

Impacts of Heavy Snowfall During December 1989 in the Lake Erie Snowbelt

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ABSTRACT

December 1989 was the coldest December on record in the Lake Erie snowbelt. Snowfall totaled 100 to 200 cm, twice the average December snowfall. The snow had minimal impacts on schools districts. Over half (54%) of the districts had no closures due to snow but costs for snow removal increased for schools. Ski centers reported a 50% to 100% increase in revenues over December 1988 and the best December skiing in many years. Lake ports had higher operating costs and loss of shipments. Costs for snow and ice control on Interstate 90 in the snowbelt increased at least \$1326/km over December 1988, but traffic flow was maintained. Person-hours spent on snow and ice control on I-90 increased 59%. An average of 111,000 kg/km (200 tons/mile) of salt and grit was spread on Interstate 90, an increase of 50,000 kg/km (89 tons/mile) over December 1988. Colleges, airports, and viticulture had only minor disruptions due to the snow.

INTRODUCTION

December 1989 was the coldest December of the century in the Great Lakes region (Climate Analysis Center, 1990). Unusually cold winter temperatures generally bring excessive snowfall to the snowbelts of the Great Lakes (Eichenlaub, 1970, Schmidlin, 1989). This pattern held in December 1989 as the persistent flow of arctic air across the lakes brought frequent lake-effect snowfall to the snowbelts. Numerous societal impacts of snowfall have been documented by others, but previous research focused on urban areas (Rooney, 1967; de Freitas, 1975). The goal of this research was to sample and describe the impacts of the heavy snow of December 1989 on human activities in the Lake Erie snowbelt.

THE REGIONAL SETTING

The Lake Erie snowbelt lies southeast of the lake from the eastern suburbs of Cleveland to the southern suburbs of Buffalo and extends about 80 km inland (Eichenlaub, 1970). Its boundaries are not firmly defined, but may be reasonably defined as that area with a mean annual snowfall of 200 cm (80 inches) or more (Figure 1). Lake effect snow occurs outside the snowbelt but mean snowfall is roughly doubled by the influence of the lake within the boundaries indicated (Eichenlaub, 1970; Changnon and Jones, 1972; Schmidlin, 1989). Average annual snowfall within the Lake Erie snowbelt is greatest, about 500 cm (200 in) on the highest ridges of western New York. Elevations within the snowbelt range from 175 m at the lake shore to 670 m on the highest ridges.

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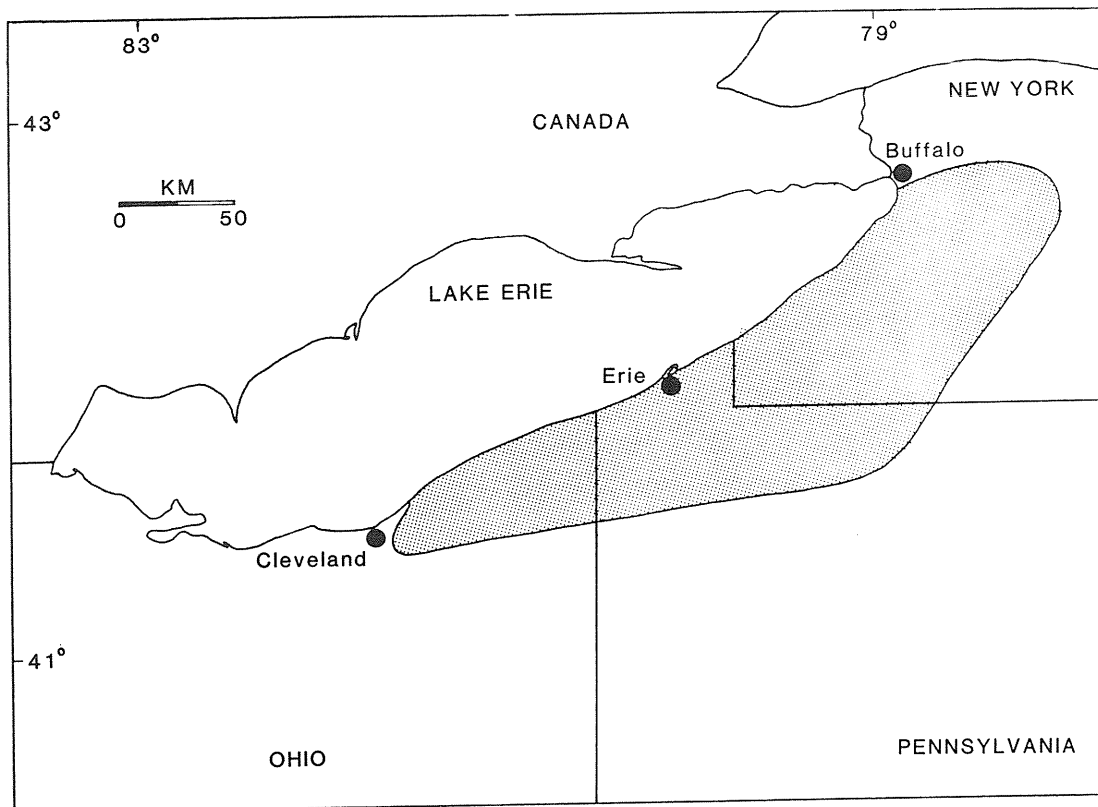


