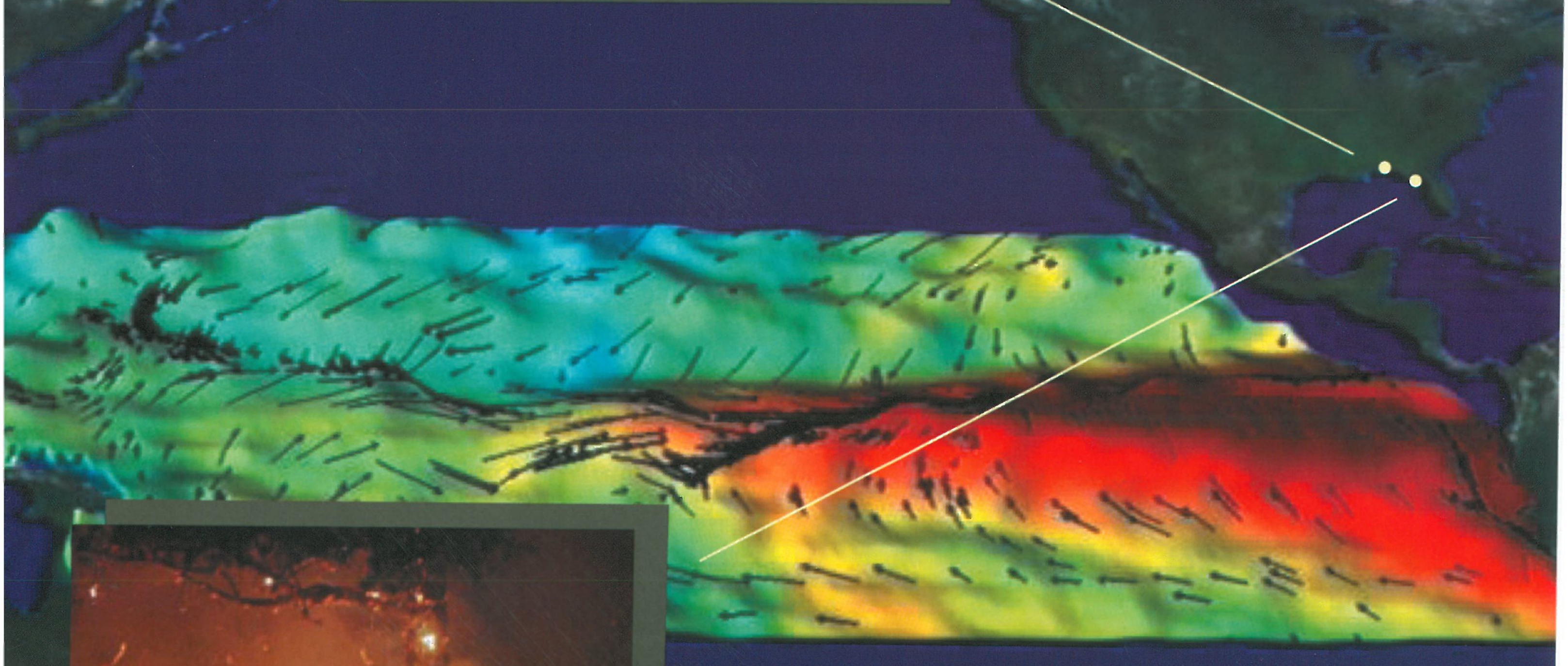
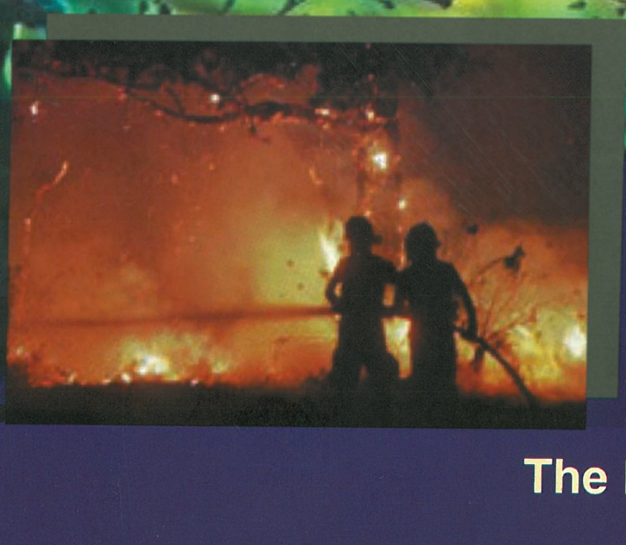
# El Niño, La Niña and Florida's Climate: Effects on Agriculture and Forestry





## The Florida Consortium

*The Florida State University/COAPS*
*The University of Florida/IFAS*
*The University of Miami/RSMAS*

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## ACKNOWLEDGMENTS

This booklet was prepared by the Florida Consortium, which is a collaborative effort of the Center for Ocean-Atmospheric Prediction Studies (COAPS) at the Florida State University, the Institute of Food and Agricultural Sciences (IFAS) at the University of Florida, and the Rosenstiel School of Marine and Atmospheric Science (RSMAS) at the University of Miami. The Florida Consortium seeks to identify regions susceptible to climate variability, assess the vulnerability of agriculture and production systems in these regions, and develop strategies to cope with climate change. The Florida Consortium has its base support from the NOAA Office of Global Programs. In addition, we have support from the National Science Foundation and the InterAmerican Institute for Global Change Research.

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# *El Niño, La Niña and Florida's Climate: Effects on Agriculture and Forestry*

The Florida Consortium


THE FLORIDA STATE UNIVERSITY
Center for Ocean-Atmospheric Prediction Studies

UNIVERSITY OF FLORIDA
Institute of Food and Agricultural Sciences

UNIVERSITY OF MIAMI
ROSENSTIEL SCHOOL OF MARINE & ATMOSPHERIC SCIENCE


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Cover: The background image shows sea surface height as well as temperature (colors) and wind (arrows) departures from normal during the El Niño of 1997-1998. The raised, bright red area indicates surface temperatures in excess of 80°F. Image provided courtesy of The Laboratory for Hydrospheric Processes, NASA/Goddard Space Flight Center. Also pictured is an AP wire photo of Florida forest fires in the summer of 1998, and a drought-damaged corn field. Photo taken by Milt Putnam, UF/IFAS.

# FOREWORD

A remarkable scientific breakthrough has enormous financial implications for agriculture and forestry in Florida and the Southeastern United States. It is now possible to forecast El Niño and its opposite, La Niña, months in advance by monitoring the Pacific Ocean west of Peru.

These phenomena are extremely important since they affect climate in Florida and the Southeastern United States. Note that we refer to climate and not weather. Weather is the day-to-day variations in temperature and precipitation. Weather is chaotic and not predictable past a few days. Climate variations are shifts of average weather patterns due to global conditions such as ocean temperatures. An example of weather is a hard freeze in Central Florida that lasts for 2-3 days. In contrast, one's heating bill may be smaller due to a warmer winter, which is climate. Climate may also mean more rainfall over the early parts of the growing season. Farmers and foresters can now know months in advance if a drought or more rain than normal is anticipated during different seasons of the year. Although there is still uncertainty about weather on a day-to-day basis during these seasons, knowing that these climate patterns are likely will allow decision makers to plan ahead to minimize the risks associated with such patterns.

In this booklet we have prepared maps and graphs to illustrate the average shifts of rain totals and temperature during different seasons due to a typical El Niño and La Niña. These graphs are based on historical data (e.g. 1948 to 1997) from dozens of weather stations across Florida and historical records of El Niño and La Niña events. Simply, El Niño usually means a wetter winter, and maybe cooler; fewer hurricanes in the previous season; and fewer forest fires, except for the early summer, such as in June 1998. La Niña usually means winter and spring drought; and more hurricanes in the preceding hurricane season. These shifts in climate and El Niño/La Niña predictions can have important implications for farmers. For example, strawberry growers have learned to plant varieties more tolerant to dry conditions in La Niña years. Some potato farmers in south Florida have crowned their fields in El Niño years to allow excess January rains to run off. There are potentially many other money-making possibilities for farmers in Florida and other states in the Southeastern United States. This publication is provided solely for information purposes. The information does not constitute either a prediction of future weather conditions or recommendations to modify agricultural practices.

We are continuing to study these ideas and opportunities, and would appreciate hearing about efforts utilizing information in this report. Please browse our website at (http://www.coaps.fsu.edu/lib/Florida_Consortium), or contact us via email, fax, or telephone.


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# INTRODUCTION

In the winter of 1982-1983, one of the strongest El Niño events measured this century developed undetected in the waters of the tropical Pacific. California and the Gulf Coast were battered by strong winter storms, while other parts of the country were drier and warmer than normal. The event opened the eyes of the nation as well as the scientific community to the potential climate impacts caused by fluctuations in sea surface temperatures of the equatorial Pacific Ocean. This year to year variability of climate influences many aspects of our daily lives, with impacts ranging from our comfort level when we work or travel to disasters such as hurricanes and floods. It can also influence the productivity and safety of our work. The agriculture and forestry industries are particularly vulnerable to variations in climate. With a heightened awareness of El Niño and La Niña driven climate patterns, these sectors have expressed the need for more detailed information on which to base their decisions.

### *What are El Niño and La Niña?*

Recorded as far back as the 1500's, unusually warm water appeared periodically off the coast of Peru. This often occurred around Christmas, thus the phenomenon was called El Niño for the Christ child. Satellite measurements and moored buoys now show that the warm waters of an El Niño extend along the equator well out into the central Pacific (see cover). The tropical Pacific can be thought of as a large bathtub. Normally, trade winds blow from east to west, piling up warm water around Indonesia and Australia. During an El Niño, the trade winds die down and the warm water sloshes back towards the South American coast, resulting in sea surface temperatures that are much warmer than normal. In a La Niña, stronger than normal trade winds bring up cooler water from the ocean's depths, causing the sea surface to be colder than normal. Although El Niño and La Niña return every 2 to 7 years, the tropical Pacific can be thought of as neutral, or near normal, a majority of the time. In fact, neutral years outnumber El Niño or La Niña years over 2 to 1.

### *How Ocean Temperatures Affect Florida's Climate*

The jet stream is a fast moving ribbon of air that circles the globe several miles above the ground. The jet stream is responsible for steering storms and fronts, driving the day-to-day weather we all experience. In an El Niño winter, the warm surface waters of the Pacific provide a source of heat and moisture that strengthens the jet stream, pulls it further south and keeps it flowing west to east across the southern United States. The new position guides winter storms into California and along the Gulf Coast. These storms provide abundant rainfall and cooler temperatures for Florida and the deep South. In La Niña winters, a weaker jet stream strays to the north and meanders across the country. Fronts and storms do not make it down to Florida as often and the winters are warmer and dryer than normal.

Through their relatively predictable influence on the climate of Florida and surrounding states, El Niño and La Niña have important implications for agricultural production. El Niño and La Niña influence yields of winter vegetables, some citrus species, sugarcane and field corn in Florida, and several crops in the neighboring states. This booklet summarizes the effects of El Niño and La Niña years on the climate of Florida and the Southeast, with particular emphasis on effects that potentially impact agriculture and forestry. Maps of the Southeast United States are presented that show how average seasonal temperature and precipitation changes during El Niño and La Niña years. These maps depict these changes for not only Florida, but also for neighboring states. To concentrate on Florida, graphs show average monthly values of temperature, precipitation and other variables important to agriculture. For convenience, the graphs are based on six of Florida's climate divisions (excluding the Florida Keys) for selected weather variables, and on seven locations that have solar radiation data for potential evapotranspiration and rainfall deficit. In addition, the graphs present differences between El Niño and neutral years and between La Niña and neutral years to highlight times of the year when these two conditions have the most impacts.

