Center for Ocean-Atmospheric Prediction Studies (COAPS) Economic Impact of Wildfire Forecast(s) in Florida Final Report

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Florida's Wildfire Forecast: An Attempt to Measure its Economic Impact

Introduction

The Florida State University Center for Ocean-Atmospheric Prediction Studies (COAPS), has produced wildfire forecasts (or Keetch-Byram Drought Indices) for the State of Florida, since 2004. This forecast is utilized by the Department of Agriculture and Consumer Services – Division of Forestry and is published on the AGClimate website[1]. The KBDI values range from 200 to 800. COAPS was interested in validating the KBDI forecast in terms of the economic impact of the forecast. COAPS collaborated with the FSU Center for Economic Forecasting and Analysis (CEFA) to conduct a study that examined the economic impact of the wildfire forecasts for Florida. From February to July 2006, CEFA developed an economic impact methodology pertaining to the COAPS wildfire forecasts for Florida.

Forecast Background

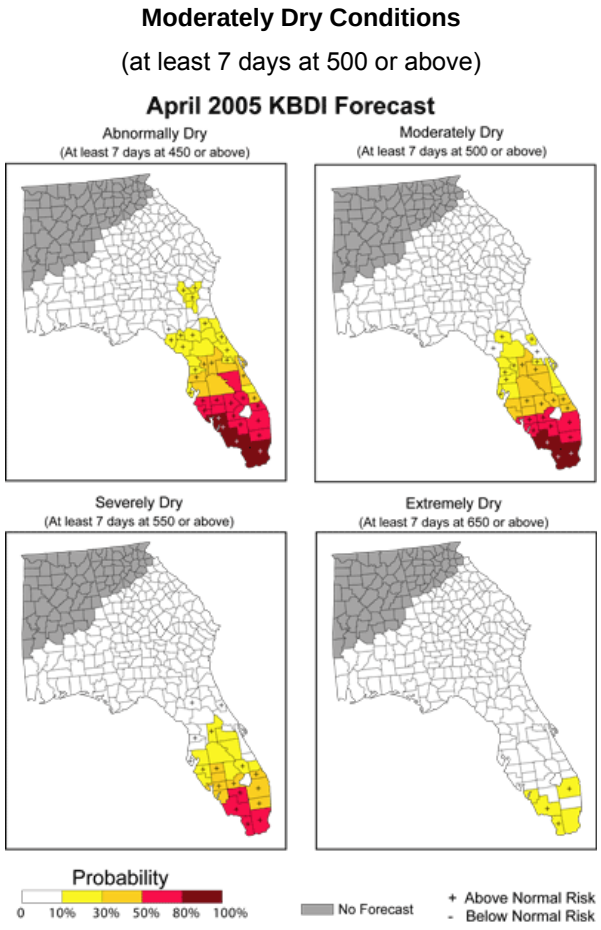
The Keetch-Byram Drought Index (KBDI) has been used by the Florida Division of Forestry to indicate the dryness of the surfaces, the soil, and more specific surface fuels. It can be seen as logical to assume high values of drought are associated with a high risk of wildfire. Therefore, widespread drought will be used as an indicator of wildfire outbreaks.

According to the Florida Division of Forestry, the index uses 35 years of rainfall and temperature measurements from nine locations in the state. For the Northern region of Florida, measurements are taken in Pensacola, Tallahassee and Jacksonville. For the Central region, measurements are taken from Daytona, Gainesville and Orlando and for the Southern Region, the measurements are taken from Tampa, Fort Myers and Miami.

During winter season, the conditions are driest in the south, wetter to the north and in frontal passages in the central area. During summer, rainfall increases, particularly in the southern portion of the state. Annually, Florida's wildfire season begins in January and peaks in May and June. It is important to note that the forecast is based on land characteristics, such as dryness. Figure 1 is an example of an April 2005 KBDI wildfire forecast report for Florida.

[1] http://www.agclimate.org

Figure 1. KBDI Florida Forecast for April 2005.



Methodology to Measure the Economic Impact of a Wildfire Forecast

It is often difficult to measure the economic impact of a wildfire since the wildfire's impact is site-specific and thus damages of the areas and facilities affected by wildfire are exclusive to that region. In order to quantify the economic impact of Florida's wildfire forecast, CEFA has developed the following methodology:

1. Development of a CEFA economic impact index of wildfires in Florida

   The CEFA economic impact index comprises economic quantitative variables and is a measure of the economic impact evolution of wildfires in Florida since 1985 to 2001[2].

