# A century of natural disasters in a state of changing vulnerability: New Jersey 1900-99

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## Introduction

Everywhere on Earth relationships between societies and their physical environments are subject to periodic disturbances. Natural hazards are one important source of such perturbations. In addition to threatening the lives of people and acting as a drain on the public purse, floods, storms, blizzards, forest fires and droughts also signal the existence of flawed societal responses to environmental constraints on the human use of the physical world. When these events occur, the provisions that humans make to buffer themselves from harm are put to the test. Often these measures prove their worth but - sooner or later - protective adjustments become mismatched with changing hazards and losses ensue. (Kates, 1997) In an accompanying atmosphere of crisis, hurried and ill-considered searches for improved alternatives are all too frequent, thereby helping to recreate the conditions for subsequent disasters. Fortunately, outcomes of this kind need not occur. Scientists, planners and managers who understand the process of adjustment and keep watch for telltale shifts in patterns of events and human responses are in a good position to help society avoid major losses by identifying and redressing deteriorating relationships between people and nature well before they give rise to full blown catastrophes.

New Jersey provides both an excellent laboratory for studying the changing calculus of natural hazard and an ideal context for applying the results. Not only is there a comparative wealth of documentary material about a wide range of 20th century natural hazards and their consequences; the need for improved management of risks and vulnerabilities is acute. In this state the task of adjusting human populations to environmental constraints has long been hampered by galloping demands for the conversion of open spaces to urban uses, by a limited supply of usable land, and by the rapid pace of societal change: hence new arrangements for living with hazards are incubated in the equivalent of a pressure cooker. Given the increasing degree to which other parts of the world are subject to similar problems, New Jersey functions as a valuable bell-weather. To paraphrase Mayor Kenneth Gibson's well-known 1970 comment about Newark's status as a trend-setter for American's urban problems (Jackson 2000:198): wherever the world's developed areas are going with respect to natural hazards, New Jersey is likely to get there first. For that reason above all others historically-informed studies of New Jersey's experience with natural hazards are both necessary and desirable.

There is already a large body of scholarship on the human dimensions of natural hazards, much of it produced since World War II by geographers (Alexander 2000; Blaikie et al. 1994; Burton, Kates and White 1978 and 1993; Hewitt, 1997; Wisner et al, 2004), sociologists (Drabek 1986; Mileti et al. 1999; Quarantelli 1998), anthropologists (Hoffman and Oliver-Smith 2002; Oliver-Smith and Hoffman 1999) and other social scientists. After some early seminal studies of floods, droughts and environmental diseases as drivers of societal change (McNeill 1976; Toynbee 1934-1961; Wittfogel

1957), historians largely neglected this field. However, a number of recent books (Dickie, Foot and Snowden 2002; Johns 1999; Mulcahy 1999; Perez 200; Schama 1987; Steinberg 2000) and collections of history conference papers (Mauch and Pfister forthcoming) promise to reverse this trend. To date there have been no comprehensive history-focused studies of New Jersey's natural hazards although many researchers in the natural and social sciences have sketched the historical background of New Jersey hazards in works that addressed other themes. (Berger and Sinton 1985; Nordstrom et al. 1986; Psuty and Ofiara 2002; Pyne 1982) The present examination is therefore a path-breaking endeavor.

A canvas of New Jersey's 20th century experience with natural hazards and disasters offers a valuable perspective on today's issues of hazard management and environmental policy-making in general. It is based on analysis of evidence from a wide variety of sources. Among others, these include federal and state government reports, published professional literature from the field of natural hazards research and archived editions of the *New York Times*. Websites sponsored by non-governmental organizations, local history buffs and hazard interest groups have also been tapped, including a number that carry oral, written and photographic records of specific New Jersey disasters. Personal experiences of New Jersey hazards and a career studying the human dimensions of natural hazards and disasters also infuse the analysis. Nevertheless, the unstudied sources that might have informed this chapter remain vast, diverse and not always obvious, so it makes no claims to being a truly comprehensive survey of available information.  Rather it is a sample of the whole that is as useful for helping to pose questions as it is for providing pertinent answers.

Natural hazards are not extreme in New Jersey compared with many other places but that they have proved to be important both in their own right and as prompts to broader environmental management actions.  Seven events are singled out as possible candidates for a "Great disasters of 20$^{th}$ century New Jersey" list.   This section is followed by an analysis of trends in the major components of hazard.  Finally, pre-1900 records of New Jersey hazards are queried to explore the possibility that twentieth century data provides an unrepresentative picture of the state's potential for catastrophe. We begin by considering the New Jersey's status as a hazardous place.

## A state of modest extremes

The terms "New Jersey" and "natural disasters" are not an obviously well matched pair.  For one thing, some kinds of hazardous natural phenomena that are common elsewhere do not exist within state boundaries (e.g. volcanoes, avalanches, icebergs). Others that *are* present, do not pose high levels of risk to human life and property (e.g. earthquakes, subsidence). Yet others that gave evidence of activity in the far distant past have not been associated with damaging events in New Jersey since European settlement began here some three to four centuries ago (e.g. tsunamis).

New Jersey's list of truly threatening natural events is mainly populated by coastal storms, blizzards, forest fires, river floods and periodic droughts.  Yet even among these there are few that would rate a mention on the roster of noteworthy American natural disasters. There are no in-state equivalents of: the Galveston hurricane of 1900 or Miami-Dade County's Hurricane Andrew (1992); the massive, catastrophic fires that consumed Peshtigo (1871) or Yellowstone National Park (1988); the Mississippi floods of 1927 or 1993; or the Great Plains "dust bowl" droughts of the 1930s. Blizzards may be an exception (Kocin and Ucellini 1990). The state's experience with the great northeastern blizzard of 1888 and its successors in 1947 and 1996 clearly merits attention (Ludlum 1983), though New Jersey's blizzard record has been overshadowed by the more newsworthy accounts of neighboring places like New York city, which were also affected by the same events. (Cable 1988) In per capita annual losses of insured property from all types of weather-related catastrophes, New Jersey ranks 34th among the 50 states.[i] Compared to other parts of the country, this is a state of modest natural extremes. But disasters do occur and their repercussions have been widespread.

## Major disasters

Any attempt to construct a list of major 20th century natural disasters is necessarily a difficult exercise that involves: choosing criteria for different types of impact (e.g. deaths, injuries, economic losses, evacuees etc.); selecting damage thresholds (i.e. at least "x" deaths per year; minimum public service disruption times); bridging gaps and resolving inconsistencies among different data sets (e.g. precise counts versus estimates); and similar complications. The aggregation of losses at different scales adds further problems. For example, are events that produce large but diffuse patterns of losses equivalent to those that involve smaller loss totals heavily concentrated in single communities? Should communities that suffer repeated moderate losses be lumped together with communities that experience a single acute severe disaster? Different evaluators employ different methods for answering these questions with different implications for interpreting the outcomes.

Some small New Jersey communities have been destroyed and subsequently rebuilt – often more than once (e.g. Forked River, Ocean County 1930 fire; Harvey Cedars, Ocean County 1944 tropical storm, 1962 and 1992 nor'easters). (New Jersey Division of Parks and Forestry 1999; Savadove and Buchholz 1997) Others are chronically hazard prone – frequently in the news and often damaged without being entirely devastated. Municipalities like Wayne (Passaic County), Warren Grove (Ocean County) and Sea Bright (Monmouth County) are representative examples. One of the state's larger communities - Atlantic City - has experienced significant storm damage at least ten times during the century (1903, 1934, 1944, 1954 (twice), 1962 (devastating), 1978, 1984, 1991 and 1992). (Federal Emergency Management Agency 2000) Another (Trenton) includes one tornado (1902), three floods (1903,1955, 1975) and one blizzard (1996) on its list of most newsworthy events of the 20th century. (http://www.capitalcentury.com/)

The growing importance of natural hazards and disasters in New Jersey is reflected in the increasing frequency with which they provide a reason for gubernatorial Emergency Orders.[ii] (Table 1) These orders have the force of law and may remain in effect indefinitely, although most are intended to be temporary. They generally permit

