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Increasing Losses from Weather Extremes in Illinois: Their Causes and Future Implications

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ABSTRACT

Illinois experienced record high financial losses from weather extremes during the 1990s. Questions about the causes of the extreme losses were raised by those most impacted including state government agencies, the insurance industry, agricultural interests, the public, and other weather-sensitive sectors of the economy. Answers were sought using analysis of historical records of all forms of extreme weather events and only heavy rain events displayed any recent increase. Studies of societal changes including population growth, demographic shifts to large urban areas, business becoming highly dependent on high speed freight shipments, a greater dependence on electrical power, and a general growth in wealth were identified as key factors causing recent increases in losses. The lack of changes in most storm frequencies or intensities, coupled with these lifestyle shifts, reveals that changes in the weather and climate are not the explanation for the increased losses in Illinois. Societal change is the answer. The societal factors will continue to make losses ever larger in the future, and if a shift in climate to more storms occurs as some predict, the situation would become much worse.

INTRODUCTION

The 1990s had the most costly and deadly weather events in Illinois' history. Losses amounted to $1.1 billion from the 1993 flood (Changnon, 1996), and $0.65 billion from the 1996 summer flood in northeastern Illinois (Changnon, 1999a). The century's mostly deadly weather event, the July 1995 heat wave, led to 753 deaths (Changnon et al., 1996). Another major heat wave in July 1999 killed 101 in Illinois (Palecki et al., 2001). Illinois led the nation with 123 tornadoes in 1998. In January 1999 the state's second worst blizzard of the century led to 34 deaths and closed down the northern half of Illinois for several days. Losses and costs of repairs amounted to $0.3 billion (MCC, 1999). Governor Edgar declared the entire state a disaster area.

Many persons and institutions in Illinois were seriously impacted by these losses. Those most affected included the insurance industry, government agencies providing relief and

rebuilding damaged infrastructure, and the state's weather-sensitive business communities. This included the state's agriculture interests (farmers and agribusinesses), retail business, manufacturing, and transportation. A mix of societal and economic conditions make Illinois very vulnerable to severe weather with a potential for extremely large losses. For example, Illinois is the core of the nation's transportation systems and has the nation's busiest airport. Chicago is the rail hub of the nation, and Illinois is the heart of the nation's trucking industry. Severe weather, including floods and winter storms, close or slow various forms of transportation for days and weeks.

The seriously impacted groups in Illinois have been asking the scientific community key questions about the huge losses of the 1990s. Were the high losses of the 1990s a singular unique period, such that high losses would disappear in the new millennium? Were the large losses the start of an upward trend that would continue into the foreseeable future? Would the future experience even worse losses? What were the causes of the recent high losses, a temporary climate fluctuation or a permanent shift in climate? Was the change in the 1990s related to global warming?

A series of studies involving the physical and social sciences have been pursued and special databases developed to answer these questions. The goal of the research was to identify the causes of the increased weather-related losses and to assess possible future trends in Illinois.

ESCALATING LOSSES

Federal and state disaster relief for weather extremes escalated in the 1990s, setting national records: $15.8 billion in federal aid was paid during 1992-1998, and a one-year record $7 billion paid in 1994 (Sylves, 1998). Illinois spent more than $2 billion in relief and assistance costs. Hurricane Andrew in 1992 set an all-time loss record for one event ($30 billion), followed by the 1993 flood ($19 billion) in the upper Midwest (National Research Council, 1999). These huge losses focused attention across the nation on the escalating costs of natural hazards. The Clinton Administration and Congress responded to the loss problem because its magnitude threatened efforts to balance and reduce the federal budget. For example, the 1993 flood losses led to major changes in the flood insurance and crop insurance laws (Changnon and Easterling, 2000).

A recent study of property insurance data for the Midwest showed that 46 severe weather events, each causing more than $100 million in insured property losses, occurred during 1990-1999, as compared to 48 such events in the entire 30 preceding years (Changnon, 1999b). Figure 1 presents the trend of these major damaging storms in the Midwest, showing the values grew from 4 per 5-year period in the 1960s to more than 20 per 5-year period in the 1990s. There is no doubt that within the region losses from extremes have grown rapidly.

