APPENDIX D

The December 2008 Ice Storm in New Hampshire

Kathleen F. Jones
Cold Regions Research and Engineering Laboratory
Hanover, New Hampshire 03755

Chapter Structure

A. INTRODUCTION

The December 11-12, 2008 ice storm caused long power outages in New Hampshire and the surrounding states. Difficulties in restoring power were attributed to the abundant trees in the region affected by the storm and the large area that the storm covered. Many utilities had to restore power to customers in their own service area and did not have the personnel to also help other utilities with whom they had mutual aid agreements. This report was commissioned by NEI

Electric Power Engineering for their storm response analysis for the New Hampshire Public Utilities Commission.

The severity of this ice storm can be quantified in terms of the equivalent radial glaze ice thickness R_{eq}, and the return period of storms resulting in R_{eq}s that were seen in this event determined. The shape of the ice that forms on the branches and twigs of trees and on the wires of power distribution lines, and conductors and shield wires of power transmission lines varies depending on the local weather conditions, the orientation of the line to the wind direction, any heat generated in the wire/conductor by the current, any rotation of wires as ice accretes, and any change in orientation of twigs and branches as ice accretes. The equivalent radial thickness of the ice on a wire is the thickness it would have if the actual shape was redistributed to make the ice uniformly thick around the wire. R_{eq} does not vary with the wire diameter (Jones 1998), so it can be used to determine the weight of ice per unit length W on wires or branches of any diameter:

$$W = \rho\pi\left(R_{eq}d + R_{eq}^{\,2}\right) \qquad (1)$$

The equivalent radial ice thickness is not measured at weather stations, and is not typically reported. Forecasters or weather observers sometimes report the thickness of ice on the ground or another horizontal surface. These reported thicknesses can include ice pellets and snow as well as freezing rain because these types of precipitation often occur in the same weather event. There are often many reports of the maximum dimension D_{max} of ice accreted on a branch or wire. This will include icicles, which form in conditions where the heat of fusion is removed relatively slowly (low winds, temperature near freezing) when impinging rain drops freeze as they start to drip off. Note that

$$\begin{aligned} R_{eq} &= 0.5\left(D_{\max} - d\right) \text{ for round accretion cross sections} \\ R_{eq} &< 0.5\left(D_{\max} - d\right) \text{ for non-round accretion cross sections} \end{aligned} \qquad (2)$$

Data from weather stations is used to estimate R_{eq}. The map in ASCE Standard 7 *Minimum design loads for buildings and other structures* (ASCE 2005) is based on the analysis of historical weather data using the Simple ice accretion model (Jones 1998) with hourly weather data. The ice load maps in ASCE Standard 7 are also being adopted by ASCE Manual 74 (ASCE in press). Values for long return periods were determined by fitting the generalized Pareto distribution, using the method of probability weighted moments, to a sample of the largest ice thicknesses, grouping the weather stations into superstations to reduce sampling error. This approach for mapping ice thicknesses and concurrent gust speeds is described in detail in Jones

et al (2002). R_{eq} can also be estimated directly from a freezing-rain sensor using the Automated Surface Observing System one-minute, page 2 data (Ryerson and Ramsay 2007). For this analysis of the December 2008 ice storm, both methods are used. Alan Ramsay provided equivalent radial ice thicknesses from the freezing rain sensor.

In the next section the freezing rain storm forecasts are summarized, a map of the total precipitation for December 11-12 is presented, the footprint of the ice storm is delineated, and equivalent radial ice thicknesses are calculated from weather data. A description of the storm damage is provided in Section 3, along with damage footprints and descriptions of previous storms in the region from http://cmep.crrel.usace.army.mil/ice. Finally in Section 4 the return period of storms in this region with similar ice thicknesses is estimated.

B. PRECIPITATION, ICE STORM FOOTPRINT, AND R_{EQ}

The December 2008 ice storm was part of a larger system that brought precipitation ranging from rain to freezing rain to snow to ice pellets to the northeastern United States. Forecasts for freezing rain were issued from the Taunton, Massachusetts, Gray, Maine, and Albany, New York, forecast offices for the region affected by the storm. Portions pertaining to New Hampshire are summarized here:

- The forecast from Taunton, Massachusetts at 5:10 pm on December 10 mentions the likelihood of heavy ice pellets or freezing rain occurring in portions of the interior of the forecast region on Thursday (December 11) and Thursday night. The forecast states that the potential for a major ice storm exists, but the most likely locations of 1 or 2 inches of ice (all ice amounts in forecasts are on a horizontal surface; they are not equivalent radial ice thicknesses) is not known and will be sensitive to the depth of the subfreezing layer of air. If the subfreezing layer of air is cold enough or thick enough the precipitation will likely fall as ice pellets, decreasing the severity of icing on structures. Light freezing rain with significant icing is expected on Thursday at Hartford CT, Westfield and Worcester MA, and Manchester NH, with some ice pellets at Manchester. An ice storm warning is issued for Massachusetts (forecast zones 2-4, 8-12, 26) with a winter storm warning issued for New Hampshire (forecast zones 11, 12, 15).
- The forecast from Albany, New York, at 12:43 am on December 11 issues an ice storm warning and flood watch for Massachusetts (forecast zones 1-25) and a winter storm warning for portions of Vermont (forecast zones 13-15)
- The forecast from Gray, Maine at 7:12 am on December 11 warns of heavy accumulating ice with power outages expected across portions of Maine and New Hampshire. Freezing rain is expected to approach one inch over interior sections, with power outages and downed tree limbs becoming a significant problem in some communities. It is suggested that high precipitation rates tonight might slow the accretion of ice compared to a steady long period of light freezing rain. Hefty ice accumulations are also expected across

portions of the coast. The situation will be monitored closely in case shifts in the pattern imply coastal ice accretions of greater than one-half inch.

- The forecast from Taunton, Massachusetts issued at 4:28 pm on December 11 issues an ice storm warning for western Massachusetts and southern New Hampshire; a winter weather advisory and flood watch for eastern, northeastern and western Massachusetts; and an ice storm warning and flood watch for central and eastern Massachusetts.

Freezing rain began essentially simultaneously in Massachusetts and New Hampshire with freezing rain first observed at Jaffrey, Concord, and Manchester between 6 am and 9 am (LST), and at Lebanon at 6 pm on December 11. At Whitefield and Berlin freezing rain began almost a day later, between 3 and 5 am on December 12. At many of these airport locations freezing rain was preceded by ice pellets. At higher elevations in the area, that precipitation might also have been freezing rain instead of ice pellets because of the thinner layer of overlying cold air. The end of freezing rain is difficult to determine because stations in the region most severely affected stopped transmitting data during the storm, presumably because of power outages. In general freezing rain and ice pellets ended some time on December 12.

Daily accumulated water-equivalent precipitation is measured and archived for hundreds of cooperative weather stations and hourly weather stations in the region. At most stations precipitation is measured early in the morning (typically 0700) each day. For those stations the storm precipitation is taken as the sum of the measured amounts from the mornings of December 12 and 13. At about 20% of the stations precipitation is measured sometime between the late afternoon and midnight. For those stations the storm precipitation is taken as the sum of the measured amounts from the evening hour on December 11 and December 12. Those accumulated precipitation amounts are shown in Figure D-1 as a contour plot. The locations of the weather stations that provided data for this map are shown in Figure D-2. Precipitation is heaviest in eastern Connecticut, Rhode Island, and southeastern Massachusetts, and generally decreases toward the north and west. Some of the small scale variation shown on the map may be due to variation in the measurement time from station to station. But some of the variation is likely because of power outages at hourly weather stations because of the ice storm. For example, the bulls eye in the middle of Massachusetts comes from the Worcester weather station where no data was archived from 0700 December 12 through 1300 December 13.

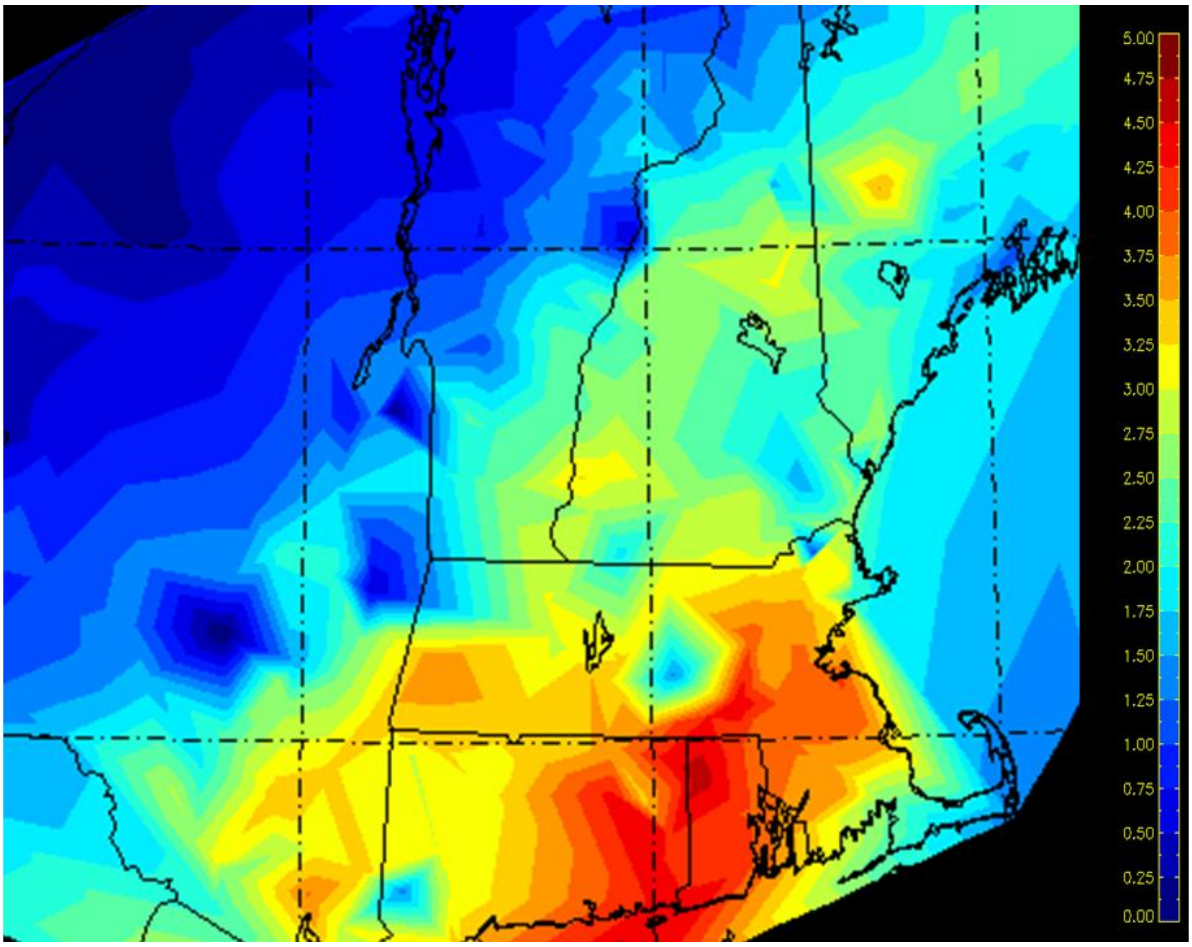

Figure D-1 – Accumulated precipitation (inches) December 11 to 12, 2008.

The precipitation fell as freezing rain for part of this two-day period in only a portion of the region with significant precipitation. Information on damage associated with the ice storm was compiled from newspaper articles from the Portland *Press Herald*, Augusta *Kennebec Journal*, Concord *Monitor*, White River Junction *Valley News*, Rutland *Herald*, Albany *Times-Union*, *New York Times*, Pittsfield *Berkshire Eagle*, Springfield *Republican*, Worcester *Telegram Gazette*, and the *Boston Globe* as well as from the Taunton and Albany storm compilations. Areas where trees, power lines, or communication towers were damaged by the ice or a combined ice and wind load are included in the damage footprint. In many storms much of the damage to distribution lines and transmission lines in narrow right-of-ways is from ice-covered trees and branches falling on wires and conductors (Jones 1999). Locations where the storm caused slippery roads but no other effects are not included. The storm footprint in Figure D-3 extends from northwestern Connecticut, western Massachusetts, and east central New York across southern Vermont and the upper Connecticut River valley, the southern half of New Hampshire and the northern two-thirds of Massachusetts, and into Maine. The storm also affected an area around Wilkes Barre and Scranton Pennsylvania. The power outages reported in

Rhode Island during this period were likely due to high winds and flooding rather than ice as temperatures there remained above freezing.