Table 1

Executive Orders issued for natural disaster-related purposes (1941-1999)

| GOVERNOR | TERM | EOS | HAZARD EOS | DATES | TYPES |
|---|---|---|---|---|---|
| Edison | 1941-44 | 9 | 0 | - | - |
| Edge | 1944-47 | 8 | 0 | - | - |
| Driscoll | 1947-54 | 39 | 0 | - | - |
| Meyner | 1954-62 | 32 | 1 | 9/22/54 | Flood-related administration |
| Hughes | 1962-69 | 61 | 1 | 6/12/68 | River Flood |
| Cahill | 1970-74 | 57 | 2 | 8/30/71<br>8/3/73 | River Flood<br>River Flood |
| Byrne | 1974-81 | 113 | 7 | 3/22/74<br>12/5/74<br>7/15/75<br>11/1/78<br>9/12/80<br>12/17/80<br>2/7/81 | Drought<br>Winter Storm<br>Storm-flood<br>Flood Insurance<br>Drought<br>OEM<br>Drought –water emergency |
| Kean | 1982-90 | 226 | 14 | 4/27/82<br>2/18/83<br>3/29/84<br>4/5/84<br>4/17/85<br>4/16/85<br>5/17/85<br>9/26/85<br>1/22/87<br>1/26/87 | Coastal storm<br>Winter storm<br>Coastal storm<br>Coastal storm<br>Drought–water emergency<br>Drought-water emergency<br>Drought-water emergency<br>Hurricane<br>Winter storm<br>Winter storm |

| | | | | | |
|---|---|---|---|---|---|
| | | | | 2/13/87<br>2/23/87<br>4/5/87<br>8/14/89 | ERC<br>Winter storm<br>Severe weather-flood<br>Wildfire |
| Florio | 1990-94 | 115 | 6 | 10/31/91<br>1/4/92<br>12/11/92<br>3/15/93 | Severe weather-coastal flood<br>Severe weather-coastal flood<br>Severe weather-flood (3 EOs)<br>Blizzard |
| Whitman | 1994-2000 | 123 | 8 | 9/13/95<br>1/7/96<br>6/28/96<br>11/5/96<br>8/22/97<br>2/6/98<br>8/5/99<br>9/15/99 | Drought-water emergency<br>Blizzard<br>Severe weather-flood<br>Severe weather-flood<br>Severe weather-flood<br>Severe weather-flood<br>Drought-water emergency<br>Tropical storm Floyd flood |
| TOTALS | 1941-1999 | 781 | 39 | | |

the Governor to direct organs of the state to take specific actions in relation to rapidly developing problems or other crises. Between January1941 and the end of 1999, 781 Emergency Orders were issued by governors of New Jersey. Thirty-nine of these involved States of Emergency or other actions in relation to threatened or actual natural disasters. Orders terminating or rescinding previous orders (c.39 more) are not included. River floods (19), droughts (8), winter storms/blizzards (7) and coastal storms (5) clearly dominate these actions, accounting for 32 of the 39. Hurricanes/tropical storms (2) and wildfires (1) triggered three orders. The rest were administrative actions.

As noted above, these numbers suggest that the importance of natural disasters, as gubernatorial issues, increased significantly beginning in the 1980s. However, it is possible (indeed likely) that other factors should also be taken into consideration. Since 1974 governors have made increasing use of Executive Orders to conduct a wide range of government business (not just disaster relief), whether because of difficulties with the legislature or for other reasons. This accounts for at least part of the upsurge in disaster-related orders after 1970. Nevertheless, the mere fact that governors attached enough importance to natural disasters to warrant the issuance of Executive Orders is reason enough to believe that they have been high on the state's political agenda in the latter part of the 20th century. Moreover, the frequency with which such orders have been issued – once or twice a year on average in the last two decades – illustrates the extent to which state residents have become familiar with the notion of New Jersey as a hazardous place.

Executive Orders and other disaster declaration data tend to understate the publicly perceived hazardousness of New Jersey with respect to certain kinds of risks. Chief among these is flooding. For example, New Jersey ranks fourth among all states in numbers of flood insurance polices in force. During 2000 there were 174,744. This is less than the 1,737,222 in Florida, 353,152 in Louisiana and 358,413 in California but well ahead of many states that are much larger than New Jersey and have greater susceptibility to flooding. New Jersey also has a relatively high rank (18th) with respect to insured losses from all types of weather-related catastrophes. (Abend 2001) During the 1990s these losses exceeded $1.2 billion or approximately $143 per head of population. This is comparable to the per capita losses in California during the same period ($150) but well behind those of Hawaii ($1,649), Florida ($1,427) and fifteen other states. Bearing these caveats in mind, a list of New Jersey's major natural disasters might look something like Table 2.

This table prompts a number of observations. First, it includes seven events – three river floods, two coastal storms, one drought and one multi-blaze forest fire episode. Most hazard events lasted a number of days and one – the sixties drought - stretched over several years, perhaps a decade. Second, disasters did not occur at regular intervals. Most (71%) took place during the century's middle decades (1940s, 50s and 60s). These were also the most deadly disasters, accounting for almost all disaster fatalities. Third, weakening tropical storms have proved much more problematic than hurricanes, especially for inland areas where they produced record-setting floods in the Delaware, Raritan and Passaic basins. Fourth, the number of people killed by natural disasters in New Jersey has been relatively small.[iii] However, the scale of economic and material losses has been large and growing. Given the costs of tropical storm Floyd and estimates of the costs for a repetition of the 1903 Passaic flood, it seems likely that New Jersey has entered an era where billion dollar natural disasters are increasingly likely. (Vermeule 1903) However, before we can accept these judgments a number of analytic complexities need to be addressed. Chief among these is the nature of natural hazard.

Table 2

Major Natural Disasters in New Jersey 1900-1999

| DATE | TYPE | LOCATION | IMPACTS |
|---|---|---|---|
| October 7-10, 1903 | **Flood** after passage of tropical storm | Passaic River basin | $7 million damages; estimated 2000 cost of repeat up to $3 B |
| September 14, 1944 | Tropical (**coastal) storm** | Long Beach Island, Brigantine, Atlantic City, Ocean City, Sea Isle City | 8 deaths, 460 homes and 217 other buildings destroyed, c. 3,600 buildings damaged; $25 million loss |
| August 7-13, 1955 | **Flood** after passage of tropical storms Connie & Diane | Delaware, Raritan & Passaic River basins | Worst along middle Delaware and in Blairstown on Paulins Kill, at least 50 deaths in NJ and PA |
| March 6-9, 1962 | Nor'easter **coastal storm** | Entire Jersey oceanfront coast | 10 deaths; $130-400 million loss; Half Cape May's population evacuated |
| April 20-22, 1963 | 37 major **forest fires** | Pine Barrens | 7 deaths, 186 homes and 197 outbuildings destroyed; 190,000 acres burned |
| 1960s | **Drought** | Statewide | Considered the 20th century drought of record but may have been surpassed by 2000-2002 drought. |
| September 16-17, 1999 | **Flood** after passage of tropical storm Floyd | Raritan and Passaic River basins | 4 deaths and $1 billion loss statewide |

# The nature of natural hazard

Natural hazard is a joint product of human and non-human components that can be summarized with the aid of a simple two-variable formula wherein "risk" stands for the natural contributions and "vulnerability" represents the human ones.

Hazard = (Risk) x (Vulnerability)

Here attention is directed to the (neglected) human side of the equation, so risk is treated as a single, uncomplicated, set – though it is, in fact, a more complex variable.[iv] Vulnerability can be further broken down into three primary components:

Vulnerability = (Exposure) x (Resistance) x (Resilience)

Roughly speaking, exposure is a measure of the population at risk, resistance can be equated with the effectiveness of existing measures that are intended to prevent, avoid or reduce losses, and resilience refers to the capacity of a hazard-impacted community to resume functioning in an acceptable manner after experiencing serious loss. *Ceteris paribus*, communities with high levels of exposure, low resistance capabilities and poor resilience are most likely to suffer disaster – even though risks may not be very large.

## Risks

Five kinds of natural risks have historically been particularly important in New Jersey and continue to be troublesome today. Blizzards and droughts can be experienced anywhere in the state but the other three common risks (floods, coastal storms, forest fires) exhibit distinctive spatial patterns. The nine southernmost counties[v] (Fig. 1), that comprise the Inner and Outer Coastal Plains (Fig. 2), are most at risk to coastal storm-related winds, floods and erosion as well as forest fires. Here risk is primarily a function of an exposed position with respect to storm tracks, low-lying topography, the unconsolidated nature of surface geology, high percolation rates of the dominant sandy soils, and the extent to which the region is covered with fire-susceptible vegetation. The remaining twelve counties of central and northern New Jersey (Middlesex, Mercer, Hunterdon, Somerset, Warren, Sussex, Morris, Bergen, Passaic, Hudson, Essex, Union) are most at risk to various kinds of river flooding. In this region watersheds tend to be small, steeper than elsewhere and floored with impervious rocks that shed runoff quickly into numerous streams. Although blizzards and droughts can occur anywhere, they are more troublesome in central and northern counties that are more urbanized, more elevated, colder and lack major aquifers.

