United States' Hurricane Counts: 1801-2000

Short Title: U.S. Hurricanes: 1801-2000

Brian H. Bossak[1] *and James B. Elsner*[2]
Department of Geography
Florida State University

[1]*Current Address: U.S. Geological Survey*
Center for Coastal and Watershed Studies
600 4th Street South
St. Petersburg, FL 33701

[2]*Address: Florida State University*
Department of Geography
Tallahassee, FL 32306

Email: bbossak@usgs.gov
Phone: 727-803-8747 ext. 3046

ABSTRACT

The debate over the effects of climate change on North Atlantic tropical cyclones has spurred interest in longer records of hurricanes. We have developed a digital tool, called the HHIT, which collates tropical cyclone information from a variety of sources over the period 1800-1850, effectively serving as a base dataset from which estimated counts of U.S. hurricanes can be extracted. Here we use descriptive statistics to compare estimated hurricane counts from the period 1801-1850 with counts from 1851-2000 in 50-year intervals. We find that the seasonal distributions of U.S. hurricane activity are robust over the last two centuries, and that the greatest risk of a U.S. hurricane is consistently between Sept. 9th and Sept. 18th. We also find that the number of years experiencing extreme U.S. hurricane activity (4 or more landfalls) has decreased since 1851. Moreover, an inverse relationship between the number of hurricanes striking the East coast and the Gulf coast of the U.S. has occurred since 1801. This is consistent with previous findings regarding the effect of the North Atlantic Oscillation on North Atlantic basin hurricane tracks and steering.

Introduction

Encompassing a diameter of between 200 and 1300 kilometers and possessing a wind velocity of ≥ 33 ms^{-1} ($\geq$74 mph), hurricanes are capable of inflicting widespread destruction. Estimates put the average annual cost of hurricane damage in the U.S. at $4.8 billion dollars (Pielke and Landsea, 1998). The scientific basis for predicting tropical cyclone activity months in advance is based on a research spanning several decades (Gray, 1968; Gray, 1984; Gray, 1990; Bove et al., 1998; Elsner and Kocher, 2000; Maloney and Hartmann, 2000). The majority of this research is conducted on data spanning no more than 100 years or so (Elsner et al., 2000; Landsea et al., 1996). The impact of global warming on U.S. hurricane frequency and intensity is still the topic of much debate (Landsea, 2000), and it has been noted that longer records of tropical cyclone activity are necessary in order to conduct more definitive research regarding anthropogenic changes to tropical cyclone development (Nott and Hayne, 2001).

The HURricane DATa base (HURDAT or best-track), maintained by the U.S. National Hurricane Center, is the official record of tropical storms and hurricanes for the Atlantic Ocean, Gulf of Mexico and Caribbean Sea, including those that have made landfall in the United States (Jarvinen et al.~1984). Important revisions to the data set (reanalysis), correcting systematic and random errors, have recently been completed for the second half of the 19th century and early 20th century (Landsea et al. 2003). The analysis presented here uses the latest version of HURDAT as of July 2003, which includes reanalysis of all storms prior to 1911.

Less reliable but still useful U.S. hurricane information is available back to the beginning of the 19th Century. Historical accounts of hurricane occurrence and landfall exist in a variety of documents that include compendiums sorted by region and date, documents analyzing records for individual states, and personal research. Information sources in these works include observations, ship records, newspaper accounts, personal letters, and governmental archive reports.

For several reasons, this collection of hurricane information has not been utilized as scientific evidence pertaining to early American hurricanes. First, the information exists in various and scattered archives and extensive work is needed to access and collate this information. Second, the information has, for the most part, not been mapped, and the geographic context of the information has not been emphasized. Finally, in many cases, the documents contain little quantitative information. We contend that knowledge of the past occurrence of U.S. hurricane landfalls, even if incomplete, helps us to understand hurricane climate variability and change (e.g., Elsner and Bossak, 2001).

We utilize collated documental evidence of past U.S. hurricanes for the period 1800-1850. The documental evidence has been incorporated into the Historical Hurricane Impact Tool (HHIT), which can be utilized for statistical analysis and for comparisons with modern records (for more information, see Bossak and Elsner, in review). A similar effort in collating climate records in historical shipping logs from European countries during the period from 1750 to 1850 is being undertaken at the Universidad Complutense Madrid; this EU-funded program is titled the Climatological Database for the World's Oceans 1750-1850 (CLIWOC). These shipping records contain climate information that can be compiled for use in climate research, similar to the data in the HHIT. The data in the CLIWOC may one day be utilized to expand the HHIT data further back in time, possibly to 1750.

In order to have comparable datasets, we use the years 1801-2000 in this study, and divide the total 200-year dataset into four time intervals (1801-1850, 1851-1900, 1901-1950, 1951-2000).

Sources used to compile the U.S. Hurricane data in the HHIT

David Ludlum's 1963 monograph, entitled *Early American Hurricanes: 1492-1870*, is a compilation of high-quality textual summaries of tropical cyclone activity over the western North Atlantic and Gulf of Mexico (Sharkov, 2000). Major sources include Garriott (1900), Fassig (1913), Tannehill (1956), and Dunn and Miller (1960), which are based on the work of Poey (1855) and others. The monograph contains local newspaper accounts of shipboard damage reports that were published in newspapers, personal letters and diaries, as well as records in archives that provide descriptions and dates for the storms. Some of the reports include meteorological observations. For example, below is an excerpt from the post surgeon at Ft. Brooke (near present-day Tampa, FL) during the hurricane of September 25, 1848:

> '*The tide rose 15 feet above low water…the water commenced rising very fast at 10 A.M. and continued to rise until 2 P.M.' The surgeon also noted "the fall of the barometer from a prestorm reading of 30.12" at 0900/24th and 29.92" at 2100 to a low of 28.18" sometime prior to 1500/25th, indicative of a storm of the severest type. By 1500 the glass had recovered to 28.55" and the wind was coming out of the south.*' (*Ludlum,* 1963, p.154)

Ludlum (1963) is the primary source document for the HHIT. However, we also include data from more recent historical chronologies compiled by Ho (1989), Barnes (1998, 2001), Sandrik (1999), Cotterly (1999), Forty-Sixth Weather Squadron (1999), Roth (1998, 2000), Roth and Cobb (2001), and Prokop (2001). These works contain additional information about some of the storms listed in Ludlum (1963) as well as notes on storms not mentioned. Table 1 lists the sources used to compile the tropical cyclone information in the HHIT (for a more detailed explanation of the HHIT, see Bossak and Elsner, in review).

Figure 1 is a flow chart that describes the conditions under which storms were assigned to hurricane or non-hurricane (tropical storm or extratropical cyclones) classifications in the HHIT. Meteorological observations that support hurricane intensity on land result in a storm being classified as a hurricane. Damage reports suggesting hurricane force winds or intensity estimations are utilized as additional classification criteria. The “Other” category includes tropical storms and extratropical cyclones. The HHIT includes only storms that were considered to be tropical cyclones by the original authors.