Figure 1. The Lake Erie snowbelt.

Population in the snowbelt is approximately 1.8 million. The major population centers are Erie, Pennsylvania (1987 metropolitan population 282,000), and portions of the Cleveland and Buffalo metropolitan areas. The flat land within 10 km of the lake shore forms a major agricultural, industrial, and transportation corridor with Interstate 90, U.S. Route 20, and rail lines parallel to the lake. Elsewhere, the landscape in the snowbelt is rolling to hilly with a patchwork of farms, forests, and numerous small communities. Drainage is primarily through small streams into Lake Erie but includes the upper portion of the Allegheny River which flows south into the Ohio River.

THE WEATHER OF DECEMBER 1989

Temperatures were below average nearly every day of the month and significant thawing did not occur until the last day of December (data are from NOAA/Climatological Data, by state). Overall, the average temperature for December 1989 in the Lake Erie snowbelt was about -9C (15.5F), which was 7C (13F) below the 1951-80 mean. Extreme minimum temperatures were in the -15C to -18C (5 to 0F) range along the lake shore but were colder than -25C inland from the lake (Figure 2). Minimum temperatures of -30C (-22F) in the Ohio portion of the snowbelt on December 24 were among the coldest December temperatures ever recorded in those regions.

Total snowfall for December 1989 was about twice the 1984-88 average. In general, the core of the snowbelt received 130-200 cm (50-80 in) of snowfall (Figure 3). The greatest total at an official station was 212 cm (83.5 in) at Sinclairville, New York. The National Weather Service at Erie, Pennsylvania, measured 170 cm (66.9 in) which was the greatest recorded for any month in over 100 years of record-keeping there. As is usual in lake-effect snowstorms, the snowfall pattern on individual days was very complex with snow squalls giving

30-40 cm in narrow bands 5-10 km wide. An example of this occurred on December 20 as an intense narrow band of snow developed over Erie County, Pennsylvania. This event gave 49 cm (19.2 in) of snow to Erie in 24 hours, including 30.5 cm (12 in) in 3 hours.

Measurable snow fell on 20 to 25 days during December 1989 in the snowbelt. The greatest amounts fell during the first and third weeks of the month. During the period December 15-22, snow totals ranged as high as 100 cm (40 in) at Sinclairville, New York, 78 cm (31 in) at Colden, New York, and 71 cm (28 in) at Chardon, Ohio. Depths reached 50-75 cm (20-30 in) across much of the region by Christmas. The depth of 99 cm (39 in) at Erie on December 21 exceeded the previous record depth of 76 cm measured in January 1985. Lake-effect snow is generally of low density. The 30.5 cm of snowfall measured at Erie in three hours on December 20 melted to only 0.66 cm of water to give a density of 0.022 g/cm³ and a snow/water depth ratio of 46:1. Snow/water ratios of 20:1 to 35:1 were common in daily snowfall. The 99 cm (39 in) deep snowpack at Erie on December 21 contained only 5 cm of water.

