

Long-Range Fire Behavior Assessment

Florida Area

2001 Fire Season



May 4, 2001

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Executive Summary

Fire (either prescribed or wild) has played a major role in shaping and maintaining most of the ecosystems in Florida, so large fires and extreme burning conditions are not unusual. Florida has the highest frequency of lightning strikes in the United States, yet most wildfires are human-caused. The vegetation has evolved with fire and the area contains some of the most volatile fuels found anywhere. These "normal" conditions can result in rapid growth, but usually increased nocturnal relative humidity and high soil moistures result in few long duration fires.

However, June and July of 1998 saw firefighting resources from across the nation mobilized to Florida because of threats to communities, the result of numerous large, long-duration, high-intensity wildfires. These fires required aggressive suppression tactics incorporating many aviation resources, over an extended period of time, and mop-up techniques not normally used in Florida. For example, the strategy of flanking a fire toward a swamp was no longer viable, since many of the swamps would not provide a natural barrier. Many experienced local fire managers report that wildfires burning in March and April have been more severe than the same period in 1998.

The Keetch-Byram Drought Index (KBDI) has been relied upon for many years as an indicator of fire danger and fire behavior, by fire managers and the public. However, many fire managers now feel the index grossly underestimates current fire behavior and fire danger. The primary reasons for this could be that the continued drought has resulted in no recharging to the vegetation root system, resulting in much lower than normal live fuel moistures when compared to "normal" years.

Based upon drought, fire weather forecast, and related firefighting experiences in 2001 the Fire Behavior Assessment Team assigned in late April, 2001 felt the following factors are important considerations;

Scenario Description for the May – July, 2001 Fire Season	Northern Florida Probability	Central Florida Probability	Southern Florida Probability
Less Severe and/or Shorter Than Normal	27 %	24 %	22 %
Normal Fire Season	34 %	34 %	35 %
More Severe and/or Longer Than Normal Fire Season (example, 1998)	38 %	41 %	43 %

The analysis performed by the evaluation team supports the concerns of local fire management personnel regarding the current effectiveness of the KBDI index during extended drought situations.

A standardized system of measuring and recording live fuel moistures should be implemented in Florida.

Introduction

Florida began to have significant wildfire activity in January, 2001, much earlier than the past three years.

Since mid-February, 2001, the Florida Unified Command has been operational to quickly and efficiently respond to wildland fires on virtually any jurisdiction. This statewide approach was first implemented in 1999 following 1998 fire season when 126 homes and 86 vehicles were destroyed by wildfires.

On April 25, 2001, a Fire Behavior Assessment Team was ordered by the two Incident Commanders (Joe Ferguson, USDA-FS and Jim Karels, Florida DOF). By April 30th, 42 homes had already been destroyed throughout northern and central Florida.

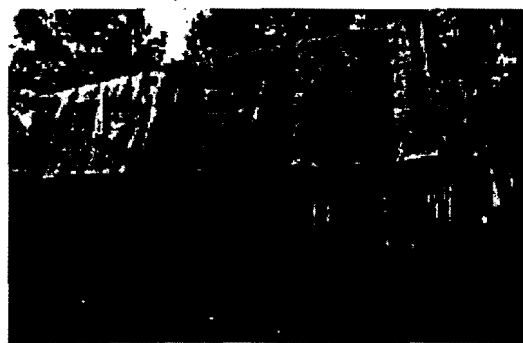


The objectives for the assessment by the team were to;

- Conduct a brief analysis and make projections of wildland fire potential for the upcoming months.
- Produce a white paper on the wildland fire severity, and provide appropriate recommendations.
- Produce a concise Florida fire behavior briefing package for the 2001 season.

The purposes for an area-wide (Florida and Okefenokee National Wildlife Refuge) fire behavior assessment report may include;

- Assist in strategy development at the State, Regional, and National level.
- Help prioritize and pre-position limited firefighting resources.
- Provide a briefing foundation for interested citizens, political leaders, and out-of-area firefighters.
- Help local fire managers better quantify their fuels, weather, and fire behavior situation.



Similar assessments have been done in other parts of the United States and previously in the Southern states in 1998 and 2000. Though the specific objectives vary on each project, generally they are conducted by an outside group to gain an unbiased overview of an unusual situation, over a relatively long term and large scale compared to a specific single wildfire event.

The team assigned included;

Dave Lukens (Wallowa-Whitman National Forest, Baker City, OR), Team Leader.
John Robertson (Umatilla National Forest, Pendleton, OR), Long Term Fire Behavior Analyst.
Noel Livingston (Umatilla National Forest, Pendleton, OR), LTAN and Operations Specialist.
Jim Brenner (Florida Division of Forestry, Tallahassee FL), Fire Behavior Analyst.
Scott Goodrick (Florida Division of Forestry, Tallahassee FL), Fire Weather Meteorologist.
Roberta Bartlette (Fire Science Laboratory, Missoula MT), NVDI-Greenness Specialist.

In 1998 more than 10,00 firefighters were mobilized from 47 states in order to protect the citizens, private property and natural resources of Florida. At the peak there were more than 156 fire suppression aircraft involved. The 1998 fires were unusual also because large fires made up a greater fraction of fires than in even the severest fire years that preceded it, and hotel revenues declined in response to the fires, a pattern not seen in previous years. Therefore the 1998 fire season provides a good benchmark for fire managers both from Florida and from outside the state. Since that time, precipitation amounts have rarely met historical monthly mean levels. Following initial discussions it became apparent that wildland fire conditions from 1990 through 1997 were much different than from 1997 to the present.



So the intent of this paper is to provide;

- A brief review of "normal" Florida fire weather, fuels, and fire behavior conditions.
- Documentation on the wildland fire situation since 1998.
- A projection for the remainder of the 2001 season.
- Some thoughts on "what it will take to return to normal" in the Florida area.
- Some comparisons of various fire danger indicators that may prove useful during extraordinary weather cycles.



"Normal" Florida Season

Weather Conditions

The state of Florida experiences a range of annual precipitation patterns. In the southern part of the state the year can be broken down into a wet season (May-September) and a dry season (October-April). In the northern part of the state, precipitation has an almost bimodal distribution (2 rainy seasons, summer and winter, and 2 dry seasons, spring and fall). Central Florida falls somewhere in between with spring and fall being generally drier than the winter and summer seasons. The summer rains that provide most of Florida's annual rainfall begin in late May for the southern part of the state with the rain pattern progressing northward to encompass the entire state by mid to late June. The May through June time frame, when the rainy pattern is developing, is when most of Florida's lightning fires occur and the majority of Florida's wildfire acreage burns. The increase in lightning fires is directly tied to the fact that most of Florida's summer rainfall comes from thunderstorms. May rainfall for the state averages 3.95" with the north part receiving around 4.25", 3.25" for the central part and 4.75" in the south. For June, the state averages 6.64" (north=6.25", central=6.50", south=7.75").

Fuels and Fire Behavior:

Regardless of the weather conditions it is important to look specifically at fuels in Florida, how they are arranged, and not be fooled by their "green appearance".

Live fuel moistures for central Florida in June commonly range from 130 to 140%.

Vegetation and thus fuels are largely dependent on elevation. This may seem an over statement at first because Florida is not known for its topography, however, the type of vegetation that occupies a site is directly related to its relationship to the water table. Generally the higher elevations are dominated by a pine and associated brush or grass, while the lower elevations are dominated by hardwoods, cypress or marshes.

Much of the forested land in central and northern Florida is managed for timber and pulp. As a result these lands are harvested and then immediately put back into production through planting. The wetter areas are generally not harvested due to difficulties associated with working on wetter soils. Pine forests make up the dominant fuel type with wet lands (swamps) being the next most common. These fuel types exist in a manner related to slight elevational differences creating a discontinuous fuel array across the landscape that normally limits fire size, as the swamps don't usually burn.

Fuel treatment also plays a role in limiting fire spread and intensity in the pine dominated fuels. Repeated underburning maintains the brush at a lower fuel loading. Fires burning in treated stands still carried fire but rate of spread and flame length was observed to be less.



The lower rate of spread and flame length often made it possible to contain the fire when suppression forces were available.

The uplands are generally occupied by pine species with an understory of palmetto and associated brush species. Gallberry is also commonly found as an associated species. These fuel profiles are often called flatwoods and reside upon well drained white sandy soil. These plant communities and associated fuels can be described by Fire Behavior Prediction Models:

southern rough (fuel model 7) and mixed chaparral (fuel model 4). The flammability of the live fuels allows fuels to burn at much higher dead fuel moisture contents than found in other fuel types. The southern rough model best fits fuels where the height of the palmetto is about 3 feet high or less. Under these conditions the rate of spread was predictable while the flame length was under predicted by as much as a factor of 2. Where the palmetto exceeds 6 feet in height a fuel model 4 tended to over predict the rate of spread slightly (perhaps as much as 25%) while observed flame lengths seemed to match those predicted.

Generally the rough is described by its age, for example 1 year or 3 year rough. Fuel bed height and loading increases with the age of the rough. The amount of dead material also increases. Cast pine needles tend to drape over and through shrubs which add to the fuel in the brush. Of course fire behavior is directly related to fuel bed depth and loading and increases likewise. Several areas were described as being 20 years old or older. Fire behavior in these older stands was observed to be very intense and the added fuel load generally contributed significantly to the spotting problem.

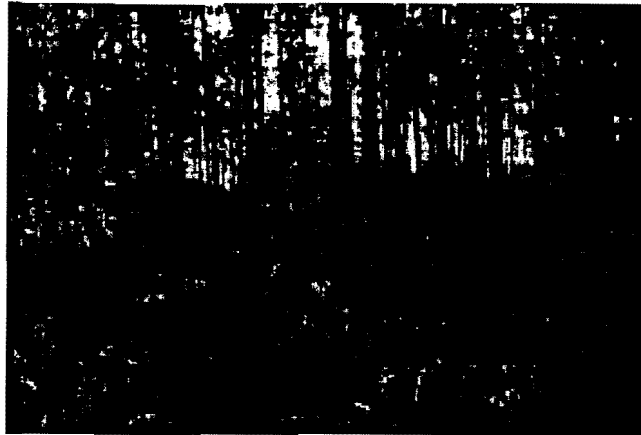
Maximum spotting distances range from one quarter to one half mile with instances of spotting up to one mile recorded. Spotting perpendicular to the spread direction has also been observed. These distances were generally 50 feet or less but some as far away as 200 feet have been noted.

Flanks and backs of the fire can also be very active when fires make major runs. Subtle wind changes had a significant effect, increasing fire intensity on the flanks and rear of the fires during active runs in flatwoods.

There are other fuel profiles in the pine dominated fuels. These could best be described as young stands of pine with a grass dominated understory (fuel model 2) or recent land clearing operations.

Although pine crowns can be removed in many fire runs, these are generally passive crown fires. The crowns consume as or just after the surface fire spreads under them. This is not to say that active crown fire runs do not occur but rather they are likely to be the exception as opposed to the rule. This is largely due to the species of pine and the spacing where the pine is under management (which most of it is). Sand pine will support active crown fire.

The lowlands tend to be covered by water most of the year under normal conditions. These fuels are generally referred to as swamps, bay heads, cypress domes or stringers but local naming conventions are used that generally relate to the dominant tree species. These range from Cypress dominated stands on the sandy soils where the organic layers are 1 foot deep or less to the wetter sites dominated by hardwoods where the organic soils are much deeper and finer (referred to locally as muck). This may be an oversimplification on the part of the authors but variations are subtle and not easily identified by those who do not work with this vegetation on a regular basis. Hardwood species include sweet gum, wax myrtle, magnolia, gallberry, sweet bay, loblolly bay, red bay, and red maple. Sabal palm (cabbage palm) can be seen in the transition zone between the swamps and the flatwoods and is a major contributor to spotting. Major groupings are related to the amount of sand or organic material found in the soil (how well drained the soil is).



Cypress, is a very significant fuel component in the Western and Southwestern portion of the state, such as the Big Cypress Preserve. Grass and shrub profiles best described as marshes are also present.

Pure marshes are found near some lakes and contain grasses and associated brush. These fuels burn even when water is present (burn above the waterline).

Titi is a shrub that reacts much like palmetto in that it has very volatile foliage and burns when dead fuel moisture contents are high. Titi is generally found in northwestern Florida and occupies wetter sites than palmetto. It can dominate the vegetation and is then referred to as a titi swamp. Melaleuca in Southeast and Southwest Florida burns very much like Titi – if water is in the understory – and there is not sufficient rain to move the fire off the ground – the fire will go out – however, if the understory is dry – and there is any kind of wind these fuels will crown quickly.

Fuel model 8 (compact hardwood litter) and fuel model 9 (loose hardwood litter) are used to model the rate of spread in swamps although spotting is usually the major cause of fire spread as opposed to surface spread. In a fuel model 6 (dead brush) might also be used to model these fuels (particularly in the transition between flatwoods and swamp). They would only burn under low RH's and under higher wind speeds. Marginal spread occurs where the fire is backing and the flame on the flanks is not much more than a couple of feet.

The dominant fire behavior factor relating to most of the swamps is standing water. When wet, the majority of the swamps are essentially a natural fire break. During dry periods when water level lower, fuels that are normally wet become available. Generally, fire does not make major runs in these fuels and in some cases they would not even carry fire. During drought conditions however, these areas play a major role by carrying ground and surface fire to pine islands which can then spot into flatwoods. Flame lengths up to 6 feet have been observed in swamp areas when fire from the flatwoods runs into them.

The soils in the swamps are generally high in organic content. As a result they will burn as a smoldering fire if water levels are low. Rate of spread is very low but under drier and windy conditions can sustain a low flame length and torch out brush causing spots. Due to the nature of the fuel it will continue to burn and hold fire for long periods of time even under moist conditions. The potential for holdover fires is high and mopup is difficult. Also, aerial heat detection devices do not easily identify these heat sources. Even during the day smoke may not be visible several yards away.

The organic layer can be deep (up to 6 feet or more) in bays (swamps). Here soils are not well drained. Drought conditions can leave these normally wet sites high and dry. The organic layer is more like peat and is extremely difficult to extinguish. Holdover fires are highly likely to remain until such time as the areas become completely saturated.

The organic layer is less deep where cypress are found. Again cypress is generally found in wet areas so these fuels are generally not a problem. However, when dry this layer burns much like duff and can be responsible for holdover fires. Mop-up is difficult due to the lack of soil. Water can be used in mopup especially when wetting agents are added. However, getting 100% effectiveness is very difficult.

One of the major factors that contributes to the fire behavior is the flammability of the live fuels. This is not often recognized by those who do not work with these fuels regularly. These fuels tend to burn at much high fuel moisture contents and higher relative humidity than any other fuels. Rate of spread and intensity becomes critical when the RH drops to 35% or below but active burning in flatwoods was observed with RH's of 80 percent. When the RH's fall to 35% or lower the flanks and rear of the fire can exceed the ability of tractor plow lines to hold without additional support.

After an area has burned there is potential for the area to re-burn or carry fire again due to one or more of the following causes. First, the organic layers can re-burn due to continued drying when exposed to sun and winds. Second, leaf and needle cast from the scorched shrub and tree vegetation can be re-deposited on top of blackened surfaces providing new fuels. Lastly, the scorched leaves of shrubs become available as fuel that can carry fire for short distances. Only the last situation presents any problem directly related to the safety of fire fighters. In the first two cases, however, the indirect result is for fire to carry over firelines in the newly deposited litter or through dried organic layers and across control lines.

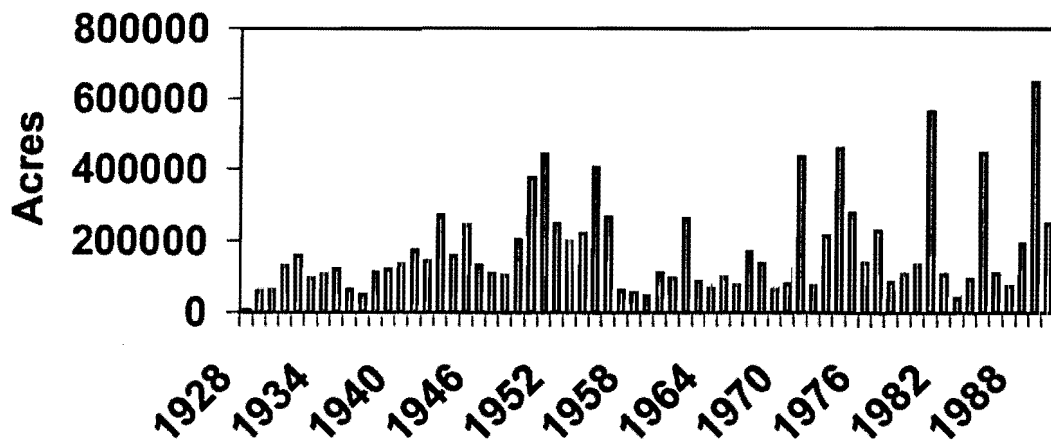
In summary, the flatwoods during the fire season always have the potential for large fires. Normally, these fires are contained by tractor plow firelines and the wet swamps. During drought conditions the swamps will also carry fire, complicating mopup efforts and increasing potential for escape fires.