Tropical Cyclones in the HHIT

The HHIT includes evidence from 90 tropical cyclones during the 51-year period from 1800-1850. Of these, 56 are estimated to have hit the United States at hurricane intensity (>73 mph) and 24 at major hurricane intensity (>110 mph). The most active year was 1837 with 10 tropical cyclones, 6 of which made landfall along the U.S. coast. The second most active year was 1844, with 8 tropical cyclones and 4 landfalls. Thirty-seven of the 51 years had evidence of at least one tropical cyclone (including tropical storms). The exceptions were 1801, 1802, 1805, 1807, 1809, 1823, 1826, 1828, 1832, 1833, 1836, 1838, 1845, and 1847.

Table 2 lists the tropical cyclones present in the HHIT. The table lists the basic storm information including year, date of initial landfall, storm name, and estimated intensity. In addition, the estimated landfall location is listed, with separate intensity estimates for tropical cyclones that make more than one landfall. There are a handful of tropical cyclones that were recorded as making landfall more than once in the 1800-1850 period (6). Only one of these tropical cyclones was associated with a second U.S. landfall at hurricane intensity (1850, Storm 2, Aug. 23/25).

Seasonal Activity

Descriptive statistical analyzes can be performed on the hurricane information assembled in HHIT. The HHIT includes chronological listings of tropical cyclones by year and provides estimated landfall dates for each tropical cyclone to strike the U.S. coast. The HHIT includes information denoting which cyclones are estimated to have made landfall at hurricane intensity. The analysis in this paper utilizes the HHIT data from 1801-1850 to generate a 200-year record of U.S. hurricanes that extends from 1801 to 2000.

Comparisons are made between the numbers of U.S. hurricanes in four 50-year intervals (1801-1850, 1851-1900, 1901-1850, 1951-2000). There are 54 hurricanes in the period 1801-1850 (two of these hurricanes do not have a recorded date of landfall). This compares with 88 known hurricanes in the period 1851-1900, 92 hurricanes in the period 1901-1950, and 72 hurricanes in the period 1951-2000 (Table 3). The earliest period contains the lowest number of recorded hurricane strikes. This is likely the result of undetected storms introducing a temporal bias in the overall record. However, natural variability is quite large, as evidenced by a 17% reduction in the number of landfalls between the first and second halves of the 20th century. Therefore, it is not easy to tell how much of the reduction is due to missing storms and how much is due to natural variability.

Questions about the most likely period of activity within a season are determined across intervals. These comparisons are less affected by the temporal bias under the assumption that the probability of not detecting a storm is independent of the time of year. For each of the four periods, we count the number of landfalls using 19 consecutive 10-day bins, beginning with June 1. Figure 2 is a set of bar plots indicating date of first landfall. The hurricane season begins in June and peaks in September. Fewer storms are noted by mid-October with the season ending during November. The seasonal onset appears more gradual than its termination producing skewness in the distribution of landfall counts. The sample coefficient of skewness (γ) calculated using the method of Fisher is:

$$\gamma = \left[\frac{\sqrt{n(n-1)}}{n-2} \right] \frac{\frac{1}{n}\sum\left(x-\bar{x}\right)^3}{\left[\frac{1}{n}\sum\left(x-\bar{x}\right)^2\right]^{1.5}} \tag{1}$$

where *n* is the total number of storms.

The greatest skewness is noted in the earliest interval with a value of -0.767. For the other periods, values are -0.798 (1851-1900), -0.220 (1901-1950), and -0.432 (1951-2000). The negative values indicate there are more storms after the mean date than before, and this is true regardless of the period. The hurricane season mean date is September 4th (1801-1850), September 6th (1851-1900), September 2nd (1901-1950), and September 1st (1951-2000). The hurricane season median date is September 9th (1801-1850), September 10th (1851-1900), September 4th (1901-1950), and September 7th

(1951-2000). The means and medians cluster in time during the first 10 days of September. The distributions appear to be robust over the entire period of record, with the greatest threat of a U.S. hurricane landfall occurring during the days between September 9th and September 18th.

Figure 3 shows the cumulative probability functions. The probability functions appear similar across periods. To compare the distributions statistically, we use the Kolmogorov-Smirnov Goodness-of-Fit Test (K-S GOF test). The formal notation for the K-S GOF test is:

$$D = \text{maximum } |\text{CRF}_o(X) - \text{CRF}_e(X)| \qquad (2)$$

where D is the maximum absolute difference between cumulative values, $\text{CRF}_o(X)$ is the observed cumulative relative frequency for variable X, and $\text{CRF}_e(X)$ is the expected cumulative relative frequency for variable X. This statistic is used as an alternative to the chi-square GOF test for testing the similarity between two frequency distributions. Although the K-S GOF test requires continuous data, only very small errors are created when using discrete data (McGrew, Jr. and Monroe, 2000). In this case, we utilized a two sample K-S GOF test to compare the 1801-1850 seasonal distribution with the 1851-1900 seasonal distribution under the null hypothesis of no significant difference between them; the result (p-value = 0.807) demonstrates that the two distributions are similar (there is not enough evidence to reject the null hypothesis). Similar procedures were performed for the 1801-1850 and 1901-1950 (p-value = 0.774) and the 1801-1850 and 1951-2000 (p-value = 0.850) distributions. The results show that the shape of the distribution of the seasonal hurricane landfall activity in the 1801-1850 period does not differ significantly from the three other seasonal distributions from 1851-2000. This provides some check on the historical documents of Ludlum and others. For instance, the seasonal distributions suggest that it is unlikely that the documents contain information about extratropical systems. If such systems were included, one would expect the shape of the distribution during the early half of the 19^{th} century to be somewhat different from the other periods. Extratropical systems, such as Nor'easters and winter storms, are more likely to occur in the winter and spring seasons.

The monthly distribution of U.S. hurricane landfalls was also examined. Figure 4 depicts the monthly landfall distribution for each of the four 50-year periods. While the number of U.S. hurricanes is different for each period (as discussed earlier in this section), the shape of the monthly distribution has remained relatively constant. For instance, in all periods the season builds slowly until August, when landfall activity begins to pick up. September represents the peak of hurricane activity for all of the 50-year periods, with activity moderating by October, and ceasing rapidly in November.

Annual Activity

Figure 5 notes the annual occurrence of landfalls for each of the four 50-year non-overlapping periods. The figure describes the number of years experiencing 0,1,2,3, or ≥4 hurricane landfalls. Changes in the frequency distribution are evident between periods. Especially noteworthy is the positively skewed nature of the occurrence distribution in the first period. Also of note is that the number of years experiencing extreme U.S. hurricane activity (4 landfalls or more) has been decreasing over the last 150 years.