Some of the stations shown in Figure D-2 are airport stations with hourly weather data. Most of the hourly stations are Automatic Surface Observation System (ASOS) stations, with no human observers. The stations have battery backup for only one-half hour, so in lengthy power outages, which are common in significant freezing rain storms, data may not be collected for a portion of the storm. A few ASOS stations are augmented by observers who can continue to make measurements and record data even when the power is out. The weather elements that are measured at these stations that are required for the Simple ice accretion model are precipitation type, precipitation amount, and wind speed. The more detailed CRREL ice accretion model (Jones 1996) also uses air temperature and dew point data in a heat balance calculation to determine how much of the impinging precipitation freezes. The Simple model assumes that it is cold and windy enough that all the precipitation that impinges on a cylinder (e.g. wire, conductor, cable, branch, twig) freezes to it. When the two models differ, the Simple model R_{eq} may represent more severe conditions in the vicinity of the airport. In both models, in any hour with freezing rain, all the precipitation is treated as if it were freezing rain. In many hours the local conditions indicate different precipitation types, typically freezing rain and ice pellets or freezing rain and snow occurring at various times. Assuming all the precipitation is freezing rain in these hours is intended to represent what might be occurring at higher elevations or locations with a different upper air temperature profile in the vicinity of the station. Both models determine the accretion of ice on a horizontal cylinder with axis perpendicular to the wind direction. There will be less ice on horizontal cylinders that are parallel to the wind direction or on vertical cylinders. At hourly weather stations with freezing rain sensors, R_{eq} can also be estimated from the detailed sensor data that is archived by the National Climatic Data Center (NCDC).

Simple model R_{eq}s at 10 m (33 ft) above ground and freezing rain sensor R_{eq}s at 2 m (7 ft) above ground for the thirty stations with archived hourly weather data in and near the ice storm footprint are provided in Table D-1. There was no archived data for the Bedford MA or Rochester NH stations. Precipitation type is not recorded at the Milton MA station. Freezing rain was not observed in this storm at the three Connecticut stations and two of the Massachusetts stations in Table D-1. At seven stations where there was freezing rain, the calculated R_{eq}s are low because of data missing from the archive from power outages or data transmission errors. Note the generally lower values from the icing sensor than are provided by the Simple model with its conservative assumptions. Icing sensor response is within 20% of a specified standard, with a flat distribution between those limits. Time series of the weather data as well as modeled equivalent radial ice thicknesses and values determined from the freezing rain sensor are provided for Worcester MA and Concord NH in Figure D-4 and Figure D-5, respectively. In the second panel the type of precipitation uses the codes Z for freezing rain, I for ice pellets, R for rain, and S for snow.

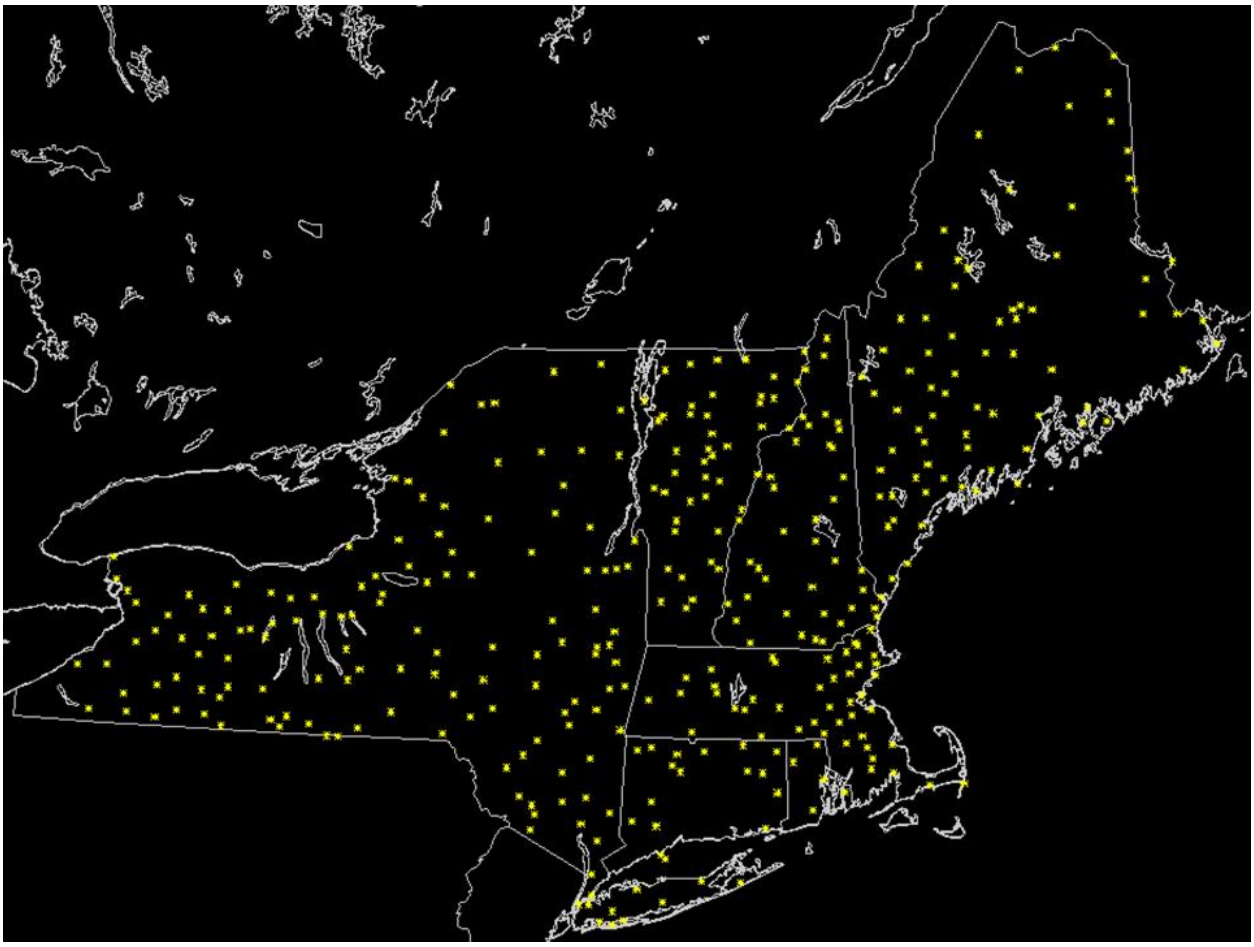

Figure D-2 - Weather Stations for Figure D-1

The largest modeled R_{eq} in this storm is 22.7 mm (0.9 in.) in Augusta ME. For seven hours of the storm the precipitation at the Augusta weather station was a mixture of freezing rain and ice pellets. As ice pellets bounce off objects, the equivalent radial thickness of ice on wires and twigs would accumulate to 0.9 in. only at locations near Augusta where the precipitation was actually all freezing rain.

In Albany NY R_{eq}=20.6 mm (0.8 in.), with ice pellets and freezing rain for five hours.

In Massachusetts ice thicknesses were more than 16.2 mm (0.6 in.) and more than 17.0 mm (0.7 in.) at Lawrence and Worcester, respectively. Data is missing at the height of the storm, so these should be considered lower bounds on R_{eq} in the vicinity of these two stations. Ice pellets and freezing rain occurred in the same hour for five hours at Lawrence and three hours at Worcester.

Modeled ice thicknesses in Vermont are relatively low with 3.9 mm (0.2 in.) at Bennington. Precipitation amounts are missing at Springfield for the entire storm, and there is no data at all

after 1000 UTC on December 12 so that area with likely significant icing is not represented by the weather station data.

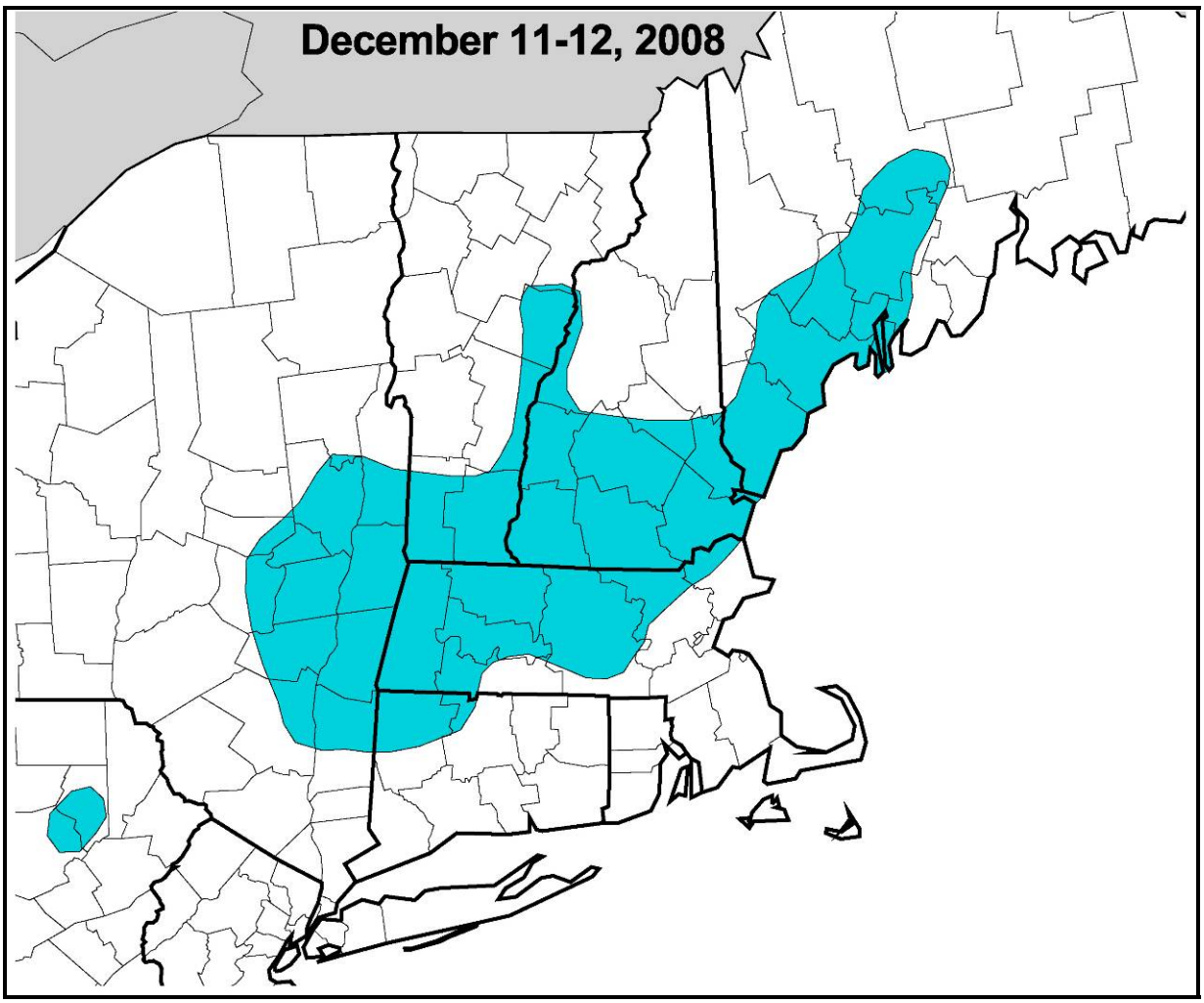

Figure D-3 - Ice storm footprint; region with damage to trees, power lines, and communication towers.