Wildfires

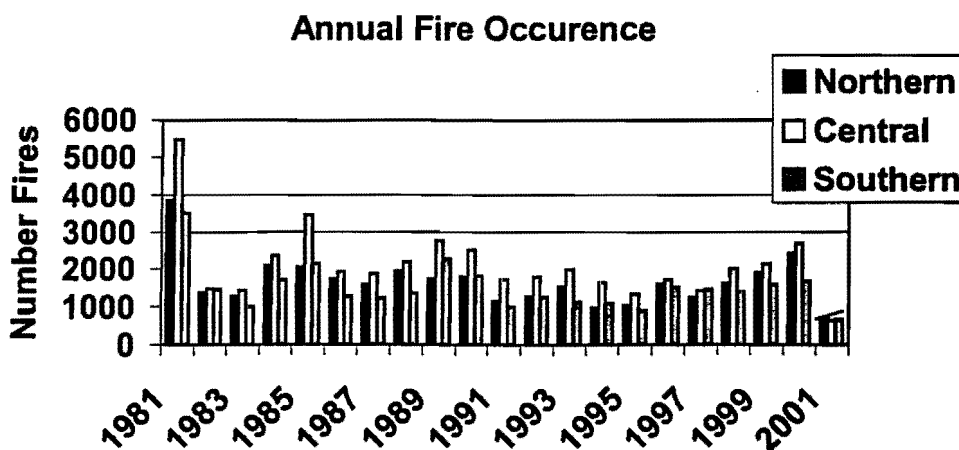
The state of Florida experiences a high number of wildfires annually. The majority of these events are human caused (83%) statewide, with the majority of large lightning fires occurring in late spring and early summer. The Division of Forestry experiences a much higher number of fires than do the Federal Agencies within the state.

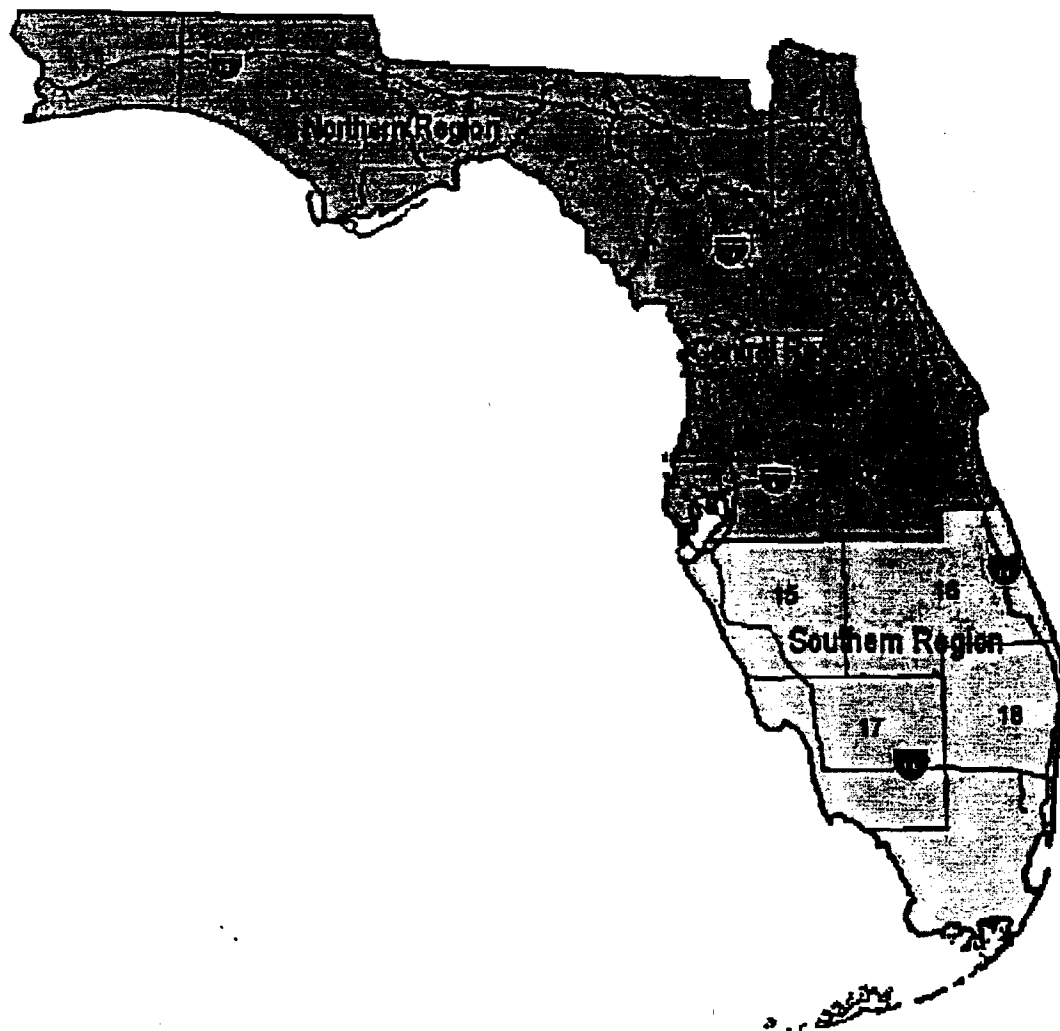
Division of Forestry historical fire records indicate a high frequency of large fire years over the past 80 years. The following illustrates acreage burned on DOF protected lands. Acreage under DOF protection was increasing between 1928 and 1972 (from 700,000 to 26,000,000 acres). Of note are the large number of acres burned in the mid 1950s, mid 1970s, 1981, 1985 and 1989.

Acres Burned (1928-1990) Florida Division of Forestry



Fire occurrence by zones or Regions varied significantly across the analysis period, with 1981 by being the most active year. The relative occurrence between Regions however remained more uniform, with the Southern Zone seeing the fewest starts and the Central Region the most. The following chart summarizes fire occurrence for the Florida Division of Forestry, National Forest of Florida, and Everglades and Big Cypress National Parks. For this analysis, fire records were gathered from the Florida Division of Forestry, the National Forests of Florida, and the Everglades and Big Cypress National Parks.

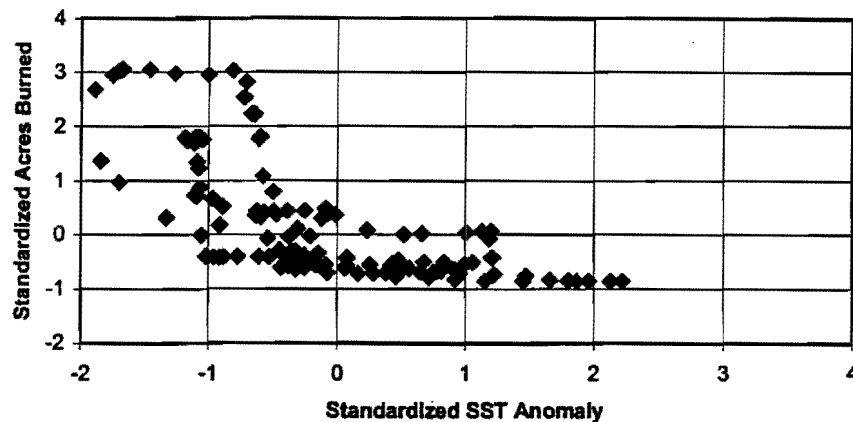




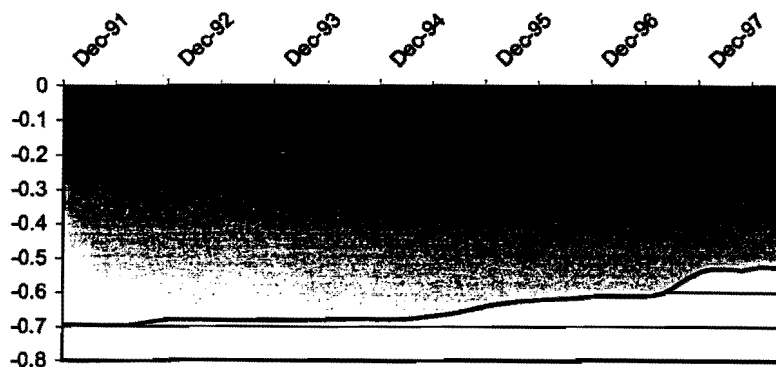
1998 through 2000 Florida Wildland Fire Season

It has been well established that severe wildfire seasons in Florida are closely tied to the negative phase of ENSO, more commonly referred to as La Niña. For Florida, the negative phase of ENSO is generally characterized by warmer and drier than normal while the positive phase (El Niño) provides cooler and wetter conditions. In the spring of 1997 a major warm event began that continued into 1998, producing flooding rains during early 1998.

In April of 1998 ENSO changed from the positive phase to the negative phase. The April-June period of 1998 was the driest such period in the 104 years of record in Florida. The May-June period was the hottest such period on record as well with high temperature records being either tied or set 22 times during June for the Melbourne NWS Office. This La Niña event lasted through April of 2001 although its impact on atmospheric circulation patterns remains.

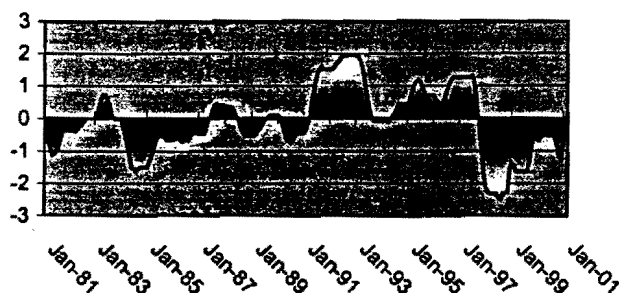


Relationship between Pacific sea surface temperature anomalies and acres burned by wildfires in Florida for 1981-1991.

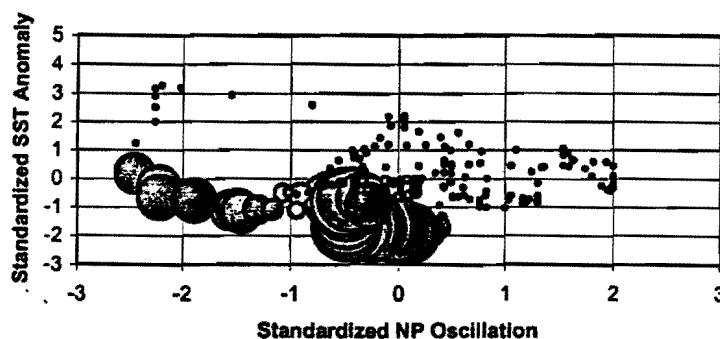


Change in correlation between sea surface temperature anomalies and wildfire size since publication of study and its subsequent use as a planning tool.

The drop in correlation between ENSO and fire activity is partly due to the use of this relationship in fire season planning, but an additional factor that contributes strongly is the North Pacific Oscillation (NPO). The NPO is another climate oscillation like ENSO that acts to moderate the impact of ENSO. During a warm phase of the NPO the effects of El Niño are amplified while the effects of La Niña are diminished. The cold phase of the NPO amplifies La Niña's impact. The 1990's were largely dominated by the warm phase of the NPO while the 1980's were dominated by a negative phase that contributed to the strong relationship for the 1981-1991 period and the reduced correlation during the 90's. In 1997, the NPO changed to a cold phase, which likely weakened the impact of the largest El Niño on record and strongly amplified the transition to La Niña during the spring of 1998. Comparing NPO, ENSO (as indicated by the sea surface temperature anomaly) and wildfire size shows that this combination produces a very strong relationship. Severe wildfire season's in Florida occur when the sea surface temperature anomaly in the equatorial Pacific Ocean is below 0.5 and the NPO index is also below 0.5.



Time series of North Pacific Oscillation

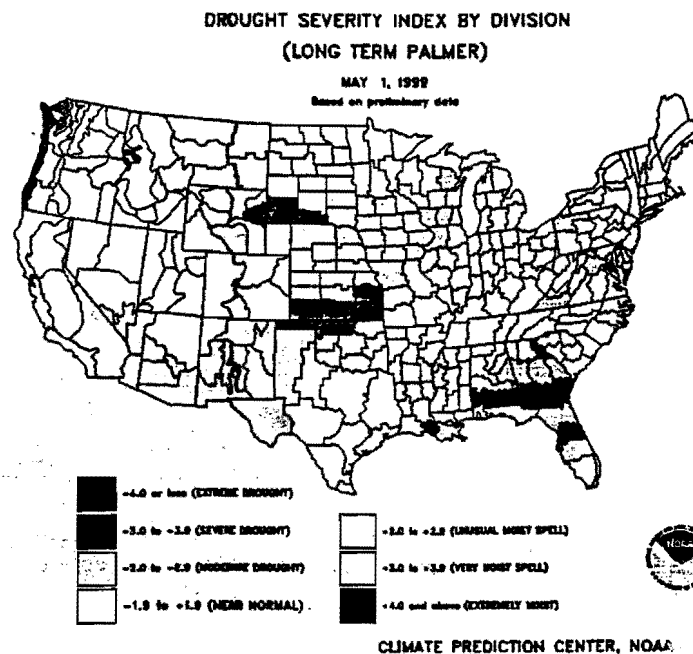
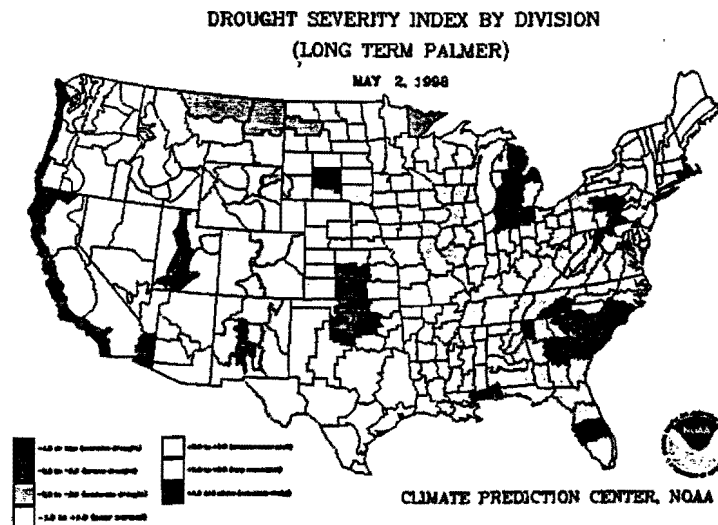


Relationship between ENSO, NPO and wildfire size in Florida
(indicated by size of bubble).

The La Niña event that began in the spring of '98 ended around the beginning of March of 2001. Despite a return to normal sea surface temperatures in the Pacific Ocean, the atmosphere is still exhibiting circulation patterns consistent with a La Niña event. This is likely due to the amplifying effect of a negative NPO index. The weak La Niña dramatically limited winter precipitation for much of Florida for the third year in a row. As a result, the Florida peninsula is entering May in a state of severe to extreme drought which is in sharp contrast to conditions at the start of May 1998.

Precipitation

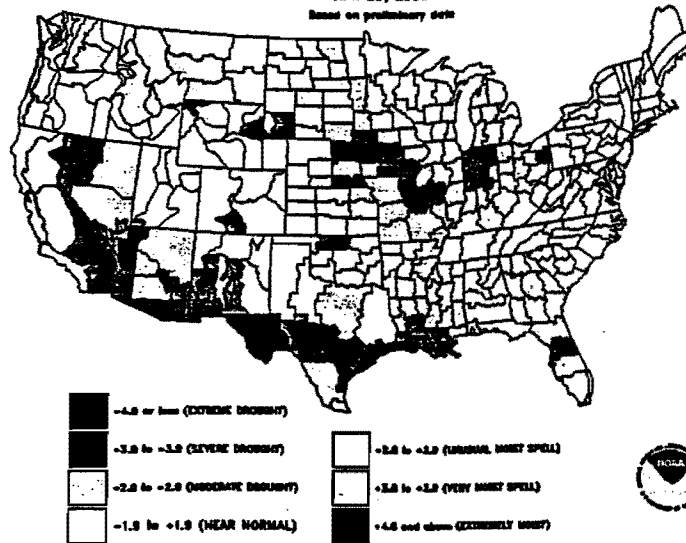
With the start of a La Niña event coupled with a cold phase of the NPO dry conditions are expected for Florida. The 1998-2000 period did not disappoint. In March of 1998, Florida was still receiving flooding rains due to El Niño, however, in April the rains ceased and the state began drying out. By the start of May The Palmer Drought Severity Index was still indicating wetter than normal conditions despite no significant rain during the past month. This drying trend continued until early July when Florida's wet season finally began. To date, the rains of the winter of 1997-1998 were the last significant wet period experienced in Florida and 2000 was the driest year on record in Florida. The following sequence of maps illustrates the transition from wetter than normal conditions (as measured by the Palmer drought severity index) at the beginning of May 1998 through the severe/extreme drought conditions present at the start of May 2001.