Table 4 notes the summary statistics for all U.S. hurricanes for the four 50-year periods from 1801-2000. The most active period in terms of total U.S. hurricanes was 1901-1950, when there were 92 storms recorded. The least number of reported hurricanes was 54 in the 1801-1850 period. Table 4 also lists the number of major hurricane landfalls by period, with 1901-2000 (1801-1850) being the most (least) active in terms of major U.S. hurricanes with 37 (24) reported landfalls. In addition, the ratio of major U.S. hurricanes to total U.S. hurricanes is noted. Figure 6 depicts the numbers of total and major U.S. hurricanes by period. As is evident in the figure, the 1801-1850 period possesses the least number of reported hurricanes likely due to an incomplete count. The Gulf states and Florida had very little population at this time and some storms may have gone undetected. In fact, the metadata for the NOAA reanalysis project responsible for extending the official U.S. hurricane record back to 1851 (Landsea et al., 2003) notes this likelihood in its project documentation. The authors note that the following regions were likely too under-populated for accurate storm counts before the indicated year: Texas - south: 1880; Texas - central: < 1851; Texas - north: 1860; Louisiana: 1880; Mississippi: < 1851; Alabama: 1830; Florida - northwest: 1880; Florida - southwest: 1900; Florida - southeast: 1900; Florida - northeast: 1880. Their definition of “settled region” for these estimates is two inhabitants per square mile, and the population statistics are based on U.S. Census data and other historical analysis. Therefore, the accuracy of the early 19th century hurricane data (1801-1850) is likely directly tied to the number of inhabitants along the U.S. coastline throughout that period. In support of this, it would follow that if the population was limited along the coastline, then perhaps stronger storms would have been noted, and weaker storms may have been less so. However, even the stronger storms are not likely to have been sampled at their maximum intensity. Therefore, in addition to the bias in the number of storms present in the collated hurricane list, a bias in the storm intensity could also be present. Figure 6 also notes the ratio of major hurricanes recorded in each period to the total number of hurricanes for each period. The highest ratio of major hurricane to total hurricane landfalls in each period occurs in the 1801-1850 period. This finding supports the speculation that perhaps only the strongest storms were noted in portions of the 1801-1850 period, while weaker storms may have gone unrecorded. However, there is natural variability evident in the data, as the second largest ratio occurs in the most recent 50-year period.

Regional Activity

The U.S. coastline was divided into three landfall zones in order to better understand regional aspects of U.S. hurricanes (we utilize landfalls in this section, not individual storms, due to the coastal divisions). The Gulf coast region comprises the U.S. Gulf coast from Texas to Alabama. Florida is considered a separate region, and the U.S. coastline from Georgia through Maine is called the East coast region. Table 5 presents the summary statistics for each of these three regions from 1801-2000. The Gulf coast and Florida receive the bulk of U.S. hurricane landfalls, but in both 1801-1850 and 1951-2000, the East coast region records more landfalls than Florida. The statistics in Table 5 demonstrate that the annual average for hurricane landfalls in Florida during the most recent temporal period (1951-2000) is much closer to that in the earliest period (1801-1850) than in the preceding 100 years (1851-1950). From 1851 to 1950, one could expect Florida to have a hurricane landfall approximately three out of every four years. The annual average hurricane landfall in Florida during 1801-1850 and 1951-2000 was closer to one landfall every two and a half years (a 43% reduction in annual average landfall probability). Large swings in natural variability are evident in the East coast annual landfall averages; the Gulf coast region appears to have an unusually low annual average during the 1801-1850 period.

The ratio of landfalls in each region to the total number of landfalls for each period is also noted. Figure 7 details the ratios for each of the three coastal regions for the four 50-year periods. During the first and third periods, the Gulf coast and the East coast appear to have an inverse landfall relationship, whereas in the second and last periods, the ratios are similar. This pattern has been noted in association with the phase of the North Atlantic Oscillation (Elsner et al., 2000; Elsner et al., 2001). Florida also demonstrates an inverse relationship with the East coast across all time periods: when there is a high ratio of landfalls in Florida, there is a lower ratio of landfalls in the East coast region, and vice versa.

Summary

Here we have discussed the extension of the U.S. hurricane record prior to the beginning of the official record, which begins in 1851. We generate a dataset of U.S. hurricanes from 1800-1850 for use in statistical analysis and hurricane climate research. The sources and techniques used to generate the list of tropical cyclones affecting the U.S. from 1800 to 1850 are detailed in the text and in Figure 1. Descriptive statistics of U.S. hurricane activity from the first half of the 19th century are compared with statistics of U.S. hurricanes from the late 19th through the 20th century in order to analyze the accuracy of earlier records and view any apparent trends. Seasonal distributions appear robust throughout the last 200-years, with the greatest risk of a U.S. hurricane occurring from September 9th through September 18th of any given year. Monthly activity is quite robust as well; August, September, and October are by far the most active months for U.S. hurricanes over the last 200 years. Annual activity exhibits an apparent reduction in recorded U.S. hurricanes in the 1801-1850 period, likely due to low coastal population values during this time. The number of years experiencing extreme U.S. hurricane activity (4 or more landfalls) in any 50-year period has been decreasing since 1851. The highest ratio of major U.S. hurricanes to all U.S. hurricanes is highest in the 1801-1850 period. Regionally, landfall counts exhibit an inverse relationship between years with high numbers of Gulf coast and East coast landfalls. This phenomenon has been noted in more recent U.S. hurricane data and has been related to the North Atlantic Oscillation. Our results show that this inverse relationship has been occurring for the last two centuries. In addition, Florida seems to fluctuate between periods of high and low hurricane activity.

Climatic influences on U.S. hurricanes, such as the NAO, ENSO, and the PDO, can be investigated for their impact on U.S. hurricane frequency and location, over longer time periods than have been previously studied. In particular, the link between any speculated increase in the magnitude and/or frequency of El Niño events and their relationship with extremely active U.S. hurricane years is worthy of further exploration, as well as the apparent regional landfall cycles.

Acknowledgements. The research is supported by NSF BCS-0213980. The views expressed in this paper are those of the authors and do not necessarily reflect the official policy of the NSF.

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TABLE CAPTIONS

TABLE 1. Source and source code used in **Table 2**.

TABLE 2. List of Tropical Cyclones in the HHIT. Major refers to category 3 or higher on the Saffir-Simpon scale. Estimated landfall location and Saffir-Simpson category at landfall are included. See **Table 1** for a list of sources.

TABLE 3. Summary statistics of seasonal U.S. hurricane activity. Note that the "Best Track" data extends back to 1851.

TABLE 4: Summary Statistics for U.S. total and major hurricanes, by period.

TABLE 5: Summary statistics and averages for U.S. hurricanes, by region.

FIGURE CAPTIONS

FIGURE 1. Flow chart demonstrating the process of categorizing historical tropical cyclone information in the HHIT. The classified list of tropical cyclones in the HHIT is detailed in **Table 2**.

FIGURE 2. Seasonal distribution of U.S. hurricanes in four 50-year intervals from 1801 to 2000. U.S. hurricane counts are collated into nineteen 10-day bins over the hurricane season (June 1 through November 30).

FIGURE 3. Cumulative Probability Functions for the seasonal activity presented in **Figure 2**. A K-S GOF test performed on the seasonal distributions indicates no significant difference between periods. June 1st represents day 1 of hurricane season, while November 30th represents day 180.

FIGURE 4. Monthly distribution of U.S. hurricane activity for four intervals from 1801 to 2000. The shape of the monthly distribution is relatively robust to temporal changes.

