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STATE OF ILLINOIS

DEPARTMENT OF REGISTRATION AND EDUCATION



*Record Winter Storms in Illinois,
1977-1978*

by STANLEY A. CHANGNON, JR., and DAVID CHANGNON



ILLINOIS STATE WATER SURVEY

URBANA

1978

REPORT OF INVESTIGATION 88



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Reference: Changnon, Stanley A., Jr., and David Changnon. Record Winter Storms in Illinois, 1977-1978. Illinois State Water Survey, Urbana, Report of Investigation 88, 1978.

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Record Winter Storms in Illinois, 1977-1978

Stanley A. Changnon, Jr., and David Changnon

ABSTRACT

The Midwest, including Illinois, experienced in 1977-1978 its most severe winter since weather records began in the early Nineteenth Century. The major impact in Illinois came from a record-breaking number of 18 severe winter storms. In a normal year only 4 storms occur. The record winter began with three snowstorms in late November and ended with an extremely damaging ice storm in late March. Unusual snow patterns occurred with several storms and they lasted in Illinois much longer than usual. Weather conditions (low pressure centers) producing many of the storms were more often of Canadian origin than usual, and these lows had lower pressure and moved slower than normal, resulting in higher surface winds and longer lasting and hence more severe storms. Cold temperatures coupled with the frequent snowstorms resulted in record long lasting snow cover with up to 120 days with 1 inch or more cover in northern Illinois and 90 days in southern Illinois.

The storms led to deaths of 62 persons and injuries to more than 2000. Utilities and communication systems suffered great losses due to damages to lines, poles, and towers. Transportation losses included damaged vehicles, delayed shipments, and great delays in bus and airline service; however, railroads benefited with increased usage and helicopters and snowmobiles proved valuable in rescue service. The local, state, and federal institutions were beset with enormous and costly problems including care of roads and lost taxable income due to absenteeism.

INTRODUCTION

Record winter storms and the resulting record totals of snowfall, accumulations of ice, and snow coverage occurred in Illinois during the winter of 1977-1978. Eighteen major storms occurred in 4-month period, bringing losses that caused an enormous economic impact and great human suffering with 62 deaths and more than 2000 injuries. The severity of these storms impacts on the design of future structures and on the individual and institutional adjustments to be considered in future years.

It is not easy to specifically name one winter as being worse than another over a large area, particularly when one considers the amount of snowfall, the length of the winter, and the severity of the temperatures. Nevertheless, by most standards, the winter 1977-1978 in Illinois will rank as one of the worst since Illinois was settled more than 180 years ago. This monstrously severe winter, which claimed many lives and cost billions of dollars, has had a great and continuing impact on the industry, commerce, utilities, and local and state governments of Illinois.

Review of Severe Winters

The severity of winter is often characterized by certain conditions. For example, in the past, Illinois has had extremely cold periods of 1 to 2 months duration, with or without much snowfall. Examples of extremely cold, short

winters of this kind are the December 1976—January 1977 period with an average temperature of 17.0°F (−8.3°C) and the December 1917—January 1918 period with a mean temperature of 16.8°F (−8.4°C). However, neither of these periods was accompanied by excessive snowfalls nor prolonged cold and heavy snow cover throughout the typical 4-month winter of Illinois which generally lasts from late November through late March.

Another important way that Illinois winters have been categorized is by the severity of the snowfall, including the amount that falls, the frequency of severe winter storms, and the duration that snow covers the ground. A classical example of an extreme snow situation is the famous winter of 1830-1831 (Ludlum, 1968). Heavy snowfalls in late December 1830 led to snowfall depths of 2 to 4 feet over the entire state. This enormous deep cover lasted for two months, and was followed by a major thaw in late February. That winter also had some extremely low temperatures in the −10 to −20°F (−23.3 to −28.8°C) range in northern Illinois. It remains one of the most severe winters on record.

The question can be raised, "How does the winter of 1977-1978 rank among other severe winters?" With all factors considered, it quite likely ranks as the worst in Illinois since the first form of weather records began shortly after 1800. There were not record numbers of extremely low daily temperatures in 1977-1978, nor did the 2-month pe-

riod of December-January reach the degree of coldness that they had in three prior winters. However, the mean temperatures of the winter season, defined climatologically as from December through March, produced an average temperature that was lower than any 4-month period since reliable temperature records began in the middle of the 19th Century. The Chicago winter average was 22.4 F (−5.3 C), that at Urbana was 23.5°F (−4.7°C), and that at Mt. Vernon was 28.1 F (−2.2°C), all record low values for northern, central, and southern Illinois, respectively. Winter temperatures were generally 7°F (north) to 9°F (south) below long-term normals. Nearly continuous below-normal temperatures existed throughout Illinois for this 4-month period. Only brief excursions above normal occurred in mid-December and early January. Below-normal daily temperatures persisted for more than two months, from early January to mid-March, throughout the state. Moline in northern Illinois had 41 winter days with minimum temperatures below 0 F (−17.8 C), and St. Louis had a total of 53 days with below freezing temperatures during the 90 days of 'official winter' (December, January, February). Thus, on the temperature side, the total winter of 1977-1978 in Illinois was a record breaker. However, it did not have the short periods of extreme cold found in a few other past winters.

In relation to snowfall, the winter of 1977-1978 was also a record breaker in many parts of Illinois. November through March snowfall totals in Chicago and northeastern Illinois exceeded 80 inches (203 cm) where 30 inches is normal. In several central Illinois locales, totals were over 60 inches (152 cm) and most areas had 40 to 50 inches where 20 inches (51 cm) is normal. In southern Illinois, totals ranged from 30 to 40 inches (76 to 102 cm) where averages are 10 to 15 inches (25 to 38 cm). Thus, snow totals were two to three times the average values in this record winter. The values obtained in northeastern, central, and southern Illinois were new winter records. In most other areas of the state, the 1977-1978 snow totals ranked second or third behind large seasonal totals of 1911-1912, 1917-1918, 1925-1926, and 1959-1960.

The state experienced 18 severe winter storms, each of which produced 3 inches (7.6 cm) or more snowfall somewhere in the state, and half of the storms were accompanied by extensive freezing rain. This was 50 percent more severe winter storms than the record number of 12 storms that occurred in 1911-1912 (Changnon, 1969). Most points in the state experienced 7 or 8 severe storms, each producing 3 inches or more snow in 24 hours. An example is Urbana in central Illinois. There, eight snow storms occurred including ones that produced 4.2 inches on 27 November, 8.7 inches on 5-6 December, 4.7 inches on 8 December, 5.0 inches on 15-16 January, 7.0 inches on 25-26 January, 11.3 inches on 13-14 February, 4.7 inches on 2 March, and 7.1 inches on 7 March. This was followed by an extremely damaging ice storm on 24-25 March depositing between 0.5 inch (1.3 cm)

and 1.0 inch (2.6 cm) of ice on streets, trees, and exterior surfaces. Importantly, many of the 18 snow storms brought large parts of Illinois to their knees with transportation halted and businesses and schools closed repeatedly due to the heavy snow and drifting from high winds, often coupled with damaging ice deposited beneath the snow.

There were three periods, each composed of 1 or more storms, which were extremely damaging. These were the periods of 2-9 December, 24-29 January, and 24-28 March.

Notable Severe Winter Storms in 1977-1978

The 2-9 December period was a series of three snow storms in close sequence, each preceded by glaze in certain parts of the state and later accompanied by high winds. Record cold persisted throughout the eight days. These storms were particularly bad in central Illinois where certain locales had a 3-storm total of over 14 inches (35.6 cm) of snow. Figure 1 is a series of newspaper headlines from central Illinois where the storms closed schools, stranded thousands of travelers, closed many businesses, and stopped inter-city transportation for four days. This period was ended by above-normal temperatures in mid-December.

The second major severely damaging storm and follow-on period was 24-29 January. This storm was uniquely bad in the eastern half of Illinois. It began as an ice storm followed by a major blizzard. Paralysis resulted, as shown in figure 2. Towns were isolated, 15 people died largely by freezing or suffocating in stranded autos, 317 were injured in a storm-induced wreck of two commuter trains in Chicago, and more than 500 automobile accidents occurred. Three days of high winds in the 30 to 60 mph range kept snow blowing and drifting so that plows could not even attempt to clear the roads. Temperatures remained below normal for weeks after the storm, but transportation systems were reopened by early February.

The final extremely severe period resulted from a major ice storm on 24-25 March. Rain fell throughout the state and began freezing over the northern two-thirds of Illinois on the morning of the 24th with freezing rain continuing until the morning of the 25th. In a 90-mile wide belt, oriented east to west across the state, the ice layer varied from 0.5 to 2.0 inches (1.3 to 5.1 cm) thick, bringing extreme damage to wires and trees, and resulting in power outages that took up to two weeks to repair. One million people were without power for more than 24 hours, over 1000 automobile accidents occurred, and an estimated \$20 million in tree losses occurred. In the area of severe ice damage, rainfall varied between 1.0 and 2.5 inches (2.5 and 6.4 cm), and most of this froze. In fact, the amount of rain largely determined the severity of the damage, being worst in the southwest portion of the state. The Governor later declared 24 counties as a disaster area. Warm temperatures beginning 28 March led to melting of the ice cover.