It is worthwhile observing that risk has long ranked higher as an object of scientific inquiry than any of the other components of hazard. As Ian Hacking points out (Hacking, 1990), in the nineteenth century the advent of probability theories and statistical tools for measuring departures from norms opened the way for the scientific analyses of events – such as floods and storms - that had hitherto been consigned to the unexplained realm of chance. In New Jersey, as the $20^{th}$ century unfolded the amount, spatial coverage and types of scientific data about risks changed markedly and it is difficult to make sense of the evolution of human adjustments to hazard without taking this into account. (It might be added that scientific attention to vulnerability – though still limited - is currently on the increase and it may well be necessary to provide a similar analysis of public knowledge about vulnerability in future accounts of hazard adjustments.)

Public and non-governmental organizations have been observing, monitoring, measuring, gathering, collecting, analyzing and reporting on natural risks in New Jersey for more than a century. The systematic collection of (scientific) information about extreme natural risks began in the eighteenth century and continued throughout the 19$^{th}$ century but most of what is known today is derived from 20$^{th}$ century observations and records. By the beginning of the 20$^{th}$ century the age of exploration, surveying and mapping was long past its peak in New Jersey and public environmental agencies were more concerned with rationalizing the exploitation and use of natural resources or with protecting citizens – and especially their property - against harm from natural extremes.

Systematic weather observation and record keeping in New Jersey began during 1886, although individuals had established local networks of observers from the 1840s onwards. (Ludlum 1983: 8-17) Natural disasters played an important role in speeding the installation of data gathering instruments as well as the collection and cataloguing of readings. In almost every case these actions were sparked by concern about the prospect of continuing heavy property losses – first of timber, later of structures exposed to river floods and even later of oceanfront homes and commercial properties.

Losses due to **forest fires** spawned a number of information-gathering initiatives by state and federal government agencies. Systematic and continuing records of forest fires in New Jersey were first kept in 1872. A decade later Franklin Hough prepared a *Report on Forestry* (Hough 1882) in which he indicated that "the whole country (New

Jersey) is overrun about every twenty years by fire" - especially during 1820, 1829,1832-33, 1856-59, 1865-66, 1870-1872, 1875, 1880-1885, 1900, 1902 and 1908-1909. (New Jersey Department of Parks and Forestry 1999; New Jersey-Department of Environmental Protection, Forest Fire Service 1990; Pyne 1982, p. 63) This was followed up by Pinchot and Graves' seminal report on New Jersey's Pine Barrens fires. (NJ Report of the State Geologist 1899).

**Floods** stimulated similar efforts to gather data about environmental fluctuations. The US Geological Survey issued its first two flood reports nationally on the Passaic River floods of 1902 and 1903. (Hollister and Leighton 1903; Leighton 1904) Although stream gauges had been installed in New Jersey as early as 1887 the instrumentation of New Jersey's rivers for purposes of collecting data on water flows and river heights received a major boost from these floods. (http://nj.usgs.gov/publications/FS/fs-109-02/). More specialized flood warning gauges were also deployed in a number of places.[vi] From a handful of stream-gauging stations in 1900 the numbers eventually grew to 206 by the early 1990s, only to experience an approximate 50% cutback (to 92) – mainly as a result of government fiscal retrenchment but also due to the development of more efficient recording devices and remotely sensed information systems.

Data on **coastal storms** in New Jersey has been collected since the second half of the 19th century as part of state and national weather observation networks but storm-related erosion was a greater source of worry. By 1900 the New Jersey oceanfront was already festooned with bulkheads, seawalls, groins and jetties of all kinds – wooden, stone, concrete and metal but – as pointed out by early geomorphologists like William Morris Davis and Douglas Johnson – their net effect on the supply of sediments necessary to sustain beaches and other coastal landforms was often to make matters worse. (Dean 1999; U.S. Coast and Geodetic Survey, 1877)   However, shore erosion did not attract state and federal government attention until the century was already well advanced.  Concern about disappearing sand and collapsing buildings spurred the New Jersey Board on Commerce and Navigation[vii] (1922) to fund studies designed to identify causes and possible responses.  Johnson was a key player in this work and organized study teams from the US Army Corps of Engineers to conduct path-breaking research on beaches near Long Branch (1929).  This research in turn stimulated the federal government to constitute a formal Beach Erosion Board in 1930 that later evolved into the Corps' Coastal Engineering Research Center (1964) – a leading international research institution for engineering-related responses to coastal erosion and storm damage that is still active. (Quinn 1977; U.S. Army Corps of Engineers 2002)  Subsequently these traditions have been carried forward by new generations of geographers and geologists such as Norbert Psuty, Karl Nordstrom. Stewart Farrell and Susan Halsey - based at Rutgers University, Stockton State College and other institutions.  These researchers have been highly influential in supplying the New Jersey Department of Environmental Protection's coastal engineering and management programs with scientific analyses of coastal problems and policy advice.

## Exposure

Natural risks are an essential part of natural hazards but they are far from being the most significant driver of the upward trend in hazard losses that has characterized the

$20^{th}$ century in New Jersey. An increasing degree of exposure to risk has been a far more potent force. That more and more people and investments are being placed in areas at risk is perhaps the most important component of rising vulnerability to natural disasters.

Population and population density figures provide a surrogate measure of exposure to natural hazards. It is widely accepted that population is an important driver of hazard both because larger populations often mean larger numbers of people at risk and because larger populations require increased infrastructure and other material investments for their support. All other things being equal, the most hazard-susceptible sites are usually avoided by developers during early phases of settlement, but later come under increasing pressure when safer alternatives have already been exploited. New investments in locations at risk then contribute to heavier losses by amplifying risk-driving natural processes and also raise the total loss potential by placing newer and more expensive investments in harm's way.

The population of New Jersey grew by almost 450% (447%) during the 20th century, in the process propelling a change in the state's dominant landscapes from a mixture of small towns and moderate sized cities amid a predominantly rural setting to an overwhelmingly urban and suburban landscape whose rural surroundings are rapidly receding. [viii]The rate of population expansion was fastest in the first three decades (1900-1930) but the largest absolute increments occurred during the 1950s and 1960s.[ix] (Table 3) The fewest numbers were added during the 1930s depression era. Compared with the decades that preceded them the two most recent decades (1980s and 90s) were a period of reduced population growth.

Table 3

NEW JERSEY DECADAL POPULATION CHANGES

| DATE | ABSOLUTE INCREASE | % INCREASE |
|---|---|---|
| 1901-10 | 653,498 | 34.7 |
| 1911-20 | 618,733 | 24.4 |
| 1921-30 | 885,434 | 28.1 |
| 1931-40 | 118,318 | 2.9 |
| 1941-50 | 665,164 | 16.0 |
| 1951-60 | 1,241,403 | 25.7 |
| 1961-70 | 1,101,382 | 18.0 |
| 1971-80 | 196,659 | 2.7 |
| 1981-90 | 365,365 | 5.0 |
| 1991-2000 | 684,162 | 8.9 |

Today New Jersey hosts around eight and a half million residents. They are not evenly distributed throughout the state or among its various natural risk zones. Historically, most people have lived in the suburbs of New York and Philadelphia as well as along the transportation corridor that runs between the two. This is one of the least (naturally) risky parts of the state. Although patterns of growth have varied both in time and space throughout the century, the general trend has been toward more people, in denser concentrations, in increasingly risky locations. Recent growth has been strongest in the small watersheds of northern and central New Jersey, in coastal counties and along the fringes of the Pine Barrens. Four recently suburbanized counties (Bergen, Middlesex, Monmouth, Ocean) now account for one third (32.8%) of the state's population, up from about one seventh (13.8%) at the beginning of the century. Two counties that lie mostly within the flood-affected Raritan River basin (Middlesex, Somerset) grew by 930%. The four oceanfront counties – which are most exposed to coastal storms and beach erosion - grew 916% and much of the new population there moved onto barrier islands and former wetlands that are among the most at-risk locations. (U.S. Department of the Interior 1994) Likewise, Burlington County, which contains a major piece of the fire-susceptible Pine Barrens, grew by 727%.[x]

The shift to riskier locations appears even more dramatic on the local scale than at the county or state levels. Although comprehensive data on hazard zone occupance are not yet available for the municipal level, Stafford Township in Ocean County provides an example. The township occupies a slice of the Pine Barrens fronted by wetlands along Barnegat Bay. It is exposed to serious risks of forest fire and contains at least one old village community (Warren Grove) that was sited and constructed with fire protection specifically in mind (Berger and Sinton 1985) as well as a number of large modern housing developments scattered throughout the woods. It also hosts the extensive Beach Haven West "lagoon" housing complex that is sited on filled wetlands adjacent Barnegat Bay where there is a clear risk of flooding. Some real estate developers style Stafford "the fastest growing municipality in the fastest growing county in New Jersey."