FIGURE 5. Frequency of U.S. hurricanes, by annual count, for four 50-year periods from 1801 to 2000.

FIGURE 6. Total and major U.S. hurricanes from 1801 to 2000. The ratio of major hurricanes to total hurricanes is also noted. The 1801-1850 interval exhibits the highest ratio of major hurricanes to total hurricanes recorded.

FIGURE 7. Ratio of major hurricanes to total U.S. hurricanes, by region, 1801-2000.

TABLE 1.

Source	Source Code
Ludlum	L
Roth (Roth and Cobb)	R
Ho	H
Barnes	B
Dunn and Miller	D+M
Cotterly	C
Prokop	P
46th Weather Squadron	WX
Sandrik	S

TABLE 2.

Year	Date	Storm	Major	Region	Landfall Location (est.)	Source
1800	August ??	Storm 1	No	G	New Orleans, LA (1)	R
1800	Oct. 4	Storm 2	Maybe	E	Charleston, SC (2-3)	L
1803	Unknown	Storm 1	No	E	New Bern, NC (1)	B
1803	Aug. 29	Storm 2	No		Offshore – NC (1)	R
1804	Sept. 6	Storm 1	Yes	E	GA/SC (3)	L,R,D+M,S
1804	Oct. 9	Storm 2	Maybe	E	NJ (2-3)	L, R, D+M
1806	Aug. 22	Storm 1	Yes	E	NC (2-3)	L, R
1806	Sept. 16	Storm 2	No	F	FL (1)	S
1806	Sept. 28	Storm 3	No	E	NC/VA (1)	R
1808	Sept. 12	Storm 1			Unknown - VA/MD (TS)	R
1810	Sept. 12	Storm 1		E	SC (TS)	L
1811	Sept. 10	Storm 1	No	E	SC (1)	L, D+M
1811	Oct. 5	Storm 2	Maybe	F	FL (2-3)	S
1812	Aug. 19	Storm 1	Yes	G	LA (3)	L, R
1812	Oct. 1/5	Storm 2	No	F	FL (1-2)	S, D+M
1813	Aug. 28	Storm 1	Yes	E	SC (3)	L, R, D+M, S
1813	Sept. 16	Storm 2	Yes	F	FL (3)	S
1814	Jul. 1	Storm 1	No	E	SC (1)	D+M
1815	Sept. 3	Storm 1	Yes	E	NC (3-4)	L, B
1815	Sept. 23	Storm 2	Yes	E	NY/CT (3-4)	L, H, D+M, C
1815	Sept. 28	Storm 3			Offshore - SC (TS)	D+M
1815	Oct. 24	Storm 4	No		Offshore – VA (1)	R
1816	Sept. 18	Storm 1		E	VA (TS)	R
1817	Aug. 7	Storm 1	No	F; E	1-FL/GA (1) 2-SC/NC (TS)	S
1818	Sept. 12	Storm 1	Maybe	G	TX (2-3)	L, R
1819	Sept. ??	Storm 2		G	Gulfcoast (TS)	B
1820	Sept. 13	Storm 1	No	E	SC/NC (1-2)	L
1821	Sept. 3	Storm 1	Yes	E; E	1-NC/VA (4-5) 2-NJ/NY (TS)	L,B,H,D+M,R
1821	Sept. 15	Storm 2	Yes	G	MS (3)	L,B,R,WX
1822	Jul. 8	Storm 1		G	MS (TS)	L
1822	August ??	Storm 2	No		Offshore – NC (1)	D+M
1822	Sept. 27	Storm 3	Maybe	E	SC (2-3)	L, D+M, R
1824	Sept. 14	Storm 1	Yes	E	GA (3-4)	L,B,D+M,PR,S
1825	Jun. 2	Storm 1	No	F	FL (1-2)	S
1825	Oct. 2	Storm 2	No	F	FL (1)	S
1827	Jul. 30	Storm 1	No		Offshore – NC (1)	D+M
1827	Aug. 25	Storm 2	Yes	E; E	1-NC (3-4) 2-MA (TS)	L,B,D+M,R
1829	Aug. 26	Storm 1		E	VA (TS)	R
1829	Sept. 10	Storm 2	No	G	TX (1-2)	R
1830	Aug. 15	Storm 1	Maybe	E	NC (2-3)	L,B,D+M,S,R
1830	Aug. 24	Storm 2	No		Offshore – NE (1)	L, B
1830	Oct. 6	Storm 3	No		Offshore - Mid. Atl. (1)	L
1831	Jun. 10	Storm 1		F	FL (TS)	D+M,S

1831	Aug. 17	Storm 2	Yes	G	LA (3-4)	L,B,R
1831	Aug. 28	Storm 3		G	LA (TS)	L, R
1834	Sept. 4	Storm 1	No	E	NC (1)	L, R
1835	Aug. 18	Storm 1	Yes	G	TX (3)	L, R
1835	Sept. 15	Storm 2	Yes	F	FL (3)	L,B,S
1837	Aug. 1	Storm 1	No	F	FL (1)	L,D+M,S
1837	Aug. 7	Storm 2	No	F	FL (2)	L,B, WX
1837	Aug. 6	Storm 3	Maybe	F	FL/GA (2-3)	L, D+M, S
1837	Aug. 18	Storm 4	No		Offshore - SE coast (1)	L,B,R,S
1837	Mid-Aug.	Storm 5	No	F	FL (1)	B
1837	Aug. 30	Storm 6	Yes	F	FL (3)	L,B,D+M,S
1837	Sept. 13	Storm 7		F	FL (TS)	L
1837	Sept. 26	Storm 8		F	FL (TS)	L,S
1837	Oct. 1	Storm 9	Yes	G	1-TX*(Strafe) 2-LA (4-5)	L,R,B,D+M,WX
1837	Oct. 29	Storm 10			Offshore - NC (TS)	L,B
1839	Aug. 28	Storm 1	No		Offshore (2)	L,R
1839	Sept. 15	Storm 2		G	LA (TS)	R
1839	Nov. 5	Storm 3	No	G	TX (1)	R
1840	Jun. 19	Storm 1		G	TX/LA (TS)	R
1841	Sept. 14	Storm 1		F	FL (TS)	L,B
1841	Oct. 3	Storm 2	Maybe		Offshore (2-3)	L, D+M, R
1841	Oct. 18	Storm 3	No		Offshore – FL (1)	L,B
1842	Jul. 13	Storm 1	Yes	E	NC/VA (3-4)	L,B,D+M
1842	Aug. 2	Storm 2			Offshore (TS)	S
1842	Aug. 24	Storm 3	No	E	NC (1)	D+M,B
1842	Sept. 8	Storm 4	No	G	TX (1-2)	L, B
1842	Sept. 17	Storm 5		G	TX (TS)	L,R
1842	Sept. 22	Storm 6		F	FL (TS)	L,B
1842	Oct. 4	Storm 7	Yes	F	FL (3)	L,H,B,S,R,D+M
1842	Oct. 26	Storm 8			Offshore- FL (TS)	L,S
1843	Sept. 13	Storm 1	Yes	F	FL (3-4)	L,B,D+M,WX
1844	Jun. 12	Storm 1		G	LA (TS)	R
1844	Aug. 4	Storm 2	Yes	G	TX (3)	L,R
1844	Sept. 8	Storm 3	No	F	FL (1)	L,H,B,S
1844	Oct. 3	Storm 4	No		Offshore (2)	L,B, D+M
1846	Sept. 8	Storm 1	Yes		Offshore - NC (3-4)	L,B
1846	Oct. 11	Storm 2	Yes	F	FL (4-5)	L,H,B,S,D+M
1848	Aug. 18	Storm 1		G	LA (TS)	L
1848	Sept. 25	Storm 2	Yes	F	FL (4-5)	L,H,B,D+M,S
1848	Oct. 11	Storm 3	Yes	F	FL (3)	L,B,D+M,S
1848	Oct. 17	Storm 4	No	G	TX (1-2)	R
1849	Sept. 13	Storm 1	No	G	TX (1)	L
1849	Oct. 6	Storm 2	No	E	MA (1)	L
1850	Jul. 18	Storm 1	No	E	NC (1-2)	L, R
1850	Aug. 23/25	Storm 2	Maybe	F	1-FL (2-3) 2-NY/CT (1)	L,B,D+M,R
1850	Sept. 8	Storm 3	No		Offshore (1)	L

