

A Severe Weather Climatology for the WFO Miami, Florida County Warning Area

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1. Introduction

The core mission of the National Weather Service (NWS) is *the protection of life and property*. When the weather turns "severe", life and property become more at risk. This paper serves to provide a climatological perspective of "severe" weather across the Miami Weather Forecast Office's (WFO) County Warning Area (CWA). The author believes that a firm knowledge of the severe weather climatology of the local area is essential in fulfilling the NWS's core mission. Through an understanding of *where* and *when* severe weather is most common across South Florida, as well as the most common mode of severe weather, a historical foundation will be set to aid the warning forecaster towards success in fulfilling the NWS's core mission.

A "severe thunderstorm", by National Weather Service definition, produces at least one of the following:

1. *Tornado.*
2. *Winds greater than or equal to 50 knots (58 mph).*
3. *Hail 3/4 of an inch in diameter or larger (As of 2010, criteria changed to 1 inch in diameter or larger).*

Each of these severe weather modes will be looked at closely in this paper, both from an overall South Florida perspective, as well as on a county-by-county basis within WFO Miami's CWA.

This article is an update of Dan Gregoria's original analysis and now includes data through 2012.

2. WFO Miami's County Warning Area (CWA)

WFO Miami's CWA is comprised of mainland South Florida, Lake Okeechobee, and a portion of the Gulf of Mexico (to the west) and Atlantic Ocean (to the east). Miami's CWA contains 6 South Florida counties and part of a seventh [[Figure 1](#)]. They include: Miami-Dade, Broward, Palm Beach, Collier, Glades, Hendry, and the mainland portion of Monroe County. (Monroe County is made up of the Florida Keys and the far Southwest tip of the Florida Peninsula). U.S. Census Bureau data as of April 1, 2010

(Source: U.S. Census Bureau publication number (CO-EST2011-01-12)) shows that the total population of the Miami CWA is approximately 5.9 million. "Snowbirds", or people who travel from northern climates to southern climates during the winter months, likely bring the population figure even higher during the wintertime, though exact numbers are unknown. [Figure 2](#) shows the population distribution and [Figure 3](#) shows the land area distribution of each county within Miami's CWA (except the mainland portion of Monroe County, since almost the entire population of Monroe County is contained in the Florida Keys). The 3 most populated counties within Miami's CWA lie along the Atlantic coast. Miami-Dade is the most populated county, comprising 42% of the total CWA population. Broward County follows in second (29%) followed by Palm Beach County (22%). Ninety-three percent of the population lives in the 3 Atlantic coastal counties! The largest cities on the Atlantic coast are Miami (in Miami-Dade County), Fort Lauderdale (in Broward County), and West Palm Beach (in Palm Beach County). Along the Gulf coast, the largest city is Naples (in Collier County). Though interior areas of South Florida are sparsely populated, there are a few towns which lie near the Lake Okeechobee region. They are: Immokalee (in Collier County), Moore Haven (in Glades County), La Belle and Clewiston (in Hendry County), and Belle Glade and Pahokee (in Palm Beach County).

An aerial view of South Florida [[Figure 4](#)] shows the South Florida landscape. Two national parks (Everglades and Biscayne) and a national preserve (Big Cypress) comprise about 2.4 million acres of the interior of South Florida. Three Seminole Indian Reservations (Miccosukee, Big Cypress and Brighton) make up another 384,000 acres of interior South Florida. This map shows the dense population along the Atlantic Coast with another maximum in population along the Gulf Coast and very little population in between.

[Figure 5](#) shows the decadal population trends for the Miami CWA. The CWA population between 1950 and 1980 almost quadrupled, increasing 370%, reaching over 3 million by 1980. Between 1980 and 2010 the CWA population increased 78%. As of April 1, 2010, the population of the Miami CWA (excluding mainland Monroe County) was 5,938,179, of which 5,564,635 live in the 3 metropolitan Atlantic coastal counties and 373,544 live elsewhere.

3. Data

Data used for this analysis was obtained from the Storm Prediction Center's (SPC) database of severe weather (www.spc.noaa.gov) and the monthly Storm Data published by NOAA's National Climatic Data Center. The SPC database includes tornado data from 1950 through 2002 and hail and wind data from 1955 through 2002. Data from 2003 to 2012 was retrieved from Storm Data (www.ncdc.noaa.gov).

The quantity of storm data for the Miami CWA is rather limited due to the aforementioned population density of the Miami CWA. Since a wide expanse of the CWA is sparsely populated, many severe weather events go by unnoticed. This can result in misleading statistics, as the more populated areas will "appear" to have more

severe weather, when this is actually not the case. Limitations of the data must be remembered when analyzing the following statistics.

4. Climatology

a. Tornadoes

Tornadoes across South Florida are typically “weaker” than those of the plains states, though strong tornadoes have occurred. One such tornado occurred in Miami on April 5, 1925, killing 5 people and injuring 35. The estimated property loss was between \$200,000 and \$300,000 (Gray, 1925). The strength of the 1925 Miami tornado is unknown, since tornado ratings did not begin until 1971. However, damage pictures from the 1925 tornado suggest that this tornado could have been an F3. It was Dr. Theodore Fujita who developed a tornado rating scale in 1971, called the Fujita Scale, or F-Scale [Figure 6]. Tornado intensities are assigned rankings based on damage assessments by National Weather Service personnel. On February 1, 2007, the Enhanced Fujita Scale replaced the original F-scale and the ratings using this new scale are incorporated into the historical analysis, keeping the original F-scale ratings for tornadoes before 2007. The EF/F-Scale distribution of tornadoes across the Miami CWA is provided in Figure 7. Since 1950, ninety three percent of observed and rated tornadoes, or 439, were rated EF/F0 or EF/F1. Seven percent, or 31, were rated EF/F2 or EF/F3. Thirty tornadoes were not rated. There have been no observed tornadoes rated either EF/F4 or EF/F5 across the Miami CWA since 1950.

1) Annual Tornado Distribution

Since 1950, a total of 500 tornadoes have been observed across Miami's CWA. Figure 8 shows the annual tornado count across the Miami CWA from 1950 to 2012. The decadal trends show a dramatic increase in observed tornadoes since 1980. In the period 1950-1979, the average number of tornadoes observed each year was only 5. However, in the period 1980-2012, the average number of observed tornadoes annually jumped to 11. This dramatic increase in the number of observed tornadoes is due to not only the aforementioned increasing population, but also a result of the implementation of the National Weather Service's storm verification program, which began in 1980. So whether or not there may be an actual increasing trend in the number of tornado occurrences across South Florida cannot be determined.

Since 1950, the average number of observed tornadoes annually has been eight. The most observed tornadoes in any given year since 1950 was 31, occurring in 1998.

2) Monthly Tornado Distribution

Figure 9 shows the monthly distribution of tornadoes across the Miami CWA. The peak month of tornado occurrence is June. There is a gradual increasing trend during the first half of the year and a gradual decreasing trend during the second half of the year. The month of minimum tornado activity is December, with only 9 tornadoes observed since

1950. The greatest number of EF2/EF3 tornadoes (7) occurred in March, followed by June (4) and October (4).

Tropical cyclone-related tornadoes account for 14 percent of tornadoes from June through November, with a total of 39 since 1950. In fact, more than half of the total number of tornadoes in October (14 of 25) were spawned from tropical cyclones. Other months containing tropical cyclone-related tornadoes are June (6), August (5), September (6), and November (8).

In comparing the monthly distribution of tornadoes for each county, [Figure 10](#) shows that tornado occurrence peaks in June for all but Palm Beach County (peaks in August) and Hendry County (peaks in September).

3) Hourly Tornado Distribution

[Figure 11](#) shows the hourly distribution of tornadoes across the Miami CWA. Clearly, the times of greatest tornado activity are during the time of maximum heating, from noon through 5 PM LST, but especially from 2 PM to 5 PM LST. The maximum time of tornado occurrence is at 2 PM LST. The minimum time of tornado occurrence is at 12 AM LST.

4) County-by-County Tornado Distribution

The greatest number of tornadoes across the Miami CWA has occurred in Palm Beach County, accounting for 30 percent of the observed tornadoes. [Figure 12](#) shows a county comparison of observed tornadoes across the Miami CWA from 1950-2012. Detailed tornado distributions for each individual county are provided below.

- [Figure 13](#) Miami-Dade County Tornado Distribution 1950-2012.
- [Figure 14](#) Broward County Tornado Distribution 1950-2012.
- [Figure 15](#) Palm Beach County Tornado Distribution 1950-2012.
- [Figure 16](#) Collier County Tornado Distribution 1950-2012.
- [Figure 17](#) Glades County Tornado Distribution 1950-2012.
- [Figure 18](#) Hendry County Tornado Distribution 1950-2012.
- [Figure 19](#) Mainland Monroe County Tornado Distribution 1950-2012.

b. Severe Wind

1) Annual Severe Wind Distribution

Since 1955, a total of 903 severe wind reports were received across the Miami CWA. [Figure 20](#) shows the annual distribution of severe wind reports across the Miami CWA from 1955 to 2012. Again, a substantial increase in severe wind reports can be seen over the years, likely due to population increases. Since 1955, the average number of severe wind occurrences annually has been 16. The year of greatest severe wind occurrences was 2009, when 73 reports were received.

2) Monthly Severe Wind Distribution

[Figure 21](#) shows the monthly distribution of severe wind reports across the Miami CWA. Severe wind occurrences are most common during the months of May, June, July, and August, coinciding with most of the South Florida wet season. The peak in severe wind occurrences for the Miami CWA is June, as was the case for tornadoes. Severe wind occurrences drop off significantly in September as the wet season winds down, remaining low until March, at which time occurrences begin to increase in advance of the wet season.

3) Hourly Severe Wind Distribution

[Figure 22](#) shows the hourly distribution of severe wind occurrences across the Miami CWA. The time of greatest severe wind occurrences is from 1 - 4 PM LST, with the peak occurring at 2 PM LST. Clearly, as was the case for tornadoes, severe wind occurrences are most common during the late afternoon hours, centered around the time of maximum heating.

4) County-by-County Severe Wind Distribution

The greatest number of severe wind occurrences across the Miami CWA has occurred in Broward County, accounting for 31 percent of the total reports. Miami-Dade County and Palm Beach County are not far behind, accounting for 30 percent and 22 percent of the total reports, respectively. [Figure 23](#) shows the county comparison of severe wind events. Detailed severe wind distributions for each individual county are provided below.

[Figure 24](#) Miami-Dade Severe Wind Distribution 1955-2012.

[Figure 25](#) Broward Severe Wind Distribution 1955-2012.

[Figure 26](#) Palm Beach Severe Wind Distribution 1955-2012.

[Figure 27](#) Collier Severe Wind Distribution 1955-2012.

[Figure 28](#) Glades Severe Wind Distribution 1955-2012.

[Figure 29](#) Hendry Severe Wind Distribution 1955-2012.

[Figure 30](#) Mainland Monroe Severe Wind Distribution 1955-2012.

c. Severe Hail

The majority of hail sizes reported across the Miami CWA are at the lowest range for what is considered to be “severe”, $\frac{3}{4}$ of an inch. In 2010, the criterion for “severe” hail was changed to one inch in diameter; however, for this paper $\frac{3}{4}$ of an inch is still used in order to keep the data consistent. [Figure 31](#) shows the distribution of hail sizes across the Miami CWA.

1) Annual Severe Hail Distribution

Since 1955, there have been a total of 501 severe hail reports across the Miami CWA. [Figure 32](#) shows the annual distribution of severe hail for the Miami CWA. The data reflects the increase in population and implementation of the NWS Verification Program in 1980. The increase in activity since the 1980s cannot be attributed to any particular weather and/or climate phenomena based to lack of data in the earlier decades.

2) Monthly Severe Hail Distribution

[Figure 33](#) shows the monthly severe hail distribution along with the observed hail sizes for each month. The number of severe hail occurrences peak dramatically in May. Severe hail occurrences decline markedly by late summer.

3) Hourly Severe Hail Distribution

[Figure 34](#) shows the hourly distribution of severe hail occurrences for the Miami CWA. The times of greatest severe hail occurrences are from noon through 6 PM LST, but especially from 2 PM to 4 PM LST. The peak in severe hail occurrences is at 3 PM LST. Since 1955, there have only been 10 severe hail occurrences between the times of midnight and 8 AM LST.

4) County-by-County Severe Hail Distribution

The greatest number of severe hail reports has occurred in Miami-Dade County (33%), followed closely by Broward County (29%), then Palm Beach County (22%). [Figure 35](#) shows the county comparison of the number of severe hail reports. [Figure 36](#) breaks the severe hail reports down by county along with the observed hail sizes for each county. Detailed severe hail distributions for each individual county are provided below.

- [Figure 37](#) Miami-Dade Severe Hail Distribution 1955-2012.
- [Figure 38](#) Broward Severe Hail Distribution 1955-2012.
- [Figure 39](#) Palm Beach County Severe Hail Distribution 1955-2012.
- [Figure 40](#) Collier County Severe Hail Distribution 1955-2012.
- [Figure 41](#) Glades County Severe Hail Distribution 1955-2012.
- [Figure 42](#) Hendry County Severe Hail Distribution 1955-2012.
- [Figure 43](#) Mainland Monroe County Severe Hail Distribution 1955-2012.

5. Summary

Since 1950, there has been a total of 1,904 severe weather occurrences across the Miami CWA (tornadoes = 500 since 1950, severe wind = 903 since 1955, and severe hail = 501 since 1955). On average, “severe” weather impacts the Miami CWA 33 times annually. [Figure 44](#) shows the total distribution of all severe weather reports (tornadoes, wind, and hail) for each county. Approximately 82 percent of all severe weather reports occurred along the Atlantic Coast, which is no surprise given that this is the most densely populated area of the Miami CWA. All 3 elements of “severe” thunderstorms (tornadoes, severe wind, and severe hail) are most common during the late afternoon hours. Tornadoes and severe wind occurrences both peak during the month of June, while severe hail occurrences peak in May [[Figure 45](#)].

In general, the severe weather season across South Florida peaks in the late spring and early summer. It stretches well into the latter part of the summer in part to the influence and/or impact from tropical systems.

6. Acknowledgements

The author would like to thank Rusty Pfof, WFO Miami's Meteorologist-In-Charge, Dr. Pablo Santos, WFO Miami's Science and Operations Officer, and Robert Molleda, WFO Miami's Warning Coordination Meteorologist, for their insight, review and critique of this paper.

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- National Oceanic and Atmospheric Administration/National Weather Service/Storm Prediction Center, 2013: Enhanced F Scale for Tornado Damage. [Available online at <http://www.spc.noaa.gov/faq/tornado/ef-scale.html>]

8. Figures



Figure 1. WFO Miami's County Warning Area.

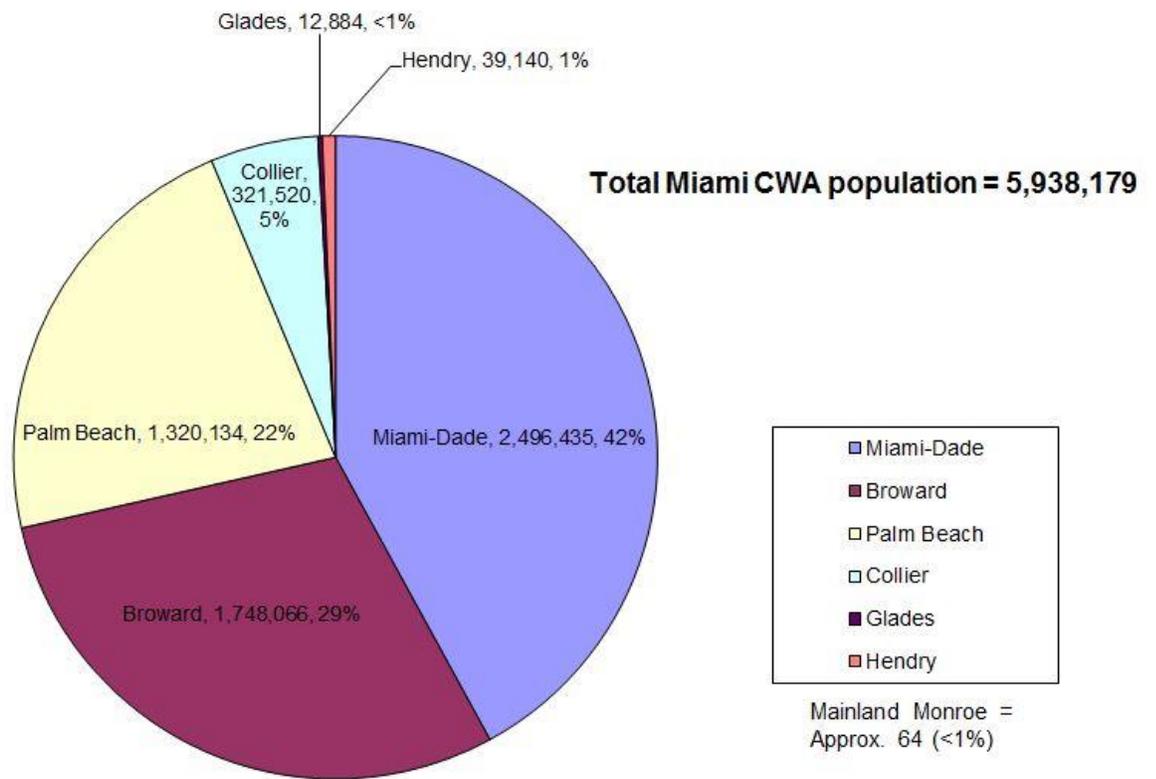


Figure 2. Miami CWA County Population Distribution as of April 2010 (Source: U.S. Census Bureau publication number (CO-EST2011-01-12)).

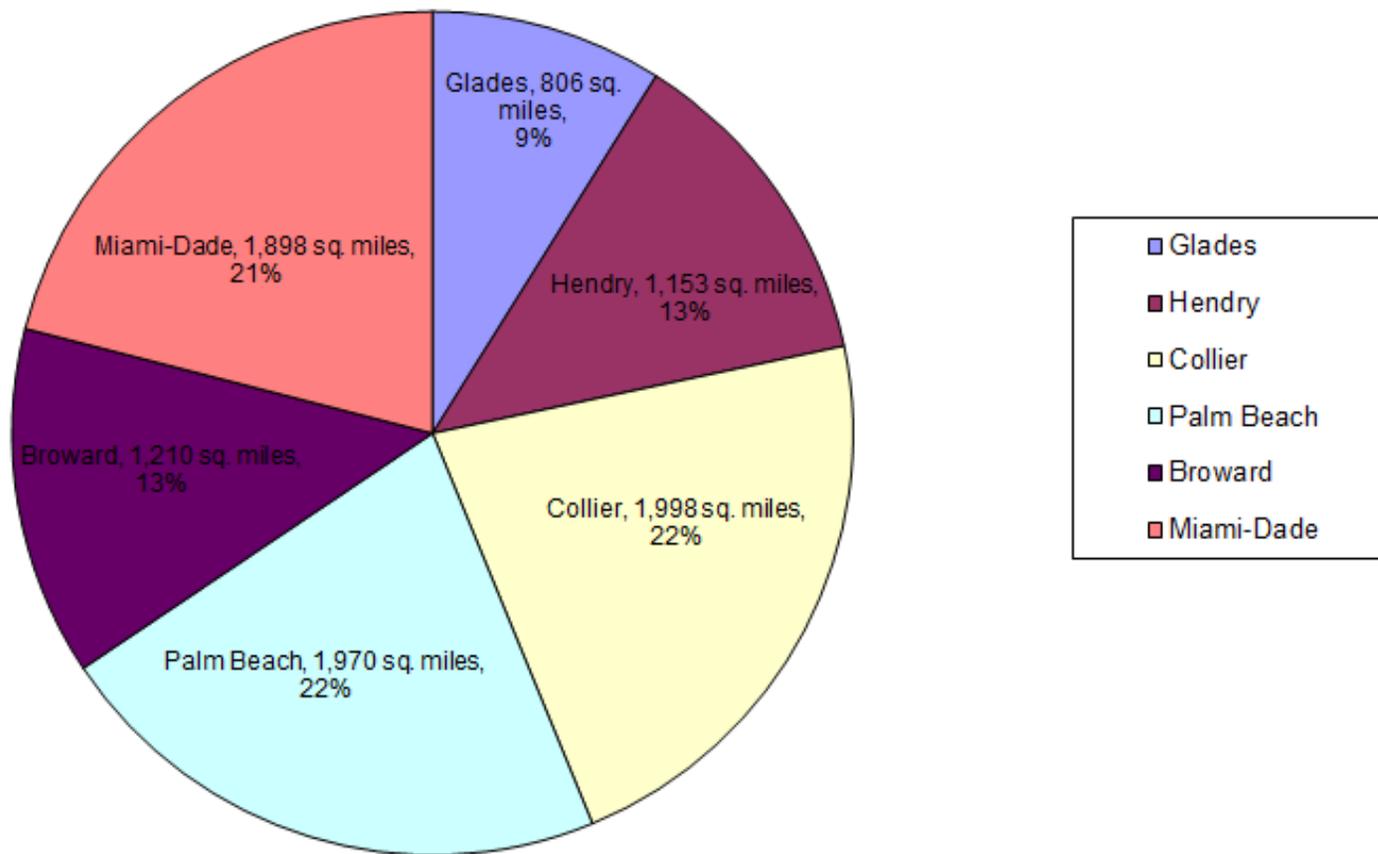


Figure 3. County Land Area Comparison within Miami's CWA



Figure 4. Aerial Photograph of South Florida.