[2] The availability of data was constrained to 1985-2001.

2. Determination of the relationship between the CEFA wildfire economic impact index and the actual wildfire fires in Florida and on a national level.

   As expected, there is a positive relationship between the fires in the region and the economic impact, in terms of dollars of damage, to the state.

3. Extrapolation of a quantitative measure from the COAPS wildfire forecast.

   Since the COAPS KBDI wildfire forecast is an "image" of the different dryness levels of the different areas in Florida, by determining the areas with the same level of dryness and therefore, probability of wildfires, will yield a quantitative value measure of the forecast.

4. The measurement of the relationship between the COAPS wildfire forecast and the actual fires in Florida (and on a national level).

5. Once the relationship between the CEFA wildfire economic impact index and the COAPS KBDI wildfire forecast has been estimated, we can apply the economic impact of the forecast on a broader basis (nationally).

Development of the Index

CEFA has created an index that gives an estimation of the damages of the wildfire each year in the State of Florida. The economic and ecological devastation of wildfires depends on many variables including: the location of the wildfire, the current market situation of the timber market, the public areas around the wildfire, etc. Therefore, each wildfire has its own unique site-specific impact. With that in mind, CEFA has created an index that attempts to capture the economic impact of Florida's wildfire.

The literature suggests that the impact of a wildfire is quantified by the following variables (Morton et al, 2003):

- Suppression cost of the wildfire
- Damage to timber resources
- Cost of restoration
- Alteration of wildlife habitat
- Cultural/archaeological damages
- Damages to public facilities
- Public health impact
- Tourism impact
- Transportation impact

From the previous variables, it is highly subjective and very difficult to measure variables such as:

- Alteration of wildlife habitat
- Cultural/archaeological damages
- Damages to public facilities

Concerning the alteration of wildlife habitat, a price or monetary value is necessary to apply to the current habitat in the area. Regarding cultural/archaeological damages, there is not an established market for some cultural pieces. Finally, public facilities have a cost associated with it, but not a sales price.

Due to the challenge of quantifying all these aforementioned wildfire impacts, CEFA has selected the variables that included those based on readily available data:

- Estimation of the cost of fire suppression in Florida
- Damage to timber sources: Southern pine prices
- Number of fires in Florida
- Number of acres on fire in Florida.

In addition, the following critical economic variable was added to the list:

- Yearly average property loss per fire in Florida.

The cost of suppression data was obtained from the Wildland Fire Leadership Council. The cost of timber is specific for Southern pine prices and was collected from the USDA. The number of fires and acres on fire each year was obtained from the Division of Forestry of the Florida Department of Agriculture and Consumer Services, and the yearly average property loss per fire in Florida data were collected from the U.S Fire Administration.

Table One depicts the data that will be used to construct CEFA's economic impact index of wildfires. Once these data has been obtained, the index is a linear combination of the estimated total cost of wildfire suppression per acre, the damage to timber resources (included in the Southern pine prices) and the average property loss per fire in Florida. The Index is developed in the following manner: using a simplistic but necessary assumption[3] that the cost of suppression of fire in Florida is 1/50 of the national cost, as presented in Table Two.

[3] It is important to know that the assumption that the suppression cost of wildfires in Florida is 1/50 of national suppression cost is clearly a simplistic one, however it has been difficult to obtain Florida's data regarding wildfires due to the time lag associated with the agencies that collect wildfire data at the state-level.

Table One. Data Used for the Construction of the Economic Impact Wildfire Index.