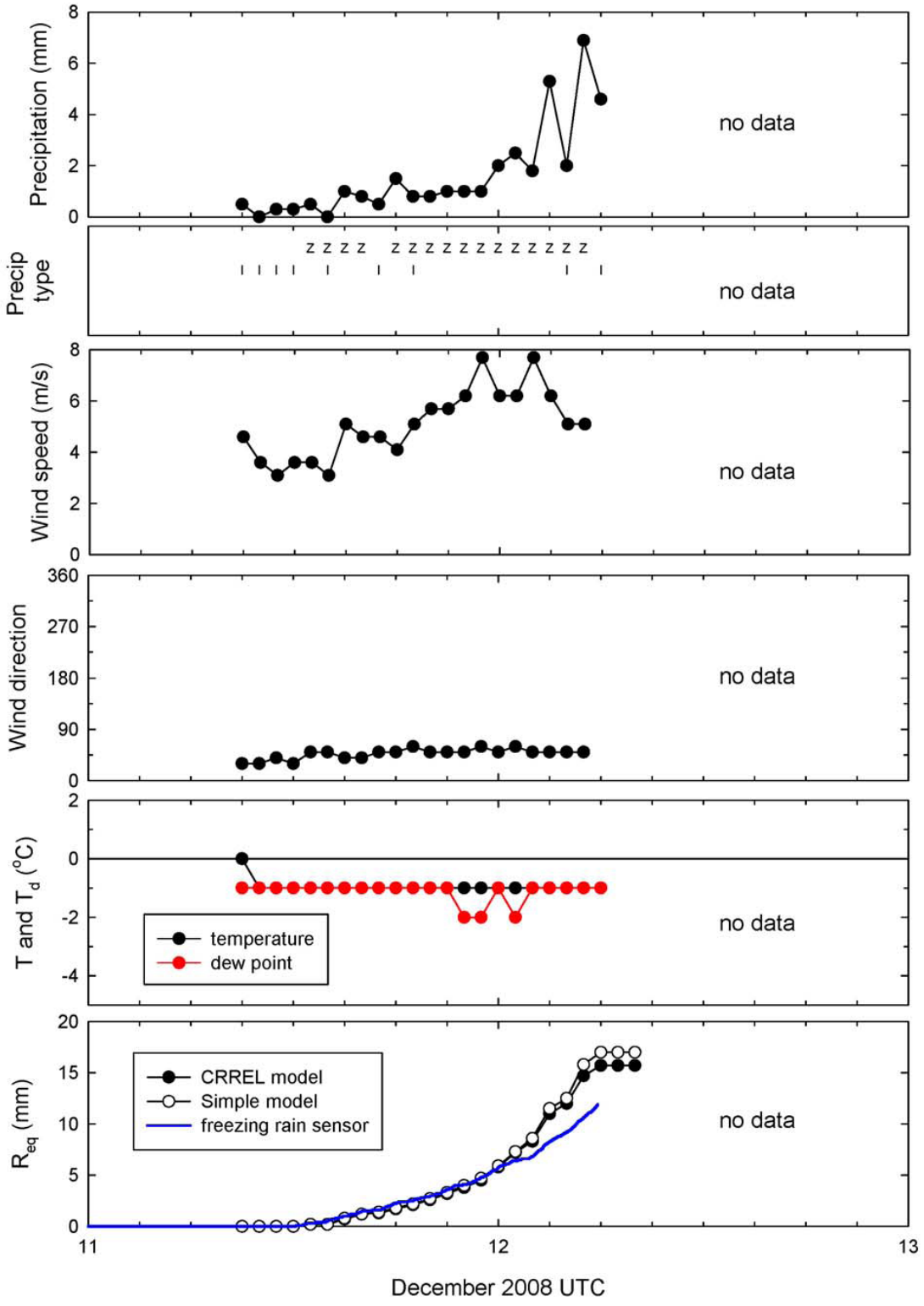

Figure D-4 - Storm time series for Worcester, Massachusetts. Equivalent radial ice thicknesses from the CRREL and Simple models and from the freezing rain sensor are in the bottom panel.

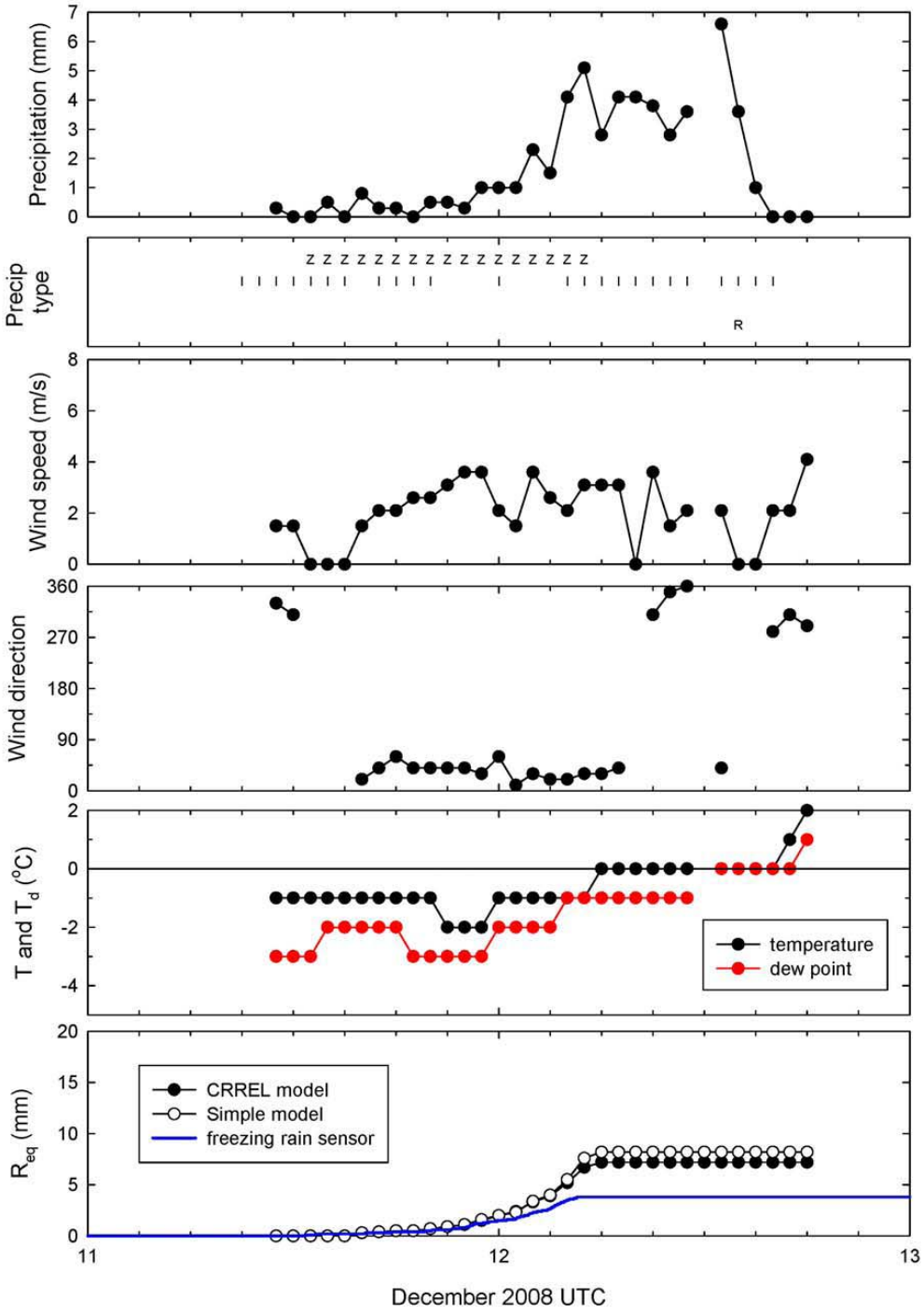

Figure D-5 - Storm time series for Concord, New Hampshire. Equivalent radial ice thicknesses from the CRREL and Simple models and from the freezing rain sensor are in the bottom panel.

Table D-1 - Equivalent radial ice thickness at stations with hourly weather data.

Station		Simple model R_{eq} (mm)	Hourly data comments (times are UTC)	Sensor R_{eq} (mm)	Freezing rain sensor comments (times are UTC)
HARTFORD	CT	-	no freezing rain until December 17	-	
WILLIMANTIC	CT	-	no freezing rain until December 17	-	
WINDSOR LOCKS	CT	-	no freezing rain until December 17	-	
BEVERLY	MA	-	no freezing rain until December 17	-	
FITCHBURG	MA	3.2+	no data 12/0400 to 2200	0.8+	missing data
LAWRENCE	MA	16.2+	no data 12/0800 to 2000	3.8+	missing data
NORWOOD	MA	-	no freezing rain until December 17	-	
ORANGE	MA	3.5+	no data 12/0900 to 2000	1.0+	missing data
PITTSFIELD	MA	1.1		2.5+	data ends 12/12 at 0332
WESTFIELD	MA	0		0	
WORCESTER	MA	17.0+	no data 12/0700 to 13/1300	12.2+	ASOS power off from 12/1100
AUGUSTA	ME	22.7		5.7	
FRYEBURG	ME	14.5		4.2	
PORTLAND	ME	12.4		6.7	
WISCASSET	ME	10.3+	no data 12/1000 to 2100	-	missing data for entire event
BERLIN	NH	6.1	missing 12/1400	2.5	
CONCORD	NH	8.2	no data 12/1200	3.8	
JAFFREY	NH	9.8+	no data 12/0700 to 17/1700	1.6+	missing data
LEBANON	NH	7.1		4.7	
MANCHESTER	NH	13.2		4.3+	ASOS power off from 12/1600
WHITEFIELD	NH	7.5	freezing rain reported for 6 hours with T>0^{o}C	2.5	out of calibration
ALBANY	NY	20.6	missing 12/1000	6.1	
BINGHAMTON	NY	4.4		4.7	
GLEN FALLS	NY	6.9		2	
MONTGOMERY	NY	5.3	wind data missing for 11 hours	2.5	
POUGHKEEPSIE	NY	0.1		0	
SYRACUSE	NY	0.7		-	no icing sensor
WILKES-BARRE	PA	0.5	freezing rain reported for 20 hours with T>0^{o}C	0.3	out of calibration
BENNINGTON	VT	3.9		3.3	
SPRINGFIELD	VT	0+	no data 12/1000 to 13/1600; missing precip data	0.8+	missing data

The largest modeled ice thicknesses in New Hampshire are 13.2 mm (0.5 in.) at Manchester and more than 9.8 mm (0.4 in.) at Jaffrey. As hourly data for Manchester continued after the power outage that ended the freezing rain sensor data prematurely, some of the weather data there was apparently recorded by human observers. On December 14 the CRREL Ice Storm Team measured R_{eq}=14 mm (0.6 in.) on a twig (Figure D-6a) from the top of a birch tree bent over under the weight of ice by the parking lot at Temple Mountain State Reservation (Figure D-6b), about 4 miles east of Peterborough on Route 101, and 7 miles northeast of the Jaffrey airport. There was substantial tree damage in the area, with trees and branches on wires (Figure D-6c). The air temperature was still below freezing at this location at an elevation of about 1500 ft, two days after the freezing rain storm, and the ice appeared to be intact. This was the largest measured ice thickness in the team's survey of the region between Manchester and Keene, New Hampshire. In some areas the ice was already melting so that the ice samples at those sites provide only a lower bound on R_{eq}. Simple model ice thicknesses from Table D-1 are mapped in Figure D-7. Wind speeds during the storm were low to moderate. At locations where temperatures remained cold (e.g. higher elevations) following the freezing rain, the wind blowing on ice-covered trees and wires might have added to the damage. In general wind-on-ice loads do not appear to be significant in this event.

Figure D-6 - CRREL Ice Storm Team Site 9:
a) Ice sample with R_{eq}= 14 mm
b) Icicle covered Temple Mountain sign and wires, with ice-covered trees in the background
c) Route 101 headed toward Peterborough; wires sagging, trees on wires, and broken pole in road.

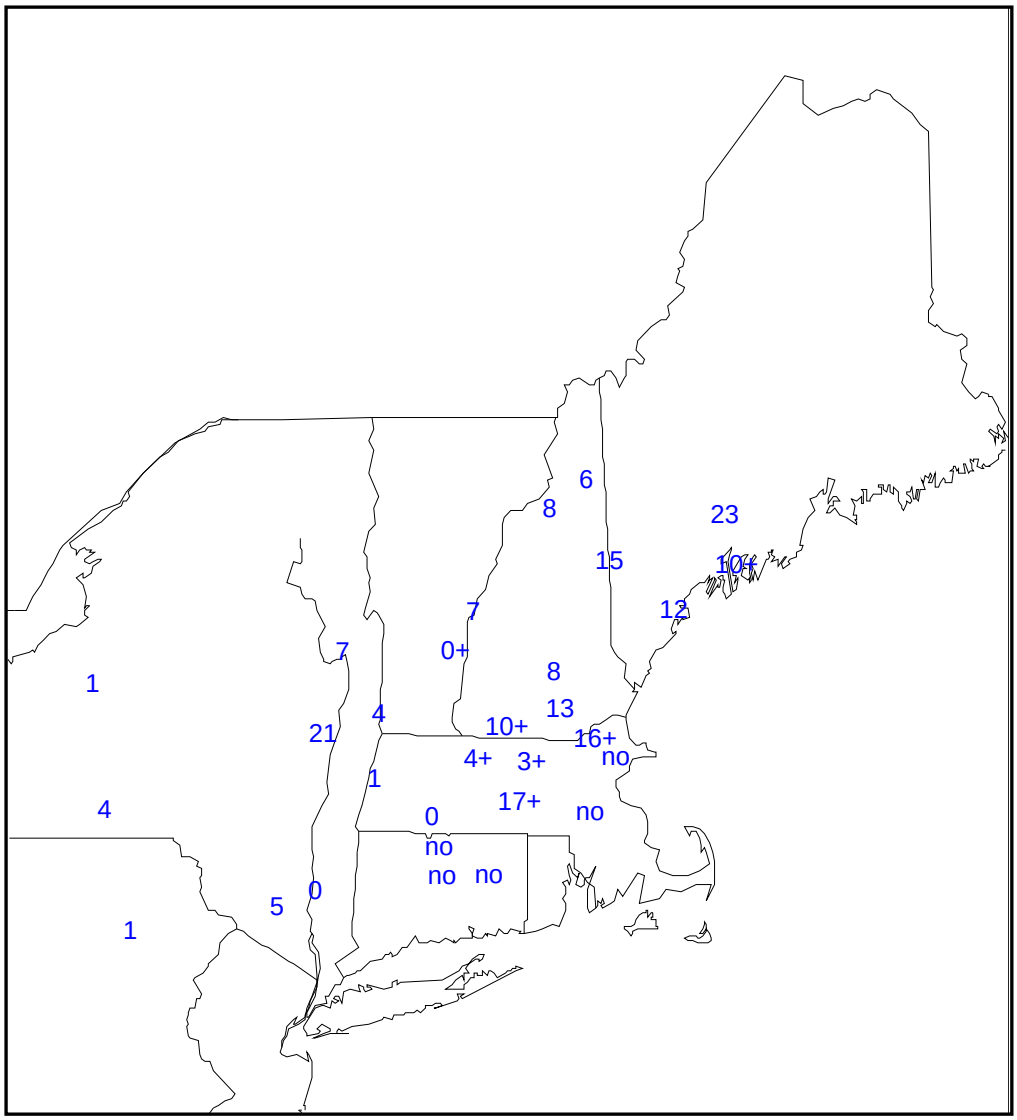

Figure D-7 - Equivalent radial ice thicknesses R_{eq} (mm) for December 11-12, 2008 at hourly weather stations from the Simple ice accretion model: "no" indicates that no freezing rain was observed; "+" indicates that weather data was not recorded for some hours of the storm so the mapped value is a lower bound.