Monday, November 28, 1977
**Snow, Freezing Rain Bring
Usual Rash Of Accidents**

**Cafe Doubles As
Delivery Room**

Wednesday, December 7, 1977 * *

Blowing snow, cold cripple

**State
plagued
by snow**

Bridge Crash Kills Woman

Friday, December 9, 1977 * * 15 Cents

Cities battle fresh snowdrifts

**Schools
closed
again**

SNOWBOUND!!

Snowplows trying again

**14 SHOPPING TRIPS
TO THE GROUND**

STANDING STILL

Snow Closes Roads, Delays Trains

**22 stuck
in drifts
rescued**

Another set of impressive snow statistics from the 1977-1978 winter pertained to the duration of snow cover on the ground. The heavy snowfalls, high winds, and nearly continuous below-normal (and freezing) temperatures provided the circumstances for record long periods of snow cover. In northern Illinois, there was measurable snow on the ground for 130 consecutive days following a heavy late November snowfall, and for 95 consecutive days the cover exceeded 1 inch (2.5 cm) in northern Illinois. Southern Illinois, where average snowfall is low and snow cover is usually brief, had a run of 50 straight days of 1 inch or more from late January through early March. In fact, snow of more than 1 inch depth covered the ground over most of Illinois for two months after January 12. Everywhere records for the number of days of snow cover were set.

All these facts combined (prolonged cold, record number of severe storms, and record snow cover) to make the winter of 1977-1978 the worst since the white man settled in Illinois in the early 1800's and began keeping weather records. Therefore, an in-depth investigation of the snow and glaze conditions of the winter of 1977-1978 has been made. The first part of this report examines, in detail, the 18 severe storms. Treated are their magnitude, the storm motion, the areal extent of heavier snow, time of occurrence, and those synoptic weather conditions that produced each of them. This storm discussion is followed by a storm and winter snow summary. The monthly and seasonal totals and snow cover are evaluated. In the final section of the report, a variety of impacts resulting from these severe winter storms are discussed.

DRIFTS CLOSE C-U

Blizzard Forces Central Illinois To Standstill

January 26, 1978

THE CHAMPAIGN-URBANA NEWS-GAZETTE

Unexpected Visitors
Breakfast At Farm

Statewide Storm
A Real Paralyzer

Snowmobile makes run
to open airport passage

Commuter Trains Hit

CHICAGO (AP) — icy tracks are being blamed for the crash of two Illinois Central Gulf commuter trains that sent 317 persons to hospitals, officials said.

Two die in snowdrift
Indiana trucker
found dead in cab
Waiting Out The Storm,
Their Car Became A Crypt

January 27, 1978

THE CHAMPAIGN-URBANA NEWS-GAZETTE

Illinois Digs
From Drifts
Despite Winds

Snow stalls
area sports

School Closings Cause Problems

Figure 2. Headlines from central Illinois newspapers pertaining to the late January storms

Acknowledgments

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in the preparation of this manuscript are deeply appreciated and we dedicate this to Phyllis Changnon. The editing of the manuscript by Loreena Ivens is deeply appreciated. John Brothers helped by preparing the graphics and securing photographs from news services.

ANALYTICAL METHODS

The analysis of the individual storms began with the weather records of each station. Records from 70 stations in Illinois that report snowfall were used to plot storm maps.' This procedure was identical to that used to define winter storms in 1900-1960 (Changnon, 1969). These maps represented periods, ranging from a few hours duration up to 61 hours, during which the winter precipitation, snow and/or glaze, fell nearly continuously over all or parts of the state. At each station, the following information was plotted on the individual storm maps: the beginning and ending times and dates, the amount of snowfall, the amount of precipitation, and the occurrence of other weather phenomena such as high winds, sleet, and glaze. These storm maps then became the basis for further analysis of each storm.

The beginning times were used to plot isochrones across the state, allowing determination of the direction in which the advancing storm moved. The times also allowed determination of the earliest beginning and latest ending times of the storm within the state. The beginning and ending times at the stations in the heaviest storm area (typically 5 to 10 stations) were used to develop and calculate point durations, and these values in turn were averaged to get a mean storm point duration. Isohyetals, based on the point snowfall values on each map, were constructed to develop the storm snowfall pattern. The extent of areas with greater than 3

inches (7.6 cm) and greater than 6 inches (15.2 cm) were determined by planimetry of these maps. The highest and lowest snowfall values on each storm were identified. Examples of the storm maps appear on figures 3-5.

Snowfall totals for each month in the season were obtained from Climatological Data for Illinois (EDS, 1977, 1978). Monthly maps and seasonal maps were constructed from these values. These totals were compared with records for 25 Illinois stations distributed throughout the state and with records back to 1900 so as to determine the rank of the 1977-1978 values. In a similar vein, the snow depth data, taken at representative stations in northern Illinois (Antioch), central Illinois (Urbana), and southern Illinois (Mt. Vernon), were analyzed and compared with their historical records, extending back to before 1890.

The variety and magnitude of impacts resulting from these severe storm conditions were studied. Damage information as reported in Storm Data (EDS, 1978) and Weatherwise (1978) was used. Much of the impact information came from extensive examinations of Illinois newspapers published throughout the November 1977-March 1978 period. An absolute measure of the economic and human costs cannot be derived. However, available information presents a general estimate of the types of impacts and some measure of their severity.

ANALYSES OF STORMS

Storm Patterns

The patterns of the 18 severe winter storms in the winter season are portrayed in figures 3-5. These show that three began in November, five in December, three in January, four in February, and three in March. Normally, severe winter storms in Illinois are slightly more common in January with an average of one per year in the months of January, December, February, and March (Changnon, 1969). The 18 in 1977-1978 was 4.5 times the average frequency and 50 percent more than the prior record (12 in 1911-1912). Previous maximum values for each month included one storm in October, two in November (record broken in November 1977), four in December (record broken in December 1977), four in January (one less in January 1978), three in February (record broken in February 1978), and five in March (two less in March 1978). Hence, new monthly record frequencies occurred in November, December, and February with near record values in January and March. This reveals the prolonged storminess that characterized the winter of 1977-1978.

Inspection of the 18 patterns reveals that effects of Lake Michigan to increase snowfall were apparent in 3 of the 18 storms: those on 8-9 December, 12-14 January, and 6-7 February. As Changnon (1969) noted, lake-effect heavy snowfalls in extreme northeastern Illinois usually result when intense low pressure areas are located east of Illinois and produce strong flow from the northeast across Lake Michigan. This air picks up moisture over the lake because the lake is relatively warmer than the air, resulting in a production of snowfall over the land area adjacent to the lake as the air is cooled and lifted.

Another interesting snowfall pattern was obvious in four storms when relatively narrow east-west oriented bands of snowfall extended across the state. The dates of these storms included 2-3 December, 12-14 February, 2-3 March, and 6-8 March. The last three of these storms had quite heavy snowfalls. These all occurred with the passage of deep low pressure centers across the southern edge of Illinois.

Still another severe storm pattern occurred on 24-26 January (figure 4). This unique pattern (none comparable occurred in the 1900-1977 period) resulted from an extremely