Table 4

# CHANGES IN POPULATION BY COUNTY

| COUNTY | 1900 | RANK | 2000 | RANK | % INCREASE |
|---|---|---|---|---|---|
| Atlantic | 46,402 | 13 | 252,552 | 15 | 544 |
| Bergen | 78,441 | 9 | 884,118 | 1 | 1,127 |
| Burlington | 58,241 | 11 | 423,394 | 11 | 727 |
| Camden | 107,643 | 4 | 508,931 | 8 | 473 |
| Cape May | 13,201 | 21 | 102,326 | 20 | 891 |
| Cumberland | 51,193 | 12 | 146,438 | 16 | 286 |
| Essex | 359,053 | 2 | 793,633 | 2 | 221 |
| Gloucester | 31,905 | 17 | 254.673 | 14 | 798 |
| Hudson | 386,048 | 1 | 608,975 | 5 | 158 |
| Hunterdon | 34,507 | 15 | 121,989 | 18 | 354 |
| Mercer | 95,365 | 6 | 350,761 | 12 | 368 |
| Middlesex | 79,762 | 8 | 750,162 | 3 | 940 |
| Monmouth | 82,057 | 7 | 615,301 | 4 | 750 |
| Morris | 65,156 | 10 | 470,212 | 10 | 722 |
| Ocean | 19,747 | 20 | 510,916 | 7 | 2,587 |
| Passaic | 155,202 | 3 | 489,049 | 9 | 315 |
| Salem | 25,530 | 18 | 64,285 | 21 | 251 |
| Somerset | 32.948 | 16 | 297,490 | 13 | 903 |
| Sussex | 24,134 | 19 | 144,166 | 17 | 597 |
| Union | 99.353 | 5 | 522,541 | 6 | 526 |
| Warren | 37,781 | 14 | 102,467 | 19 | 271 |
| STATE | 1,883,669 | | 8,414,350 | | |

http://www.nj.com/newhomes/community/stafford.html. In 1940 the township had a population of 1,253; today it is home to 22,532 – an increase of 1,798% in 60 years, with almost half of that growth occurring in the last decade of the century. Similar growth has appeared around the fringes of the Pine Barrens in many other municipalities. In 1960 the population of Whiting (Ocean County) was less than 4,000; by 1990 it was almost 36,000. Today, senior citizens make up three-quarters of Whiting's population. (http://www.caucusnj.org/caucusnj/special_series/pinelands_transcripts.pdf) When fires threaten communities on the edges of the Pinelands, it is common for news media to report precautionary evacuations of retirement housing complexes, rehabilitation centers and nursing homes. Many residents of these areas are elderly and a substantial proportion are also handicapped, infirm or otherwise have limited mobility – clear indicators of heightened vulnerability to hazard.

Census-based population figures tend to understate the case for increased human exposure to natural hazards in some areas. This is because they record population according to domiciles, rather than the activity spaces that people occupy during the course of a day, a week, a year or a lifetime. For example, seasonal populations in resorts that line the Jersey Shore are customarily up to ten times larger than winter populations. How this compares to 19h century totals is presently unknown. Whether they are now more dispersed than previously is also difficult to assess. Towards the close of the 19th century it was possible to reach most of the shore via good mass transit links from inland (e,g, railroads). Most of these subsequently ceased operating by the mid-20th century.

Table 5

## CHANGES IN POPULATION DENSITY BY COUNTY (persons/sq. mile)

| COUNTY | 1900 DENSITY | RANK | 2000 DENSITY | RANK | RANK CHANGE |
|---|---|---|---|---|---|
| Atlantic | 103 | 16 | 561 | 15 | +1 |
| Bergen | 335 | 7 | 3,778 | 4 | +3 |
| Burlington | 111 | 12 | 805 | 12 | 0 |
| Camden | 485 | 5 | 2,292 | 6 | -1 |
| Cape May | 52 | 19 | 401 | 16 | +3 |
| Cumberland | 105 | 15 | 299 | 17 | -2 |
| Essex | 2,850 | 2 | 6,285 | 2 | 0 |
| Gloucester | 98 | 17 | 784 | 14 | +3 |
| Hudson | 8,214 | 1 | 13,044 | 1 | 0 |
| Hunterdon | 80 | 18 | 284 | 19 | -1 |
| Mercer | 422 | 6 | 1,553 | 9 | -3 |
| Middlesex | 257 | 8 | 2,422 | 7 | +1 |
| Monmouth | 174 | 10 | 1,304 | 8 | +2 |
| Morris | 139 | 11 | 1,003 | 10 | +1 |
| Ocean | 31 | 21 | 803 | 13 | +8 |
| Passaic | 839 | 4 | 2,639 | 5 | -1 |
| Salem | 107 | 14 | 190 | 21 | -7 |
| Somerset | 108 | 13 | 976 | 11 | +2 |
| Sussex | 46 | 20 | 277 | 20 | 0 |
| Union | 965 | 3 | 5.059 | 3 | 0 |
| Warren | 206 | 9 | 286 | 18 | -9 |
| STATE | 254 | | 1,134 | | |

Now movement is almost entirely by private automobile – in theory granting greater spatial and temporal flexibility to travelers but in practice constrained by routing bottlenecks such as the bridges and causeways that are the bane of evacuation planners. (New Jersey State Policy Office of Emergency Management 1992) In a similar fashion diurnal commuting flows bring huge numbers – in the hundreds of thousands at least – to metropolitan centers like New York and Philadelphia as well as workplaces that are increasingly dispersed throughout the state. Exposure to hazard is often as much a function of the time of day and the day of the week as the location of a home address. Between 9 am and 4 pm on weekdays suburban neighborhoods and entertainment venues are typically empty while cities, central business districts and schools are typically full. The effect of a sudden snowstorm may be chaotic at rush hour during the week but benign on Sunday. These kinds of population shifts complicate the assessment of human vulnerability but have less effect on the vulnerability of structures and infrastructures because they remain fixed in place. This is one reason why vulnerability assessments have tended to focus on the vulnerability of things rather than the vulnerability of people – thereby introducing biases into public policies and hazard management programs.

It would be misleading to suggest that the trend in exposure has been solely in one direction. Some older at-risk communities have declined or even disappeared. Small Pine Barrens villages (e.g. Harrisville) have been abandoned in the 20th century – as much because of their declining economic fortunes as the repeated fire danger. Today there are no private homes on Sandy Hook in Monmouth County or on Island Beach in Ocean County and few in the floodplain of the Raritan River below Bound Brook. In each case pre-existing land uses have been replaced by federal, state or local parks and recreational areas that are less susceptible to hazard-related losses. For example, photographs taken in the opening decades of the 20th century show farm machinery active in fields near New Brunswick that are now part of an extensive County Park (Johnson Park) – a testament to efforts to replace other uses with open space and recreational facilities that began in the 1930s. On the other hand these positive changes have been heavily outweighed by others that added to the potential hazard burden.

## Resistance

Theoretically, even a highly exposed population is not necessarily vulnerable to hazard if it is well protected. Many kinds of protective adjustments were in place by 1900 and many others were adopted in the ensuing one hundred years. The fact that disasters continue to occur suggests that these measures have not been foolproof. However, the picture is a complex one both because there are many different kinds of adjustments and because every kind has had a somewhat different history. Moreover, some adjustments have fared better than others, some appear to be operating at the limits of their effectiveness and some have never been tested by the kinds of events they are designed to offset. There have also been clear shifts in public preferences for certain types of protective measures; responses that were once commonplace are no longer embraced, though the legacy of their previous popularity lingers on. In addition, innovations are always appearing either in the form of products for sale or institutional reforms promoted by different interest groups, so the theoretical range of adjustments ebbs and flows over time.

Broadly speaking, in 1900 **forest fires** were regarded as a nearly inevitable fact of life in New Jersey. Loss bearing was probably the most common adjustment together with voluntary fire-fighting efforts by forest residents and post-disaster relief provided by other community members, churches and charitable organizations. Some communities were abandoned after fires but it is difficult to be sure whether fires were the basic cause of abandonment since economic problems generally were a strong corollary factor. There was no organized system of warning for fires, nor any special plans for evacuation and sheltering. Permanent engineering works for fire control had not been invented, fire insurance was available but rarely adopted in rural areas that were most at risk to fires. Some communities in the Pine Barrens had evolved practices for protecting emergency fire-fighting water sources and for clearing fire-breaks around clustered buildings but there was no government-sponsored hazard zoning. (McPhee, 1976)

By the year 2000 there had been major changes. Some adjustments had reduced vulnerability to fires and others had increased it. Among the former were a state-government sponsored Forest Fire Service composed of a mixture of paid and voluntary personnel, trained and equipped with special vehicles, assisted by fire watching towers, then by airborne spotters, finally by computerized wildfire models and remotely sensed satellite imagery. Deliberate efforts to replace private (absentee) ownership of forested land with public preserves, parks and recreation areas and to regulate the use of environmentally sensitive lands through a new state-created Pinelands Commission (1979) also helped to reduce vulnerability to fires. However, shifts in the economy and demography of Pine Barrens communities often had the incidental effect of increasing vulnerability as more people and capital investments flooded into peri-Pineland districts. Many of the newcomers were retirees or elderly infirm who were physically vulnerable to fire risks and most were reluctant to authorize local tax increases necessary to provide expanded public services, including better fire protection.