A word of caution is in order. This booklet shows averages for a number of past El Niño and La Niña events. However, not all El Niño, neutral, or La Niña years are the same. A particular event may not have the monthly averages shown in the graphs. Although the average of past years is a good indication of what future El Niño or La Niña years will be like, it is not a precise prediction of what will happen in a specific year.

## DATA AND METHODOLOGY

### *Defining El Niño and La Niña*

The first step in the analysis is to classify each year between 1946 and 1997 as El Niño, La Niña or neutral. There are many different ways to define an El Niño or La Niña. We use an index developed by the Japan Meteorological Agency (JMA) that is based on sea surface temperature anomalies (departures from monthly normals) averaged over an area of the eastern Pacific between 4°N and 4°S and between 90°W and 150°W. The index is smoothed with a five-month running mean to isolate long term trends. The JMA categorizes an El Niño as at least six consecutive months with averaged sea surface temperatures in the defined area at least 0.9°F (0.5°C) higher than normal, including the months of October, November, and December. A La Niña (or cold phase) is defined the same way except for averaged sea surface temperatures at least 0.9°F below normal.

Each El Niño, La Niña or neutral year is defined as beginning in October and running through September of the next calendar year. The year is defined in this manner to capture the maturation of an El Niño or La Niña, which usually peak in December and January, and their subsequent decay through the following summer. Each year from 1946 through 1997 is classified as El Niño, La Niña, or neutral according to the JMA index (Table 1).

### *Maps of Temperature and Precipitation Anomalies*

The climate data used in preparing the maps are from the 1998 release of the U.S. Historical Climate Network (USHCN) data set from the National Climatic Data Center (NCDC). The stations were chosen for length of record, homogeneity, quality and spatial coverage.

The data were quality controlled by NCDC, then adjusted for a number of biases including time of observation, station relocation/instrument change, missing data, etc. The result is a homogeneous monthly data set suited for the study of long term climate trends. For the purposes of this study, only observations from 1946 through 1997 were used. Data quality and missing values were a concern for earlier observations. Also, each station must have less than 5% missing values during this time period in order to be considered.

The maps were prepared using the USHCN station data for the Southeast United States. For each station, seasonal averages of mean temperature and total precipitation were computed for warm, cold, and neutral years. Anomalies, or departures from the neutral conditions, were found by subtracting the neutral seasonal average from the El Niño or La Niña seasonal average. When plotted on a map, these anomalies show the areas of Florida and the Southeast that are most affected by El Niño and La Niña.

### *Graphs of Monthly Average Climate Statistics*

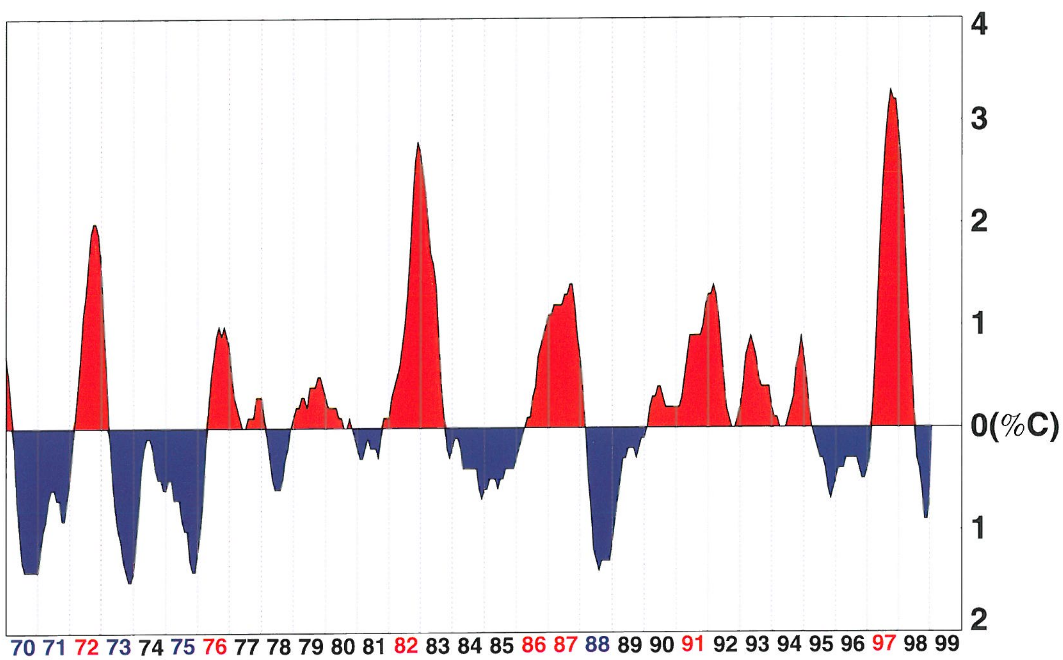
Monthly average rainfall and temperatures were calculated from daily data from five weather stations in each climate division in Florida (except for Division 7, the Florida Keys) for preparation of the graphs. We used available weather stations with at least 95% complete records from 1948 to 1995. Where more than five stations were available in a climate division, we selected those that gave the best spatial coverage. Heating degree-days were calculated from hourly temperatures interpolated from the daily minima and maxima. The best methods to calculate reference evapotranspiration require solar radiation data. Reliable solar radiation data were available for enough years (1961-1990) at only a few locations in and around Florida. Graphs of reference evapotranspiration and precipitation deficit were derived for seven locations.

To compute the graphs, monthly values for each climate division were calculated as an average of the five stations, weighted by the number of days of available data from each station to account for possible unequal numbers of missing data for the different stations. For each calendar month, the average was calculated separately for the El Niño, neutral, and La Niña years.

## **Table 1:** El Niño, La Niña and Neutral Years

| El Niño | Neutral | | La Niña |
|---|---|---|---|
| 1951 | 1946 | 1978 | 1949 |
| 1957 | 1947 | 1979 | 1954 |
| 1963 | 1948 | 1980 | 1955 |
| 1965 | 1950 | 1981 | 1956 |
| 1969 | 1952 | 1983 | 1964 |
| 1972 | 1953 | 1984 | 1967 |
| 1976 | 1958 | 1985 | 1970 |
| 1982 | 1959 | 1989 | 1971 |
| 1986 | 1960 | 1990 | 1973 |
| 1987 | 1961 | 1992 | 1975 |
| 1991 | 1962 | 1993 | 1988 |
| 1997 | 1966 | 1994 | |
| | 1968 | 1995 | |
| | 1974 | 1996 | |
| | 1977 | | |

### Pacific Sea Surface Temperature Anomalies (JMA Index)



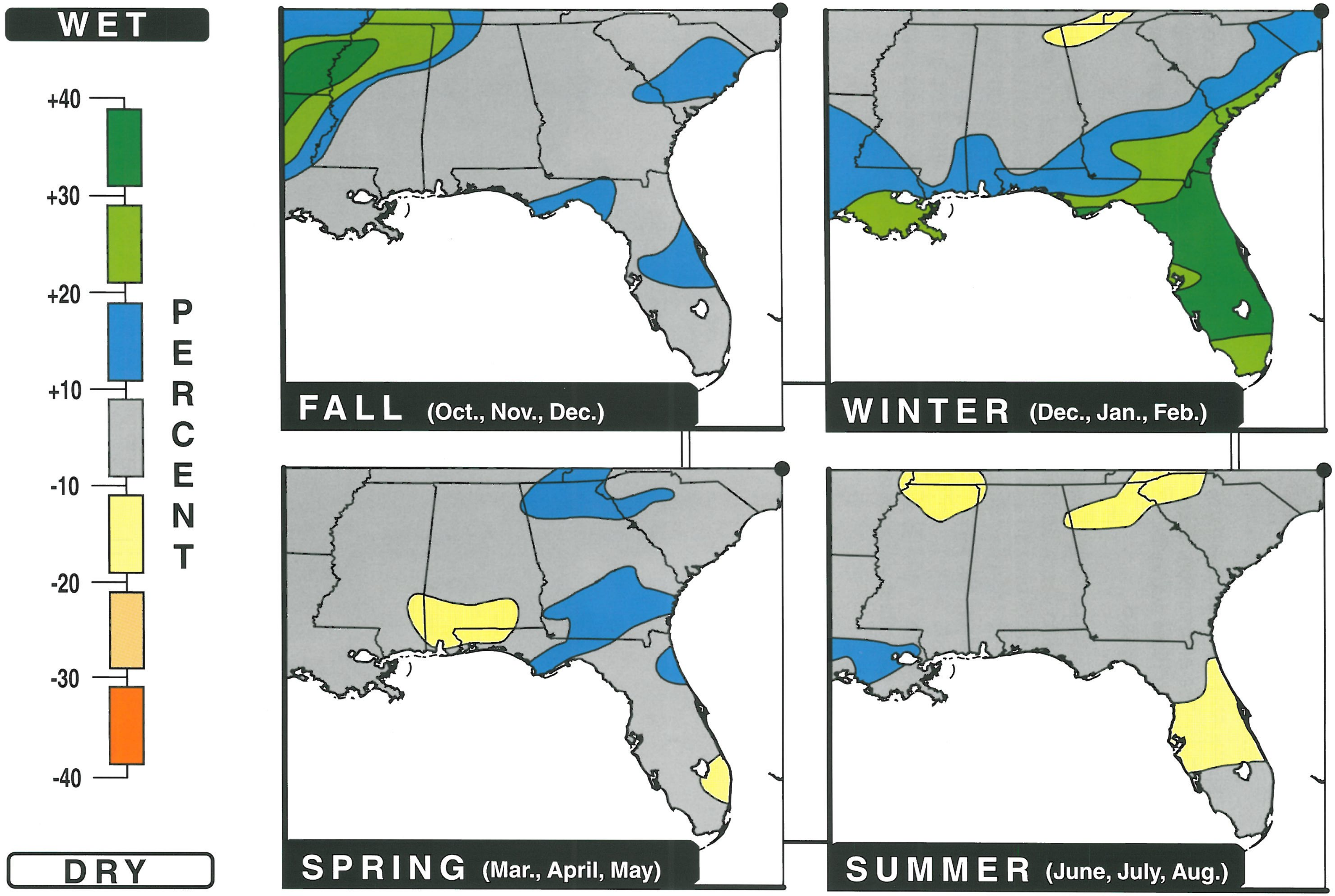
## PRECIPITATION

Inadequate water availability is probably the most important factor limiting crop production in the absence of irrigation. Excess water can affect crops adversely by damaging root systems, leaching plant nutrients, favoring development of some diseases, and sometimes delaying field operations.

