HYDROMETEROLOGICAL DISASTERS IN THE STATE OF FLORIDA
Scientific Findings of the ENSO Disaster Risk Management in Latin America Project

The state of Florida is located in the southeast of the United States with a population of around 17 million inhabitants, dispreads in 54,252 Square miles divided in 67 counties. Besides having the highest agricultural income in the South, other economic sectors of industry are construction, tourism and their associated services with a Gross State Product at 472.1 billion in 2000. In addition, 40% of all U.S. exports to Latin America and South America pass through Florida.[1]

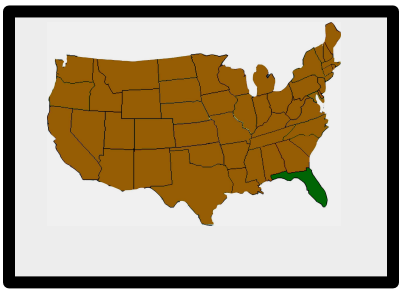

Figure 1: Florida State's location

Florida weather:

Florida is known as the Sunshine state due to its subtropical climate. Located in the south of the Northern Hemisphere in the humid subtropical climate zone, characterized to have hot and humid summers and soft and wet winters.

The south area of the state has a stronger influence from the tropical savanna region, sharing a similar climate with most of the islands of the Caribbean; precipitations are more highly concentrated in the warmer months. The chief factors that govern Florida's climate are latitude, land and water distribution, prevailing winds, storms and pressure systems, ocean currents and altitude.

During the winter, North Florida is occasionally invaded by massive cold fronts that originate in Canada. Although the temperature within these air masses rises significantly during their passage to Florida, they are capable of bringing intense cold to the state. [2]

Average Annual Temperature in Florida		
Location	**Summer**	**Winter**
North	80.5 (F) degrees (26.9 C)	53.0 (F) degrees (11.7 C)
South	82.7 (F) degrees (28.2 C	68.5 (F) degrees (20.3 C)

Table 1: Average annual temperature in Florida State's[3]

Florida´s climate

[1] State of Florida. Com. Florida quick facts. http://www.stateofflorida.com/Portal/DesktopDefault.aspx?tabid=95

[2] Mort Winsberg, David F. Zierden and James J. O'Brien, Climate of Florida. http://www.coaps.fsu.edu/climate_center/FLClimate.htm

[3] State of Florida. Com. Florida quick facts. http://www.stateofflorida.com/Portal/DesktopDefault.aspx?tabid=95

The majority of Florida lies at the most southern end of the Northern Hemisphere humid subtropical climate zone characterized by long, hot and humid summers and mild and wet winters. Normally designated a tropical savanna, the southern part of the state shares a Caribbean climate.[4] Latitude, land and water distribution, prevailing winds, storms and pressure systems, as well as ocean currents are the primary factors that affect Florida´s climate. The third most critical climate variation is El Niño-Southern Oscillation (ENSO)[5]. According to the EP-MAIA, the three coldest winters that have been recorded were in 1976-7, 1977-78 and 1978-9[6].

El Niño

El Niño, Spanish for the child, is a large-scale climatic fluctuation of the tropical Pacific Ocean that normally occurs around Christmas time and disappears by the end of March. Typically, an ENSO weakens the strong easterly winds of the equatorial Pacific, which allows warm eastward-flowing subsurface waters to rise, increasing surface temperatures 2-3.5'F and sometimes as much as 7-11'F in the central and East Pacific. El Niño´s warms waters continue to deepen, while cold, upwelling, nutrient'rich waters fail to reach surface waters resulting in warm, nutrient-poor waters that devastate coastal fisheries. An ENSO may affect the South American coast with heavy rainfall, which may cause drier than typical conditions in Indonesia. The effects of El Niño result severe economic disruption causing draughts, flooding and coastal storms along with thousands of deaths and billions of dollars of damage to property and livelihoods[7]

Weather as Resource:

The favorable conditions offered by subtropical temperatures in Florida, have made its climate an important resource for state growth, especially for Florida's two important industries: tourism and agriculture. The agriculture of citrus and sugarcane began to be developed in the 18th century, together with the breeding of bovine livestock. Later, cotton was introduced. Today, citrus production in Florida makes up two-thirds of the entire production of the United States.

The tourist industry, developing since the mid-nineteenth century, plays an increasingly important role in Florida's economy with almost 59 million visitors in 1999, generating employment for almost 900 thousand people. These millions of tourists each year stimulate an enormous increase in the service sector of Florida's economy representing 77% of the state's product. [8]

While the climate, among other reasons, has encouraged agriculture and tourism to prosper, the climate has also been a factor of risk that impedes and sometimes harms these sectors of the economy. Hurricanes, tornados, strong winds, rains, floods and freezes are alone some of the phenomenon that, depending on their magnitude, can involve enormous economic and social damage. We cannot know their magnitude in advance since the intensity of each one is part of a greater dynamic relationship with other factors, like humidity, wind, time and topographical relief. For instance el Niño

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[4] Winsberg, Mort. (Climate of Florida)www.coaps.fsu.edu/climate_center/FLClimate.htm

[5] The first two crucial climate variations are the daily and seasonal cycles. These result from relationships between the sun and the Earth on time scales of days and years, respectively.

[6] EPA-MAIA-Climate.htm

[7] ElNino-Southern Oscillation_The Columbi Encyclopedia, Sixth Edition_2001.htm

[8] State of Florida. Com. Florida quick facts. http://www.stateofflorida.com/Portal/DesktopDefault.aspx?tabid=95

(Southern Oscillation phenomena) typically brings 30%-40% more rainfall and cooler temperatures to Florida in the winter.

HURRICANES IN FLORIDA
1970 – 2001

Due to it geographical location, Florida is frequently the first landfall of hurricanes in US territory. Historically this state has been one of the most affected by this type of natural hazard in the nation and has necessarily adopted measures to minimize the effects of such events. Normative and technical measures, and improved weather forecasting techniques have played an important role in minimizing damages by hurricanes.

Between 1970 and 2001, Florida has been afflicted by hurricanes that caused economic damage and social disruption in 11 separate years (see Table 1). According to the DesInventar Florida 1 database, on which this synopsis is founded, during the 1970-2001 period, hurricanes were responsible for 58 deaths, the destruction of more than 250,000 homes, and economic losses of more than $28 billion.

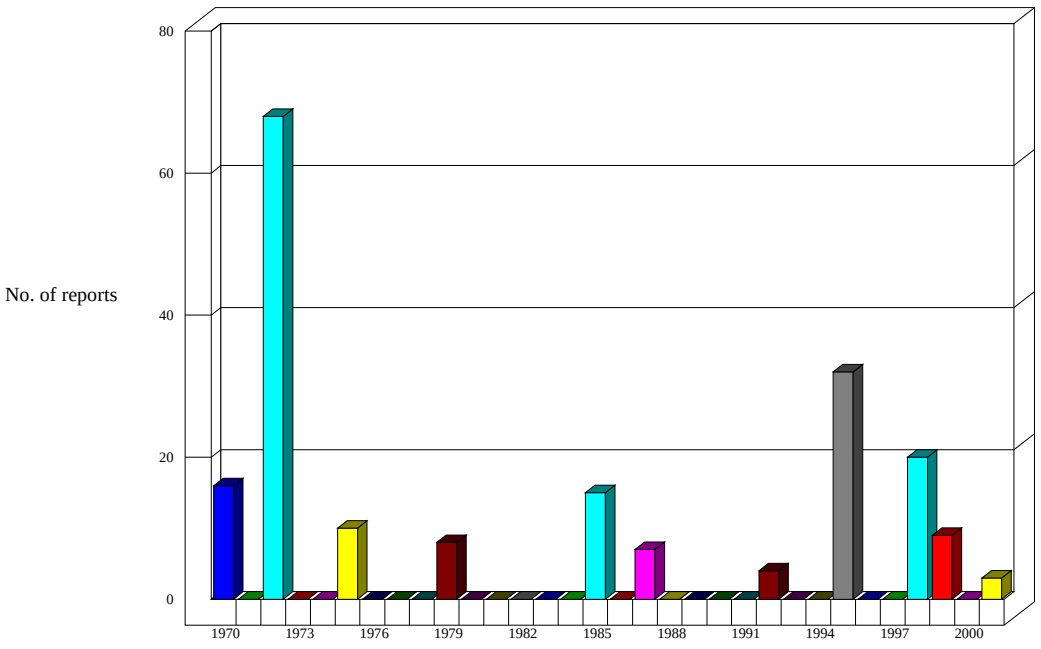

Table 1: Hurricanes in Florida (1970-2001)
Source: DesInventar Florida 1 database.

In the last three decades, hurricanes occurred exclusively during the period between June through November[9]. Although June is the month that registered the highest

[9] The earliest hurricanes in the year occurred on June 2, and the last occurred on November 21.

number of reports by county in the database (See Table 2), August is the month with the highest number of events

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Except for Hurricane Andrew, in which the death toll was 44**,** the number of victims due to hurricanes in the last thirty years is minimal compared with previous decades. However, the economic damages caused by this type of natural event are enormous, with Hurricane Andrew creating the majority of the losses during the period of study. The total economic losses between 1970 and 2001, according Desinventar 1 is $28,578,329,175, of which 25 billion correspond to Hurricane Andrew. Although the number of houses damaged or destroyed is placed at 25,000, there were roughly 250,000 people left homeless by the storm. If an average of four to five people per household is used, the number of homes destroyed could have been as high as 50-60,000. Regardless, Andrew was the most destructive hurricane in the recorded history of the United States.

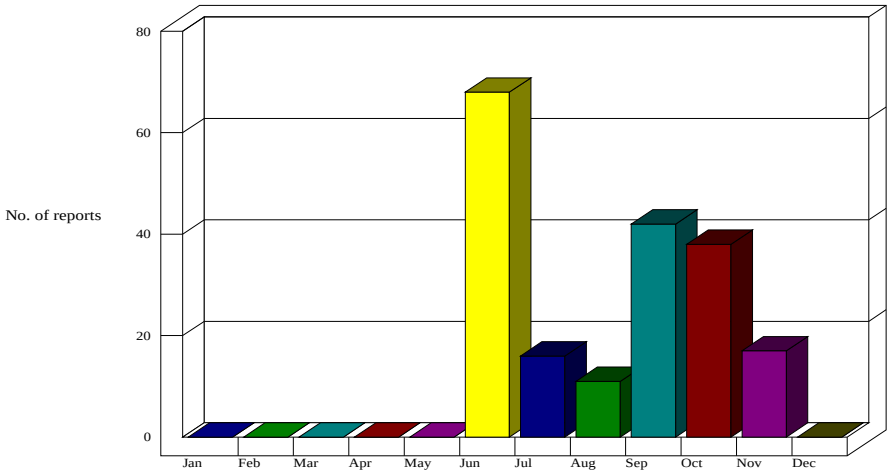


Table 2: Temporal distribution of Hurricanes in Florida (1970-2001)
Source: DesInventar Florida 1 database.

June: 68 reports, 1 event
July: 16 reports, 1 event
August: 11 reports, 4 events
September 42 reports, 3 events
Octuber: 38 reports, 2 events
November: 17 reports, 2 events

Source: DesInventar Florida 1 database

TORNADOS

Florida leads the nation in terms of total number of annual tornados occurring per 10,000 square miles and ranks third in terms of overall number of tornados (FEMA).