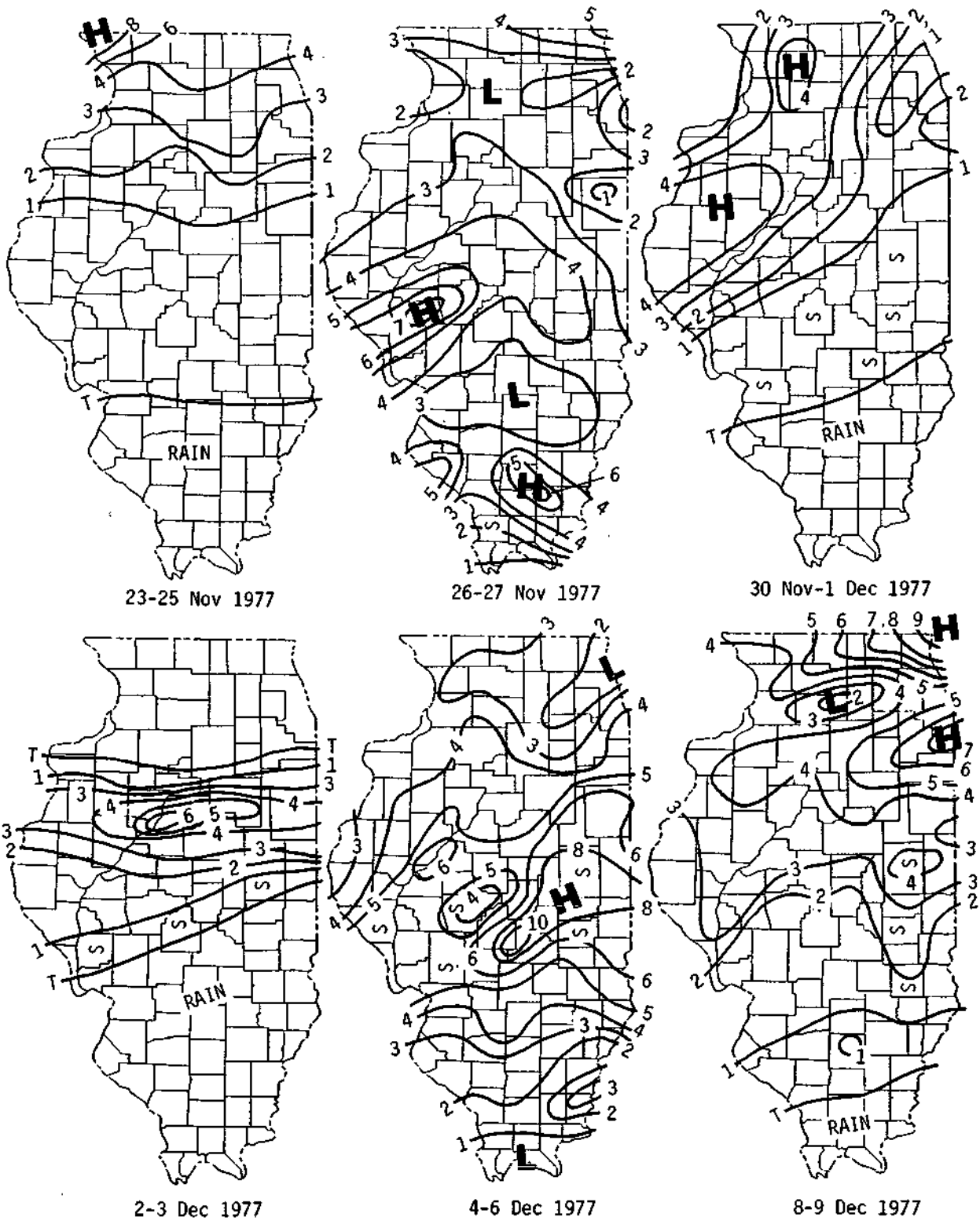


Figure 3. Snowfall patterns of the first six severe winter storms in 1977-1978 winter

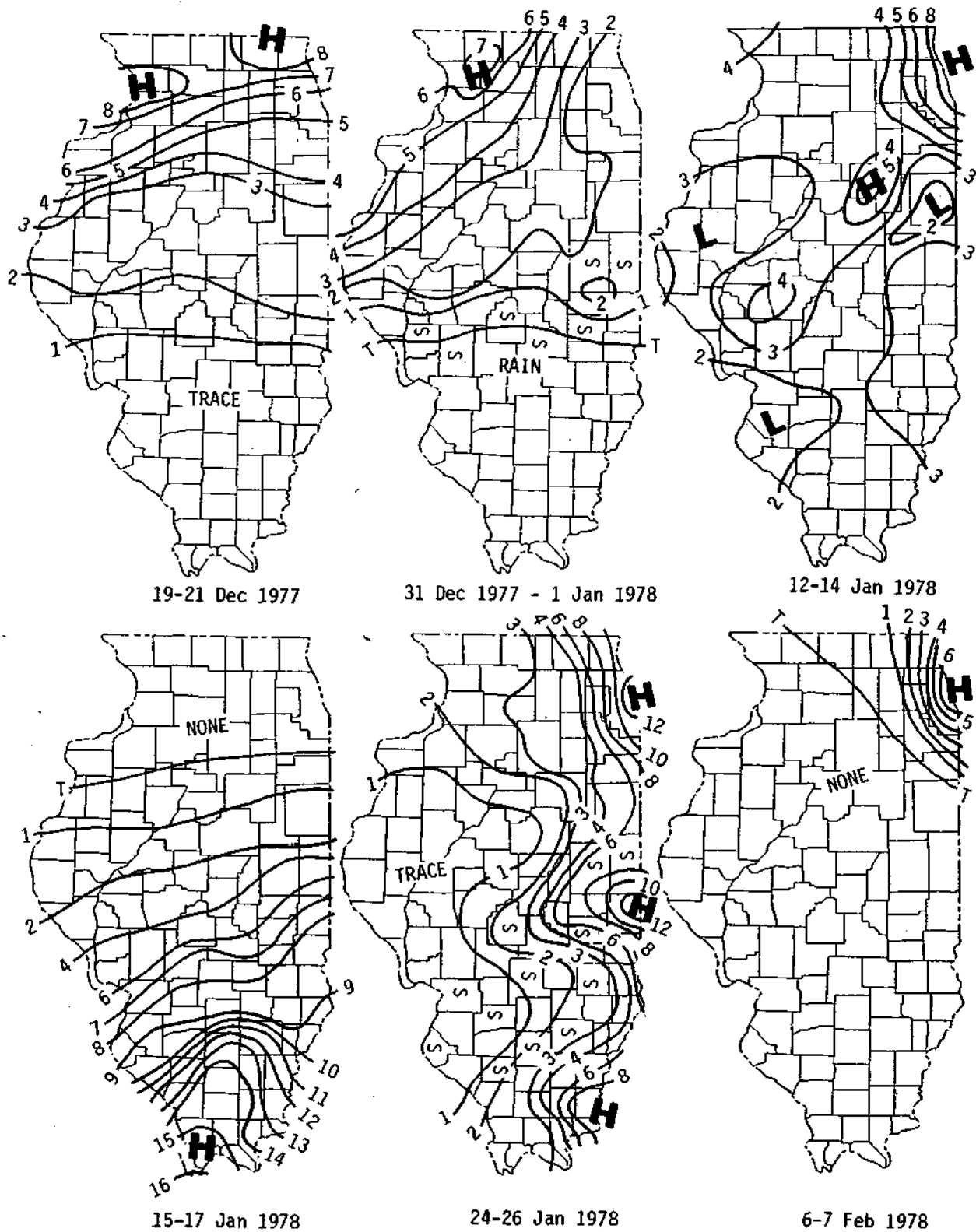


Figure 4. Snowfall patterns of the second six severe winter storms in 1977-1978 winter

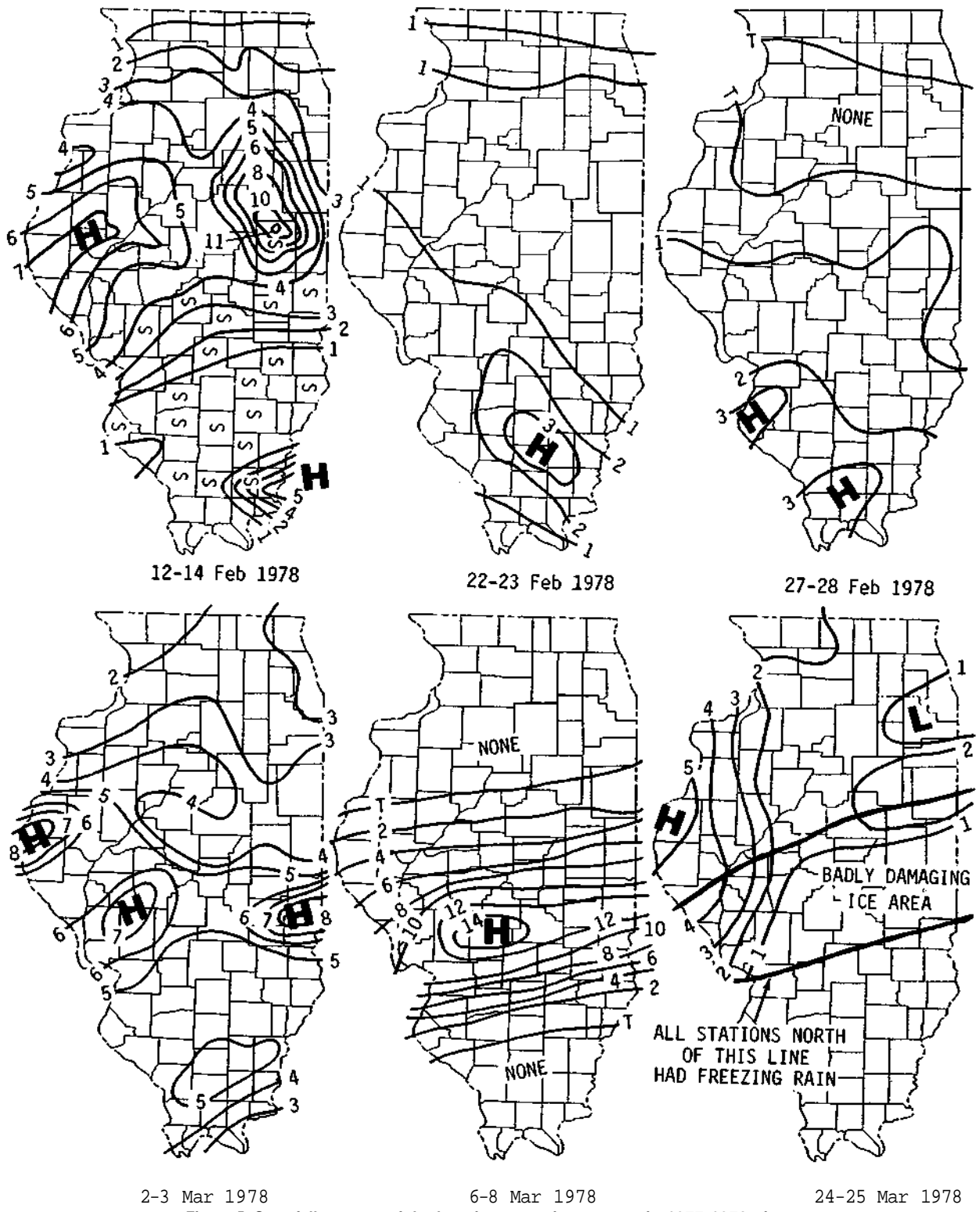


Figure 5. Snowfall patterns of the last six severe winter storms in 1977-1978 winter

deep low pressure center that advanced from the southern United States across Indiana where it then intersected with a second low from Alberta. It deepened over Ohio to produce record low pressure values and extreme damage in Illinois, Indiana, and Ohio. The south-to-north motion of this deep low (until it joined the Alberta low) produced the essentially north-south orientation of the isohyets shown for this storm. Lake related enhancement of the snow also occurred as the low deepened farther east of Illinois.

