporator in order to remove water, leaving a thick, sweet syrup. Wood, fuel oil or gas can be used to heat the evaporator. Once the desired sugar content, color and flavor have been reached, the syrup is ready to be packaged and sold.

There are approximately 2000 maple producers in the province of Ontario. These producers harvest approximately 8000 ha of sugarbush per year (Chapeskie, 1997). Typical operation sizes range from 500 to 3000 taps, but larger and smaller operations also exist (Chapeskie, 1997). A 'tap' refers to a hollow instrument that is inserted into the side of the tree that allows sap to flow from the tree into a bucket or collection tube. The general practice in the region is to use two taps per tree. In Ontario, approximately 90% of syrup is sold by retail at the farm. The rest is sold as wholesale or bulk to packers and distributors (McKibbon, 1989). As the size of an operation increases, the proportion of sales to bulk and wholesale generally increases (McKibbon, 1989).

Fixed costs for a maple operation include the sugarbush itself, the sugarhouse, sap collection equipment, syrup production equipment and overhead management costs. Variable costs include labor, fuel, utility expenses, some tapping equipment, packaging and marketing costs. Variable costs for a tubing system account for approximately 60% of total annual costs. For bucket systems, variable costs account for approximately 70% of the total because of the additional labor requirements (Canadian Farm Business Management Council and the Ontario Ministry of Agriculture, Food and Rural Affairs, 2000).

2. Methods, data sources and important assumptions

A partial capital-budget spreadsheet model was developed to characterize the changes in maple syrup producers' revenues and costs attributable to the 1998 ice storm. Stochastic simulation was used in conjunction with these partial capital budgets in order to incorporate variability in yields and prices in the analysis. These estimated losses were compared to the level of financial and in-kind assistance jointly provided by the federal and provincial governments.

Capital budgets were formulated for two size classes (1000 and 3000 taps) and three damage classes (light, moderate and severe). All operations were assumed to use a tubing system to collect sap, since a bucket system is usually unprofitable at these sizes (Dave Chapeskie, personal communication). The three damage classes were defined based on the average percentage of crown loss: light (0–25% crown loss), moderate (26–50% crown loss) and severe (51–75% crown loss). The very severe class (75–100% crown loss) (Lake, 1999) was not examined in our analysis, since less than 1% of the sugarbush area in eastern Ontario was found to be in this damage class.

Two projected cash-flow simulations were developed for each size and damage combination; one without the ice storm impacts (baseline scenario) and one with the changes in costs and revenues due to the storm damage (ice storm scenario). Costs with the effects of the ice storm reflect the implementation of remedial activities, and revenues were affected by the reduced syrup production. Operating costs, revenues, depreciation and income tax were calculated and used to compute the net cash flows for each year. Annual cash flows were discounted and summed to obtain the net present value of cash flows over the recovery period for both scenarios. The value of producer losses from the storm is calculated as the difference between the present value of cash flows without and with the storm. The time frame for each capital budget is the time period in which the maple trees were expected to recover from storm damage to the point that the expected yield under average weather conditions had returned to the 1 l/tap per year level. This could be achieved through a combination of individual tree recovery or through the replacement of damaged trees by new trees or trees that had been previously untapped. The length of the estimated recovery period varies with the damage class.

The analysis incorporated a number of assumptions and expert forecasts regarding the recovery rate for maple trees and the changes in costs and revenues following the storm. Sensitivity analyses were conducted in order to examine how the results were affected by changing these assumptions and forecasts. The parameters varied in sensitivity analyses include recovery times, the marginal tax rate and some of the management responses assumed. Stochastic simulation was used to reflect the effects of variability in future yields and prices.

Economic data used in the capital budgets were taken from a study conducted by the Canadian Farm Business Management Council and the Ontario Ministry of Agriculture, Food and Rural Affairs (2000). Labor was valued at a wage rate of $8.00 (Cdn) per hour (for hired labor and as the opportunity cost of self-labor) and all price and cost data are in 1999 Canadian dollars. In the absence of storm damage, syrup yield per tap per year for normal weather conditions was set at 1 l, based on recent production levels. Depending on weather conditions during the production season and on management practices, yields can vary from 0.5 to 1.5 l/tap per year (Canadian Farm Business Management Council and the Ontario Ministry of Agriculture, Food and Rural Affairs, 2000). For the stochastic simulations, syrup yield was characterized as a normally distributed random variable with a mean value of 1 l/tap per year and with 95% of the distribution between 0.5 and 1.5 l/tap per year. This produced a standard deviation of syrup yield of 0.2551 l/tap per year.