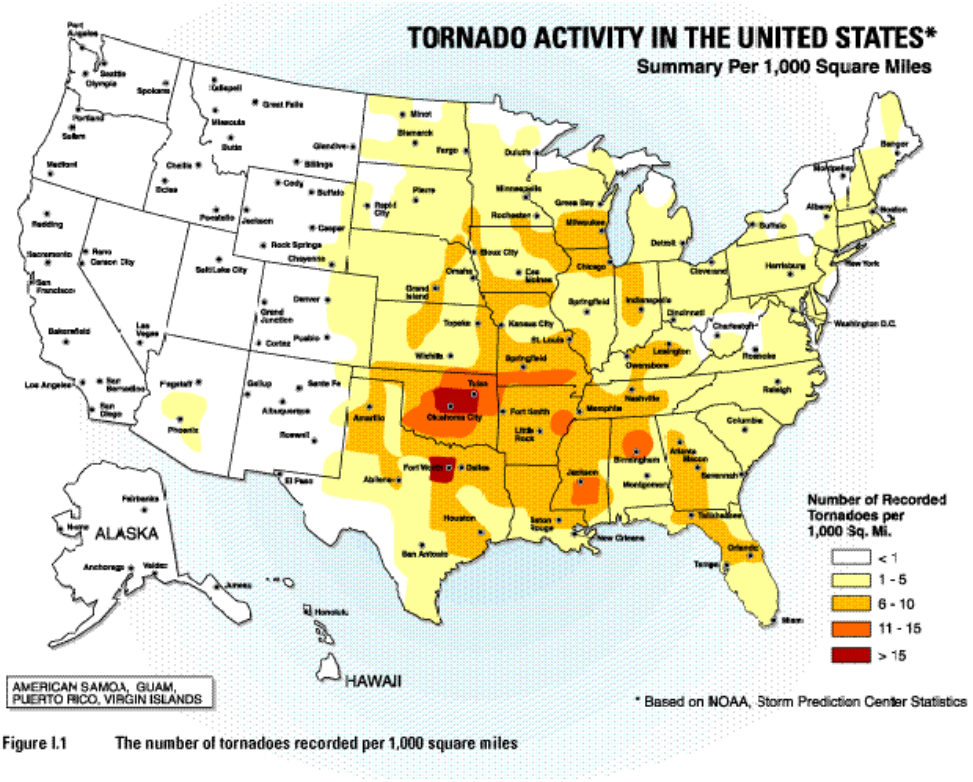
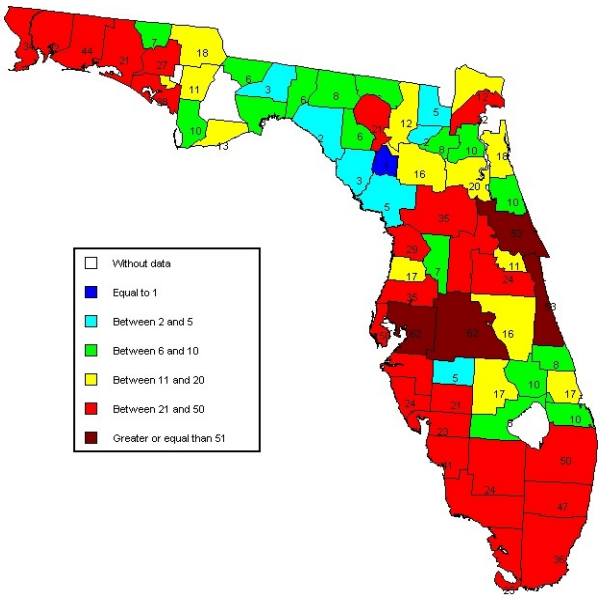
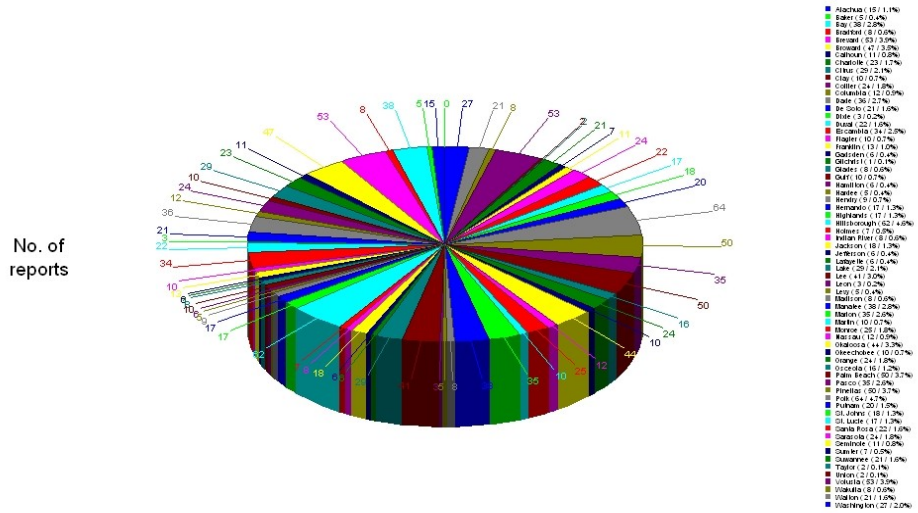


Figure I.1 The number of tornadoes recorded per 1,000 square miles

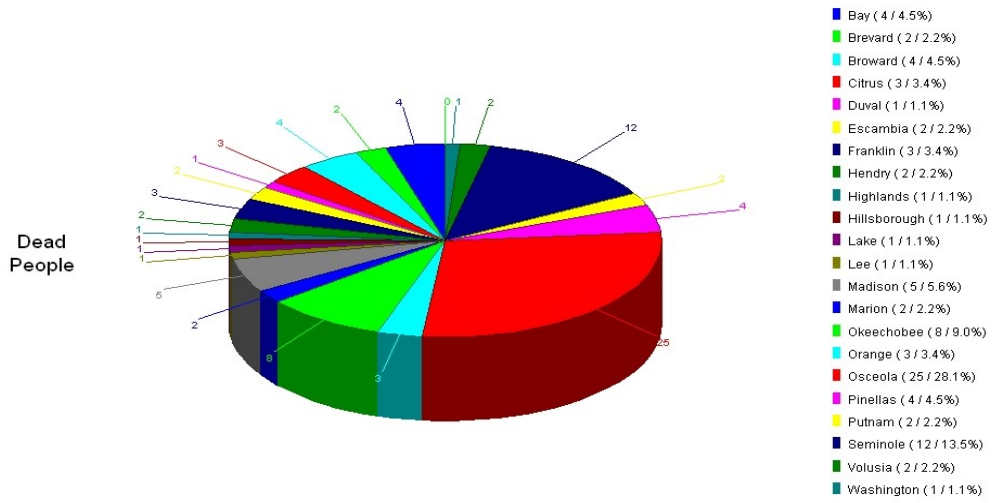
Yet, tornados in Florida are small, short-lived events that seldom take lives. While the greatest number of tornados occur in June, July, and August, Florida's deadliest tornados take place in early spring; February, March and April. Winter and spring tornados are more powerful as a result of jet streams moving across the Gulf of Mexico.

Throughout the rest of the nation, the most violent tornados occurring throughout take place in the afternoon and early evening due to a buildup of heat throughout the day. However, violent Florida tornados can occur at any time of the day or night. This temporal factor increases resident vulnerability as most people are asleep after midnight and do not receive tornado warnings relayed through radio or television. NOAA provides a weather-alert radio for approximately $40.00 Still, Florida tornados are usually so small and short-lived that the weather service is unable to issue a timely warning.

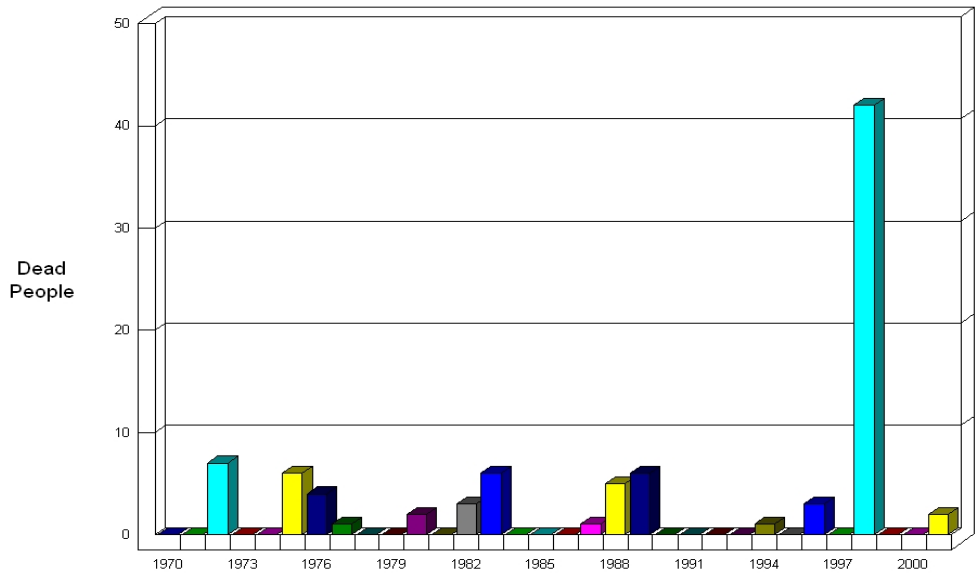




Since 1972, 89 people in Florida have been killed by tornadic events. Overall, the greatest number of tornado-related deaths have occurred in Osceola County.

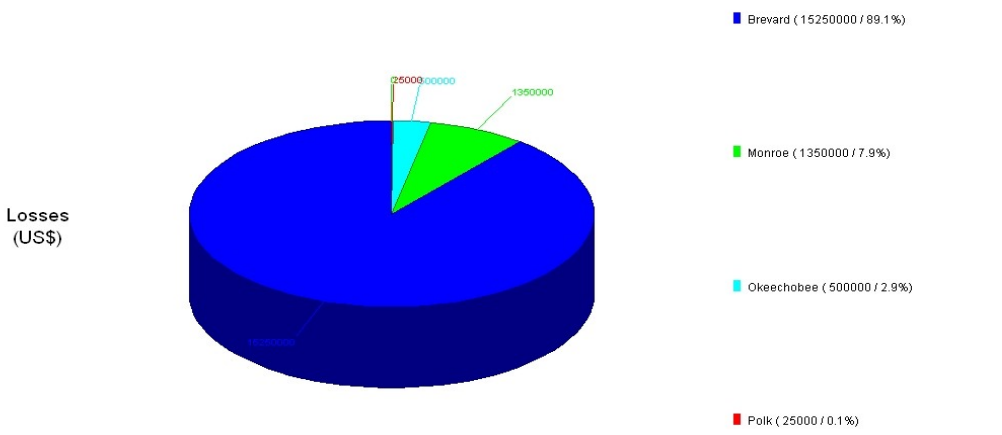


Statewide, more deaths occurred as a result of tornados in 1998, than any other historical year.