DROUGHT SEVERITY INDEX BY DIVISION
(LONG TERM PALMER)

APR 29, 2000

Based on preliminary data

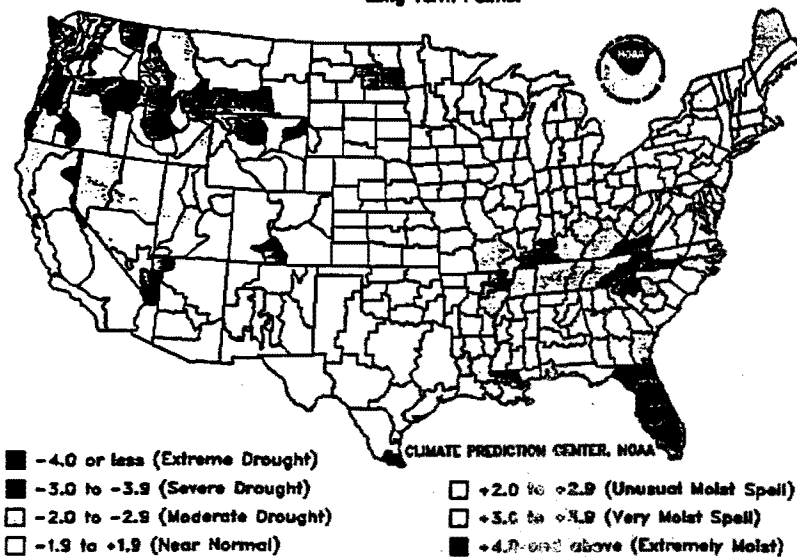


CLIMATE PREDICTION CENTER, NOAA

Drought Severity Index by Division

Weekly Value for Period Ending 28 APR 2001

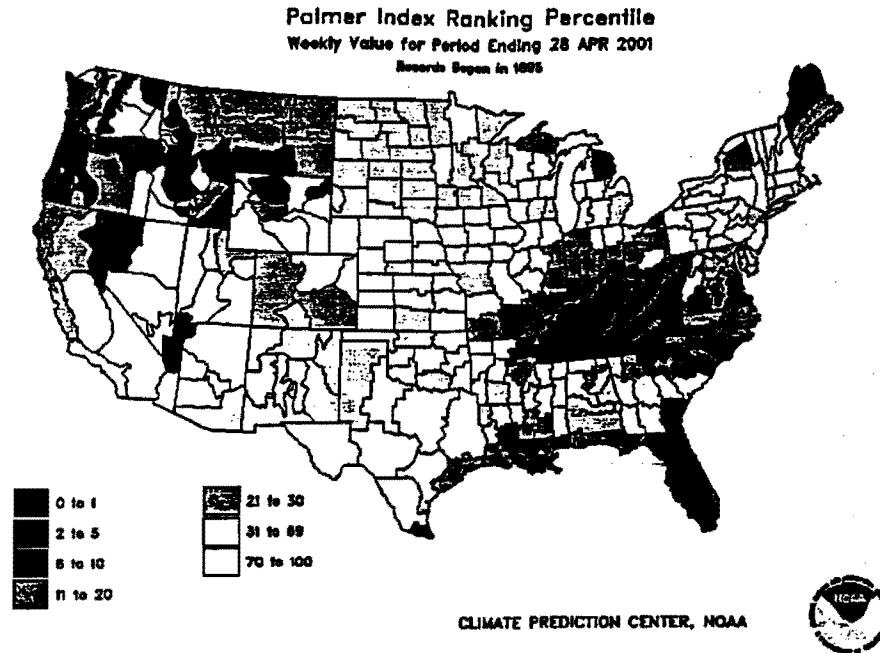
Long Term Palmer



CLIMATE PREDICTION CENTER, NOAA

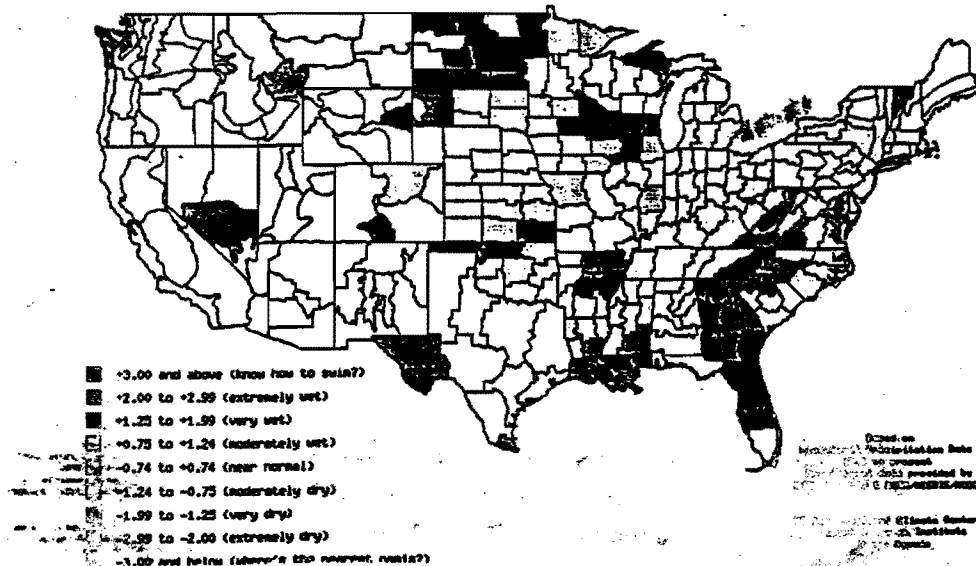
Palmer Drought Severity Index for late April/early May 1998-2001 showing the progression of Florida's prolonged drought. Note CPC changed the color scheme for 2001.

The cumulative impact of 3 years of drought is evident in the percentile ranking of the Palmer Index. The majority of the Florida peninsula currently has Palmer Index values in the driest 2-5% since records began in 1895. Above normal March rainfall helped improve these conditions by moving parts of the peninsula out of the 0-1% category. However, below normal rainfall during April has largely erased any benefit from the March rains as many of Florida's lakes remain dry and stream flow measurements are at near record lows.



Florida's current drought conditions ranks among the worst 2-5% of drought conditions recorded in the state since 1895

36-month Standardized Precipitation Index through the end of March 2001



Standardized Precipitation Index for the three-year period of the current drought.

1998 through 2000 Fire Behavior

The State of Florida has experienced a period of increased fire activity, beginning in the spring of 1998 and continuing through the 1999 and 2000 fire seasons. A combination of weather conditions, continued drought, and available fuels have resulted in an increased level of fire behavior over that seen throughout the rest of the 1990's.

Fuels and fuel availability played a major role in the spread and intensity of the wildland fires that plagued Florida in May through July of 1998. The continuity and amount of fuels were critical to describing how fire behaved. Most of the fire spread was not directly related to extremely high wind speed or exceptionally low relative humidity. In central Florida, major spread events during early July could be attributed to westerly winds as opposed to the more common sea breeze/land breeze pattern. Available and abundant fuels continued to influence fire behavior in 1999 and 2000. The fire season of 1998 developed following a wet winter and was particularly severe due to a very dry spring and a delay in early summer moisture, which pushed the fire season well into July. While some moisture was received during the summer and fall of 1998, the fire season of 1999 essentially started under drought conditions, which worsened throughout the spring fire season. Again, some recovery occurred but the 2000 fire season began under the third year of drought conditions, which still continue. Conditions of low live fuel moisture and abundant forest fuels resulted in continued heightened fire behavior during the 1999 and 2000 fire season. Additionally, because of dry conditions as well as concerns about the effects of fire on drought stressed trees, the usual fuel reduction burning that typically takes place throughout the state has been reduced since 1999 further adding to available fuels and increasing the risk of high intensity fires.

1998 live fuel moistures in pine and associated shrubs were measured at 80% (central Florida) in June as opposed to a more normal 130 to 140%. As of July 10th they had only recovered to 105% still far below normal for this time of year.

- Pine Uplands

Pine Uplands, also known as flatwoods, were one of the predominate fuel types involved in the active fire of 1998. Fire behavior in these fuel types has been moderate to extreme, depending upon understory accumulation and weather conditions.

Spotting distances, particularly in the pine uplands were often observed up to one half mile in advance of the fire front thus making actual determination of rate of spread difficult. Spotting perpendicular to the spread direction was also observed. These distances were generally 50 feet or less but some as far away as 200 feet were noted.

Flanks and backs of the fire were also very active when fires made major runs. Subtle wind changes had a significant effect, increasing fire intensity on the flanks and rear of the fires during active runs in flatwoods.

Where crown fires occurred most observers in 1998 stated that these were passive crown fires. The crowns were consumed as or just after the surface fire spread under them. This is not to say that active crown fire runs did not occur but rather they were likely to have been the exception as opposed to the rule. This is largely due to the species of pine and the spacing where the pine is under management (which most of it is). Sand pine supports active crown fire but it was not noted to occur over sufficient acres to be a major factor in fire spread in the areas where the fires burned. In 2000 the Okefenokee National Wildlife Refuge experienced two crown fires that were observed with independent crown spread, both occurring in slash pine plantations. As a result fire management on the Refuge has been modified such that the primary response on running fires is to employ flanking rather than head attacks.

- **Lowlands**

Lowland areas are typically vegetated with a mix of hardwood species that either prefer the high water tables found or are not resistant to the fires that frequent the adjacent uplands. The organic layer on these sites can be deep (up to 6 feet or more) in bays (swamps). Here soils are not well drained. Drought conditions have left these normally wet sites high and dry. The organic layer is more like peat and is extremely difficult to extinguish. Holdover fires are highly likely to remain until such time as the areas become completely saturated.

The dominant factor relating to most of the swamps is a lack of standing water. This allowed fuels that are normally wet to become available. Generally, fire did not make major runs in these fuels in 1998 and in some cases they would not even carry fire. They did however, play a major role by carrying ground and surface fire to pine islands, which would then spot into flatwoods. Flame lengths up to 6 feet were observed in swamp areas when fire from the flatwoods ran into them. Drought conditions in 1999 and 2000 resulted in insufficient recharge of groundwater and as a result the swamps continued to develop as problem areas for fire suppression, primarily due to their inaccessibility, their potential to hold fire which will later spread to unburned fuels, and the increased fire activity which they were beginning to support. Additionally, these stands have continued to smolder and smoke, extending period of smoke around communities and along major highways.

The flatwoods during the season always have the potential for large fires. Normally, these fires are contained by tractor plow firelines and the wet swamps. Due to the dry conditions the swamps have also been carrying fire. This is complicated by soils that will not support the weight of the tractor plows. Fires have continued to holdover in the swamp areas until they become fully saturated again. The likelihood of accomplishing 100% mopup in the organic soils is low. Any fires that escape into flatwoods have presented the opportunity for significant spread.

Summary

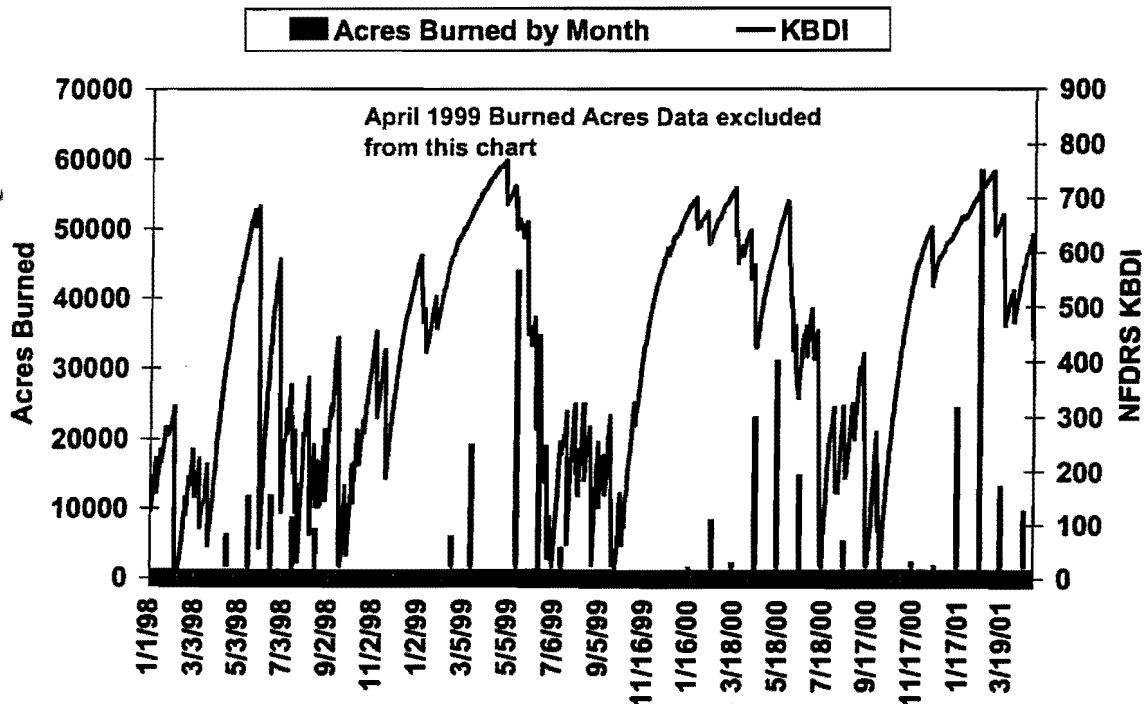
While the 1998 fire season seems to overshadow 1999 and 2000, actual fire behavior has been observed to be increasing over the past three years. Most fire management personnel are relating their success in suppressing fires in 1999 and 2000 to an increased suppression response, particularly aggressive initial attack with tractor plows, air support, and engines followed by substantial mopup and patrol efforts, rather than a reduction in fire behavior.

Fireload versus KBDI

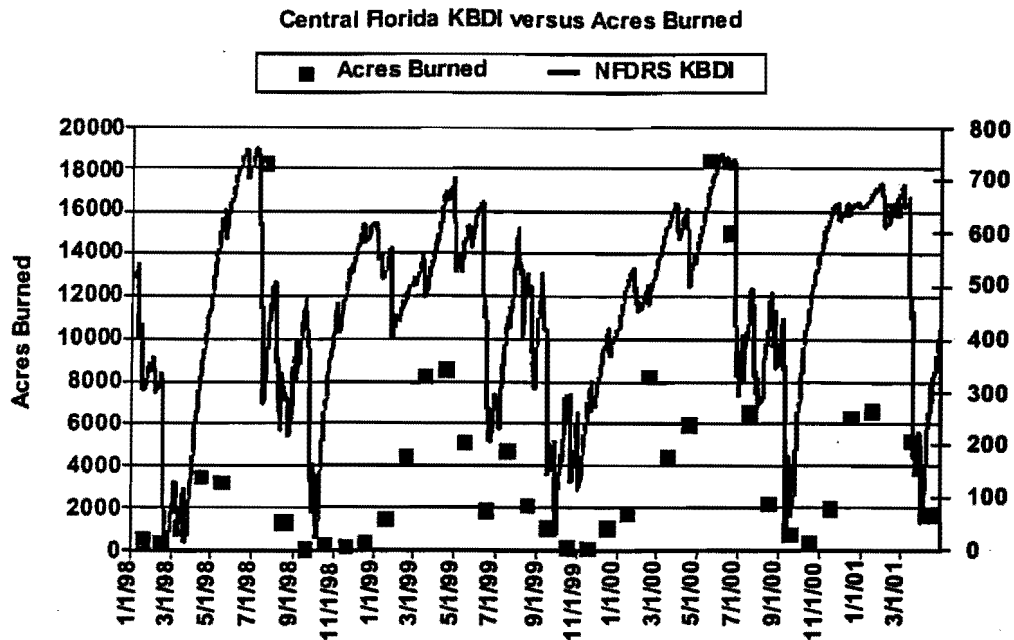
The chart below displays the acres burned on State owned and protected lands in south Florida along with the Keetch Byram Drought Index (KBDI) for the same period.

In south Florida the KBDI has reached over 700 in each of the last 3 seasons. Frequent moisture in the

Southern Florida NFDRS KBDI versus Acres Burned

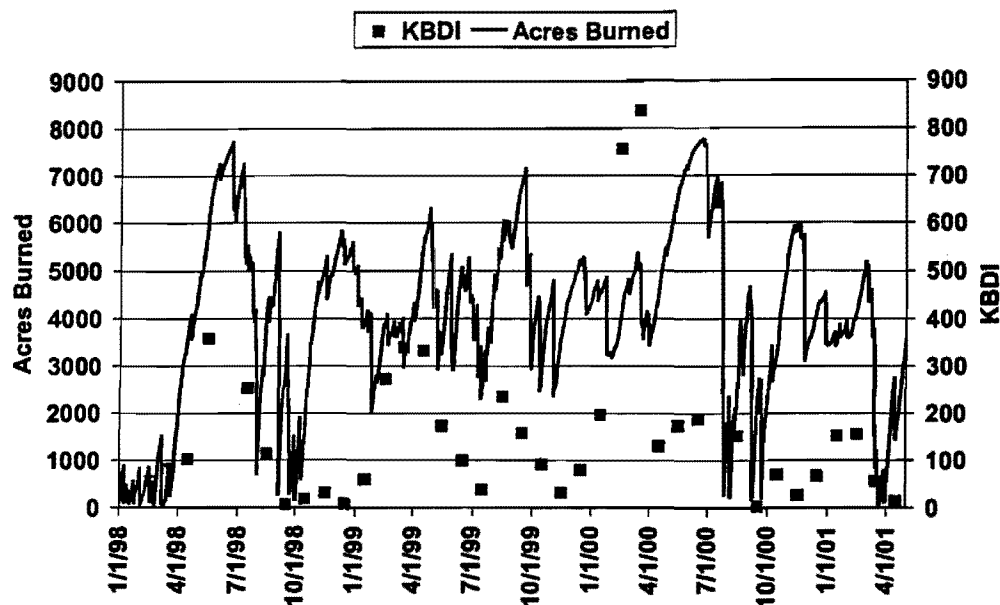


spring of 1998 helped to suppress fire activity. Longer dry periods in 1999, 2000 and now 2001 resulted in peaks in the Index that have held for long periods. These dry periods have been associated with large acreage lost. The acreage burned in April of 1999 (over 185,000 acres) made viewing the chart difficult and so this data point was not included. It is important to note that these fires (April of 1999) occurred at the peak of the KBDI.