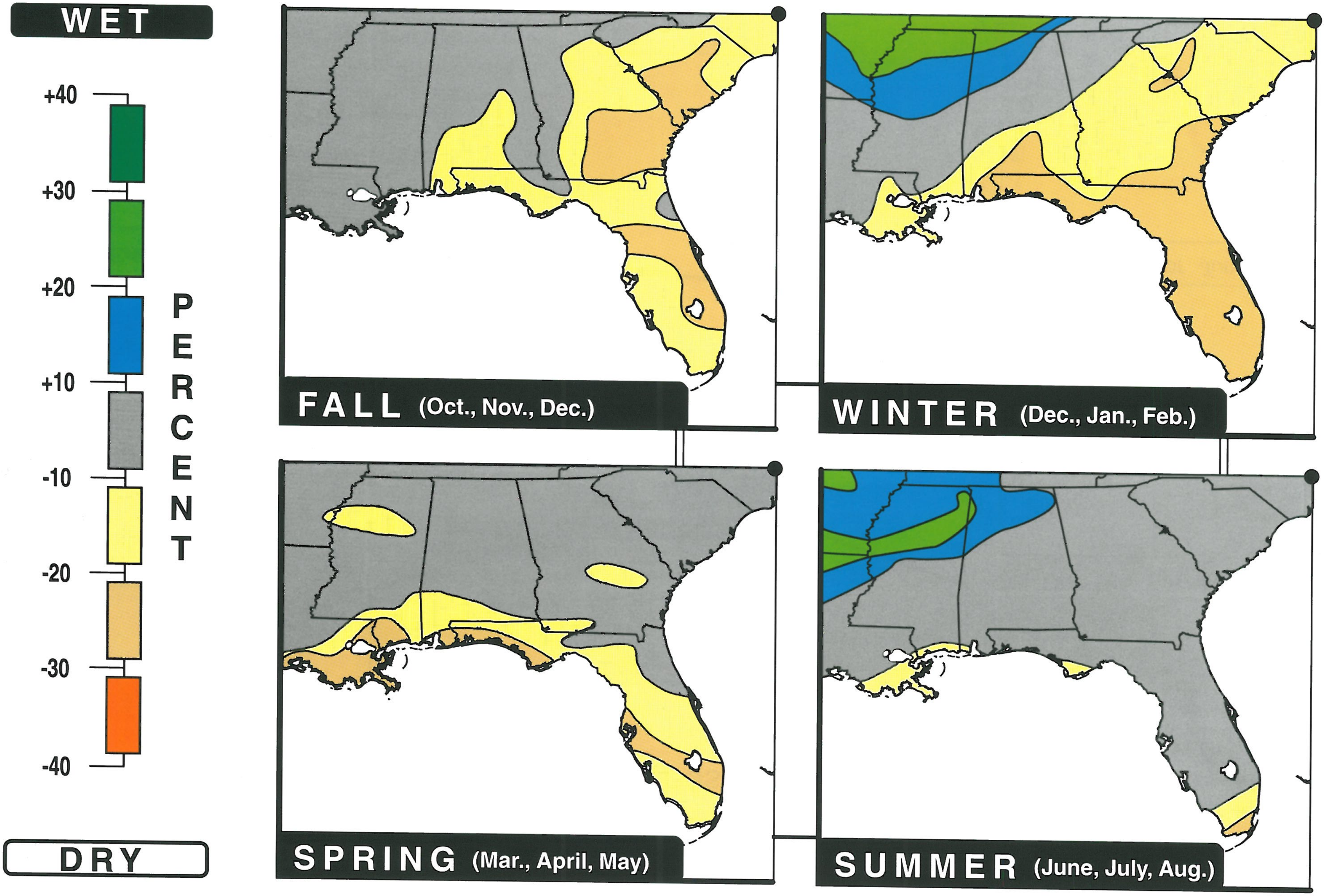
One of the most striking impacts is the increase in average winter (November to March) rainfall during El Niño years, and the decrease in La Niña years. Florida is particularly vulnerable, with an excess of over 30% of the normal seasonal total across much of the state during an El Niño winter. La Niña has the opposite effect, with deficits of 10% to 30% lasting from fall through winter and spring. The monthly deviation from normal due to either El Niño or La Niña conditions exceeds 30% in all of Florida's climate divisions, and 50% in the southern peninsula (Divisions 4 and 5) during some part of the year. The excess winter rainfall in El Niño years can affect yields of winter-harvested vegetables adversely.

Flood damage assessment of mango tree at Homestead, Florida as a result of tropical storm Gordon in 1995. Picture was taken by Dr. Johnathan H. Crane, University of Florida/IFAS Tropical Research and Education Center, Homestead, Florida.

# El Niño Seasonal Precipitation Anomalies

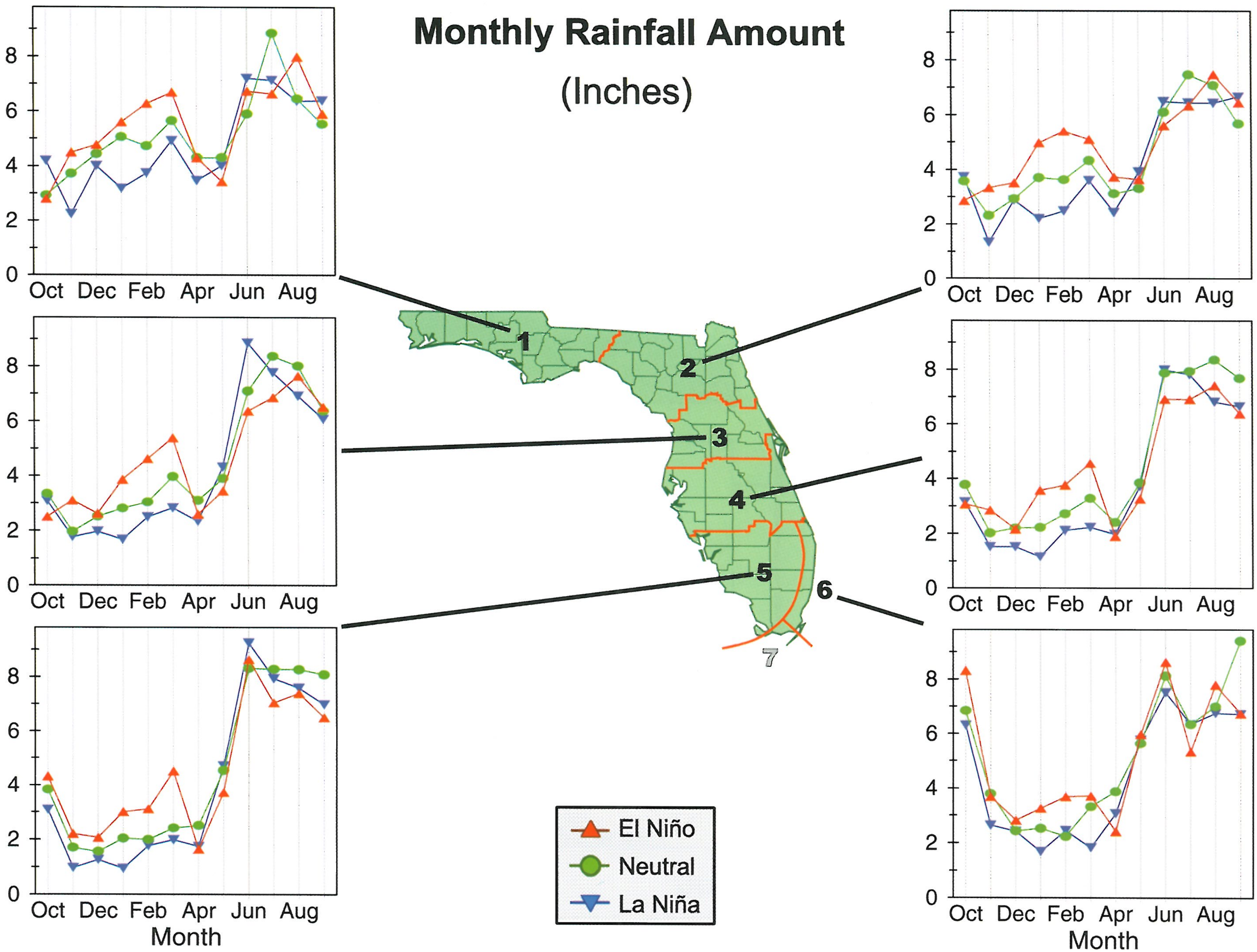


# La Niña Seasonal Precipitation Anomalies



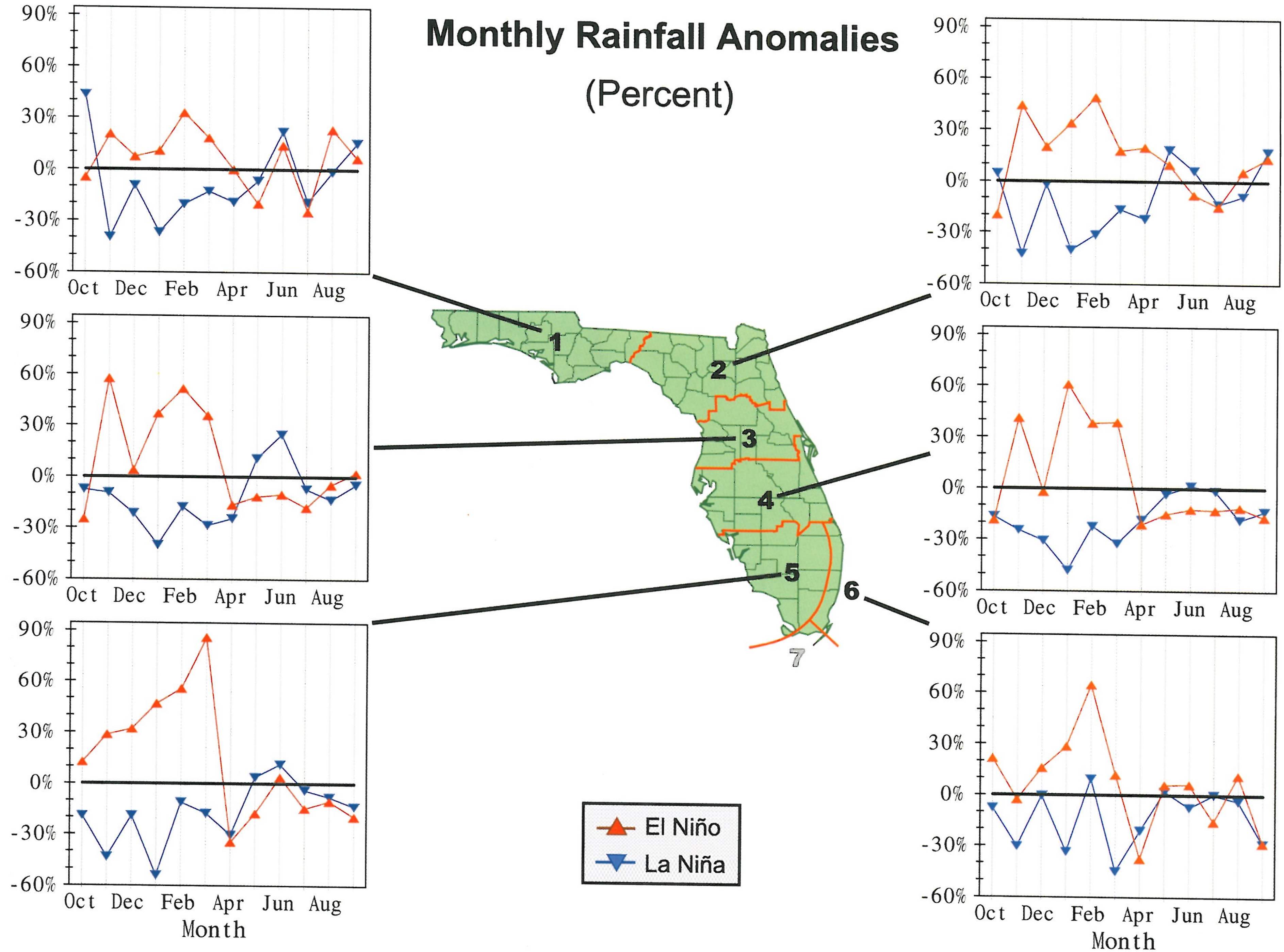
# Monthly Rainfall Amount

(Inches)