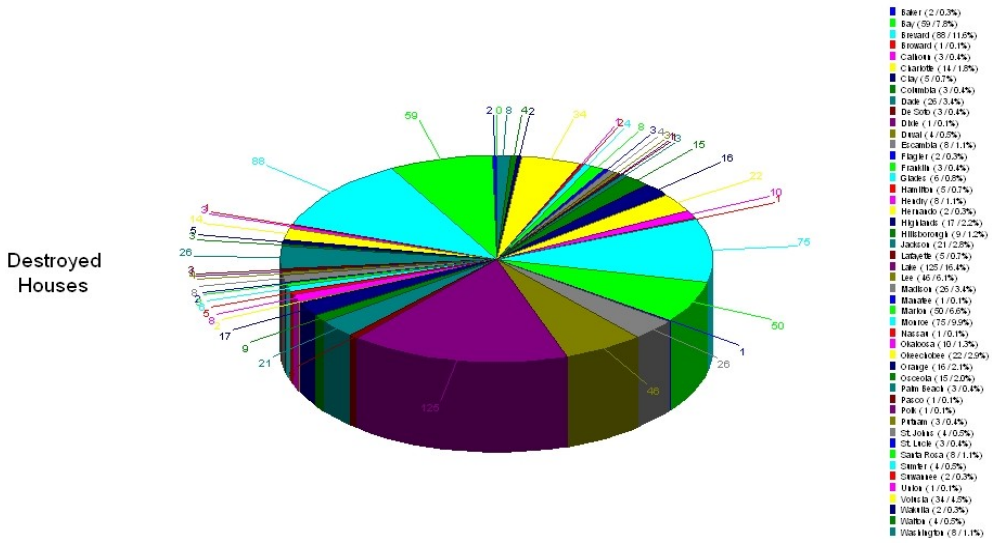


Death-toll of deadliest Florida tornados (disaster.org)		
Northeast	1939	4
Northwest	1962	17
Central	1998	42
South	1928	5

Brevard, Monroe, Polk and Okeechobee counties have experienced the greatest number of losses in U.S. dollars than other Florida counties.



Counties with the greatest number of destroyed houses: Brevard, Dade, Lake, Marion, and Monroe.



Risk and vulnerability

- New residents
- Mobile homes or substandard housing
- Poor communication
- Increased proximity to a designated tornado shelter
- Travelers (in cars, etc)
- Offices, condominiums, hotels

(Floridadisaster.org)

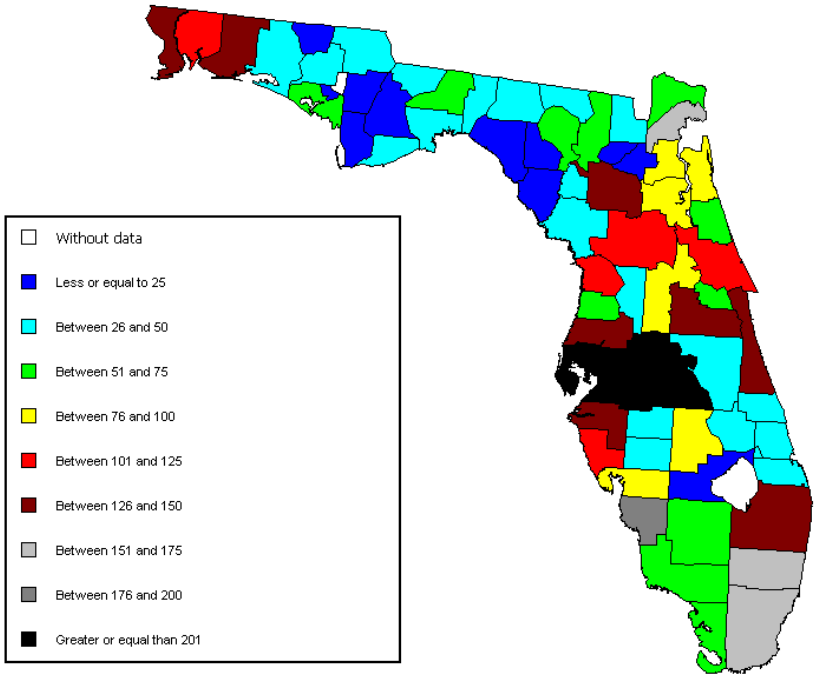
***Fujita Scale**

F0	Gale Tornado	Branches break	40-72mph
F1	Moderate Tornado	Mobile homes turned	73-112mph
F2	Significant Tornado	Roofs ripped off	113-157mph
F3	Severe Tornado	Trains overturned	158-206mph
F4	Devastating Tornado	Cars thrown	207-260mph
F5	Incredible Tornado	Houses thrown	261-318

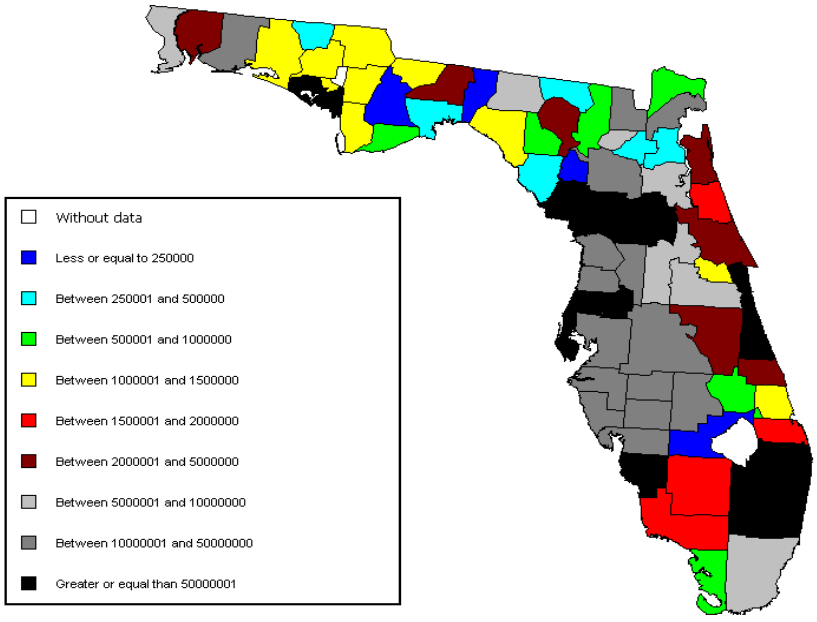
STORM/LIGHTNING EVENTS

According to the National Agricultural Safety Database, Florida has more thunderstorms, and thus, more lightning strikes, than any other state. In "Boating and Lightning Protection", a report written for the NASD, William J. Becker states that an average of ten people die and thirty people are injured in Florida as a result of lightning every year. Approximately fifty percent of these deaths and injuries occur in a recreational context and nearly forty percent of those involve recreational water activities, such as boating, surfing, swimming, etc. Our own ENSO database reveals that employment-related activities such as construction and maintenance work and other purely accidental circumstances account for a large number of casualties associated with lightning and storms as well. Damaging strong winds, hail, and lightning associated with thunderstorms also have drastic economic impacts on the state of Florida, with the monetary losses totaling in the hundred of billions of dollars for the entire state over the last thirty years, according to the ENSO database. The database also reveals that every county in Florida has reported at least $100,000 of losses due to thunderstorms in the thirty year period from 1970-2000.

Thunderstorms occur when warm, moisture-laden air rises as a result of warming temperatures and evaporates, forming cumulous clouds that darken as more moisture accumulates. The upper portions of the clouds develop a positive charge, the lower portions a negative charge, and the negative charges along the bottom of the cloud attract positive charges along the ground. These positive charges try to accumulate as close to the cloud as possible, usually on the tallest object around, and lightning occurs when the difference between the positive and negative charges becomes great enough to overcome insulating resistance and force a conductive path between them. Aside from lightning, another common phenomena associated with thunderstorms are gusts of rapidly descending air that can exceed over 100mph known as downbursts, which can incur bodily harm and cause significant damage to infrastructure, the environment, etc.



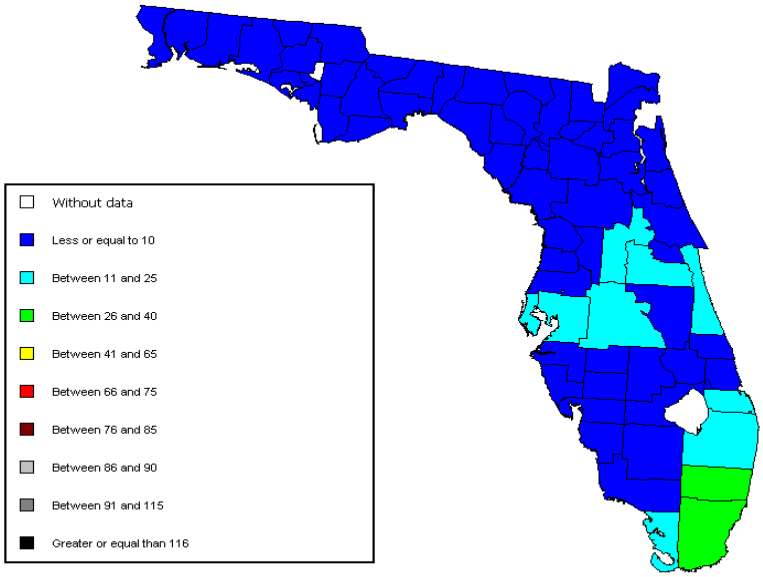
Number of Reports of Strong Wind, Lightning, and Storms



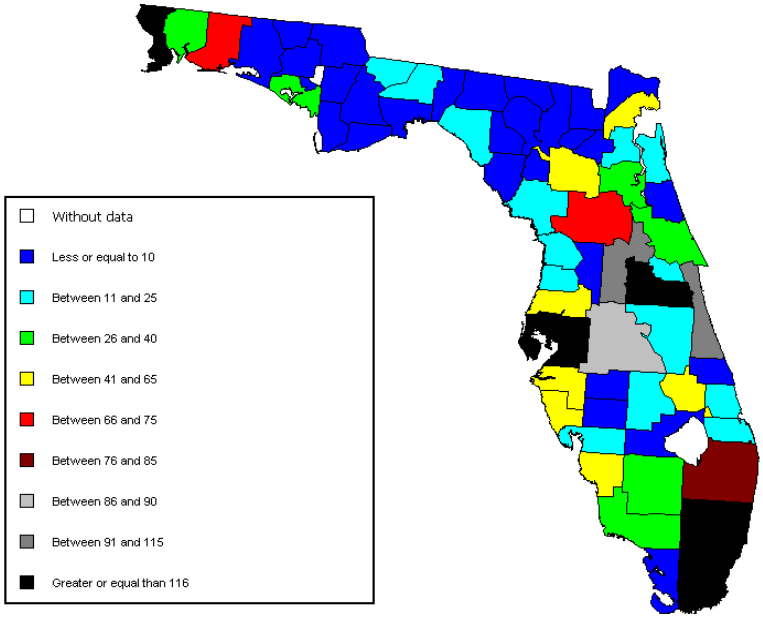
Losses in US Dollars due to Storms and Lightning

According to the Florida Division of Emergency Management, the interior sections of central Florida receive the most thunderstorms with 100 plus days per year. Thunderstorms are also frequent in coastal areas as well, with an average of 80 to 90 thunderstorm days per year. The ENSO database reveals that two areas, the Gilchrist/Marion county area and the Pinellas/Hillsborough/Polk county area have reported the greatest loss amounts due to thunderstorms and lightning in the Florida

during the past thirty years. Pinellas and Hillsborough counties are also the sights of the most injuries and fatalities due to storms and lightning in the state.