Responses to **coastal storms** in 1900 offered some contrasts to the fire adjustment experience. Here a big difference was the existence of a system of life-saving stations at three-mile intervals along a coast that was much more sparsely populated than at present.[xi] Together with federally-sponsored storm warning systems for mariners and others that had been in existence since the 1870s, these provided forms of protection not available to residents of fire-exposed communities. However, the primary beneficiaries of such adjustments were seafarers, owners of commercial cargoes and fisher folk, many of whom were not in-state residents. Although the life-saving stations disappeared by mid-century the concern for preserving lives offshore was replaced by a concern for saving them onshore. Beginning in the 1970s coastal evacuation planning became an important activity for federal agencies (e.g. the Army Corps of Engineers, Philadelphia District) working in concert with the New Jersey Division of Emergency Management/ State Police. (New Jersey State Police Office of Emergency Management 1992) The presence of "evacuation route" signs on highways leading inland from the oceanfront is now one of the most common modern sights for coastal visitors. If they look around they can usually make out the sirens that sound the alarms that signal evacuations. Not so visible, but perhaps more important, is a system of state, county and local emergency management that plans and trains for storm emergencies in the event they occur. This system is responsible for responding to all types of emergencies, including man-made ones as well as natural and it extends throughout the state, not just the coastal areas. With the help of voluntary organizations that manage emergency shelters and provide post-disaster relief to victims (e.g. American Red Cross) the formal emergency management system has made major strides in recent years to upgrade the status of planning for - and coping with – sudden emergencies. Together with its federal counterpart (e.g. the Federal Emergency Management Agency FEMA) the state-level emergency managers were – at century's end - also in the process of shifting priority attention to the task of hazard mitigation (i.e. addressing the underlying causes of disasters instead of responding to their consequences). For example, under the provisions of Project Impact, Trenton, Atlantic City and Avalon were among New Jersey communities that had agreed to serve as case study sites for a wide range of hazard mitigation initiatives. However, the entire agenda of hazard protection seems to have been reconfigured following the terrorist attacks of 9/11/2001. It is too soon to be sure what the eventual outcomes will be but initial signs suggest that the welcome shift toward mitigation has come to halt, indeed gone into reverse. (Mitchell 2003)

In 1900 another major difference between adjustments to coastal storms and adjustments to forest fires was the profusion of (mainly) privately constructed coastal defense works (e.g. bulkheads, groins, embanked railroad rights of way) near built up areas like Sea Bright, Asbury Park, Long Branch and Atlantic City. Heavy losses to these features were already placing the future of adjacent homes in doubt at the beginning of the century. (http://www.srsd.org/search/studentprojects/2000/redhouse/) Thereafter there were repeated searches for more effective engineered structures – and for the funds to pay for them - that continue to the present without achieving more than partial and localized success. For example, in 1928 the New Jersey Budget Commission granted $855,000 for coastal protection, mostly for construction of groins (sometimes erroneously referred to as "jetties"). This was succeeded by calls for federal assistance and a grant of $4 million was authorized by President Roosevelt. Since seawalls, bulkheads and groins were employed to no avail, requests for more ambitious solutions were made. At one point in the early 1960s the Army Corps of Engineers discussed the possibility of placing massive rock groins at intervals of a few hundred yards along the coast from New York to Mexico supplemented by back beach sand pumping and replanting.

During the second half of the 20th century a great deal of criticism was directed at these "hard" engineering adjustments to storm and erosion risks. (Craghan 2001) Today, the previous emphasis on "hard" engineering has been increasingly replaced by a shift to "soft" engineering (e.g. beach nourishment, dune re-vegetation) but the legacy of structure-led coastal defenses persists almost everywhere. The change was beginning to occur at mid-century in the form of beach nourishment conducted by the Beach Erosion Board but such schemes have become the norm during the past two decades.[xii] On the one hand nourishment reflects a growing desire to replicate natural processes rather than oppose them – as massive walls and other structures had done. But on the other hand nourishment is expensive because sand is swept away by storms and requires periodic replenishment. In addition, US Army Corps of Engineers-sponsored nourishment schemes require the benefiting communities to share only a small proportion of the costs

(c. 5-10%) with the rest being borne by state and local governments. This passes a disproportionate share of the expenses for coastal protection on to larger non-coastal constituencies that do not necessarily benefit as much as coastal property owners. In other words debates about coastal protection have increasingly turned on issues of equity and distributional justice as much as concerns about absolute cost, environmental impact and technical appropriateness. Finally, though nourishment appears to retard erosion quite well, it does not necessarily help with flooding because storm surges can elevate sea levels, thereby allowing water to pass into back beach areas or entirely across barrier islands where houses and infrastructures are located.

The residents of coastal areas have been quick to take up one non-engineering adjustment after it became available following passage of the National Flood Insurance Act (1968)[xiii]. This legislation was intended to link the purchase of federally subsidized insurance with municipal agreements to control land use in floodplains – river as well as coastal - in ways that would eventually reduce the numbers of structures at risk. However, the latter provisions have generally been interpreted to mean elevating homes above expected flood levels. Not only does this assume that available records of storm damage are sufficient to be an accurate guide to the future, it forecloses on other possible land use options. In effect local governments have been reluctant to live up to their (land use control) side of the bargain and floodplain development has increased in many places – especially along the coast. Efforts to introduce dune management legislation that would have substituted another form of "soft engineering" (i.e. artificially constructed and planted dunes) and supporting land use controls for protective structures also failed.

Among coastal property owners in New Jersey the rate of adoption of flood insurance is among the highest in the USA and payouts after major storms are commensurately large. In 2000, $11 billion in New Jersey coastal property carried federally-based flood insurance. These buildings are generally owned by people who are more affluent that the average and presumably better able to bear the losses. Many are "repeat offenders" who gain reimbursements for damage inflicted by several storms. On third of all flood claims submitted from New Jersey to date (i.e. c. $131 million of $403 million) are accounted for by just 3,887 coastal properties. Sixteen of New Jersey's beach towns rank among the top 200 communities nationwide with multiple losses. (*The Inquirer* (Philadelphia), March 7, 2000)

**River flood** control in the United States has been popularly identified with the building of massive engineering structures including dams, flood walls, diversions, levees and retention basins on a regional scale by large agencies like the US Army Corps of Engineers. New Jersey possesses a number of projects that fit into this conception but they are not the norm. More usual have been smaller earth-filled berms and levees (such as the one that rings the religious community of Zarephath on the Raritan) or so-called channel "improvements" and drain-and-fill schemes for low-lying marshy areas. Many municipalities have also favored periodic channel clearance projects that are intended to ease the movement of water but often are the ecologically destructive equivalent of clear-cutting forests. It is sometimes the case that engineering structures which were built for entirely different purposes function, inadvertently, as flood control devices. For example, long, high railroad embankments serve to retard incoming floodwaters from the Passaic River in Wayne and in Bound Brook from the Raritan River.

There are believed to be about 1,600 dams in New Jersey. Most were erected by private owners or by local communities for purposes of power generation or impounding of recreational ponds. Since the 1980s such dams have themselves been seen as contributors to flood risks because many are not maintained and fail during heavy rainstorms. Three dams failed and 21 others were damaged during Tropical Storm Floyd (1999). (http://www.state.nj.us/dep/nhr/engineering/damsafety/floyd.htm) The removal of dams and the nurturing of damaged ecosystems are now components of a new field of "restoration ecology" which has come to be included as a responsible of the Army Corps and others who work to protect flood prone areas.