C. DAMAGING ICE STORMS IN THE REGION

The December ice storm damage is summarized below from the newspaper reports listed in Section 2 along with summaries and damage footprints of previous damaging ice storms in this region from http://cmep.crrel.usace.army.mil/ice in reverse chronological order. The ice thicknesses in these summaries are those reported in *Storm Data* (NOAA 1959-present) and the newspaper reports used in the summaries. They are not equivalent radial ice thicknesses.

December 12-14, 2008

11,000 utility customers in Pennsylvania lost power in freezing rain storm; utility poles to WYOU transmitter in Scranton were downed on December 11.

Worst ice storm in 21 years (October 4, 1987) in New York's Capital Region; 229,000 (or 311,000) National Grid, NY State Electric and Gas, and Central Hudson customers without power; outages down to 141,000 (December 13), 42,000 (December 15), 2,000 (December 17); ice more than 1/2 inch thick; extensive damage for National Grid; Amtrak cancelled service between the Capital Region and New York City because of trees blocking the track; basements flooding; phone and cable TV outages also; high winds on December 15 caused more outages; National Grid replacing 350 poles and resetting 772,000 ft of wire.

326,000 National Grid, Unitil, NStar, Western Massachusetts Electric Co., and municipal utility customers lost power in the worst ice storm to hit central Massachusetts in years; in western MA freezing rain in the higher elevations above about 1400 ft felled trees and power lines; outages down to 200,000 (December 13), 95,000 (December 16), 36,000 (December 17), 8000 (December 19); some without power for 10 days; many who lost power also have no water; snow on December 17 slowed down restoration work and caused more outages; telephone poles snapped like toothpicks; tree limbs tangled with downed power lines turned streets into obstacle courses; 1500 National Guard troops helped to clear fallen trees from roads and performed aerial assessments of the damage; 20,000 Charter Communications cable TV customers in central MA still without service on December 16; Verizon phone customers also lost service; widespread disruption of commuter rail leaving North Station because of signal systems down and trees blocking tracks; tree damage in Worcester compounded by the need to control downed limbs infested with the Asian Long-horned beetle; schools cancelled because of lack of electricity and closed roads; minor flooding.

Ice storm clipped Connecticut leaving 16,500 Connecticut Power and Light customers in small northwest CT towns at higher elevations without power; 4,400 still without power on December 13.

In Vermont this was the second most costly storm in the 78-year history of Central Vermont Public Service; 35,000 utility customers lost power with 6,500 still out on December 14; ice up

to 1 inch thick and multiple trees down on every line; more than 45 snapped poles; dozens of state and local roads closed.

Up to an inch of ice across the southern half of New Hampshire downed trees and wires and left 440,000 Public Service of NH, Unitil, NH Electric Coop, and National Grid customers without power; largest outage in NH history; 175 National Guard soldiers deployed to help clear debris and evacuate residents; outages down to 300,000 (December 13), 138,000 (December 15), 44,000 (December 18); unprecedented storm damage for PSNH, with many central power lines damaged, and entire systems needing to be rebuilt; Monadnock, Nashua, and Derry regions hard hit; PSNH crews had strung 55 miles of wire by December 18; PSNH doubled its spending on tree trimming to $13 million last year.

Worst ice storm in a decade in Maine left 220,000 utility customers without power for days; most outages since the January 1998 ice storm when 270,000 customers lost power; outages down to 30,000 (December 15), 8,000 (December 16); 70% of homes and businesses in York County lost power; tree branches encrusted in ice up to 1 inch thick ripped off and fell on power lines causing heavy damage to the electrical distribution system; not much wind; Central Maine Power had to replace 125 poles; outages disrupted the state's fuel distribution when storage tanks could not be pumped; Amtrak cancelled service between Portland and Boston because of branches on the tracks; CMP doubled its tree trimming budget this year to $18 million but 75% of the trees that fell on the power lines were outside the trim zone (8 ft on either side of the wires and 15 ft above and below).

6000 National Grid customers in Rhode Island lost power; these outages were likely from the strong coastal winds.

January 4-10, 1998

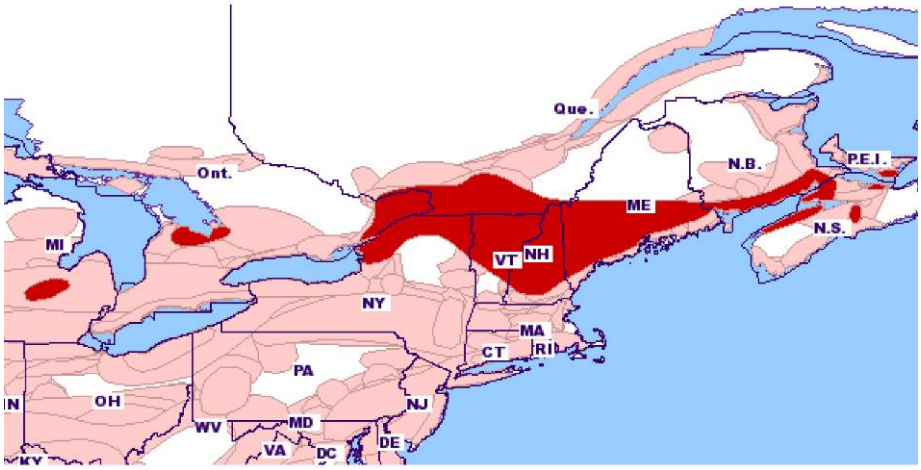

Figure D-8 - January 4-10, 1998 Ice Storm

Freezing rain in Michigan cut power to 2300 Consumers Energy customers.

Freezing rain in Owen Sound region of Ontario; 1.5 inches of ice causing power lines to sag 10 to 15 feet; ice-covered branches on wires caused extensive outages.

Ice storm in eastern Ontario knocked out power to 232,000 utility customers, with 300 transmission line towers damaged; Ontario Hydro had 149,000 customer outages, 36 municipal utilities outages causing an additional 122,000 customer outages, along with 100 towers damaged, 10,750 poles broken, and 2150 transformers damaged; three 115 kV lines that supply Glocester, Greely, Russell, Manotick, and Navan disabled; 90% of Metcalfe without power starting Jan 6 and still without power on Jan 10; much of Ontario Hydro's rural system has to be rebuilt from the ground up; 1000 poles in VanKleek Hill area have to be replaced; 67,700 Hydro Quebec customers in the Outaouais lost power, from the Pontiac to Low; rural region to the east of Ottawa still paralyzed by the power outage on Jan 11 with 15,000 still without power on Jan 12; hundreds of 1000s of trees destroyed; 1000s of fallen trees blocking city streets in Ottawa, where large trees shattered like fragile crystal; highway 417 towards Quebec closed because of electric wires and tree branches fallen on the road; 2000 military personnel sent to clear roads for hydro crews; emergency declared.

Worst ice storm of the century in Quebec; dozens of transmission lines collapsed; ice thickness three or four times the wire diameter in some places; 20 mm of ice on trees and wires near Victoriaville; 300 transmission line towers down, including dozens toppled like dominoes near Ste. Julie; high-tension line at the bottom of the St. Lawrence River near Montreal; 1,393,000 Hydro Quebec customers lost power with 800,000 without power on Jan 9, 590,000 out on Jan 13, 400,000 on Jan 15; 1000 towers toppled and 24,000 poles downed; another report says 100 large lattice towers and 500 smaller lattice towers will have to be replaced; two of the three transmission lines on the North Shore collapsed; all but one of the five transmission lines feeding Montreal went down; seven towers of 735 kV line near Drummondville came down like dominoes closing Highway 20; some of the system will have to be totally rebuilt; 14,000 Hydro Sherbrooke customers lost power; many roads closed in Estrie region because of flooding or trees and wires in the road; five of the dozen prisons, with 1500 detainees altogether, had no power for more than 48 hours; almost everyone in the "triangle of darkness" formed by Granby, Boucherville, and Saint-Hyacinthe lost power and 170,000 customers there still without power on Jan 16; Iberville was without power from Jan 5 until Jan 25 and residents were burning 700 cords of firewood daily; at least 14,000 trees in Montreal uprooted or severely damaged with no fewer than 21,000 trees damaged by the ice; hardly a sugarbush is intact, with tubing buried under fallen branches; 30% of maple trees affected; 5500 dairy producers in Quebec and Ontario had to dump 13.5 million liters of milk; two water treatment plants in Montreal lost partial power; parts of Montreal without water; city subway system shut down temporarily; four Montreal bridges closed and areas in front of tall buildings were roped off; major businesses like IBM and Alcan closed; Rolling Stones concert in Montreal cancelled when falling ice tore holes

in the fabric roof of the Olympic Stadium; Quebec relies on electricity for 41% of energy consumption; 4000 military personnel sent to clear roads for Hydro Quebec crews.

Major ice storm in New York crippled a 9700 square mile area; tens of 1000s of trees damaged; roads closed by ice and downed trees; foot to 18 inches of snow on Jan 15 slowed repairs; Gouverneur prison used as shelter; storm knocked out power to 130,000 utility customers with 116,500 still out on Jan 12 and 61,000 on Jan 18; 99,600 Niagara Mohawk customers lost power, with 59,000 still without power on Jan 15, and 10,000 poles down; New York State Electric and Gas still had 15,000 customers without power on Jan 15; Massena Electric department had lines damaged by huge trees coming down; 75% of Jefferson County without power; Fort Drum without power from Jan 8 to Jan 11, but 1200 families in the off-post military housing still without power on Jan 14; farmers in Clinton County shared three truck-sized portable generators so they could milk their cows; 249th Engineer Battalion installed more than 50 FEMA-supplied generators where needed (e.g. hospital, nursing home, Indian reservation) National Guard called out to help with storm cleanup; federal disaster declaration; flooding followed ice storm, with the Black River flooding in Watertown, Carthage and Philadelphia.