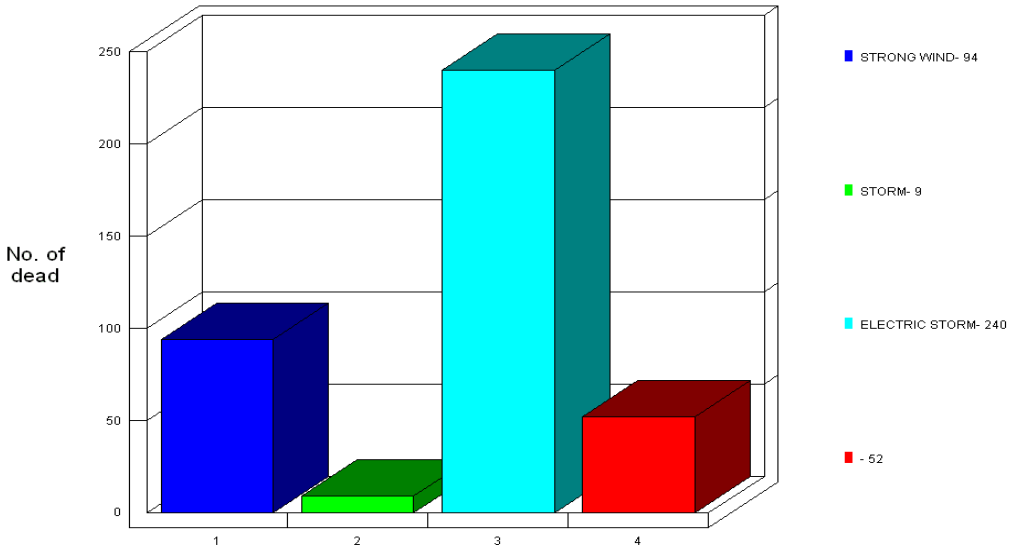
Number of Lightning/Storm-Related Deaths per County

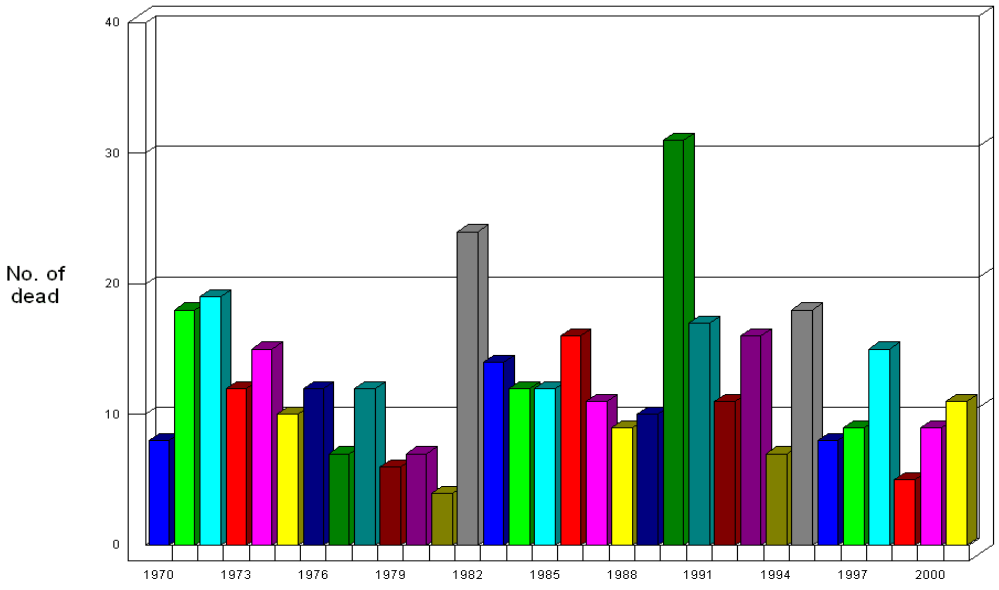


Number of Lightning/Storm-related Injuries per County

The disproportionate impact of thunderstorms on these areas correlates with the fact that they both lie within the coastal zone of Florida that receives an average of 80-90 thunderstorm days a year. The high losses due to storms reported by Gilchrist and Marion counties could be related to the frequency of agricultural activity in those areas, as strong winds, hail, and lightning certainly have the potential to have serious impacts on crops and livestock. While Pinellas and Hillsborough counties are both highly urbanized and therefore at risk of infrastructural damage due to winds associated with storms, Polk county also sustains a fair amount of agricultural activity, which could account for high

losses due to storms there. Recreation plays a large role in injuries and fatalities due to lightning and thunderstorms in Florida, and numbers of such casualties are much higher in Pinellas and Hillsborough counties than in other areas. The fact that both counties are located on the Gulf Coast in prime areas for water recreation and tourism could account for many of these fatalities, as could the rapid urbanization of this area and resulting construction and maintenance demands, which force more workers outdoors in an area that experiences frequent thunderstorm activity.





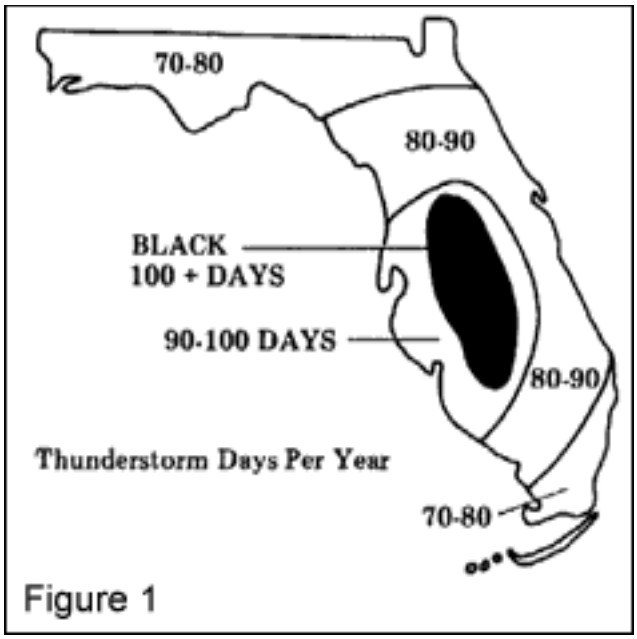
References:

Becker, William J. “Boating-Lightning Protection,” National Ag Safety Database, http://www.cdc.gov/nasd/docs/d000001-d000100/d000007/d000007.html, 9/2/04

ENSO database

"Severe Thunderstorms" Florida Division of Emergency Management, http://www.floridadisaster.org/bpr/EMTOOLS/Severe/thunderstorms.htm, 9/2/04

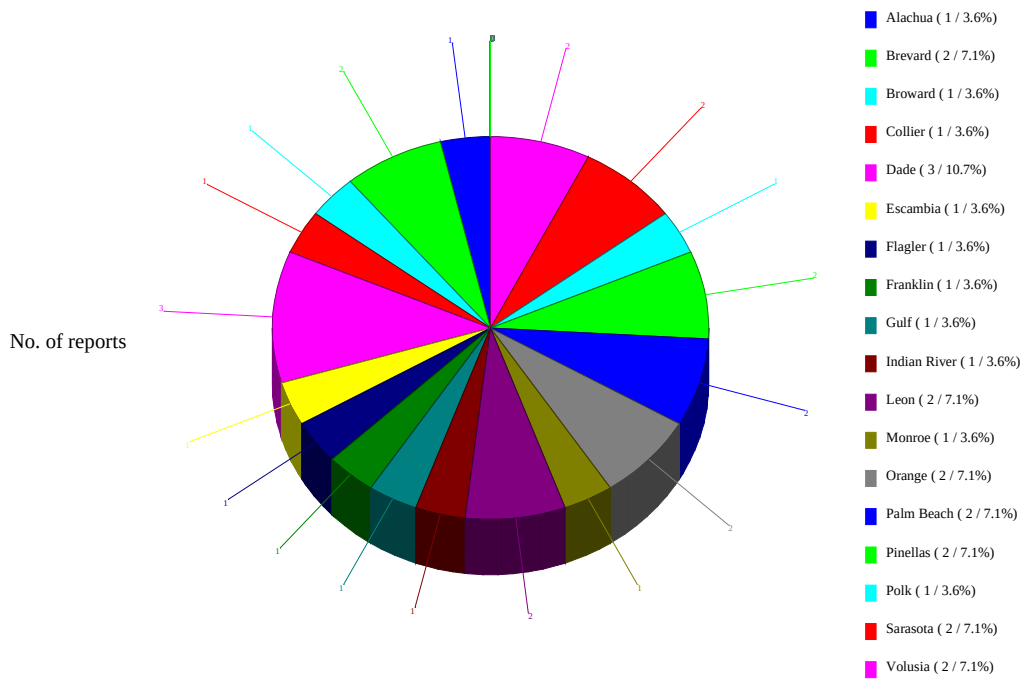
"Thunderstorms" Santa Rosa County Office of Emergency Management, http://www.santarosa-emergency.com/tstorm.html, 9/2/04

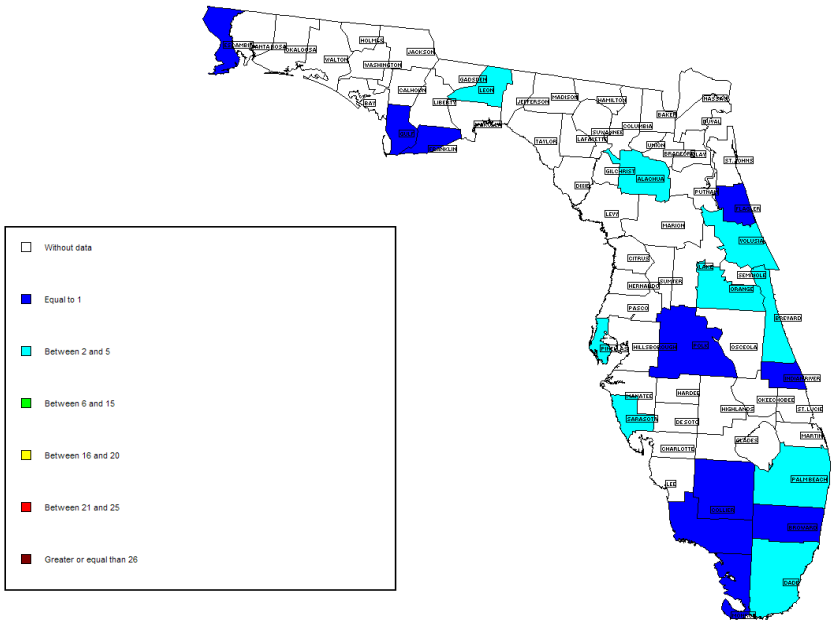


Thunderstorm days per year

FLOODS

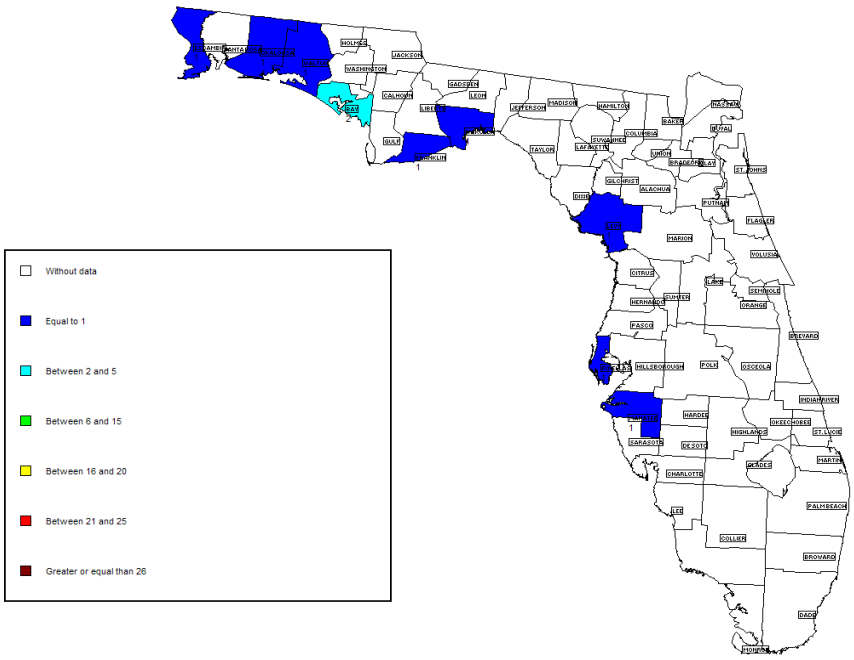
Floods occur at the intersection of natural factors such as rainfall intensity and duration, ground permeability, and runoff, with cultural factors such as physical infrastructure (i.e. asphalting, sewerage, drainage). Flash flooding occurs when the ground under a storm becomes saturated with water so quickly that it cannot be absorbed. The runoff collects in low lying areas and flows rapidly downhill. As a result, anything in its path is picked up by the rising waters and swept into drainage conduits, catch basins, or nearby bodies of water. In urban areas, flash flooding can be exacerbated by the presence of blocked or inefficient drainage systems and extensive asphalted surface area facilitates the rapid flow of volumes of water that would normally be absorbed into the ground. Of course, flooding is a natural phenomenon that can occur in any area where the carrying capacity of waterways is charged. Along coastal areas, storm surges can temporarily flood low-lying areas, and in cases of suspended storm activity, certain areas may become inundated for indefinite periods.