Large flood control dams have been proposed, most notably after the 1903 Passaic floods (Brydon 1974, p. 225) and after the 1955 floods on the Delaware River. (Thompson 1976) The Corps of Engineers has a long list of flood control projects (e.g. levees, flood bypass tunnels) in various stages of planning and development but these have been on the books for many years - sometimes many decades - without most coming to fruition. At present there are a total of 15 active Corps of Engineers flood control projects in northern and central New Jersey. Most are being evaluated for feasibility and have not progressed – indeed may never progress - to the design or construction stages. High cost, lack of economic justification, major environmental impacts or lack of public acceptability are among the reasons for not proceeding. Nonetheless requests for engineering works continue to be made. The case of the Upper Rockaway River (Morris County) is typical. The floodplain of this stream contains at least 1,000 structures that have been flooded in 1971, 1973, 1977, 1979, 1984, 1996, 1999 and 2000. Six studies have been conducted by the Corps but no engineering works were ever constructed. (US Army Corps of Engineers 2002)

It should not be thought that engineering structures represent the only – or even the most effective – way of protecting communities against flooding. But they do seem to be the alternative that has sprung first to mind among government leaders and laypersons in the 20th century. Perhaps, reared in a culture that has long celebrated the achievements of industrial engineering technology (e.g. Alexander Hamilton's Society for Useful Manufacture, the Roebling family, Thomas Edison etc) New Jerseyans, like many Americans, are culturally attuned to the "tech-fix"! However, national policymakers have been encouraging the use of non-structural alternatives for the past two decades. Among others these include: the restoration of natural flood protection ecosystems (e.g. wetlands); flood proofing (e.g. raised lower floors, lower floors used as parking decks, lack of ground floor openings that would admit water, moveable building contents); government funded buyout and removal programs for repeatedly damaged structures; combined flood insurance and hazard zoning schemes; purchases of flood-affected land for open space uses; removal of habitually flooded underpasses; moveable flood gates at strategic openings and improved flood warning and evacuation systems. Some of these adjustments are now beginning to appear in disaster affected New Jersey towns.

Responses to **drought** in 20th century New Jersey have been cyclical and heavily dependent on expanding water supply infrastructure. Typically, as population increased, demand rose beyond the supply capacity of local water systems – a condition that was usually revealed by a significant drought. This triggered a search for new sources of supply that proved sufficient until they were again exceeded by rising demand, thereby setting off another search for additional supplies. New reservoirs were preferred adjustments in central and northern parts of New Jersey where underground water supplies were sparse and difficult to develop but the glaciated upland topography provided sites for impounding rivers. (Elsewhere, in southern New Jersey, large underground aquifers and lack of suitable reservoir sites encouraged communities to rely on pumped well water.) However, surface reservoirs near cities often became polluted as urbanization increased and new sources were sought at greater distances from users. By 1900 some of the state's larger cities were already pumping water from lakes and reservoirs up to thirty miles beyond municipal boundaries. Newark began drawing from the Pequannock Watershed as early as 1891. Seventeen years later Jersey City started receiving water from the Boonton Reservoir 25 miles to the west. It is worth noting that the search for "pristine" water reflects the enduring importance of risk perception in the selection of adjustments to hazard. Many water specialists have pointed out that properly treated river water is not only just as safe to drink as water from distant hills but also much nearer to hand and often immediately available in large quantities. But these arguments have largely fallen on deaf ears; consumers often make judgments about risk that are at variance with those of technical experts.

Reservoir construction was particularly vigorous during the opening decades of the 20th century with subsequent additions – usually triggered by specific droughts - during the 1930s, early 1950s, and early 1960s. (New Jersey State Climatologist 2004) For example, Oradell (1901) and Boonton (1908) reservoirs were among the first additions. Wanaque, begun in 1920 and finished in 1930, was later extended in the late 40s and early 50s after a 1929-32 drought raised questions about its ability to meet existing demands. It is now the largest single reservoir supplier in the state. Around this time the Delaware and Raritan Canal was also converted to water supply purposes. Two big reservoir additions followed during the severe 1960s drought – Spruce Run (1963) and Round Valley (1965). Since then the pace of reservoir construction has tailed off with the last significant additions occurring in 1989 (Merrill Creek) and Manasquan (1990).

Today the era of reservoir construction for water supply purposes seems to be at an end, partly because New Jersey has run out of appropriate sites but also because other means for increasing the efficiency of water use or reducing demand now appeal to state leaders and residents. Lands that were acquired by the state for future reservoir sites have been turned over to open space uses (e.g. proposed Six Mile Run Reservoir site, in Franklin Township, Somerset County). During the 1960s and 70s various studies pointed out the benefits to be obtained by interconnecting the state's many separate water purveyors (Carey, Greenberg and Hordon 1972) so that water surpluses in one system could be shared with others that were in deficit. This became one of the foundations of a

State Water Management Plan (1982), that was itself an innovative attempt to deal with a range of water issues in a more comprehensive way that heretofore.[xiv] Subsequently, there has been an upsurge in efforts to encourage water conservation, not only during drought periods, but also on a long-term basis. The State's Extension Services, environmental groups and other advisory bodies now promote low flow restrictors for shower heads, toilets, and other appliances as well as the use of gray water and water recycling. Indeed the Eagleton Institute's New Jersey Poll has asked more questions about conservation-related adjustments to drought than about any other natural hazard. This is an indicator that political leaders and citizens alike now regard droughts as a legitimate and fruitful area for innovative public policy making. Emergency drought restrictions on water use have also come into their own - facilitated by new institutional arrangements among the governor of New Jersey, public water agencies and private water supply systems. These began during the 1970s. In the most recent drought emergency (March 2002-March 2003), the state adopted increasingly stringent bans on outdoor watering practices and the issuance of building permits was suspended in three townships of Atlantic County because aquifers on which this area relies were not being recharged sufficiently quickly to ensure a reliable supply of potable water to an expanding population. Although this was an emergency procedure, the threat of invoking gubernatorial powers to protect water resources has acted as a chastening reminder that New Jersey in now in an era where drought adjustments that require changes in human behavior are being seriously contemplated and enacted. For a society long committed to "technological fixes" as a first preference means of hazard management, this is a signal departure.

## Resilience

When employed in the context of disasters, "resilience" usually refers to the capability of a victim or a disaster-affected city to rebound from loss. At first glance resilience would seem to carry only positive connotations; surely the ability to resume one's customary activities quickly and fully after suffering adversity is entirely praiseworthy? But what if those activities were ill-advised to being with? Or there exist alternative more appropriate sites on which they might be practiced? Or if there are better ways of using the places that are susceptible to hazard? Would the best interests of society not be better served by adjusting to these constraints rather than re-establishing the circumstances that prompted disaster?

Has New Jersey become more resilient since 1900? At first glance the answer would seem to be a simple "yes"; after all, in the first half of the century it was not unheard of for residents to withdraw from fire-stricken homes in the Pine Barrens or for railroad companies to abandon bridges and rights of way that were repeatedly damaged by coastal storms and erosion – both tacit admissions that some New Jerseyans had not found successful ways of sustaining their desired land use practices in the face of natural extremes. These kinds of responses all but disappeared after World War II as the drive to develop New Jersey's open spaces accelerated, even when these were exposed to hazard.

Whether New Jersey has become more resilience or less resilient to natural disasters during the 20$^{th}$ century is difficult to assess. Part of the problem arises because of differing conceptions and definitions of resilience, part from a shortage of data with which to measure resilience and part from lack of agreement about whether the attainment of some kinds of resilience ultimately forecloses better alternatives for coping with future hazards. When these caveats are taken into consideration it seems likely that New Jerseyans live in a state that is now more certain of recovering from extreme events than at any previous time but mainly as a consequence of the greater interconnectedness, among different areas and different communities, that is a product of "modernization". In other words, so long as a relatively small number of disaster stricken communities can call upon aid from a larger pool of non-disaster stricken communities, disaster recovery is assured - even if the cost of poor hazards management choices becomes very expensive.[xv]

When employed in the context of disasters "resilience" usually refers to the capability of a disaster victim or a disaster-affected city to rebound from loss. It has become common to find that the leaders of such communities often employ the notion of resilience to mobilize public support for tasks of reconstruction and recovery. Victims are typically informed that they will not be defeated by adversity but will rise, phoenix-like from the debris of disaster, to shape a future that will be both grander and better than it might otherwise have been. In such appeals, community resilience is equated with personal qualities of hardiness, independence, ambition and resourcefulness that are much celebrated in the popular imagery of American culture. This can sometimes be a smokescreen that allows leaders to compensate for lack of foresight and for failure to engage in actions that might have prevented or mitigated disaster.