TABLE 3.

Period	No. Hurricanes	Mean Date	Median Date	Skewness	Mode Interval
1801-1850	52	Sept. 4	Sept. 9	-0.767	Sept. 9-18
1851-1900	88	Sept. 6	Sept. 10	-0.798	Sept. 9-18
1901-1950	92	Sept. 2	Sept. 4	-0.221	Sept. 9-18
1951-2000	72	Sept. 1	Sept. 7	-0.432	Sept. 9-18

TABLE 4.

Period	U.S. Hurricanes	Annual Average U.S. Hurricanes	Major U.S. Hurricanes	Annual Average Major Hurricanes
1801-1850	54	1.08	24	0.48
1851-1900	88	1.76	27	0.54
1901-1950	92	1.84	37	0.74
1951-2000	72	1.44	31	0.62

TABLE 5.

Period	Gulf Total	Florida Total	East Total	Gulf Average	Florida Average	East Average
1801-1850	13	19	23	0.26	0.38	0.46
1851-1900	32	35	29	0.64	0.70	0.58
1901-1950	39	36	19	0.78	0.72	0.38
1951-2000	30	21	28	0.60	0.42	0.56

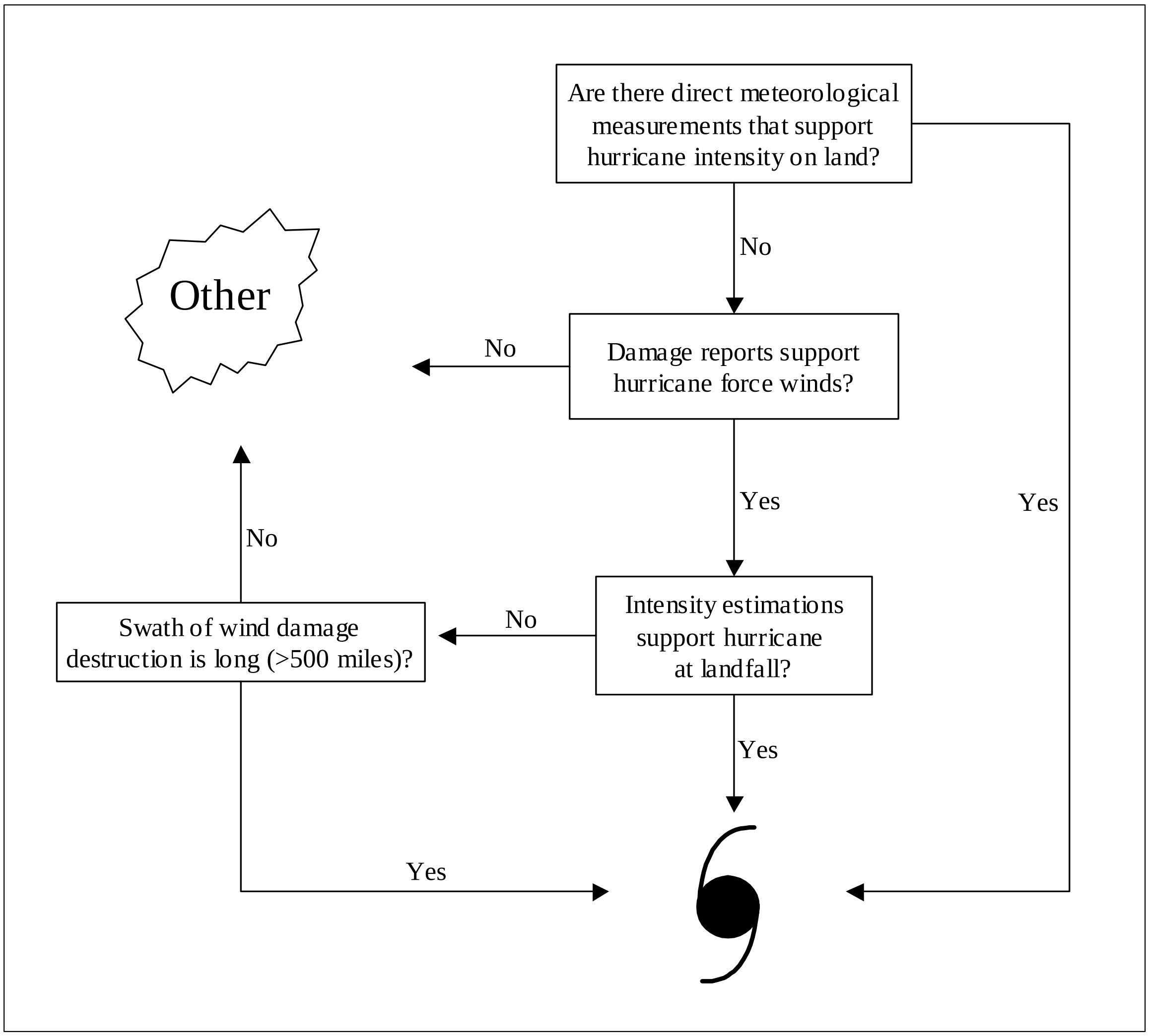

Are there direct meteorological measurements that support hurricane intensity on land?
No
Yes
Other
No
Damage reports support hurricane force winds?
Yes
No
Swath of wind damage destruction is long (>500 miles)?
No
Intensity estimations support hurricane at landfall?
Yes
Yes

FIGURE 1.