The chart for Coastal Plains displays the KBDI as well as the number of acres burned for each month. In 1998 the KBDI was near zero in March and much of April. Starting in mid to late April it increased rapidly to well over 700 before dropping early July. It is important to note that the above chart does not contain the fire data for the month of June 1998. During June over 350,000 acres were burned in central Florida. This spike made observing the other fires on this graph impossible so that data point was not included. KBDI zeroed out in October of 1998 only to rise rapidly and remain above 500 for much 1999. Note the large acreages that burned in March through August of this period. After dropping to zero in October 1999 the Index climbed steadily peaking at over 700 in June of 2000. Once again large acres burned in March, April, May, June, July and even August before dropping. KBDI immediately begin climbing again in late October, with fire activity also increasing. March of 2001 once again dropped the Index back to near zero however, fire activity has not dropped off (over 2000 acres were reported as of the time this was written in early May). Once again the index is on the rise as we head into the worst part of Florida's fire season that generally takes place in May and June.

North Florida KBDI versus Acres Burned

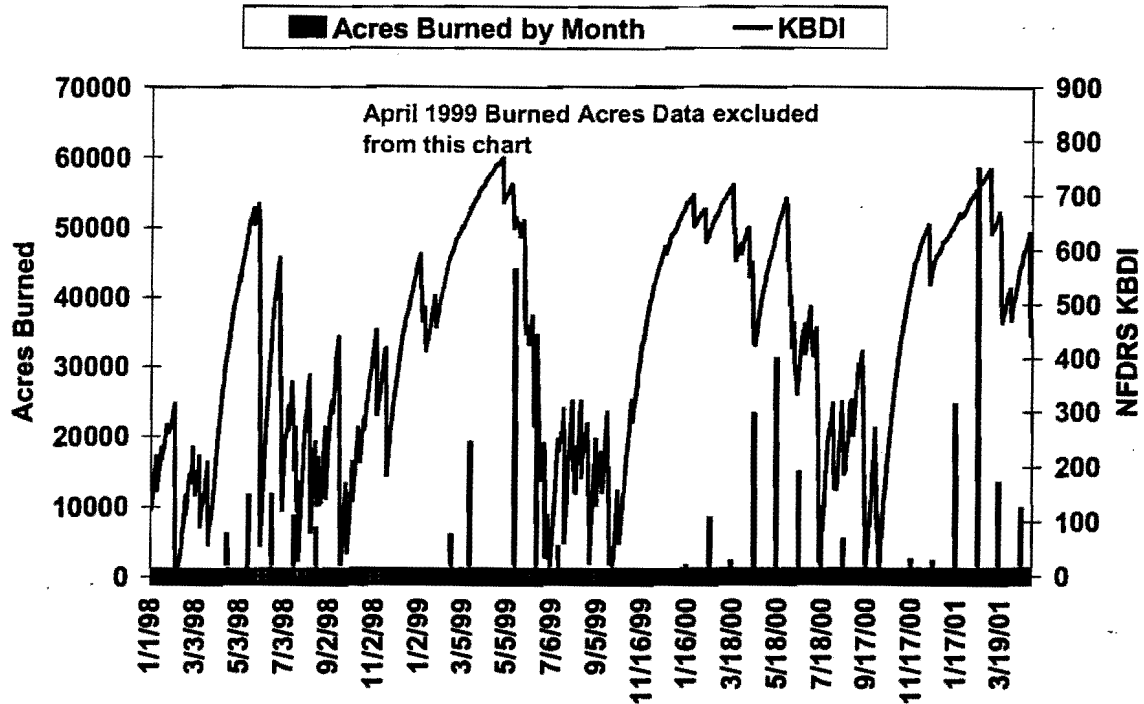


This chart relates the KBDI to acres burned in North Florida. Although not as significant as the acres burned in south Florida the fire seasons have been long and unrelenting. This period started with a significant wet period in early 1998 and with the exception of the brief drop in September of 1998 the Index has remained high. Note that the KBDI did not drop to zero between October of 1998 and September of 2000. After October of 2000 the Index has risen back to the 400 or 500 levels early this year before dropping after heavy rains in March.

The chart below displays the acres burned on State owned and protected lands in south Florida along with the Keetch Byram Drought Index (KBDI) for the same period.

In south Florida the KBDI has reached over 700 in each of the last 3 seasons. Frequent moisture in the

Southern Florida NFDRS KBDI versus Acres Burned



spring of 1998 helped to suppress fire activity. Longer dry periods in 1999, 2000 and now 2001 resulted in peaks in the Index that have held for long periods. These dry periods have been associated with large acreage lost. The acreage burned in April of 1999 (over 185,000 acres) made viewing the chart difficult and so this data point was not included. It is important to note that these fires (April of 1999) occurred at the peak of the KBDI.

2001 Florida Wildland Fire Situation

Fuels and Fire Behavior

2001 marks the fourth consecutive year of drought in the state of Florida. Early season fire activity began in January and has been increasing into spring with little relief in the way of precipitation. Numerous fire managers have reported that fires in late March and April are burning with intensities usually associated with fires in late May at the height of the fire season.

Fuel amounts and availability continue to be the primary factor behind the high fire activity in the state of Florida. The effects of the continuing drought are influencing fuels, both directly and indirectly, in several ways.

Live fuel moisture trends across the state indicate that live fuels are only partially recovering during the wet portions of the year. In June of 1998 the live woody fuel moistures in central Florida flatwoods (Ocala NF) were observed at 80% during what was the peak of the fire season. Observations in 2001 at the same location indicated live woody fuel moistures of 75% in late April, prior to the districts peak fire season. If this trend continues, available live fuels, a primary fire carrier, will be more available and contribute to greater fire intensities and rates of spread than seen during the 1998 fire episode.

During the winter and spring of 2001 Florida experienced freeze damage. The Ocala National Forest for instance estimates up to 5% of the oak brush on the forest is frost killed. While not continuous statewide, this increase in dead vegetation will result in increased intensities and rates of spread where it occurs.

Drought conditions continue to reduce the water levels in the bays, swamps, stringers, ponds and lakes across the state. From a fuels standpoint this is leading to an increase in available fuels in what are normally natural fuel breaks. In 2001 some bays and swamps are not only holding fire as seen during the 1998 season but are beginning to support active fire spread. Drier conditions in the organic soils associated with bays and swamps increase the potential for deeper and longer burning ground fires and the associated problems with breakout fires and long term smoke events these fuels present.

The high fire danger seen for the past three years and concern about tree stress due to drought have resulted in an overall reduction in the prescribed fire program (State and Federal). While this trend is not uniform, some units being able to achieve their burn programs due to increased precipitation locally, the overall result is an accumulation of surface fuels and live vegetation. In general, land managers attempt to maintain upland pine stands on a 3 to 5 year rotation so as to manage understory vegetation (modeled as FM 7). Once understory vegetation exceeds 5 years without fire it develops sufficient fuel that understory burning may result in unacceptable mortality to the overstory and wildfires have the potential to burn with high intensities. Generally, the older understory vegetation is modeled as a FM 4 due to the high intensities and rates of spread associated with it.

- **Pine Uplands**

Fire activity in pine uplands has been moderate to high for early spring burning. Upland fires have been exhibiting rate of spread and spotting usually associated with late May (height of fire season) events.

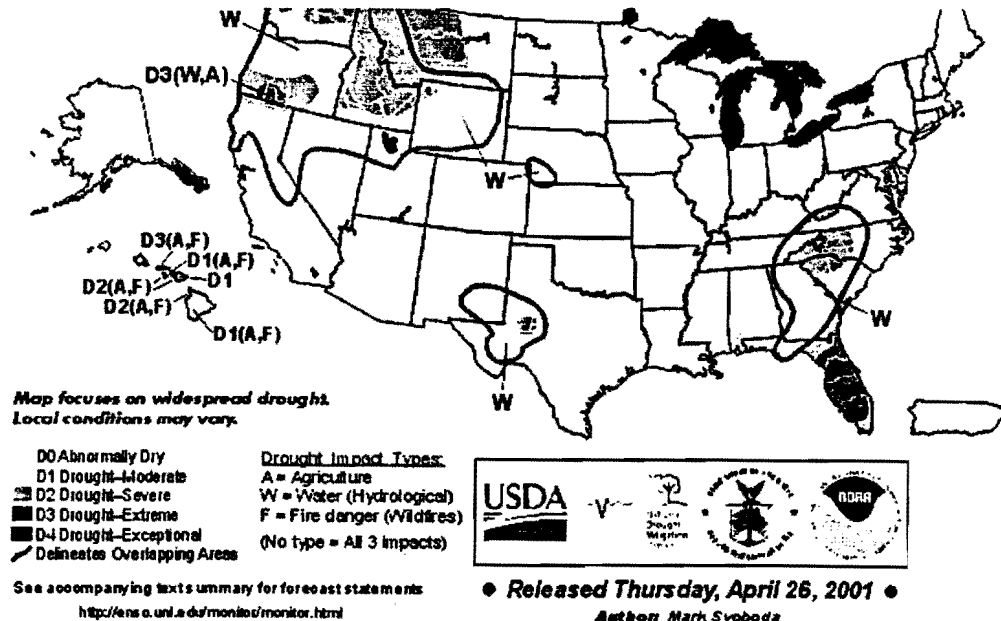
- Lowlands

As mentioned above, lowland fuels are more available than normal due to reduced water level, resulting in increased burning activity in bays, stringers, ponds and swamps and in some cases across dry portions of lakebeds. The potential for deeper burning muck fires (groundfires) continues to increase.

2001 Emergency Water Management

Following are some significant comments from the Florida Drought Emergency Partnership Meeting, Tallahassee, Florida, March 23, 2001;

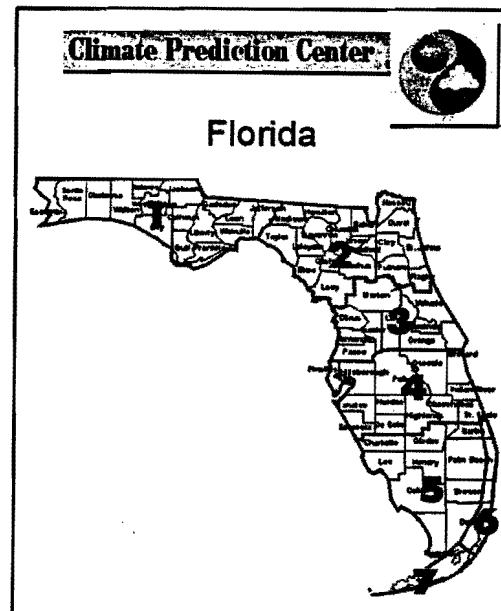
"Whether drawn by the National Weather Service of the National Drought Mitigation Center or the U.S. Department of Agriculture, the current drought maps of the nation tell a nearly identical and sobering story."



"Both the Palmer Drought Severity Index and the USDA Drought Monitor indicate that most of central and south Florida are experiencing extreme to exceptional drought."

WEEKLY PALMER DROUGHT AND CROP MOISTURE DATA FOR THE CLIMATE DIVISIONS IN THE SOUTHERN REGION CLIMATE PREDICTION CENTER, NCEP, NWS, NOAA WEEK 8 OF THE 2001 GROWING SEASON IS THE WEEK ENDING 28 APR 2001

ST	CD	CLIMATE DIVISION	PRECIP NEEDED TO END DROUGHT (IN)
FL	1	NORTHWEST	3.83
FL	2	NORTH	8.86
FL	3	NORTH CENTRAL	11.78
FL	4	SOUTH CENTRAL	8.27
FL	5	EVERGLADES/SW COAST	6.51
FL	6	LOWER EAST COAST	5.31
FL	7	KEYS	5.06



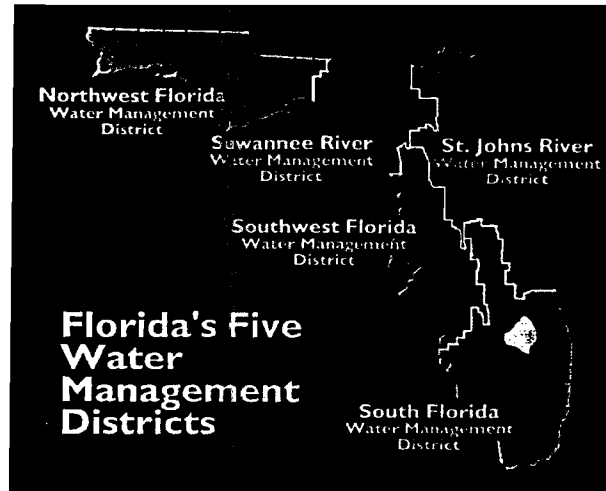
"All five Water Management Districts report the overall conditions are currently worse than this time a year ago."

"The

reports many area lakes remain dry or well below normal levels. Ground water levels throughout the district remain near historically low levels.

"The Suwannee River Water Management Districts reports record low levels in three bodies of water generally used to measure water levels.

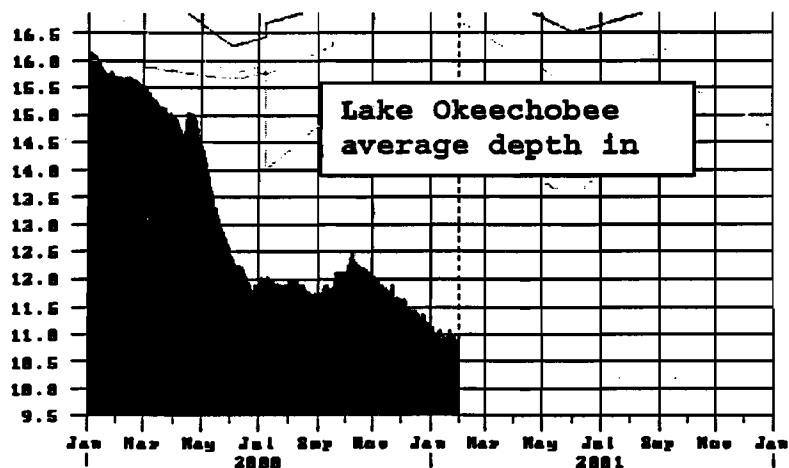
"Southwest Florida Water Management District remains under stringent water use restrictions in place since May of 2000. 179 wells have experienced problems due to agricultural freeze protection activities primarily along areas near I-4. Residents are using bottled water or are connecting to a non-affected supply of a neighbor. The Peace River is flowing at 14% of its normal volume while the Hillsborough River is at 15% of its normal volume – even with ground water augmentation.

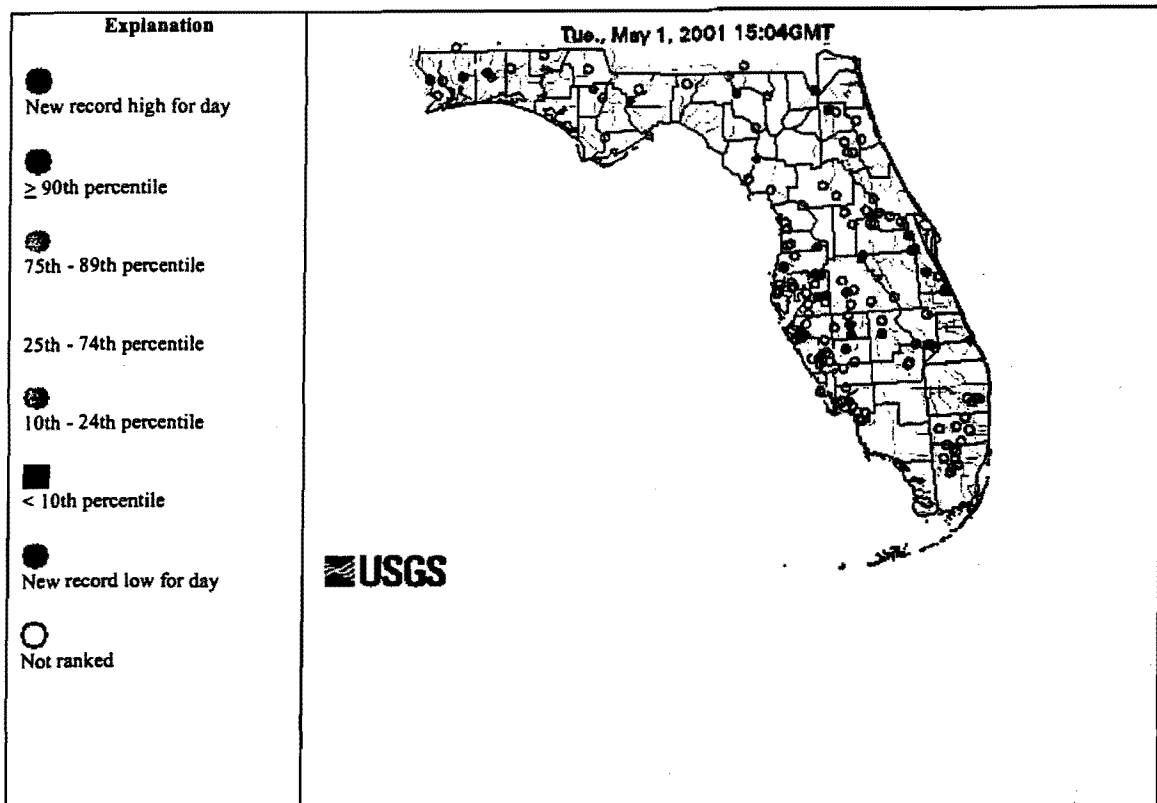


Phase 3 restrictions have been imposed by the South Florida Water Management District. The effected areas are in: Palm Beach, Hendry, Glades, Martin and Okeechobee counties, surrounding Lake Okeechobee. A Phase 3 restriction indicates an extreme water shortage and aims to have a 45% reduction in water use.