# Monthly Rainfall Anomalies

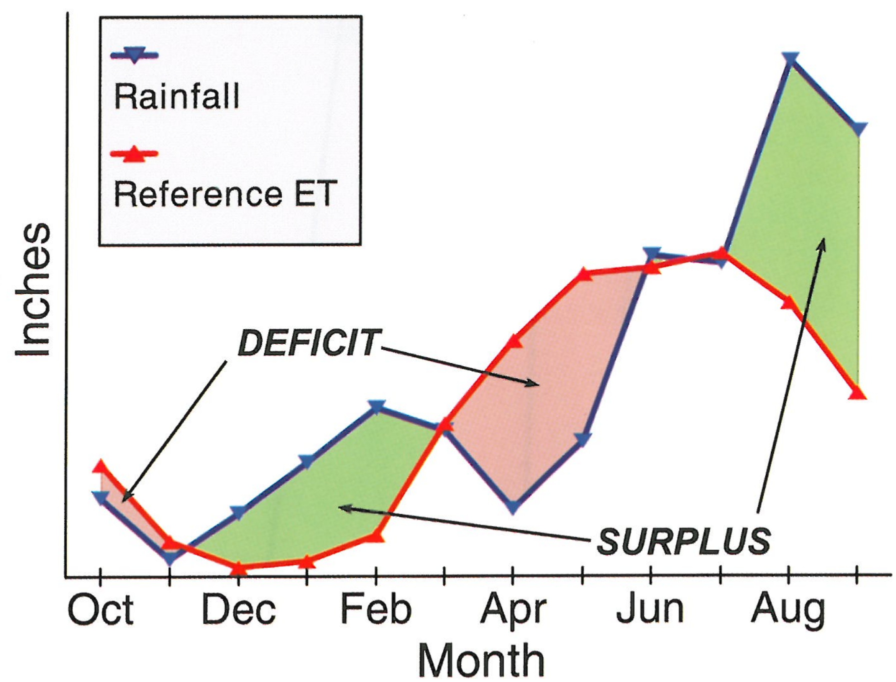
(Percent)



## EVAPORATION AND RAINFALL DEFICIT

Evaporative demand, or potential evapotranspiration, influences the amount of water plants need each day, and the amount of stress that plants experience when water supply is inadequate. Reference evapotranspiration (ET) is the maximum rate of evaporation from a short, growing, well-watered grass under given air temperature, humidity, wind and solar radiation.

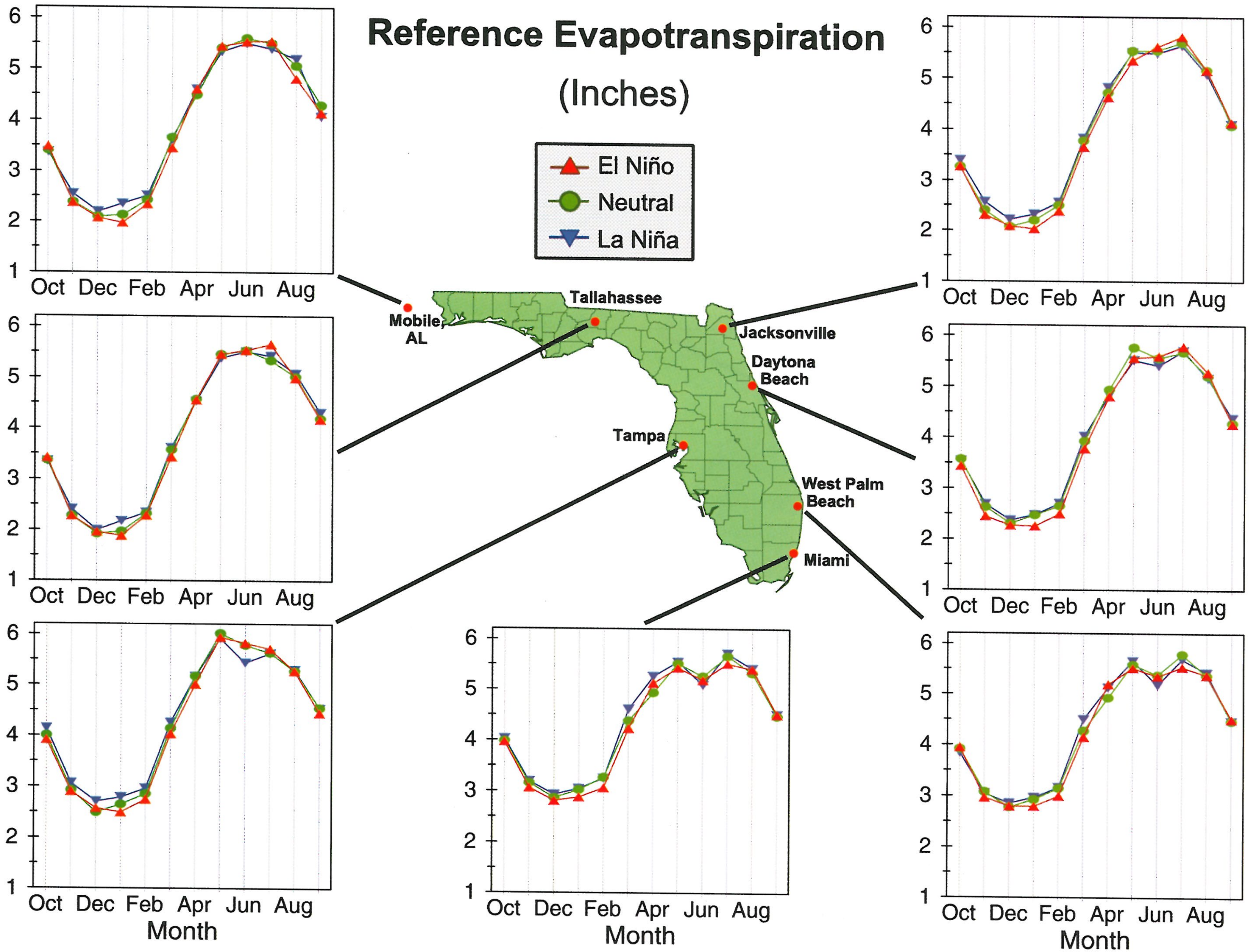
Under rain fed production conditions, precipitation represents the supply of water, and reference evapotranspiration the upper limit of demand for water. As the graph below indicates, precipitation surplus or deficit is the difference between the two. A surplus occurs when rainfall exceeds reference ET. Rainfall less than reference ET indicates a deficit. Precipitation deficit is a useful indicator of the potential for water stress in crops, and therefore the need for supplemental irrigation. However, actual water use and irrigation requirements are considerably more complicated, depending on characteristics of the crop and soil, and on the timing of rainfall.



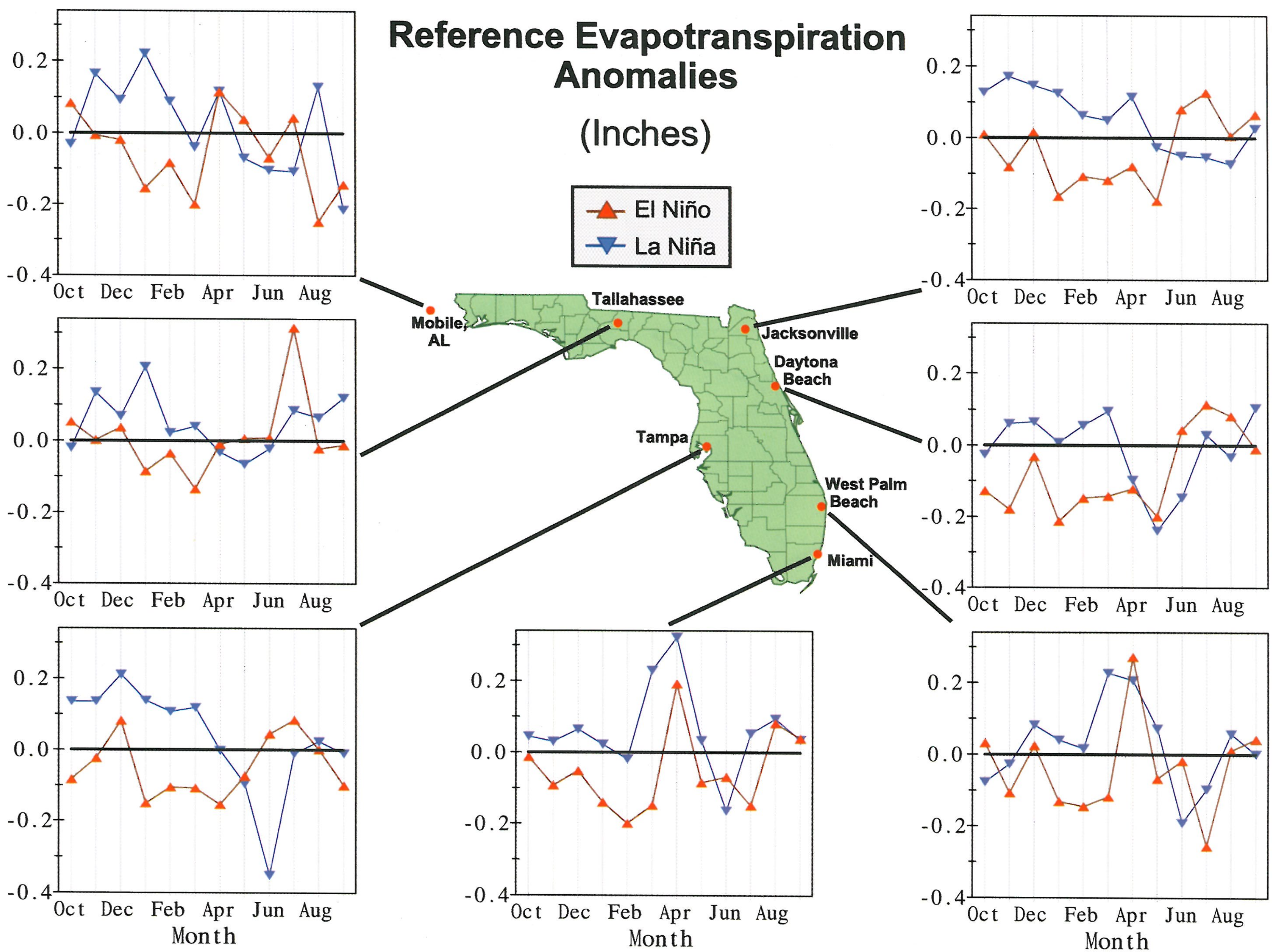

In most of the state, reference ET is higher than normal in La Niña years and lower than normal in El Niño years from November to March. However, the difference seldom exceeds two-tenths of an inch. The critical period for rainfall deficit is from March to May in most of the state. The deficit is likely to be more severe in April in northern Florida, and in March in southern Florida during La Niña years. Rainfall deficit is generally less (equivalently, surplus is greater) in El Niño years from January to March. The impact of El Niño and La Niña on rainfall deficit are less consistent in the summer months.