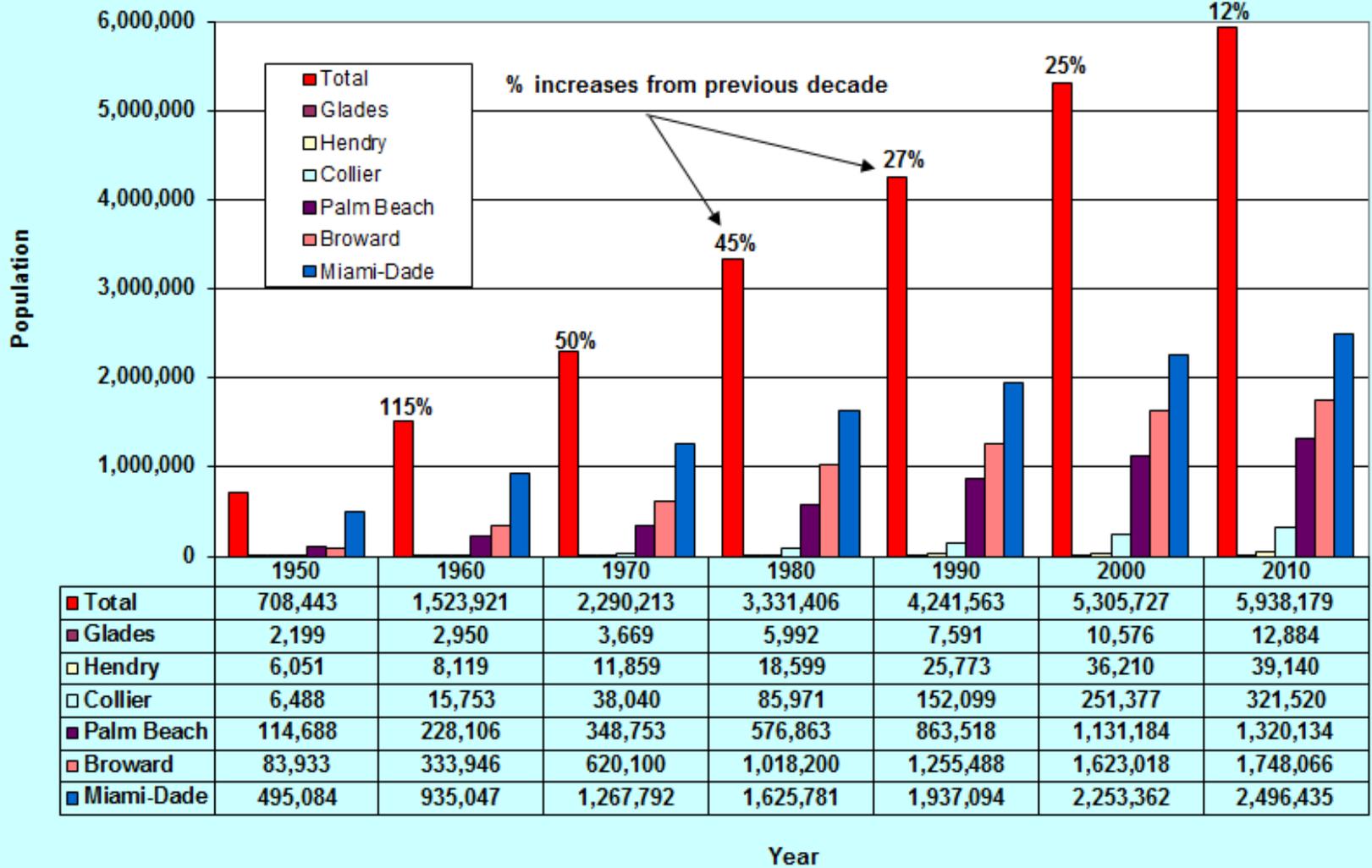


Figure 5. County/CWA Decadal Population Trend for the Miami CWA (Forstall, 1990, 2004 and U.S. Census Bureau publication number CO-EST2011-01-12).

Enhanced Fujita Tornado Damage Scale

SCALE	WINDS (MPH)	TYPICAL DAMAGE
EF0	65-85	Light damage. Peels surface off some roofs; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged
EF1	86-110	Moderate damage. Roofs severely stripped; mobile homes pushed off foundations or overturned; moving autos blown off roads.
EF2	111-135	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	136-165	Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
EF4	166-200	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
EF5	Over 200	Incredible damage. Strong frame houses leveled off foundations and swept away; automobile- sized missiles fly through the air in excess of 100 meters (109 yds); trees debarked; incredible phenomena will occur.

FUJITA SCALE			OPERATIONAL EF SCALE	
F Number	Fastest 1/4-mile (mph)	3 Second Gust (mph)	EF Number	3 Second Gust (mph)
0	40-72	45-78	0	65-85
1	73-112	79-117	1	86-110
2	113-157	118-161	2	111-135
3	158-207	162-209	3	136-165
4	208-260	210-261	4	166-200
5	261-318	262-317	5	Over 200

Figure 6. Fujita Tornado Damage Scale (Source: www.spc.noaa.gov/faq/tornado/ef-scale.html).

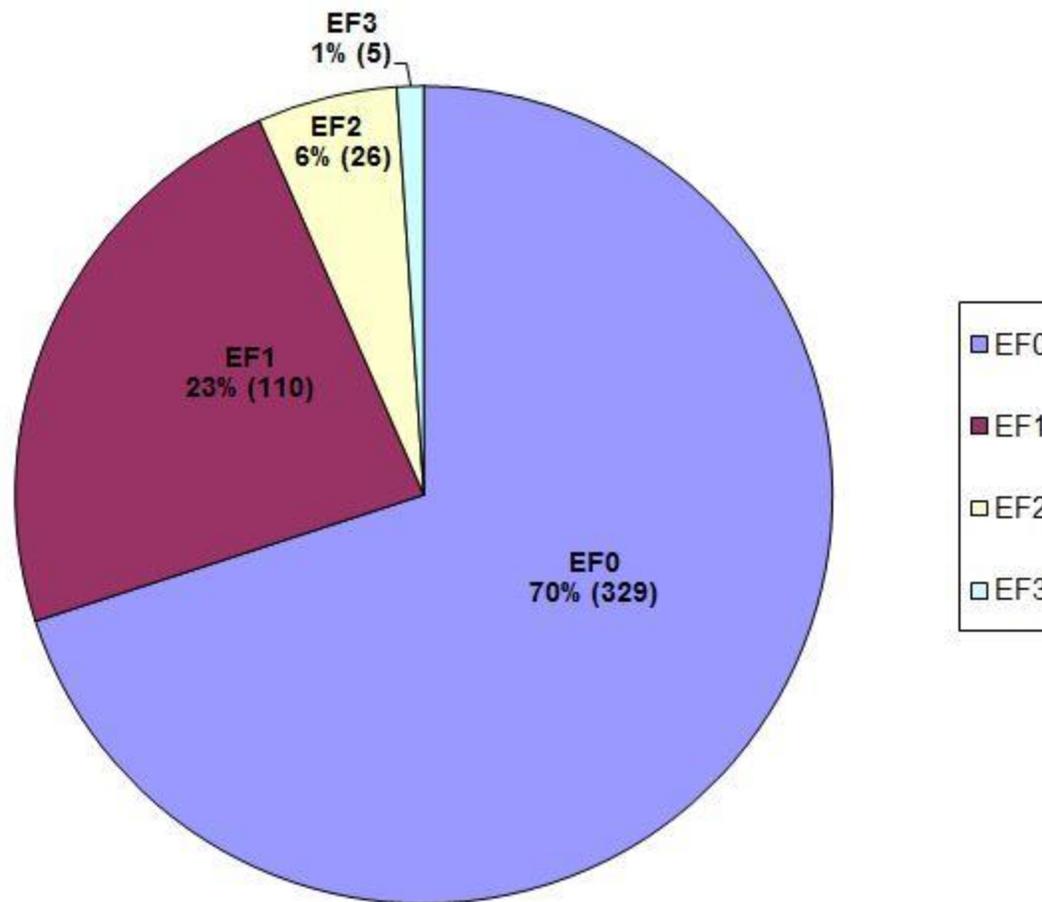


Figure 7. Tornado F-Scale Ratings for the Miami CWA 1950-2012.

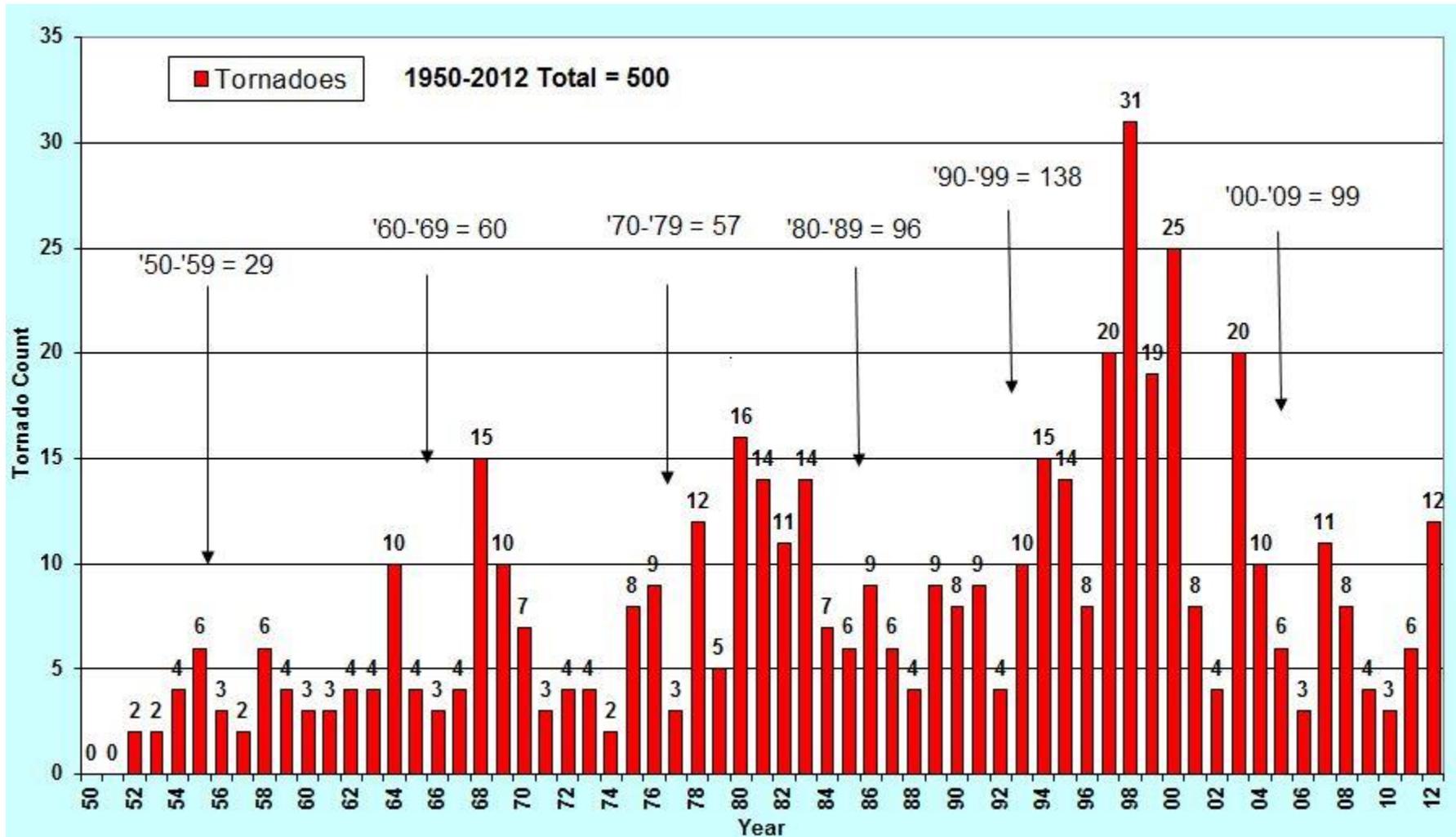


Figure 8. Annual Tornado Distribution for the Miami CWA 1950-2012.

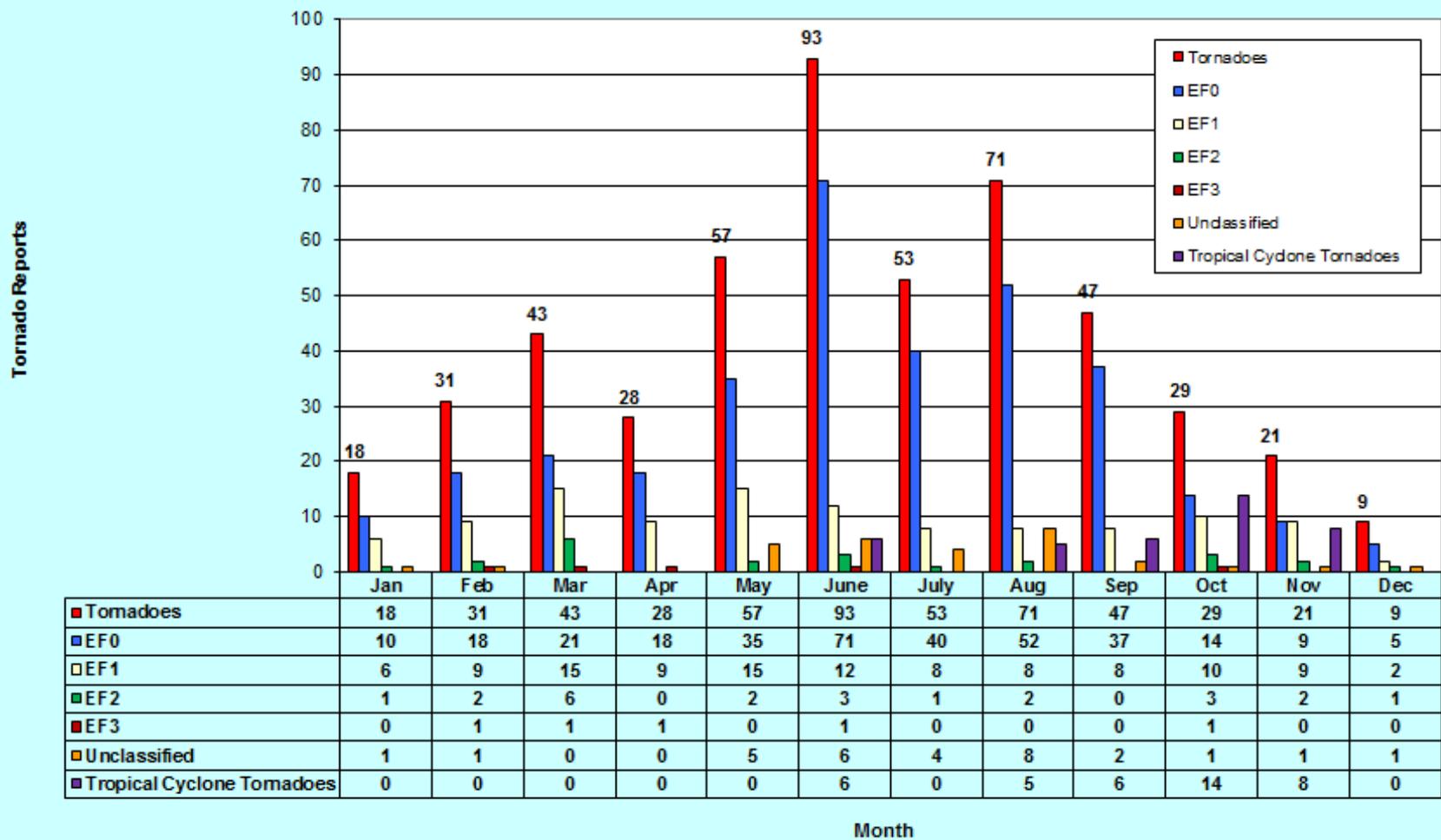


Figure 9. Monthly Tornado Distribution for the Miami CWA 1950-2012.

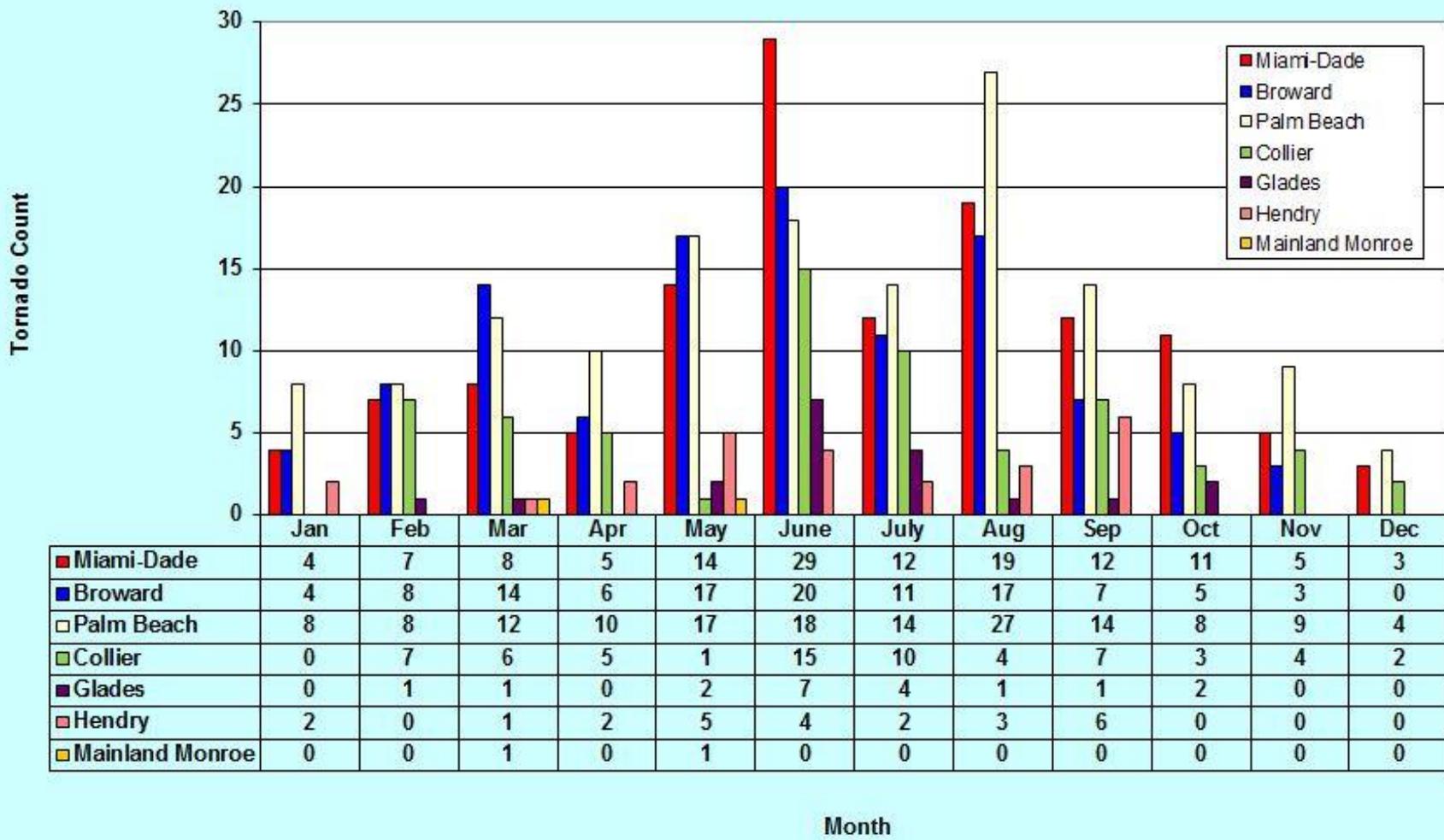


Figure 10. Monthly County Comparison of Tornadoes for the Miami CWA 1950-2012.

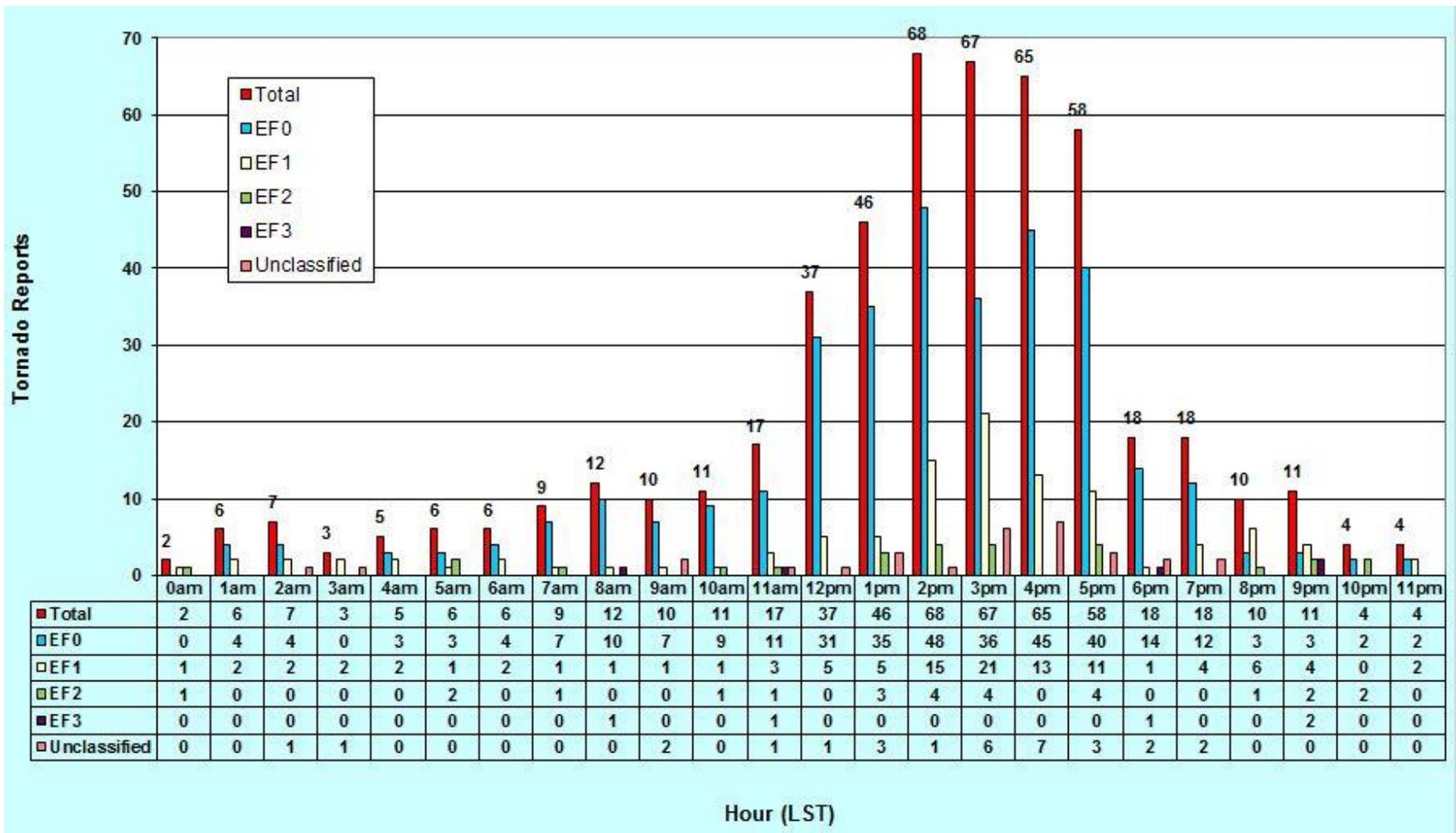


Figure 11. Hourly Tornado Distribution for the Miami CWA 1950-2012 (Times are in LST).