	Wildfire Leadership Council (National Data)	USDA	Florida Data	Florida Data	Florida Data (4)
	A	B	C	D	P
	Cost of fire suppression	Damage to timber resources: Southern pine prices**	Fires*	Acres*	Average Property Loss Per Fire
	$ dollars	$ dollars	Units	Units	$ dollars
1981	$97,822,618	185	13,917	582,441	n/a
1982	$27,158,985	144.6	4,692	107,099	n/a
1983	$31,803,617	160.7	4,148	40,389	n/a
1984	$62,011,053	158.8	6,872	95,512	n/a
1985	$160,473,143	118.2	8,621	443,816	5,050
1986	$110,252,540	112.3	5,478	109,894	3,303
1987	$252,402,013	147.3	5,170	75,167	3,132
1988	$413,603,415	161	5,916	193,881	3,676
1989	$317,762,959	169.1	7,291	645,331	3,157
1990	$219,750,976	182.6	6,665	249,912	3,099
1991	$109,938,530	194.3	3,985	86,948	3,173
1992	$254,825,229	222.6	4,324	82,230	3,287
1993	$108,512,905	273.3	4,680	80,484	4,036
1994	$667,557,238	330.5	3,600	180,048	3,086
1995	$167,660,724	389.56	3,343	48,586	3,383
1996	$493,420,582	344.57	4,180	93,849	3,714
1997	$151,326,227	412.39	4,027	146,122	3,725
1998	$215,441,312	406.76	4,899	506,970	4,112
1999	$344,683,686	368.7	5,645	355,239	2,008
2000	$978,947,398	392.35	6,723	210,851	2,872
2001	$646,395,202	351.12	4,805	403,737	5,711
2002	$1,146,024,767	368.41	3,065	56,835	n/a

Table Two. Estimated Cost of Wildfire Suppression in Florida, by Year.

	A/50=E
	Estimated Florida cost of suppression*
Year	$ Dollars
1981	$1,956,452.36
1982	$543,179.70
1983	$636,072.34
1984	$1,240,221.06
1985	$3,209,462.86
1986	$2,205,050.80
1987	$5,048,040.26
1988	$8,272,068.30
1989	$6,355,259.18
1990	$4,395,019.52
1991	$2,198,770.60
1992	$5,096,504.58
1993	$2,170,258.10
1994	$13,351,144.76
1995	$3,353,214.48
1996	$9,868,411.64
1997	$3,026,524.54
1998	$4,308,826.24
1999	$6,893,673.72
2000	$19,578,947.96
2001	$12,927,904.04
2002	$22,920,495.34

The estimated wildfire suppression values divided by the number of fires will give as the estimated total cost of suppression per fire, as outlined in Table 3.

Table 3. Estimated Total Cost of Suppression per Fire, in Florida, by Year.

	E/C=F
	Estimated total cost of suppression per fire
Year	$ Dollars
1981	141
1982	116
1983	153
1984	180
1985	372
1986	403
1987	976
1988	1,398
1989	872
1990	659
1991	552
1992	1,179
1993	464
1994	3,709
1995	1,003
1996	2,361
1997	752
1998	880
1999	1,221
2000	2,912
2001	2,691
2002	7,478

Finally, the estimated total cost of suppression per fire divided by the number of wildfire acres, is the estimated total cost of wildfire suppression per acre, as presented in Table 4.

Table 4. Estimated Total Cost of Wildfire Suppression per Acre, by Year.

	F/D=G
	Estimated total cost of suppression per acre
Year	$ Dollars
1981	0.000
1982	0.001
1983	0.004
1984	0.002
1985	0.001
1986	0.004
1987	0.013
1988	0.007
1989	0.001
1990	0.003
1991	0.006
1992	0.014
1993	0.006
1994	0.021
1995	0.021
1996	0.025
1997	0.005
1998	0.002
1999	0.003
2000	0.014
2001	0.007
2002	0.132

The final result of the index is a weighted average (derived from the Table One relationship between the variables); with the assumption that 10% of the index

represents the estimated total cost of wildfire suppression per acre, 30% comes from Southern pine prices, and 60% stems from the average property loss per fire. The index process is summarized in Table 5, from 1985 to 2001.

Table 5. Economic Impact Index Derived from Total Cost of Wildfire Suppression per Acres, Southern Pine Prices, and Average Property Loss per Fire[4].