# Reference Evapotranspiration

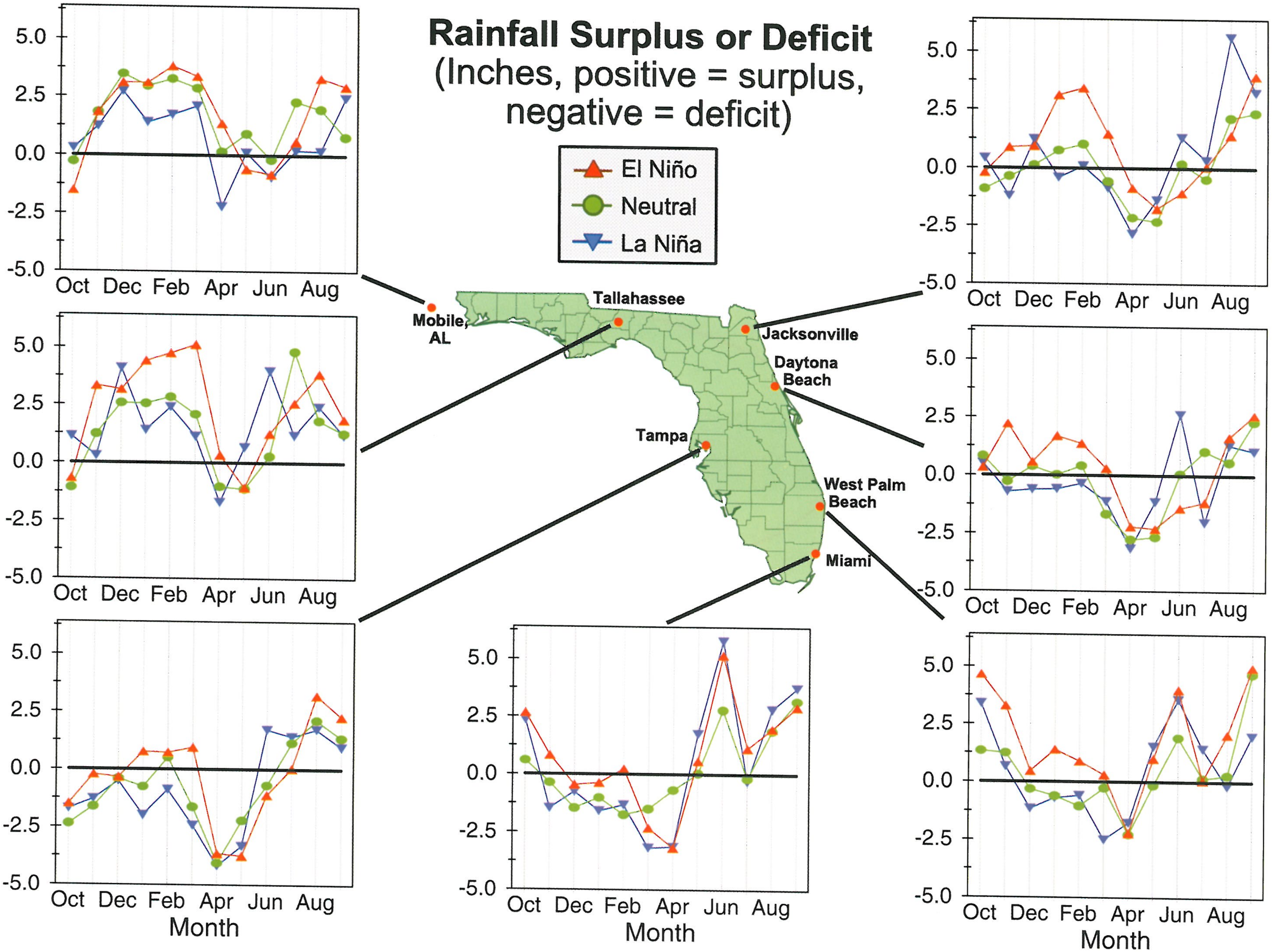
(Inches)



# Reference Evapotranspiration Anomalies (Inches)

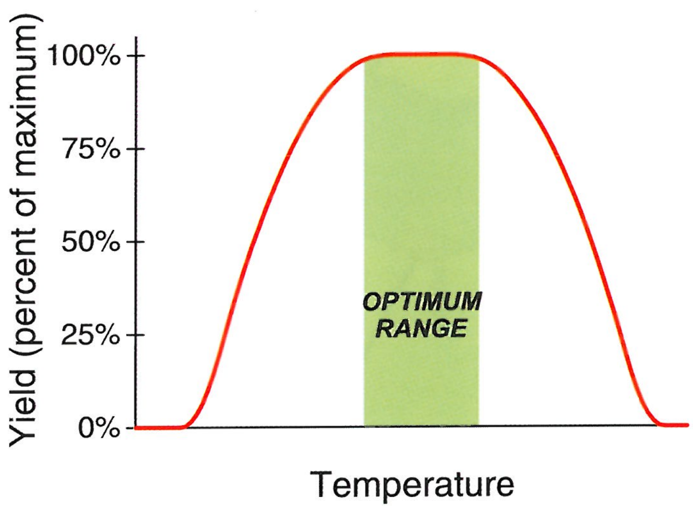


# Rainfall Surplus or Deficit
(Inches, positive = surplus, negative = deficit)



# TEMPERATURE

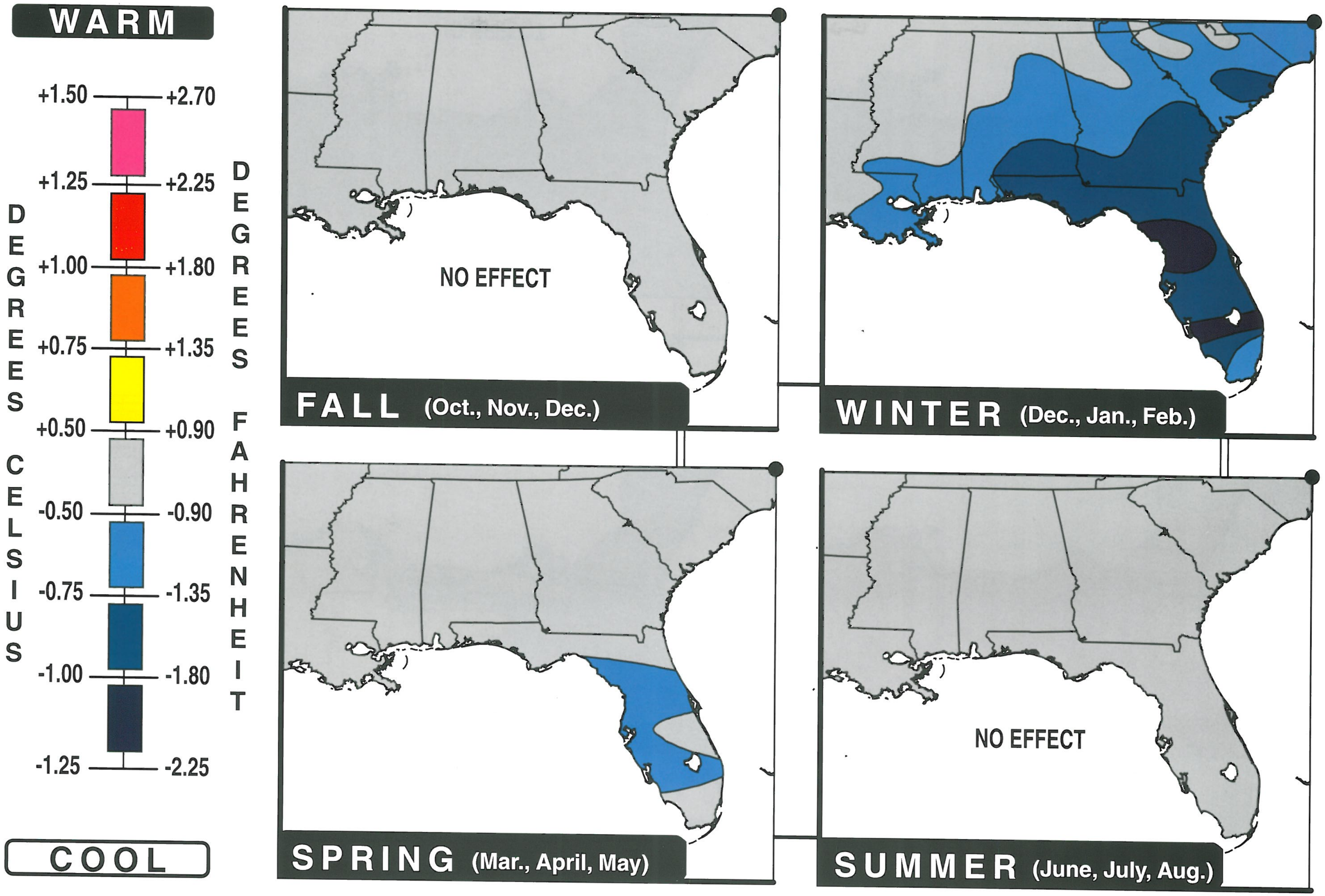
Crops and animals are affected adversely when temperatures are either too hot or too cold. The idealized graph below shows how yields of an irrigated crop might respond to season-average temperatures. Different crops have different optimal temperatures. Because mammals regulate their body temperature, they tend to have wider optimal temperature ranges than crops, but experience heat stress at temperatures lower than many crops. Temperature also influences the rates of biological processes, and therefore the timing of flowering and harvest. Temperatures above or below critical target values also influence energy costs associated with heating or cooling. The section on degree-days discusses these effects on crop development and livestock heat stress.



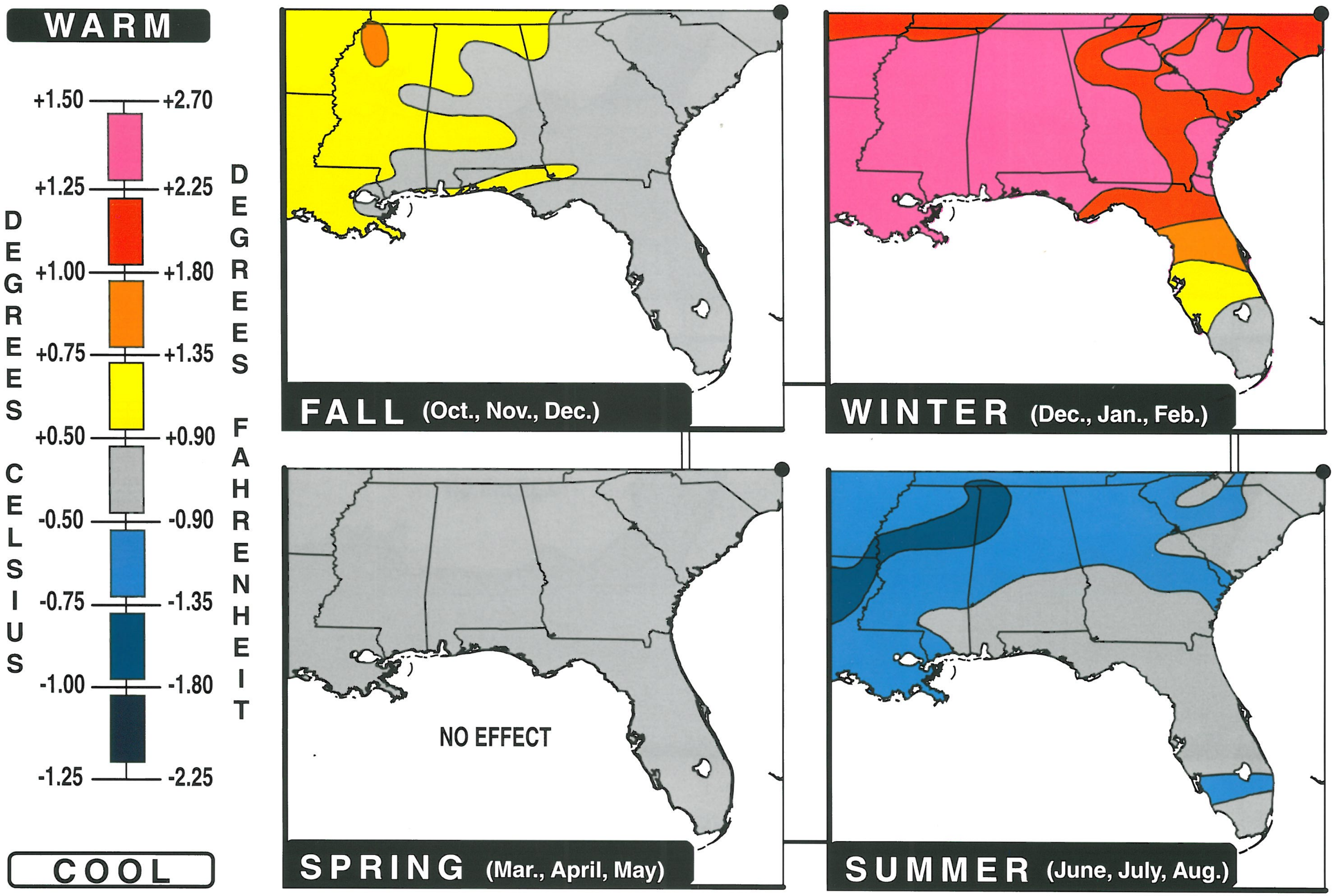

Changes in average daily maximum or minimum temperatures associated with El Niño or La Niña conditions are much smaller than the differences between seasons. However, departures from normal are significant in Florida, especially during winter months. Florida and the Gulf Coast can expect to see average temperatures 2°F to 3°F below normal during El Niño years. La Niña has the opposite effect, with temperatures 2°F to 4°F above normal during winter months. La Niña's effect on temperature is more pronounced in north Florida, Alabama, and Mississippi.