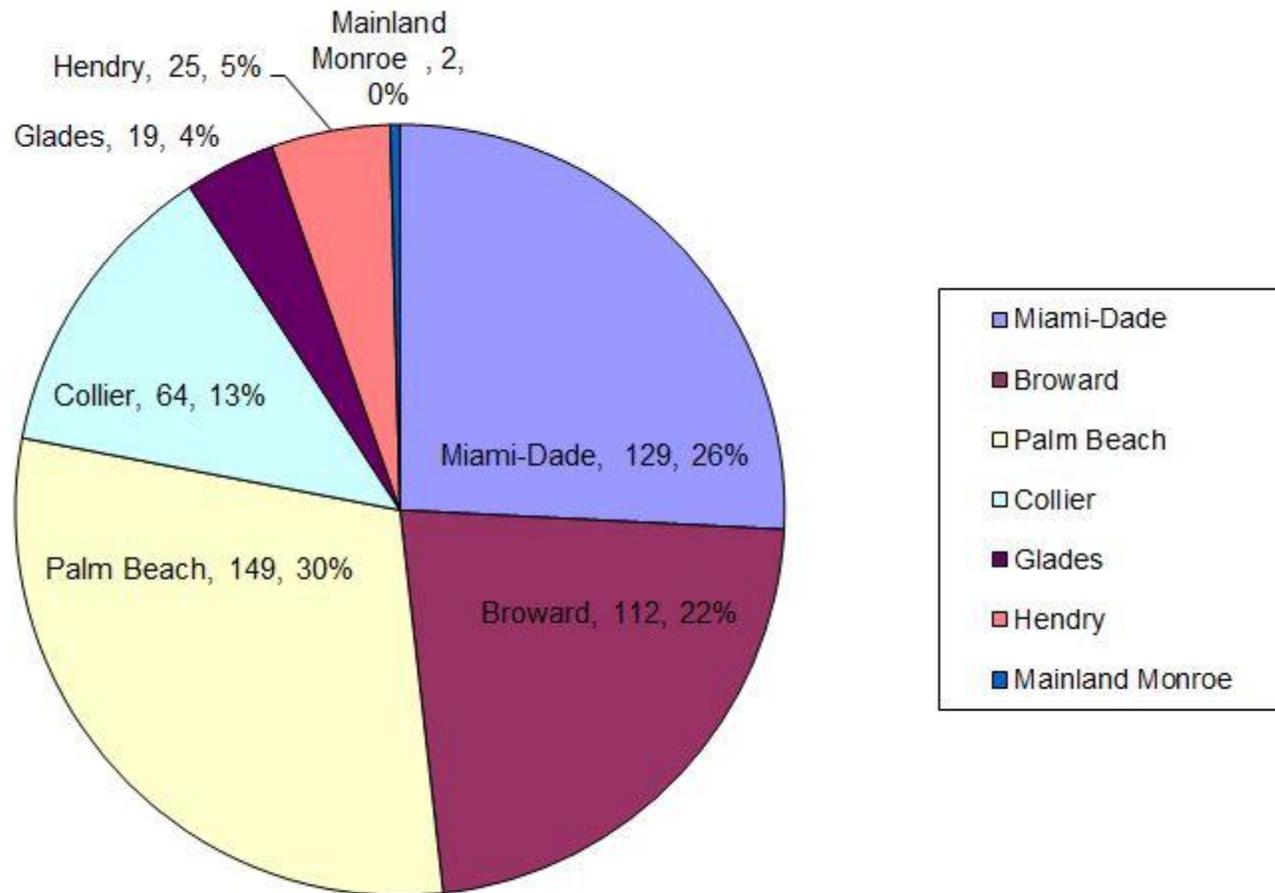


Figure 12. County Comparison of Tornadoes 1950-2012.

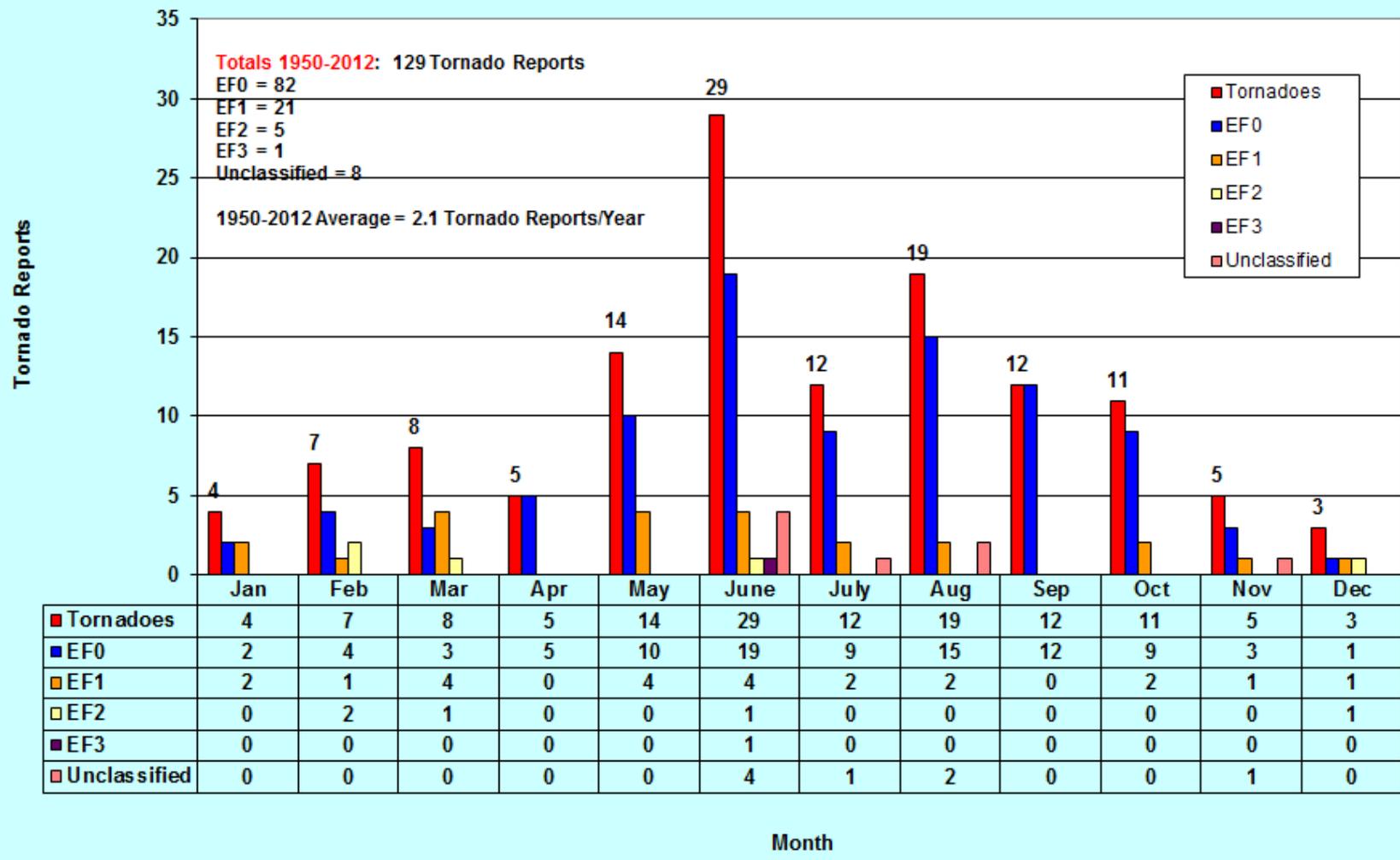


Figure 13. Miami-Dade County Tornado Distribution 1950-2012.

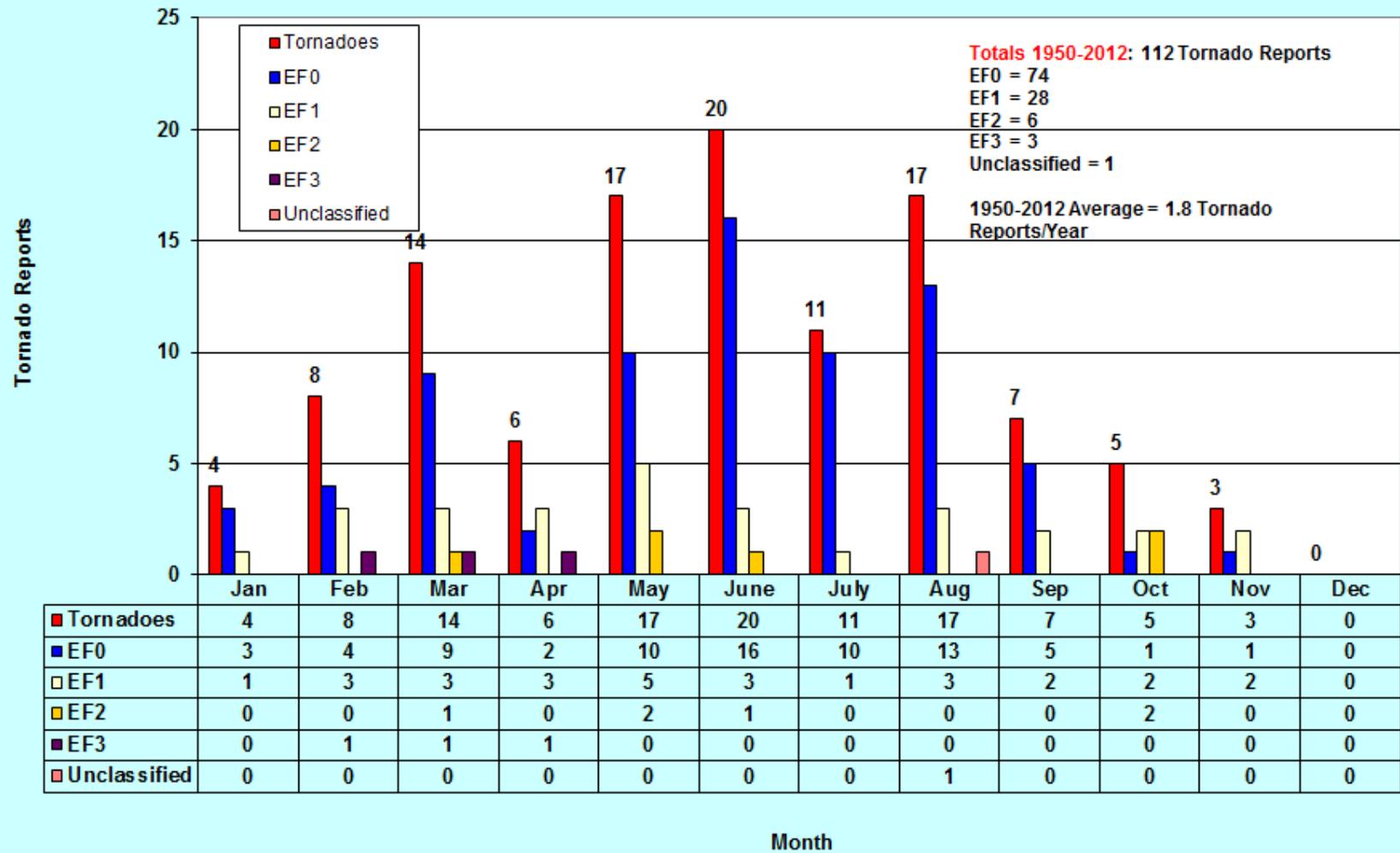


Figure 14. Broward County Tornado Distribution 1950-2012.

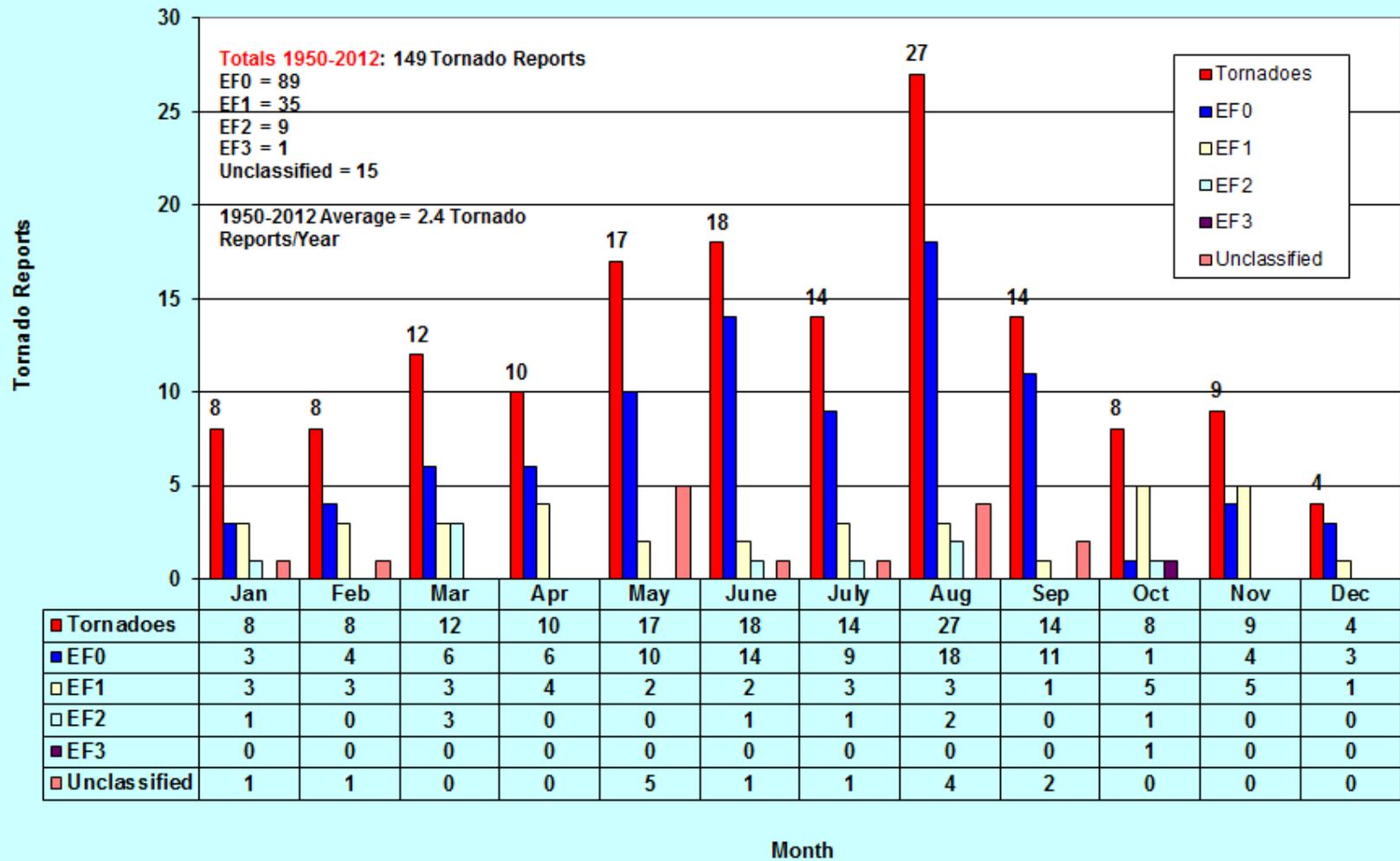


Figure 15. Palm Beach County Tornado Distribution 1950-2012.

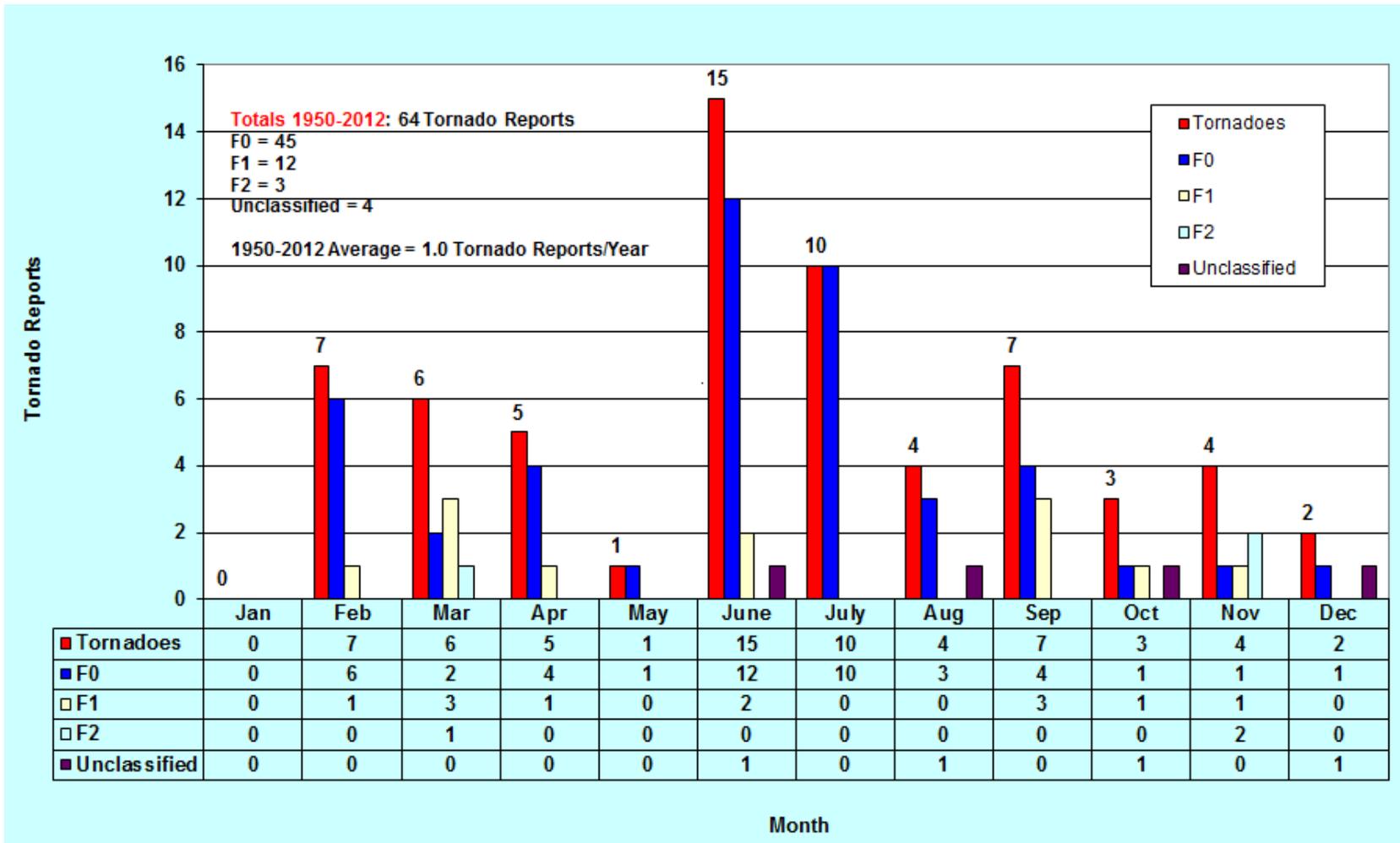


Figure 16. Collier County Tornado Distribution 1950-2012.