Flood losses in Illinois rank as the third highest in the nation, averaging $257 million annually since 1983. Within Illinois and the Midwest, on the average, flood losses have been increasing over time at a greater rate than elsewhere in the nation (Changnon et al., 2001). Over the 45-year period (1955-1999) Illinois had $5.195 billion in flood losses, and 74% of these losses occurred in the last 15 years (1985-1999). Flooding leads as the

single most damaging weather hazard in the State. Ever increasing heavy precipitation since the 1940s has led to increased flood peaks on State rivers (Changnon and Demissie, 1996).

Major losses to private and public institutions in Illinois from the severe 1999 blizzard amounted to $0.3 billion and many problems centered on transportation (Table 1). Many of the severe transportation problems created numerous other problems (MCC, 1999). Most retail businesses were closed for 1 or 2 days and lost business for several days thereafter. Blocked streets and country roads led to school closings throughout Illinois lasting 3 to 7 days. Even by January 9, a week after the storm, only 47 percent of the students in Chicago schools were able to attend classes. Because the Midwest is the prime source of fresh blood supplies and many donors could not reach hospitals to donate blood, the storm also created a nationwide blood shortage.

National winter storm losses in the 1950-1997 period, as measured by the property insurance industry, had a significant upward trend, peaking at nearly $0.6 billion per year during the 1990s (Changnon and Hewings, 2001). Illinois averaged $102 million annually in winter storm losses during the 1990s.

Heat waves are another weather hazard that have caused increased losses. Illinois, during the 1990s, experienced two of its most deadly heat waves. Although of relatively short duration, the 1995 event led to 753 state deaths, the greatest on record (Changnon et al., 1996). The heat waves in 1995 and 1999 also caused major power outages in the Chicago metropolitan area as various components of the region's power system failed. Heat waves rank as the single most deadly type of weather event in Illinois. The annual average number of heat-related deaths is 74, compared to 6 from lightning, 5 from tornadoes, and 4 from floods (Changnon et al., 1996).

A data base created from historical property insurance records for 1949-1998 served as the basis for a study of thunderstorm-related losses in Illinois. Each event causing $1 million of more in losses, labeled a catastrophe by the insurance industry, was identified (Changnon, 2001). These losses included those due to tornadoes, hail, high winds and/or lightning. In the 50-year period, Illinois had 156 thunderstorm catastrophes and they caused losses totaling $5.148 billion (Changnon, 2001). Temporal analysis of their incidence revealed that 96, or 61%, have occurred since 1988. The losses were also concentrated in recent years with $4.2 billion, or 82% of the state's total, in the 1989-1998 period.

In summary, the losses from floods, winter storms, thunderstorms and their damaging conditions, and heat waves all display major increases during the 1990s, reaching record high levels.

CAUSES

Some scientists claimed that these recent increases in losses from weather extremes in Illinois and elsewhere in the nation since 1990 were a signal of climate change due to global warming (Nicholls, 1995). Other scientists claimed the recent aberrations were a part of the normal fluctuations that occur in the highly variable continental type climate

of the Midwest (Changnon et al., 1997). Still others say the increased losses may not be a result of shifts in the weather but rather increased vulnerability of our nation's populace to weather extremes (Kunreuther, 1998).

Possible Physical Causes

In order to determine the causes, historical data on the frequency and intensity of actual weather events that cause losses were analyzed. Special 100-year historical databases on thunderstorms, heavy rainstorms, and hailstorms were developed to facilitate this research. A recent study of storm activity in Illinois showed the same frequency of thunderstorms during the 1990s as in the prior 40 years (Changnon and Changnon, 2001). The annual frequencies of hail days in Illinois were assessed and they revealed a peak in mid century but no increases during the last 20 years (Changnon, 1995). Crop-hail losses in Illinois, after adjustment for changing liability, have been in a slow but steady decline over the past 25 years. Analysis of heavy rain events occurring over periods of 1 to 7 days duration and during the 1921-1996 period, revealed a continuing increase since the 1950s with the highest number in the 1990s (Kunkel et al., 1999a). The amount of rain in annual peak rains has also increased over time (Changnon and Demissie, 1996).