The average price of maple syrup is based on the weighted average of retail, wholesale and bulk sales according to the proportions of these sales for each size of operation. The average price for maple syrup used in this analysis is $12.76/l for a 1000-tap operation and $11.87/l for a 3000-tap operation (Canadian Farm Business Management Council and the Ontario Ministry of Agriculture, Food and Rural Affairs, 2000). Larger operations often sell proportionately more syrup to the wholesale and bulk markets. The price of syrup varies due to prices in markets for substitute sweeteners and other factors. To reflect the effects of product price variability, the annual price of syrup was modeled as a normally distributed random variable with 95% of the distribution between ±$0.92/l of the mean price, based on data from 1989–1999. We assumed that unit costs and the price of maple syrup were constant in real terms throughout the time period considered. Market level analysis conducted by Kidon et al. (2001) found that the storm did not have an appreciable effect on the market price of syrup. Additional supply from regions that were not adversely impacted by the storm was apparently able to offset the production shortfall in regions where damage occurred. In addition to the data sources identified above, in August 1999, a survey of maple syrup producers in eastern Ontario was conducted in order to gather information on changes in syrup production and sugarbush management that had occurred in the region following the 1998 ice storm (Kidon, 2000; Kidon et al., 2000).

We assumed that the sugarbush itself (land and trees), as well as sap collection equipment, sap and syrup tanks, evaporator equipment, packaging equipment, tools, structures and buildings were purchased prior to 1998, and so these costs were not included in the partial budget. A 10% depreciation rate was applied to the maple production equipment in each of the capital budget scenarios, since depreciation affects the amount of taxes paid, and in turn, net cash flows (Canadian Farm Business Management Council and the Ontario Ministry of Agriculture, Food and Rural Affairs, 2000).

Producers in eastern Ontario experienced an increase in capital costs following the ice storm. Damage to pipelines, buildings and equipment because of ice accumulation required partial or complete replacement of these assets. This new equipment was depreciated at the same 10% rate as the equipment that it replaced, but the total depreciation charge is obviously higher on this newer equipment. There has been some suggestion that this equipment replacement might have improved enterprise productivity, since newer equipment generally reflects incremental improvements in technology, but is was beyond the scope of this study to measure these productivity gains. Some producers expanded roadways into previously untapped areas of the sugarbush in order to tap new trees.

Table 1
Changes in costs for a 1000-tap maple syrup operation due damage from the 1998 ice storm

Damage class	Changes in operating costs		Changes in capital costs	
	Additional activities	Total cost per operation ($)	Additional activities	Total cost per operation ($)
Light	Additional annual bush maintenance for 2 years[1] (50 person-h/year) Tap 900 taps in 1998, 920 in 1999 and 1000 thereafter	$400 in 1998 and 1999	Replacement of tubing in 1998 (additional 1200 ft., for 50 taps)	$120 in 1998
Moderate	Additional annual bush maintenance for 4 years (100, 100, 50, 50 person-h/year) Labor for pipeline repair in 1998 and 1999 (an additional 18 h/year) Tap 600 taps in 1998, 850 in 1999 and 1000 thereafter	$800 in 1998 and 1999, $400 in 2000 and 2001 $144 for 1998 and 1999	Replacement of tubing in 1998 (additional 6000 ft., for 250 taps)	$600 in 1998
Severe	Additional annual bush, maintenance for 6 years (150, 100, 100, 50, 50 50 person-h/year) Labor for pipeline repair in 1998 and 1999 (an additional 18 h/year) Tap 550 taps in 1998, 610 taps in 1999 and 1000 thereafter	$1200 in 1998, $800 in 1999 and 2000, $400 for 2001–2003 $144 in 1998 and 1999	Replacement of tubing in 1998 (additional 12 000 ft., for 500 taps) Expansion of roadways in 1998	$1200 in 1998 $200 in 1998

Additional bush maintenance refers to the labor involved in clean-up of debris, thinning and pruning, removal of trees, etc., following the ice storm. The estimates are based on a wage rate of $8.00/h per person, a cost of new tubing of $0.10/ft. and an average cost for roadway expansion of $200 (Canadian Farm Business Management Council and the Ontario Ministry of Agriculture, Food and Rural Affairs, 2000). All monetary values in the table are in undiscounted constant 1999 dollars.