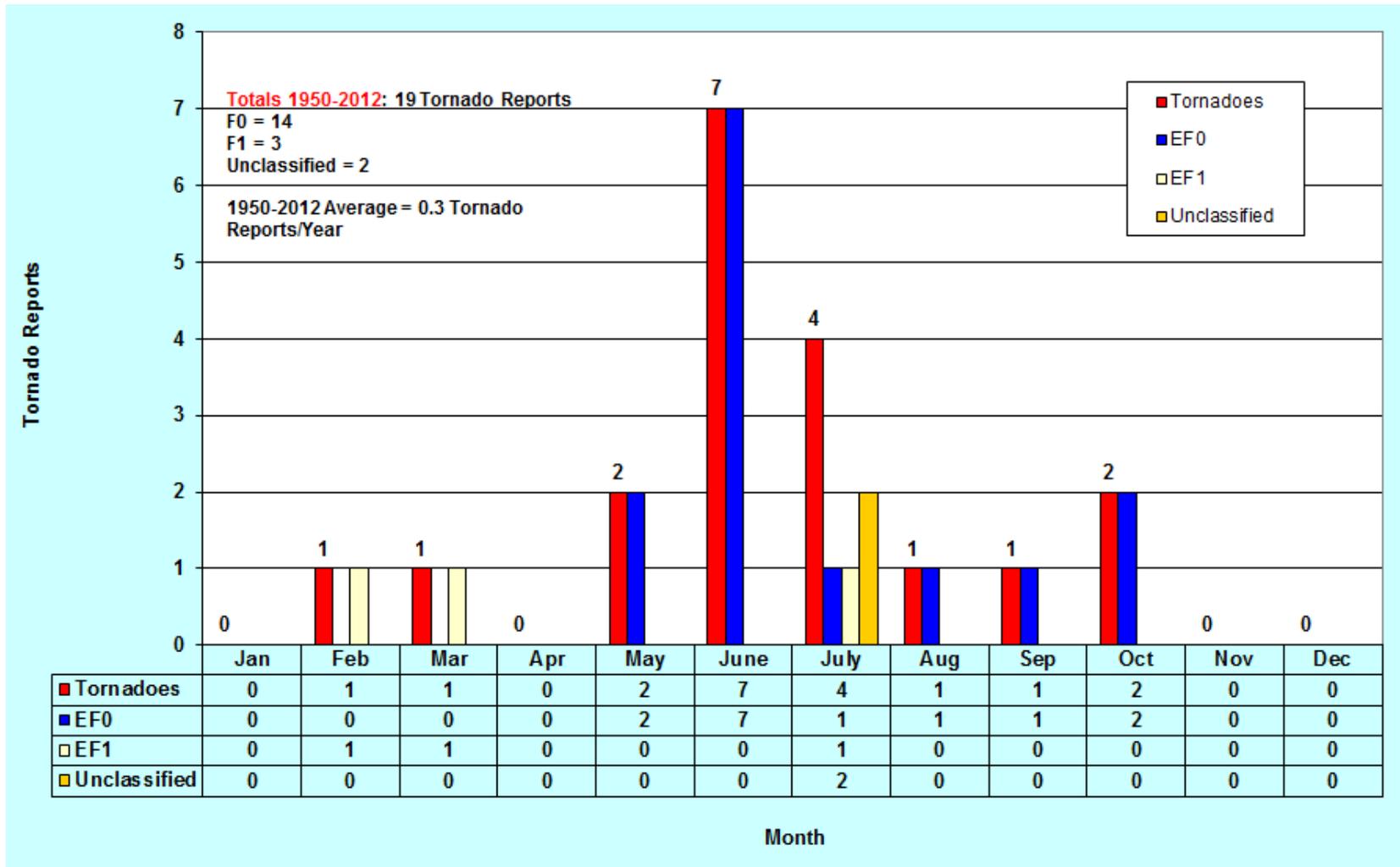


Figure 17. Glades County Tornado Distribution 1950-2012.

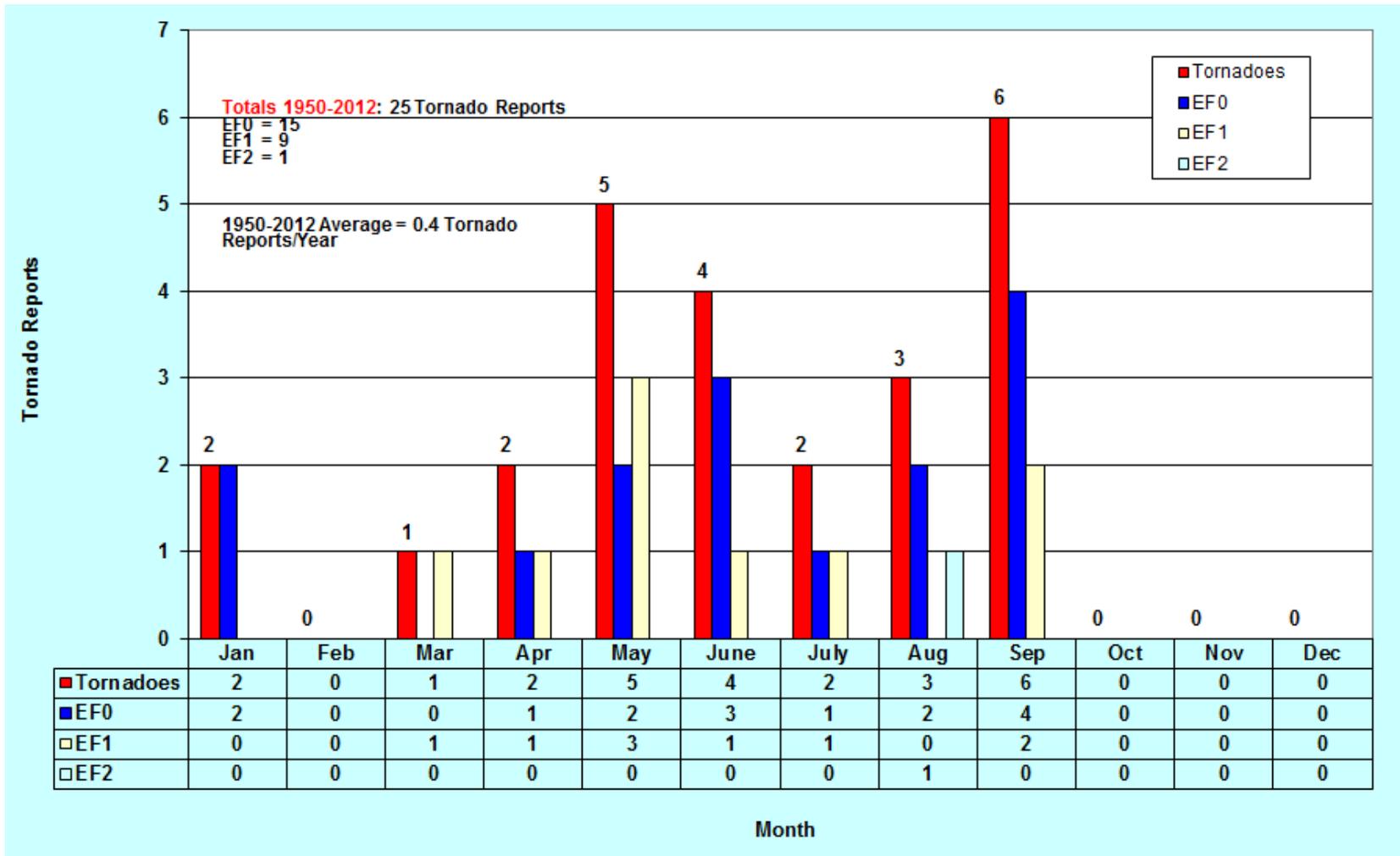


Figure 18. Hendry County Tornado Distribution 1950-2012.

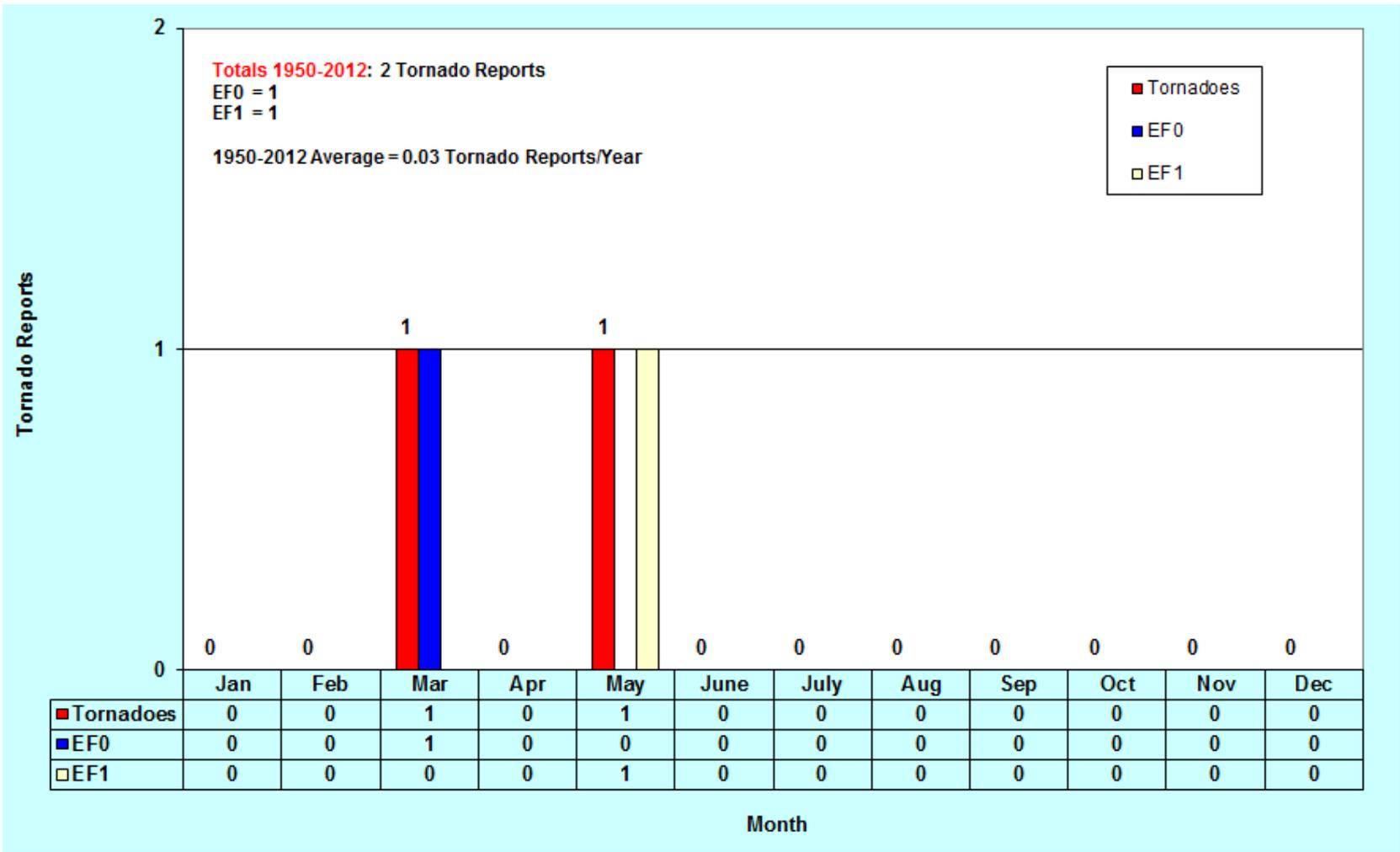


Figure 19. Mainland Monroe County Tornado Distribution 1950-2012.

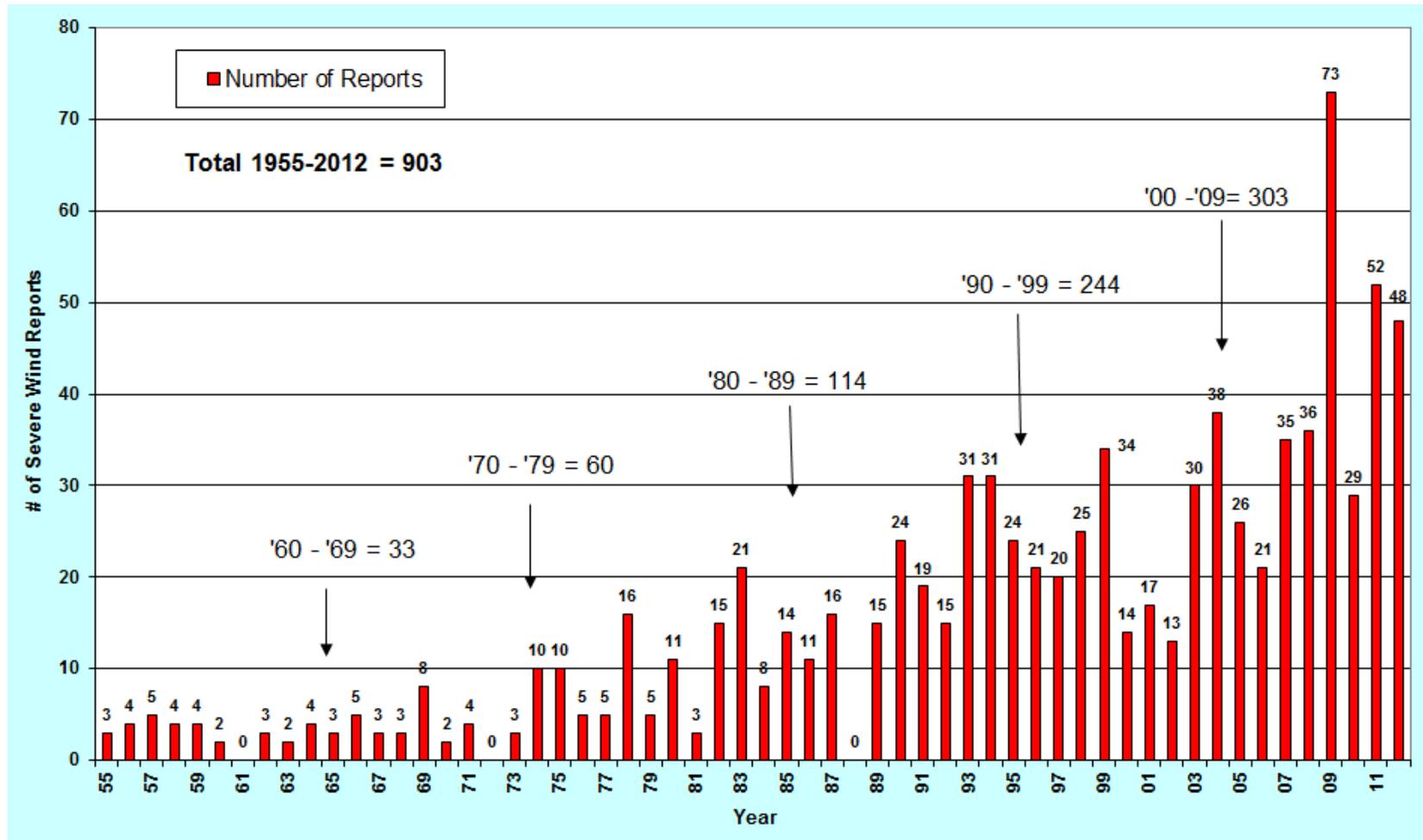


Figure 20. Annual Distribution of Severe Wind Reports for the Miami CWA 1955-2012.

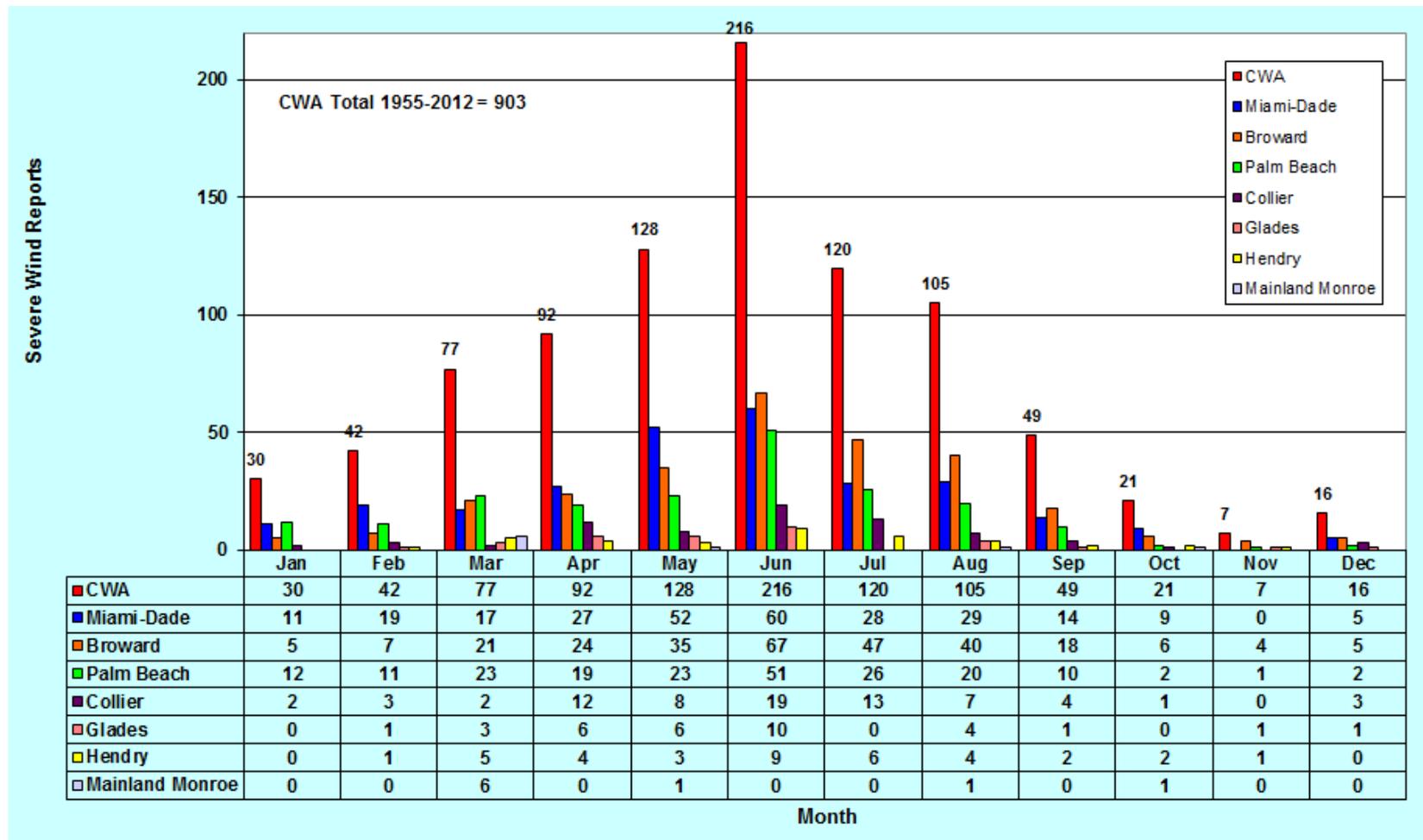


Figure 21. Monthly Distribution of Severe Wind Reports for the Miami CWA 1955-2012.

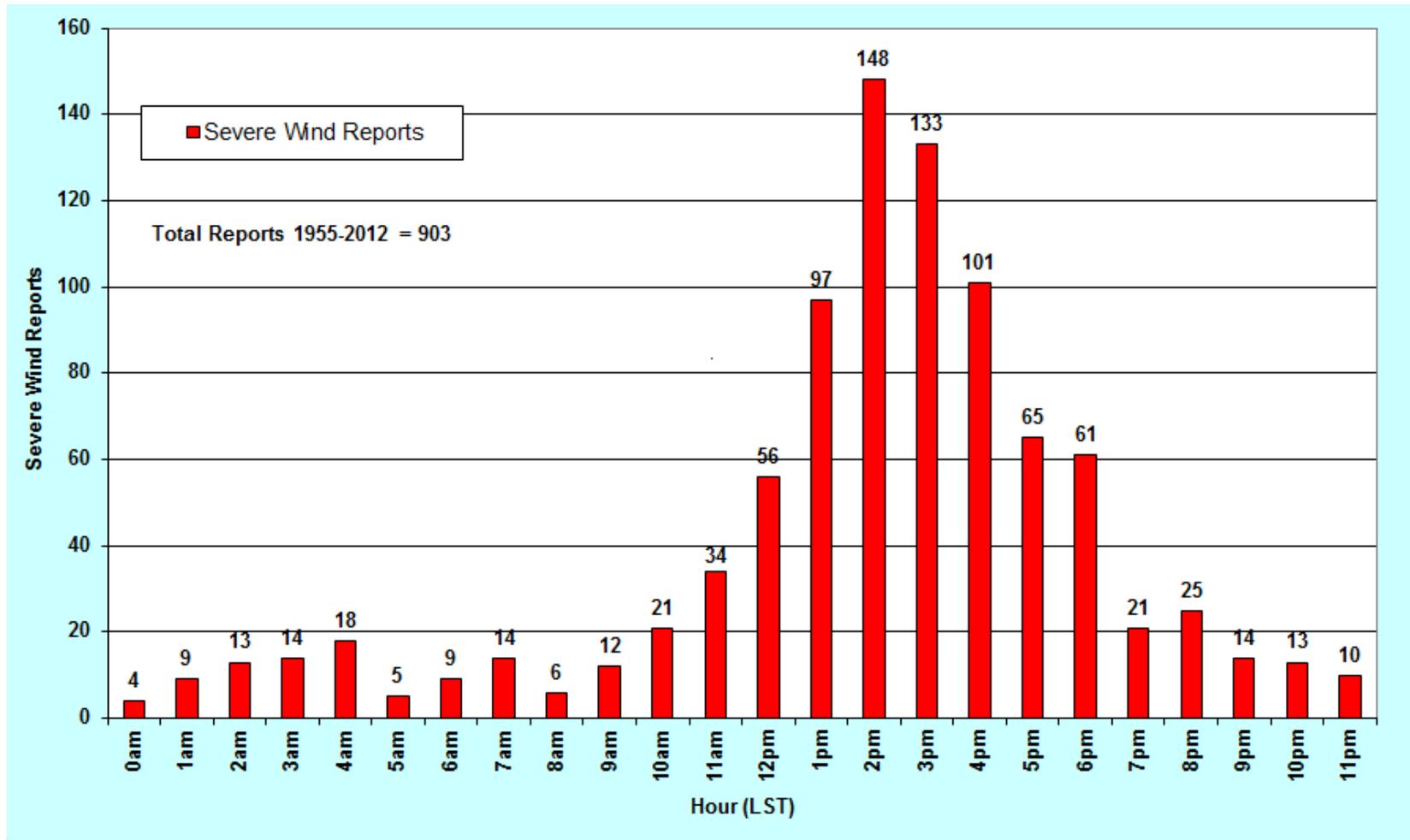


Figure 22. Hourly Distribution of Severe Wind Reports for the Miami CWA 1955-2012.