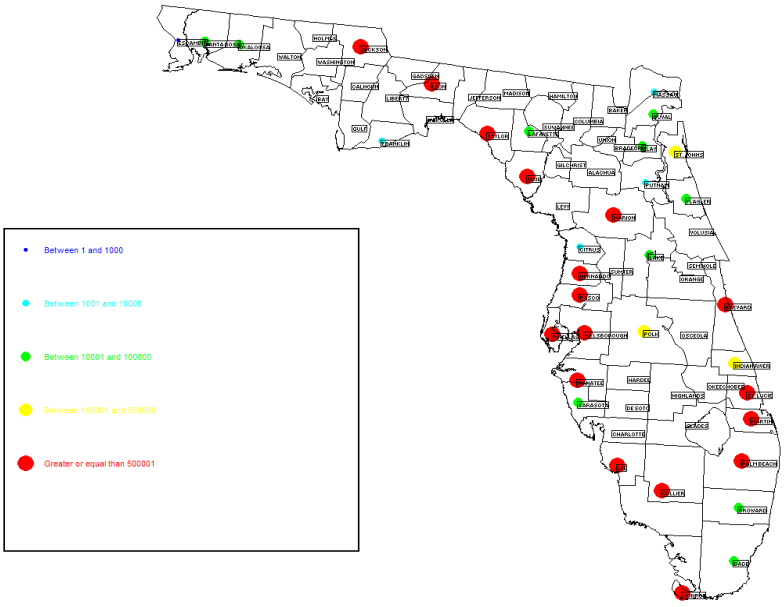


The pie chart and map above both illustrate the indices of heavy rains reported across the state of Florida (all charts included in this report are for the period from 1970-2001). Dade County, followed by Pinellas, Volusia and Alachua counties are the most highly represented here and, coincidently, counties with some of the highest population densities. Therefore, it can be inferred that there is a direct relationship between urbanization/infrastructure and accrued rain damage. Although flooding can occur in any part of the state, it is most dangerous in those areas not equipped to handle high intensity downpours. However, several rural counties are included in these graphs. This leads me

to believe that both rural and urban areas are affected in relatively different ways – that certain economic, political and municipal (physical) structures combine in different forms creating conditions that are more or less affected by climatic phenomena. For example, why is it that Alachua County reports more incidences of heavy rains than several southern coastal counties that have historically born the brunt of most tropical storms? I posit that it is the preponderance of a high-density population, making it more susceptible to structural damages such as fallen trees and damaged roofs, as well as water damages to neighborhoods of sub-standard housing oftentimes located nearest urban waterways (drainage ditches, watersheds, catchment basins).



The above map represents cases of evacuation in response to flood-related events. What is of note here is that although the highest indices of flood-related damages were reported in highly urban areas, the most severe and sustained cases occurred in predominantly rural areas. I point out that in the case of Franklin County, the causal factor for this high flood intensity is the succession of at least two tropical storms – Tropical Storm Beryl and Tropical Storm Alberto. Probably one cause of sustained flooding conditions was the relative proximity of one event to another. Tropical Storm Alberto occurred on July 5, 1994 and generated inland flooding that persisted into August. Directly afterwards, on August 16, Tropical Storm Beryl formed and moved across the panhandle dropping almost eleven inches of rain in the region in less than one day. In less urban areas, the lack of expansive or efficient sewerage systems may delay the absorption/recession rate and homes of lower quality – most likely located in more at-risk areas – may be more completely damaged than those found in urban areas.



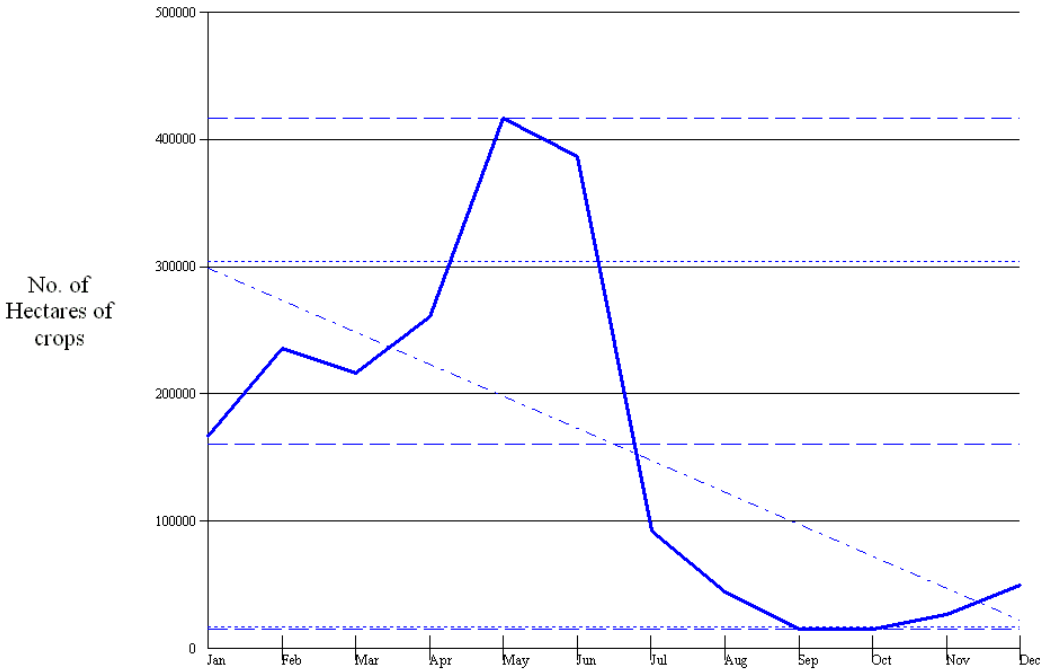
Represented above are indices of overall losses related to flood events. What becomes strikingly clear is the susceptibility of coastal areas to flood conditions. Many coastal areas accumulated damages well into the million dollar range. Definitely, lowland areas and most highly urbanized areas along the coast are most likely to be damaged by sustained flood events. We cannot not assume that it is entirely possible to qualify net damages, but we find it likely that the characteristics of flood damage within rural and urban areas will differ somewhat. Both areas suffer certain structural damages – inundation of roads, houses and businesses – yet urban areas might be more adequately equipped with resources to recoup or prevent certain damages. Also, many counties depend on a predominantly agricultural based economy. Therefore, a sustained inundation of croplands could be more threatening to a rural areas economy more so than a sustained inundation of certain urban districts. A destroyed crop (of animal or vegetable) can have residual deleterious effects, engendering a stage of lack and crisis (in the absence of alternatives). However, we do not wish to overlook the gravity of urban flooding situations. We can assume that coastal areas will be those in which real estate values are the highest, where fewer, larger homes are constructed, and/or locations of downtown urban centers (St. Augustine and St. Petersburg, for example). Therefore, their proximity to large bodies of water increases their vulnerability to flood situations. The immediate and tangible net damage accrued in the instance of urban flooding situations is obvious in their prevalence in the Desconsultar dataset. These types of damages can be quickly surveyed and tallied. However, the resilience of crops and livestock can be eroded during sustained inundation. Situations facilitating the emergence and spread of water-borne diseases can obliterate livestock and crops can slowly be deprived of much needed sunlight and carbon dioxide. Also, increased water turbidity (amount of sediment in water) incredibly affects aquacultures and, as a result, the fishing and tourism industry which, for many rural coastal areas, might possibly be a pillar of the local economy. Since these effects/damages might not be realized until the upcoming fishing/tourist season, they might find themselves under-represented in datasets. Furthermore, a rural, predominantly agricultural/fishing community might find itself even more at risk due to a lack of economic alternatives.

It is not surprising that flooding along coastal areas would be a recurring phenomenon. Some of the most visible and immediately recognizable outcomes of flooding in these areas are shoreline erosion, inundation of low-lying inland areas, and structural damages, as well as crop damages. However, flood conditions, if sustained or severe, can affect water quality to the detriment of local communities and industries. These corollary effects are often deferred and do not emerge until after the flooding event has occurred and may pan out over extended periods of time. Therefore, the net accumulative damage may be much greater than originally calculated. Also, the qualitative consequences of such events, although often the most crucial, are often barely alluded to and receive little consideration in damage reports.

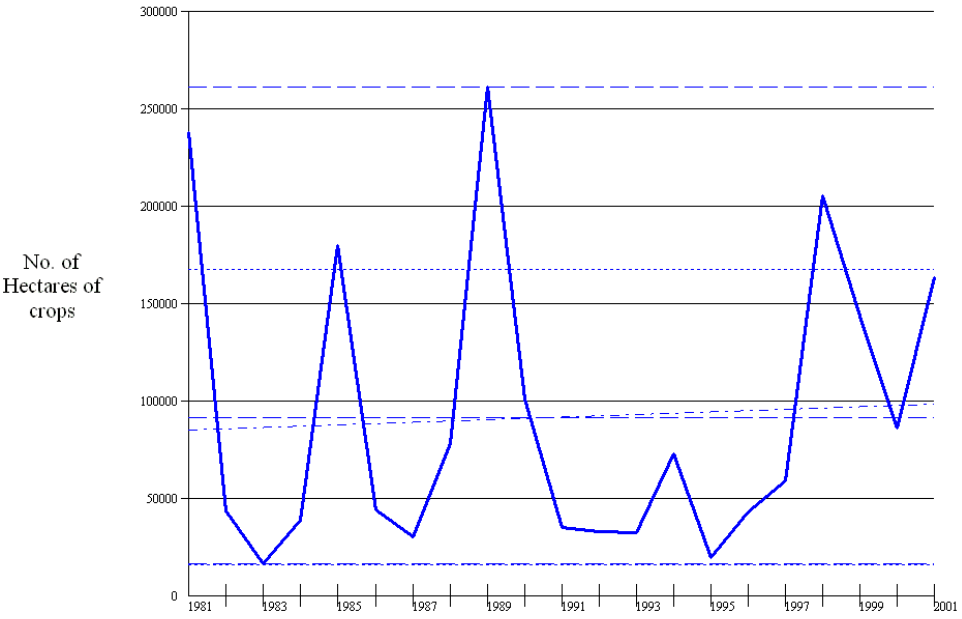
1DROUGHT

Changes in the sea surface temperature in the western pacific, the El Nino/La Nina phenomenon, in combination with the Southern Oscillation referred to as ENSO has been related to climatic changes worldwide as well as Florida. During an increase of the sea surface temperature in the Pacific (El Nino), the state of Florida will experience wetter years than ususal. During a decrease of the sea surface temperature (La Nina), Florida will experience drier years. In these drier years, which can and have resulted in droughts, the environmental, economic, and social structure of the state will be impacted in many direct and indirect ways. Because of the nature of drought as a creeping-phenomenon or non-event in comparison to hurricanes, tornadoes, and floods, the most eminent and best denoted losses are first-order losses of biophysical nature as in forest fires as DesInventar Florida 2 reflects. All other losses shown by DesInventar Florida 1 are agricultural losses. The more subtle, temporally deferred, and second or third-order impacts of drought are harder to quantify as can be seen in the lack of data offered by DesInventar Florida 1 and 2.