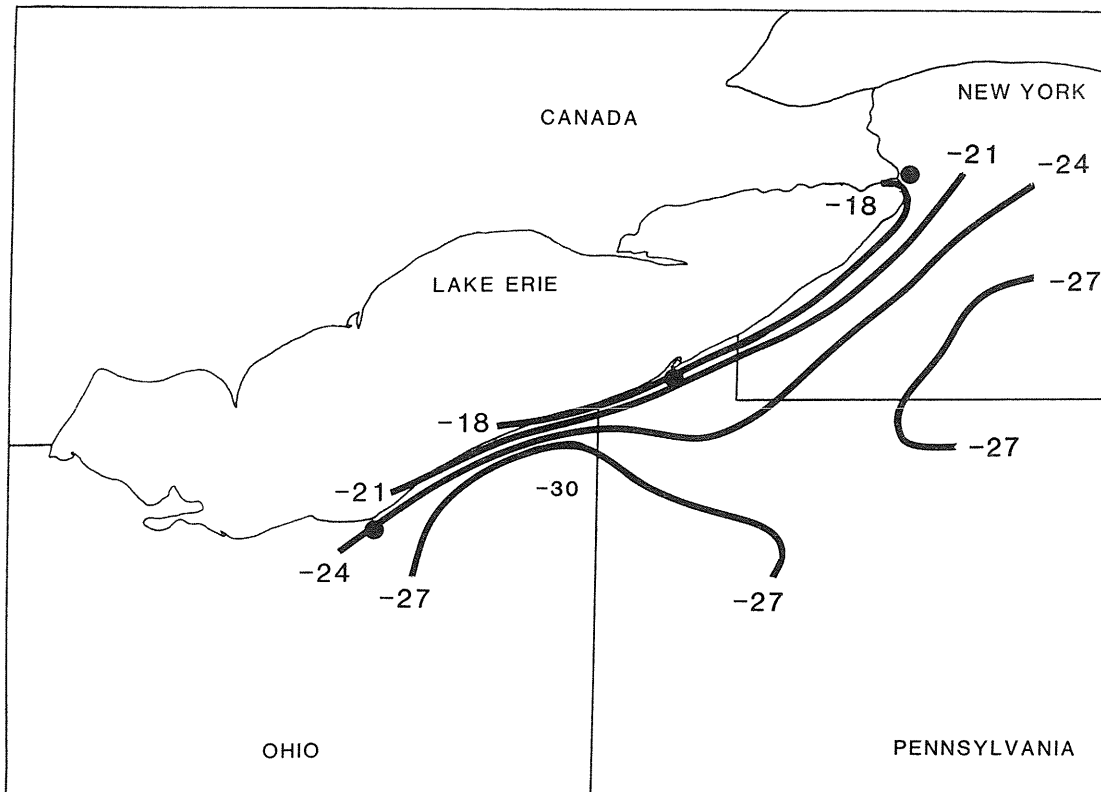


Figure 2. Minimum temperature (C) during December 1989.

IMPACTS ON THE REGION

Research on the impacts of heavy snow was completed primarily through surveys of affected segments of the society. Summaries are given below from surveys of school districts, colleges, ski centers, agriculture, lake ports, airports, highway departments, and retail outlets of winter goods. Other segments of society, such as health care, highway safety, general retail sales, and others, were undoubtedly affected but were not surveyed here.

School Districts

Surveys were sent to 52 school district superintendents in the Lake Erie snowbelt of Ohio, Pennsylvania, and New York. Replies were received from 39 (75%) districts. The last scheduled day of classes before Christmas break was December 20, 21, or 22 for 87% of the districts. Snowfall during December 1-22, 1989, accounted for about 90% of the monthly total in the snowbelt.