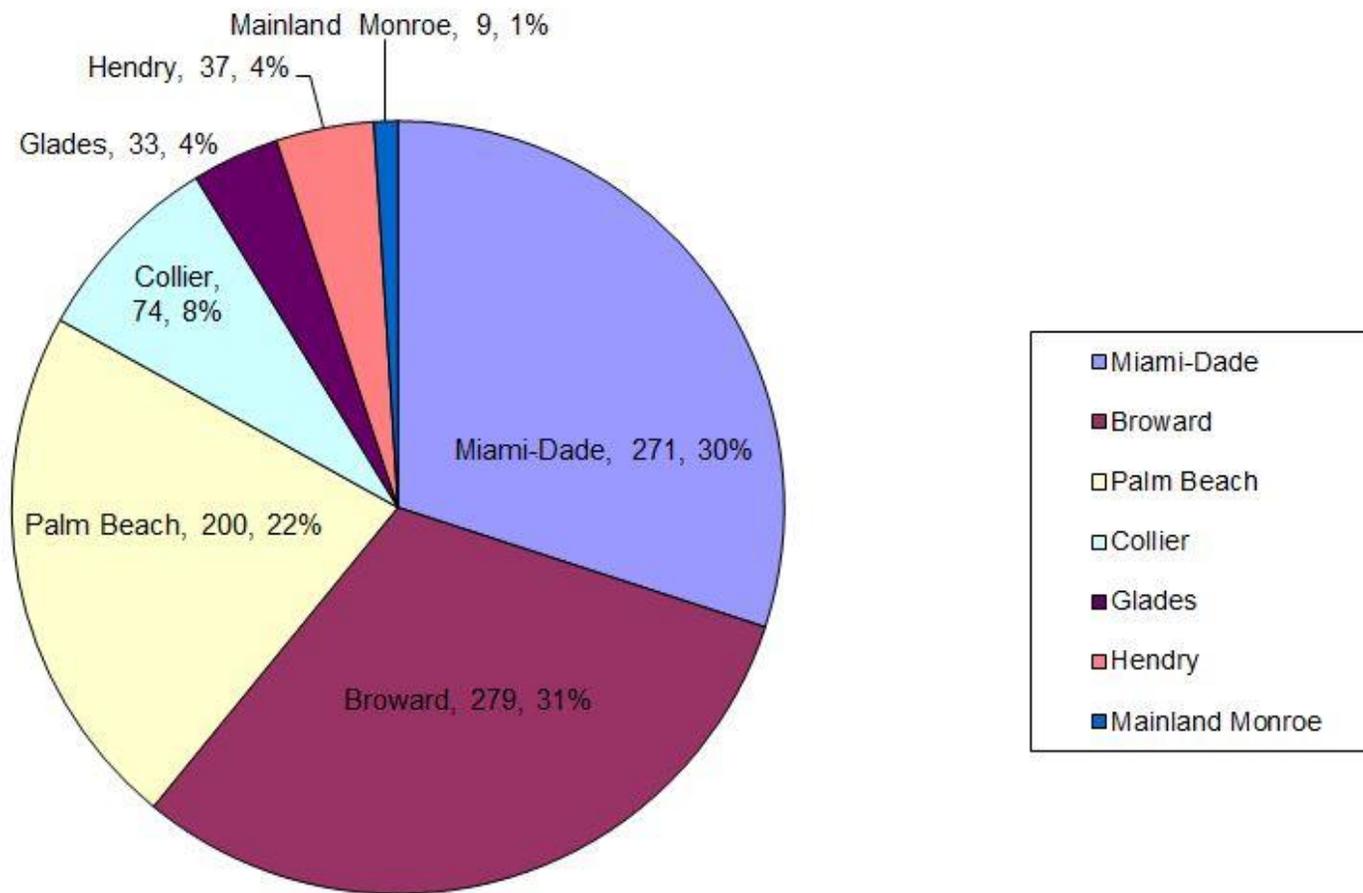


Figure 23. County Comparison of Severe Wind Reports Miami CWA 1955-2012.

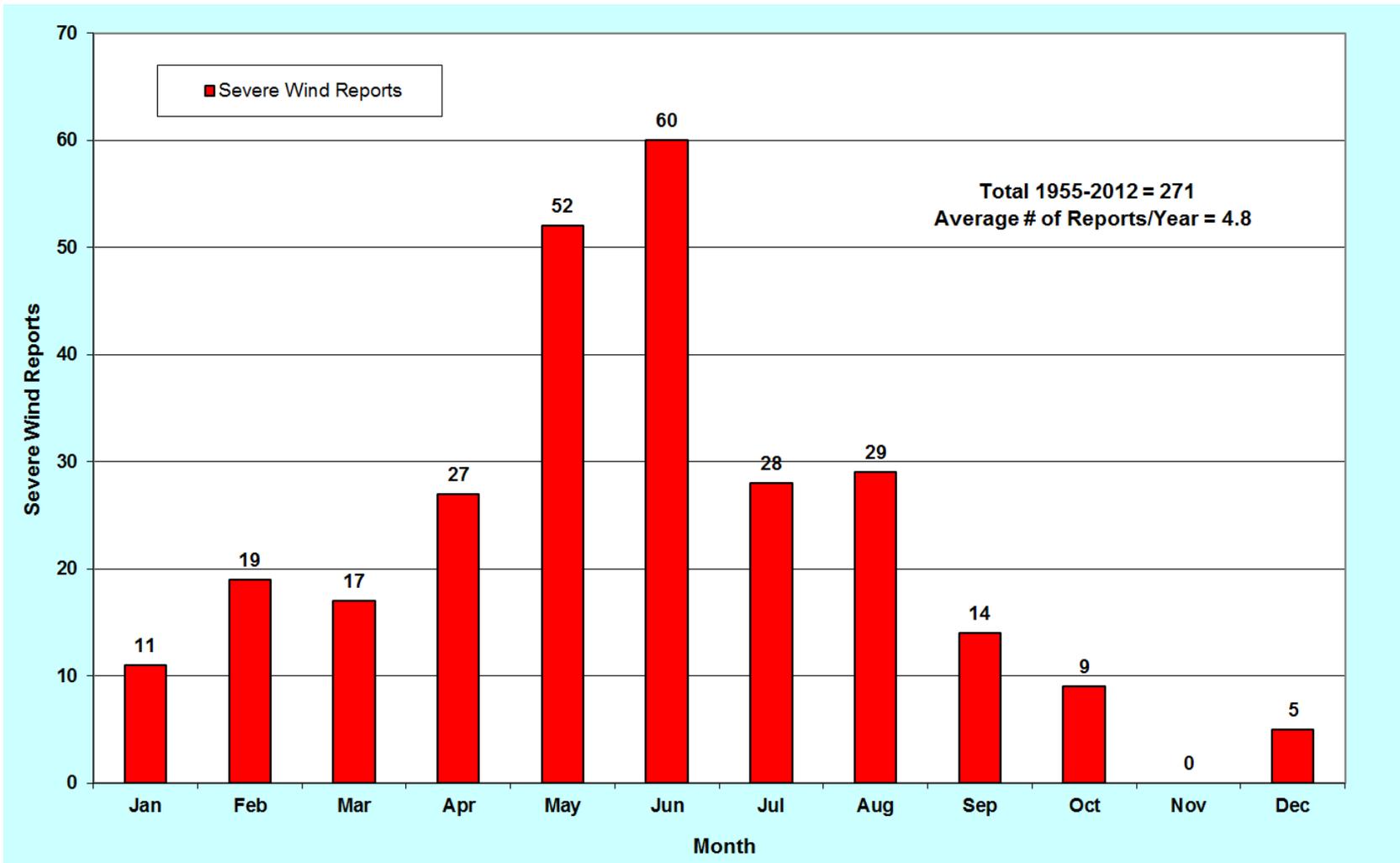


Figure 24. Miami-Dade County Severe Wind Distribution 1955-2012.

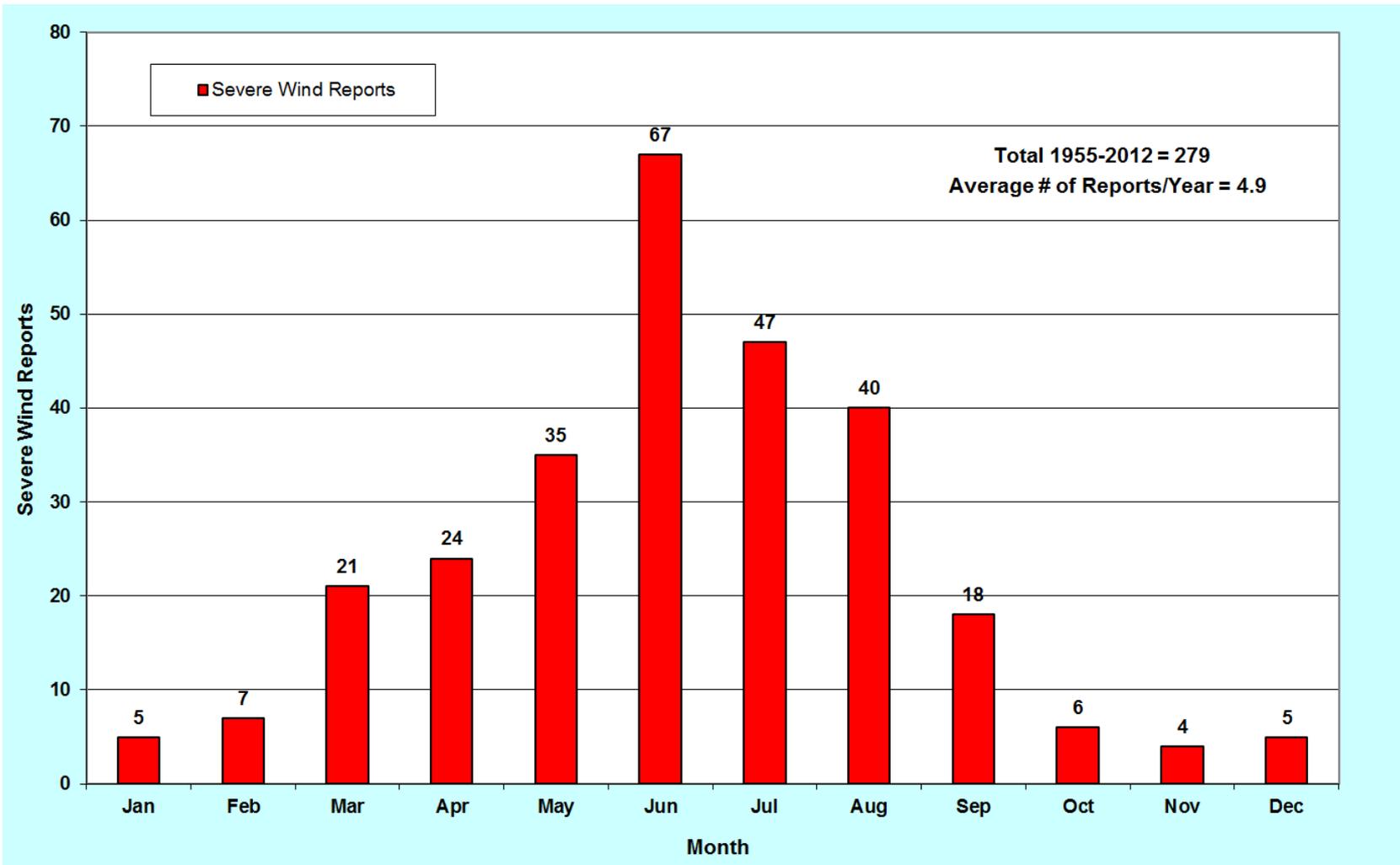


Figure 25. Broward County Severe Wind Distribution 1955-2012.

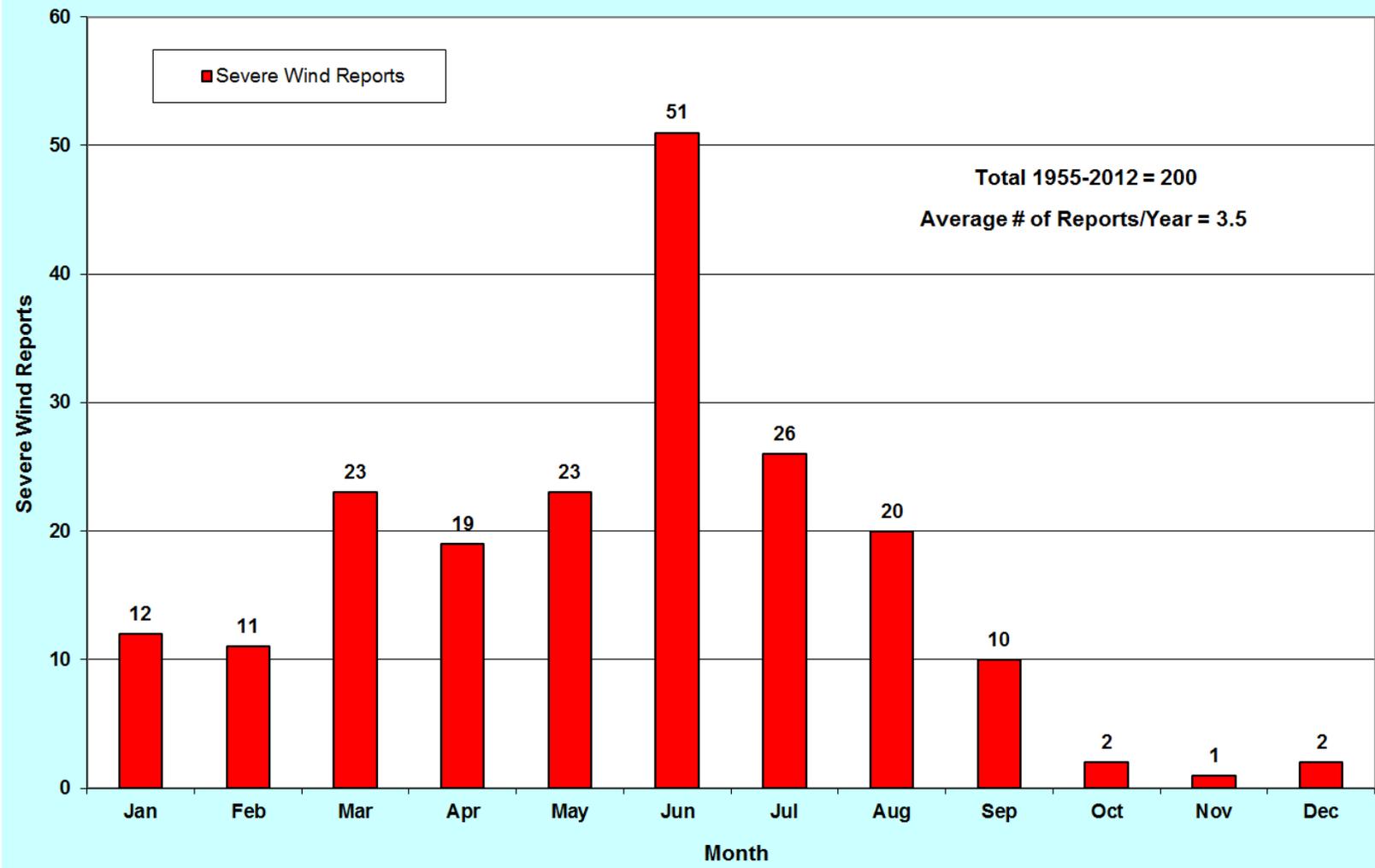


Figure 26. Palm Beach County Severe Wind Distribution 1955-2012.

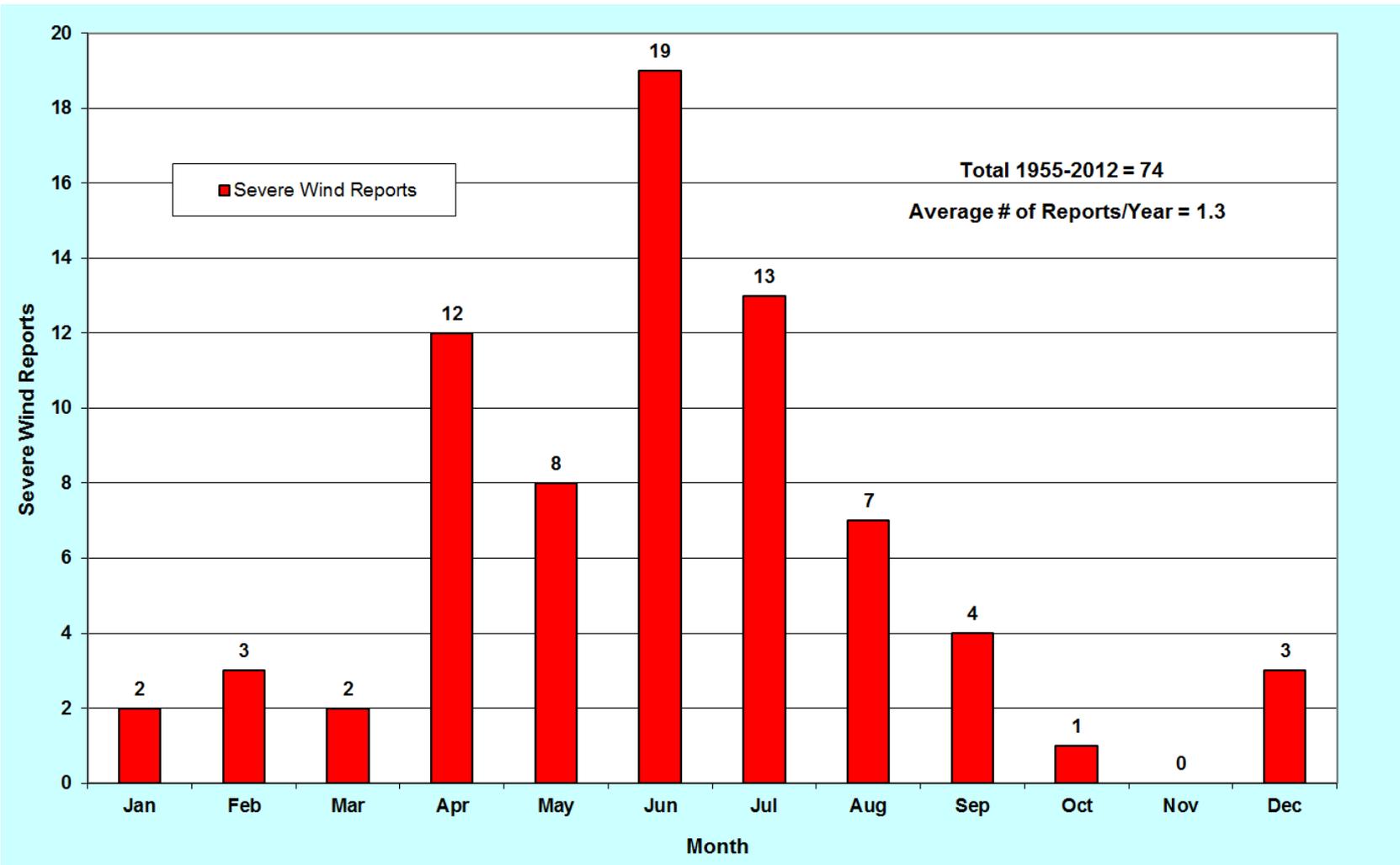


Figure 27. Collier County Severe Wind Distribution 1955-2012.

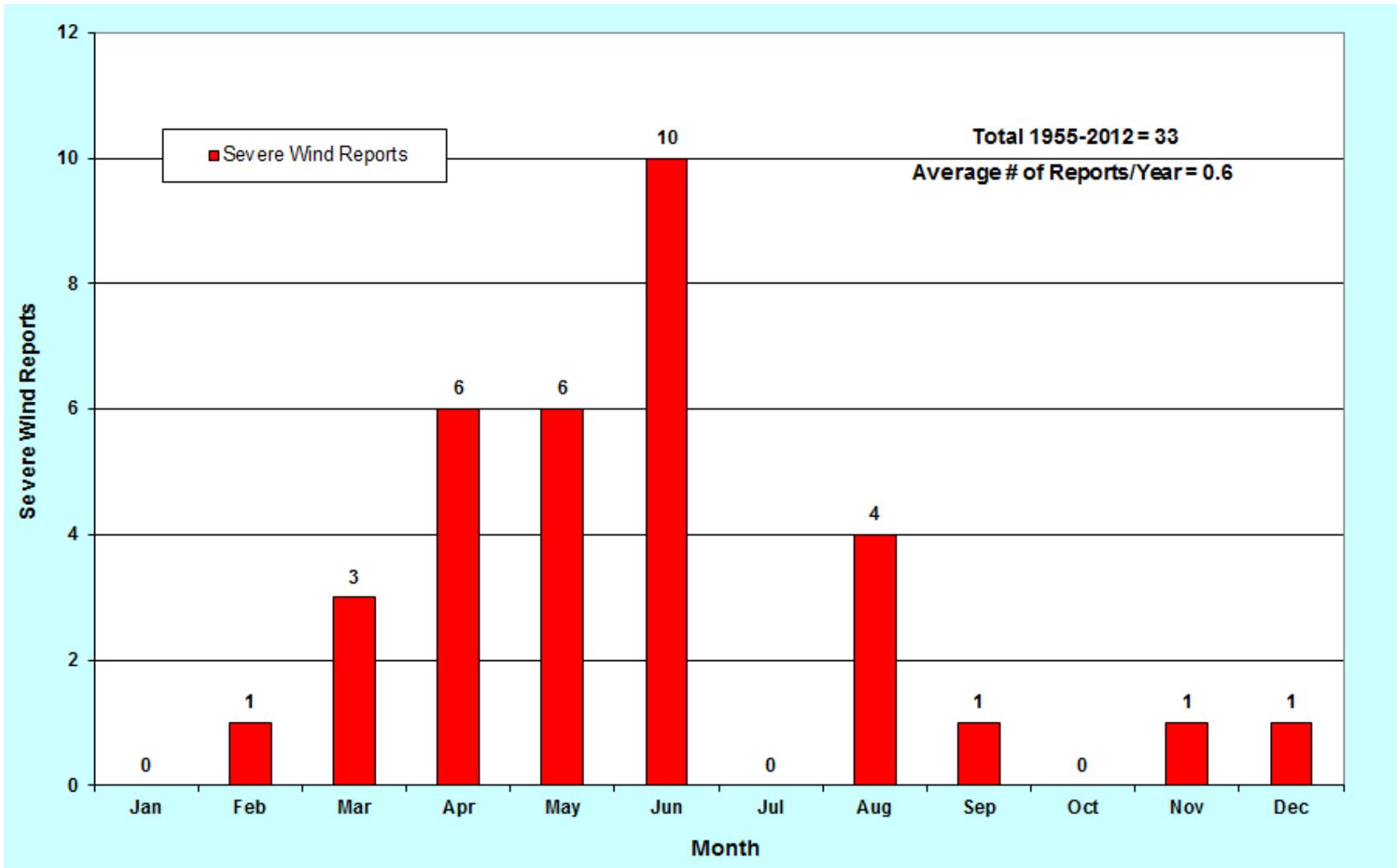


Figure 28. Glades County Severe Wind Distribution 1955-2012.