INDEX CREATION							
					USDA	Florida Data (4)	
	D/C=T	A/50=E	E/C=F	F/D=G	B	P	**INDEX****
	Acres per Fire in Florida	Estimated Florida cost of suppression*	Estimated total cost of suppression per fire	Estimated total cost of suppression per acre	Damage to timber resources: Southern pine prices	Average property loss per fire	Y = 0.1*G+0.3*B+0.6*P
	Units	$ Dollars	$ Dollars	$ Dollars	$ Dollars	$ dollars	
1981	42	1,956,452.4	141	0.000	185.0	n/a	n/a
1982	23	543,179.7	116	0.001	144.6	n/a	n/a
1983	10	636,072.3	153	0.004	160.7	n/a	n/a
1984	14	1,240,221.1	180	0.002	158.8	n/a	n/a
1985	51	3,209,462.9	372	0.001	118.2	5,050	3,065.5
1986	20	2,205,050.8	403	0.004	112.3	3,303	2,015.5
1987	15	5,048,040.3	976	0.013	147.3	3,132	1,923.4
1988	33	8,272,068.3	1,398	0.007	161.0	3,676	2,253.9
1989	89	6,355,259.2	872	0.001	169.1	3,157	1,944.9
1990	37	4,395,019.5	659	0.003	182.6	3,099	1,914.2
1991	22	2,198,770.6	552	0.006	194.3	3,173	1,962.1
1992	19	5,096,504.6	1,179	0.014	222.6	3,287	2,039.0
1993	17	2,170,258.1	464	0.006	273.3	4,036	2,503.6
1994	50	13,351,144.8	3,709	0.021	330.5	3,086	1,950.8
1995	15	3,353,214.5	1,003	0.021	389.6	3,383	2,146.7
1996	22	9,868,411.6	2,361	0.025	344.6	3,714	2,331.8
1997	36	3,026,524.5	752	0.005	412.4	3,725	2,358.7
1998	103	4,308,826.2	880	0.002	406.8	4,112	2,589.2
1999	63	6,893,673.7	1,221	0.003	368.7	2,008	1,315.5
2000	31	19,578,948.0	2,912	0.014	392.4	2,872	1,840.9
2001	84	12,927,904.0	2,691	0.007	351.1	5,711	3,531.9
2002	19	22,920,495.3	7,478	0.132	368.4	n/a	n/a

**Assumption: 10% of the index comes from the timber prices and 30% for the suppression cost per acre and 60% from total property loss per burned acre.
*Assumption: Florida suppression cost is 1/50 of the total US suppression cost.

Note: Clearly the INDEX is a linear combination of the "G" variable (Estimated total cost of suppression per acre), "B" (Southern pine prices) and "P" total property loss per acre.

CEFA used the level of Southern pine prices (as opposed to the change in price, or marginal price) since the level of the prices has a higher correlation with the number of wildfires in Florida than the change in prices, as it is depicted in Table 6.

Table 6. Regression Statistics Regarding Timber Prices, Change in Timber Prices, and Number of Fires.

Timber prices = f (Number of Fires)			Change timber prices = f (Number of Fire	
SUMMARY OUTPUT			SUMMARY OUTPUT	
Regression Statistics			*Regression Statistics*	
Multiple R	0.843634		Multiple R	0.141316685
R Square	0.711718		R Square	0.019970405
Adjusted R Square	0.661718		Adjusted R Square	-0.030029595
Standard Error	153.4787		Standard Error	35.80948257
Observations	21		Observations	21

[4] 1/43 of the events that the National Interagency Fire Center accounted for from 1997-2005 for large fires (100,000+ acres) in the US: http://www.nifc.gov/stats/lrg_fires.html, represent Florida. It was assumed that Florida represents 1/50 of the total US suppression cost (given the number of states in the U.S.). This approximation is an assumption based of detailed data about wildfires on a statewide basis.

The weights of 10% for the estimated total cost of wildfire suppression per acre, 30% for the prices of Southern pine and 60% for the total property loss per burned acre was given in order to find the best fit for the regression equation and also to try to minimize the weight of the estimated total cost of suppression per acre (since this variable had a very simplistic assumption on it, i.e., the cost of wildfire suppression is 1/50 of national suppression cost).[5] In addition, the cost of wildfire suppression is not independent of the number of wildfires in Florida (hence the weight of this variable was restricted to 10%). In order to validate the index, the following regression, is shown in Table 7.

Table 7. CEFA's Economic Impact Index as a Function of Wildfires in Florida.