Despite its popularity as a theme of public rhetoric, resilience is the most poorly understood and least-documented aspect of vulnerability to disaster. Comprehensive data on rates and degrees of disaster recovery in New Jersey are lacking and must be inferred from anecdotal evidence or limited case studies. Moreover, interpretations of resilience are complicated by the fact that somewhat different concepts and criteria are employed, depending on whether the operative notion of resilience is individual or collective. The paragraphs that follow consider in turn these two types of resilience.[xvi]

Given the low levels of deaths and injuries inflicted by extreme natural phenomena in New Jersey it might be thought that few people have had much cause to worry about disasters in the 20th century, thereby minimizing the likelihood that individual resilience will be relied on as an adjustment to hazard. However, several countervailing factors must also be taken into account. First, disruption of normal activities and loss of material welfare remain as major concerns of individuals even when personal safety is no longer at issue; accelerating economic losses due to disaster are characteristic of New Jersey. Second, some groups are disproportionately likely to suffer disaster losses. This is especially true of minorities and other disadvantaged groups. Third, there has been a more general "shift to anxiety" triggered by the occurrence of uncertain but wrenching societal and environmental changes towards the end of the 20th century; these may reinforce or exacerbate specific individual concerns about environmental hazards.

Each of these factors has had some effect on resilience as a component of New Jersey's hazard management. Threats to property values are often sensitive public issues in a state where: (1) much personal wealth is invested in homes; (2) municipalities are heavily dependent on property taxes to finance schools or local government; and (3) property insurance companies are increasingly reluctant to offer coverage for coastal storm and erosion damage. In such settings, rising property losses due to natural hazards could be major sources of personal anxiety and thereby major challenges to individual resilience.

There can be little doubt that some New Jersey populations are more frequently called upon to be resilient in the wake of disaster than others. A persuasive case can be made for the argument that marginalized immigrants have long been at disproportionate risk from natural hazards in New Jersey. Early in the century immigrant farmers suffered heavily from fires in the Pine Barrens. To a significant degree they became scapegoats in the eyes of longer term residents who frequently held them responsible for poor vegetation management practices and irresponsible land clearance techniques that contributed to the fires: "Hundreds of uneducated immigrants have invaded the Pines, owing to the cheapness of the land and proximity to large cities. Few of these have brought with them European forestry ideas, and many of the most disastrous fires are those which they carelessly set in clearing their farms." (State Geologist 1899, p. 289)

Later in the century some poor minority populations became disproportionately concentrated in floodprone parts of older cities like New Brunswick, Newark and

Paterson. For example, the worst affected victims of Tropical Storm Floyd (1999) were primarily migrants from Central America who occupied rental apartments in low-lying sections of the ironically named Bound Brook. These and other immigrants have frequently lack resources of local knowledge, accumulated wealth, family and community support networks, language skills and experience of New Jersey norms and customs. Elderly retirees in the Pine Barrens and some coastal communities who are disproportionately exposed to fire, erosion and storm hazards also lack knowledge, mobility and resources necessary to ensure successful protection against hazard.

Throughout the 20th century there have been massive changes in the assumptions that govern human expectations about the future, leading to greater uncertainty. Perhaps the most important of these is the dawning realization that humans possess the capacity to destroy both the human species and the habitable Earth. One component of this concern has been fed by the experience of global wars characterized by major assaults on civilian populations, weapons of mass destruction and genocide. Another reflects the declining value of remoteness in a globalizing world where no location is ultimately secure from attack or the influence of others. Another is the discovery that humans have altered natural ecosystems and life-support systems in fundamental ways, including artificially enriching the carbon content of the atmosphere and dissipating much of its protective ozone shield. (U.S. Environmental Protection Agency 1997) As the century came to a close, New Jerseyans were becoming increasingly aware that they lived in a predominantly human-constructed state where the margins of safety against natural hazards that were once provided by undeveloped lands and low-density populations were now considerably shrunken. In this respect the capstone event of the 20th century may not have occurred until 2001, when this new sense of vulnerability was underscored by the terrorist attacks of 9/11.

All of these changes have probably affected the resilience of individual New Jerseyans but it is presently impossible to be specific about the details. The most that can be said at present is that, in the absence of effective anticipatory and mitigative actions, increased uncertainty probably places greater demands on the resilience of individuals in post-disaster situations, perhaps diverting resources away from other more productive tasks.

The role of collective resilience is a quite different story. In the past two or three decades many New Jersey governments and private firms have adopted plans for protecting infrastructure against natural hazards. Network interconnections, redundancies, backups, failsafe technologies, and the like increasingly form a cushion against that subset of rare events that used to occur more frequently. The net effect of these adjustments is to increase the scale at which systems fail. Higher probability events are better buffered than previously but the very largest extremes are at least as potent as ever and probably more so because they are less expected.

Granted the fact that the post-disaster resilience of some people is less than others, there remains the matter of deciding what constitutes an acceptable standard for measuring successful resilience. It has often been assumed that a return to the *status quo* *ante* is evidence of recovery - the quicker, the better. In recent years hazards researchers have come to question this view because it often perpetuates human behaviors and land uses that contribute to future disasters. For this reason resilience is now being reinterpreted to mean recovery that leaves individuals and communities better prepared to prevent, avoid or reduce the impacts of future extreme events. Under the earlier interpretation, resilience has clearly increased throughout the 20th century but if the revised view of resilience is employed, it is not at all clear that resilience is growing.

## Conclusions

The five types of natural hazards discussed here have played different roles in the lives of New Jerseyans during the 20th century and the nature of those roles has changed in different ways throughout that period. One way to understand these dynamics is with reference to trends in the major components of hazard.

Briefly stated, **risks** of storms, floods, droughts, blizzards and forest fires have changed only incrementally in the past century. However, shifts of population and investment patterns within the state have placed – and continue to **expose** - a large number of people and a vast slice of wealth in places that are inherently risky. For this reason, if no other, state policymakers should be prepared to address problems of accelerating losses in: (1) coastal counties (storms, erosion, forest fires); (2) some other parts of south Jersey (e.g. Burlington county – fires); and (3) flood and drought susceptible suburbanizing sections of central and northern New Jersey as well as older inner cities with flood vulnerable immigrant populations.

In so doing, it will be important to remember that contextual forces that are unconnected with natural hazard will play a large role in driving the processes that expose humans to loss. Many of these will remain the same but it is also possible that 21st century hazard-producing environments will be surprisingly different from those that we have been accustomed to. Some phenomena may not remain exclusively within the realm of hazard and may also become thought of in other ways. New variants of old hazards may appear together with entirely new risk-causing processes.

The history of 20th century **resistance** to hazard in New Jersey is highly complex. On the whole it is a tale of increasing ability to guarantee the safety of humans but not of buildings, infrastructure and other valued entities. But the addition of more types of adjustment from which choices might be selected and the competition among proponents and among potential users for favored alternatives, serves to complicate the process of adoption of protective measures. Trends are detectable, such as the tendency for higher levels of government to take on more of the responsibilities for protecting individuals at risk or for paying the costs of their failures to do that job themselves. Likewise, there has been a shift away from engineering technologies towards non-structural alternatives. There is also clear evidence that the limits of some adjustments are close to being reached (e.g. coastal evacuation systems; fire suppression).

Trends in **resilience** are strongly modulated by considerations of scale. It is clear that the state as a whole is now more able to bounce back from disaster than at any previous time but the future of small disaster-stricken communities (e.g. less than 10,000 population) can still be tenuous. Population subgroups that are marginal to the societal mainstream are is the worst position of all, either because they may wish to remain anonymous to officialdom (e.g. illegal immigrants), because they lack the resources with which to secure their rejuvenation (e.g. elderly, poor, single mothers with dependent children) or because they are unaware of the sources of assistance that are available (e.g. recent migrants, linguistic minorities).

Some of the common features that wind their way through the 20$^{th}$ century experience of natural disasters in New Jersey can be best stated in the form of **four dilemmas** that beset public policy makers.

First, is the question of whether to frame hazard management policies with respect to **worst case risks** (e.g. great hurricanes, floods of record) **or lesser extremes** (e.g. dying tropical storms, local stormwater runoff hotspots) that may be more important not just in the aggregate but also because the mediating effects of increasing vulnerability may be just as great for smaller scale physical events as for larger ones. (In other words if people move into the most at-risk places, even very small risk increments can produce disproportionate losses.) Arguments can be advanced in behalf of both policies – planning for hurricanes has undoubtedly improved New Jersey's chances of staving off losses due to nor'easters and dying tropical storms but it also undercuts the credibility of warning systems that are rarely validated by actual hurricanes. Waiting for the next great Pine Barrens fire is a bit like waiting for Godot – New Jerseyans might take pride in having crafted fire management systems that have functioned increasingly well for most of the 20$^{th}$ century but without the comforting guarantee that they will perform so effectively when the "big one" eventually occurs.