Ice storm in Vermont; more precipitation in four days than the average total for January; 33,200 utility customers lost power; power lines and tens of 1000s of trees snapped from weight of ice; tree damage compared to the 1938 hurricane; farmers unable to milk cows; 6500 utility customers across the state still without power on Jan 13; in Pittsburg and Errol the ice on trees and wires had not melted on Jan 14; Citizens Utilities had 1/2-inch-diameter wires as big as coke bottles with accreted ice--the weight broke poles or pulled them out of the ground; poles came down like dominoes; CU had 1400 customers without power from Guildhall to Norton; all customers in Grand Isle County were reconnected by Jan 18; Vermont utilities had 9000 customers still without power on Jan 10; 13,000 Central Vermont Public Service customers lost power with 8,000 still out on Jan 8; 10,000 Green Mountain Power customers lost power with 5000 still out on Jan 10; 10,000 Burlington Electric Department customers lost power; Central Vermont Public Service 46 kV line and Green Mountain Power transmission line down, so one-quarter of Addison County was without electricity; electric distribution system in Isle La Motte and Alburg needs to be rebuilt from the ground up; some Bell Atlantic customers lost phone service (2000 from South Burlington office) elevation difference noted in many areas including St. Johnsbury; in Strafford area, ice damage began at about the 1700-ft level and increased in severity with elevation, with damage mostly confined to summits and south and southeast facing slopes; Windsor County Forester observed that eastern and southern hillsides above 1500 ft were most severely affected; thousands of trees, some of them a century old, were toppled or crippled; trees in South Reading looked like they were run over by a lawnmower; Granby was like a war zone; century-old sugar maples splintered in Tunbridge; some of heaviest tree damage was in Orange and Windsor counties; in Burlington 25% of the public trees (crabapples, pine, green ash, black walnut) either toppled or will have to be cut down, and another 25% were damaged; in the Champaign Islands maples, cottonwoods, and apple trees were hard hit; 90% of trees on the

University of Vermont campus were damaged; 60% of the 5000-mile-long state trail system was crippled by fallen trees; tree tops and tubing in sugarbushes damaged; worst storm in a long time for CVPS.

Severe ice storm in New Hampshire knocked out power to 67,586 utility customers; sugar bush and timber damage; damage generally occurred in areas between 1000 and 2000 ft above sea level where ice accreted 1 to 3 inches thick on trees and power lines; large differences in ice accretion occurred with small differences in elevation; little icing in some town centers (e.g. Laconia, Pittsfield, New Durham, Hanover, Colebrook, Stewartstown, Stratford, Enfield, Croydon, Lyme, Cornish, Plainfield, Grantham), but heavy icing with tree damage in the surrounding hills; 250 poles, 80 crossarms and 430 transformers had to be replaced; New Hampshire utilities still had 34,500 customers without power on Jan 10; entire town of New London without power; most of Newport without power on Jan 10; 55,000 Public Service of New Hampshire customers lost power with 43,000 out Jan 9, 30,000 on Jan 10, 15,500 on Jan 11, 11,500 on Jan 12, 1150 on Jan 14, and a handful on Jan 18; more than 11,000 New Hampshire Electric Coop customers lost power with 10,000 out on Jan 9, 6000 on Jan 11; 1000 on Jan 14, 150 on Jan 18; DC transmission line from Quebec to Massachusetts damaged along its route through New Hampshire; aerial survey estimated that 5% of the forest was severely damaged with birches and maples at elevations around 1200 ft hit the hardest; south and, perhaps, east facing slopes in Grantham area were hit the hardest; 2 million of the 5.5 million acres of forest had at least some damage; 900 trees down across the trail from Pinkham Notch to Tuckerman Ravine on Mt. Washington, but temperatures remained above freezing at the summit and down to halfway on the auto road; 100s of blowdowns in the White Mountains National Forest; still ice on trees at higher elevations on Jan 24; 300-ft-tall radio tower in Laconia coated with 1 to 1.5 inches of ice collapsed; 2310 phone customers lost service; 16 communities declared a state of emergency; federal disaster declaration for all except Rockingham County; National Guard called up; worst ever ice storm for some old-timers. Another freezing rain storm on Jan 24 hit Manchester, Nashua, and Rochester and surrounding towns with scattered outages cutting power to 31,000 PSNH customers.

Severe ice storm in Maine, followed by single-digit temperatures on Jan 12, knocked out power for 365,000 utility customers; winds gusting to 35 or 40 mph and temperatures in the mid-teens slowed efforts to restore power to the utility customers still out on Jan 14; one third of outages lasted for more than a week and some had no power for three weeks; some summer homes may not get power until spring; ice accreted up to several inches thick on trees and power lines; half-inch guy wire in Bar Harbor was covered by ice that was 9 inches in diameter; 3200 poles, 1.2 million feet of wire, 1600 crossarms, and 2100 transformers had to be replaced (note that these totals are less than the estimates for CMP alone); 291,500 Cental Maine Power customers lost power with 212,000 customers still out on Jan 10, 185,000 on Jan 11, 142,000 on Jan 12, 98,000 on Jan 14, 82,775 on Jan 15, 47,000 Jan 18, 14,183 on Jan 20, 3200 on Jan 22, 1500 on Jan 23; longest outages were in the Augusta, Lewiston and Bridgton districts with 17 days required for

restoration of power; had to replace 2 to 3 million feet (several 1000 miles) of cable/line, 2,500 poles, 4000 crossarms, 5250 transformers; 50,000 Bangor Hydro Electric customers lost power with 20,000 still out on Jan 12, 6700 on Jan 14, 6600 on Jan 15, 3782 on Jan 16, 1400 on Jan 18, 100 on Jan 20; 8-mile section near Deblois of H-frame 115 kV transmission line serving downeast Maine cascaded, so Indeck woodfired plant in Jonesboro brought online to help provide power to the 10,000 customers in the area using the lower voltage Route 1 line, which had also been damaged; industrial generators also brought in; Indeck (asking 6 cents/kwh) and Bangor Hydro (offering 3.8 cents/kwh) at odds over cost of power from plant, power ultimately provided at cost as needed; 10,000 of Eastern Maine Electric Coop's 12,000 customers lost power with a few hundred still out on Jan 14; major part of the state's transmission system was patched together by Jan 12; most gas stations along the Maine Turnpike closed on Jan 13 with no power for the pumps; almost every road in Acton blocked by fallen trees with limbs encased in 2 inches of ice; a line of 12 poles along route 201 in Gardiner knocked to the ground by fallen trees and branches; Maine Public Radio responsible for doing emergency broadcasts, but had no emergency generator, so was off the air for four days; public television was off until Jan 15; still outages in rural Otis, Mariaville, North Ellsworth and Bucksport on Jan 20; a dozen streets, down from 100 on Jan 9, in Waterville still blocked by trees and power lines on Jan 20, with work slowed by two days of snow; only minor damage to phone system, with one low-hanging wire severed by tractor-trailer rig and another burned through by a live power wire; Bell Atlantic using backup generators, maintained by 87 people, to keep the system's battery power on line; also had damage to more than 6000 local phone lines; relatively light damage attributed to the company's improving the reliability and survivability of the infrastructure over the past ten years, with stranded cables that can withstand 10,000 psi stresses; State Cable customers lost service in the ice storm from power outages to the system, broken cable drops to houses, and damaged transmission lines; still 4900 without service on Jan 15; seven communication towers collapsed; top 70 feet of WEZQ tower on Blackcap mountain fell off; 300-foot tower of 104.7 The Bear on Mount Waldo came down because of heavy icing; trolley service disrupted; extensive timber damage; worst devastation in 33 years for Bangor city forester; 200 city trees in Bangor will have to be removed; birch trees with 6- to 9-inch trunk diameters bent to the ground; pine trees splintered; major event to the forests, particularly in southern Maine; greatest toll was in hardwood stands, worse where foresters had thinned the trees to encourage growth; 2.1 million of the state's 19 million acres of forest had the worst damage, with moderate damage to 2.5 million acres and light damage to 5.9 million acres; National Guard and Brunswick Naval Air Station loaned CMP flood lights so the line crews could work at night; additional tree and power line crews and trucks flown in by Air Force; the power system was fragile after repairs had been made because of all the damaged trees near the lines; rash of generator thefts from homes, businesses, telephone switching stations, and utility company buildings; thefts of equipment from CMP trucks; CMP trims branches on a five-year cycle; worse than hurricanes Gloria (1985) and Bob (1991); compared to Dec 19, 1929 ice storm; worse than the flood of '87 or the hurricane of '68; National Guard and public works employees helped with tree clean up; federal

disaster declaration for the entire state. Another devastating freezing rain storm with gusts to 25 mph on Jan 24 hit the Portland, Brunswick, and Alfred districts cutting power to 75,000 CMP customers, with 12,000 still without power on Jan 25, and 1000 on Jan 26; 1 or 2 inches of ice on top of the wires with 4-inch long icicles; 90% of Wells without power; Cousins and Littlejohn Island hard hit; Prince's Point Road hit with long outages in both storms; little damage to poles.

Ice storm in New Brunswick cut power to 28,000 New Brunswick Power customers, 2500 for four days; heavy build up of ice snapped main feeder lines; St. John Energy still had 500 customers without power on Jan 14; several poles toppled outside St. George where there was no power; St. George and St. Andrews declared state of emergency; hardwood tree damage.
Ice storm in Nova Scotia cut power to 20,000 Nova Scotia Power customers; power outages in the Annapolis Valley lasted three days for 500 customers in rural areas; severe apple tree damage feared.

Ice storm in Prince Edward Island knocked out power to a few hundred (or more) Maritime Electric customers for 10 to 12 hours; high winds to 130 km/hr caused wires to gallop and slap together, also pulled down poles.

On Jan 16 new ice storm hit Connecticut knocking out power to 16,200 utility customers.

November 19, 1986

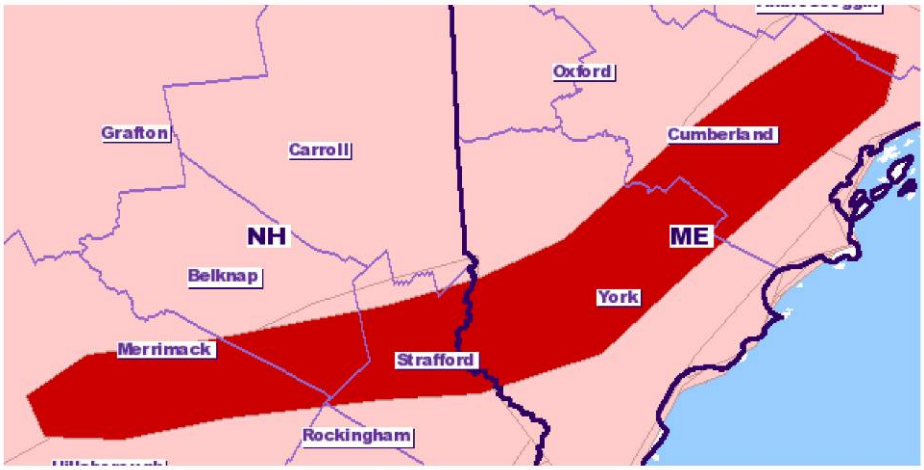

Figure D-9 - November 19, 1986 Ice Storm

Snow and freezing rain storm in New Hampshire loaded branches which broke onto utility lines; scattered power outages; 700 in the Lakes Region without power for up to 7 hours; 3200 in Manchester without power for a few hours; 1000 in Milton without phone service for up to 12 hours.

Narrow swath of freezing rain in Maine raised havoc with trees and power lines; ice-laden branches broke onto power lines; 12,000 utility customers were without power.

January 3-7, 1986

1 inch of ice on trees in Maine in sleet and freezing rain storm caused weekend-long power outages.

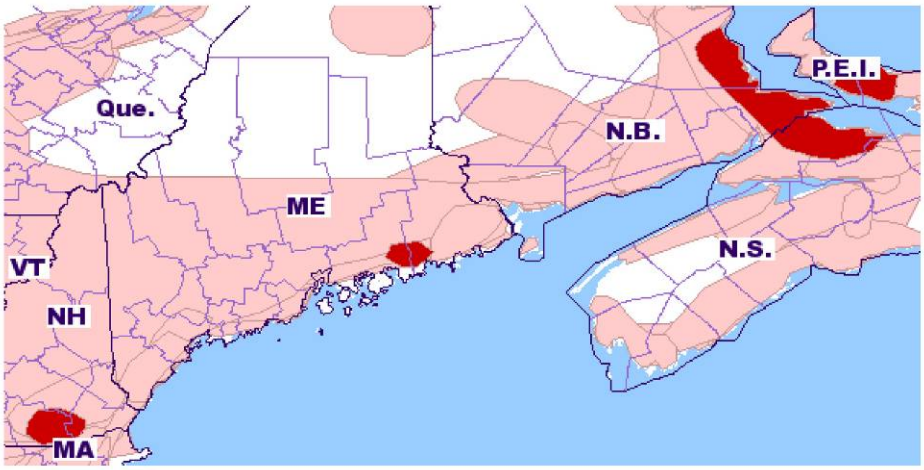

Figure D-10 - January 3-7, 1986 Ice Storm

Freezing rain in New Hampshire caused power outages for 100s.

Power out for several 1000 customers in New Brunswick; drifting snow and high winds made repairs difficult.

Snow, freezing rain, and wind left 1000s without power in Nova Scotia for up to four hours.

Worst ice storm of winter in Prince Edward Island caused massive outage; winds to 120 km/hr; wires galloping and poles down on main transmission line; power not restored for 10 to 12 hours; phones out in some areas.

Not mapped: 10,000 without power in Cape Breton at some time during the weekend.