St Johns Water Management District has issued water shortage orders for all of Seminole and Volusia and portions of Brevard, Lake, Marion, and Orange counties. Ground water levels in Lake, Marion, Polk, Seminole and Volusia have declined 3 to 4 feet in the last year, while ground water levels in southwest Orange county have declined almost 9 feet. A severe water shortage has been declared and Phase 2 restrictions have been put into place to reduce water use by 30%.

Lake Okeechobee is known as the 'liquid heart' of South Florida. It is the second largest fresh-water lake in the continental United States, second to Lake Michigan. But due to the recent drought in the southern part of the state, the lake has also been affected. As of February 8, 2000, the average depth of Lake Okeechobee was 10.84 ft, which is down from 15.66 ft at this time last year.





"It is reported that decisions regarding the use of water of domestic water for drinking versus fire fighting may well be approached in the very near future."

Fire Danger and Greenness Imagery

Current vegetation condition, or greenness can be monitored over large geographic areas using the Normalized Difference Vegetation Index (NDVI). NDVI is calculated from red and near infrared reflected light that is remotely sensed at a 1-km resolution. NDVI relates directly to the amount of actively photosynthesizing vegetation. High NDVI values, illustrated in dark green shades on the maps, indicate abundant, moist vegetation. The EROS Data Center (EDC) collects, processes and distributes the remotely sensed image data. Daily images are used to prepare weekly composite images in a process that selects the brightest or highest value pixel for each pixel location from the several days of images, thus reducing interference due to clouds or smoke.

Vegetation abundance and condition varies across geographical areas with differences in soils, topography, and soil moisture as well as vegetation moisture status. Remotely sensed greenness values vary with vegetation type as well. In the images displayed below, stream and river corridors are visible due to the increased abundance and adequate moisture status of the plants in the water network area. The low NDVI values in the southeastern portion of Florida reflect urban areas, sawgrass, savanna and marsh. Effects of long term weather patterns on vegetation can be observed by comparing images through a season or from the same time over several seasons. Time-series NDVI images can be used to assess the timing and extent of greenup and curing (Burgan and Hartford 1993) and can be used to relate vegetation condition to fire danger (Burgan and others 1996). The technique of comparing vegetation greenness between years has become a useful means of illustrating the effect of long term weather patterns on live fuels and relating the fire potential in live fuels to that of past years.

In early spring, 2001, EDC began processing images with an improved algorithm for reducing atmospheric interference. These 2001 NDVI images show much higher greenness values than those of previous years due to the new procedures. All historical image data (back to 1989) will be processed to the new standard so direct comparison will again be possible, but at the time of this assessment, the 2001 data cannot be directly related to previous years' data. David Lloyd of EDC provided pixel value data from both procedures for image scenes of Florida through a 9-week period in 1998 including April. This data indicated a shift upward of about 14 in mean and median NDVI values in the Florida scenes prepared with the updated processing. For this analysis, the pixel values for NDVI scenes for mid through late April of 2001 were uniformly adjusted downward by 14 to approximate the values that would have been obtained had the images been prepared as in previous years'.

Remotely sensed NDVI images compare the current vegetation condition in Florida in late April to that of an active fire year, to a year with abundant early season moisture and to successive dry years. The 1989 image illustrates vegetation greenness during an exceptional fire year. The 1998 image shows the effects of adequate winter and spring moisture in encouraging plant growth that spring. While the shift in NDVI values is subtle, the drought that has persisted in Florida since summer of 1998 is illustrated by the vegetation condition as overall NDVI declined in 1999, shows a partial recovery in 2000 then declines further in 2001. Vegetation in central and south central Florida appear impacted to a greater extent than that in the north or south regions of the state. Overall, vegetation condition in late April remains superior to that of 1989.

The series of images below portray the vegetation condition in mid-to-late April across the state of Florida. Images in this area show little weekly change in vegetation through the three-week period, but frequent interference with clouds, made comparisons between years difficult. A maximum pixel value composite was created from images of the last 3 weeks of April for each of the years from 1989 through 2001. These composites allowed comparison between years of the maximum vegetation condition in mid-to-late April. The process also eliminated cloud interference that remained in the weekly composites.

Comparison of Normalized Difference Vegetation Index images for mid through late April



NDVI 1989



NDVI 1998



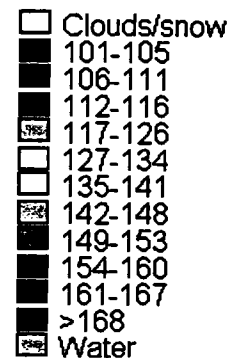
NDVI 1999



NDVI 2000



NDVI 2001



Fire Season Indicators

The Fire Behavior Assessment Team was also asked to provide comparisons of various fire danger indicators that could prove useful during extraordinary weather cycles.

After interviews with some fire managers, and an initial examination of NVDI and Palmer Drought maps, it appears there may be differences in wildfire danger across the state. The Division of Forestry had done other comparisons using north, central, and southern segments of Florida, so these same boundaries were used for this analysis;

In order to do a correlation of fire danger and wildfires, numerous weather analysis runs were made comparing;

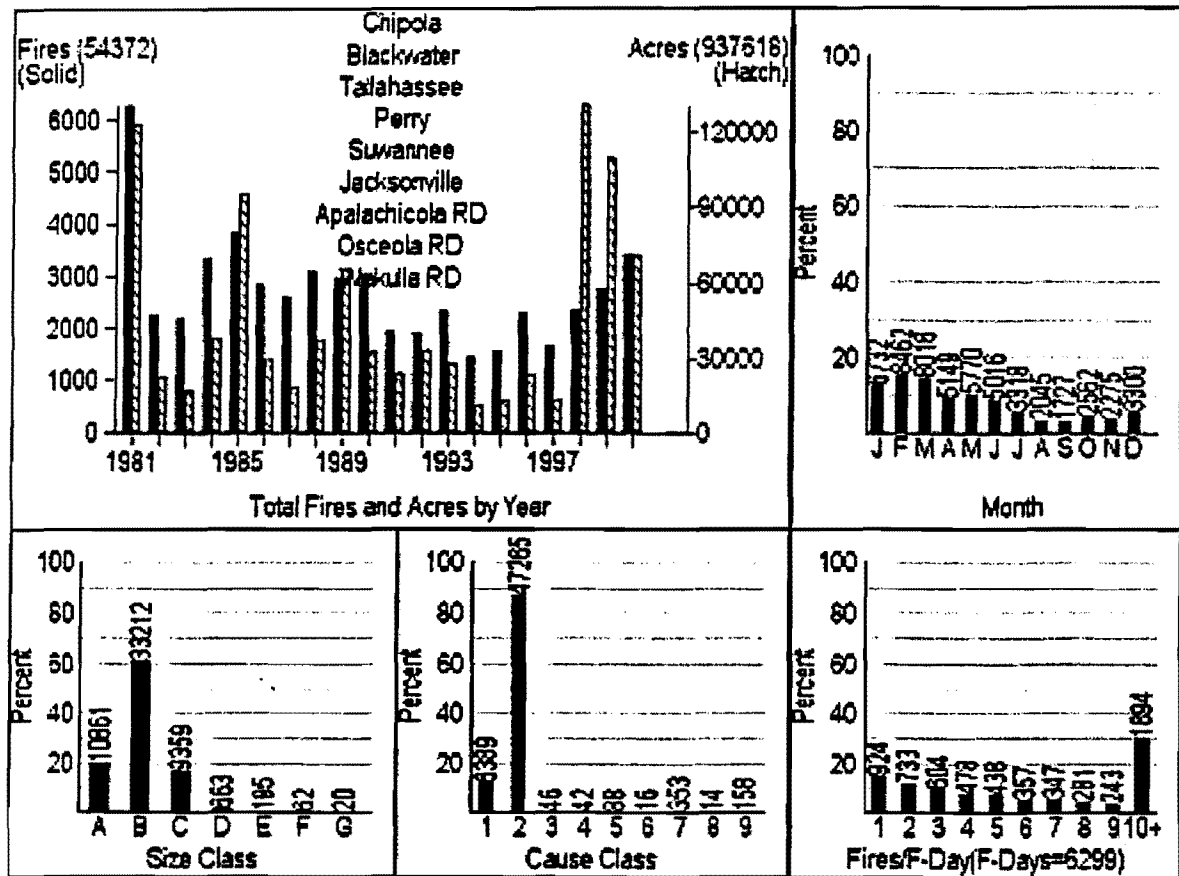
- representative federal (USDA-FS and DOI-NPS) NFDRS weather station inputs, gathered using weather stations for the north, central, and southern parts of the state,
- measured live woody fuel moisture values from three stations in representative locations for the areas of Florida,
(In many locations around the State live woody (shrub) vegetation is collected and dried. This value is then used as input to the NFDRS to help keep it more closely correlated with actual fire danger conditions. Unfortunately this data is not always routinely collected at all locations. This meant that gaps in the woody fuel moisture data.)
- state (DOF) KBDI values for the same three segments of Florida.
(The Florida Division of Forestry calculates the KBDI on a 4 km resolution grid by using NEXRAD Doppler radar precipitation estimates. The National Weather Service's network of NEXRAD radars produce an hourly precipitation product on a 4 km grid. The Division of Forestry combines this information with daily rainfall measurements from NWS observing stations to produce a detailed view of the past 24 hours rainfall across the state. This new precipitation dataset, which has been adjusted to agree with observations, is then used as the rainfall input to the KBDI calculation. This allows the KBDI to capture the isolated showers and thunderstorms that comprise the majority of Florida's rainfall. With KBDI data every 4 km across the entire state, the Division of Forestry can more reliably assess drought conditions across the state through the use of mean values for the state, individual Forestry districts and individual counties. In addition, the driest part of a region can be easily identified. This system has been in use since the spring of 1999.)

The fire danger outputs were then compared against wildfire acres burned, large fires (greater than 1,000 acres), and multiple fire days (20 fires or more) for the three areas. Since this was a regional analysis, for potentially large-scale mobilization of out-of-state firefighting resources, these thresh-holds were selected. Because of the frequency of ignitions in Florida, this required developing a database of wildfires for both state and federal protected lands.

Northern

Representative fire weather station used was Sanborn, #082201 with an associated NFDRS fuel model of "D", Southern Rough.

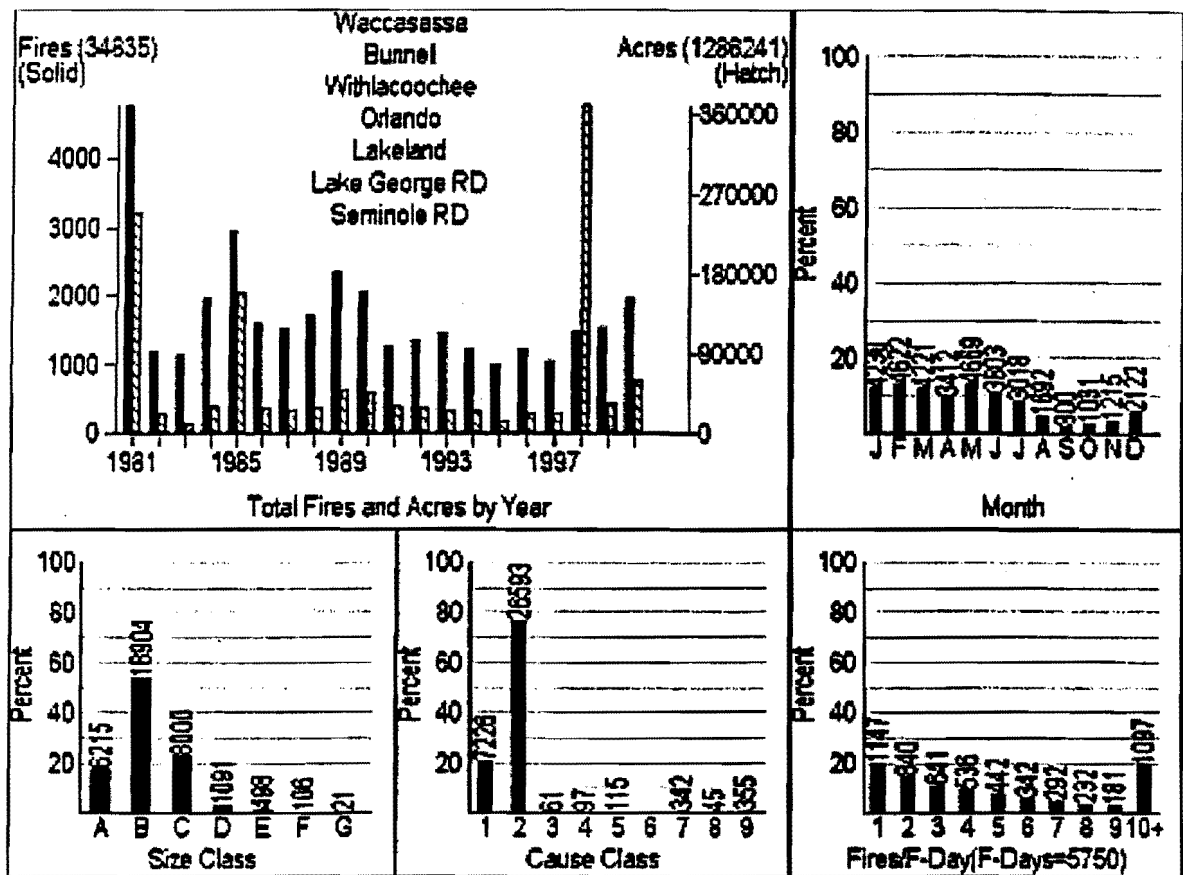
Fire occurrence from 1981 to 2000 is illustrated below. Fire records for the Chipola, Blackwater, Tallahassee, Perry, Suwannee, and Jacksonville District of the Florida Division of Forestry and the Apalachicola, Osceola, and Wakulla Ranger Districts of the National Forest of Florida are included. Note the relatively low number of "D" and larger fires historically. Fire occurrence peaks in February with the majority of the fire activity occurring in the spring.



Central

Representative fire weather station used was Central, #083501 with an associated NFDRS fuel model of "D", Southern Rough

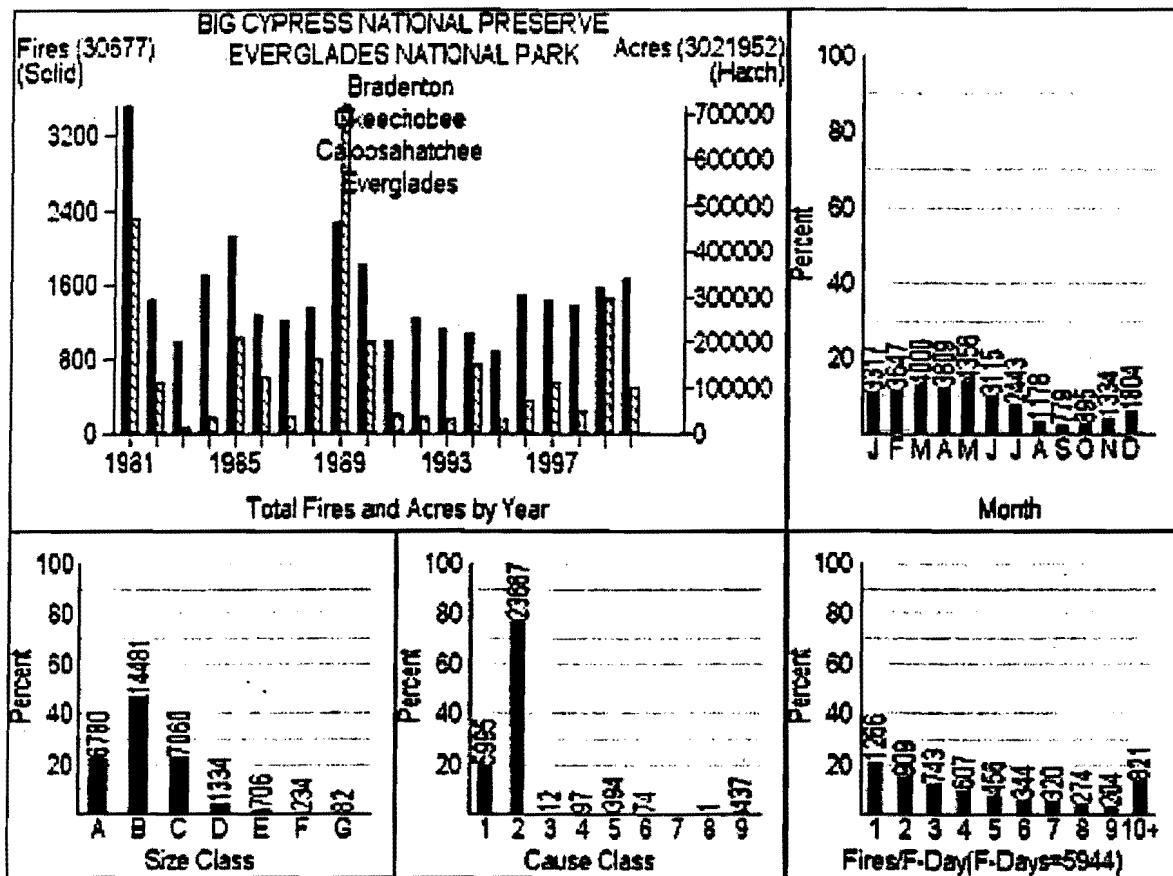
Fire occurrence from 1981 to 2000 is illustrated below. Fire records for the Waccasassa, Bunnell, Withlacoochee, Orlando, and Lakeland Districts of the Florida Division of Forestry and the Lake George and Seminole Ranger District of the National Forest of Florida are included. Note the relatively low number of "D" and larger fires historically. Fire occurrence peaks in May although it appears the period of January through June experiences steady fire activity.