		C	M
	INDEX	Florida Data (3)	National Data (5)
Year	$Y = \alpha G + \beta B + \zeta P$	Fires (3)	Fires (5)
1985	3,065.5	8,621	133,840
1986	2,015.5	5,478	139,980
1987	1,923.4	5,170	143,877
1988	2,253.9	5,916	154,573
1989	1,944.9	7,291	121,714
1990	1,914.2	6,665	122,763
1991	1,962.1	3,985	116,953
1992	2,039.0	4,324	103,830
1993	2,503.6	4,680	97,031
1994	1,950.8	3,600	114,049
1995	2,146.7	3,343	130,019
1996	2,331.8	4,180	115,025
1997	2,358.7	4,027	89,517
1998	2,589.2	4,899	81,043
1999	1,315.5	5,645	93,702
2000	1,840.9	6,723	122,827
2001	3,531.9	4,805	84,079
	Average	5,256	
Florida Department of Agriculture and Consumer Services: Division of Forestry (3)			
National Interagency Fire Center (5) http://www.nifc.gov/stats/fires_acres.html			

As demonstrated below in Table 8, the R square is 88% (fairly high) and the intercept is positive as expected; that is, the greater the number of fires in Florida, the greater the economic impact. Finally the p-value is very close to zero, hence the values are significant.

Table 8. Regression Results Regarding Number of Fires in Florida and Economic Impact Index.

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.94275							
R Square	0.888778							
Adjusted R Square	0.822111							
Standard Error	761.8412							
Observations	16							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	69570143.02	69570143.02	119.8654342	3.00753E-08			
Residual	15	8706030.658	580402.0439					
Total	16	78276173.68						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
8621	0.403277	0.036834681	10.94830737	1.49812E-08	0.324766148	0.481789	0.324766	0.481789

* INDEX = f (Wildfire in Florida 'C')

[5] This was a trial an error procedure, or calibration of the index, in order to approximate the "best fitting" line that represented the relationship between economic impact and number of wildfires.

Although the CEFA Economic Impact index has been constructed for Florida it is also correlated with the wildfires on a national level. The following regression is presented in Table 9.

Table 9. Regression Results of CEFA's Economic Impact Index as a Function of National Wildfires.

Index = f (Wildfres Nationwide)								
SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.947187							
R Square	0.897164							
Adjusted R Square	0.830497							
Standard Error	732.5572							
Observations	16							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	70226572.53	70226572.53	130.8634513	1.72393E-08			
Residual	15	8049601.151	536640.0768					
Total	16	78276173.68						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
133840	0.018006	0.001574004	11.43955643	8.28753E-09	0.014650997	0.021361	0.014651	0.021361

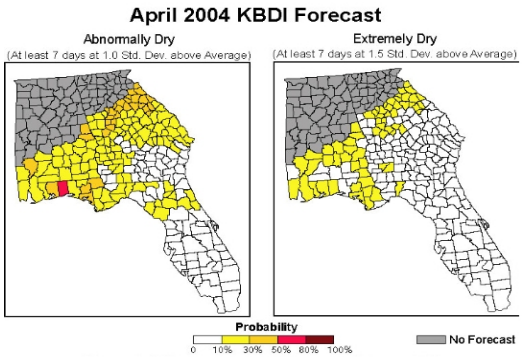
*INDEX = f (Wildfires National 'M')

Table 9 allows us to logically link the construction of the COAPS wildfire forecast and the CEFA economic impact index for Florida in order to derive an economic estimation of the COAPS KBDI wildfire forecast.

Quantification of the COAPS KBDI Wildfire Forecast

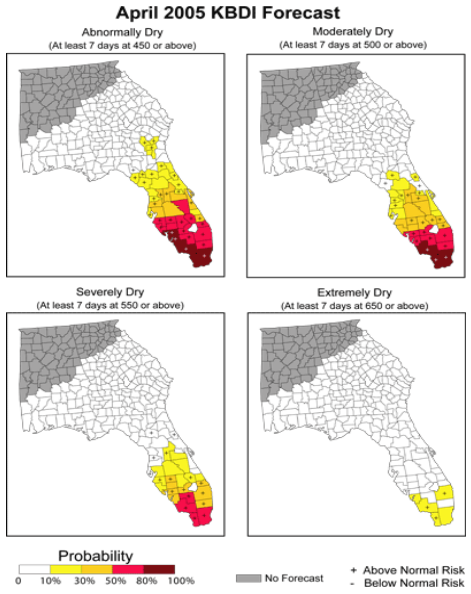
In order to model the relationship between the CEFA economic impact index with the COAPS's KBDI wildfire forecast, a quantification of the wildfire forecast has been created. The number of regions (from 220 regions depicted in the COAPS KBDI forecast) of Florida with at least a probability of 50% has been summarized for each month. For example, April 2004 had the value of 1, for one week, as it is shown in Figure 2.