Maple production operating costs include labor for sap collection, processing and maintenance, syrup processing materials, fuel, electricity and other expenses, such as advertising and tap rental. These costs are incurred annually. Producers also experienced increases in operating costs involving sugarbush maintenance, equipment maintenance, thinning and pruning. Fallen debris from damaged branches needed to be removed so that the sugarbush would be accessible and safe for tapping activities. Some damaged trees required additional pruning to remove broken limbs, or whole trees may have been removed if the damage was severe enough. We assumed that there are a sufficient number of trees within the sugarbush which had not been previously tapped to replace any that die. This assumption is based on available data which indicate that very few trees, mainly those with extremely severe damage, are showing signs of early mortality since the 1998 ice storm (Boulet, 2000). The results of the maple producers' survey also indicated that many producers have made up for lost taps by tapping new trees.

Tables 1 and 2 list the estimated changes in capital and operating costs for each operation size and damage class as determined by the results of the maple producers' survey and discussion with agroforestry experts (Kidon, 2000; Kidon et al., 2000). The changes in costs represent the situation for the mean damage rating within the range of crown loss for each of the damage categories.

Revenue from syrup sales depends on the price of syrup, the yield of syrup per tap and the number of taps in the sugarbush. Following the ice storm,

Table 2
Changes in costs for a 3000-tap maple syrup operation due to damage from the 1998 ice storm

Damage class	Changes in operating costs		Changes in capital costs	
	Additional activities	Total cost per operation ($)	Additional activities	Total cost per operation ($)
Light	Additional bush maintenance for 2 years (150 h/year) Tap 2700 taps in 1998 and 2760 in 1999, 3000 thereafter	$1200 in 1998 and 1999	Replacement of tubing in 1998 (3600 ft. for 150 taps)	$360
Moderate	Additional bush maintenance for 4 years (300, 200, 100, 100 h/year)	$2400 in 1998, $1600 in 1999, $800 in 2000 and 2001	Replacement of tubing in 1998 (additional 18 000 ft., for 750 taps)	$1800
	Pipeline repair in 1998 and 1999 (an additional 54 h/year) Tap 1800 taps in 1998, 2250 in 1999 and 3000 thereafter	$432 in 1998 and 1999		
Severe	Additional bush maintenance for 6 years (500, 200, 150, 150, 100, 100 h/year)	$4000 in 1998, $1600 in 1999, $1200 in 2000 and 2001, $800 in 2002 and 2003	Replacement of tubing in 1998 (additional 36 000 ft., for 1500 taps)	$3600
	Pipeline repair in 1998 and 1999 (an additional 54 h/year) Tap 1650 taps in 1998, 1830 in 1999 and 3000 thereafter	$432 in 1998 and 1999	Expansion of roadways in 1998	$200

See Table 1.

many producers reduced the number of taps in their operation because of access limitations and to minimize stress on the damaged trees. The Ontario Ministry of Agriculture, Food and Rural Affairs recommended that producers reduce their tapping intensity by at least 1 tap per tree following the ice storm in order to minimize additional stress on damaged trees (Ontario Ministry of Agriculture, Food and Rural Affairs, 1998). Many producers who were interviewed in the producers' survey reported reducing the number of taps in their operation in the 1998 and 1999 seasons. This information was used to estimate the reduction in the number of taps per operation. On average, producers in each of the damage classes reported planning to return to pre-storm tapping levels in the 2000 season.

Table 3 reports our projected yield calculations for the three damage classes. The reduced syrup yields in 1998 and 1999 experienced by producers in the three damage categories were calculated from our survey results (Kidon, 2000; Kidon et al., 2000). After 1999, future yields consequent to storm damage for each damage category were linearly projected from the 1999 reduced yield to an average yield of 1 l/tap per year at the end of the estimated recovery periods of 5, 10 and 15 years for the light, moderate and severe classes, respectively (Dave Chapeskie, personal communication).

Income from farm activities is taxed by both the federal and Ontario provincial governments. It was assumed in this study that the combined federal and provincial marginal tax rates are

Table 3
Projected mean annual syrup yield for each damage class during the ice storm recovery period

Year	Mean annual syrup yield (l/tap)		
	Light damage	Moderate damage	Severe damage
1998	0.72	0.54	0.39
1999	0.93	0.87	0.68
2000	0.96	0.88	0.71
2001	0.98	0.9	0.73
2002	1	0.92	0.75
2003	1	0.93	0.78
2004	1	0.95	0.81
2005	1	0.97	0.83
2006	1	0.98	0.85
2007	1	1	0.88
2008	1	1	0.9
2009	1	1	0.93
2010	1	1	0.95
2011	1	1	0.98
2012	1	1	1

Source: Kidon (2000).

approximately 25% and 40% for the federal tax brackets, respectively (Revenue Canada, 2000). Following Kidon et al. (2001) and Kula (1984), a real 5% discount rate was used to discount all annual cash flows in terms of 1999 dollars.