Southern

Representative fire weather station used was Cache, #086702 with an associated NFDRS fuel model of "D", Southern Rough

Fire occurrence from 1981 to 2000 is illustrated below. Fire records for the Big Cypress and Everglades National Parks and the Bradenton, Okeechobee, Caloosahatchee, and Everglades District of the Florida Division of Forestry are included. Note the relatively low number of "D" and larger fires historically. Fire occurrence is most frequent in the spring with May seeing the highest frequency.



Based on the information above, fire occurrence is the heaviest during the period of January through June in all zones. Midsummer fire activity is substantially lower through November, at which point fire activity historically begins to increase. In all zones, fire occurrence during the summer and fall was $\frac{1}{4}$ to $\frac{1}{2}$ that of the spring activity.

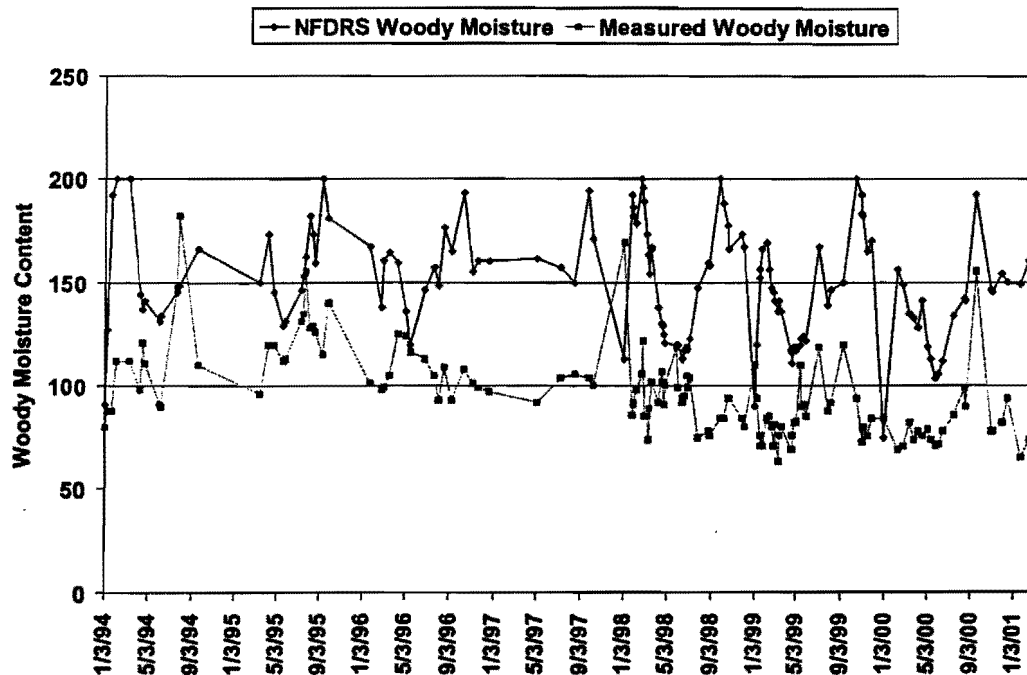
Live Woody Fuel Moisture

Live fuel is the primary carrier of fire in most Florida fuels. The ability to model the contribution of live fuels in predicting fire behavior and fire danger is critical to being able to predict fire behavior and fire danger in coastal plain fuels.

The National Fire Danger Rating System includes processes that model both woody and herbaceous fuel moistures, however these processes may be limited in their ability to predict or reflect changes in fuel moisture. The charts below display the woody live moisture predicted by NFDRS compared to measured woody moistures taken at three sites in Florida. The predicted woody moisture (NFDRS) is predicted for the same site where the woody moisture samples are collected.

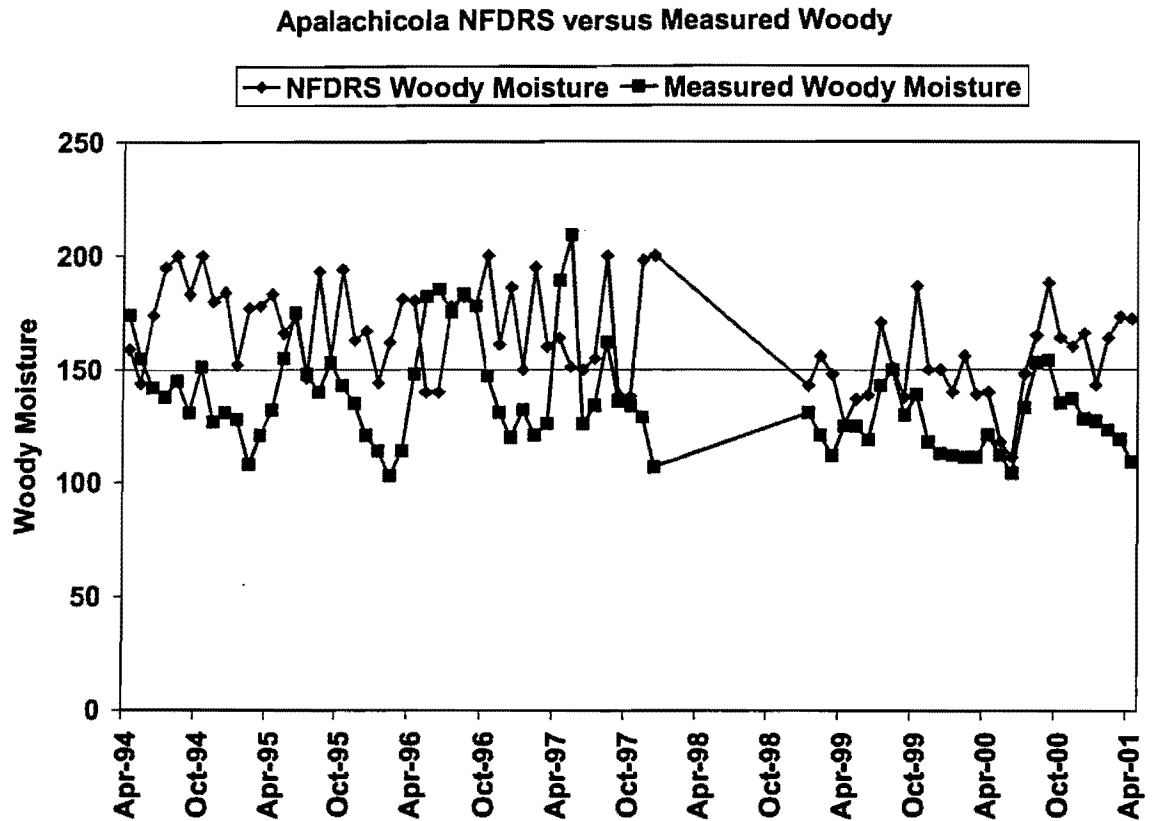
At central the measured woody typically runs about 50% lower than NFDRS woody moisture. Since live fuels can have a significant affect on fire behavior the over prediction of woody moisture content can

Central NFDRS versus Measured Woody Moisture

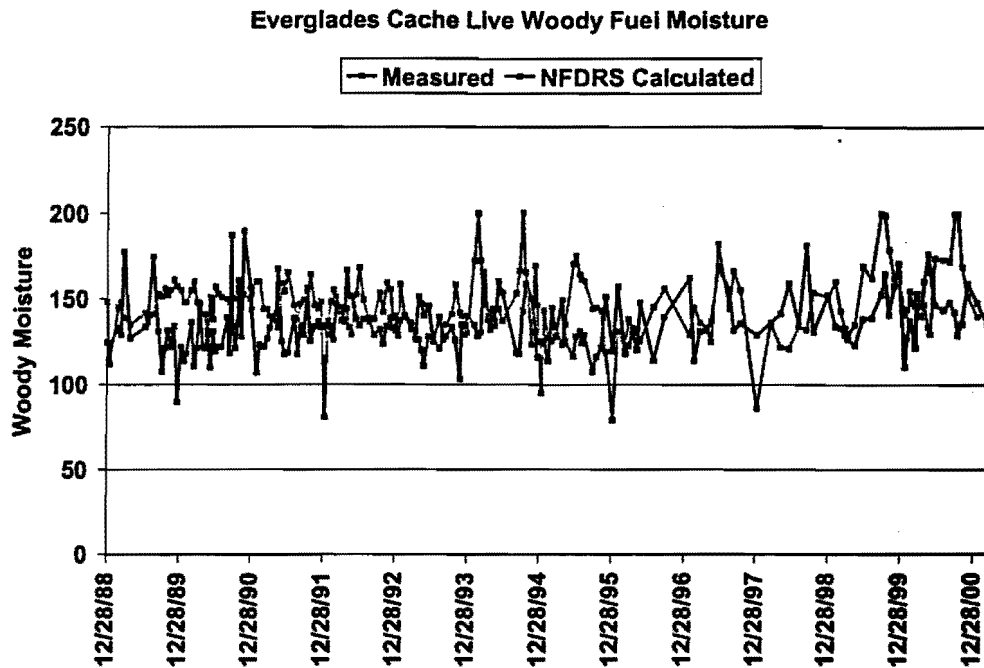


reduce predicted fire behavior and under estimate fire danger. Although in general the trend is comparable some periods show a considerable discrepancy. Note the period between 1/3/98 and 9/3/00, here NFDRS has predicted several drastic increases in woody moisture while the measured changes have changed much less or even gone in the opposite direction.

The next chart is a comparison of northern Florida. Again, some trends are well modeled while others seem to run in opposite directions. The predicted NFDRS moisture is 20 to 30% higher than the measured.

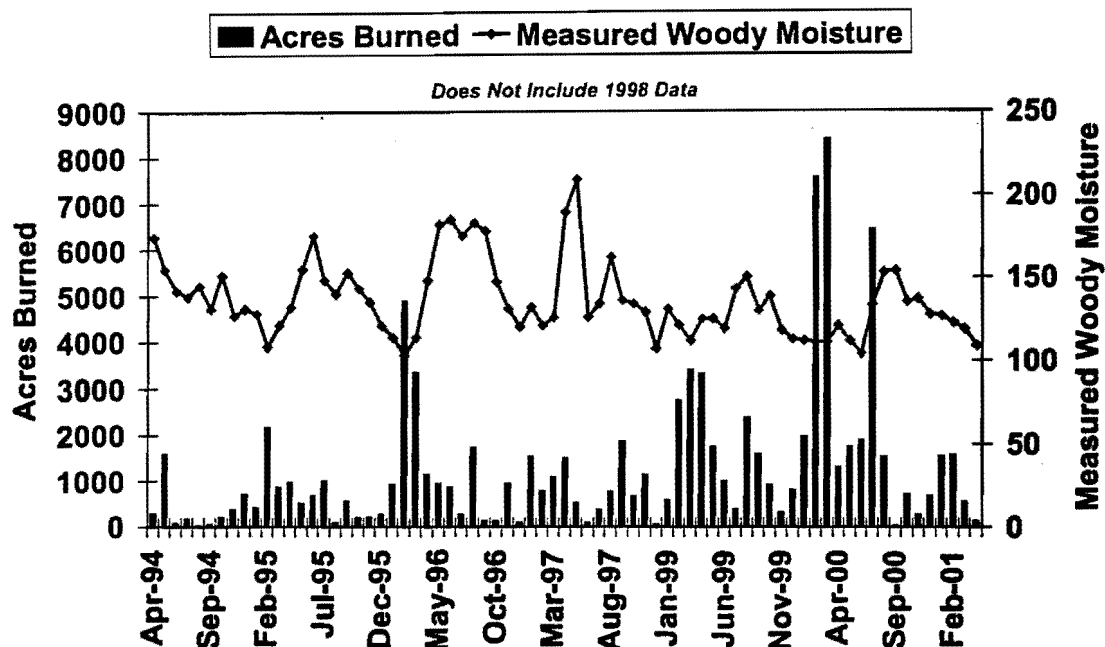


The last chart shows the relationship in southern Florida and was taken at the Everglades National Park. This is the longest running set of measured data that was available to the Team. Here the NFDRS and the measured run about the same moisture content with the NFDRS running just a bit higher. Trends at times are well modeled while at other times they go in opposite directions.



NFDRS also uses freeze and greenup processes. This means that NFDRS is dynamic in that it can move moisture in and out of fuels over time. The green up period reflects fuels at a very high moisture content and generally happens in the spring with new growth. After green up fuels lose moisture for about 2 weeks before coming into equilibrium with the environment. The freeze occurs in the fall and removes moisture and even transfers loading from the live to the dead category. These processes are different in Florida particularly where freezing may not occur. However the model requires both greenup and freeze in order to function. The chart below demonstrates how this can effect the woody moisture over time. As can be seen from the chart this is a short term effect but could be critical at certain times of the year. After freeze occurs all woody moisture becomes set at 75% and remains there until greenup occurs. No fluctuation takes place in the model. For the purpose of these analyses the Freeze date was set at 12/31 and greenup was set at 1/1. This allows the model to calculate woody moisture based on weather observations for all but about two weeks in early January. Moving these dates may provide a method of tuning the outputs to better reflect either actual moistures or fire danger outputs.

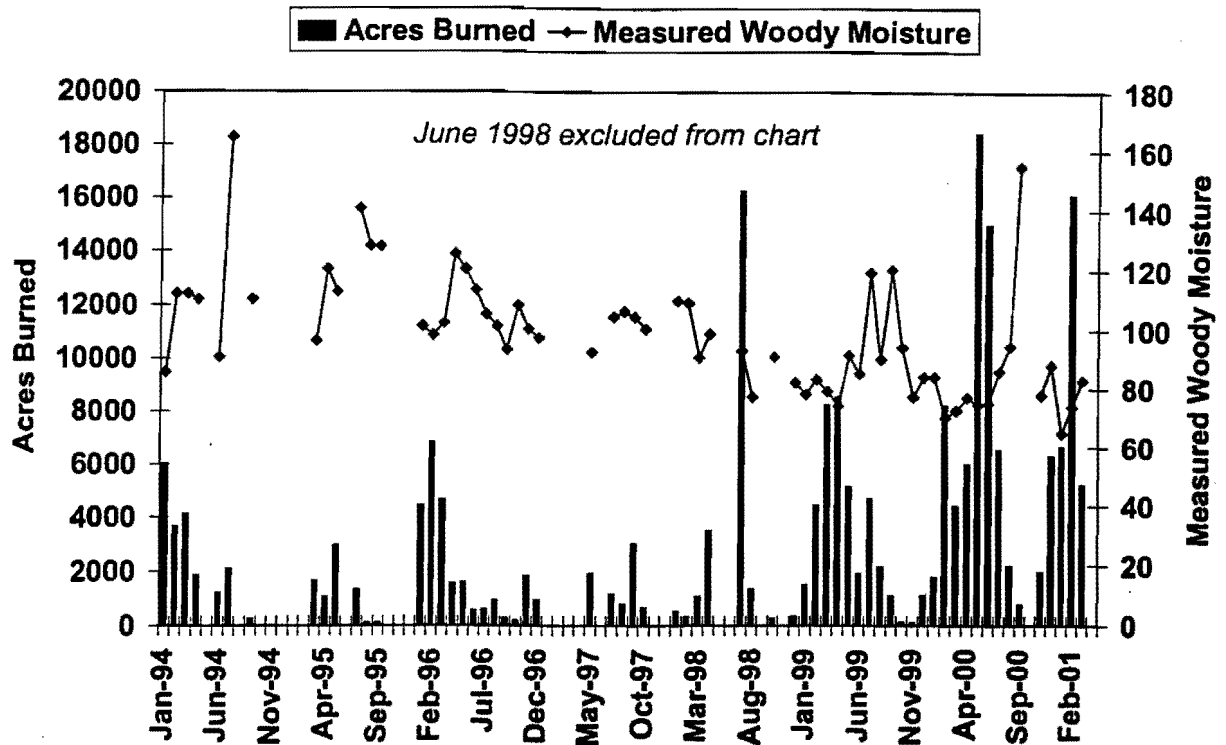
North Florida State Acres Burned vs Measured Woody Moisture



The chart above displays burned acres of State owned and protected lands in northern Florida (Blackwater, Chipola, Tallahassee, Swanee and Jacksonville Districts). This was perhaps the best data set as it contained measured fuel moistures from April 1994 until present with the important exception of 1998. There were no observations for 1998 one of the busiest fire years in recent history in northern Florida. The observations were taken on the Apalachicola National Forest.

Note that low points in measured woody fuel moisture are often associated (as you would expect with) higher acreage burned. In particular note February of 1995; February and March of 1995; February, March and April of 1999 and February, March and April of 2000.