Figure 2. Probability of 50% or Greater for the KBDI Forecast for April 2004.



In the same manner, in April 2005, as depicted in Figure 3, one week had 4 regions with probability more than 50%, the next week 9 regions, another week 16, and the fourth week, zero regions to be counted.

Figure 3. Probability of 50% or Greater for the KBDI Forecast for April 2005.



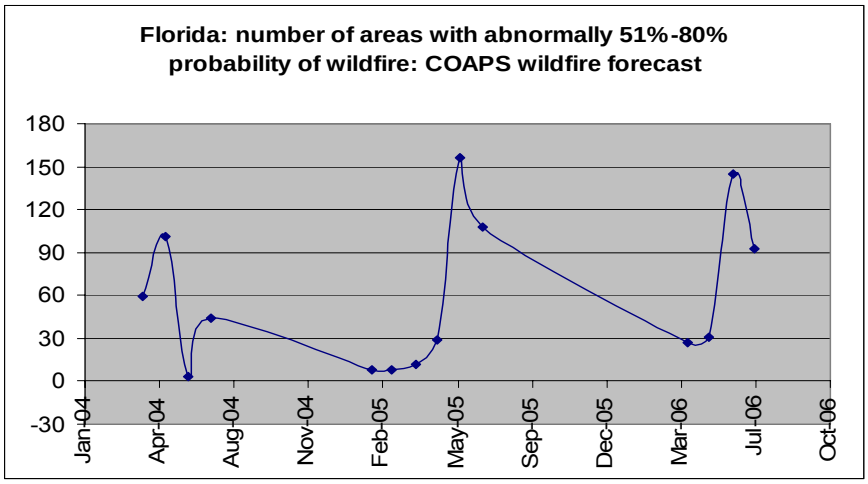
The results from counting all the areas with probability more than 50% are presented in Table 10 for 2004 to 2006.

Table 10. KBDI Forecast Monthly Probabilities from 2004 – 2006.

	Quantification of the Wildfire Forecast in Florida							
	Abnormally		**Moderately**		**Severely**		**Extremely**	
	450		500		550		650	
	51%-80%	81%-100%	51%-80%	81%-100%	51%-80%	81%-100%	51%-80%	81%-100%
April-04	59	94					74	25
May-04	101							
June-04	3							
July-04	44							
February-05	8	3	5	2	3			
Mar-05	8	3	7	1	4			
April-05	12	4	6	3	4			
May-05	29	19	22	8	15	1		
June-05	156	11	80	1	1			
Jul-05	108	52	89	12	49			
April-06	27	36	29	14	8	8		
May-06	31	40	31	24	24	14	1	
June-06	145	30	75	2	11	1		
Jul-06	93	12	35		12			

CEFA used the "abnormally" labeled values (which is listed as index 450 in Table 10) since they construct the longest series of data. Clearly, the quantitative construction of the wildfire forecast is seasonal, as expected.

Figure 4. The Number of Acres with "Abnormal" (51 – 80%) Probabilities of Wildfire According to the COAPS KBDI Wildfire Forecast.



Comparison of the Quantitative values of the COAPS KBDI Wildfire Forecast and the CEFA Economic Index

At this point, it would have been ideal to directly compare the relationship between CEFA's economic index and the quantification of the COAPS KBDI Wildfire Forecast, however, we can not compare this variables directly since the data created from the wildfire forecast is per month and from 2004 to 2006, while the CEFA economic index is currently constructed from 1985 to 2001, on a yearly basis. However, it is possible to compare the relationship of each variable with one in common: the number of wildfires in Florida and on the national level.

The NOAA National Climatic Data Center publishes the number of wildfires nationally and monthly, on an annual basis. Hence, by subtracting the data from month to month it is possible to extrapolate the number of wildfires nationally on a monthly basis (Tables 11 and 12).

Table 11. July 2006 National Wildfire Statistics from the National Interagency Fire Center.