One example of biophysical and first-order impacts of drought are the conditions leading to the spread of forest fires, which is reflected in the detailed level of data available regarding date of fire reported, number of incidents, and amount of acreage burned . In total, 117789 incidents of forest fires by date and county and acreage burned have been recorded. The amount of acreage not only varies with seasonal temperature and rainfall conditions (Graph1), but also increases at least threefold during drought years (Graph 2).Between the years of 1970 and 2001, Florida had five major droughts. The first occurred from 1970-1977, for which no forest fire data is available. All the other droughts, 1980-1982, 1985, 1988-1990, 1998-2001, correspond with a threefold increase of amount of hectares burned. Each drought roughly corresponds with a major spike depicted in Graph 2. The detailed information available regarding forest fires allows an analysis showing the significance of drought conditions impacting the scale of forest fires.

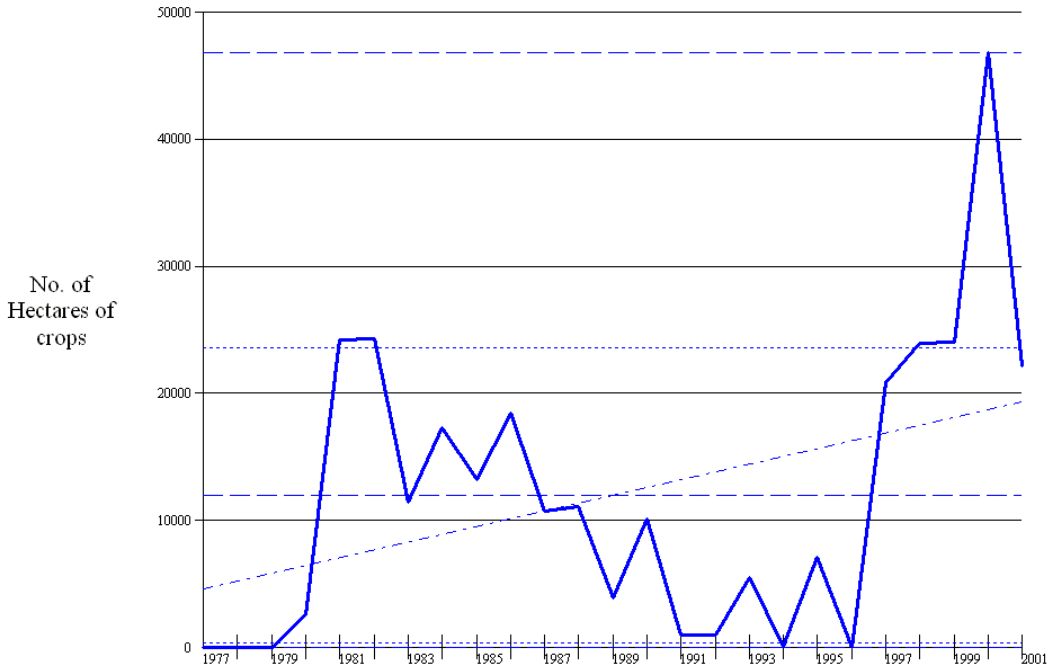


Graph 1 Source: DesInventar Florida 2

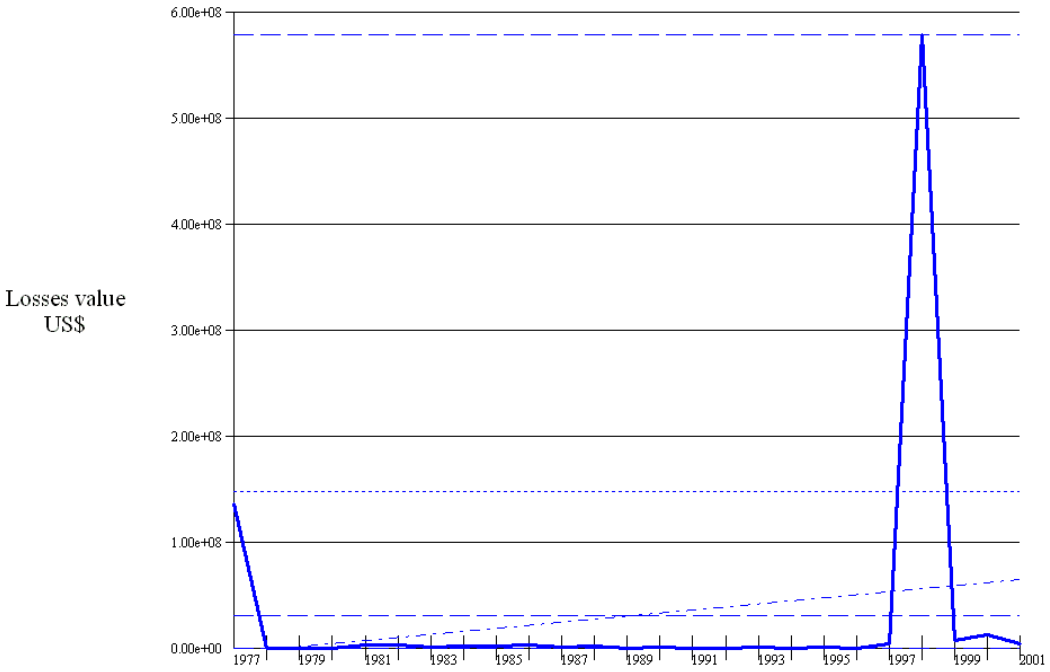


Graph 2 Source: DesInventar Florida 2

Another effect of drought encompasses Florida's largest economic sector, the agricultural sector. This sector is usually the first economic sector impacted by a lack of precipitation and decrease in soil moisture. Between the years of 1970 and 2001, 421 entries, the totality of drought entries, of DesInventar Florida 1 report damage to the agricultural sector in either dollar value (Graph 3) or number of hectares of crop destroyed (Graph 4). In 1977 and in 1998, the graph depicting damage in dollar value (Graph 3) shows spikes in economic losses of the agricultural sector. Both of these years, correspond with either the beginning in 1998 or the end in 1977 of a historical drought. None of the sources providing the information of the losses of these two drought years give information on the amount of hectares lost due to drought. The graph depicting damage in number of hectares of crop destroyed (Graph 4) shows and increase of crop losses during the 1980 -1982 and the 1998-2001 droughts. The nature of the source as a crop insurance may, however, not accurately reflect the amount of hectares of crops lost in reality. Due to the information available regarding agricultural losses caused by drought as reflected in DesInventar Florida 1, the data analysis may as in the 1977, the 1980-82, and the 1998-2001 droughts show impacts on the agricultural sector; in the remaining cases of 1970-76, 1985, and 1988-90, the data available, shows no or no extreme impacts of the drought conditions in comparison to the wetter years. One reason for the partial weakness of correlation between the lack of precipitation and agricultural losses due to drought may lie in the heavy reliance on irrigation (2.23 million acres in 1998 (Smajstrla and Haman)) of Florida's agricultural sector.



Graph 3 Source: DesInventar Florida 1



Graph 4 Source: DesInventar Florida 1

The more subtle, of second- or third- order, and temporally deferred impacts of drought are harder to quantify as can be seen in the lack of data offered by DesInventar Florida 1 and 2. These expected numerous impacts are either of temporally deferred biophysical nature or are weblike. The increase of salinity of fresh water due to the lower levels of water tables caused by the drought and magnified by human water usage as in the heavy reliance of agriculture on irrigation or a increase in population pressure would be one example of these kinds of impacts. Another example would be the lowering of lake and river levels to a point in which recreational use such as canoeing and other water sports including fishing because of the diminished fish population becomes impossible. This has had an effect on the economy of places, which are heavily reliant on the tourism sector as their source of income. This loss in visitors will indirectly impact revenue collected by local and state governments. Another example beginning with the lack of precipitation are the impacts on the livestock industry. The factors affecting this sector are diseases picked up due to the lack of quality of rangeland and the decrease of water in amount and quality. Also forest and rangeland fires become more numerous and threaten livestock. Impacts of this complex nature due to droughts are rarely measured in a comprehensive way as no data is available as DesInventar Florida 1 and 2 mirrors.

The drought data available in DesInventar Florida 1 and 2 is data of direct, relatively sudden, and biophysical nature. The level of detail of Florida DesInventar 2 shows a clear correlation between droughts and forest fires. The remaining drought data in Florida DesInventar 2 shows agricultural impacts only. These entries, however, do not show as clear a correlation between Florida's drought years and the impacts of either dollar value or amount of hectares lost. All other impacts of drought because of number and order of effects are not reflected in any of the DesInventar databases.

FOREST FIRES

Forest fires are recurrent in Florida where about 5,000 events happen every year. As in other natural and human induced adversities, forest fires have not been recorded in detail by official institutions in the state. During the period of research of the ENSO Project, which spans from 1971 to 2001, two sets of data were collected. The first set is composed of fragmented data collected principally by NCDC, and NOAA, which recorded mainly events that have caused social or economic losses. Although such data is the only source of information on economic damage caused by forest fires in Florida, it shows only a limited part of the actual number of forest fires that have occurred in this state[10]. The Division of Forestry of the Florida Department of Agriculture started to collect data on forest fires since 1981. This data set shows a detailed record of the events occurred in Florida, but it does not document the economic losses caused by the forest fires.

To improve the information base on forest fires in Florida, the ENSO Project has used the data from these two sets of sources, and made two databases on these events. The first database (DesInventar Florida 1 database) contains 453 forest fire events, which show the social and economic damage caused by these calamities (Figure 1). The second database (DesInventar Florida 2 forest fires database) contains the data collected by the Division of Forestry of the Florida Department of Agriculture, which is composed of 117, 789 forest fire events that occurred between 1981 and 2001 (Figure 2). As mentioned, this database does not include social or economic damages.

[10] For example, between 1971 and 2001, the NCDC database recorded only 195 forest fires (see: http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms), which strikingly contrast with the data collected by the Division of Forestry of the Florida Department of Agriculture.