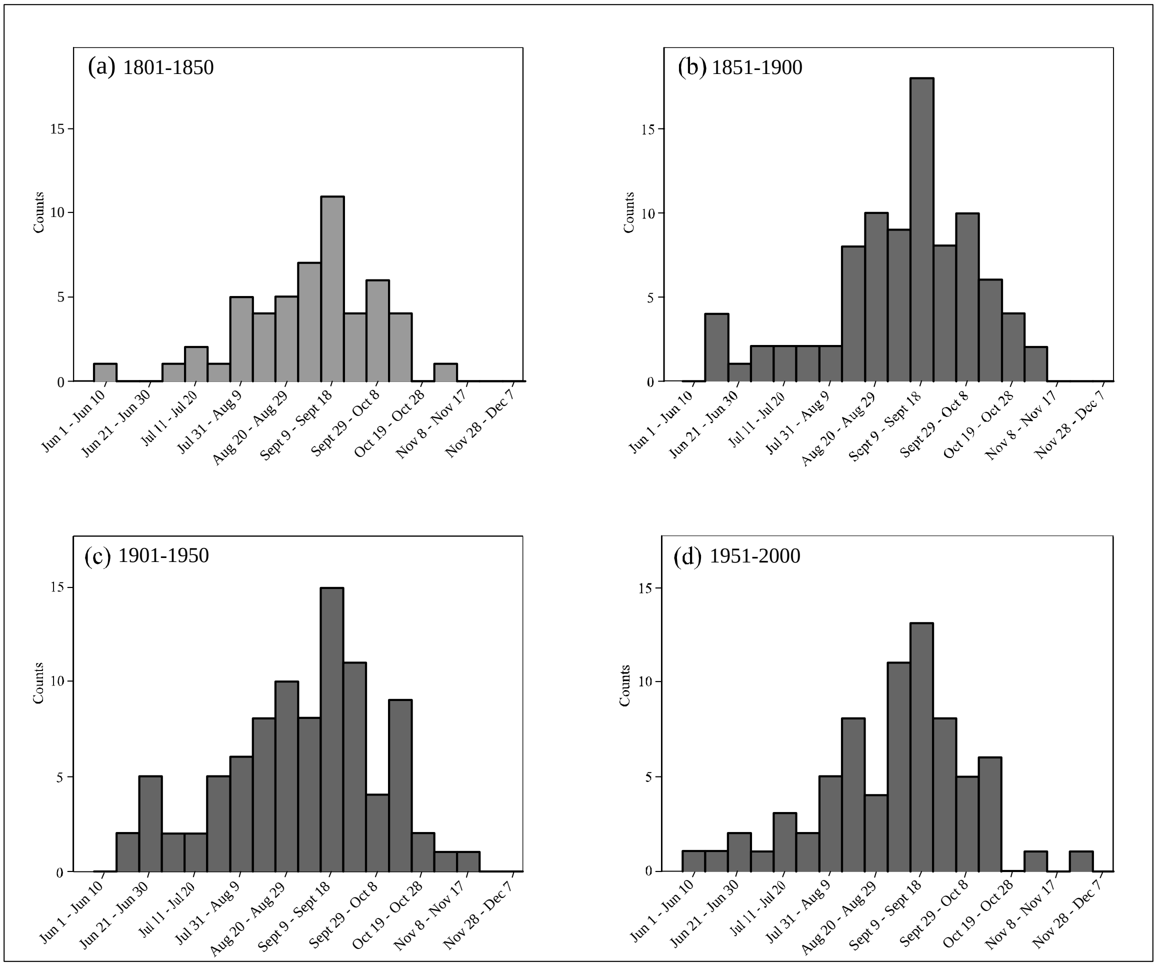

(a) 1801-1850
(b) 1851-1900
(c) 1901-1950
(d) 1951-2000
Counts
0
5
10
15
Jun 1 - Jun 10
Jun 21 - Jun 30
Jul 11 - Jul 20
Jul 31 - Aug 9
Aug 20 - Aug 29
Sept 9 - Sept 18
Sept 29 - Oct 8
Oct 19 - Oct 28
Nov 8 - Nov 17
Nov 28 - Dec 7

FIGURE 2.

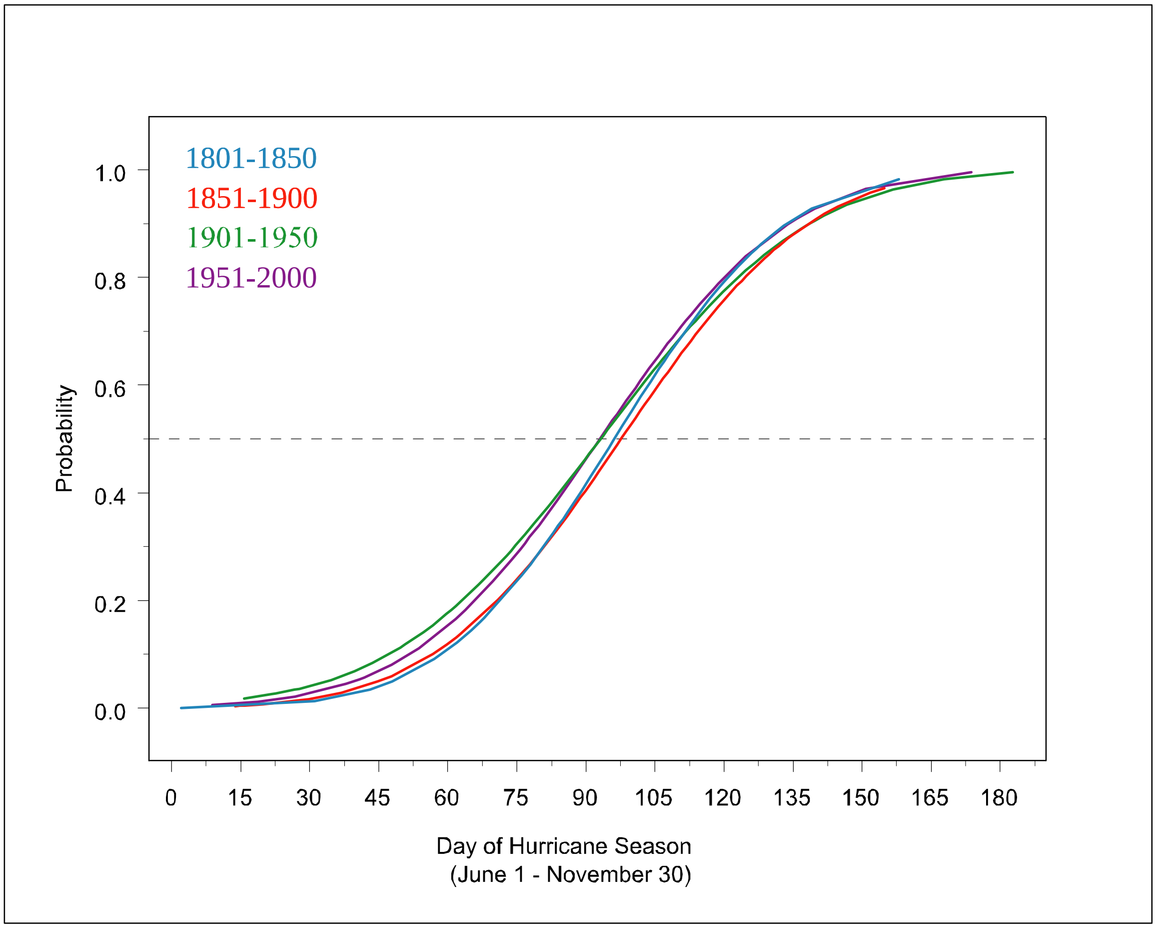

1801-1850
1851-1900
1901-1950
1951-2000
Probability
1.0
0.8
0.6
0.4
0.2
0.0
0
15
30
45
60
75
90
105
120
135
150
165
180
Day of Hurricane Season
(June 1 - November 30)

FIGURE 3.