Palisade @Risk® and Microsoft Excel® were used to generate interval estimates of storm damage, based on the distributions for prices and syrup yields discussed above. During each iteration of the stochastic simulations, a draw from the yield distribution during the recovery period was multiplied by the weighted-average reduced yield from Table 3. The same draw from the yield and price distributions was applied to both the with and without storm scenarios to make sure that a simulated year with good prices or good weather affected revenues from damaged and undamaged trees consistently. Simulations of 1000 iterations were executed. This process generated an interval estimate of the value of losses from the storm.

3. Results

The expected net present value of losses and the associated 95% confidence intervals for each of the six size and damage types are reported in Table 4. The average net present value of losses for 1000-tap operators with light, moderate and severe damage was $5385, $13 821 and $28 721 per operation, respectively. The corresponding values for 3000-tap operations were $14 160, $37 399 and $75 630. These enterprise-level losses represent approximately 10–20% of the present value of normal gross revenues. Throughout our analysis, *Z*-distribution large-sample hypothesis tests were used to determine whether mean losses were significantly different across damage categories for a given operation size (a two-tailed test) and whether mean losses were significantly greater than the value of assistance (a one-tailed test). Both types

Table 4
A comparison of estimated losses and assistance for representative eastern Ontario maple syrup producers

Representative producer category		Recovery period (years)	Present value of expected losses due to ice storm ($/farm)	95% confidence interval for expected losses ($/farm)	Losses of normal gross revenues[a] (%)	Average financial assistance ($/farm)
Size	Damage class					
1000 tap	Light	5	$5385	$4253–6517	9.3	$3760
	Moderate	10	$13 821	$10995–16647	13.3	$16 930
	Severe	15	$28 721	$24606–32836	20.6	$27 269
3000 tap	Light	5	$14 160	$10497–17823	8.7	$11 280
	Moderate	10	$37 399	$29579–45219	13.0	$48 706
	Severe	15	$75 630	$64282–86979	19.5	$77 899

All losses are on a per-operation basis.
[a] Losses as a percentage of the present value of gross revenues in normal years (without the ice storm) over the recovery period (using a 5% discount rate).

Table 5
Sensitivity analysis results

Representative producer category		Losses in base scenario ($/farm)	Scenarios					Average financial assistance ($/farm)
Size (taps)	Damage category		Faster recovery ($/farm)	Slower recovery ($/farm)	40% marginal tax rate ($/farm)	Minimal maintenance response ($/farm)	No additional trees available ($/farm)	
1000	Light	$5385	$4700	$5933	$4785	$5215	$10 254	$3760
	Moderate	$13 821	$12 336	$14 977	$12 524	$12 598	$20 151	$16 930
	Severe	$28 721	$23 717	$39 513	$25 908	$32 040	$40 513	$27 269
3000	Light	$14 160	$12 277	$15 667	$11 637	$13 765	$26 365	$11 280
	Moderate	$37 399	$33 304	$40 622	$31 800	$35 055	$51 744	$48 706
	Severe	$75 630	$61 831	$105 652	$64 515	$86 094	$104 411	$77 899

of test were performed at a 5% confidence level. Within each operation size, the expected losses for the three damage classes were found to be statistically significantly different from one another. Estimated losses represent approximately 10% of the present value of gross revenues for the light damage categories. Losses increase to almost one-fifth of the present value of normal gross revenues for the severe damage categories. A 3000-tap operation had lower expected losses per tap than a 1000-tap operation in the same damage class.

The average government financial assistance that was available to each producer type was calculated and compared to the estimated losses. The main source of financial assistance for maple producers in eastern Ontario was the Eastern Ontario Disaster Relief Assistance program. These values are reported in the last column of Table 4.

For both sizes of operations in the light damage category, the net present value of losses is significantly greater than the average amount of assistance. This likely occurs because producers in the light damage category received assistance for additional equipment and clean-up costs, but not for tree loss or damage. Producers with moderate and severe damage were eligible for assistance for tree loss or damage. Expected losses for producers in the moderate category are statistically significantly less than the average amount of assistance. Expected losses for the severe damage class are fairly close to the financial assistance available to these producers. The difference between average financial assistance for a 1000-tap operation with severe damage and the present value of expected losses was only approximately $1400. The average assistance in this case falls almost in the middle of the 95% confidence interval for the present value of losses, so that there is a 77% probability that losses will exceed the amount of assistance for the 1000-tap operator with severe damage. The difference is somewhat larger in absolute terms for a 3000-tap operation, amounting to approximately $2300, so that the probability of losses exceeding assistance is approximately 36% in this case. However, in each of these situations, the average level of compensation falls well within the 95% confidence interval for our loss estimates. Given the lack of information available to policy makers when program parameters were set for assistance, this a remarkably close correspondence between estimated damage and average assistance.