Totals as of early July	National Number of Fires	National Number of Acres Burned
7/9/2006	61,418	4,002,383
7/9/2005	31,632	3,006,282
7/9/2004	40,646	2,989,977
7/9/2003	29,125	993,934
7/9/2002	45,617	3,155,402
7/9/2001	43,693	1,240,789
7/9/2000	51,342	2,207,704

* NIFC

Table 12. June 2006 National Wildfire Statistics from the National Interagency Fire Center.

Totals as of early June	National Number of Fires	National Number of Acres Burned
6/7/2006	44,186	2,647,575
6/7/2005	25,647	449,746
6/7/2004	32,789	564,973
6/7/2003	22,509	425,870
6/7/2002	32,541	1,270,443
6/7/2001	34,760	738,314
6/7/2000	43,713	1,190,304

Clearly, and ideally, the variable to test should be the number of wildfires in Florida, however, due to a lack of availability of monthly data on wildfires in Florida, we were reconciled to use monthly wildfire data on a national level. This relationship is logical and should be assumed as acceptable, since there was an important correlation between the number of wildfires in Florida and the number of wildfires on a national level.

CEFA ran a regression of the Florida COAPS Wildfire Forecast quantitative values versus lagged (one month) data of fires on a national level, and the results (shown in Table 14) yield a robust R-square value, a positive relationship with respect to the intercept and a highly significant model.

Table 13. The Number of National Wildfires as a Function of the Florida COAPS Wildfire Forecast ($_{t-1}$)

Abnormally 450		
51%-80%		Nationwide Number of Fires
April-04	59	
May-04	101	8,996
June-04	3	7,495
July-04	44	6,554
February-05	8	9,028
March-05	8	505
April-05	12	4,133
May-05	29	4,993
June-05	156	9,104
July-05	108	11,482
April-06	27	8,154
May-06	31	14,621
June-06	145	13,523
July-06	93	8,099
		17,232

Table 14. Regression Results Regarding Number of Fires on a National Level and the COAPS Wildfire Forecast Index.

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.803607							
R Square	0.645784							
Adjusted R Square	0.554875							
Standard Error	5578.335							
Observations	12							
ANOVA								
	df	*SS*	*MS*	*F*	*ignificance F*			
Regression	1	6.24E+08	6.24E+08	20.05446961	0.001182			
Residual	11	3.42E+08	31117817					
Total	12	9.66E+08						
	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
101	94.13605	21.02086	4.478222	0.000934137	47.86946	140.4026	47.86946	140.4026

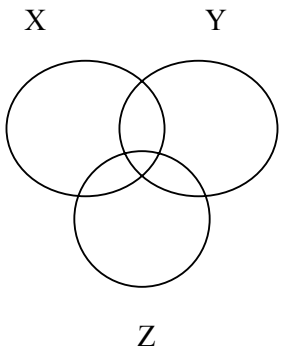
According to the previous regression, we can conclude that the quantification of the COAPS KBDI wildfire forecast of Florida has an important correlation and influence in the number of wildfires nationally, one month later. In other words, the COAPS KBDI wildfire forecast predicts wildfire well on the national level.

Final Comparison

CEFA has previously mentioned that it is not possible to directly compare the values of the CEFA Economic Index with the quantification of the COAPS KBDI wildfire forecast since each variable does not match the same time periods, however, we have found from the aforementioned regressions that both variables have an important relationship with wildfires on a national level. The R-square in the Table 9 regression is 89% and in the R-square in the Table 14 regression is 64%.

In other words, there are three variables (x, y and z) or CEFA index (x), Quantitative COAPS KBDI Wildfire Forecast (y) and Wildfires nationwide (z). The correlation between x vs z has been established, and between y vs z, however the unknown relationship is between x and y, or the CEFA index and Quantitative COAPS KBDI Wildfire Forecast, respectively.

Graphically, we have a region such as:



Partial correlation measures the region of three overlapping areas. The partial correlation (which is $r_{XY \cdot Z}$) between x and y, with the effects of z held constant, is given by the following formula:

(1) $r_{XY \cdot Z} = r_{XY} — (r_{XZ})(r_{YZ}) / \{sqrt(1 — r2_{XZ}])sqrt(1 — r2_{YZ})\}$

According to the previous equation, the goal is to estimate the partial correlation of the three variables, $r_{XY \cdot Z}$. and then solve for the correlation between x and y, which is the correlation between the Quantitative COAPS KBDI Wildfire Forecast and the CEFA economic index.