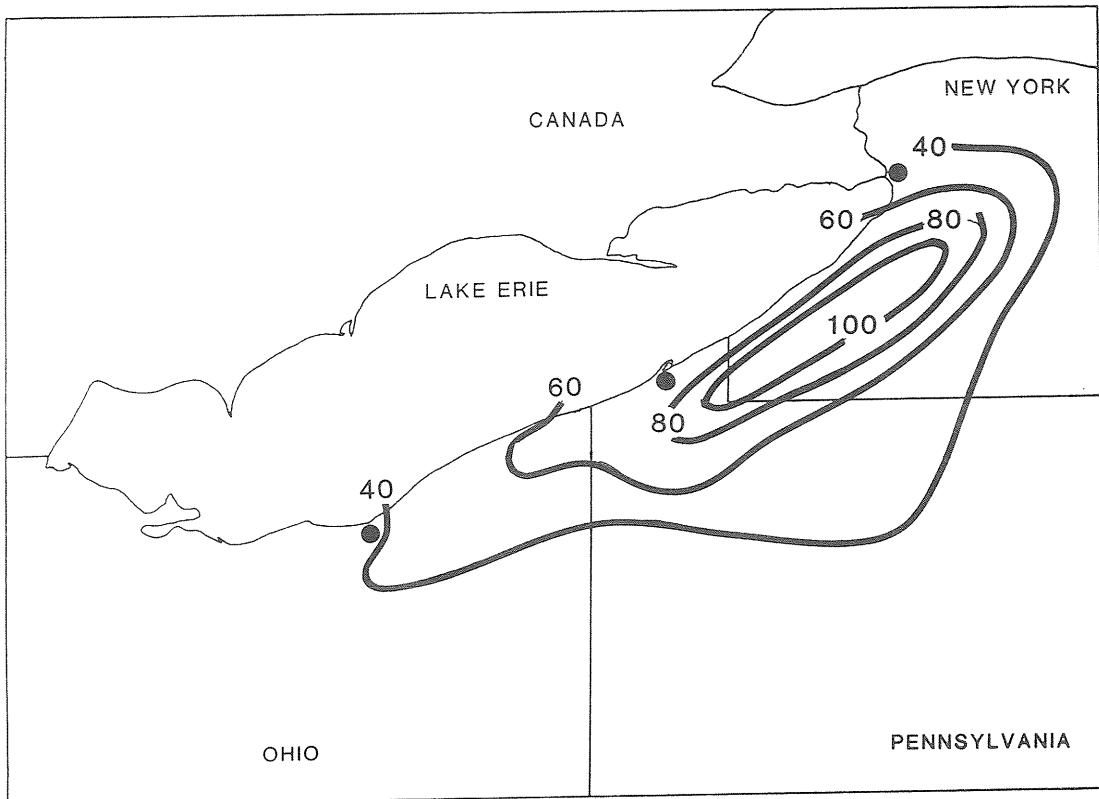


Figure 3a. Average December snowfall (cm) for 1984-88.