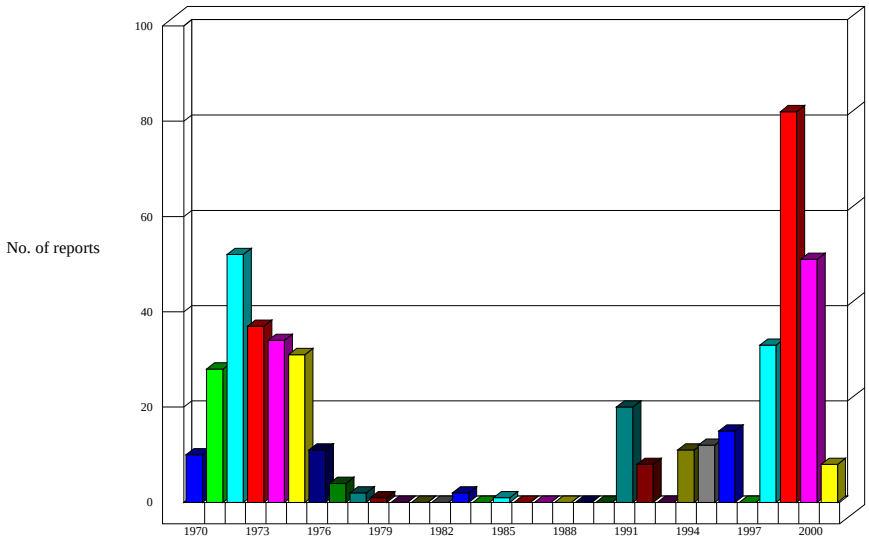


Figure 1 Forest fires with economic and social damages in Florida
Source: DesInventar Florida 1 database

With a total of 117, 789 events, Figure 2 shows the annual occurrence of forest fires recorded by the Division of Forestry of the Florida Department of Agriculture, with a mean of 5,000 events, except in 1981 when almost 15, 000 fires occurred.

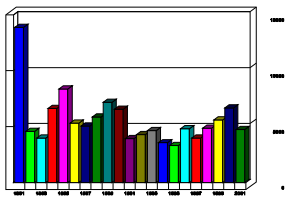


Figure 2 Reported Forest fires in Florida
Source: DesInventar Florida 2 forest fires database.

Although the high number of occurrences, forest fires have not always caused economic or social damages in Florida. As shown in Figure 1, the forest fires that caused economic or social damages are those that occurred during the period periods 1970-1979; 1991-1992; 1994-1996; and 1998-2001. One of the distinctive features of forest fires in Florida is the fact that the number of events do not necessarily correlate with the economic damages. As shown in Figure 1, 1999 is the year with most damaging forest fires, followed by 1972 and 2000. But the number of forest fires during these years

(between 40 and 80), does not mean higher economic damages nor the spatial extension of damages. The year 1998, when less than 40 fires occurred (see Figure 3), is by far the one with the highest economic losses. That year forest fires caused $380 million in losses, and burned 140,000 hectares of forests.

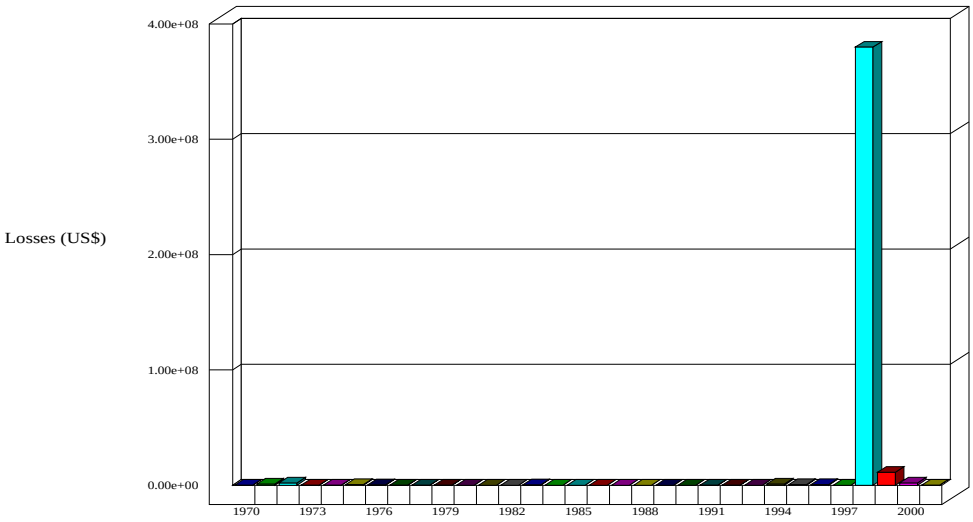


Figure 3 Economic losses Source: DesInventar Florida 1

Concerning the geographical distribution of fires during the period of 1981-2001, Polk County shows the greatest number of forest fire events. In that county 6,366 events occurred, which represents the 5.4% of the total number of forest fires in Florida. The area affected by forest fires in that county in the period 1981-2001 was 89,416 hectares, which corresponds to the 4.6% of all the forest area burned in Florida during that period.

On the other hand, in the Broward County only 599 events occurred between 1981 and 2001, which represents the 0.5% of all the forests fire events in the state. However, it was in Polk county that the biggest forest area was affected. A total area of 326,850 hectares were burned in this county, which represents the 17% of the state area. Nevertheless, the size of the area affected by forest fires in this county does not have correlate with economic losses. As Figure 4 shows, the total losses by forest fires in Broward County is $ 136,000.

The counties with the biggests economic losses are Brevard and Volusia, which, when combined, represent 87% of the total economic losses by forest fires in Florida between 1971 and 2001 (see Figure 4). In Brevard the total amount of economic damages is $ 200,082,500, and in Volusia, $150,276,000, which represent 50% and 37.5% respectively of the total economic losses occurred in Florida due to forest fires during the period 1971-2001.

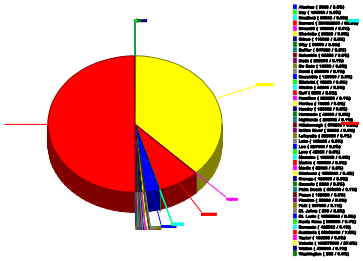


Figure 4 Economic losses by forest fires in Florida Counties
Source: DesInventar Florida 1 database

The data on forest fires in Florida, shows that the number of ocurrences or the size of the affected area do not reflect the social and economic vulnerability to forest fires in this state. It is neccesary to understand that some counties that are prone to be affected by forest fires do not suffer high economic losses, and that others where there are fewer fires, suffer high economic losses. Clearly, the issue of vulnerability of important resources to forest fires is not fully grasped and appropriate mitigation strategies are not being employed in selected areas. Another issue regarding forest fires is the environmental effect of these fires. In all the cases of economic losses by forest fires, material looses only were considered, but there are not any reference to the losses of environmental services that the burned forest could offer to the surrounding area.

FROST

Frost, when temperature drops below 32 degrees Fahrenheit, generally occurs during the months of January and December in Florida, extending for lapses of hours for up to several days. However, according to the DesInventar Database frost is not a phenomenon that has occurred annually in the state of Florida between 1970 and 2001. Instead, Florida has experienced frost 12 years of the 31 covered by the database.

Freezing Temperature Level

5	**"An Extreme Threat to Life and Property from Excessive Cold."** A very hard freeze with temperatures below 24 degrees (F)...OR...areas to widespread measurable freezing/frozen precipitation (not a trace) with coverage more than 25% within a defined area...OR...lowest wind chills below 10 degrees (F) with at least 10 mph wind.
4	**"A High Threat to Life and Property from Excessive Cold."** A hard freeze with temperatures between 24 - 28 degrees (F)...OR...patchy measurable freezing/frozen precipitation (not a trace) with coverage less than 25% within a defined area...OR...lowest wind chills 10 - 14 degrees (F) with at least 10 mph wind.
3	**"A Moderate Threat to Life and Property from Excessive Cold."** A significant freeze with temperatures between 28 - 32 degrees (F)...OR...lowest wind chills 15 - 19 degrees (F) with at least 10 mph wind...OR...widespread frost with coverage more than 55% within a defined area.
2	**"A Low Threat to Life and Property from Excessive Cold."** Near freezing with temperatures between 33 - 35 degrees (F)...OR...lowest wind chills 20 - 24 degrees (F) with at least 10 mph wind...OR...areas of frost with coverage 25 - 54% within a defined area.
1	**" A Very Low Threat to Life and Property from Excessive Cold."** Lowest wind chills 25 - 34 degrees (F) with at least 10 mph wind...OR...patchy frost with coverage less than 25% within a defined area.
0	**" No Discernable Threat to Life and Property from Excessive Cold."** Cold season weather conditions are non-threatening.

Table 2: Freezing Temperature Level[11]

Freeze warnings are issued when temperatures are forecast to be below 32°F within the subsequent 24 hours. A hard freeze warning will be issued if the temperature is expected to be below 28°F for at least three hours. Hard freezes occur in rural areas in the interior of South Florida about once every ten years, and less frequently along coastal metropolitan areas.

According to the DesInventar Database 1970-2001, 273 reports of frost are counted (representing 2.9% of the total of reports on disasters). Hillsborough and Collier have suffered frost during 11 of the 12 years that Florida has experienced freezes between the years of 1970 and 2001.

The following table expresses the frequency of the affected counties:

#Years * with Frost	Counties affected	Counties
11	2	Hillsborough, Collier
10	1	Hendry, Palm Beach
9	5	Pasco, Manatee, Lee, Hardee
8	7	Highlands, Hernando, Glades, De Soto, Citrus, Charlotte, Brevard
7	3	Marion, Lake, Dade
6	7	Volusia, Sumter, St. Lucie, Polk, Osceola, Orange, Indian River
5	5	Seminole, Sarasota, Pinellas, Okeechobee, Martin
4	2	Lecy, Broward
3	1	Putman
2	6	Monroe, Madison, Leon, Flagler, Duval, Alachua
1	28	Washington, Walton, Wakulla, Union, Taylor, Suwannee, St. Johns, Santa Rosa, Okaloosa, Nassau, Liberty, Lafayette, Jefferson, Jackson, Holmes, Hamilton, Gulf, Gilchrist, Gadsden, Franklin, Escambia, Dixie, Columbia, Clay, Calhoun, Bradford, Bay, Baker
***** Numero de años en que se han producido heladas en el estado de Florida, en el periodo 1970-2001, de acuerdo a los actuales registros de la Database Desastres (70, 71, 77, 83, 85, 86, 89, 96, 97, 99, 2000 and 2001).		

Table 3: Frequency of counties affected during frost years. [12]
Sources: Presents en la Database (Storm data, NCDC, Attaway, Jhon, A history of Florida, NOAA, A history of Florida citrus freeze and Sheldus & WWCB)

[11] http://www.srh.noaa.gov/mlb/ghwo/cold_levels.html

[12] DesInventar Database, 1970-2001.

On the other hand, the registrations of the DesInventar Database point out that between the years 1970 and 2001, in the state of Florida, the freezes have been present during the months of December and January in 12 different years. The lowest temperature reached in the same period was in Marion County during the frost of 1998 (15 degrees F) and 1971 (16 degrees F). Zierden and O'Brien point out that the state's record minimum temperature was in February, 1899 when Tallahassee experienced –2oF!

Social incidence:
The primary social problems due to frost have been some deaths and unemployment of agricultural workers. According to the database, the frost in Florida has caused eight deaths between 1983 and 2001.

Year	# Deaths	County
1983	6	Dade, Duval, Hillsborough
2000	1	Glades
2001	1	Leon

Table 4: DesInventar Database: reports of deaths in Florida due to frost between 1970-2001.