A recent study of the state's climate during the 20th Century provided additional information. Since the 1940s the state's climate has gradually become wetter, with 5 to 7 cm more precipitation per year in the 1990s as in the 1940s, and climate has become cooler by about 1ºC. Analysis of the state's 11 worst heat waves, as based on temperatures and humidity conditions, revealed most occurred in the 1930s and 1950s and there was no evidence of an upward trend (Kunkel et al., 1996). Assessment of weather effects on the state's water resources and on corn production since 1900 shows many fewer bad growing season weather conditions occurred during the 38 years since 1960 than during the first 60 years of the 20th Century (Changnon and Winstanley, 2000). Analysis of winter storms in Illinois shows little change in frequency with a slow decline over the past 25 years. The annual number of tornadoes varies greatly between years, but the number of days on which tornadoes occur has not increased over the past 40 years. The state's high frequency in 1998 was anomalous. Consequently, most types of weather and climate conditions that cause problems in Illinois and elsewhere in the Midwest have not increased and, in some instances, have even decreased (Kunkel et al., 1999b). Only heavy rains increased over time. The data for Illinois shows no indication of a recent shift in climate.

Possible Societal Causes

Studies of societal factors that could affect the magnitude of storm losses have also been conducted. Assessment of various societal conditions revealed several potential reasons underlying the recent growth in extreme weather losses.

One example relates to the causes behind increased deaths from heat waves. Conditions during the two deadly 1990s heat waves were different than in the 1930s when temperatures were worse but fewer deaths occurred. Two heat waves, much more severe and longer lasting than the 4-day July 1995 heat wave in Chicago, occurred in 1934 and 1936, causing 213 and 297 deaths, respectively, each much less than the 753 deaths in 1995. Assessment of the possible causes for these differences between the 1930s and 1990s revealed lifestyle changes were key factors, not the weather conditions (Changnon et al.,

1996). Many who died in 1995 and 1999 were elderly, living alone, without air conditioning (or without the resources to pay for its continuous operation) in locked homes with windows closed and secured (Centers for Disease Control and Prevention, 1995). In 1934 and 1936, many older people lived with their families, and a common practice to keep cool on the hot summer nights was to sleep outside on porches or in city parks or alongside Lake Michigan, a practice that many consider life-threatening in today's urban world.

Recent studies have shown that Illinois and other parts of the nation have systematically become more vulnerable to weather extremes for a variety of reasons (Changnon et al., 2000; Kunreuther, 1998). One relates to growing dependence on electrical power. For example, a short period of high temperatures in June 1998 brought extensive power shortages in Illinois and seriously affected business and computer operations in the Chicago metropolitan area. One reason cited for this outcome relates to the effects of deregulation of the power industry. A massive ice storm in southeastern Canada in January 1998 caused major damages to power transmission lines resulting in massive problems for Montreal. The lack of power led to urban water shortages because of an inability to pump water in Montreal and some of the area was without power for four weeks (Scientific and Technical Commission, 1998). Urban areas are extremely vulnerable to prolonged power outages resulting from winter storms, high winds, and excessive heat.

Changes in demographics have led to increased storm losses (Changnon, 1999c). In 1960, 58 percent of the U.S. population resided in metropolitan areas, but by 1995 this had grown to 81 percent. The population of the Chicago metropolitan area, which includes parts of northwestern Indiana and southeastern Wisconsin, had grown to 8.6 million by 1999, up 3.5 percent just since 1990. The ever-expanding metropolitan areas surrounding Chicago, as shown in figure 2, and St. Louis contain a high density of structures and vehicles where huge losses can occur, even from small-scale yet intense rain, hail, or tornadic storms. For example, a 1990 hailstorm in a new suburb of Denver caused $1.1 billion in property losses, but 10 years ago this area was pasture land and only minor livestock losses would have occurred from the same storm. Similarly, the 1996 rainstorm across the south and west suburbs of Chicago created $0.65 billion in losses, but if the same storm had occurred there in the 1940s, damages would have been to rural farm lands and hence much less than in 1996 (Changnon, 1999a).

Also significant in the loss equation is the steady growth in population. Every person has property, which in a sense increases the target at risk from weather extremes. The nation's population density was 43 persons per square mile in 1950, and 74 persons per square mile in 1997, a 72 percent increase. A related factor and feature of the state's economy has been the steady growth in wealth. The value of insured residential property increased 166 percent from 1980 to 1993, and commercial property values jumped 193 percent in this same 14-year period. Thus, the losses are higher when a damaging storm occurs. The insurance industry has been reeling from the record losses of the 1990s in the U.S., partly because rates set on past events were too low (Lecomte, 1996).