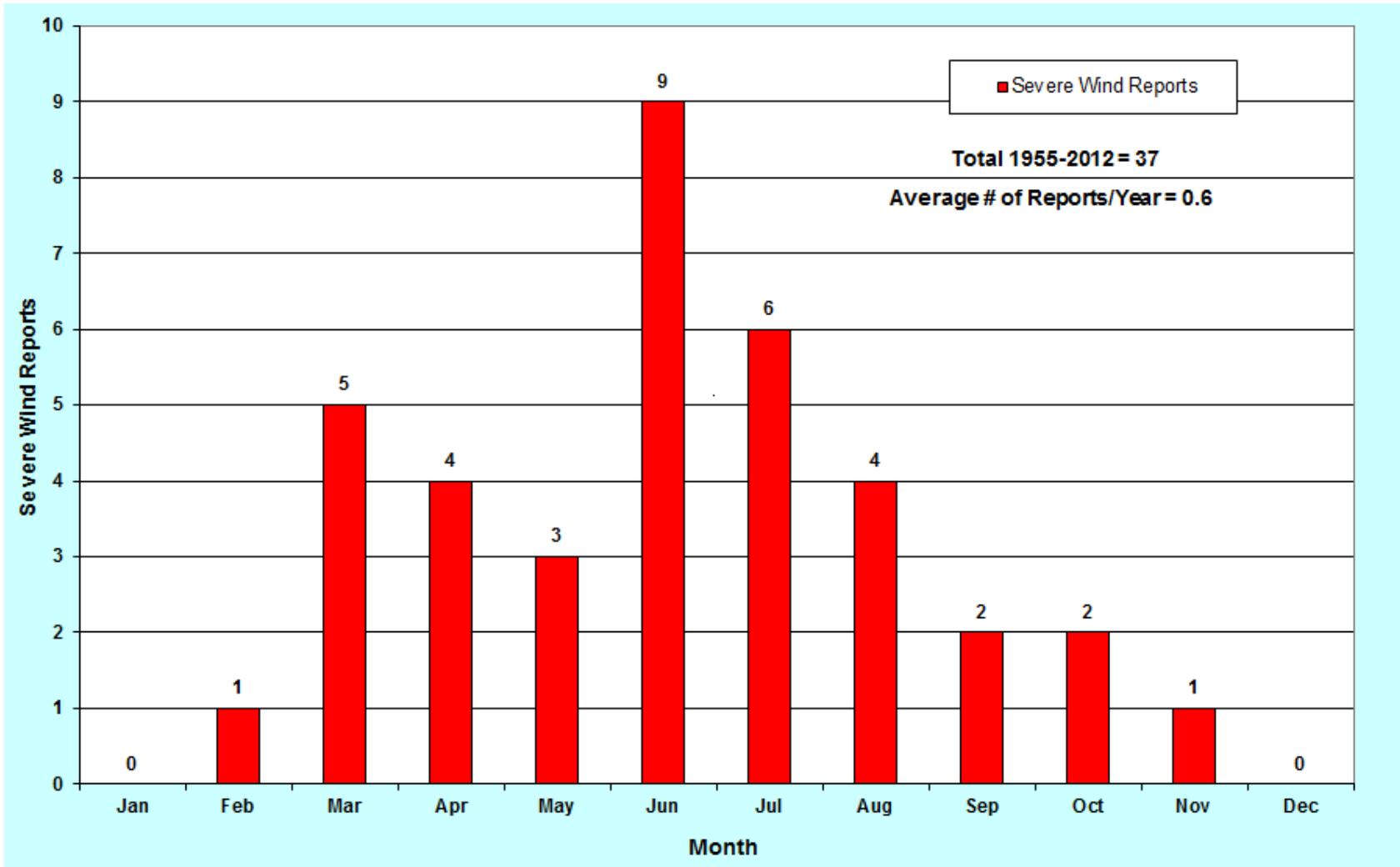


Figure 29. Hendry County Severe Wind Distribution 1955-2012.

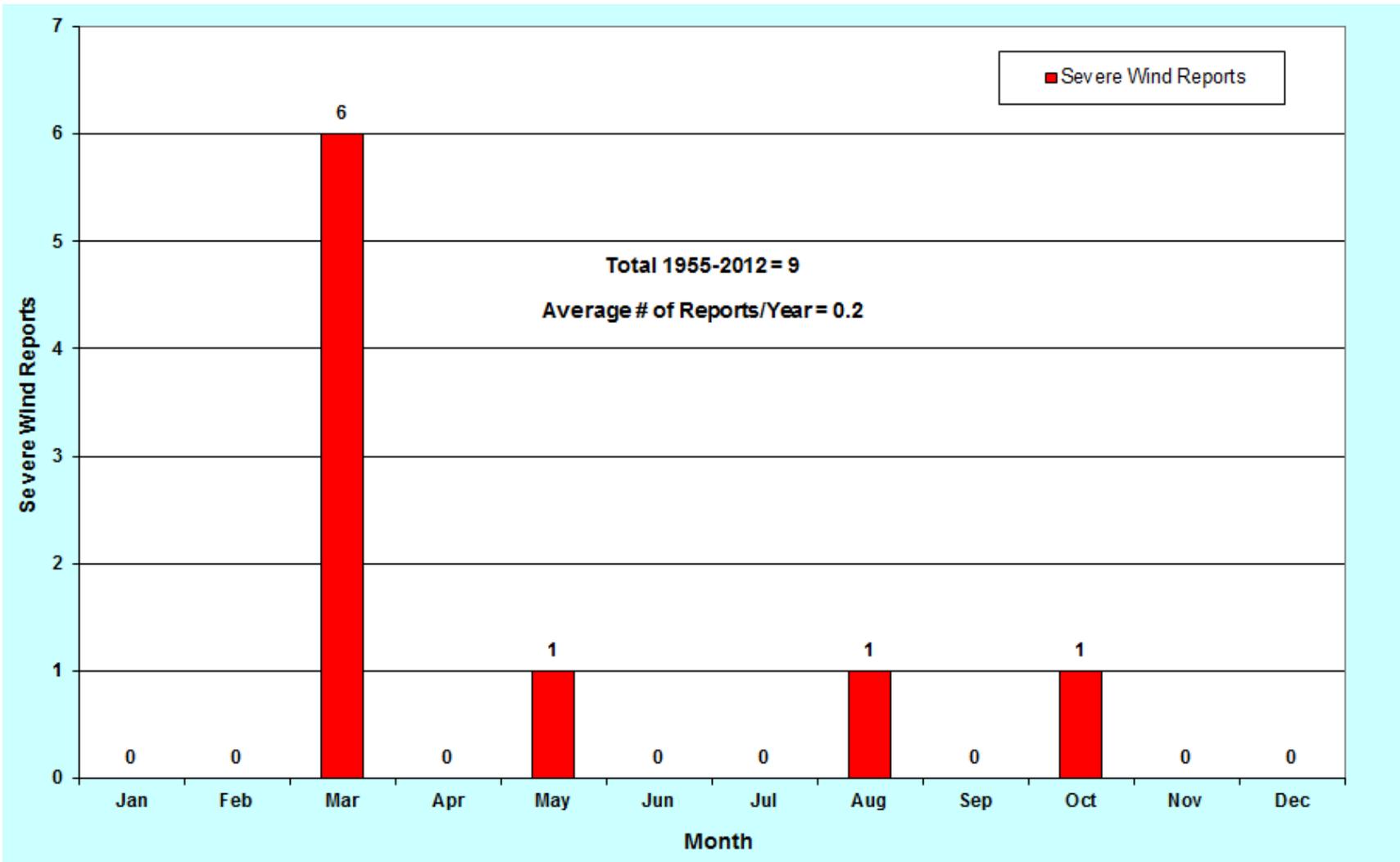


Figure 30. Mainland Monroe County Severe Wind Distribution 1955-2012.

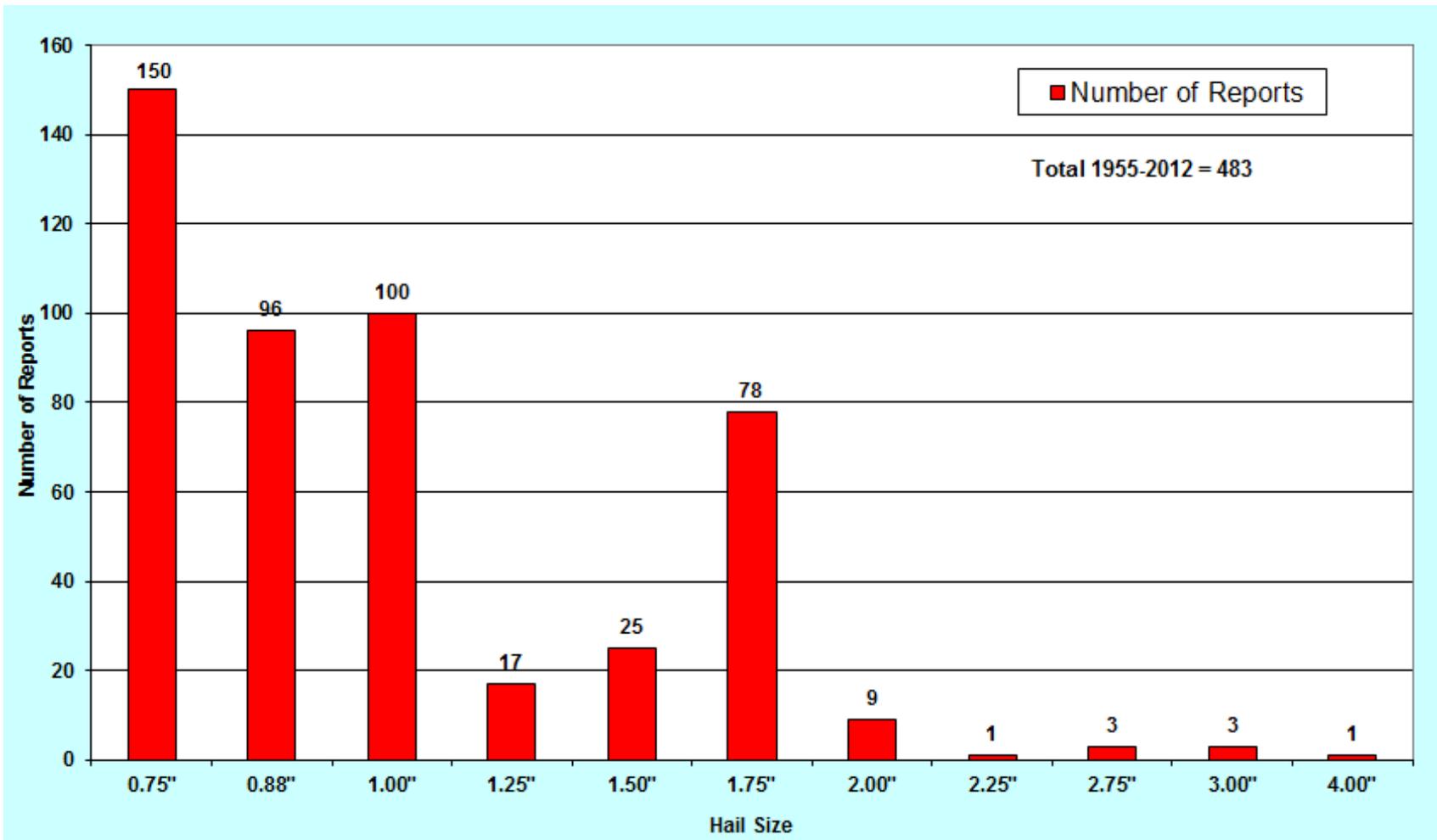


Figure 31. Hail Size Distribution for the Miami CWA 1955-2012.

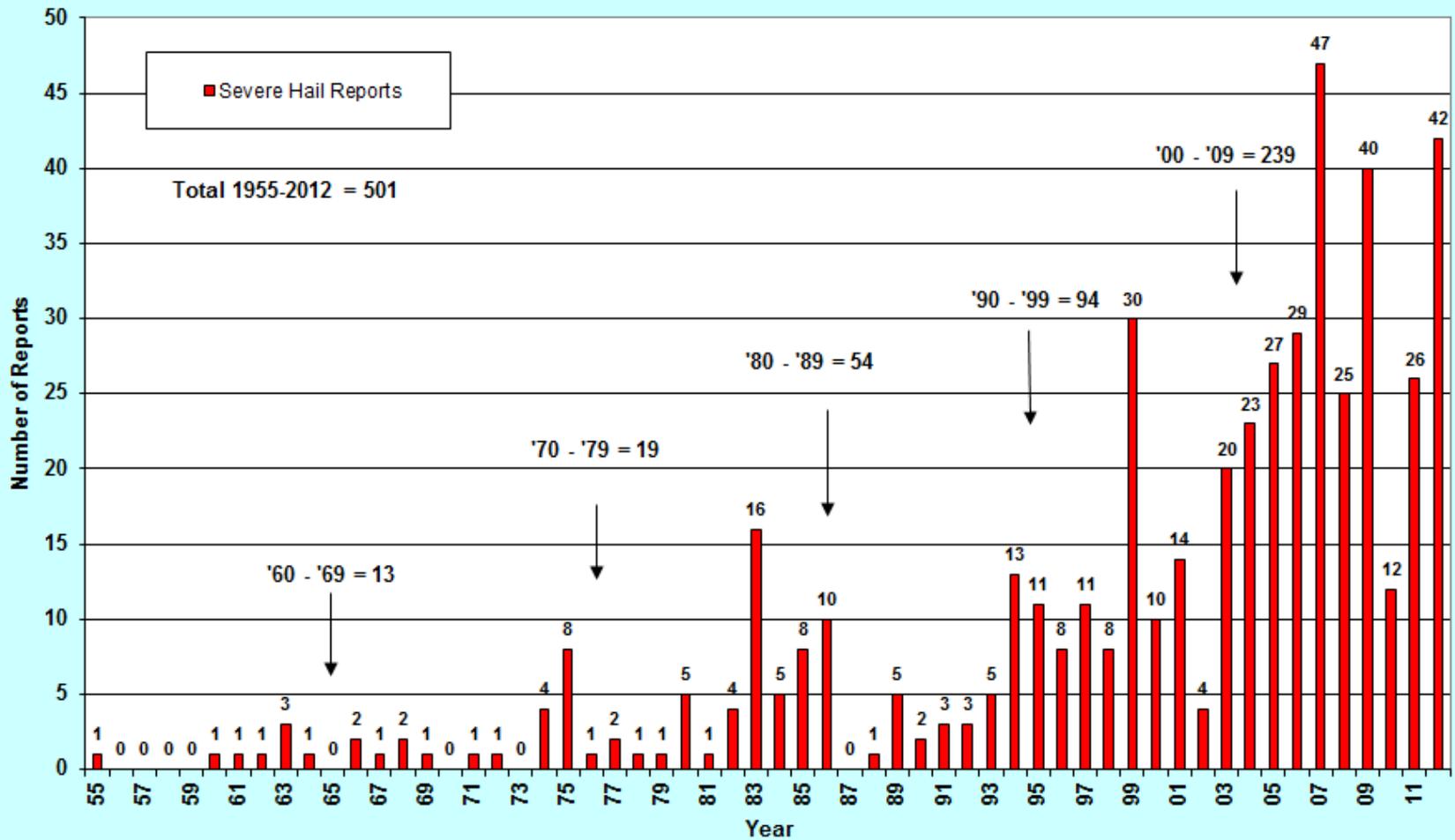


Figure 32. Annual Severe Hail Distribution for the Miami CWA 1955-2012.

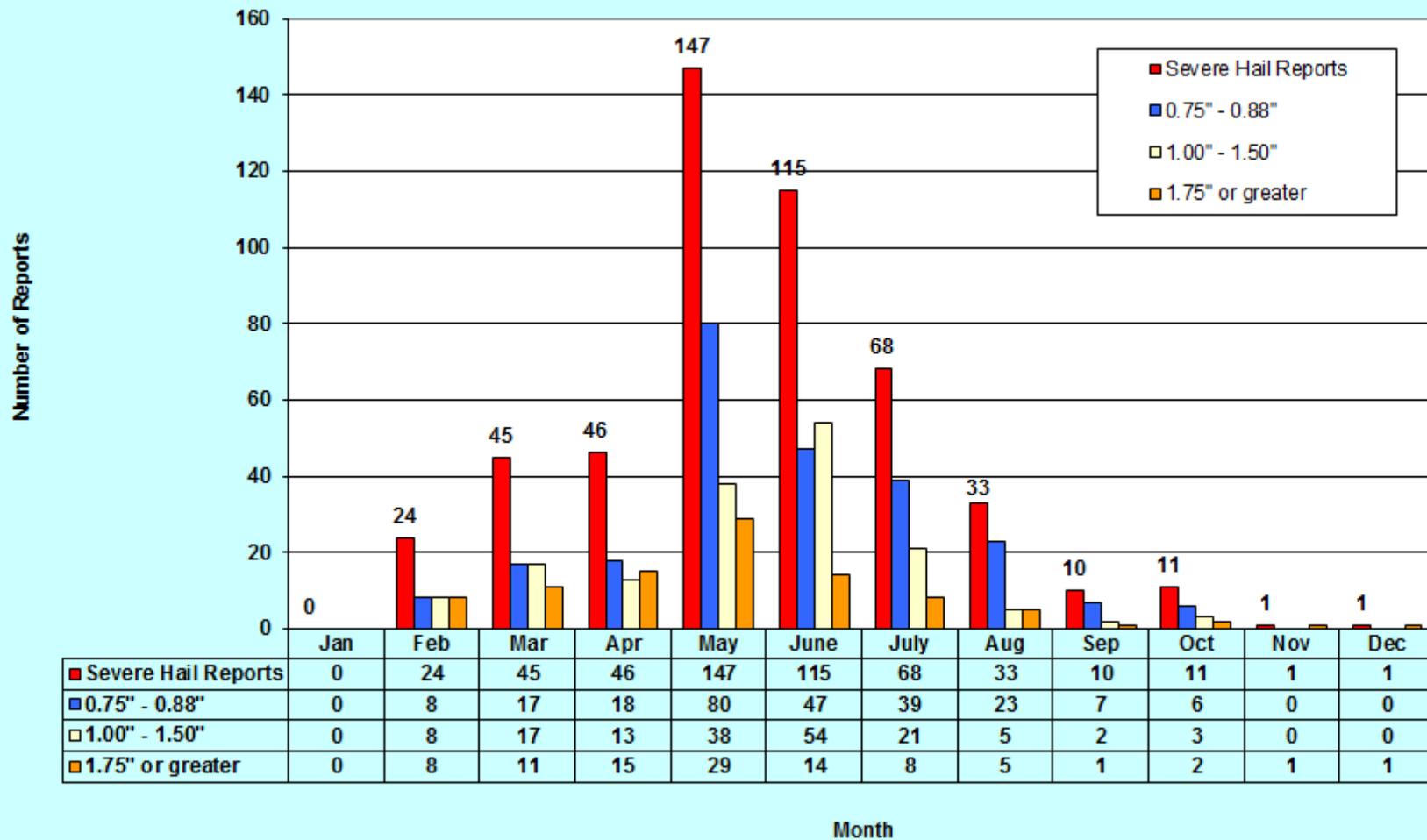


Figure 33. Monthly Severe Hail Distribution for the Miami CWA 1955-2012.

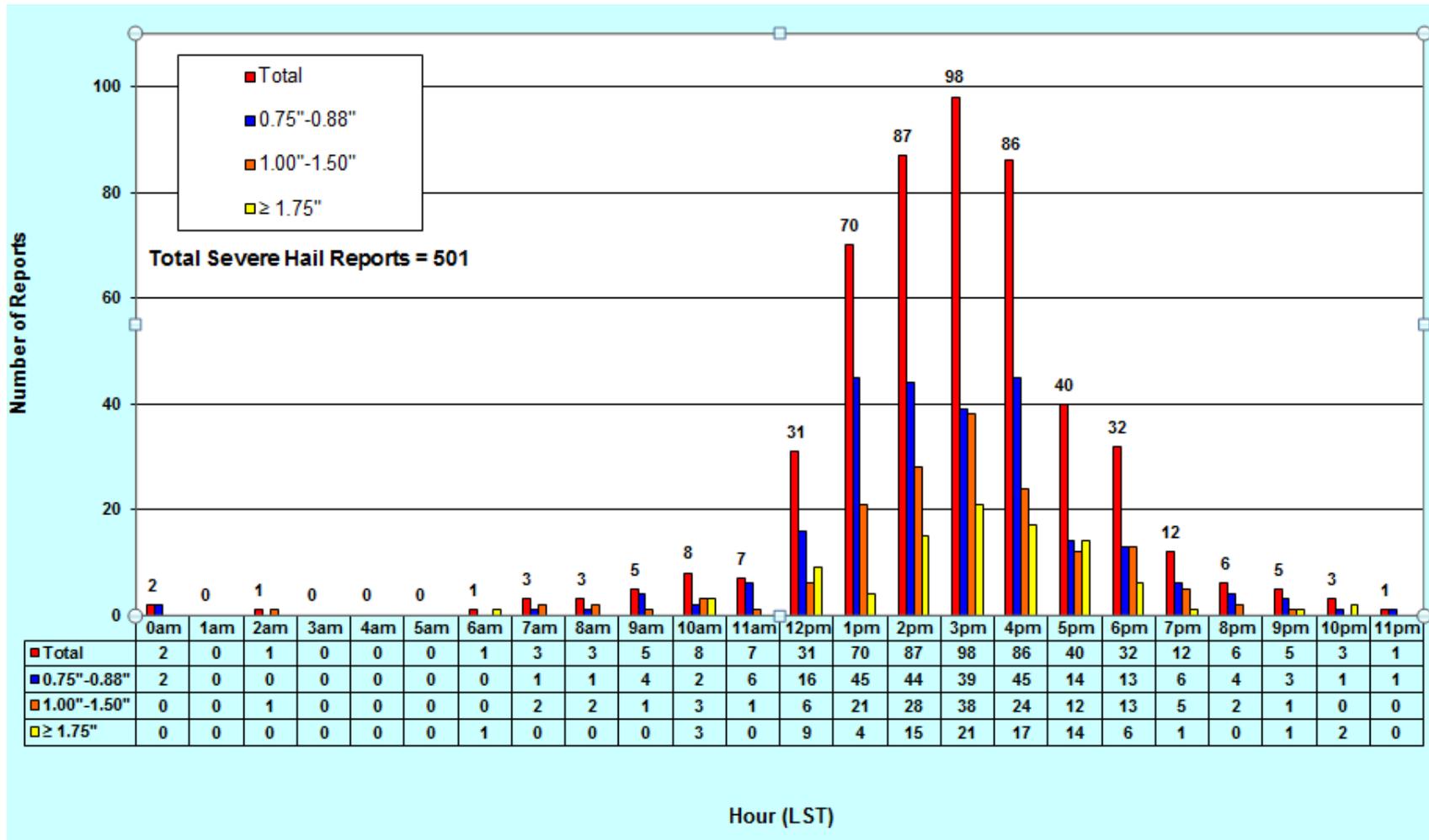


Figure 34. Hourly Severe Hail Distribution for the Miami CWA 1955-2012.