January 31 – February 4, 1982

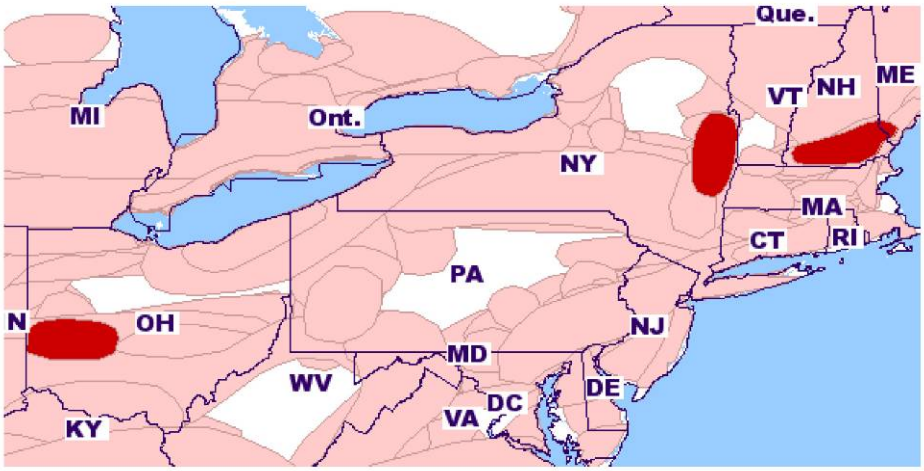

Figure D-11 - January 31 - February 4, 1982 Ice Storm

Wet snow, sleet, rain, freezing rain, and wind storm in Ohio caused power outages; broken trees and ice on wires broke wires; 17,000 Dayton Power and Light customers without power; no power or water in New Paris; outages lasted up to three days.

Heavy ice and tree branches pulled down power lines in eastern New York; 11,000 Niagara Mohawk customers in Columbia County lost power for up to nine hours; Troy hardest hit; one of the better ice storms in the past ten years.

Widespread power outages in New Hampshire in rain, freezing rain and snow storm.

Ice and broken tree limbs caused outages in Maine according to *Storm Data* but no outages were reported in the *Portland Press Herald*.

January 4-9, 1979

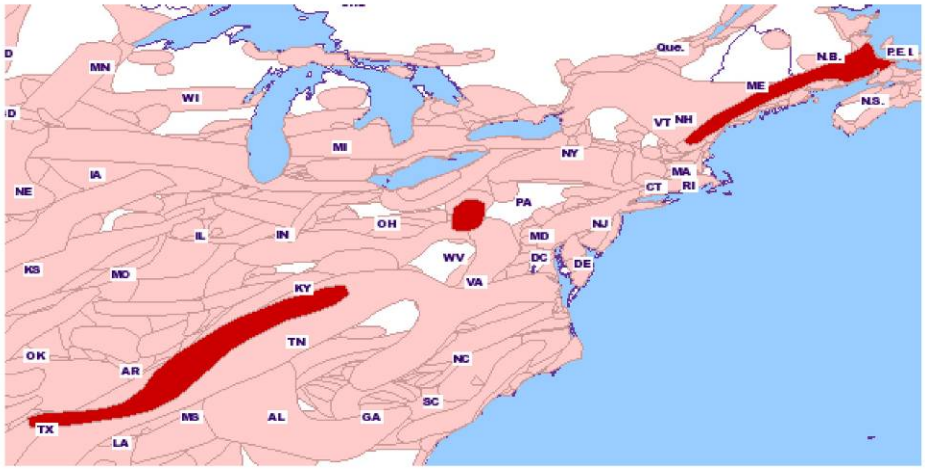

Figure D-12 - January 4-9, 1979 Ice Storm

Power and phone outages from ice-laden trees falling on wires over large parts of Whatcom County in Washington; three Puget Power substations that had been restored once went out again.

Second ice storm in a week in Texas caused scattered brief power outages.

Up to 3 inch ice accumulations in Arkansas; Arkansas Power and Light had 80,000 customers without power at the height of the storm; with many still out two weeks later; 3.5 millions acres of timber damaged; one of worst ever ice storms in the state.

Up to 2 inches of ice in Mississippi snapped limbs and broke wires and poles a few feet above ground level; 30,000 customers had no power for several days; Cleveland and Clarksdale blacked out for a day; very cold following storm; governor declared state of emergency in nine counties; Tennessee Valley Authority had outages caused by ice; extensive damage to forests and orchards.

Freezing rain caused power and phone outages and damaged trees in Tennessee; Tennessee Valley Authority had outages caused by ice.

Freezing rain in Kentucky caused power outages; ice-covered wires and tree limbs snapping wires; 50% of Warren Rural Electrical Cooperative customers in eight counties were without power for up to two days; major transmission line in Lexington knocked out by ice on the wires; phone service out for hundreds of South Central Bell customers; two poles that were cut down for firewood caused outages near London; worst ice storm ever.

Freezing rain caused power outages over most of western Pennsylvania.

1 to 2 inches of ice accumulated on trees and wires and caused a major power disruption in New Hampshire.

Heaviest ice storm in many decades in Maine coated trees and power lines with more than 2 inches of ice; 45,000 customers were without power for an extended period; moderate damage to fruit trees.

Widespread outages in New Brunswick from freezing rain; over an inch of freezing rain in Fredericton weighted trees with ice; four elm trees fell on one power line in the Fredericton district; 32 communities blacked out; some without power for two days; phones out of service for some in Moncton; not as bad as the Groundhog Day storm a couple of years ago that had cold temperatures and high winds.

December 5-21, 1977

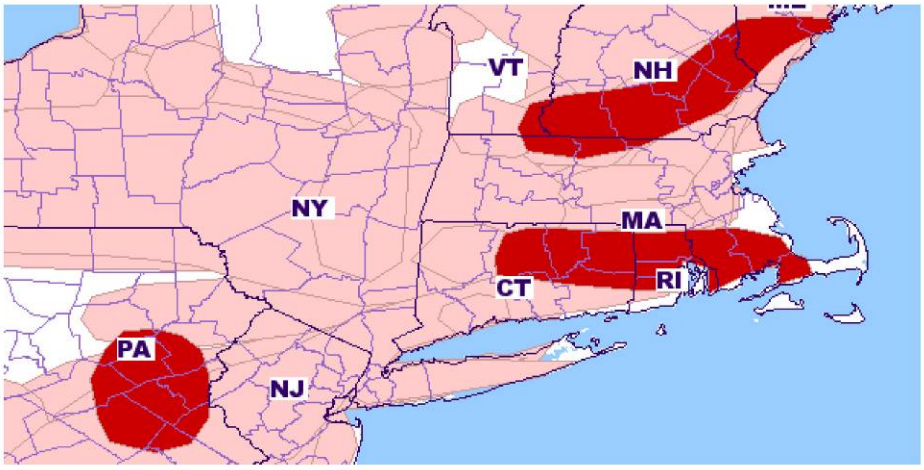

Figure D-13 - December 5-21, 1977 Ice Storm

Considerable buildup of ice from freezing rain in Pennsylvania's Lehigh Valley and northern Schuylkill Valley; trees bent and broken by ice broke power lines; 35,000 utility customers without power, some for a considerable period.

Ice from freezing rain broke tree limbs and power lines in Connecticut.

Ice broke power lines in Rhode Island.

Freezing rain broke power lines in Massachusetts.

Freezing rain caused some electrical blackouts in Vermont.

Freezing rain coated trees in New Hampshire; birch trees leaned and evergreen tree branches broke on power lines causing outages that lasted for hours.

Freezing rain, sleet and snow in Maine; Central Maine Power had scattered outages, many in rural areas; sleet jumping added to outage duration.

December 21-31, 1975

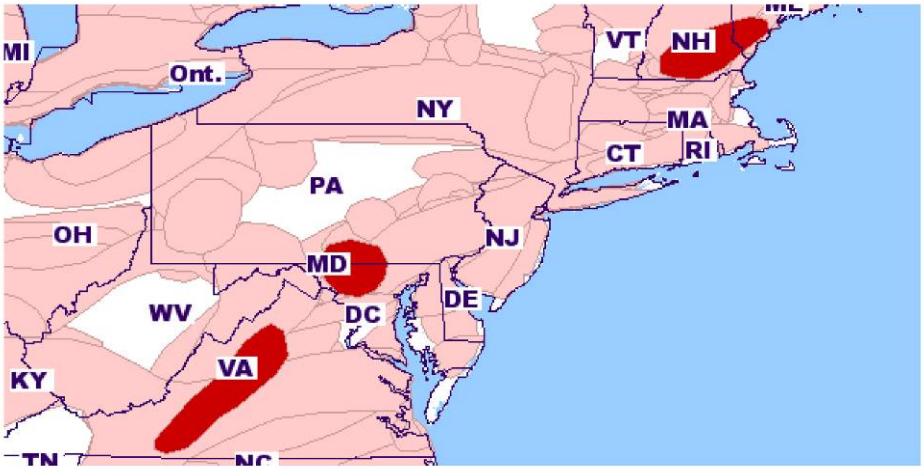

Figure D-14 - December 21-31, 1975 Ice Storm

Freezing rain in Virginia caused power outages; ice laden branches snapped off ripping down power lines; 1/2 inch of ice on objects in Charlottsville-Lynchburg area; bent trees and broken branches damaged power lines in southwestern Virginia, with outages lasting up to 82 hours; one of the most severe ice storms in recent years in that area.

Freezing rain in Maryland produced ice laden tree branches that snapped phone and power lines as they broke; service interrupted.

Heavy freezing rain in Pennsylvania downed many trees and power lines resulting in numerous power outages.

Heavy ice accumulations in New Hampshire caused tree damage and power outages.
Fallen tree limbs knocked out power in Maine.

January 28, 1973-February 3, 1973

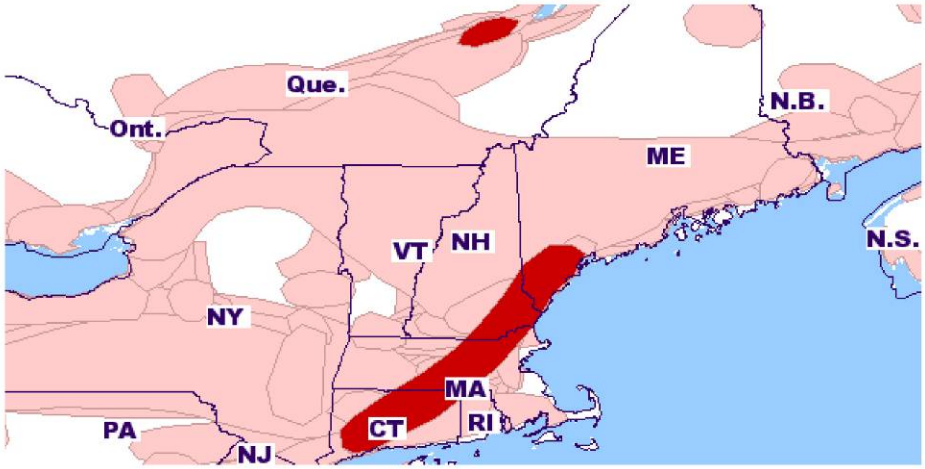

Figure D-15 - January 28, 1973-February 3, 1973 Ice Storm

Wind and ice felled trees and power lines in two storms in Connnecticut; 8500 customers were without power for various periods in the first storm; the second storm caused some outages.

Some power outages in Rhode Island from glaze and wind.

Freezing rain in Massachusetts resulted in ice thicknesses of up to 1 inch; wind blew down ice-laden branches that damaged utility lines.

Freezing rain in New Hampshire; limbs of ice-covered trees broke and cut utility wires. Scattered damage in Maine from limbs of ice-covered trees falling.

Freezing rain in greater Quebec City and east caused heavy damage to the power and phone lines on the north shore of the river; 2-inch-thick ice in some regions; 1 inch of ice on phone poles; outages caused by ice-covered trees falling on wires; 32,000 customers without power for a couple of days.

December 14-28, 1973

Numerous power outages in Maryland from freezing rain icing trees that then fell on power lines.

Ice from freezing rain broke large tree limbs and power lines in Delaware; outages lasted more than four days for homes and poultry farms; National Guard called out.