Certain businesses have also become more vulnerable. Decades of spatial diversification of the plants making parts for the assembly of products have created a situation totally dependent on the state's transportation systems to function well and fast. The huge

transportation network radiating from Chicago and across Illinois is highly weather sensitive. Transportation has always been vulnerable to weather extremes, but now many businesses dependent on shipping and existing on narrow margins have hence become co-dependent and equally vulnerable. Many shippers now minimize costly stockpiles for manufacturing a product and rely on high-speed trains and trucks to deliver their parts a day before they are needed. When the 1993 flood blocked Midwestern railroads and led to 1,100 train re-routings to circumvent the 7-state flood area, taking 4 to 5 days per train trip instead of the normal 1 day, the railroads lost $0.6 billion and many assembly plants closed for weeks (Changnon, 1994).

Still another potential factor behind increased losses was discovered during the loss assessments from Hurricane Andrew. Study of the damaged structures revealed many had been built using poor construction practices, often not meeting local building codes (Pielke, 1995). More than $4 billion in losses from Andrew was attributed to inferior construction. Whether inadequate building and home construction is a problem in Illinois is unknown, but the insurance industry is pushing for better building codes nationwide and more rigorous enforcement of codes (Lecomte 1996).

Assessment of the physical and societal causes clearly reveals that the record high weather losses of the 1990s were largely a result of various changes in society and business, and these have collectively made Illinois more vulnerable to damaging weather than ever before.

FUTURE IMPLICATIONS

A common reaction when one is shown evidence that our society has become more vulnerable to weather conditions is one of surprise and doubt. Most people believe that science and engineering have worked hard over the past 100 years to reduce society's vulnerability to weather. Indeed, air conditioning is now almost universal in Illinois homes, businesses, and vehicles, taking away much of the day-to-day heat stress of summer. Deaths due to tornadoes, lightning, floods, and winter storms have also declined over time, largely due to better forecasts. Illinois farmers now rely on technologies that allow planting and harvesting at a much more rapid rate than 40 or more years ago. This reduces the past problems of having rains that delayed the prolonged periods of planting and harvesting, as well as yield losses resulting from such untimely rains. Development of hybrids has made crops more drought resistant. Weather and storm forecasting have dramatically improved in the past 50 years, giving us more advance notice to protect ourselves against severe storms and to protect our garden plants from unexpected frosts.

Society has become less vulnerable to many day-to-day weather vagaries, but the evidence of losses during the 1990s reveals that technology does not protect us from extreme weather losses. These have resulted from population growth, changing lifestyles and business practices, and a growing dependence on electrical power. Thus, we have become more vulnerable to weather extremes, and losses will continue to grow in the future as our population continues to expand and shift to urban locales. If a future climate shift resulted in more weather extremes as some predict, then the state's losses would be even greater.

The advent of more deadly and costly weather conditions should be of great concern to everyone in Illinois. This includes the government, insurance companies, home and business owners who can be damaged, and ultimately everyone who helps pay for losses experienced by others in the form of government relief and higher insurance rates. Understanding the causes of the ever-increasing losses becomes critical for planning and establishing policies to deal with the causes. Continuous monitoring of storm activity is needed. The situation calls for plans to mitigate against future losses and efforts to modify weather-sensitive infrastructure and systems to better adapt to future extremes. Further, residents of Illinois and other states will need to understand and assume greater personal responsibility for where and how they choose to live.

LITERATURE CITED

Centers for Disease Control and Prevention. 1995 Heat-related mortality–Chicago, July 1995. Morbidity and Mortality Weekly Report, 44: 1-4.

Changnon, S.A. 1994. Trains and water don't mix. Rail Classics, 23: 54-61.

Changnon, S.A. 1995. Temporal fluctuations of hail in Illinois. Miscellaneous Publication 167, Illinois State Water Survey, Champaign. IL.

Changnon, S.A. 1996. Losers and winners: a summary of the flood's impacts. The Great Flood of 1993, Westview Press, Boulder, CO: 276-299.

Changnon, S.A. and M. Demissie. 1996. Detection of changes in streamflow and floods resulting from climate fluctuations and land use changes. Climatic Change, 32: 411-421.