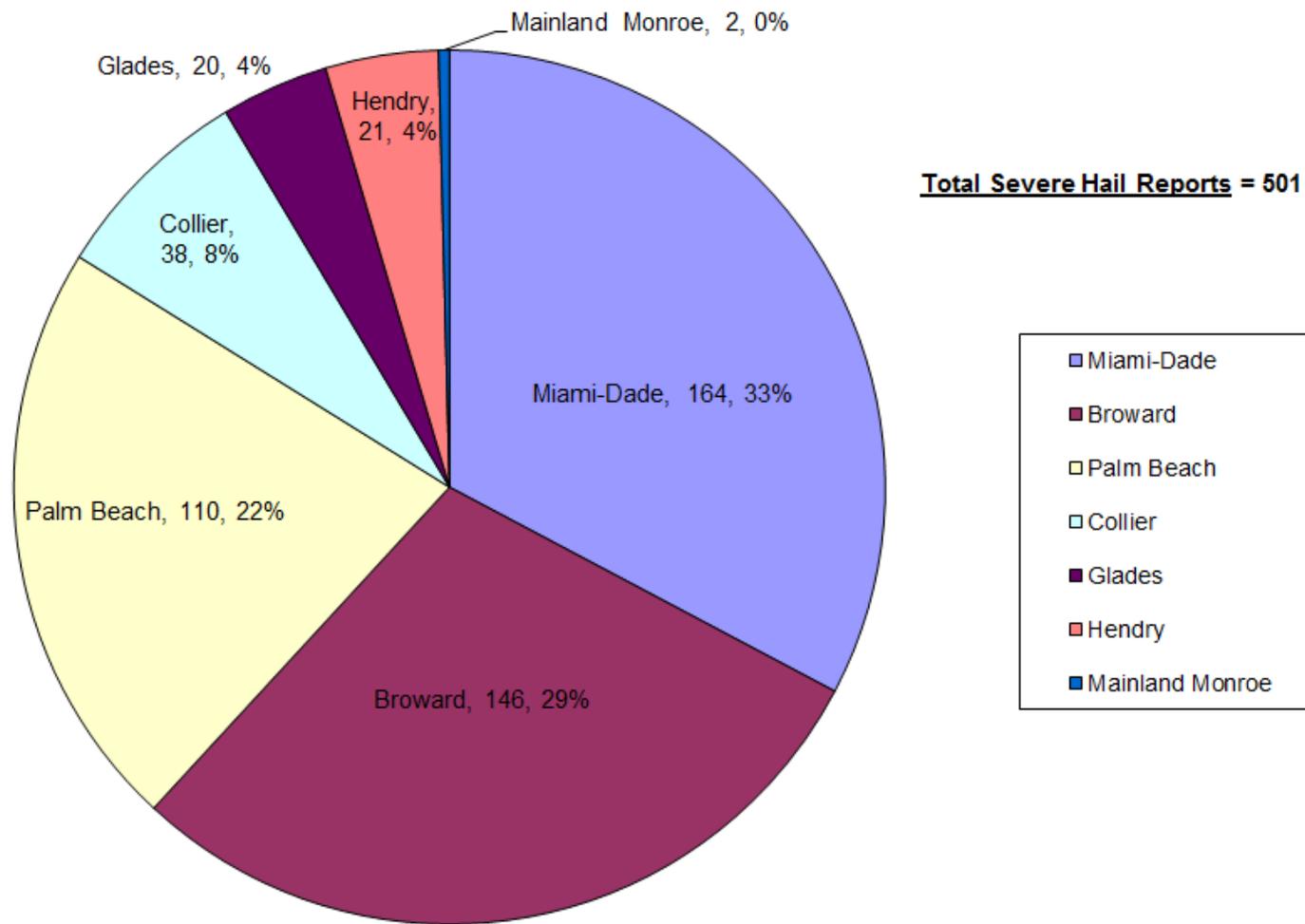


Figure 35. County Comparison of Severe Hail Reports 1955-2012.

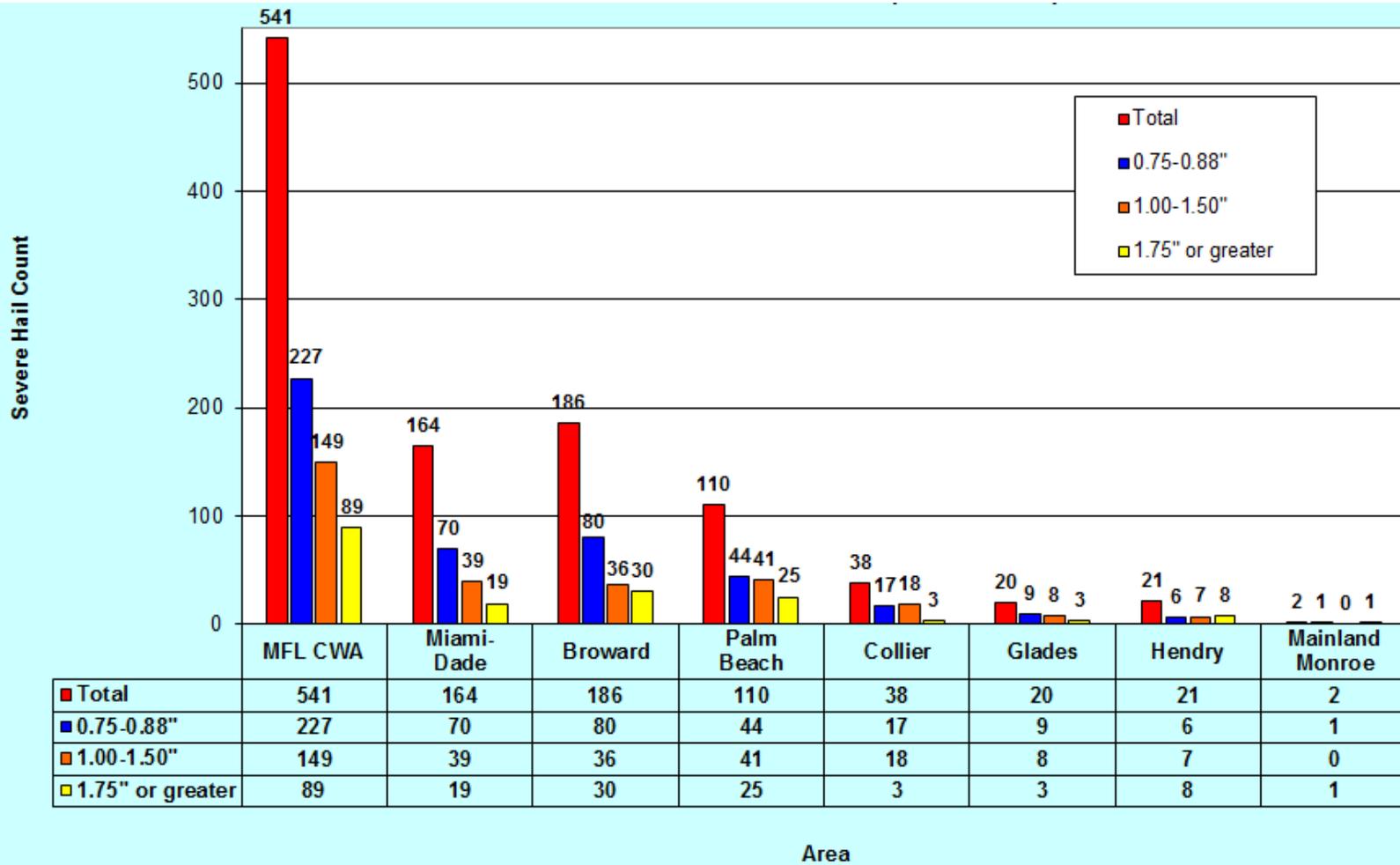


Figure 36. Severe Hail Repots and Hail Sizes for the Miami CWA and Counties 1955-2012.

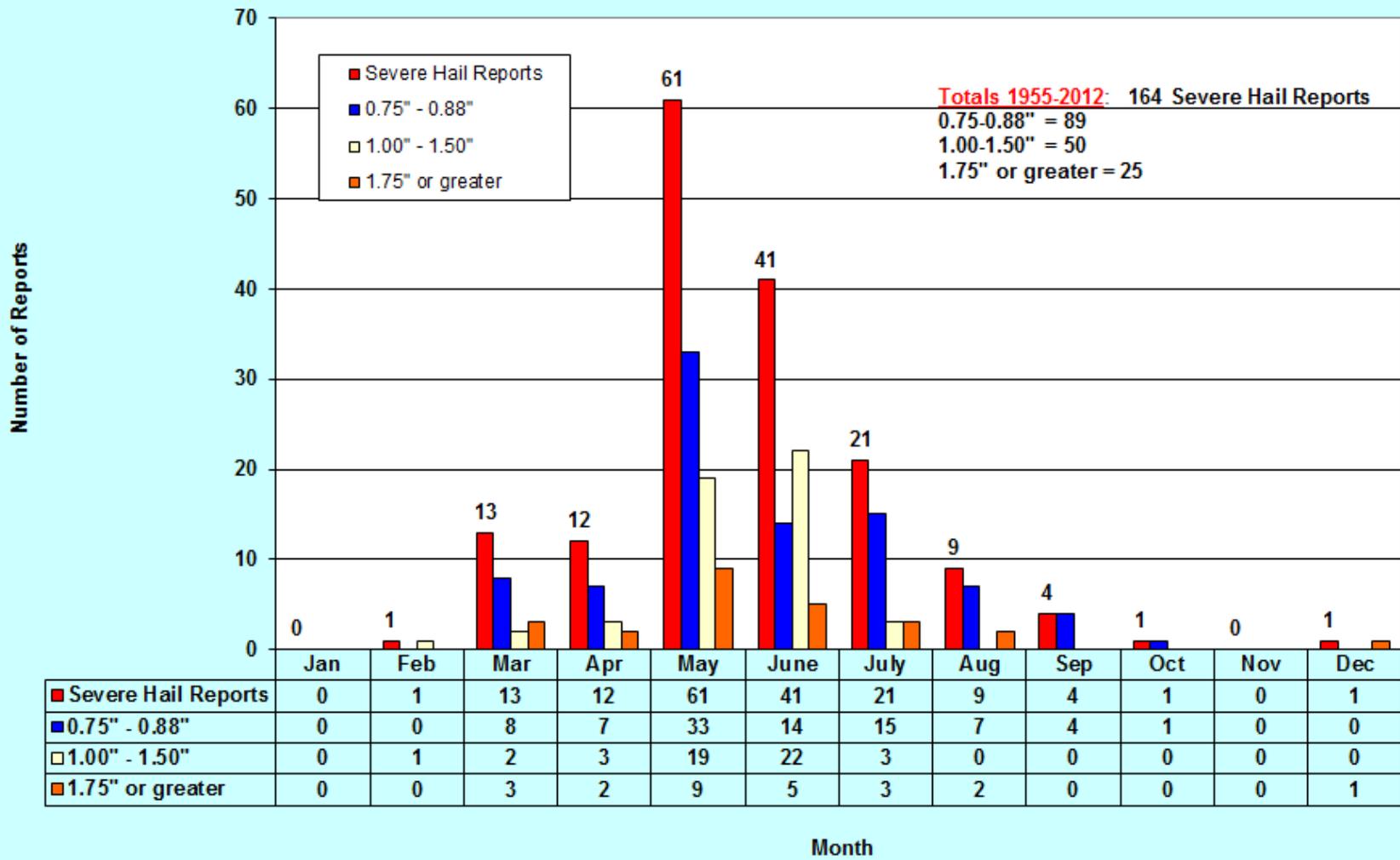


Figure 37. Miami-Dade County Severe Hail Distribution 1955-2012.

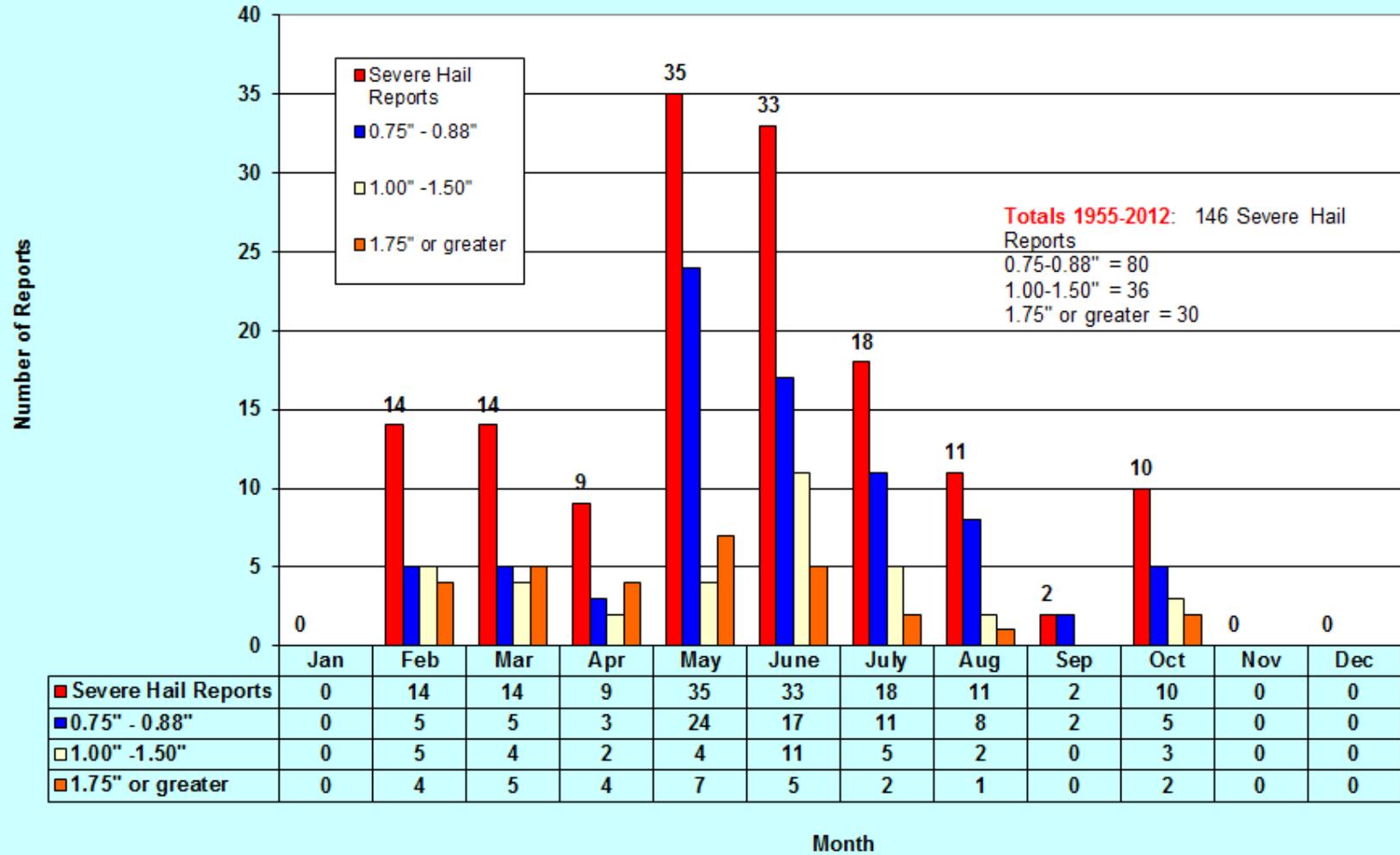


Figure 38. Broward County Severe Hail Distribution 1955-2012.

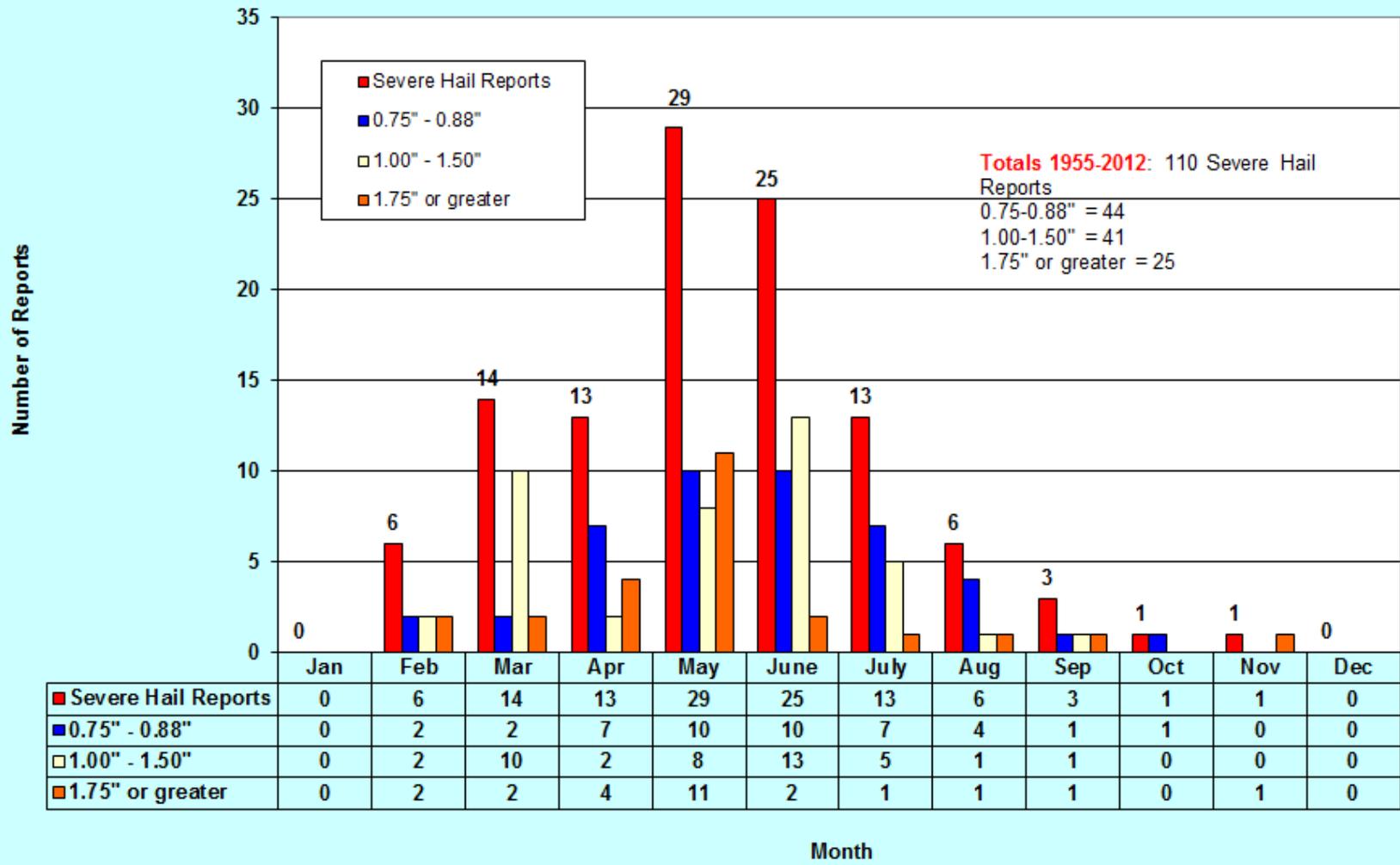


Figure 39. Palm Beach County Severe Hail Distribution 1955-2012.