An uncommon snowfall pattern, but one occasionally found in Illinois, is revealed for the storm of 22-23 February which had a northwest-southeast oriented axis. This was produced by an Alberta low that moved from the northwest across the Dakotas, Missouri, and on just south of Illinois.

Inspection of the 18 storm maps in figures 3-5 reveals that freezing rain occurred in some parts of Illinois in nine of the storms. Those storms occurring on 24 January, 12 February, and 24-25 March produced light damage. Relatively widespread glaze and moderate damages occurred in six of these storms including those beginning on 30 November, 4 December, 31 December, 24 January, 12 February, and 24 March. The most severe of the ice storms occurred on 24-25 March when two-thirds of Illinois had glaze (the northern two-thirds) and a broad belt across central Illinois had an extremely damaging ice storm.

Several of the patterns on figures 3-5 reveal the more typical snowstorm patterns found in Illinois. The most typ-

ical is that with a heavy snow area oriented WSW-ENE and across northwestern Illinois.

Areas of most frequent snowstorm maximization, as based on study of 304 storms in the 1900-1960 period, include 1) the area from near Moline to Rockford, 2) the Chicago area, 3) the area from St. Louis to Urbana, and 4) the area near Harrisburg in southeastern Illinois. Interestingly, the positions of the centers or cores of the 18 storms of the 1977-1978 winter revealed most maximizations occurred in these same four state centers. In that sense, the 18-storm sample appears representative of the general distribution of heavy snowfall areas in severe winter storms in Illinois (Changnon, 1969).

Storm Characteristics

Table 1 presents for each storm the first beginning time anywhere in Illinois and the latest ending time. The 18 storms began in Illinois anytime between 1500 and 0500 CST, with 10 beginning between 1500 and 1900 CST. This nocturnal-focused distribution differs from the historical storm distribution which shows a maximization between 0900 and 1400 CST.

The average point duration at locales with the heaviest snowfall is also listed for each of the 18 storms in table 1. These show values ranging from 6 to 61 hours. Eleven storms had point durations in the heaviest storm areas of

Table 1. Storm Time and Motion Inventory

Storm date	Begin		End		Average duration (hours) at locales with heaviest snowfall*	Direction from which storm moved
	Hour, CST	Locale	Hour, CST	Locale		
23-25 Nov	23	Aledo	09	Chicago	21	W
26-27 Nov	19	Edwardsville	15	Urbana	14	WSW
30 Nov-1 Dec	19	Griggsville	08	Chicago	8	SW
2-3 Dec	18	Quincy	03	Urbana	6	W
4-6 Dec	18	Anna	02	Ottawa	28	SW
8-9 Dec	03	Galena	24	Newton	14	NW
19-21 Dec	18	Griggsville	22	Urbana	39	W
31 Dec-1 Jan	17	Freeport	09	Freeport	10	SW
12-13 Jan	01	Anna	16	Urbana	50	WSW
15-17 Jan	21	Edwardsville, Anna	18	Paris	38	SW
24-26 Jan	01	Anna	16	Ottawa, Paris	61	SSW
6-7 Feb	18	Antjoch	06	Park Forest	10	NNW
12-14 Feb	22	Edwardsville	03	Paris	23	W
22-23 Feb	15	Griggsville	13	Mattoon	13	W
27-28 Feb	17	Edwardsville	11	Harrisburg	12	WSW
2-3 Mar	05	Griggsville	07	Ottawa	15	WSW
6-8 Mar	16	Edwardsville, Quincy	16	Paris	46	WSW
24-25 Mar	01	Newton	24	Wheaton	49	S

*Typically based on values of 5 to 10 stations in each storm

Table 2. Storm Snowfall Summary

Storm date	Highest state values (inches) and locale	Lowest state values (inches) and locale *	Areal extent (square miles)	
			3 inches	6 inches
23-25 Nov	8.5 Galena	0	8,000	500
26-27 Nov	8.1 Jacksonville	1.0 Galena	27,000	3,000
30 Nov-1 Dec	4.5 Monmouth	0	11,500	0
2-3 Dec	6.7 Peoria	0	4,700	450
4-6 Dec	10.5 Pana	0.2 Cairo	31,400	8,900
8-9 Dec	9.1 Antioch	0	29,100	2,800
19-21 Dec	8.5 Antioch	Trace	18,600	7,600
31 Dec-1 Jan	7.7 Dixon	0	12,000	2,700
12-14 Jan	8.8 Chicago	1.4 Nashville	29,200	1,600
15-17 Jan	15.5 Anna	0	26,800	19,300
24-26 Jan	12.4 Chicago	Trace	21,100	8,700
6-7 Feb	10.3 Chicago	0	1,800	300
12-14 Feb	11.3 Urbana	0.2 Cairo	21,700	5,800
22-24 Feb	3.5 Mt. Vernon	Trace	1,700	0
27-28 Feb	3.3 Cairo	0	4,200	0
2-3 Mar	8.4 Paris	1.5 Mt. Carmel	47,300	6,500
6-8 Mar	14.2 Pana	0	17,800	12,000
24-25 Mar	5.0 La Harpe	0	7,200	0

*Locale listed if lowest values occurred at only one station; in all storms of 0 or trace, these values were reported by 2 or more stations.

between 6 and 24 hours. The median duration of the 18 storms was 18 hours. Study of the 304 storms of the 1900-1960 period revealed a median point duration of 14.2 hours which is considerably less than the median of the 1977-1978 sample. The record longest storm of the past was 48 hours (in the storm core) compared with 61 hours for the storm of 24-26 January. Basically, the duration information reveals that the storms in the 1977-1978 winter were much longer than the typical severe winter storms in Illinois. This suggests slower moving synoptic weather conditions which could result in greater precipitation and more damage. The prolonged intensity of high winds associated with several of the 1977-1978 winter storms further indicates the presence of quite deep low pressure centers.

Also shown in table 1 is the direction in which the storms moved across Illinois. The frequency by direction included five storms from the W, five from the WSW, four from the SW, and one each from the SSW, S, NW, and NNW. Comparison of these motions with those in the 1900-1960 climatological sample reveals some similarity and some dissimilarities. The preference for motion from WSW and SW is common in the 1977-1978 winter and in the 61-year sample. However, the number of storms in 1977-1978 from the W, from the SSW, and S are relatively large. They reflect the difference in the tracks of the cyclones that produced several of the winter storms.

Table 2 presents a summary of the snowfall with the 18 storms. Shown are the maximum point amount and the location where it occurred and the lowest point amount and location. Storms with low values of only a trace or zero extended over many stations and these are not shown. Examination of figures 3-5 reveals where these low areas occurred. Examination of the lowest measurable values (those greater than a trace) reveals that in five storms, measurable snowfall occurred over the entire state, 56,400 square miles. Interestingly, none of the three storms producing the heavier point amounts, those with values greater than 12 inches, produced snowfall over the entire state.

The snowstorm producing the greatest total was that in extreme southern Illinois, an oddity into itself, on 15-17 January. Anna with 15.5 inches (39.4 cm) in 30 hours had the heaviest fall and a new record at Anna. Other storms with point totals over 12 inches (30.4 cm) included the storm of 6-8 March with 14.2 inches at Pana in 41 hours, and the 12.4 inches in Chicago (Midway Airport) on 25-26 January (46 hours duration). None of these totals nor others in table 2 were record single storm values.

Also shown in table 2 are values for the areal extent of regions with more than 3 inches (7.6 cm) and more than 6 inches (15.3 cm) of snowfall for each storm. In nine storms snow in excess of 3 inches fell over more than one-third of Illinois. In six storms about half the state was covered by 3

Table 3. Synoptic Weather Types with Winter Storms

	Synoptic type	1977-1978 storms		Historical frequency (percent)*
		Number	Percent	
1	Alberta low	5	26	11
2	Colorado low (south to north track)	6	32	45
3	Colorado (north track)	0	0	8
4	Colorado (south track)	3	16	7
5	Texas low	2	10	24
6	Miscellaneous	3	16	5
		19**	100	100

*Based on 304 severe winter storms in Illinois during 1900-1960

**There were 18, not 19, storms, but in one storm (24-26 January 1978) types 1 and 5 both occurred and a count was given to each

inches or more of snow, and in one storm, 2-3 March, 84 percent of Illinois was covered by 3 inches or more. Seven storms produced snowfall of 6 inches or more over more than 5000 square miles (12,950 km², or about 10 percent of Illinois). The most extensive storms, based on areas of 6 inches or more, were those on 6-8 March (see figure 6) and 15-17 January. In these, more than 20 percent of the state was covered by 6 inches of snow.