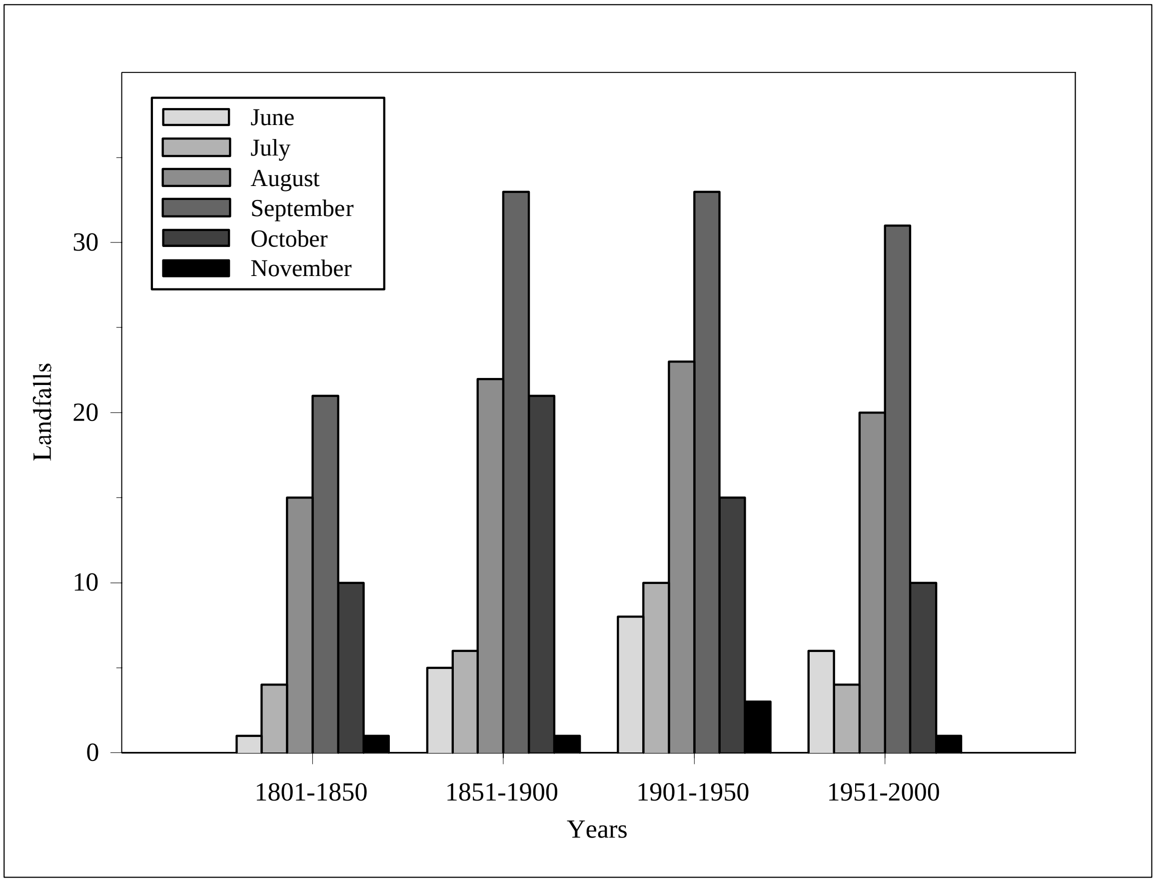

June
July
August
September
October
November
Landfalls
0
10
20
30
1801-1850
1851-1900
1901-1950
1951-2000
Years

FIGURE 4.

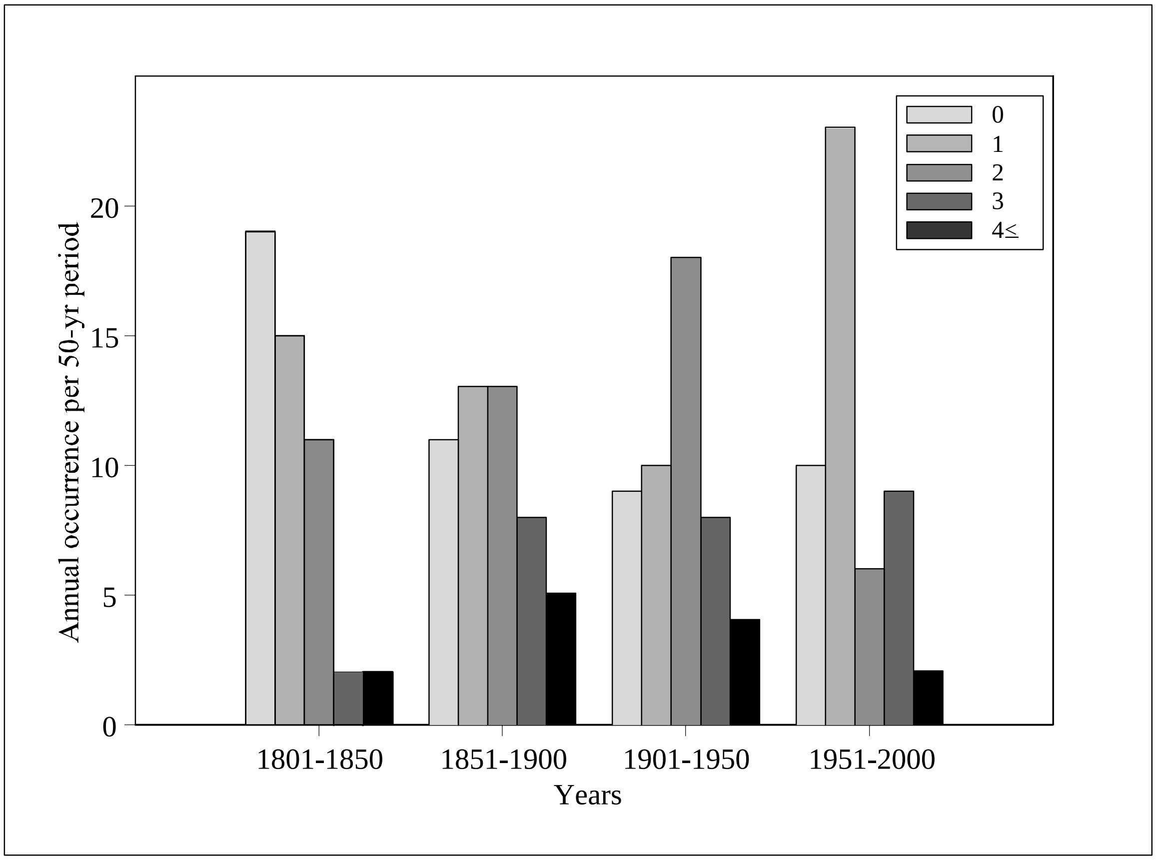

0
1
2
3
4≤
Annual occurrence per 50-yr period
0
5
10
15
20
1801-1850
1851-1900
1901-1950
1951-2000
Years

FIGURE 5.