Monthly departures from normal for Florida's climate divisions show the same trends, with greatest departures in January and February. In the winter and spring months (December to April), average daily maximum temperatures are higher than normal in La Niña years, and lower than normal in El Niño years through most of the state. The effect of La Niña on winter temperatures generally increases as we move north within the state. The effects of El Niño and La Niña on winter average daily minimum temperatures is not as strong. In southern Florida, however, average daily minimum temperatures in the summer (June to August) tend to be lower than normal in La Niña years. Lower nighttime temperatures may benefit growth and yield of some crops.

# El Niño Seasonal Temperature Anomalies

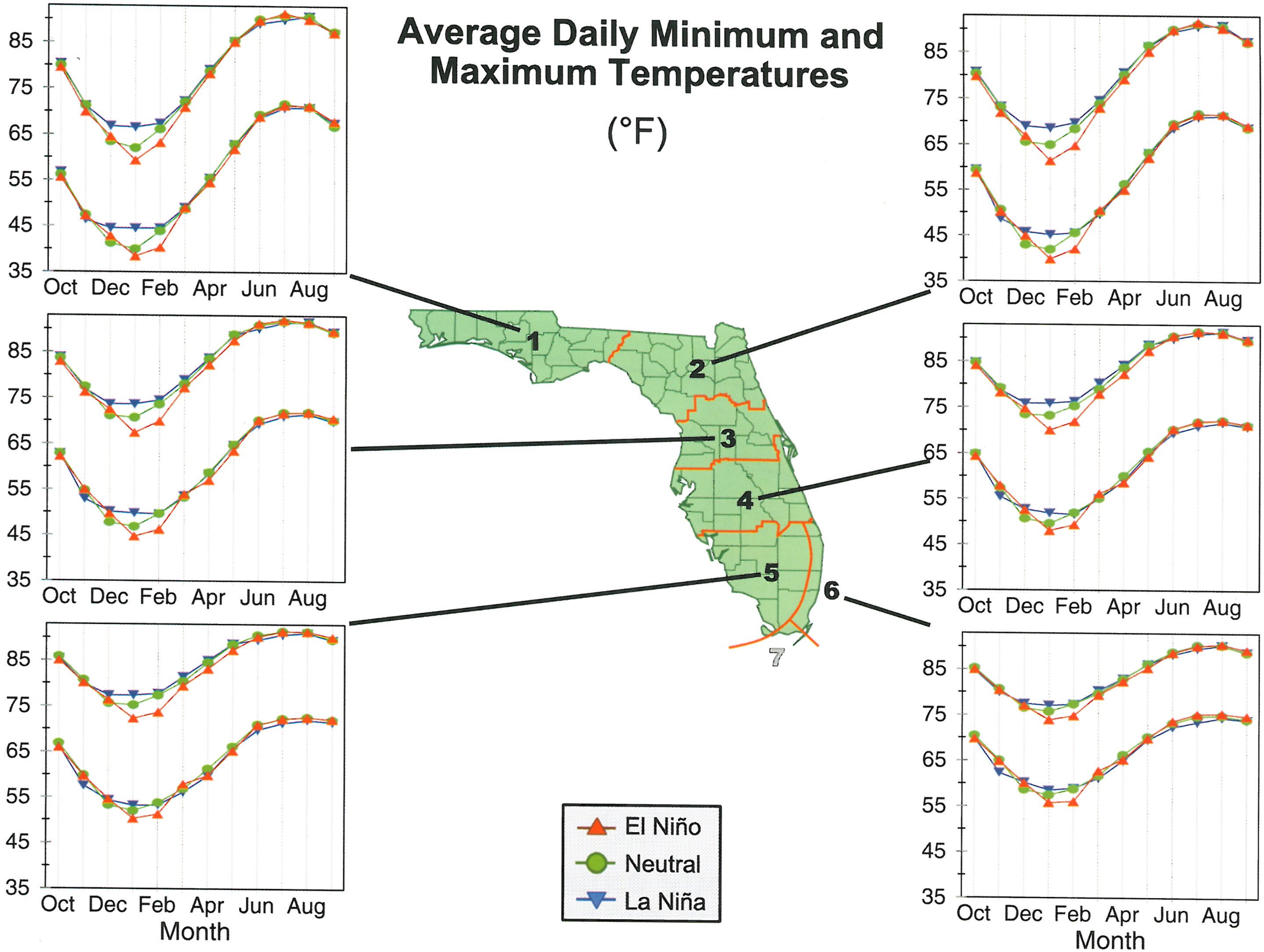


# La Niña Seasonal Temperature Anomalies



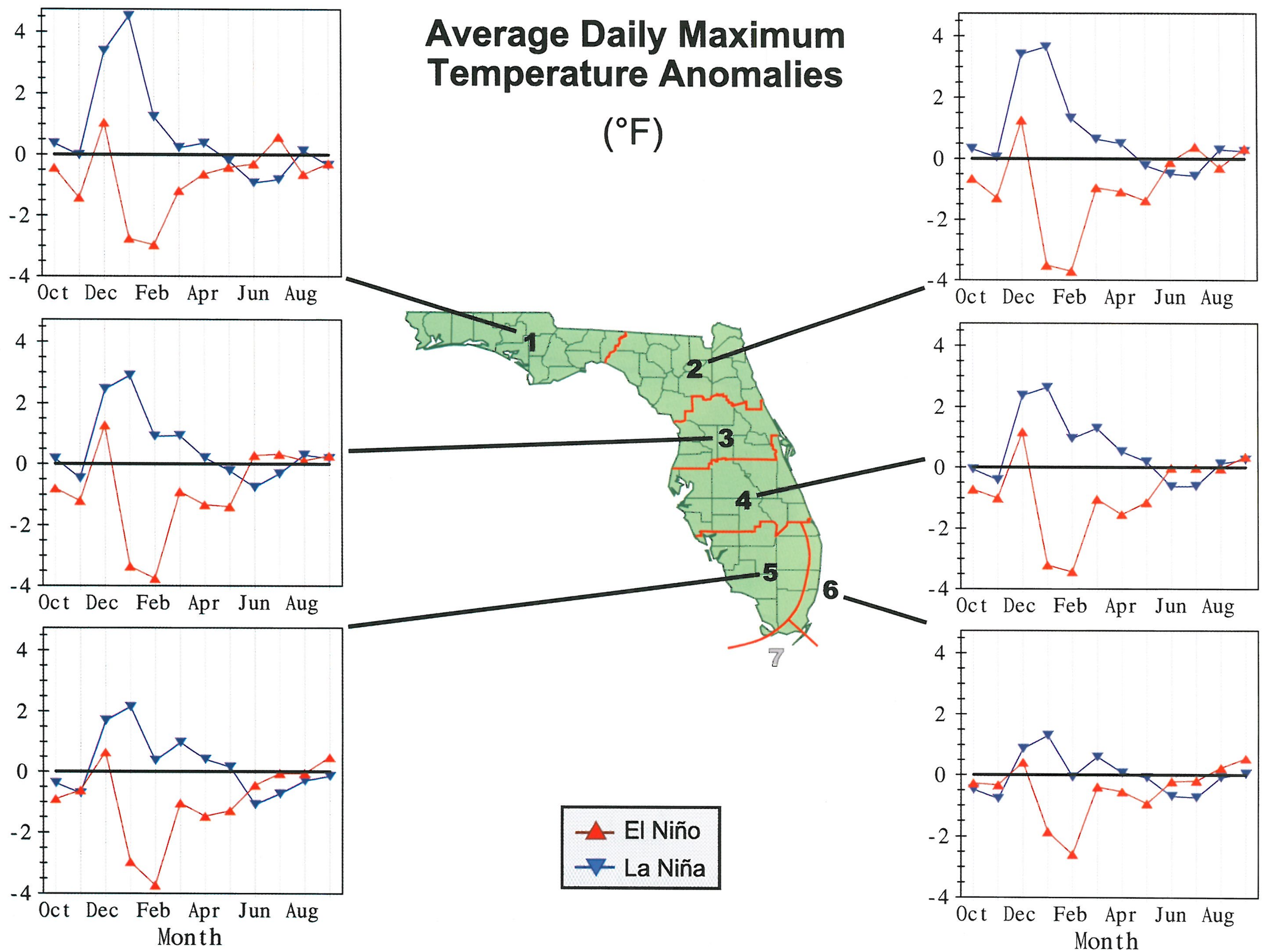
# Average Daily Minimum and Maximum Temperatures