Second, **shifts in the mix of hazard management technologies** may improve capabilities for coping with natural extremes but they also **change the parameters of hazard** in ways that alter the nature of the problem **in unanticipated directions**. We have seen that the early reliance on "hard" engineering structures for coastal protection, flood alleviation and drought mitigation has increasingly given way to new combinations of "hard" and "soft" engineering technologies and broadly "behavioral" adjustments (e.g. land use controls, water conservation) in coastal and river floodplains as well as drought-prone areas. Yet pressures to vest confidence in more narrowly conceived measures remain strong and seductive; witness the backlog of Corps of Engineers project proposals that have little chance of being adopted, or the fervor with which different interest groups advocate the supremacy of different alternatives – ecological technologies, economic incentives that affect the use of risky places, legislated penalties, institutional reforms etc. Some form of integrated hazard management system that takes account of all of the different approaches is both necessary and evolving (e.g. watershed management initiatives) but the very complexity of such a system compounds the potential for even more unanticipated outcomes. The Jersey Shore's embrace of flood insurance is a case in point; by adopting insurance we are reducing some risks while simultaneously increasing shore zone investments that raise other risks. The insurance system was cleverly designed and intended to produce a quite different outcome – lower flood damage totals as a result of lower levels of exposure!

Third, New Jersey's 20th century experience of hazard illustrates a dilemma about what is now referred to as "sustainable development". The dilemma has been present from the outset but still remained unappreciated by many environmental planners. It is no surprise that economic profits and losses have always featured heavily in the calculus of policy makers who were concerned about the state's natural hazards. Pinchot's early report about forest fires and the New Jersey Board on Commerce and Navigation's somewhat later one about shore erosion are good examples. But as the century unrolled other values have begun to be included, especially those that have to do with the long term viability of natural life-support systems. Policies that affect the role of fire in the Pinelands and the drainage of coastal wetlands are representative. Unfortunately, **sustainable communities are not necessarily safe communities**. Orrin Pilkey, a Duke University coastal scientist may be correct about the ultimate unsustainability of much coastal settlement on New Jersey's highly eroding and storm affected coast – especially as sea levels continue to rise - but few would agree to abandon any of the major coastal communities that are now only sustained by heroic efforts of beach nourishment and other measures. This sort of example serves as a pointed reminder that the sustainability/safety dilemma has not yet been properly engaged with.

Fourth, and perhaps most important of all is the dilemma of **whether the proper response to natural disasters should be retrospective and reconstructive or prospective and innovative**. For those who have suffered loss in disasters a return to the status quo ante ranks high among their desires – a fact that political leaders often recognize with promises of aid and mass media commentators underscore with human interest stories. But it is remarkable how often New Jersey's disasters have provided spurs to innovation. We owe much of our environmental monitoring system to worries about disasters – witness the stream gauges and meteorological instrumentation that provides all sorts of spin off benefits for New Jersey's populations. The Delaware River Basin Commission and the state's Water Supply Commission also owe their genesis to major floods and droughts.

Beyond these findings, are two more general issues about the contemporary relevance of New Jersey's 20th century experience with natural hazards. One of these focuses on the **changing role of "gatekeepers"** – especially scientists - who interpret natural hazards for broader publics and thereby help to organize debates about policy. In the past the scientists who staffed state environmental agencies were often passionate advocates of deeply held personal beliefs about the moral value of conservation and the necessity for activist government intervention on behalf of these views. (Hayes, 1959) In the contemporary era, when public bureaucracies have been the object of much political criticism, should we assume that the same kinds of people and agencies will play similar roles? What other possibilities might be on the horizon? Finally, considered against long term environmental and societal trends, **how representative is the state's 20th century experience with natural risks** and to what extent is the 21st century context of natural risks and vulnerabilities likely to be different? The further back in time the record of extreme events is pushed the greater the likelihood of uncovering larger extremes; and, as the evidence of expanding human impacts on climate and other aspects of the physical world accumulates, the more likely that future extremes will be different from (possibly worse than) those of the past. (Harrington 1996)  The record of 20th century disasters is certainly a valuable guide to the future but there is every indication that it can neither be regarded as a static base for decision-making nor a definitive blueprint for the future.

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Fig. 1

New Jersey Counties

Fig. 2

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# Notes

[i] During the 1990s New Jersey losses averaged $149 per capita. The national mean per capita annual loss was $299. Hawaii topped the list with $1,621 per capita and Idaho brought up the rear with $22 per capita. These figures do not necessarily correlate with total losses suffered by each state because participation in insurance schemes varies significantly among the states.

[ii] For details see: "New Jersey Governors' Executive Orders, 1941 to January 1990", Rutgers-Newark Law Library, New Jersey Digital Law Library < http://njlegallib.rutgers.edu/eo/eolist.htm#Kean> and State of New Jersey Executive Orders < http://www.state.nj.us/infobank/circular/eoindex.htm>

[iii] Deaths attributable to technological disasters – especially transportation-related fires - have been significantly larger. For example, around 400 died when the shipping piers at Hoboken burned on June 30, 1900; 137 died during the burning of the liner "Morro Castle" off Asbury Park on September 7, 1934; and 36 died in the crash of the airship Hindenburg at Lakehurst on May 6, 1937.

[iv] For example, natural risks may combine cyclical processes that operate at different rates (e.g. ENSO-driven weather cycles which shift irregularly between El Nino and La Nina stages), disjunctive one of a kind surprises, systems that are modified by humans (e.g. runoff regimes skewed by urbanization), and those that are beyond human reach (e.g. solar energy fluxes.

[v] Monmouth, Ocean, Atlantic, Cape May, Cumberland, Salem, Gloucester, Camden, Burlington

[vi] February 11, 2003 was the 100th anniversary of the first two flood warning gauges in New Jersey. The March 2, 1902 flood that damaged Paterson triggered the installation of two gauges on the Passaic and others were later added to the Pequannock and Rockaway Rivers in time to record the even larger Passaic Basin floods of 1903. <http://www.usgs.gov/public/press/public_affairs/press_releases/pr1723m.html>

[vii] Successor to the Board of Riparian Commissioners which was first established in 1864, in part because of disputes with New York State over ownership of wetlands and islands in New York harbor.

[viii] It should also be noted that abandonment of agricultural land in New Jersey has also been proceeding since the mid-19th century. Regrowth forests now occupy considerable regions, especially at higher elevations in the northwest and in the pine woods of south Jersey.

[ix] These variations raise interesting possibilities for testing certain theories about factors that promote hazard. Several scholars have argued that the rate of societal change may be a more important factor leading to disaster than the absolute magnitude of change or levels of living achieved.

[x]Some counties still have potential for further population expansion in hazard-prone locations. Along the flood-susceptible upper Delaware River (Sussex, Warren, Hunterdon) population only increased by 382% during the 20th century - significantly less than the statewide average.

[xi] The national lifesaving station system was founded in 1854 at the urging of William Newell, a bachelors and masters degree holder from Rutgers. http://www.lehsd.k12.nj.us/seaport/Thulin/william_newell.htm. Newell was later appointed superintendent of the New Jersey stations (1861) and was honored by the New Jersey State legislature in 1896 for being solely instrumental in creating the system. <http://www.lehsd.k12.nj.us/seaport/Thulin/life_saving_station_history.htm> Individual station houses were added in New Jersey throughout the early part of the 20th century and continued in their original use (under the auspices of the Coast Guard) until the end of World War II when they were decommissioned.

[xii] Craghan notes that beach nourishment schemes have been reported in New Jersey as early as 1923 and that 122 such episodes have occurred between then and 1996 (Craghan, 2001)

[xiii] One of New Jersey's US senators, Harrison Williams was a key proponent of flood insurance who introduced unsuccessful bills in 1962, 1963 and 1965.

[xiv] The validity of assumptions used to create the plan has recently been called into question by the experience of the most recent (early 2000s) drought. According to State Climatologist David Robinson, with the benefit of hindsight, we can no longer take it for granted that the 1960s drought - which is the drought of record for water planning purposes - is the most severe that is likely to affect New Jersey.

[xv] Like the well-known NIMBY (Not In My Back Yard) syndrome, this process might deserve its own label; perhaps the SITCOM (Share In The Consequences Of Mismanagement) syndrome. SITCOMs represent a dark side of the insurance principle wherein others are invited to share the costs of avoidable losses rather than unpredictable ***misfortunes.***

[xvi] For psychologists, mental health therapists and crisis counselors resilience is the ability of individuals to deal with stress, anxiety, fear and other physical or emotional traumas. For transportation engineers, utility network operators and IT users resilience is equated with the reliability of public infrastructure systems during times of acute hazard. For corporate executives and entrepreneurs resilience is signaled by minimal business interruptions and maximal continuity in the production and distribution of products or services.