The basic synoptic weather type (cyclone and/or front) that produced each of the 18 severe winter storms in Illinois was determined. These were categorized into six synoptic types, according to the typing derived from study of 304 past winter storms in Illinois (Changnon, 1969). These six types are shown in table 3. The first five are classified as to their source area, and in the case of the Colorado types, the general direction of travel of the track of the storm is also used. Most miscellaneous typings relate to frontal passages without any notable low center in or within a few hundred miles of Illinois.

The frequency of winter storms with each of these synoptic types is listed in table 3. Since one storm, that of

24-26 January, was produced by two types, a type 1 and type 5, a count was given to each type in table 3. The frequencies in each type are expressed as a percent of the total 19 events. Also shown in table 3 are the percentages based on historical frequencies of 304 storms for 1900-1960. Comparison of the two sets of percentages shows that the single record winter of 1977-1978 experienced relatively more Alberta storms (which approach from the NW or WNW) than in the historical frequency. This likely accounted for the greater frequency of storms with westerly components of motion. The record winter also had more type 4 than did the historical group. This helps account for the greater frequency of heavy snowfalls in the southern portion of Illinois during 1977-1978 since this storm tracks W to E south of Illinois. Relatively fewer instances of the type 2, type 3, and type 5 storm situations were experienced in 1977-1978 than in the historical group.

The climatological study of 304 severe winter storms (Changnon, 1969) found that the Colorado low types 2 and 4 were the primary producers of 'extreme damage' storms. These were defined as those producing more than \$200,000

WEDNESDAY, MARCH 8, 1978

Area Snowfall Strands Hundreds Record-Busting Snow Chokes Area

By POLLY ANDERSON
News-Gazette Staff Writer
The Winter of '78, already one for
the record books, was at it again
Monday and was likely to set still
another record before nightfall.

Snow Fooling Worst Winter In 90 Years

Figure 6. Headlines from southern Illinois newspapers relating to the early March period

in damages (in 1960 dollars) and one or more deaths in the state. Examination of the damages and deaths for the 18 storms under study revealed that seven of these were extremely damaging. By synoptic type these included 4-6 December and 24-26 January (type 1); 8-9 December, 15-16 January, and 12-14 February (type 2 storms); and the 6-8 March and 24-25 March (type 4). Hence, five of the seven most damaging storms of 1977-1978 were related to synoptic types 2 and 4, noted as the most frequent producers of extreme damages in Illinois.

The storms produced by synoptic types 1, 4, and 5 were noted in the historical sample to be producers of heavy snow with little or no glaze in Illinois. Storm types 2 and 3 were often a mixture of glaze and snow or just totally glaze storms. These characteristics, based on the prior large 304 storm sample, were common to the severe 1977-1978 winter sample.

Examination of the surface pressure patterns for the period of 23 November 1977 through 26 March 1978, which encompasses the 18 storms, reveals that 32 cyclones passed either across Illinois or adjoining states. Fifteen of these 32 cyclones, or 46 percent, produced severe winter storms in Illinois, a much higher ratio than the 10 percent noted in prior studies (Changnon, 1969). Thus, in one sense, the high frequency of severe winter storms and the resulting record snowfalls occurred because more of the winter cyclones in the Midwest produced heavy snow and damaging storms in Illinois.

Although no synoptic climatic study of cyclonic storms and their characteristics was made, the results from the 1977-1978 storms in Illinois suggest the key atmospheric ingredients. First of all, the great frequency of high winds, with 30 mph in 12 of the 18 storms (and lasting 1 to 2 days in seven of the storms), indicates the presence of very deep low pressure centers in these cyclones. Further, the relatively longer point durations of the severe winter storms of the 1977-1978 winter and the higher snowfall totals, both at points and over large areas, suggest many of the cyclones were moving slower than normal. The greater frequency of type 1 (Alberta) and type 4 (Colorado south) reveals more frequent southward penetrations of cold air. Hence, deeper more slowly moving cyclones penetrating more southerly and more often across the central United States appear to be the unusual feature of this record winter that led to the frequent production of heavy snowfall in Illinois.

Snow Cover

The record number of severe winter storms distributed throughout a 4-month period beginning in late November 1977, coupled with long periods of below normal temperatures particularly after early January 1978, led to prolonged accumulations of snow on the ground. Data from

three stations considered representative of northern Illinois, central Illinois, and southern Illinois were chosen for a detailed investigation of the snow cover. These three stations are shown on the inset map on figure 7.

Figure 7 presents the height profiles of the daily recorded values of snow on the ground, or snow cover, for these three stations. The impacts of the late November and mid-December heavy snow storms are clearly reflected as peaks on this graph, followed by rapid lowering due to melting and evaporation. The advent of the heavy snow storms beginning in mid-January and continuing on through February and early March, coupled with persistent below freezing temperatures throughout the state in this period, produced the prolonged periods of continuous deep snow cover.

In mid-January, Mt. Vernon reached a snow cover of 16 inches, which is a new record exceeding the previous value of 12 inches. Urbana reached a maximum in early March of 13 inches, but this was inches less than the prior record depth on the ground. Antioch achieved its maximum depth of 17 inches at the end of January, a value 6 inches under its all time record depth. Thus, the maximum depths of snow cover were not of record proportions in central and northern Illinois, although some structural damage did occur in these regions due to snow loads on roofs. For example, a factory in the Chicago area had a roof collapse from the snow load. When evaluated by snowfall and by snow depth, the winter of 1977-1978 was probably most extreme, as determined by departures (from normal, in the southern third of Illinois where snowfall totals were three to four times the average and maximum snow depths broke existing records.

The snow cover durations of these three stations are also displayed in table 4. Shown are the longest consecutive runs of days at these three stations (and the dates of beginning and ending) for snow depths of a trace or more, 1 inch or more, and 10 inches or more (25.9 cm). All the duration values shown for these depths represent new records for these stations. Also shown in table 4 are the totals, not just consecutive, for number of days of snow cover equal to or greater than 1 inch (2.6 cm). Thus, Antioch had a run of 95 straight days with snow cover of 1 inch or more (from 20 December through 24 March), but it also had another 23 days in the other parts of November and early December to total 118 days of 1 inch or more snow cover.

Monthly and Seasonal Snow Totals

November snowfall was relatively high throughout Illinois. Totals in the southwestern and southern third of Illinois were high ranked, being the greatest on record at Quincy, and the second greatest on record at White Hall, Mt. Vernon, and Harrisburg. Elsewhere the November 1977 snow totals ranked in the top ten totals of this Century.

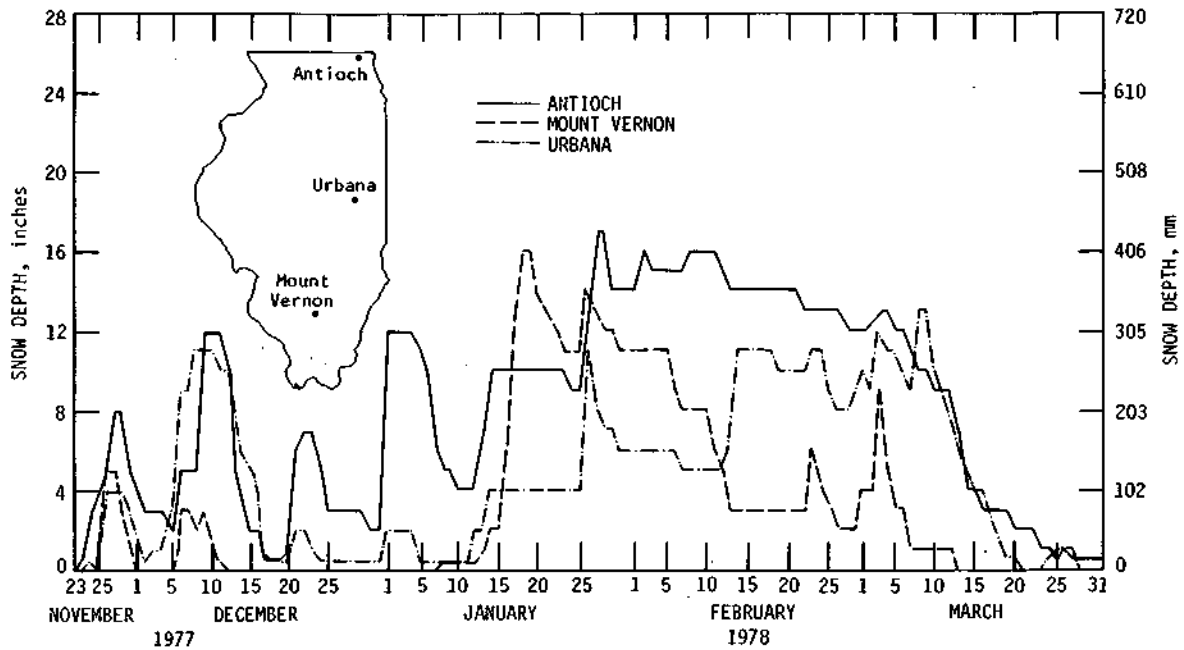


Figure 7. Temporal records of snow depth at three Illinois stations

The monthly snowfall patterns for December, January, February, and March appear in figure 8. The December snowfall pattern reflects the repeated occurrence of heavy snows in the northern third of the state. Normal December snow totals range from 2 inches (5.1 cm) in the south to 7 inches (17.8 cm) in the north. More than 20 inches fell over 4000 square miles (10,360 km²), and the northern half of Illinois had more than 1 foot (30.5 cm) of snow in December. In general, the December snowfall totals in the central part of the state ranked in the top five on record at various stations including first at Ottawa and Monmouth; second at Kankakee, Dixon, and Rushville; and third at Urbana. Most December values ranked in the top ten since 1900.