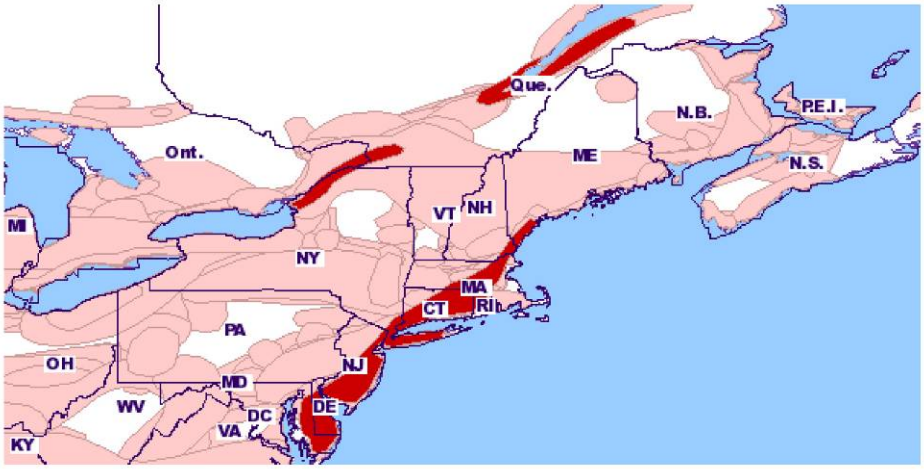

Figure D-16 - December 14-28, 1973 Ice Storm

Howling sleet and freezing rain storm in New Jersey; power failures in most counties from ice-weighted trees snapping; astronomical damage to trees.

1 inch of ice with long icicles on trees and wires in severest ice storm in many years in New York; trees and limbs fell on ice-coated wires; many communities without electricity; fallen trees obstructed streets and highways; three people electrocuted by fallen power lines.

Freezing rain in Connecticut caused ice buildup on trees resulting in greater damage than in the 1938 hurricane; power lines broken by ice and trees; 269,000 Connecticut Light and Power Company (worst storm in 20 years) customers without power, with outages lasting longer than one week; Hartford resident killed by falling tree limb; emergencies declared in Hartford, Middlebury, Vernon, and Middletown; National Guard activated to clear fallen trees; worst ice storm in history.

Freezing rain in Rhode Island covered exposed objects with thick ice and caused widespread broken trees and branches and utility failures; 100,000 customers without power at one point; roads blocked by trees.

Freezing rain in Massachusetts downed 100s of trees and utility lines; 80,000 Boston Edison customers without power for up to 24 hours; state of emergency in Marlborough; 80% of Sudbury without power; 123,000 in central Massachusetts lost power; 206-foot-tall radio tower in Framingham downed by weight of ice; most severe icing since December 1968 or longer.

Freezing rain and snow caused rash of power outages in New Hampshire.

Freezing rain and snow in Maine caused hours-long power outages; no power in Wells; most outages caused by ice-covered branches falling on wires.

Niagara Mohawk in northern New York along Lake Ontario and Seaway had scattered outages in sleet, rain and freezing rain storm from frozen switches and ice-covered branches falling on wires; thick ice on trees and wires in Massena.

75,000 Hydro-Quebec customers without power in Quebec City, Quebec and east to Mont Joli and Gaspe from freezing rain storm; gusty winds to 25 mph after storm; severe outages in Mont Joli region, where state of emergency was declared, caused by weight of ice and by branches falling on wires; many without power for up to six days; water filtration system out in Ste. Foy; 18 poles down near Ile Verte; irreparable damage to 1000s of trees; some relatively short outages to 200,000 in Montreal (pole knocked down by truck, circuit breakers tripped) and Ottawa; worst ice storm since 1961, worst of the century in the lower St. Lawrence region.

December 30, 1972- January 1, 1973

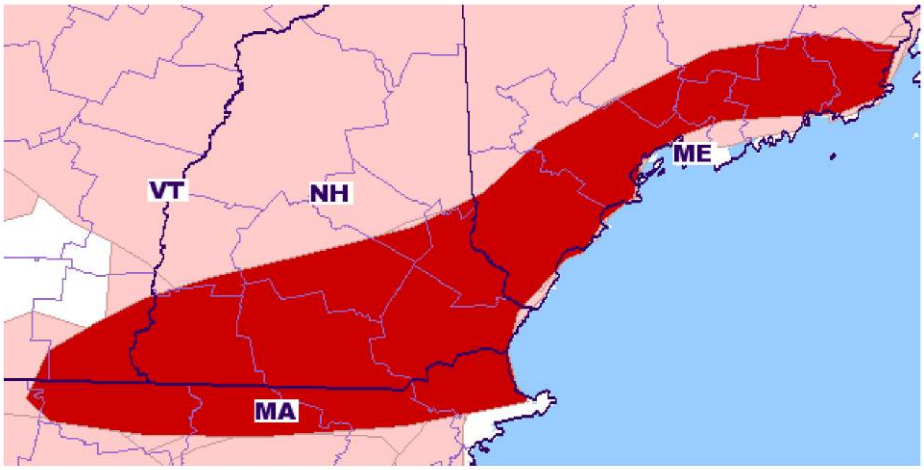

Figure D-17 - December 30, 1972 - January 1, 1973 Ice Storm

Severe icing from freezing rain in Massachusetts caused serious tree damage and power outages; ice accumulated to 1/2 to 3/4 inch thick; maples in one area suffered 50% loss.

Serious ice storm in Vermont; much tree damage, especially to maples, and utility outages.

Serious ice storm in New Hampshire with ice accumulation up to 1/2 inch and more; much tree damage from weight of ice; utility outages.

In Maine severe ice storm broke tree limbs and caused utility outages.

December 22, 1969- January 17, 1970

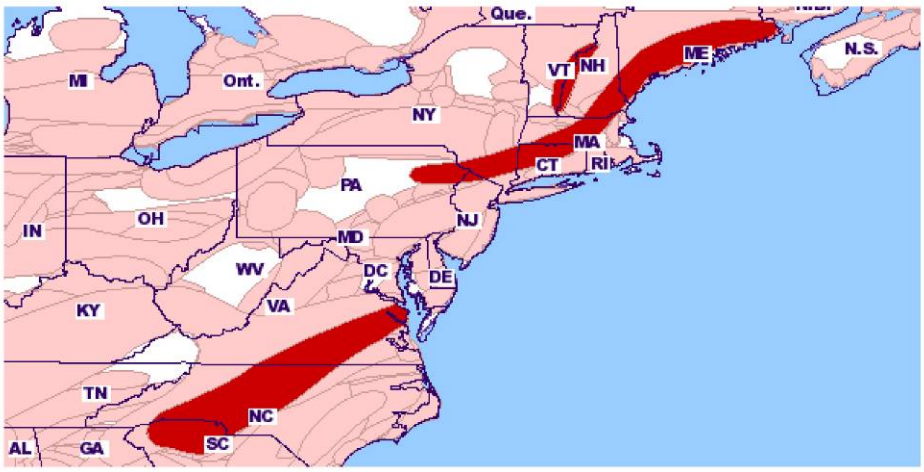

Figure D-18 - December 22, 1969- January 17, 1970 Ice Storm

Freezing rain, snow, and wind caused power failures in Pennsylvania.

Moderate utility damage in scattered areas in New York from freezing rain, with outages lasting up to 48 hours.

Two freezing rain storms in Connecticut, the first with high winds caused extensive power failures; power and communication lines knocked out in second storm also.

A severe ice storm in Massachusetts; trees and limbs weighted with ice broke and downed utility lines; widespread power outages; cars damaged by falling limbs; in the northeaster that followed heavy snow and ice on trees broke trees and limbs, causing utility outages.

Noreaster in Vermont caused freezing rain along the Connecticut River and in the Northeast Kingdom; ice built up to more than 2 inches with local reports of 3 to 6 inches on wires and twigs; devastated forests and utility lines described as "havoc unbelievable"; prolonged utility outages, up to a week or more; most severe ice storm in 40 years for the utility companies in the Connecticut Valley area where ice remained in the northern sections for up to six weeks.

Freezing rain in southern New Hampshire caused heavy icing and widespread power failures; in second ice storm spectacular glazing in north coated twigs and wires with 1 to 2 inches of ice; trees and limbs broken by thousands with devastation comparable to the 1938 hurricane; power out for the second time in a week in some areas.

Worst ice storm in many years in Maine followed a few days later by a northeaster; in the first storm 1000s of trees toppled and took utility wires with them; snow, sleet, and freezing rain in the second storm damaged 1000s of trees causing devastation like the 1938 hurricane; utility wires downed for the second time in a week in some communities.

Freezing rain in Virginia damaged utilities; 50,000 customers of Virginia Electric and Power Company in Richmond and 62,000 overall without power; heavy ice damaged trees and shrubs; power outage in Richmond caused loss of water pressure and sewage overflows into nearby creeks; wires and trees snapping up as ice melted caused more outages; some customers without power for three days.

Trees and power and phone lines damaged in North Carolina from a great deal of freezing rain; trees fell on power lines; outages lasted from a few hours up to two days.

Trees and power and phone lines damaged by freezing rain in South Carolina.

December 21, 1968-January 18, 1969

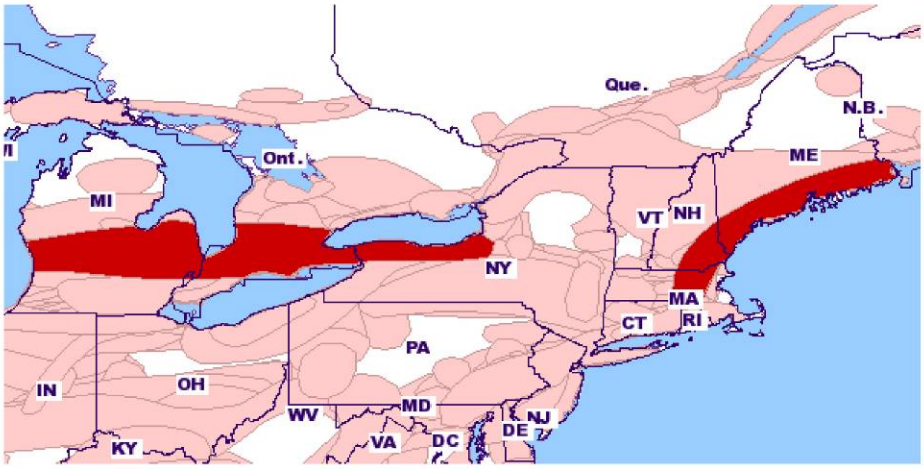

Figure D-19 - December 21, 1968-January 18, 1969 Ice Storm

Falling trees and power lines in Astoria, Warrenton, and Hammond, Oregon from freezing rain; communications out to Cape Disappointment; trees and power lines down along Highway 30; no power or phones in community north of Washougal; armor coat of ice and numerous outages in Portland after snow; first silver thaw there since December 1964.

Ice-covered trees caused outages in North Bend and Prescott, Washington.

1 to 2 inches of ice from freezing rain in Michigan; worst damage in history for utilities in Lapeer and Sanalac Counties; three to four mile stretches of poles and wires on the ground; trees broke under weight of ice; major disaster for Detroit Edison; many in rural areas without power for more than three days; whistle at St. Johns fire department froze.

Worst ice storm in 20 years for Ontario Hydro in Simcoe, Ontario; almost a crisis in Niagara Falls; up to 0.5 inch of ice in outlying areas of Hamilton; up to 3 inches of ice in Simcoe area

with residents still without power after four days; not as bad in Stoney Creek area as the storm 11 months ago, with outages lasting only 30 hours in this storm.

Freezing rain with 1/4 to 1/2 inch of ice in New York crippled counties from Niagara Falls to Oswego area; power and phone lines disrupted; worst from Niagara to Rochester with 300 lines down in Niagara County.

24 hours of freezing rain resulted in the worst ice storm since 1921 in the area just west of Boston, Massachusetts; 1/2 inch of ice or more on exposed surfaces; 100,000 without power, some for an extended time.

Ice broke trees in Maine causing utility outages.

Up to 1/2 inch of ice from freezing rain broke branches and caused utility failures in New Hampshire.

Extremely heavy ice accumulations from freezing rain in interior Rhode Island caused considerable damage.

December 25, 1967-January 19, 1968

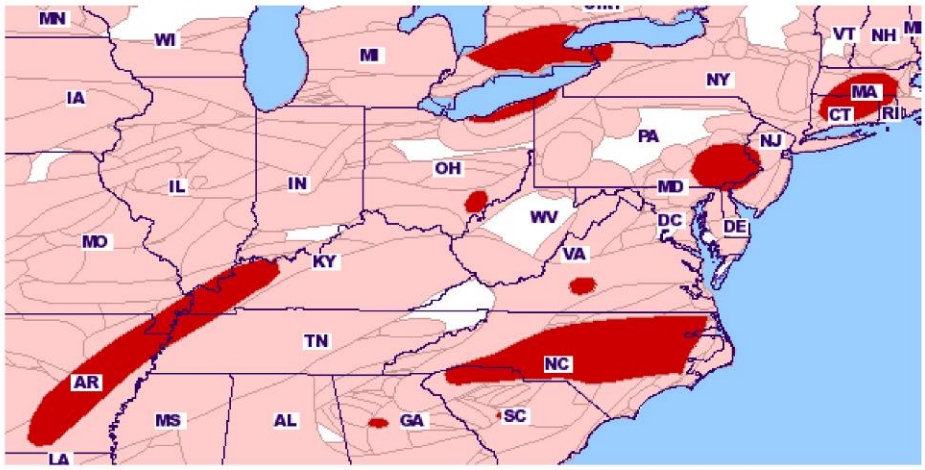

Figure D-20 - December 25, 1967-January 19, 1968 Ice Storm

Worst snow and ice storm in living memory in London, Ontario, with outages lasting more than 5 days in some areas; most power outages were caused by ice covered trees breaking on wires; birches and willows hard hit; phones out in some areas; TV tower south of Alymer collapsed; former head of London PUC compared it to the March 1922 storm that blacked out most of the city; worst ever ice storm for Toronto Hydro crippled city.