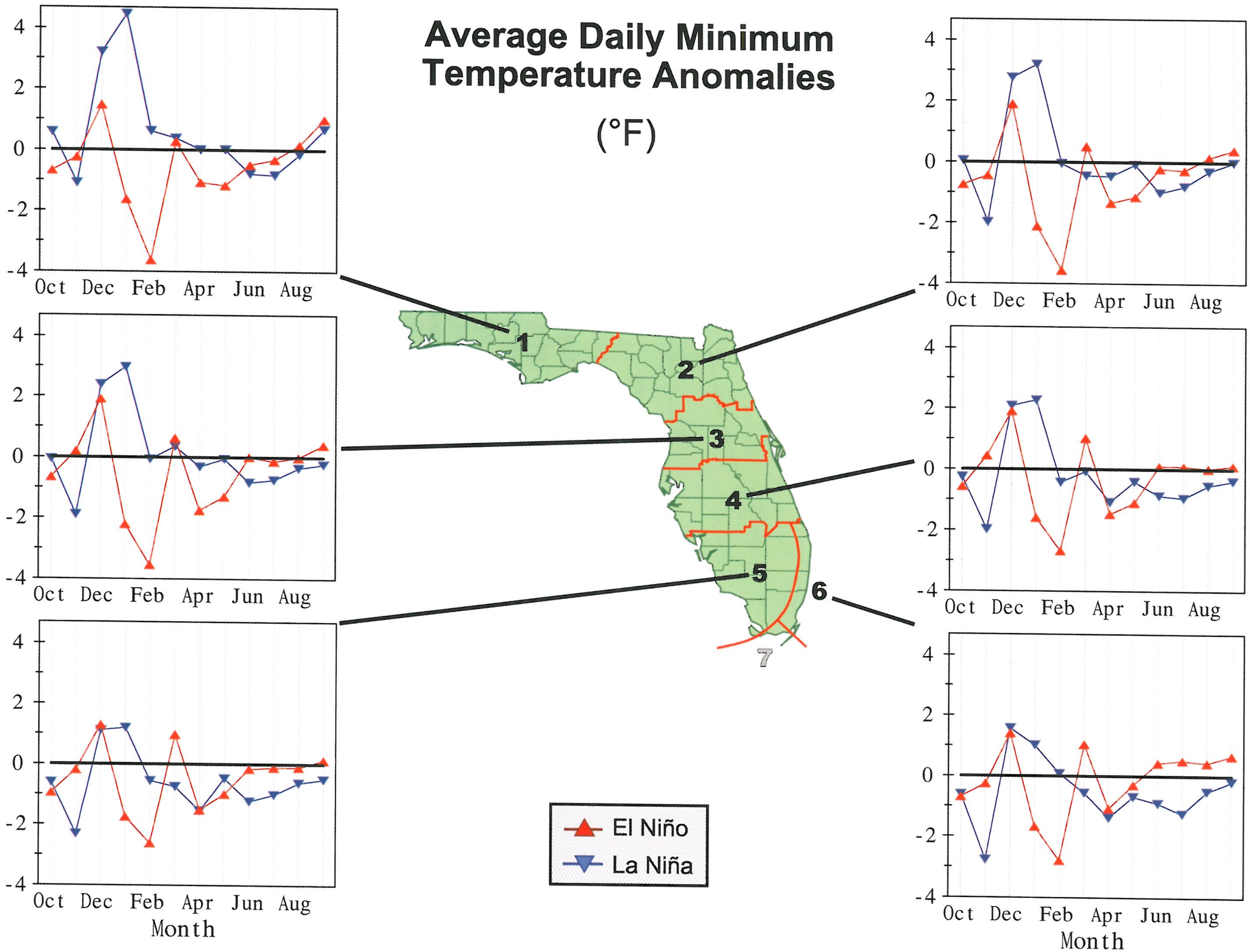
## (°F)



# Average Daily Maximum Temperature Anomalies

(°F)

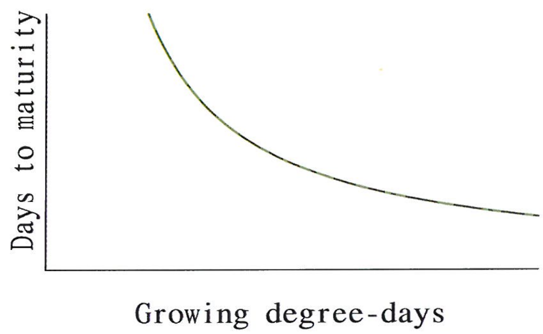




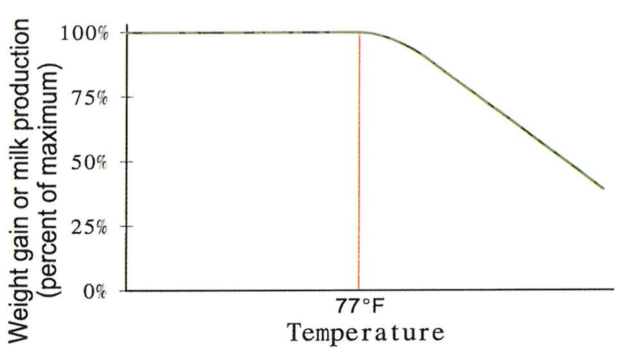
Average Daily Minimum
Temperature Anomalies
(°F)
1
2
3
4
5
6
7
El Niño
La Niña
4
2
0
-2
-4
Oct Dec Feb Apr Jun Aug
Month

# GROWING AND HEAT STRESS DEGREE-DAYS

Degree-days represent the accumulation or summation through time of temperatures above some base temperature. Degree-days above a base temperature of 50°F (often called "growing degree days") are used to estimate the time to flowering or maturity of several field crops. Higher numbers of degree-days in a given month favor earlier flowering and maturity. El Niño and La Niña influence growing degree days primarily in the winter (December through February). For winter crops that are insensitive to day length, development is likely to be about 5-10% faster than normal in December to February of La Niña years, and about 10-15% slower in El Niño years in South Florida (Division 5). Although the effect increases to the north and west (up to 35% increase in January of La Niña in Division 1), relatively few annual crops are grown north of Division 5 in the winter.

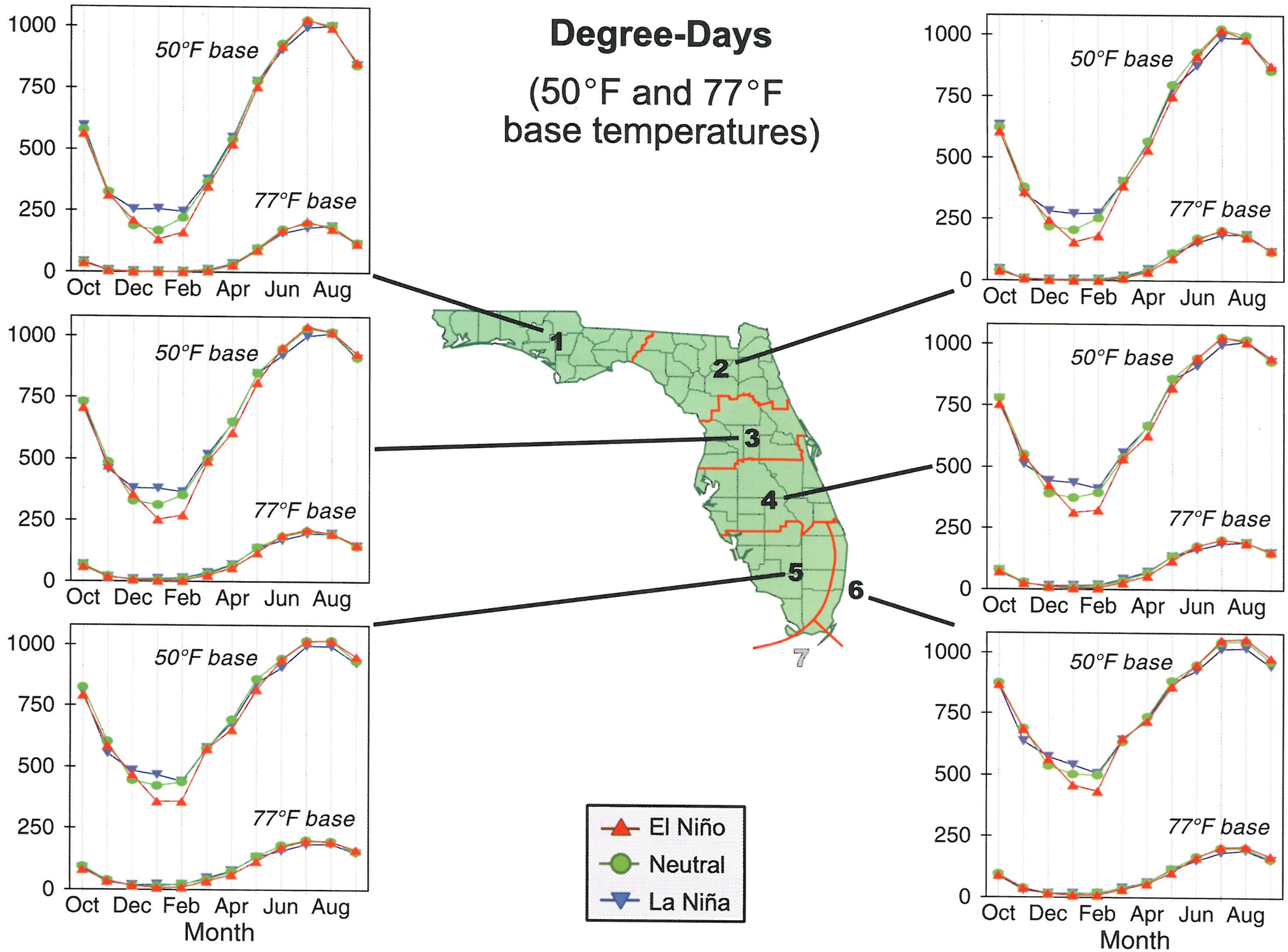



Rates of weight gain in cattle and hogs, and milk production, are reduced during periods when temperatures exceed 77°. Degree-days above 77°F ("heat stress degree-days") is a useful indicator of heat stress in livestock. Actual losses, however, depend on other factors, such as whether nighttime temperatures are low enough to allow animals to recover from stress. Monthly heat stress degree-days tend to be slightly lower in the spring (March to May) and higher in the summer during El Niño years. La Niña reduces heat stress degree-days in June and July. However, these differences are small compared to the total average heat stress degree-days in the spring and summer.



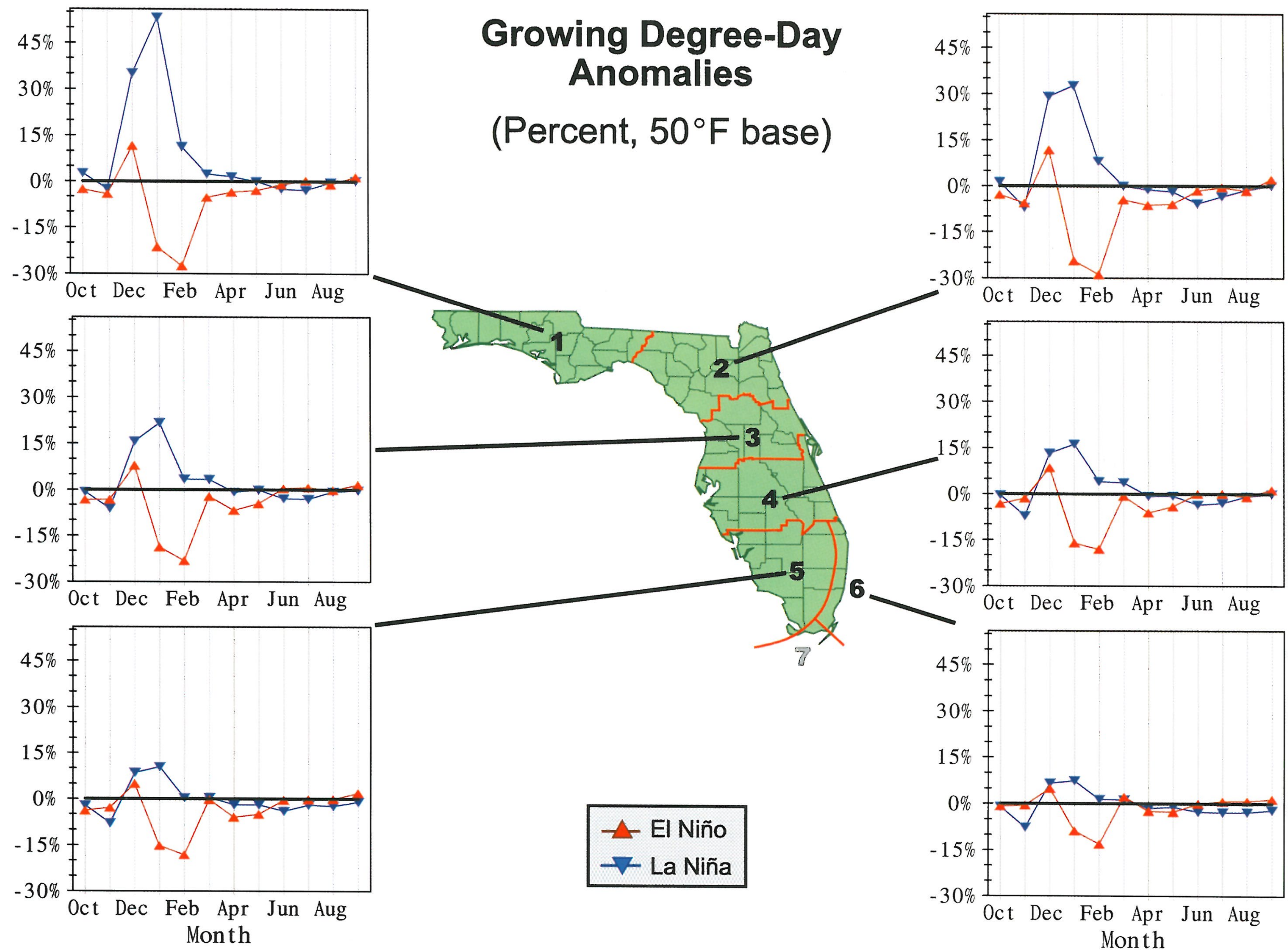
# Degree-Days

(50°F and 77°F base temperatures)