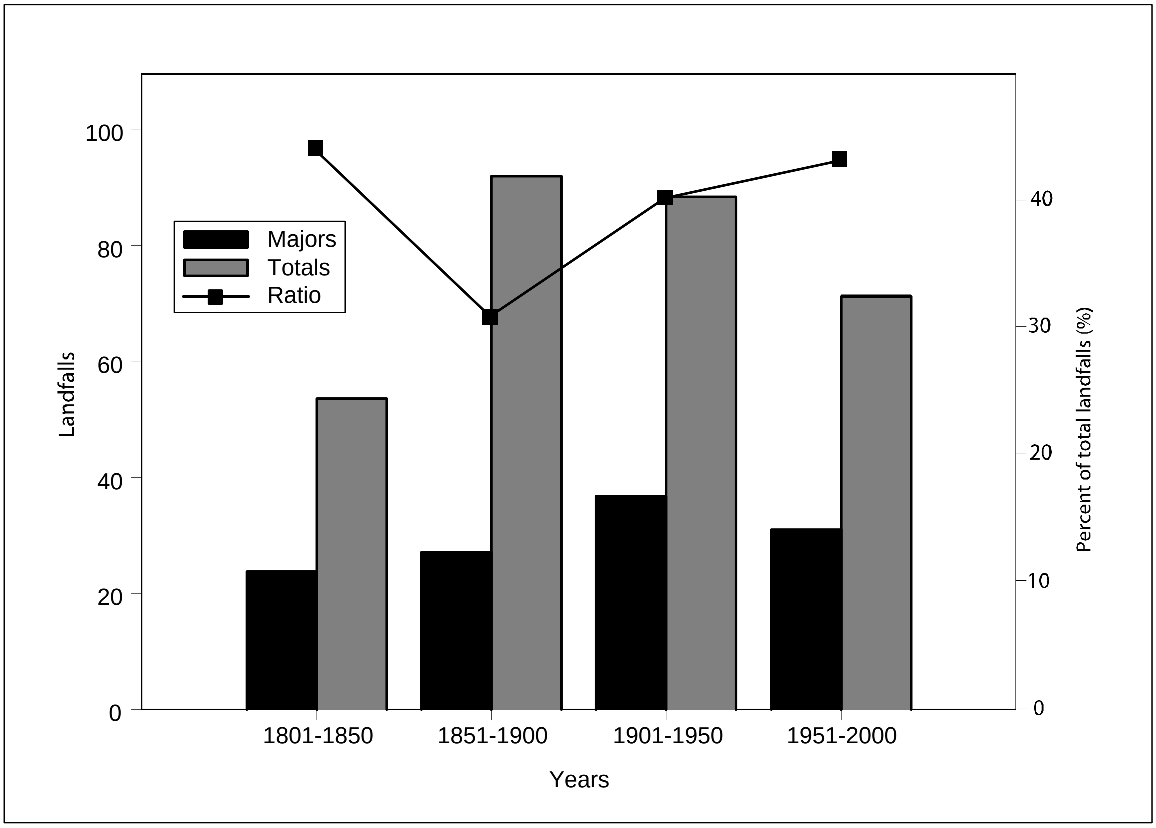
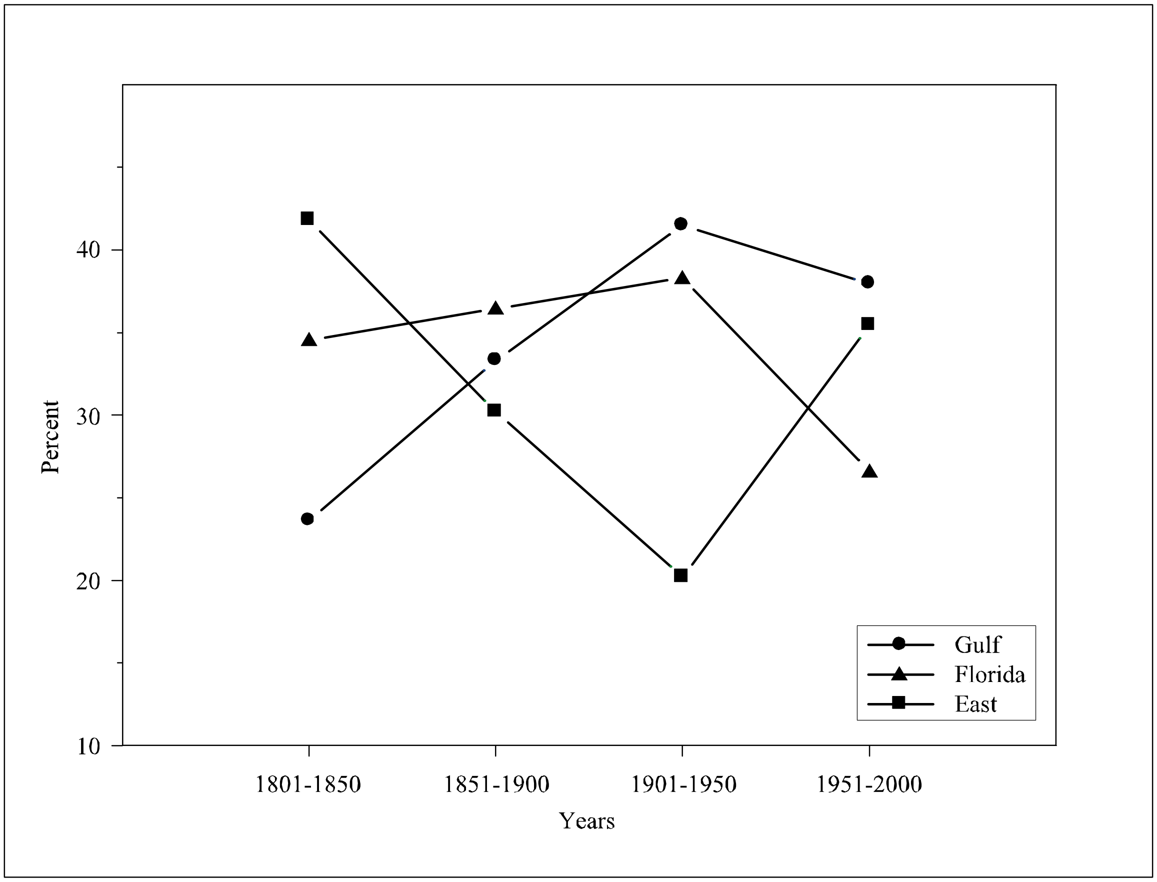

100
80
60
40
20
0
Landfalls
Majors
Totals
Ratio
40
30
20
10
0
Percent of total landfalls (%)
1801-1850
1851-1900
1901-1950
1951-2000
Years

FIGURE 6.



Percent
40
30
20
10
1801-1850
1851-1900
1901-1950
1951-2000
Years
Gulf
Florida
East

FIGURE 7.