Changnon, S.A., K. Kunkel, and B. Reinke. 1996. Impacts and responses to the 1995 heat wave: a call to action. Bulletin American Meteorological Society, 77: 1497-1506.

Changnon, S.A., D. Winstanley, and K. Kunkel. 1997. An investigation of historical temperature and precipitation data at climate benchmark stations in Illinois. Circular 184, Illinois State Water Survey, Champaign, IL.

Changnon, S.A. 1999a. Record-flood producing rainstorms of 17-18 July 1996 in the Chicago metropolitan area. Part II: impacts and responses to the flash flooding. Journal Applied Meteorology, 38: 273-280.

Changnon, S.A. 1999b. Factors affecting temporal fluctuations in damaging storm activity in the US based on insurance loss data. Meteorological Applications, 6: 1-10.

Changnon, S.A. 1999c. Record high losses for weather disasters in the U.S. during the 1990s: how excessive and why? Natural Hazards, 18: 287-300.

Changnon, S.A., R. Pielke, D. Changnon, R. Sylves, and R. Pulwarty. 2000. Human factors explain the increased losses from weather and climate extremes. Bulletin American Meteorological Society, 81: 437-443.

Changnon, S.A., and D. Easterling. 2000. U.S. policies pertaining to weather and climate extremes. Science, 289: 2053-2055.

Changnon S.A., and D. Winstanley. 2000. Long-term variations in seasonal weather conditions important to corn production in Illinois. Climatic Change, 47: 353-372.

Changnon, S.A. 2001. Thunderstorms across the nation: an atlas of storms, hail and their damages in the 20th century. National Climatic Data Center, Asheville, NC.

Changnon, S.A. and D. Changnon. 2001. Long-term fluctuations in thunderstorm activity in the U.S. Climatic Change, 50: 489-503.

Changnon, S.A., K. Kunkel, and K. Andsager. 2001. Causes for record high flood losses in the Midwest. Water International, 26: 223-230.

Changnon, S.A., and G. Hewings. 2001. Losses from weather extremes in the U.S. Natural Hazards Review, 2: 113-123

Kunkel, K.E., S. Changnon, B. Reinke, and R. Arritt. 1996. The July 1995 heat wave in the Midwest: a climatic perspective and critical weather factors. Bulletin American Meteorological Society, 77: 1507-1518.

Kunkel, K. E., K. Andsager, and D. Easterling. 1999a. Long-term trends in the frequency of heavy precipitation events over North America. Journal of Climate, 12: 2515-2527.

Kunkel, K.E., R. Pielke, and S.A. Changnon. 1999b. Temporal fluctuations in weather and climate extremes that cause economic and human health impacts: a review. Bulletin American Meteorological Society, 80: 1077-1098.

Lecomte. E.L. 1996. The industry response to catastrophes in the 1990s: business as usual won't work. Insurance Institute for Property Loss Reduction, Boston.

Kunreuther, H. 1998. Introduction. Paying the Price, J. Henry Press, Washington, DC, 1-16.

Midwest Climate Center. 1999. The January Climate Summary. Illinois State Water Survey, Champaign, IL.

National Research Council. 1999. The costs for natural disasters: a framework for assessment. National Academy press, Washington, D.C.

Nicholls, N. 1995.Long-term climate monitoring and extreme events. Climatic Change, 31: 231-245.

Palecki, M., S. Changnon, and K. Kunkel. 2001. The nature and impacts of the July 1999 heat wave in the Midwestern U.S.: learning from the lessons of 1995. Bulletin American Meteorological Society, 82: 1353-1368.

Pielke, R.A., Jr. 1995. Hurricane Andrew in south Florida. National Center for Atmospheric Research, Boulder, CO.

Scientific and Technical Commission Relating to the Ice Storm of January 1998. 1998. Facing the unforeseeable, lessons from the ice storm of 1998. Les Publication du Quebec, Canada.

Sylves, R. 1998. Disasters and coastal zone state. Sea Grant Program, University of Delaware, Dover, DE.

Table 1. Impacts in Illinois resulting from transportation problems caused by the blizzard of January 1-3, 1999.