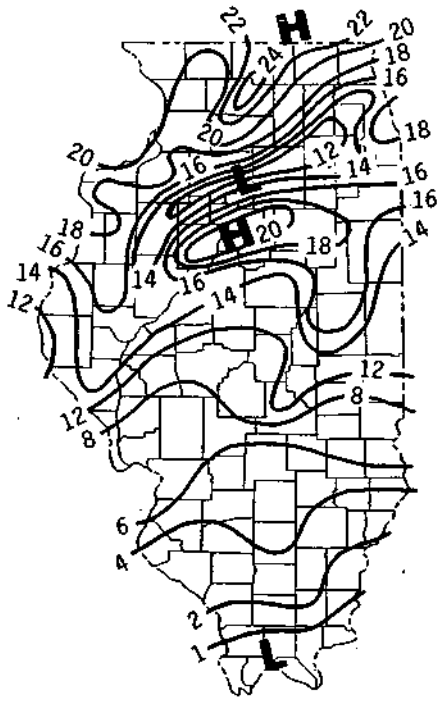
The January snowfall pattern, figure 8b, does not show exceptionally heavy snowfall values except in extreme southern, east central, and northeastern Illinois. Average January

snow totals vary from 3 inches (7.6 cm) in southern Illinois to 8 inches (20.3 cm) in northern Illinois. The areas of 5 inches in western Illinois (figure 8b) experienced average January snow totals. The January totals in southern Illinois were exceptionally high and those in parts of central Illinois ranked in the highest five totals on record. Values at Anna and Mt. Vernon ranked as highest on record, and those at Antioch, Chicago, and Urbana ranked as the second highest on record.

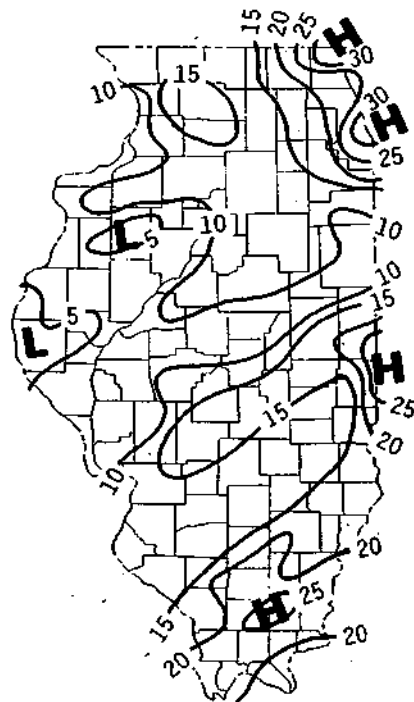
The February snowfall pattern (figure 8c) does not reflect exceptionally high values except in extreme northeastern Illinois. Average values range from 2 inches in the south to 8 inches in the north. At very few locations does this come close to record fall, ranking fifth at Quincy and seventh at a few other locations such as Urbana and Harrisburg. Chicago Midway Airport with 19.7 inches experienced a record high value.

Table 4. Snow Cover Statistics for Stations in Northern, Central, and Southern Illinois

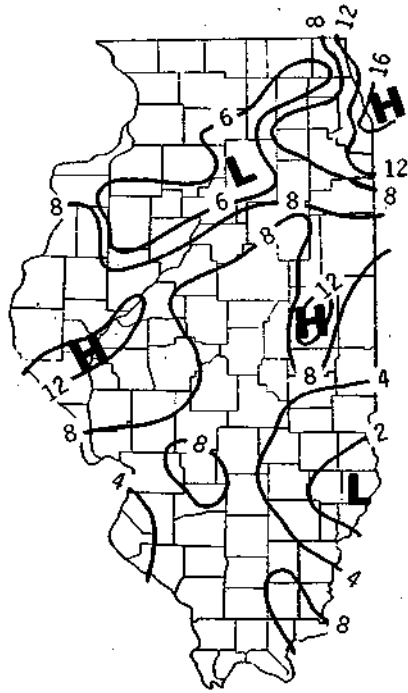
	<i>Consecutive longest runs</i>									<i>Total days cover 1 inch</i>
	<i>Cover 10 inches</i>			<i>Cover 1 inch</i>			<i>Cover trace</i>			
	<i>Dates from</i>	<i>to</i>	<i>Total days</i>	<i>Dates from</i>	<i>to</i>	<i>Total days</i>	<i>Dates from</i>	<i>to</i>	<i>Total days</i>	
Antioch (north)	1/14	3/14	60	12/20	3/24	95	11/24	4/3	130	118
Urbana (central)	2/14	3/10	25	1/12	3/18	66	11/27	3/24	118	95
Mt. Vernon (south)	1/17	2/5	19	1/13	3/12	49	1/8	3/12	54	67



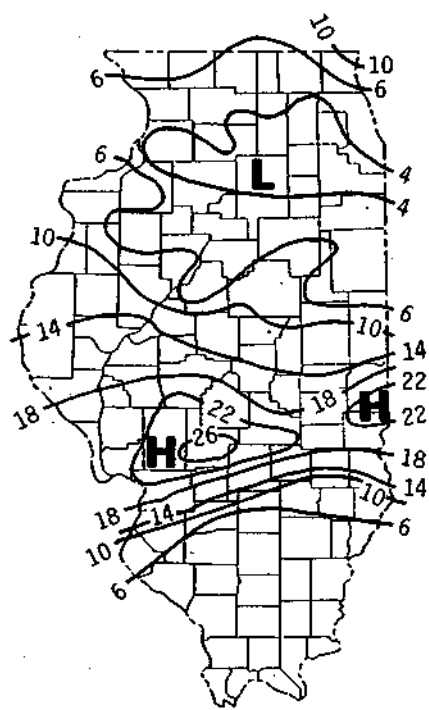
a. Total, Dec 1977



b. Total, Jan 1978



c. Total, Feb 1978



d. Total, Mar 1978

Figure 8. Patterns of monthly total snowfall, in inches

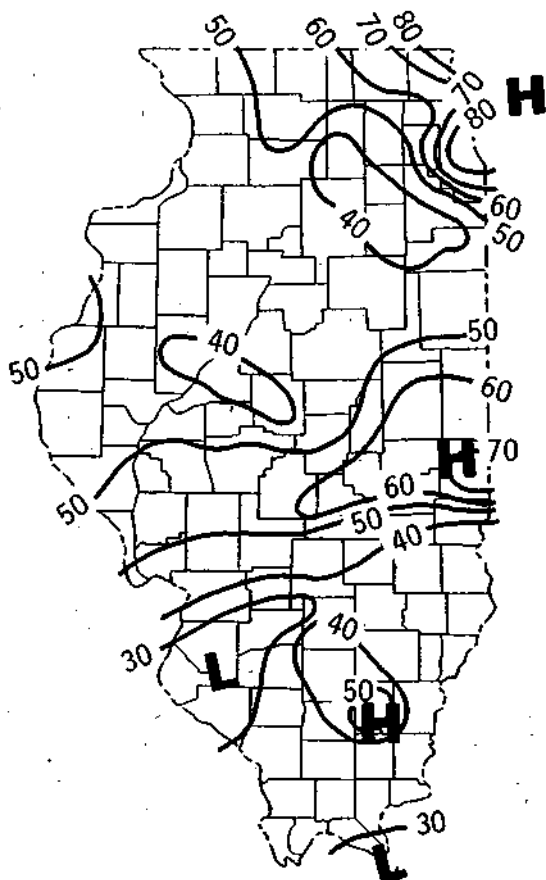


Figure 9. Pattern of the total snowfall for the 1977-1978 winter, in inches

The March pattern (figure 8d) reflects the intense snowstorms across south central Illinois. The totals ranked as record high in this area including those at Effingham and Hillsbro, and March totals at locations like Jacksonville, Decatur, and Urbana ranked as third highest on record. April snowfall was negligible in Illinois with no measurable amounts over most of the state; the highest was 1.4 inches at Waukegan in northern Illinois.

Figure 9 presents the snowfall pattern for the entire winter season which includes November 1977 through April 1978. The highest values are found in the northeastern, central, and southern parts of the state. The lowest amounts, slightly less than 30 inches (76.2 cm), found in southwestern Illinois were still more than twice the seasonal averages for that area.