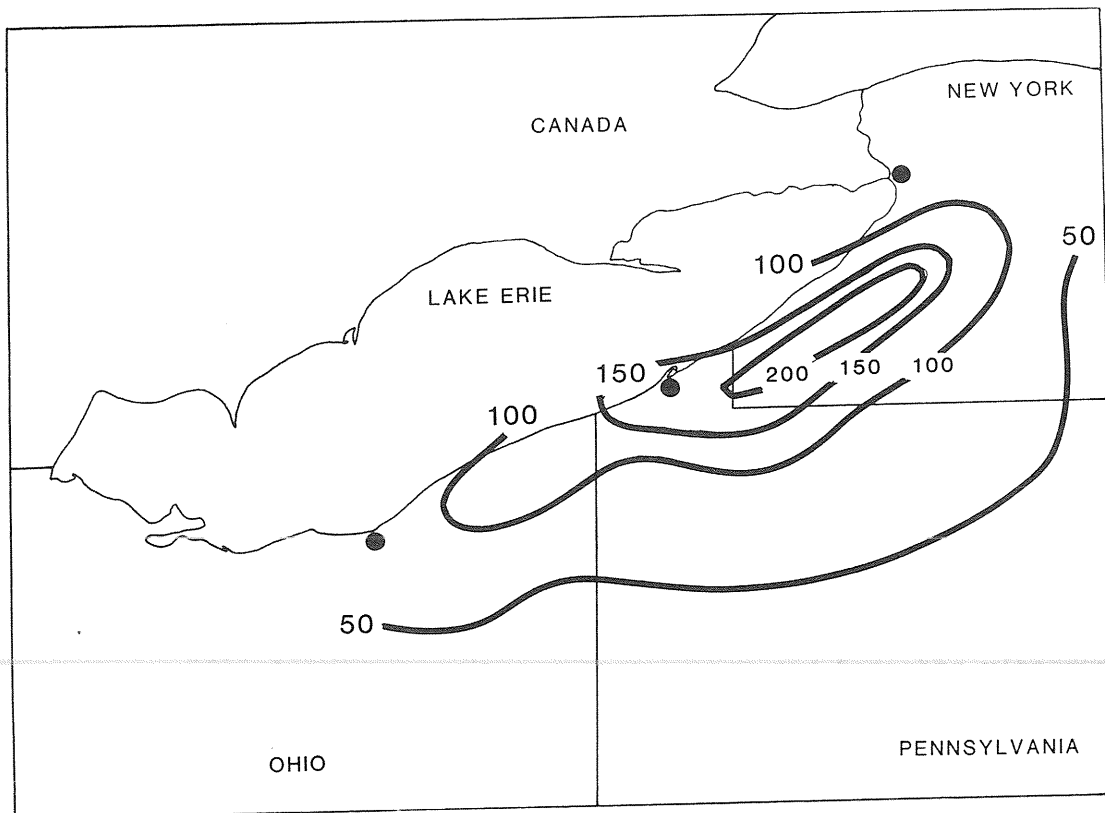


Figure 3b. Snowfall (cm) during December 1989.

Impacts of the unusually intense snow and cold on schools were minor. More than half of the districts (54%) reported no weather closures of schools during December 1989. Schools were closed for one day in 41% of the districts and for two days in 5% of the districts. More school districts reported closures in December 1989 than during December 1988 (46% vs. 10%) but most of the 1989 closures were for only one day and this represented only a minor disruption.

Snow removal operations proceeding normally in 59% of the districts. Of the districts reporting that unusual measures were taken for snow removal, most reported that extra equipment was required to remove the snow. Others reported that more overtime was paid to employees involved in snow removal and more sand and salt were used on parking lots and sidewalks. Several (18%) districts brought in heavy equipment, such as bulldozers and front-end loaders, to move snow when piles of snow prevented further plowing. Some of these services were provided by outside contractors.

The final question of the survey asked of any other impacts of the weather during December 1989 in the school district. Thirty-six percent indicated there were no other weather impacts in the district. However, 33% mentioned higher fuel costs to heat buildings and 23% noted the additional expenses for snow removal. Among the other impacts mentioned by school superintendents were:

- a) the need to remove ice dams from eaves above building entrances.
- b) cancellation of after-school sporting events
- c) rescheduled Christmas concert
- d) lower attendance due to snow and illnesses
- e) weather-related distractions from school work were more numerous than usual
- f) fewer absences in grades K-3, students were more focused on their studies.

One superintendent noted that school disruptions were minimal because most of the snow fell on weekends. Two other districts explained that their schools were prepared for heavy, frequent snow, since they are in the snowbelt. Another noted that the winter weather of December 1989 and other recent winters was not as bad as in the late 70's.

Colleges

There are no major universities within the Lake Erie snowbelt, as the snowbelt is defined here to exclude the cities of Cleveland and Buffalo. Three state universities or colleges with a total enrollment of 16,850 were surveyed - the State University of New York College at Fredonia (5400 students), Edinboro University of Pennsylvania (7500), and the Ashtabula Branch of Kent State University, Ohio (950). The last day of classes before the winter break was December 15 or 16 at all three.

There were no weather closures at these colleges except at the Ashtabula Branch of Kent State University where the campus was closed by snow on the last day of final exams. All students with exams on that day were given "incomplete" grades for those courses and the final exams were rescheduled. Other impacts at the campuses were minor and involved increased time and expenses for maintenance staff to remove snow and an increase in fuel used for heating buildings.

Ski Centers

Seven ski centers were surveyed - two in Ohio and five in the New York portions of the snowbelt. Not surprisingly, this segment of the economy profited from the cold, snowy weather. The seven ski centers averaged 29 days of skiing in December 1989, up from 21 days in December 1988, and four of the seven were open every day of the month. An increase in business over December 1988 was reported at all ski centers. One center reported that ticket sales exceeded any December in their 27 years of operation and revenues were up 110% over last year. In general, ticket sales and revenues were up 50% to 100% over 1988. The ski centers attributed the large increase in business to the weather and good snow conditions, rather than expansions or the general economy. Some reported the finest December skiing in years with excellent snowmaking conditions. One center noted that the weather of December 1989 allowed a deep base of snow to form which helped them survive the subsequent warm January. Several centers reported that bitterly cold weather and road closures hurt business on a few days.