Human Life – Auto and train-related deaths totaled 39.
Railroads – Trains were stalled or delayed by 12 to 36 hours, delaying many priority shipments to the East and West Coasts by 1 to 4 days, at great expense. Chicago's suburban train service, one of the nation's finest, was overwhelmed by travelers who were unable to use normal vehicular transport, and 3 separate train accidents resulted in 3 deaths.
Automobiles and trucks – Major auto accidents involving numerous vehicles occurred on major highways and interstates, causing more than 2,500 auto and truck accidents. Snow removal on city streets buried thousands of cars and driveways, stranding many motorists without transportation and requiring up to a week after the storm before most vehicles had been extracted from human-made snowbanks. Many travelers became trapped on highways, and thousands were housed in emergency shelters, churches, and city buildings for 1 to 3 nights.
Commercial Aviation – The storm's impact on aviation was staggering at Chicago. Northwest Airlines reported than more than 1,100 flight cancellations in January 2-4. United Airlines canceled 60 percent of its O'Hare flights during the 2-day storm. Up to 300,000 travelers were stranded for periods of hours up to four days at O'Hare Airport. Costs were in the millions of dollars, not to mention the immense stress on travelers.
Navigation – Navigation on the major Midwestern rivers was reduced by 50 percent. Cold temperatures during and after the storm created large ice floes on the Illinois and Mississippi Rivers, limiting safe barge movement and the operation of locks and dams.
Snow removal – Most Chicago streets had been cleared by January 3 because the city had put 850 snow removal trucks on the streets (610 more than normal for a heavy snow) as a result of an accurate prediction of the storm several days in advance. The cost of the snow removal and salt in the Chicago metropolitan area was $44 million, with $14 million for snow removal at O'Hare Airport.

Figure 1. The number of storms in the Midwest causing property losses greater than $100 million (adjusted to 1999 dollars) from 1960 to 1999. Totals are for 5-year periods.

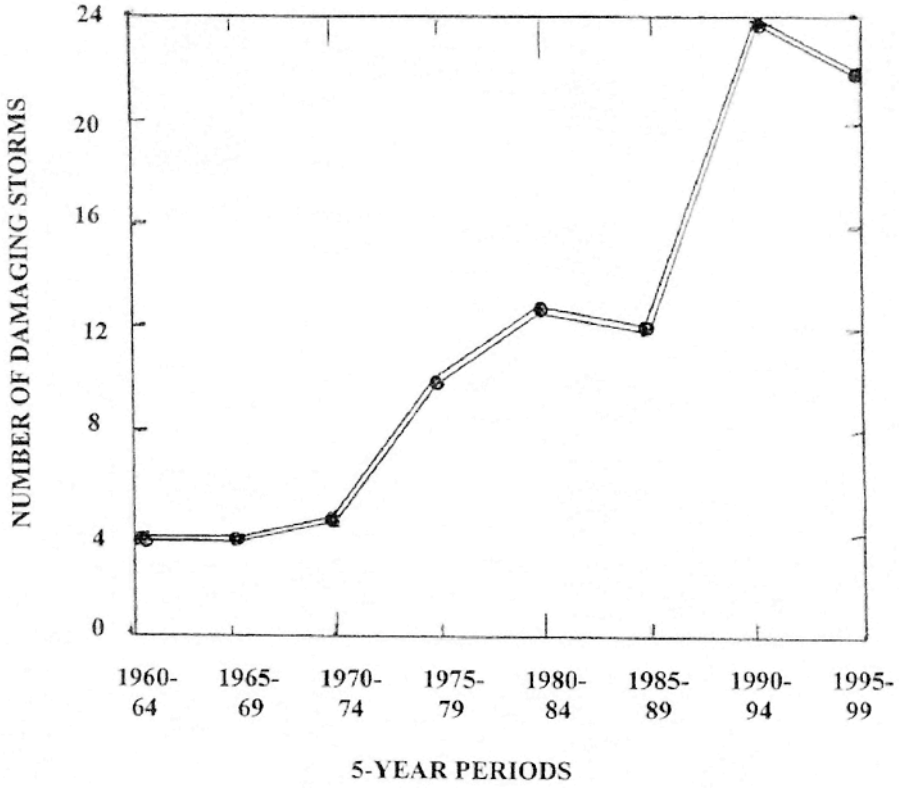

Figure 2. The growth of the Chicago Metropolitan area from 1830 to 1990.