The 70 inches in east central Illinois was four times the average for that area, and the 80 inches in northeastern Illinois was more than twice the normal for that region. Totals in most areas were between two and four times their averages.

Seasonal totals ranked as the highest on record over approximately half of Illinois including northeastern, most of south central, and the eastern half of southern Illinois. At most other stations in 1977-1978 seasonal totals ranked second, third, or fourth. Prior winters with greater totals at these locations included 1911-1912, 1917-1918, 1951-1952, or 1959-1960. The factor that made the totals so great was the continued above average totals in five consecutive months, November through March.

IMPACTS OF STORMS

The record 18 severe winter storms of 1977-1978 and the ensuing record or near seasonal snow totals and prolonged snow cover produced a myriad of impacts, largely of a disbeneficial nature. Most of the impacts resulted from the effects of the winter on the movement of people and goods. Other serious effects occurred on 'linear systems' such as communication and power lines. Various impacts are illustrated in the photographs (figures 10-12).

Available information does not allow an accurate assessment of the economic losses produced in Illinois by the winter of 1977-1978. A detailed study of the economic losses to individuals in one central Illinois area resulted in an estimate of costs attributable to the abnormality of the winter of approximately \$1 billion to individuals and their households (Changnon, 1979). This estimate did not include costs to industries, commercial establishments, communication systems, utilities, transportation systems, or to government entities. Accumulation of available information indicates that sizeable losses much in excess of \$1 billion occurred to

the transportation industries, utilities, commercial establishments, and to government institutions (through costs of added services and lost taxable income).

Although quantified losses are not available to derive an accurate statewide measure of loss, research has allowed identification of the myriad impacts. Table 5 lists those identified, grouped, and sorted by five categories (excluding deaths and injuries). These came largely from a study of newspaper accounts of the storms and their aftermath.

Transportation systems and vehicles, a major item in table 5, presents largely undesirable impacts, but some beneficial ones are shown. Benefits accrued to bus companies and Amtrak because of the greater use of in-city buses and railroads. Importantly, intercity bus service and airlines service were greatly affected with major delays (and loss of travelers) through the closing of highways and airports. The effect on automobiles and truck traffic was a story of many disbenefits with vehicles stuck, stranded, and damaged in a variety of accidents. In central Illinois, state highways and

Table 5. Assorted Impacts from the Severe Winter Storms of 1977-1978

1. *Transportation Systems and Vehicles*
 - Public transportation
 - Intercity and in-city buses
 - Stopped
 - Delayed
 - Many wrecks and many stuck
 - Greater use of in-city bus service
 - Trains
 - Delayed
 - Freight trains stuck in snow on branch lines
 - Hauled 50 percent more passengers
 - Accidents in Chicago
 - Airlines
 - O'Hare Airport at Chicago closed 1 day
 - Central Illinois airports closed 12 days
 - Passengers stranded in terminals
 - Other transportation
 - Snowmobiles used to rescue motorists
 - Helicopters widely used to deliver food and medicine, to take sick people to hospitals, and to rescue trapped motorists
 - Automobiles and trucks
 - Stranded by the thousands
 - Stuck by the thousands
 - Accidents in the hundreds
 - Major roads blocked partially or totally in central Illinois on 12 days
2. *Utilities*
 - Power lines downed, outages, line repairs
 - Higher sales of gas and electricity
 - Broken water mains
 - Unable to get service trucks to line breaks
 - Broken telephone lines
 - Great use of long-distance services
 - Television and radio towers damaged or destroyed
3. *Commercial and Industrial Establishments*
 - Sales reduced
 - Sales of goods delayed
 - Stores closed because of power loss
 - Purchases of winter gear, clothing, and CB radios increased
 - Purchases of space heaters, fireplaces, and firewood increased
 - Food stores ran out of supplies
 - Service stations sold more gas, did more service work
 - Tire stores sold snow tires
 - Motel business increased
 - Taxi firms bought snow tires
 - Roofs collapsed
 - Employee absenteeism and layoffs high
 - Deliveries of critical materials for manufacturing delayed
 - Delays, damaged trucks, perished goods, and business losses hurt shippers
4. *Human Activities*
 - Sporting events delayed or canceled
 - Stranded travelers by thousands in
 - Motels
 - Civic centers
 - Airports
 - Homes
 - More sharing with neighbors and others
 - Greater use of telephone services and delays in telephone communications
 - 'Farmer protest' efforts called off and/or delayed

Table 5. Concluded

4. *Human Activities (Continued)*
 - More walking to shops and school
 - Homes burn — fire protection services unable to reach them'
 - Playing in snow increased
 - Babies born in homes, restaurants, cars, etc.
 - Deliveries of goods and services delayed or stopped
 - Natural gas deliveries to rural areas delayed
 - Mail between cities stopped
 - Mail to citizens stopped or delayed
 - Medical and food supplies delayed
 - Garbage removal halted
 - Emergency vehicles (ambulances, fire trucks, etc.) delayed or blocked
 - Many pleasure and business trips delayed or canceled
5. *Institutional Impacts*
 - Court trials delayed
 - Illinois license plate deadline delayed
 - Illinois Emergency Services and Disaster Agency made extensive rescues (80 in one week of January)
 - Schools closed 7 to 12 days and school extended later in summer
 - U. S. Postal Service delayed
 - City, township, county, and state street and highway departments
 - Crews overworked and tired
 - Added crew members hired
 - Salt supplies exhausted or nearly so
 - Stuck and stranded cars blocked highways and delayed plowing
 - Lost work cost state in taxable income
 - Fire departments
 - Unable to reach fires
 - More fires to fight
 - Police
 - Fewer crimes
 - More accident calls
 - More minor problems (snowball fights, etc.)

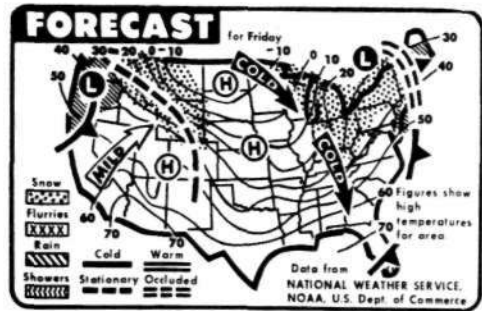
interstate expressways were totally closed for 12 days during the winter. Two vehicles were found to be of extreme utility, the snowmobile and the helicopter. They were widely used to rescue people and to deliver needed food and medical supplies.

Utilities, including the telephone, power, water, and communication systems (television and radio) had a variety of impacts and most were largely disbeneficial. The energy industries benefited by higher sales of gas and electricity, and although the telephone companies benefited by great usage of long distance services, the extensive damage to their lines and poles greatly exceeded the benefits. For example, the ice storm of 24-25 March produced damages estimated at \$3.5 million to telephone lines in central Illinois. This same storm caused two major television transmitting towers and four radio towers to collapse.

Commercial establishments (table 5) had a mixed set of impacts. There generally was a reduction in the sales of goods, and great absenteeism. Department stores in communities of 100,000 population reported lost sales totaling \$50,000 per day on several days. Power failures and blocked

in-city transportation essentially closed stores on six days in parts of central and southern Illinois. Food stores were hampered in sales by the lack of food deliveries. Purchases of winter clothing, gear, and equipment such as snow tires and CB radios were greatly increased. Service stations reported large profits. Motels received increased business due to frequently stranded motorists. Many commercial installations also suffered property damages from the deep snow and ice storms.

Several of the effects on human activities noted from the storms are listed under section 4 of table 5. As expected, many events, including high school and college athletic events, were either delayed or canceled. A major problem for travelers was being stranded. Many people spent unexpected days and nights in motels, civic centers, airports, and farm homes when they found themselves trapped in transit. People reported doing more walking within cities because of vehicular travel problems. Travel problems led to babies being born in a variety of non-hospital locations including homes, restaurants, and autos. A major problem for many individuals related to the delays or stoppage of deliveries of



Bitter cold expected

Travelers' advisory today. Windy and very cold with blowing and drifting snow mak-