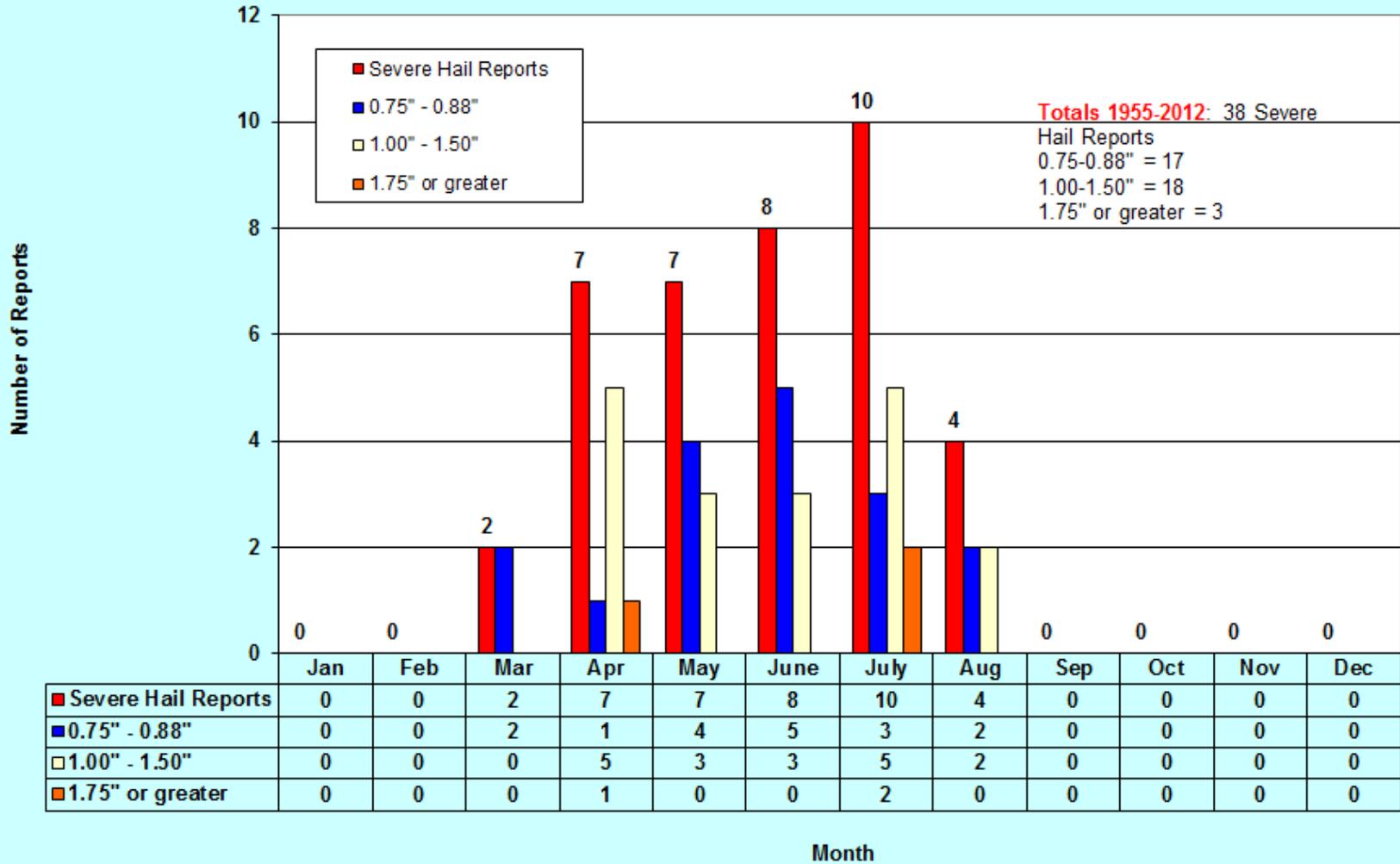


Figure 40. Collier County Severe Hail Distribution 1955-2012.

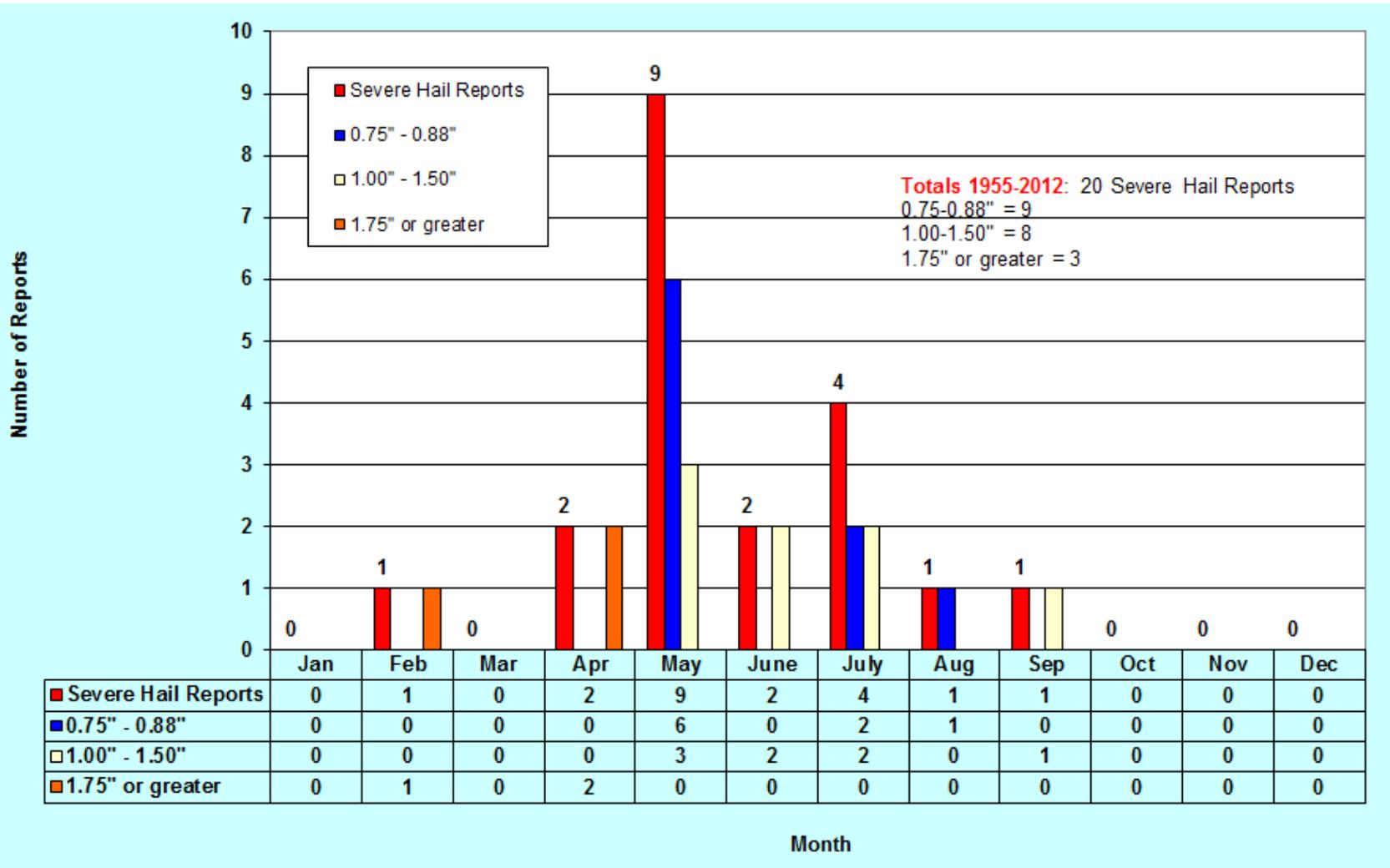


Figure 41. Glades County Severe Hail Distribution 1955-2012.

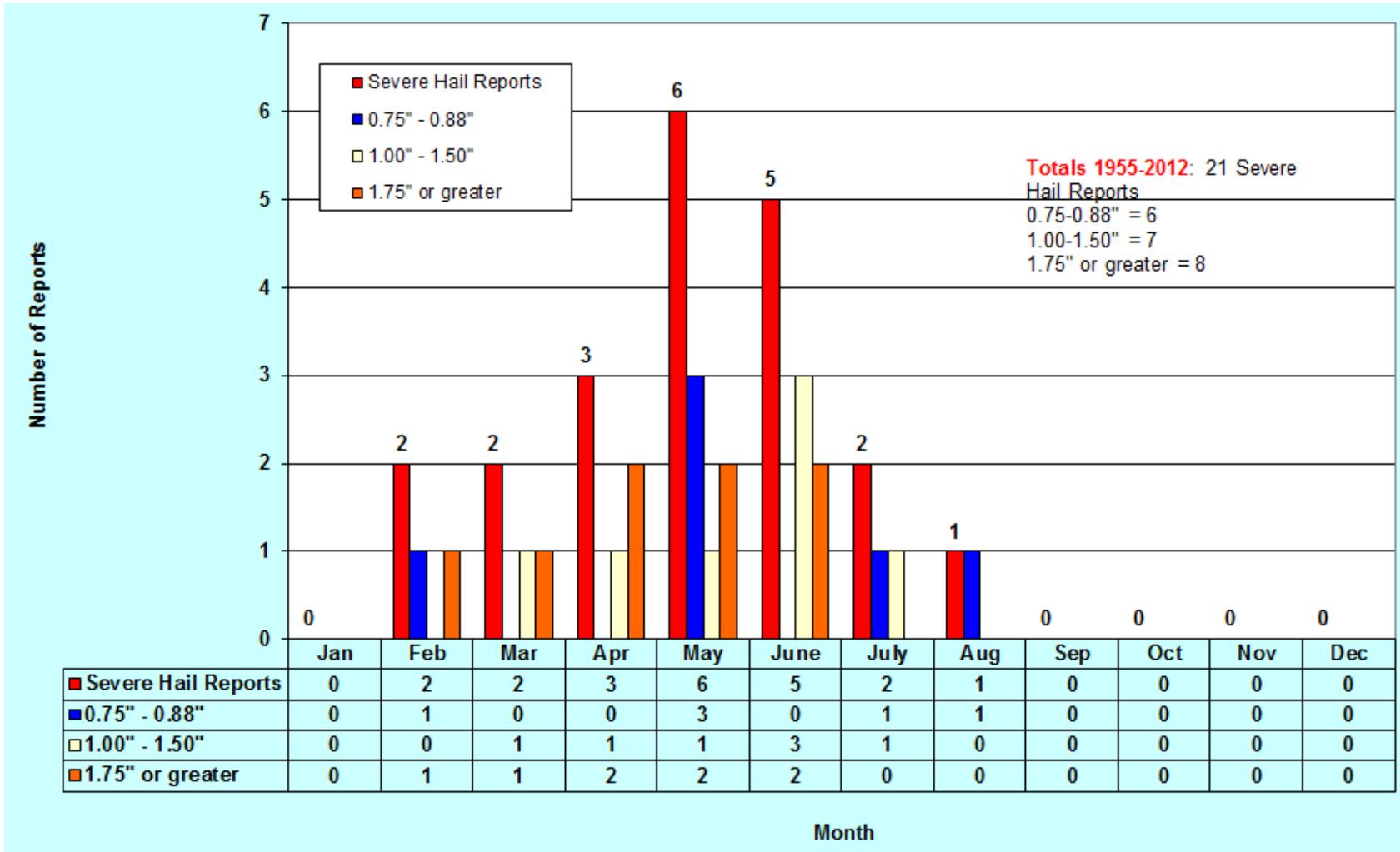


Figure 42. Hendry County Severe Hail Distribution 1955-2012.

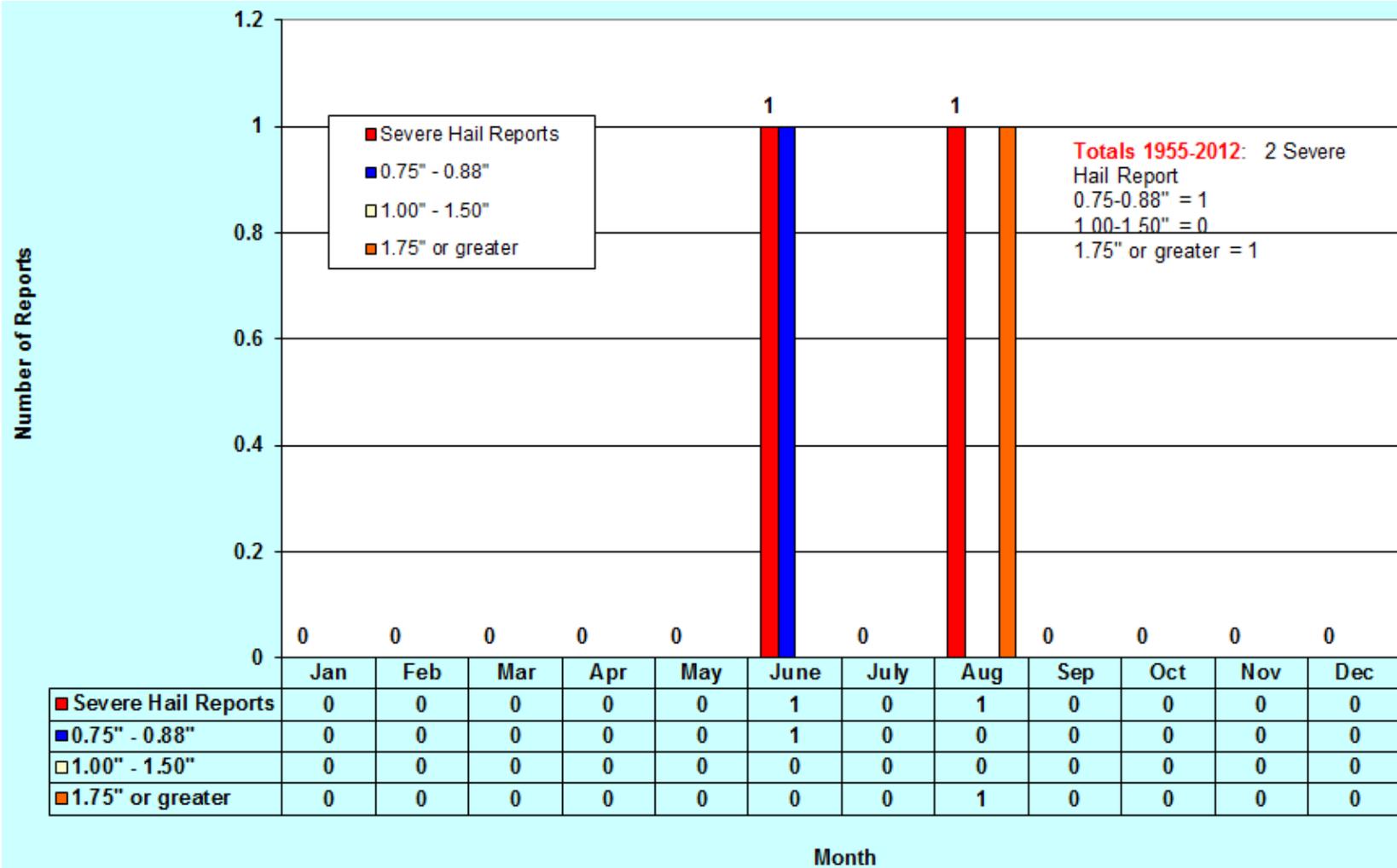


Figure 43. Mainland Monroe County Severe Hail Distribution 1955-2012.

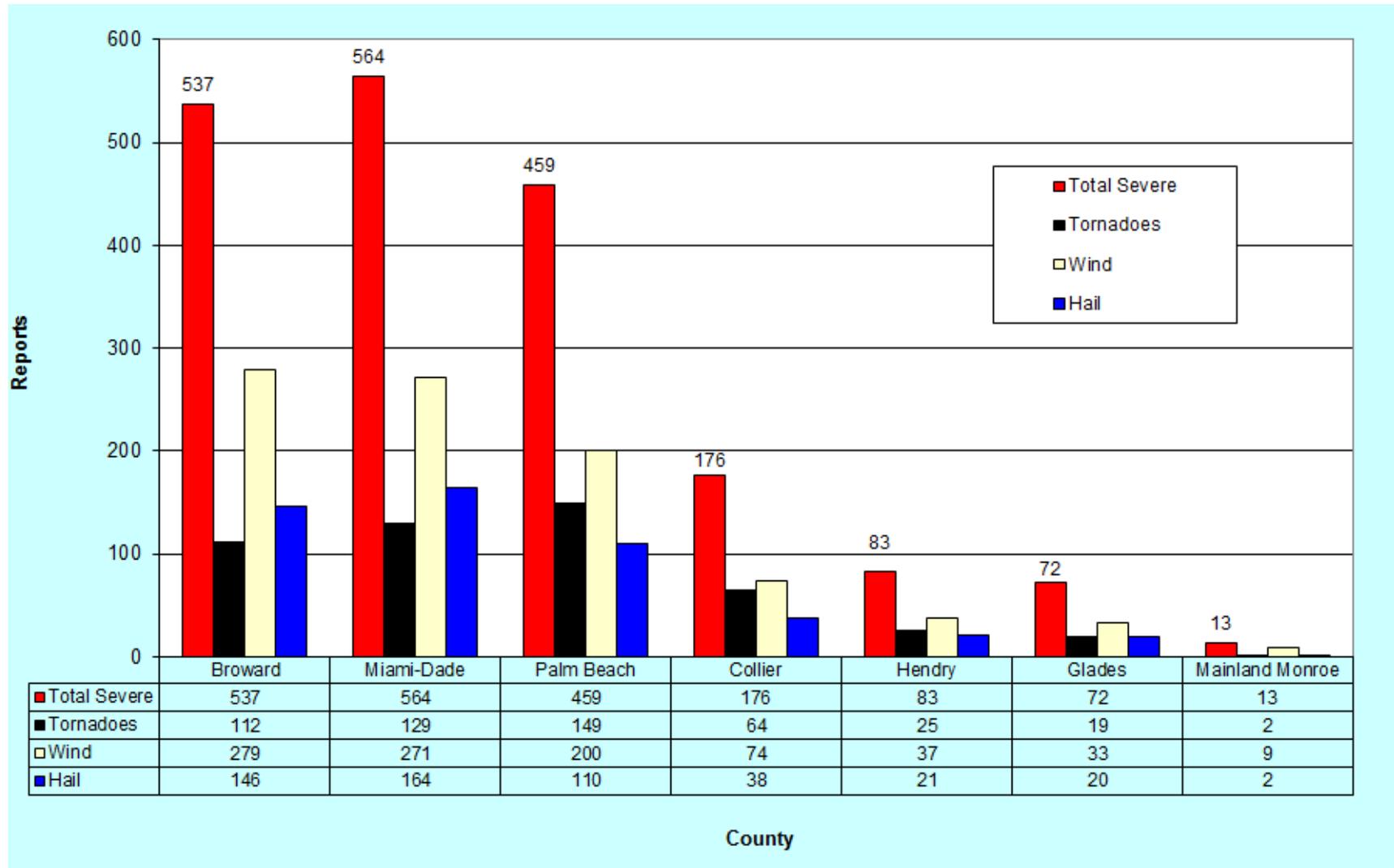


Figure 44. County Comparison of Severe Weather for the Miami CWA (1950-2012 Tornadoes & 1955-2012 Wind/Hail).

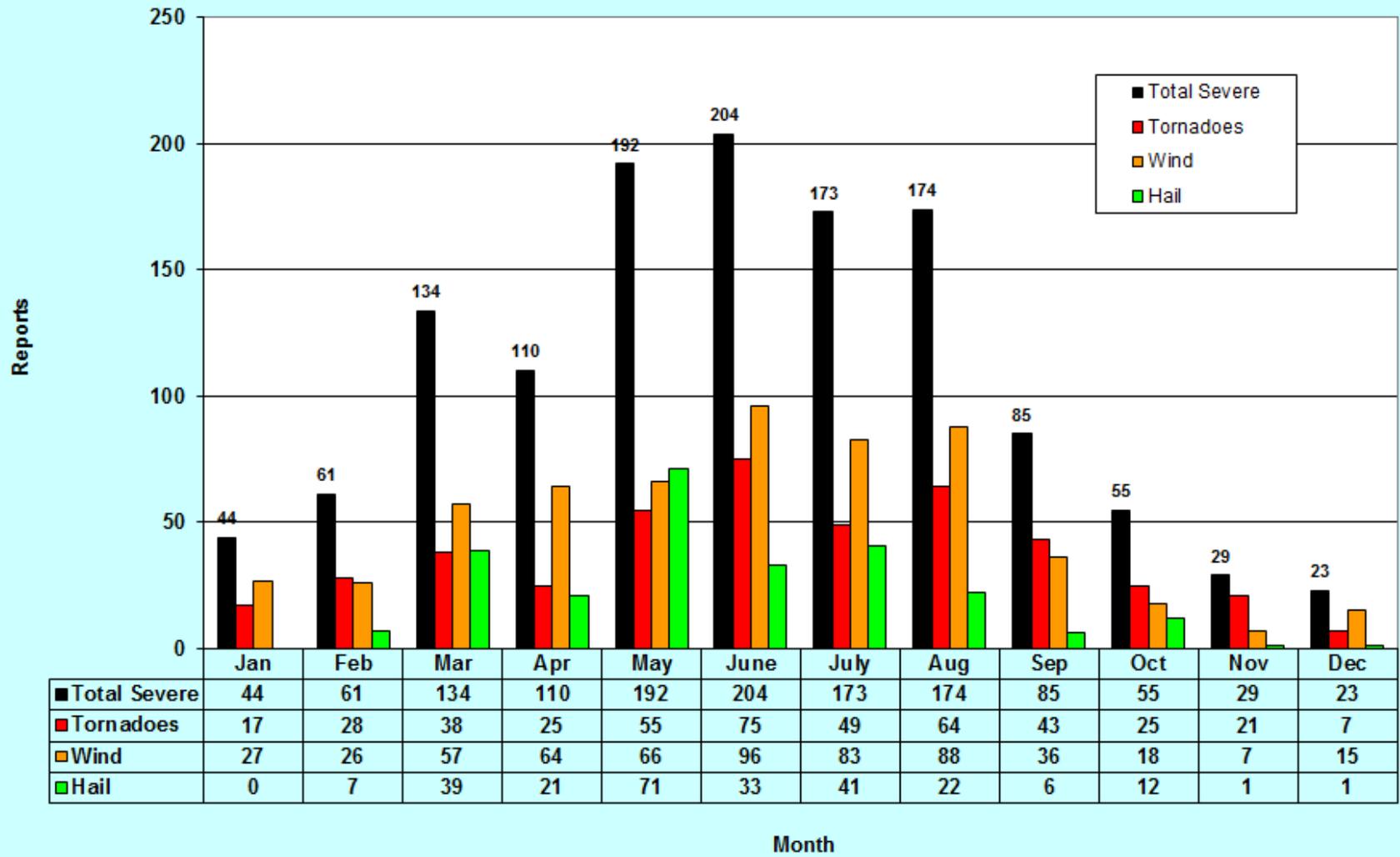


Figure 45. Monthly Distribution of Severe Weather for the Miami CWA (1950-2012 Tornadoes & 1955-2012 Wind/Hail).