However, the National Weather Service talks about a study that reports a larger figure: 124 people died from frost among the years 1979 and 1999. Especially standing out are the 26 people who died from hypothermia in 1989. [13]
Unemployment, particularly agricultural unemployment, is another of the negative impacts of the freezes. Especially since Florida's agriculture industry is extremely sensitive to dramatic temperature changes. The year 2001, according to a the report Agency for Workforce Innovation (AWI), I carry out an estimate preliminary it has more than enough in the one that points out that 8,330 workers could suffer temporary unemployment, in the areas of vegetable production (8,242), and the rest in ornamental fish production and fishing, valuing this lost around $11.2 Million. [14]

Economic incidence:
Frost has the highest economic cost in agriculture, besides causing temporary unemployment; it also affects the stability of vegetable production. Thousands of crates of citrus fruit were lost, and in some counties the land itself was detrimentally affected.

According to the DesInventar database, significant losses of up to $US 40 million per county occurred in 1983, 1985 and 1997. While 1999 was the year with frost with the least economic losses at around $US 130,000 per county affected.

Year	# Counties	Losses in $
2001	10	91,100,000
2000	8	7,499,000
1999	6	775,000
1997	5	200,000,000
1996	22	163,049,998
1989	32	104,640,000

[13] National Weather Service Forecast: http://www.srh.noaa.gov/mfl/newpage/about_cold.html, Florida Division of Emergency Management: http://www.floridadisaster.org/bpr/EMTOOLS/Severe/cold.htm
[14] Federal Emergency management Agency, FEMA: http://www.fema.gov/emanagers/2001/nat021201.shtm

1986	21	N/D
1985	28	1,230,429,200
1983	9	410,150,000
1977	67	49,253,732
1971	30	N/D
1970	35	N/D
Total		2,256,896,930

Table 5: DesInventar Database, reports of losses for year and County.

Also, some counties reported that their land was affected.

Year	# Hectares	Counties
1985	118,490	28
1989	42,680	32
1996	180	Lee
2000	100	Citrus

Table 6: DesvInventar Database, counties' affected land after frost.

In addition, during 2001, a report noted that Florida farmers have suffered severe agriculture losses in vegetable crops, sugarcane, citrus, fern, horticulture and the tropical fish industries. Those losses were estimated to total $US 179 million. (However, this information has not been reported in the database.)[15]

In conclusion, throughout most of the year, Florida's climate provides a subtropical paradise for tourists and agriculture alike. However, when the weather (unexpectedly) fluctuates and drops below freezing, the social and economic costs are high.

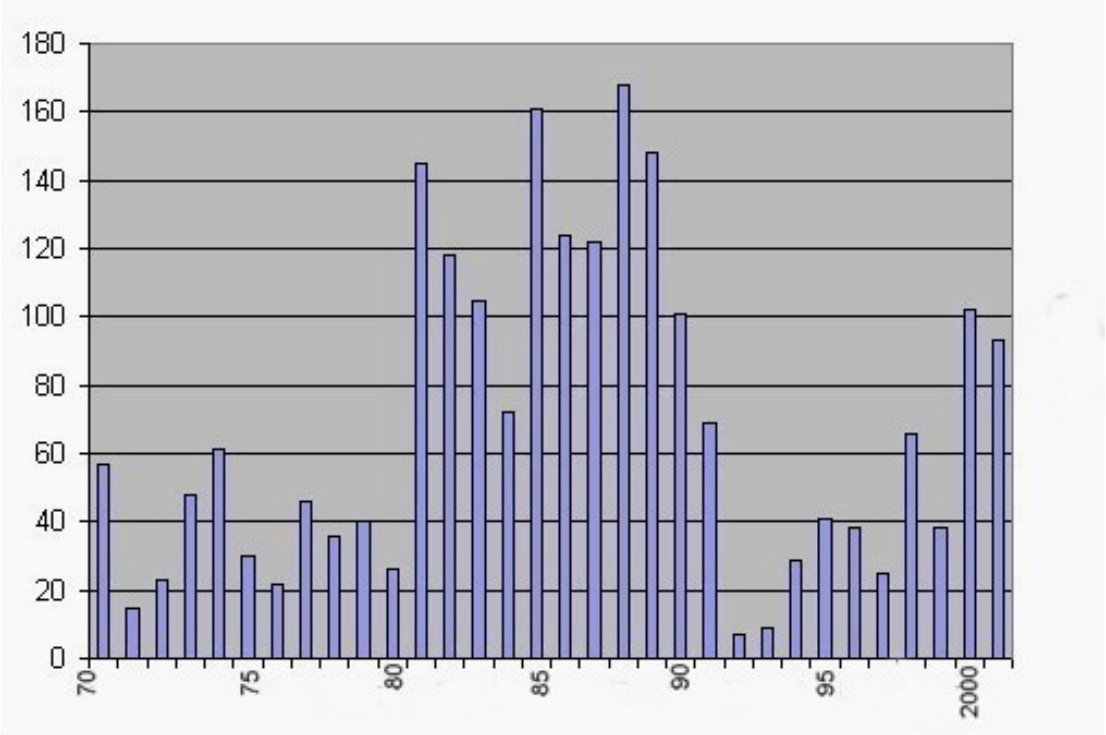
SINKHOLES IN FLORIDA

Sinkholes are naturally occurring events caused by the interaction of water and the particular carstic soil of Florida. The distinctive form of a sinkhole is the collapse of underground geological structures, which creates holes of different sizes in the surface. In the creation of a sinkhole the slow seep of rainwater works through the layers of sand. This water settles into the limestone layer, which is eroded due to the acidity of the rainwater. This process of erosion creates caves, whose walls are supported by the water level. When there is a decrease in the underground water level due to drought conditions or excessive use, the walls of the subterranean cave lose the water support and then collapse creating the typical crater of the sinkholes.

Graphic 1

Occurrence of Sinkholes in Florida
1970-2001

[15] Federal Emergency management Agency, FEMA:
http://www.fema.gov/emanagers/2001/nat021201.shtm

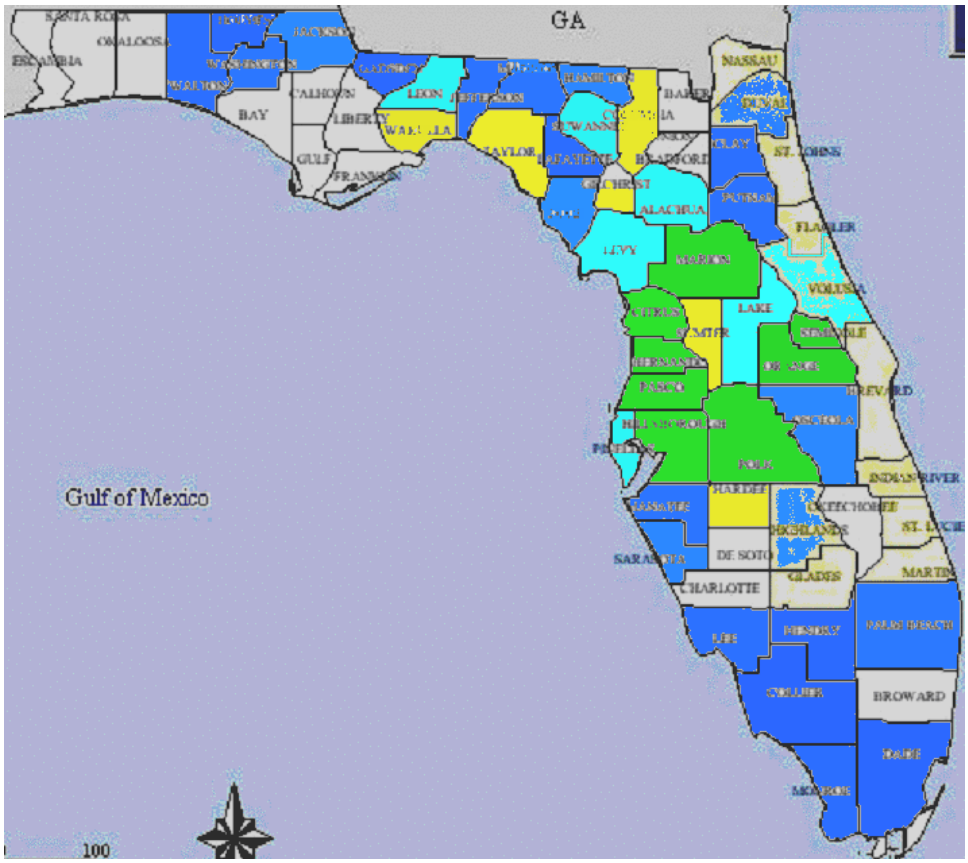


Between 1970 and 2001, 2185 sinkhole occurrences have been reported in Florida. The greatest frequency of incidence occurred in the 1980s. As shown in Graphic 1, in the 1980s between 80 and 160 cases of sinkholes occurred every year. In the decade of the 1970s less than 60 events occurred every year, and in the 1990s, there was increasing activity, from less than 10 cases in the earlier years to about 100 cases in the last year of this decade. The years of 1981, 1985, and 1988 were the three most active in sinkhole formation with 145, 161, and 168 sinkholes respectively.

The area where most sinkholes occurred is the west central part of Florida. In this area the eight counties where more than 100 sinkholes occurred during the period of study are Seminole, Orange, Polk, Marion, Hernando, Pasco, Hillsborough, and Citrus counties. Of these counties, Pasco, Hillsborough, and Citrus had more than 200 events. Near this same area of Florida, and in the north central part of the state are a group of counties in which between 40 and 100 events occurred in the period 1970-2001 (Levy, Suwannee, Alachua, Pinellas, Leon, Volusia, and Lake), and between 10 and 40 events (Gilchrist, Taylor, Sumter, Hardee, Columbia, and Wakulla). In the south and north areas of the state, are the counties where less than 10 cases of sinkholes occurred during the three decades of study (Collier, Dade, Gadsden, Hendry, Holmes, Lafayette, Monroe, and Walton, Clay, Jefferson, Lee, Putnam, Washington, Madison, Manatee, Palm Beach, Duval, Indian River, Sarasota, Hamilton, Osceola, Highlands, Jackson, Dixie) (See Map 1)

Map 1

Geographical Distribution of Sinkholes in Florida



Sinkholes are not always a "disaster." Social damages occur when a sinkhole is formed in urbanized areas. In such cases, it can cause severe damage to property and economic losses can be considerable. Of the 2185 sinkhole occurrences in Florida, 1203 cases occurred in low suburban, high urban, and industrial type of land use. There is no comprehensive record of damages caused by sinkholes. Only in some of the cases of sinkholes recorded, have property damages been assessed. This occurs mostly when insurance has been paid. But insurance companies do not pay in all the cases of sinkhole damages[16]. The Florida Statute 627.706 defines a *"sinkhole loss" as being "actual physical damage to the property covered arising out of or caused by sudden settlement or collapse of the earth supporting such property only when such settlement or collapse results from subterranean voids created by the action of water on a limestone or similar rock formation."* Cases that do not occur suddenly, for example, are not covered and then the damages are not recorded. This means that in many cases, the economic impact of sinkholes is unknown.

Maroney, Patrick F., et al
2005 Preliminary Report: Insurance Study Of Sinkholes

University of Central Florida

[16] According a recent report on sinkholes, "the number of sinkhole claims made had risen from only 35 in 1987, to 426 in 1991, and increased by 250 claims from 1990 to 1991" (Maroney et al 2005). Data after 1991 is not available.

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