Agriculture

Winter is a dormant period for agriculture in the Lake Erie snowbelt. However, grapes are grown on 15,000 ha (39,000 acres) of lake shore land in the snowbelt and this perennial vine is susceptible to winter cold damage. County extension agents indicated that winter damage was minimal. Snow cover is beneficial to the grapevine as an insulative cover from extreme winter cold. Minimum temperatures in the grape-growing areas were only -15C to -20C (5F to -4F), well above the critical winter temperature of -25C. Persistently cold temperatures during December allowed the vines to "harden" against the month's coldest temperatures on December 24.

Negative impacts of heavy snow reported from agricultural interests included a reduction in time available for winter pruning of grapevines and an increase in time spent on snow removal on farms. Three barns collapsed from the snow load in Erie County, Pennsylvania. Deep snow cover reduced freeze-up of rural pipes in the extreme cold temperatures.

Lake Ports

The combination of cold and snow affected operations at the Lake Erie ports. Ice covered western Lake Erie by mid-December and covered virtually the entire lake by December 25 (R.A. Assel, NOAA/GLERL, personal communication). This was about two weeks earlier than usual and obstructed shipping on Lake Erie and between Lake Erie and the upper lakes. Shipping schedules were uncertain so planning for port crews and facilities was difficult. At the Port of Conneaut, Ohio, the combination of cold and snow increased operating costs by 240%, increased mechanical failures by 310%, and caused 33% employee absenteeism. Ice-bonding agents, used to prevent freeze-up of port conveyor systems, were used extensively and conveyors were kept running continuously after mid-month to prevent freeze-up and start-up delays. The result was a 55% reduction in production levels. Approximately 500,000 gross tons of iron ore destined for the port of Ashtabula, Ohio, were not delivered during December due to ice conditions on Lake Erie.

Airports

Surveys were sent to seven airports and replies came from three. The largest, Erie International Airport where December 1989 snowfall totaled 170 cm, had 3258 take-offs and landings during December 1989 with 25,611 commercial passengers. Monthly statistics on snow and ice removal costs are not kept by the Erie International Airport, but were reported to have been above average. The Erie Airport was closed occasionally by snow during December but for no longer than six hours. The number of take-offs and landings at Erie was down 7% compared to December 1988 but commercial passenger traffic was up 6%. The other airports surveyed were small county facilities. The Geauga County Airport (OH) reported one day with a closed runway due to poor braking conditions in snow and twice as much plowing as usual for December. Activities at the Corry-Lawrence Airport (PA) proceeded as usual for December and were not adversely affected by the weather.

Highway Maintenance

Frequent snowfall can have major impacts on highway travel and costs for snow removal. Costs of snow and ice control include labor, equipment, and materials applied (Cohen, 1981). Detailed summaries of impacts of December 1989 snowfall on maintenance of Interstate 90 were obtained from the offices of the Ohio Department of Transportation (ODOT) in Lake and Ashtabula Counties and from the Westfield Section of the New York State Thruway Authority in Chautauqua County. The ODOT offices are responsible for the maintenance of 90 km of Interstate 90, which runs along the Lake Erie shore in the snowbelt. The Westfield Section of the Thruway Authority maintains 45 km of Interstate 90 along the lake shore.

Interstate 90 was kept open in Lake, Ashtabula, and Chautauqua Counties throughout December. The count of 321,630 vehicles that crossed the Pennsylvania-New York border on I-90 during December 1989 was only 3.5% fewer than during December 1988. The cost of this effort was greater amounts of material spread on the highway, overtime paid to road maintenance crews, and more truck use for snow and ice removal (Table 1). The average of 111,000 kg/km (200 tons/mile) of salt and grit spread on I-90 in the snow belt during December was 50,000 kg/km (89 tons/mile) greater than during December 1988. Using estimates of direct costs for wages and materials, the highway departments spent an

additional \$1326/km on snow and ice control on I-90 in Lake, Ashtabula, and Chautauqua Counties during December 1989 compared to 1988. If this figure is extrapolated over the entire 280 km of I-90 in the snowbelt, an additional expense of \$371,000 was incurred for snow and ice control on this highway during December 1989. This estimate is likely to be low because only direct costs were considered. Costs for increased equipment time on loaders in the maintenance yards and for repair of increased weathering of potholes and joint cracking were not considered in this analysis.