According to Butry, et al., the fire season of 1998 was the most devastating in Florida's recent history, with 500,000 acres burned and economic impacts of at least $600 million. The estimates of total economic surplus changes for southern pine sawtimber plus pulpwood market range from a net range of -$329 to -$509 million with a significant increase in the price of timber. With respect to property losses, the 1998 wildfires damaged or destroyed 340 homes, 33 businesses, and several cars and boats. For the 1998 fire season in Florida, the Federal Emergency Management Agency (FEMA) originally authorized $50 million for the Fire Suppression Assistance Program (FSAP), although the final tally was expected to top $100 million[6].

In a National Oceanic and Atmospheric Administration report, by the National Climatic Data Center, in June 29 1998[7], it was stated that as of June 25, 1998, extreme drought index values had been computed for Northern Florida, and other areas of the Southeast. Indeed, as Butry mentions: "the Keetch-Byram drought index, a standard measure of wildfire danger, flirted with the maximum possible value of 800 for several weeks".
It is evident that the correlation between land dryness (that represents the soul of the COAPS forecast) and the factors that are part of the CEFA index (such as suppression cost, timber prices and property loss), illustrate that Florida's 1998 wildfire season was a big part of the National registered wildfires for the whole country.

The correlation among the three variables x, y, z, or CEFA index, Quantitative Forecast and Wildfires Nationwide is clearly very high, estimated in the range of 0.6 to 0.8 (for large wildfires). Only timber prices moved 60% during the wildfire season of 1998, and FEMA suppression cost jumped 100% (of what was originally estimated). However, concerning this analysis, the assumptions considered a typical fire of around 100,000 acres (not 500,000 acres, as it was the fire season in 1998). Therefore, in order to be consistent and conservative, we assumed that the partial correlation of the three variables ($r_{XY \cdot Z}$) is in the range of 1/5 of 60% to 80%[8], picking the most conservative number: 0.12. Once we have estimated the partial correlation ($r_{XY \cdot Z}$), we can solve r_{XY}, the correlation between the CEFA index and the Quantitative COAPS KBDI Wildfire Forecast, from equation (1). We found that the expected correlation r_{XY} is 61.1%.

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[6] Butry, D.T.; Mercer, D.E.; Prestemon, J.P.; Pye, J.M. and Holmes, T.P. 2001. What is the price of catastrophic wildfire? Journal of Forestry 99(11):9-17.

[7] http://www.ncdc.noaa.gov/oa/climate/research/1998/fla/florida.html

[8] The assumption is based on a typical wildfire (100,000 acres) which is 1/5 of the 500,000 burned acres seen in Florida, in 1998.

It can be concluded that both "indexes" have positive correlation with the number of wildfires on a national level. It can be expected that there is a correlation of around 61%, between the CEFA economic impact wildfire index and the Quantitative COAPS KBDI forecast.

Conclusion:

CEFA's Economic Wildfire Impact index is primarily constructed from the average property loss per fire in Florida, cost of wildfire suppression and timber prices. Based on the regression results in this study, it can be suggested that the value of the COAPS KBDI wildfire forecast has some capability to influence the property losses in Florida with at least a month in advance for around sixty-one percent of the cases. Therefore, given a value of an average loss per fire of $2,868 (2001 USD) and the number of wildfires in Florida estimated an average of 5,256 for 1985-2001 (Table 7), it can be assumed that the economic impact of the COAPS wildfire forecast is estimated at approximately $9.2 million annually (in 2001USD)[9]. It is important, however, to note that these results apply assuming that many relationships are held constant, as in the case of the impact of 1998 wildfires on timber prices. The economic impact of the COAPS wildfire forecast was used as input to the IMPLAN model, to estimate the total direct, indirect and induced economic impacts for the State of Florida. As presented in Table 15 and in 2006 USD, in terms of output, labor income, and employment, this represents $19.1 million, $8.36 million, and 337 jobs, respectively.

Table 15. Economic Impact Results of the COAPS KBDI Forecast.

State of Florida Wildfire Forecast	Output	Employment	Income
IMPLAN results 2006 $	$19,104,409	337	$8,363,019

[9] The expected correlation between the CEFA index and the Quantitative forecast, 61%, of 5,256 (average number of wildfires per year in Florida) x $2,858 (average loss per fire) = $9.2 million annually.

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