Table 5 reports the enterprise-level expected losses for four sensitivity analyses to illustrate the effect of varying some key assumptions in our model. The recovery time for the light damage class was varied to 3 and 7 years and for the moderate class to 7 and 13 years. For the severe category, the estimated recovery time was varied from 15 to 10 and 30 years. Not surprisingly, faster recovery would mean smaller losses and slower recovery means larger ones. Losses would increase by up to 40% with slower recovery in the severe damage category, since the recovery time is doubled from 15 to 30 years.

We increased the marginal tax rate from 25% to 40% in order to examine the effects of the storm on producers whose overall personal income placed them in a higher income tax category. Expected losses for each of the representative producer categories are statistically significantly lower with a 40% marginal tax rate.

The minimum maintenance response examined the effects of not conducting selected remedial activities on estimated storm damages. In this scenario, we assumed that the producer did not carry out any additional pipeline or sugarbush maintenance during the recovery period. No roadways were expanded. This is in comparison to the base scenario, for which the additional bush and pipeline maintenance costs described in Tables 1 and 2 were incurred. The assumption that producers replaced tubing in 1998 was maintained, since it was assumed that the number of taps did not change from the base scenario and tubing replacement is most likely necessary to meet this condition. We also assumed that because no additional sugarbush maintenance (including pruning and thinning) was conducted, longer recovery periods of 7, 13 and 30 years would occur. This was based on the idea that thinning and pruning help the trees to recover more quickly from damage by removing wounded limbs (which are more prone to disease or pests) and help to improve the growth and vigor of the tree (Koelling and Heiligmann, 1996). This scenario defines the trade-off between additional maintenance costs and the benefits of faster recovery, which are important in determining the net benefits of these activities.

For the light damage categories in both operation sizes, expected losses in this scenario were less than the base scenario by approximately 3%. However, since the gain, in the form of lower expected losses, is small, it is likely prudent for producers to undertake these remedial actions to avoid the risks associated with longer recovery. Similarly, in the moderate damage categories, expected losses decreased by 6–9% under the minimal maintenance scenario. Again, this represents a small potential benefit and the additional costs may be worthwhile from a risk management perspective. It is also important to recognize that there are other criteria, such as maintaining the aesthetics and safety of the sugarbush for tourists and neighbors, that make the additional maintenance valuable. Because the severe damage categories involved a significantly longer recovery time, expected losses under the minimal maintenance response increased by 11–14% from the baseline. In this case, the additional maintenance costs are less than the present value of the benefits from faster recovery, and additional maintenance is advantageous.

The results of the producers' survey and discussion with agroforestry experts in eastern Ontario revealed that in order to make up for lost taps, many producers tapped previously untapped new or younger trees after the ice storm. This indicates that there is some capacity to shift production to previously untapped trees after the storm. Therefore, the conservative tapping guidelines (i.e. reduced number of taps per tree) recommended by the Ontario Ministry of Agriculture, Food and Rural Affairs could be followed without significantly reducing the total number of taps in the operation. The base scenario therefore assumed that maple operations would return to their pre-storm number of taps by the year 2000, which was supported by the Kidon et al. (2000) survey results. However, not all producers have access to additional trees. We examined the impact of the storm on a producer who did not have additional trees. The second last column of Table 5, under the heading of 'No additional trees available', indicates that losses substantially increase for producers in this situation relative to our baseline results.

4. Concluding comments

This study characterized the expected net present value of losses for six operation sizes and damage levels for maple syrup producers in eastern Ontario as a result of the 1998 ice storm. Variability in yields and prices was incorporated into the analysis. Because of the uniqueness of the 1998 ice storm and the deficiency in information regarding the response of maple trees to ice storm damage, incorporating variability and conducting sensitivity analyses were important since they illustrated the range of potential impacts.

Estimated enterprise-level losses were generally in the range of 10–20% of the present value of normal gross revenues for each size category. The average level of government financial assistance for each of the size and damage categories was generally remarkably close to our estimates of losses. The divergences that were observed between expected losses and assistance are modest considering the time frame and uncertainty under which the assistance programs were devised. For producers in the moderate and severe damage categories, their losses are likely fully or nearly offset by financial assistance. Producers in the light damage category will likely experience some losses net of assistance, but these will be small, since these producers were least affected by the storm.

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