Retail Sales of Winter Goods

The least successful of the efforts to sample impacts of the December 1989 snowfall was a survey of retail outlets that specialize in winter goods. Of 34 surveys mailed to retail outlets dealing in ski equipment, hardware, snow removal, and snowmobile sales or repair, only 15% returned the survey. Thus, these results represent a very small sample of a large industry.

Replies came from three sporting goods stores and two hardware stores. An increase in sales of winter goods was reported from all respondents. The sporting goods stores reported a 15% to 65% increase in sales. A sporting goods store in a small town attributed their increase in sales to the fact that local residents were inhibited by snowy roads and did not drive to larger cities to make purchases. A hardware store reported a 20% increase in sales of snow-related equipment but decreased sales overall due to the frequent snowfall. Among items that sold well in hardware stores were snow shovels, snow blowers, sidewalk salt, and gutter heat tape (to prevent ice dams). One sporting goods store reportedly made extra efforts to remain open even in the worst weather because their skiing customers expected that service from a dealer of winter sporting goods.

CONCLUSIONS

This research sampled segments of society in the Lake Erie snowbelt that may have been affected by the unusually cold and snowy weather of December 1989. Snowfall totaled 100 to 200 cm, about twice the December average. School districts maintained nearly normal operations through the month although extra expenses were incurred for snow removal and heat and some after-school events were cancelled. Colleges and universities similarly maintained nearly normal operations. Downhill ski centers experienced the best December skiing conditions in many years and sales were 50% to 100% greater than the previous year. Skiing was available nearly every day during December 1989. Agricultural impacts were minimal due to the dormant nature of winter agriculture in the region and the protective properties of snow cover in vineyards. Ports on Lake Erie lost revenues and had increased equipment costs due to the frequent snow, severe cold, and early ice on Lake Erie. Interstate 90 had no closures but hours spent on snow and ice control increased 59% and the amount of salt and abrasives spread on the road increased 82% over December 1988.

Negative impacts of excessive snowfall in the lake Erie snowbelt were most evident in transportation industries. These impacts took the form of increased costs to prevent disruptions. Positive impacts were most evident in the skiing industry. From this study, it appears that many aspects of society, including schools and agriculture, had minimal impacts from the heavy snowfalls. Using Rooney's (1967) hierarchy of snow disruptions, many activities in Lake Erie snowbelt displayed third order (inconvenience) disruptions from the snowfall of December 1989. Previous research has shown that societies in the traditionally snowy climates, where significant snow is experienced each year, cope relatively well with snowstorms (Rooney, 1967, 1969). Snowfall with a low water content, as is typical of lake effect snow, is easier to cope with than heavy, dense snowfall (Rooney, 1967). The study of snow impacts on society presented here agrees with those earlier conclusions. Costs for coping with the greater snowfall of December 1989 in the Lake Erie snowbelt increased over recent years, but serious disruptions were minimal.

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Table 1. Comparison of snow and ice control operations on I-90 in Lake and Ashtabula Counties, Ohio, and Chautauqua County, New York, during December 1988 and 1989. Numbers are combined for all three counties unless specified.

	December		Increase
	1988	1989	
Days working snow and ice control			
Lake County	17	26	53%
Ashtabula County	19	28	47%
Chautauqua County	10	22	120%
Regular person hours expended	2882	4738	64%
Overtime person hours expended	2822	4314	53%
Truck kilometers	95,918	149,944	56%
Materials			
Salt (kg)	5,278,622	8,493,842	61%
Ice grits (kg)	2,996,927	6,532,602	118%

Note: Ice grits are a mix of gravel, limestone, cinders, and other abrasives that are mixed with salt to provide traction. The use of ice grits is increasing due to environmental concerns over use of highway salt, abandonment of the "bare-pavement" policy on I-90 in Ohio, and the lower cost of ice grits compared to salt.