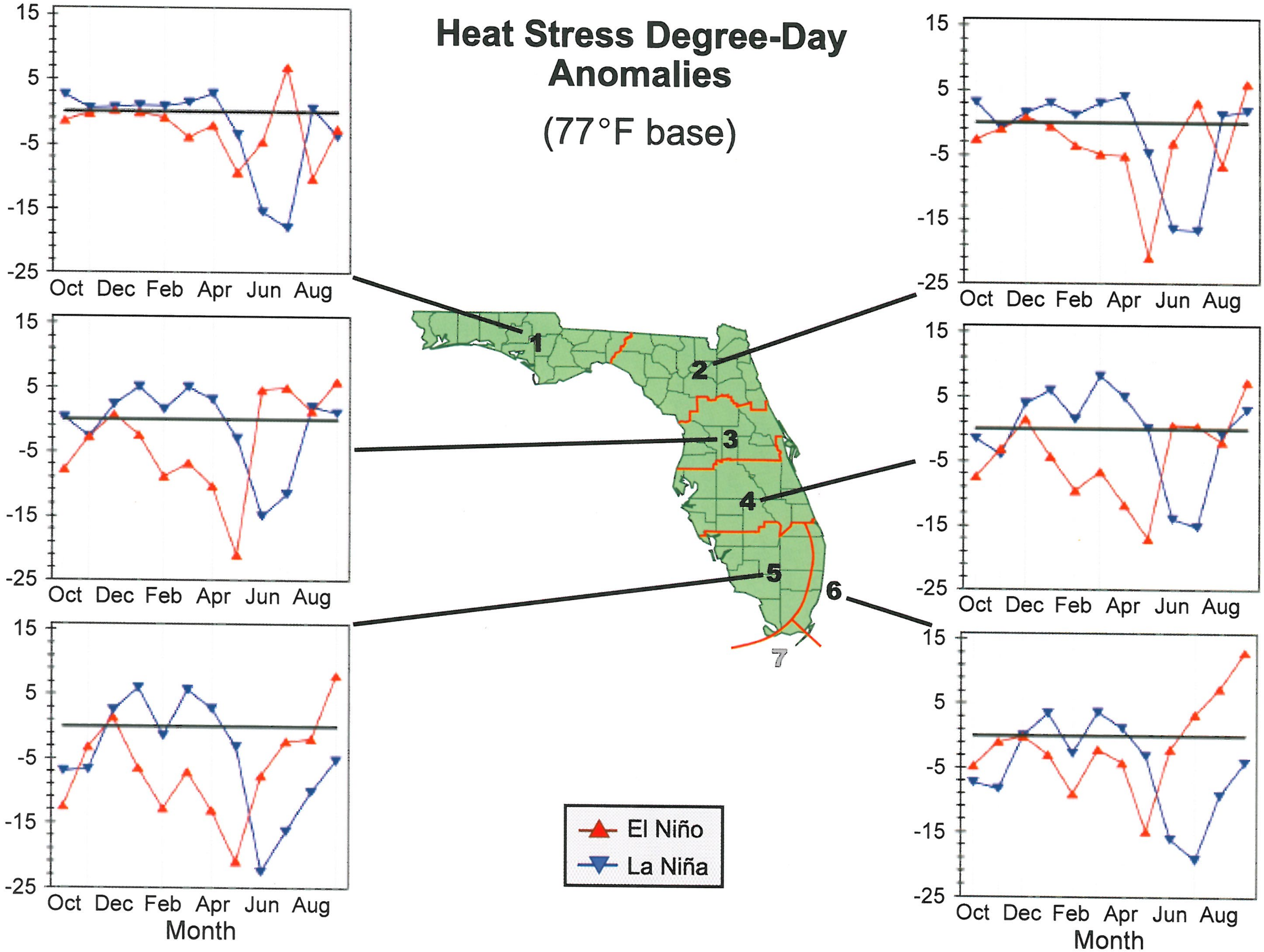
# Growing Degree-Day Anomalies

(Percent, 50°F base)



# Heat Stress Degree-Day Anomalies

(77°F base)

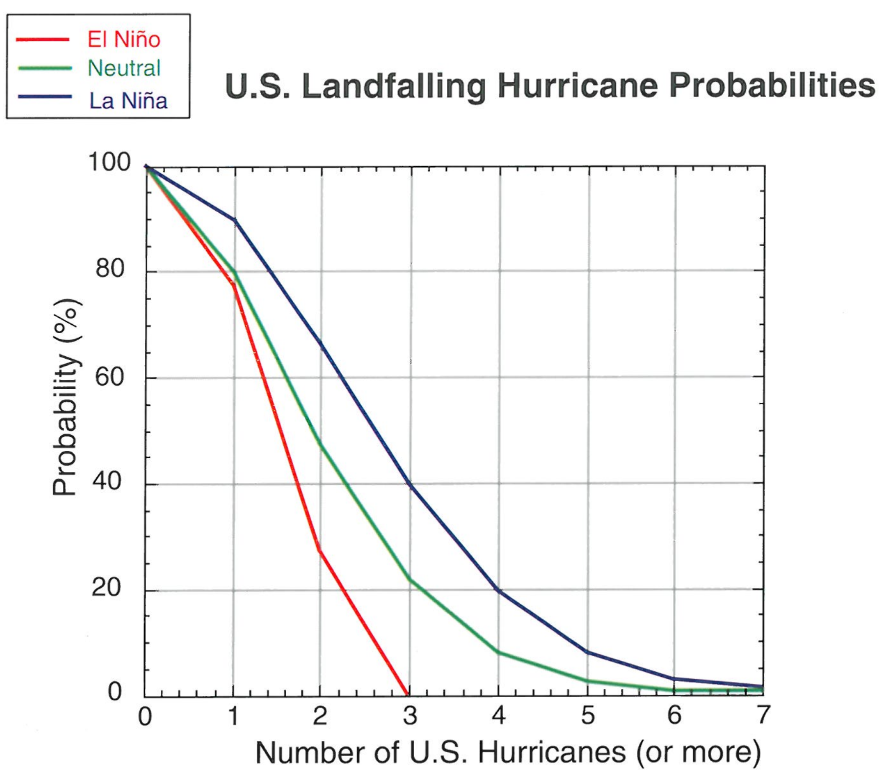


## HURRICANES

Every summer and autumn, hurricanes become a threat to Florida. With their violent winds and torrential rains, hurricanes have the potential to cause great damage to Florida's agriculture and forestry. However, the threat that hurricanes pose to the United States and Florida is not the same every year, due to the influences of El Niño and La Niña.

When El Niño conditions are present in the eastern tropical Pacific Ocean, upper level winds over the Atlantic Basin become unfavorable for tropical cyclone development. With fewer hurricanes developing, there is less threat for hurricane strikes in the U.S. Conversely, La Niña conditions favor hurricane development in the Atlantic Basin, allowing for more storms that can potentially strike the United States.

The probabilities of hurricanes making landfall on the U.S. during El Niño, neutral, and La Niña years can be assessed by studying historical hurricane records. The graph shows the probability of the minimum number of hurricanes hitting the United States during any hurricane season, based on the conditions in the eastern tropical Pacific. The figure shows that the chance of at least two hurricanes hitting the U.S. during El Niño conditions is 28%. Meanwhile, the probabilities of 2 landfalling hurricanes during neutral and La Niña years are 48% and 66%, respectively. Therefore, the chances of 2 landfalls during a La Niña year are three times greater than during an El Niño year. The changes in probability can be determined for other numbers of landfalls from the figure.

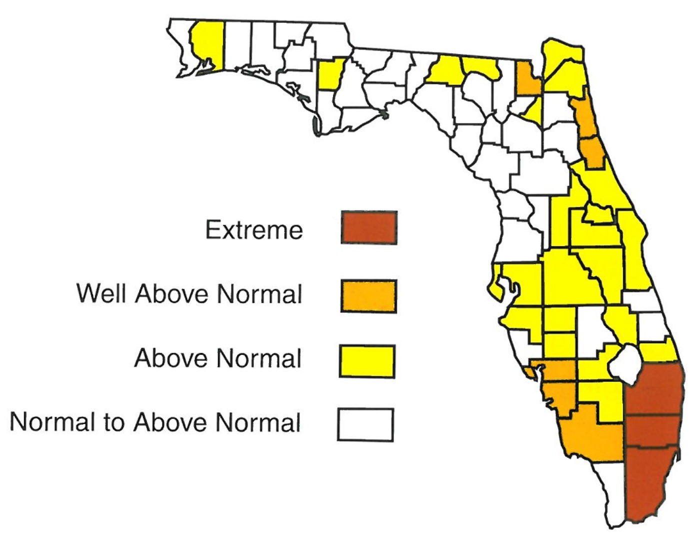


## FOREST FIRES

As with agriculture or any other activity that is highly dependent on the weather, forestry can benefit from the knowledge of climate patterns associated with El Niño and La Niña. In particular, the lack of rainfall during La Niña winters can cause an increased risk of fires in the following spring and summer. La Niña winters in Florida are characterized by below normal rainfall beginning in the fall and lasting through spring. This extended dry period runs into April, historically one of the driest months of the year for all ENSO phases. This sets the stage for extremely dry soil and forests, highly vulnerable to the threat of fire during the late spring/ summer peak fire period.

An examination of historical fire records shows that the number of acres burned in Florida each year is highly correlated to El Niño and La Niña. The study shows an increase in the number of acres burned during La Niña years, especially in southern Florida. In the limited data that was examined (1981-1998), La Niña years averaged over 500,000 acres burned in Florida while the neutral average is around 200,000 acres. The wet El Niño winters seem to suppress forest fires. The signal was most apparent for strong El Niño and La Niña events. The western Panhandle of Florida did not seem to be affected, as it receives much more rainfall in a typical year than southern Florida.

### Fire Threat in La Niña Spring



# FURTHER READING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## WEB SITES:

### *Florida Consortium:*

Florida State University/COAPS: www.coaps.fsu.edu
University of Florida/IFAS: www.ifas.ufl.edu
University of Miami/RSMAS: www.rsmas.miami.edu

### *Climate Forecasts:*

Climate Prediction Center: www.cpc.ncep.noaa.gov

### *El Niño and La Niña Information:*

Pacific Marine Environmental Laboratory: www.pmel.noaa.gov
Climate Diagnostics Center: www.cdc.noaa.gov
NOAA Office of Global Programs: www.ogp.noaa.gov/enso

### *Weather and Climate Information:*

National Climatic Data Center: www.ncdc.gov
Southeast Regional Climate Center: water.dnr.state.sc.us
Florida Climate Center: www.coaps.fsu.edu/climate_center
Florida Automated Weather Network: fawn.ifas.ufl.edu

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