Freezing rain coated trolley wires with ice in Cleveland, Ohio; power lines toppled mostly in north central and southeast counties; worst storm of the season.

Gusty sleet storm in southeastern Pennsylvania broke overhead wires; power outages in Erie from ice-covered branches falling on wires.

Weight of ice and snow broke many utility lines in Kentucky; residents without power or phones.

Power out in northwest Tennessee for up to nine hours.

55,000 outages for Arkansas Power and Light customers from glazing; 15,000 Southwest Bell customers in 20 cities lost phone service in the storm.

Freezing rain damaged trees and caused outages in Connecticut.

Two episodes of freezing rain caused outages in Massachusetts, up to 1/2 inch ice damaged trees and utility lines.

Widespread but little damage to trees and utilities in Virginia.

2 to 3 inches of ice but luckily no wind in North Carolina; several counties without power or phones for one to five days; worst power failure in Charlotte's history with 40,000 of Duke Power's 114,000 customers without power; 50% of Goldsboro without power; one of the worst ever ice storms for Carolina Power and Light, and far worse than Hurricane Hazel in 1954; 73% of Southern Pines without power, problems caused almost exclusively by longleaf pines falling in massive numbers; no gas available along I-75 from Smithfield to almost Fayetteville; large chunks of ice falling from 1400-ft WCTU-TV tower punched holes in the roof of the studio; REA chairman calls it the worst ice storm since 1942.

Freezing rain coated a power line that fell on phone cable on Paris Mountain, South Carolina; worst ice storm in 37 years in Greenville; worse than hurricane Hazel; power and phone lines in Greenville are much less vulnerable than they were at Christmas 1945 when an ice storm knocked out power to 70% of the city.

Ice accumulations from freezing rain broke a main feeder line in Marietta, Georgia; outages in metro Atlanta also from ice-covered branches falling on wires; some customers without power for two days.

January 4-19, 1962

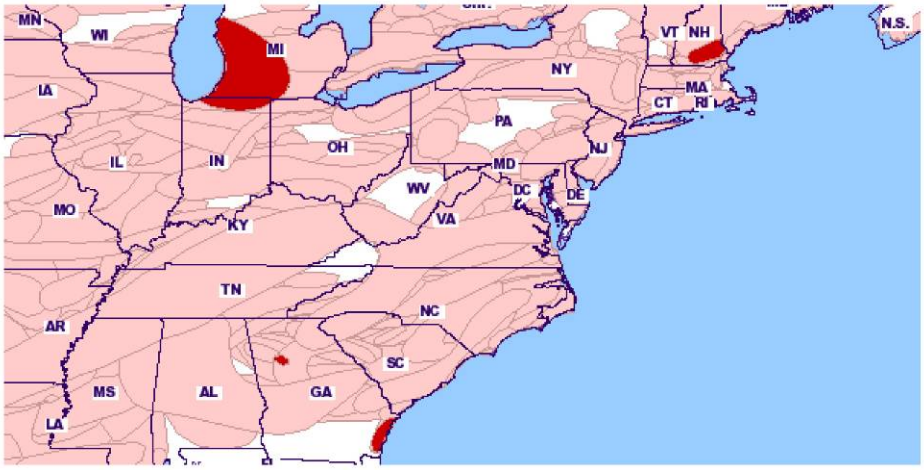

Figure D-21 - January 4-19, 1962 Ice Storm

One of the most severe and sustained ice storms in history in the Muskegon, Michigan, area; Consumers Power Company had primary lines out in at least ten parts of the county, but had them back in service within five hours.

In Indiana westerly winds to 31 mph broke ice-covered wires; phone and power lines down from weight of ice and ice-covered trees falling on wires.

Unusually severe glazing on trees and wires in New Hampshire caused some power and phone outages; great damage to trees and shrubs; worst ice storm in 30 years.

Worst ice storm in recent memory in Massachusetts and Maine, but no mention of tree or power line damage in the *Boston Globe* or the *Portland Press Herald*, disagreeing with *Storm Data*.

Southeast coastal Georgia paralyzed by unusual ice storm for several hours; phone and power lines damaged by falling ice covered trees; in Atlanta area wires broken by ice-covered trees, power restored by afternoon; Atlanta Transit using ice breakers on trolley wires.

Ice coated trees in the Hilliard area in Florida, but no reports of damage.

January 1-2, 1961

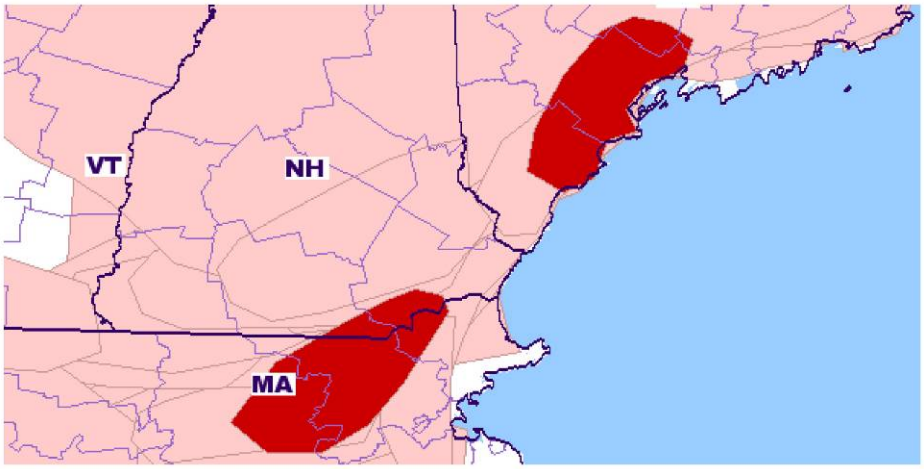

Figure D-22 - January 1-2, 1961 Ice Storm

Power lines broken by ice on wires or ice-covered trees falling on wires in Massachusetts.

Snow, rain, and sleet in New Hampshire; power outage in Salem.

Snow, rain, and sleet storm in Maine; power lines snapped under heavy coating of ice over a widespread area; tree limbs damaged wires; roads closed because of live wires; New England Telephone and Telegraph had minor damage.

December 23, 1959 - January 6, 1960

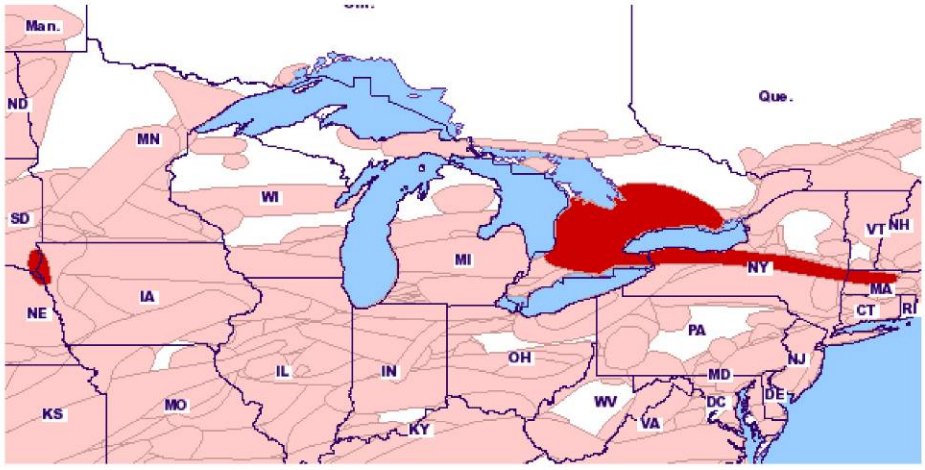

Figure D-23 - December 23, 1959 - January 6, 1960 Ice Storm

Extensive damage to trees and wires from glaze and strong winds to 25 mph in South Dakota; 40 communities without phones for more than 24 hours.

0.5 to 0.75 inches of ice in Ontario; long stretches of poles on the ground; phone, telegraph and power out; poles upside down; trees split open with poplar, birch and willow trees taking a beating; 220 kV line between Barrie and Kitchner severed, 115 kV line between Niagara and Hamilton out, 115 kV line outside London and three of four 115 kV lines from Owen Sound to Hamilton down; one week to restore power in Orangeville; worst sleet storm in years; worst in 20 years for Bell Telephone.

Worst sleet storm of major proportions in western New York since 1936; strong winds off Lake Ontario contributed to heavy icing of trees and wires; most severe ice storm of record in Rochester area with more than 40,000 utility customers without electricity--some still out on January 1--and 4500 customers without phone service; in Buffalo worst in 30 years for Niagara Mohawk, winds whipping wires, worst tree damage since 1929, 115 kV line down; 1.5 inches of ice on wires and trees in parts of Schoharie County; Warsaw in Wyoming County isolated; ice still on trees and wires on December 31.

Heavy ice and snow in Massachusetts brought down branches breaking overhead wires.

January 28 – February 6, 1951

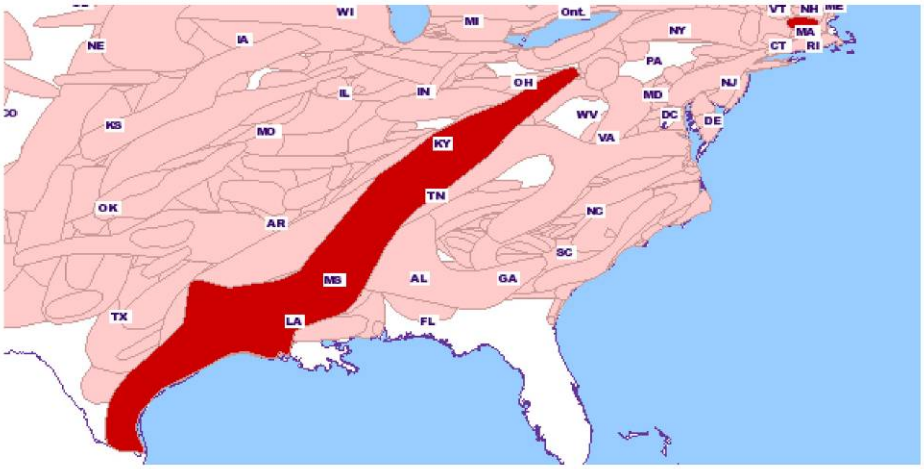

Figure D-24 - January 28 – February 6, 1951 Ice Storm

Ice storm pounded Rio Grande Valley; highlines snapped by ice; 272 phone circuits in San Antonio unusable and situation deteriorating; long distance and telegraph circuits from Houston and south out.

Southern Bell suffered the worst ice storm damage ever across Louisiana, Mississippi, Alabama, Tennessee, and Kentucky; more than 80,000 telephones out of service and 3,174 long distance circuits out of commission; service back to normal within 10 days.

Heavy icing and thunderstorm winds in Louisiana broke power and phone lines and trees; forests and pecan trees heavily damaged; 60% of phone lines to Monroe out.

Mississippi Power and Light extremely hard hit in all 44 counties; 49 towns isolated by phone and telegraph outages, expect some customers to be out for 3 to 4 weeks; severe timber damage from ice and wind, century-old oaks shattered; worse than 1915 and 1932 storms; 800 of 1000 poles between Jackson and Meridian down.

Wind and ice damage in Alabama.

Most devastating winter storm in recorded history in Middle and West Tennessee; outages lasted more than 1 week in rural areas; 80K out in Nashville area nearly shuts down industry.

Tennessee Valley Authority had 31 transmission line failures in south central Kentucky, middle Tennessee, northwest Alabama, and north Mississippi; heaviest ice was in the Tupelo and Nashville areas; switches covered by thick ice and some were damaged.

Trees and power lines down in Kentucky.

In Ohio snow and freezing rain in southeast quarter of state heavily damaged trees and power lines.

Worst sleet and ice storm in years in Massachusetts; some ice-coated trolley wires snap; ice on phone wires in central and western parts of the state.