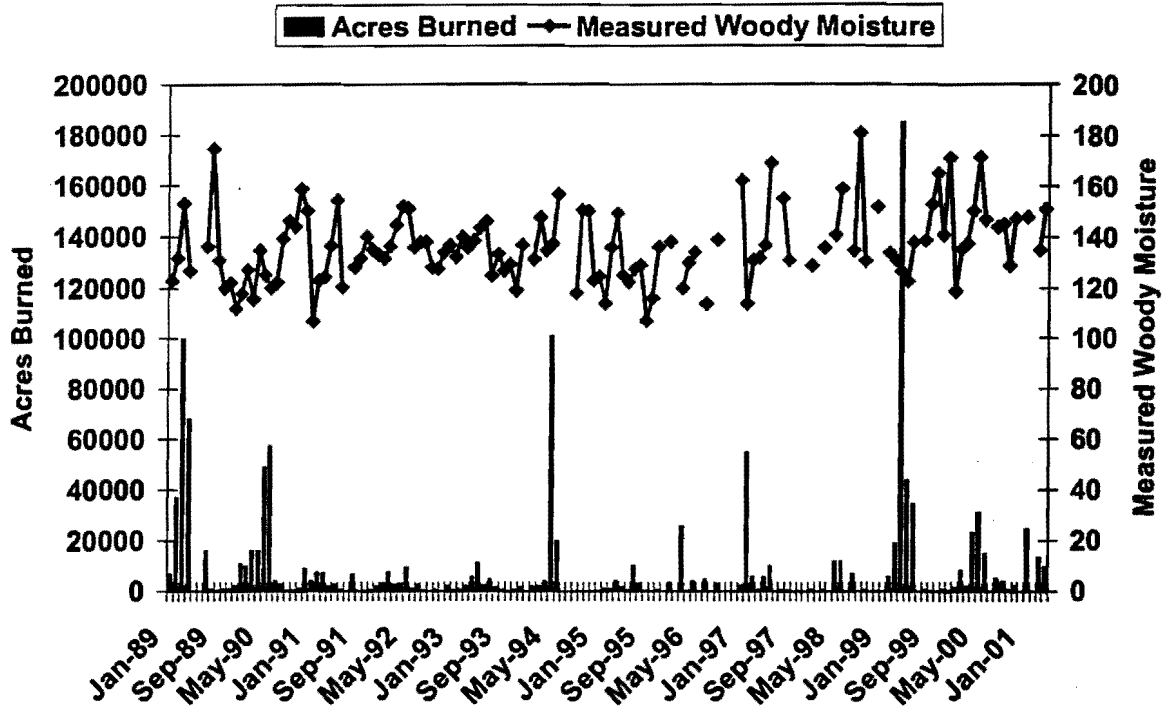
Central Florida State Acres Burned vs Measured Woody Moisture



The chart above displays the relationship between acres burned on Florida Division of Florida owned and protected lands. The burned acres represent the Districts of Waccasassa, Bunnell, Withacoochee, Orlando and Lakeland Districts. The measured woody fuel moisture data was taken from the Ocala National Forest. Data for June of 1998 was not included because in excess of 350,000 acres burned during this period in the subgeographic area. This spike so dominated the graph that few fires showed. For information in June of 1998, 708 reported fires burned 354,000 acres. The measured woody moisture was 101 percent. The relationship between woody moisture and acres burned appears poor until 1998. This may be due to missing data. After 1998 fuel moisture appears to be a better indicator of acreage burned.

One important observation (at least based on the data presented here) is that woody fuel moistures have steadily declined during the period of the 90's and into 2000. At the same time the number of acres burned has steadily increased.

South Florida State Acres Burned vs Measured Woody Moisture



The chart above represents the relationship between acres burned of State owned and protected lands and measured woody fuel moisture for the southern portion of Florida. This includes the Myakka, Okeechobee, Caloosahatchee and Everglades Districts. Woody moisture data was taken from the Everglades National Park. This data set represents the longest period of moisture data collection obtained by the risk assessment team. However, this data set also appears to have the poorest correlation to acres burned. The period of fires in early 1990 occurred at a period of low woody moisture as do fires in the late 1999 and early 2000. This data set is dominated by years of exceptionally large fire activity that masks other years. These observations were taken on a timely basis in the early years but less so recently. This may reflect in a poorer correlation than found in the other two sets of data.

Note the period of large fire activity in the late 80's and early 90's. The mid 90's have been dominated by a wet period while the late 90's and early 2000's have been dominated by drought.

In general live fuels seem to contain more moisture in the southern part of the state, the least in the central Florida, with northern Florida somewhere in the middle. This may be more a reflection of the method of data collection than in any actual moisture difference. It may be a worthwhile investment to research this issue to determine if in fact any real differences exist.

At many observation stations that provide input to the NFDRS Woody Fuel moisture are used to supplement the weather data. Once a measured observation is entered into the system it is held for 30 days. After thirty days the system reverts to calculated woody fuel moisture if a new entry is not made. This entry may be a critical factor in helping the system better model actual fire danger.

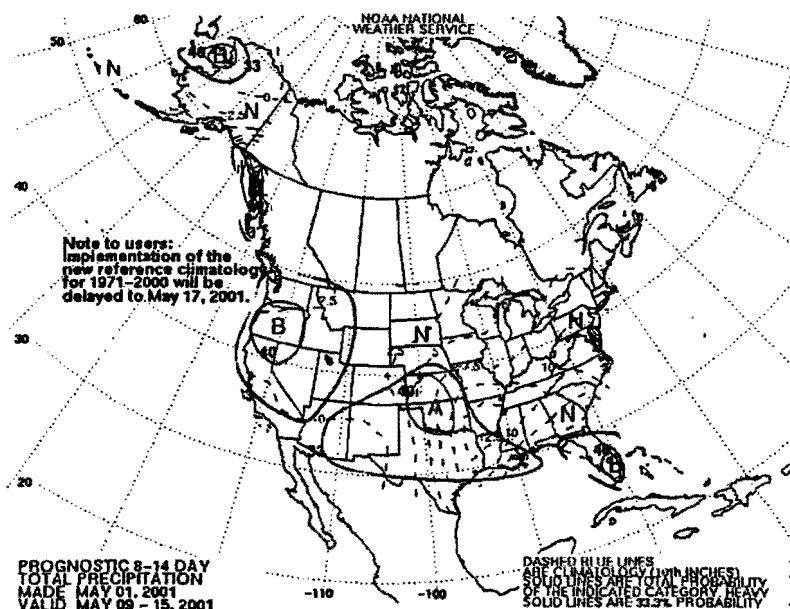
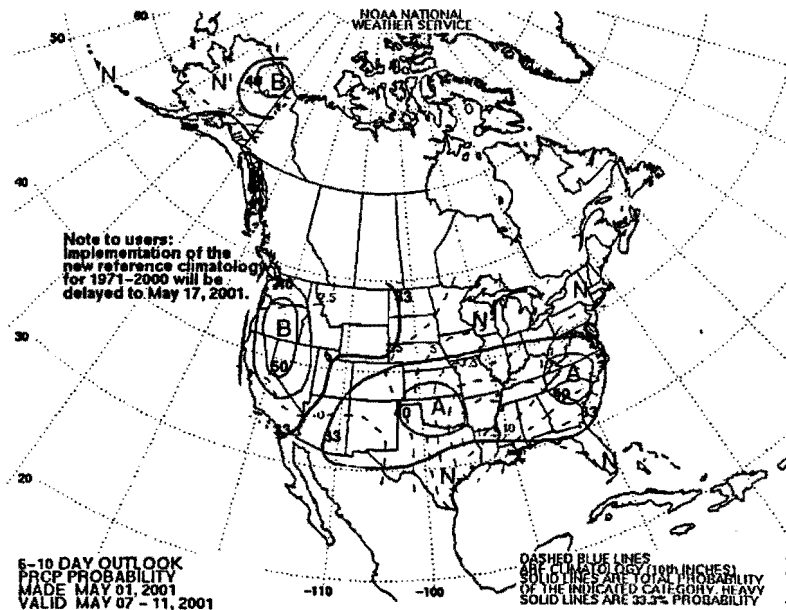
A standard systematic approach to woody moisture measurement and input may greatly help to improve the predictive capability of the NFDR system. The team was unable to verify this as input woody moistures and the effect that these moistures have on the fire danger indices are not stored in the system. Time frames negated our ability to test this hypothesis.

After producing the outputs (previous pages), the following table was developed to compare fire danger indicators that seemed to best correlate with acres burned, large fires, or multiple fire days;

May 1 Fire Danger Indicator	North Florida 1990- 97	North FL 1998	North FL 2001	Central Florida 1990- 97	Cent. FL 1998	Cent. FL 2001	South FL 1990- 97	South FL 1998	South FL 2001
NFDRS									
KBDI	588	551	459	432	489	423	573	551	459
1000 Hr	19	23	11	25	22	25	20	23	11
ERC	18	16	18	18	17	17	18	16	18
Woody Moisture	138	122	136	138	124	130	136	122	136
Measured Live Fuel Moist.	171	110	109	105	98	83	140	141	151
D.O.F. KBDI	316	310	358	398	460	440	496	414	512
<i>Acres Burned as of May 1</i>	<i>5,430</i>	<i>10,628</i>	<i>3,775</i>	<i>15,929</i>	<i>16,189</i>	<i>628</i>	<i>29,131</i>	<i>31,003</i>	<i>105,335</i>

Remaining 2001 Fire Season, 14 Day Weather Forecast

May is forecast to get off to a normal start and then become drier as the 6-10 day and 8-14 day forecasts from the National Climate Prediction Center indicate normal rainfall with near normal temperatures followed by drier than normal conditions through the middle of the month. These forecasts are based on a weakening of the high-pressure ridge that has been parked over the southeastern U.S. for the month of April. A weak subtropical ridge is consistent with expected atmospheric teleconnection patterns (North Atlantic Oscillation and Pacific-North American Patterns).

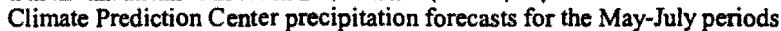


Climate Prediction Center precipitation forecasts for the 6-10 day (top) and 8-14 day (bottom) periods

The short-range forecast agrees with the CPC's forecast for May which calls for below normal rainfall and above normal temperatures. This is consistent with weakening La Niña conditions in the equatorial Pacific Ocean. Current trends in sea surface temperature in the Pacific indicate a transition from the below normal temperatures of La Niña to warmer than normal conditions for the fall. Atmospheric circulation patterns are still exhibiting La Niña type patterns which forms the basis for the CPC forecast.



The 90-day outlook from the CPC continues to persist La Niña conditions throughout this period by forecasting above normal temperatures along with below normal rainfall for Florida. Examination of the forecast for the June-August period reveals a climatology forecast for the same region which indicates equal chances of above-, below- or normal precipitation amounts. This leads to reduced confidence in the below normal precipitation forecast for the May-July period. Warming of sea surface temperatures in the equatorial Pacific Ocean since the issuance of this forecast may indicate a significant change in a primary factor that contributed to the forecast. However, since there is a lag in the response of the atmosphere to changes in sea surface temperature, the below normal rainfall forecast for May could be sufficient to lead to below normal values for the May-July period.



Source: CPC Probability of Exceedance Forecasts

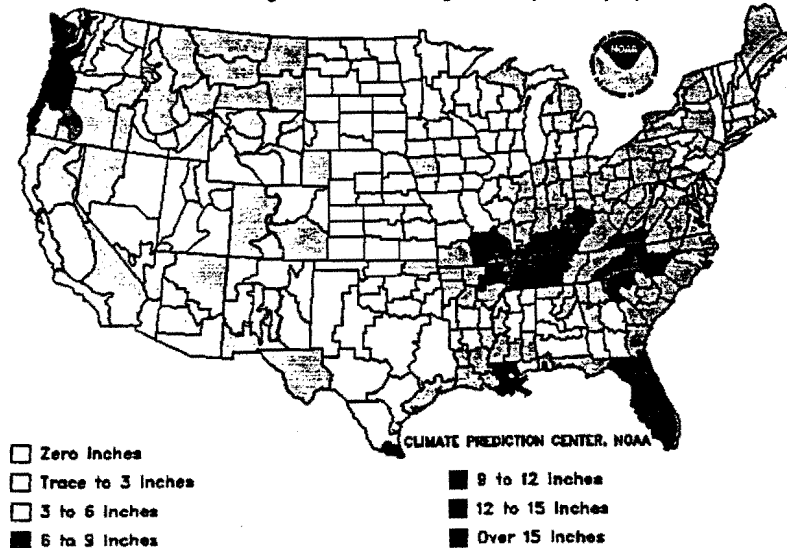
Forecast Summary

While short-term forecasts of above normal rainfall are encouraging, the overall outlook for the next 90 days calls for a good chance Florida's rainfall deficit to increase as rainfall amounts are expected to remain below normal. Current ENSO and NPO conditions suggest another year of above normal wildfire activity (both the sea surface temperature anomaly and NPO index are below 0.5). Even normal rainfall amounts for May would not have a significant impact on drought conditions in the state as May is generally a dry month, except in the southern most part of the state where the summer rainy season pattern normally develops toward the end of the month. Current estimates on rainfall needed to end the long-term drought require much of the state to receive more than 6 inches of rainfall. A forecast for below normal rainfall for the May-July period is of greatest concern for south and central Florida, as this would imply a delayed start to the summer rainy season, thus extending the fire season. In the northern part of the state, a below normal rainfall forecast is not as worrisome as May is still generally a dry month anyway. CPC forecasts for the June-August period imply normal rainfall amounts for the state which suggests that May dryness will dominate the May-July seasonal forecast, but June and July should be near normal with afternoon showers and thunderstorms developing on a regular basis.

Additional Precip. Needed (In.) to Bring PDI to -0.5

Weekly Value for Period Ending 28 APR 2001

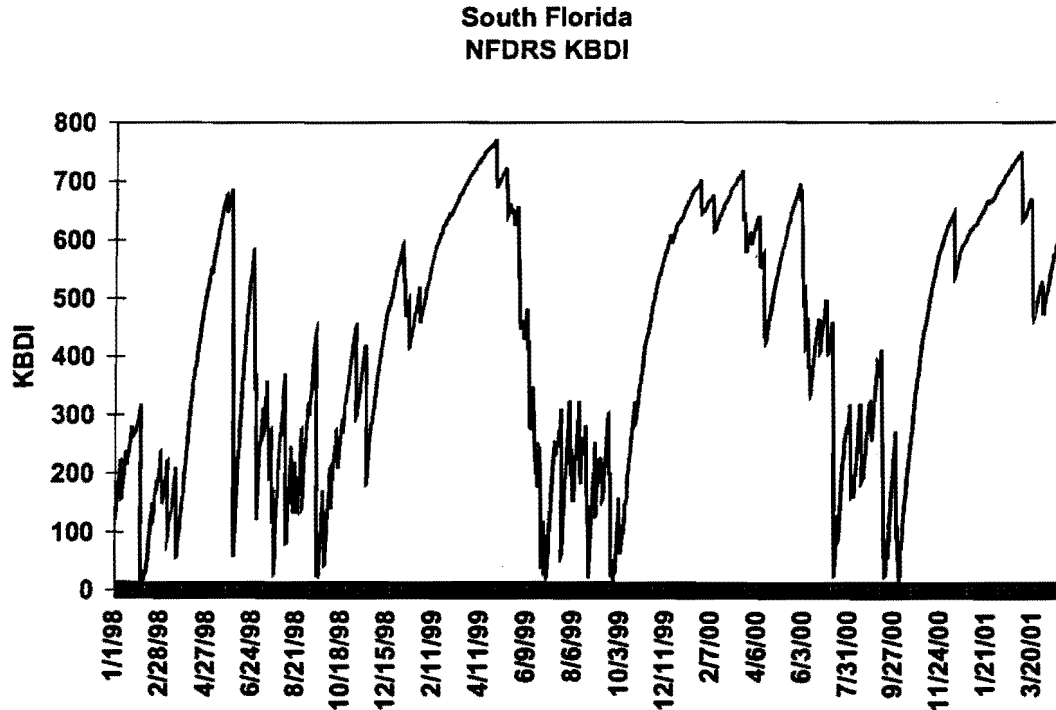
Long Term Palmer Drought Severity Index (PDI)



Estimated rainfall required to bring the Palmer Drought Severity Index back to normal conditions.

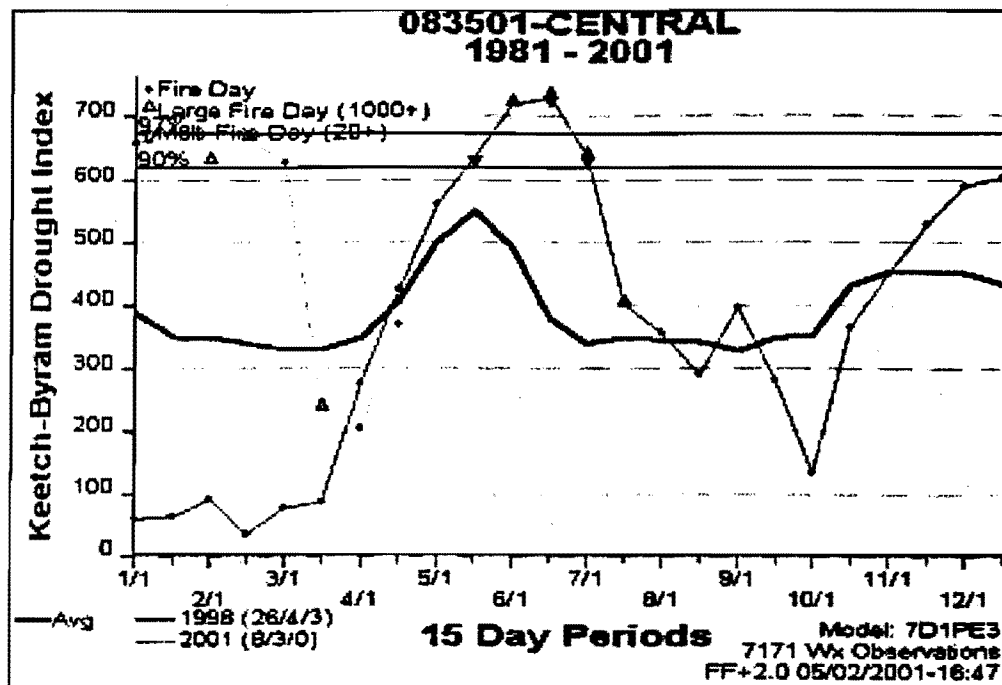
Indicators KBDI or ERC?