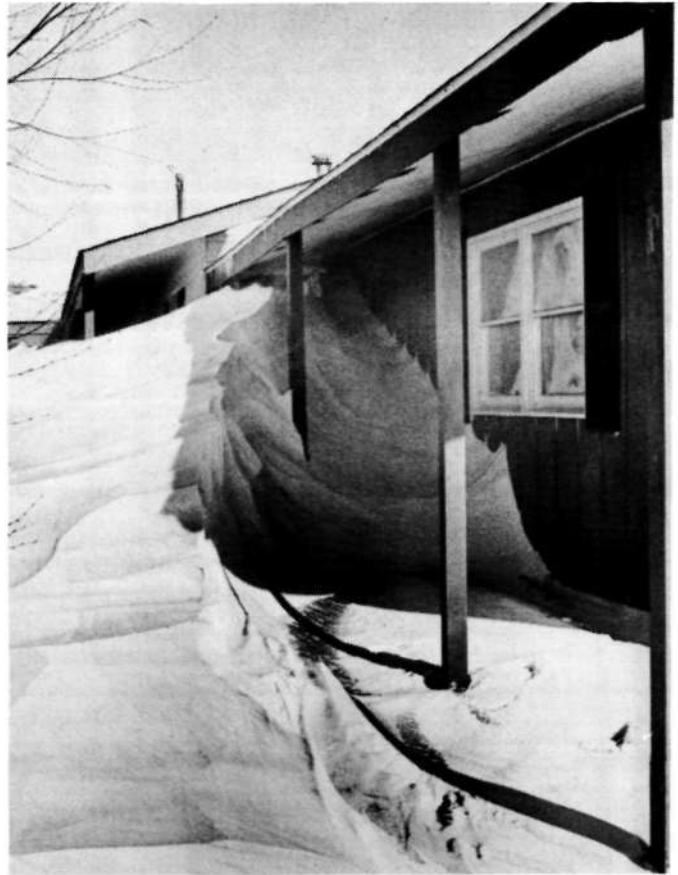
Photos courtesy of Champaign-Urbana Courier

Figure 10. Examples of transportation problems



Photos courtesy of Champaign-Urbana News-Gazette

Figure 11. Effects of snows on normally busy city streets



Photos courtesy of Champaign-Urbana News-Gazette

Figure 12. Examples of hardships experienced by people

goods and services. This included supplies of natural gas for heating in rural areas, the delivery of mail, food and medical supplies, and delays (or stoppages) in the movement of emergency vehicles such as ambulances and fire trucks.

The aforementioned impacts on individuals, commercial establishments, transportation systems, and utilities, in a sense, are integrated into a group of costly impacts on government institutions. Part 5 of table 5 lists some of the immense number of impacts on community, state, and federal institutions. Of prime importance was the effect on street and highway entities attempting to keep streets and highways open. The several days of lost work throughout the state cost the state in taxable income. An economist estimated the 2 days of lost work throughout most of Illinois on 26-27 January cost the state \$4,000,000 in taxable income. Police services were impacted with fewer crimes during the winter but more accident related calls and even many calls relating to outside snowball fights and broken windows. Court trials were delayed and Illinois had to delay its deadline for vehicular license purchases. Of great significance was the closing of schools. In some areas school closings occurred on 12 days with a minimum of 7 days in other parts of the state.

Table 6 presents available information on the injuries and deaths resulting from the winter. The best but gross estimate of injuries is that at least 2000 people were injured in Illinois due largely to a variety of vehicular accidents involving buses, trains, and automobiles. Examples noted in various storms are listed in table 6. Many injuries resulted from

Table 6. Injuries and Deaths Due to Winter 1977-1978

Injuries

Examples:

- Bus accident on 26 January = 40 hurt
- Train accident on 27 January = 317 hurt
- Car accidents on 8 March = 47 hurt
- Car accidents on 9 December = 24 hurt
- Car accidents on 26-28 January = 79 hurt
- Falls = unknown numbers, but many
- Estimate is > 2000 injuries*

Deaths

Hit by train (snow blinded)	= 1
Auto accidents	= 28
Suffocated in cars	= 16
Frozen to death	= 8
Could not reach doctor	= 3
Fell on ice	= 1
Shoveling snow	= 5
<i>Total</i>	<i>62</i>

falls on the ice and snow but there is no count of the total. Deaths resulted from seven types of causes. The greatest number related to auto accidents although 16 deaths resulted from suffocation in cars trapped in snow drifts. Eight also froze to death largely due to being trapped in vehicles in deep snow. A total of 62 winter deaths is the greatest ever recorded in a single season. Normally, 12 deaths occur due to severe winter storms in Illinois (Changnon, 1969).

SUMMARY

The winter of 1977-1978 was the worst in Illinois since records began in the mid 19th Century, and the resulting impacts were of record proportions in human suffering, frustrations, and costs. For these reasons, the dimensions of these record winter storms have been studied and delineated to provide information and design criteria needed for future structures and activities in Illinois.

The temperatures, number of severe storms, the seasonal snow totals, and persistent snow coverage were all records. Abnormally severe winter conditions lasted from 25 November till the end of March. In one sense the bad winter was exceptional because it was so prolonged (4½ months). Three extremely bad weather periods combining severe icing, heavy snow, and high winds occurred: 2-9 December, 24-29 January, and 24-28 March.

There were 18 severe winter storms, 14 more than average and 6 more than the previous record of 1911-1912. The number of severe storms in November (3), December (5), and February (4) were record highs for these months, and

the number in January (3) and March (3) were near records.

The snowfall patterns in some storms were typical but a few unusual ones were noted. These unusual patterns included very heavy snow in narrow (<100 miles wide) E-W bands across the state. Another (24-26 January) had heavy snow all along the eastern edge of Illinois and essentially none in western Illinois. The cores (highs) of the 18 storms clustered in four areas (NW, extreme NE, extreme SE and in a band from St. Louis to Urbana) where winter storms are normally heaviest.

The maximum storm snowfalls were not new records, except for one storm in southern Illinois when 15.5 inches fell (15-17 January). However, storm durations in 1977-1978 were much longer; their median was 18 hours compared with the long-term historical value of 14 hours. The 61-hour duration of one storm (24-26 January) was a new record. A preponderance of the storms moved across Illinois from the SW but an unusually large number came from the west and south.

Study of the synoptic weather conditions associated with the 18 storms revealed that the 1977-1978 conditions were generally different from those commonly occurring with severe winter storms in Illinois. Many more of the 1977-1978 storms were produced by Alberta lows and Colorado lows (with south track) than would be expected in a random sample of 18 storms. This indicates more frequent and more southerly incursions of cold air into the Midwest. Various storm information reveals the unusual nature of the 15 lows that produced 15 storms (3 were produced by fronts). The greater than normal frequency of W and WSW storm motions relates to the greater Alberta and Colorado low (south track) incidence, both of which often sweep across or near to Illinois with a west-to-east motion. The longer storm durations and lower speeds reveal that the motion of the lows was generally slower and their pressure lower. The great frequency of prolonged high winds (>30 mph) also indicates the deepness of the lows.

Finally, the fact that 46 percent of the lows in the Illinois area produced severe storms, as opposed to 10 percent in a normal winter, reveals the uniqueness of the lows, both as to their frequency and intensity of circulation. The seven really damaging storms in 1977-1978 were produced by synoptic conditions (Alberta, Colorado low with SW-NE track, and Colorado low with south track) that in the past have caused the most damaging storms. This indicates that the characteristics of storms produced by each weather condition were largely as expected, but often just more prolonged and hence more severe.

Snow coverage, due to repeated storms and persistent below freezing (and below normal) temperatures from early January through mid-March, was prolonged. Record long periods of depths for 1 and 10 inches were set throughout Illinois. The depth of the coverage set new records in southern Illinois but was not record breaking elsewhere. The total numbers of days with 1 inch or more of snow were records with 110 to 120 days in extreme northern Illinois, 90 to 110 days in central Illinois, and 60 to 90 days in southern Illinois.

The monthly snow totals were exceptionally high, attaining record highs (for 1900-1978) in some parts of Illinois in each of the five months from November through March. November totals ranked first or second in southwestern Illinois, and those in December ranked first or second highest in north central Illinois. January totals in south-

eastern Illinois were the greatest on record. The February totals in extreme northeastern Illinois ranked as the heaviest ever, and south central Illinois experienced its greatest March totals.

The cold season of 1977-1978 (November-March) produced snow totals in southern Illinois that ranged from 30 to 50 inches which were two to four times the average for that area. Central Illinois with totals of 40 to 70 inches experienced two to three times its normal, and totals of 50 to 80 inches in northern Illinois were also two to three times normal values. The seasonal falls were greatest essentially in the eastern portions of the state. Totals were the greatest on record over half the state with records in southern, south central, east central, and northeastern Illinois. Elsewhere the 1977-1978 totals ranked second, third, or fourth (largely in the northwestern third).

The storms caused an estimated \$1 billion loss to individuals (houses and personal property), and at least \$1 billion more to 1) transportation systems, 2) communication industries, 3) utilities, 4) commercial and industrial entities, and 5) institutions. Most impacts of the storms were to these five entities plus those to the general public — their activities, health, and safety. Sixty-two persons were killed from storm activity and at least 2000 were injured.

Impacts on transportation were mixed; losses were excessive to vehicles (autos, trucks, and intercity bus lines) and airlines suffered lost business. However, railroads benefited, and helicopters and snowmobiles proved invaluable. Basically, utilities and communication systems suffered great losses due to damages to lines and poles, and to towers.

Business and industry also suffered as they lost income with delayed or damaged shipments of goods, absenteeism, and damaged vehicles and structures. Certain commercial establishments who provided winter goods and services benefited. These myriad impacts integrated to present a set of enormous problems, requirements for added effort, and higher costs to local, state, and federal institutions. Transportation system costs were the major items and lost taxable income was another blow. Impacts on human activities related largely to efforts to travel and their delays. Individual and group activities were delayed or canceled, and deliveries of goods and services were delayed or halted.

The record winter weather conditions ended by 31 March 1978, but the impacts including higher costs of living and higher taxes will be felt for years.

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