Keetch Byram Drought Index (KBDI) is an indicator of available ground water. It assumes that the surface soils are saturated at when the value is 0 and that they are dry 8 inches down when the value is 800. This Index has been used successfully for many years in the coastal plain as an indicator of fire business in particular acres burned. It has also been used as an indicator of the severity of the burn. Prescribed burning at high KBDI's has lead to unwanted effect of vegetation and escapes. Below is a chart of the progression of the KBDI in south Florida from January 1998 through April 2001.

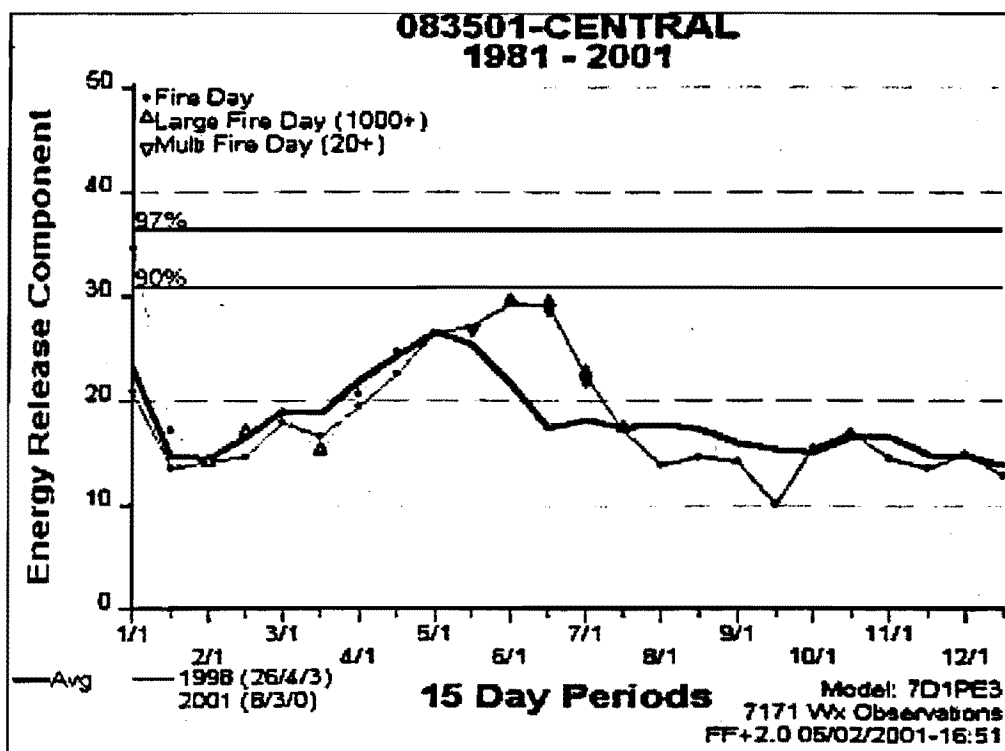


The KBDI model assumes that the water table recharges at least once year. Since the model does not go below zero it has no way of indicating extreme droughts (when the soil moisture is depleted even below the 8 inch depth). The chart above indicates that the KBDI has recharged at least 4 or more times in the last three years. However, it is a known fact that Florida is in the midst of one of its worst droughts in history. The rains that did come were sufficient to bring the KBDI to or near zero but they have not been enough to recharge the soils.

However, the Index can still be a reasonably good indicator of trends. Although under the current drought conditions most fire managers feel that it is under predicting fire potential by 100 to 200 points.



This chart displays the fire activity associated with the KBDI for 1998 and 2001. Note that the high index was associated with numerous large fire this year while the low index in early 1998 did not have any large fire major fire activity.



Note that when using Energy Release Component (ERC) from NFDRS large fires occurred even at low levels in the spring of 2001. ERC while the same values in 1998 showed no large fire activity.

This same relationship was found with many of the other NFDRS indices and components. For predicting fire danger potential KBDI is still the best indicator even though it is under predicting observed fire behavior.

Wildfire Scenarios for the remaining 2001 fire season

It is important to understand the "normal" Florida fire season and weather patterns, which are not similar to many parts of the United States. The unusual nature of the current wildland fire situation is not that fires will spread rapidly, but instead that a drought situation over multiple years has resulted in;

- measured live woody fuel moistures across some areas of the state not rising above 150% since 1998,
- historically abundant natural wildland fire barriers (swamps, cypress stands, etc) are no longer available,
- fire intensity levels normally experienced mid-fire season (May, June) are now occurring much earlier (April, May), and are returning much sooner following a short period rain event,
- previously used fire danger indicators that have widespread application across the state (KBDI) may be under-predicting,
- wildland fire suppression tactics being altered because of both increased fire intensity levels and less water available for heli-buckets and engines, which results in longer turn-arounds,
- duff and soil moisture levels much lower than experienced by many fire managers, requiring longer mop-up, and/or patrol of both wildfires and prescribed fires to prevent breakouts.

Scenario Description for the May – July, 2001 Fire Season	Northern Florida Probability	Central Florida Probability	Southern Florida Probability
Less Severe and/or Shorter Than Normal	27 %	24 %	22 %
Normal Fire Season	34 %	34 %	35 %
More Severe and/or Longer Than Normal Fire Season (example, 1998)	38 %	41 %	43 %

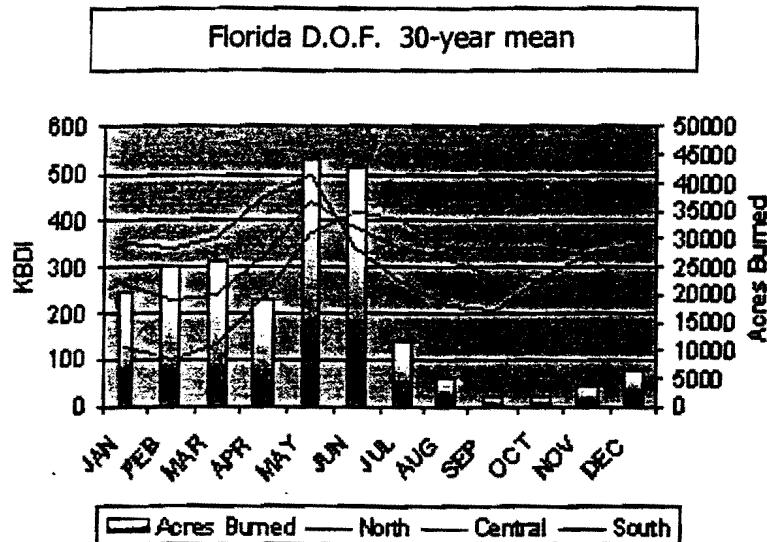
Less Severe and/or Shorter Than Normal Fire Season

Because of the persistent drought conditions, a "less than normal" fire season for May, June, July, 2001, would require a significant precipitation event, followed by a series of wet storms in a regular cycle. Since the moisture deficit is rather severe, a single large precipitation event alone will not restore the wildfire season to anything resembling normal.

Normal Fire Season for 2001 in Florida

Because of the persistent drought conditions, a "normal" fire season for May, June, July, 2001, would require a significant precipitation event, or a series of wet storms beginning soon and continuing on a regular basis. After discussing with numerous experienced fire managers and fire behavior analysts in Florida, a more "normal" fire season next year would probably require;

- a return to frequent periods of rain (not just a single or several large tropical events), resulting in;
- increased duff, soil, and live woody fuel moistures across all areas of the state and;
- ground water increase so that water source availability (ponds, ditches, lakes) for suppression resources (engines, hell-buckets) improves.



More Severe and/or Longer Than Normal Fire Season (eg May through July, 1998)

Because of the persistent drought conditions, a "more severe and/or longer" fire season for May, June, July, 2001, would mean a continuation of the weather patterns from January through April, 2001. During this period there has been a few localized significant precipitation events in certain parts of Florida, however it was not followed by a break in the drought pattern. That is, the cyclic pattern of showers has not taken place. Commonly in Florida the May-June period will see thunderstorm events, growing more frequent and wetter. Unfortunately, these early storms also start numerous lightning fires, particularly early in the period. If this pattern holds, given the drought conditions, numerous large and long term wildfires should be expected.

Implications based on scenarios as of May 1, 2001

Florida Scenario	Wildfire Initial Attack success rate is;	Firefighting resource needs are met;	Large wildfires requiring IMT's are;	Threats to communities are;	Prescribed Fire program;
Less severe and/or shorter than normal fire season.	high, minimizing damage and acreage burned.	locally, occasionally forces moved to adjacent units.	not common, Florida Area type II teams only.	rare, and short duration events.	Could achieve summer and fall targets, some backlog.
Normal fire season for remaining 2001.	moderate, assuming firefighting staffing at Most Efficient Levels or equivalent.	within the State, supplemented from out-of-state occasionally, predominately from southern U.S., usually tractor-plows.	unusual, but some wildfires may require a type I team.	unusual, but occasionally some threats last for more than two burning periods.	Could achieve summer and fall targets.
More severe and/or longer than normal fire season (eg May through July, 1998).	low, indirect attack common.	through National mobilization, including aircraft, engines, and overhead.	common, type I teams are assigned and occasionally staged to reduce re-mobilization costs.	common, and last for more than two periods with change in winds.	Little opportunity to meet targets and backlog grows.

Other implications of an extended and/or severe season;

Fire Behavior

- Extreme fire behavior expected, even a few days after a rain event. Increased potential for an independent crown fire in slash and sand pine stands.
- Mid and long range spotting common, as is active fire spread through swamps and bays.
- Despite the significant reduced live fuel moistures over "normal", a major varnish or wax secretion has not occurred for several years. Though this late winter event is not a concern this year.

Wildfire Suppression Tactics

- Multiple plow lines required in most fuels, with engine support.

Prescribed Fire

- Many units have a backlog of acres that should have been treated since 1998. Reasons include not meeting fire behavior prescription parameters, and the negative impacts witnessed to vegetation following burning (probably due to low fuel moisture related stress). The reduced fuel treatment is adding to the fire behavior problems in vegetation with one to three year fire return intervals. As an example, one experienced fire manager normally uses prescribed fire on 15,000 acres per year, but has burned virtually nothing since September, 1999.

Incident Management Teams

- Numerous large fires, particularly of long duration could require mobilization of out-of-area Incident Management Teams. If these teams are not familiar with Florida current fuel conditions, recent successful suppression strategies, and safe tactics, there is the potential for ordering of too many/few of the appropriate firefighting resources.
- There is the potential for an Incident Management Team to be mobilized to deal with the drinking water shortage.

Wildland Urban Interface

- Some estimates are that the population of Florida is growing by 1,000 people per day. The pressure to protect citizens, community infrastructure, and property will grow, with many of the new residents not coming from environments with effects of wildland fire as common as Florida.
- Potential for a large scale evacuation in heavily populated rural areas (eg Flagler County, 1998).
- Many 2001 fires in the Lakeland area have been organic soil (MUCK) fires. Interstate 4 was closed for more than one week as a result of the Stagecoach Fire, and another organic soil fire caused I-4 to be closed just prior to the Super Bowl weekend.

Mop-up and Patrol

- The Division of Forestry has an agreement with the National Guard that allows for mop-up using their personnel. However, successfully extinguishing wildland fuels in Florida is currently very difficult by even experienced firefighters with low soil and duff moistures, and reduced available water supplies.
- Though swamp areas are burning, there is still limited access for mop-up.

Large Fires

- Since many natural barriers are no longer available, strategies using swamps as containment areas are no longer successful resulting in larger fires and indirect attack. Use of roadways for indirect attack creates more potential conflicts with the driving public.
- Larger fires result in greater perimeter, and more potential for escapes.

Aviation Firefighting Resources

- In the early 1990's successful wildfire suppression in much of Florida did not rely on helicopter or air tanker support, but instead on single tractor plow lines. With current fire intensity levels and increased potential for spotting, there is a reliance on aviation support.
- Increased widespread smoke can restrict aviation support.

Air Quality

- Many surface or sub-surface fuels (muck, swamps) are burning, resulting in more smoke for longer periods, in addition to larger fires resulting in more smoke production.

Analysis Summary and Recommendations

The prolonged drought conditions in Florida have presented wildland fire managers with a challenging period since 1997. Although many firefighters from throughout all parts of the United States were in Florida during only 1998, the 1999 and 2000 seasons were also very difficult from a wildland fire protection and fire use perspective. To date, 2001 continues the period of significant events.

Based upon the assessment team's fuels, climate and meteorological analysis it appears that the remaining 2001 fire season could continue the challenges.

Several experts in fire danger have serious concerns over the use of the National Fire Danger Rating System in correlating wildland fire with fuels and fire weather in Florida.

NFDRS information stored in NFMID using the WIMS process does not store measured fuel moistures (live or dead), therefore any historical analysis does not recreate outputs displayed to fire managers during the season on a day-to-day basis.

- Based upon our brief analysis it appeared that the correlation between KBDI and fire business (acres burned, large fires, ignitions) is poor, but may be as good as ERC and other outputs from the current NFDRS commonly used in the western United States.
- A standardized system of measuring and recording live fuel moistures should be implemented in Florida. It appears that at least a bi-monthly or weekly measurement correlates to fire business. Further study would need to confirm the basic analysis conducted by this team, and it should also focus on designation of representative stations.
- Given the significance of live fuel moistures on Florida vegetation, and the problems with the NFDRS in Florida fuel situations, sampling of live fuels and adjusting live woody in NFDRS should be emphasized to weather station managers during fire season.
- The WIMS/NFDRS, or a similar process, needs to be improved in order to be able to file, retrieve, and utilize measured live and dead fuel moistures for historical analysis.

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Jim Brain, East Wenatchee, Washington,
Larry Bradshaw, Fire Science Laboratory, Missoula, Montana

Florida Wildland Fire Behavior Assessment

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Seasonal Effects of Prescribed Burning in Florida; A Review, Louisa Robbins and Ronald Myers, Tall Timbers Research, 1992.

April 26 to May 3, 2001 interviews by the Assessment Team

Phone Interviews

George Custer, Fire Management Officer, Seminole District, Ocala NF.
Fred Adrian, Fire Management Officer, Merrit Island Wildlife Refuge.
Fred Wetzel, Fire Management Officer, Okefenokee Wildlife Refuge.
Bob Panko, Fire Management Officer, Everglades National Park.
Ray Durham, Forest Area Supervisor, Bunnell District DOF.

Personal Interviews

James Hart, Forest Fire Management Officer, Florida National Forests.
Joe Ferguson, Forest Fire Staff Officer, Florida National Forests.
Walter White, Dispatcher, Ocala National Forest.
Mark Clere, Fire Management Officer, Lake George District, Ocala NF.
Whit Lear, retired Forest Fire Staff



Fire Behavior "Quick Guide" to Florida

Fires are driven in large measure by fuel availability and atmospheric stability.

Dispersion Index (atmospheric conditions-relied up heavily as indicator of fire activity potential)

0 – 40	Stable
41 – 70	Marginally Unstable
more than 70	Unstable

Mixing heights greater than 6500 feet also indicator of high fire potential

Relative Humidity of 35 – 55% can make for extreme fire behavior.

Fires can burn actively at RH's up to 80%

Precipitation events will slow or stop fire spread. Fuels will dry very quickly however and burn actively within one to two days of a major rain event.

Keech-Byram drought index (KBDI)

Utilized throughout the south as an indicator of potential fire business. May under represent conditions during period of drought. Index consequences vary by time of year and location (North/Central/South). Index 0-800

Thunderstorms – Occur throughout the year but peaks in May and June. Develops very rapidly with little warning. Strong, violent storms are normal.

Sea Breeze—Strong Influence on wind patterns and thunderstorm development. Majority of State is a peninsula.

Fuel	NFFL Fuel Model
Palmetto-Galberry	7 (when Rough less than 4 feet-usually <5 year burn cycle) 4 (when Rough more than 4 feet >5 year burn cycle)
Dense Pine	2, 4, 7, 8 (depending on ground cover)
Swamp	1 or 3 (marshes, savannahs, prairies) 4 or 6 (hardwood brush with some pine overstory, titi, wax myrtle, yaupon, and bitterbrush)
Blow Leaf	9
Grass	1, 2, 3
Muck	3, 4, 5, 6, 7
Flatwoods	7 (overstory is slashpine, loblolly and/or some pond pine)
Ridges	2 and 9
Varnished sand pine	4 (with loadings of 10-30 tpa)