December 2015

Modeling Dynamic-Fuels with an Index System: LANDFIRE Drought Based Fuel Dynamic in the Southeast United States

Introduction

The LANDFIRE (LF) Program strives to produce consistent and relevant fire behavior fuel model grids for the United States (U.S.). While these models are relevant for predicting fire behavior, including spread and intensity, during average weather conditions, they often fall short during drought or seasonably dry conditions. LF, in a continuing effort to improve the functionality of the fuel products, has proposed the use of the Modeling Dynamic-Fuels with an Index System: LF Drought Based Fuel Dynamic (MoD-FIS LF DBFD) to improve the accuracy of the Southeast fuel products. The LF DBFD systematically transitions surface fuel models based on seasonal conditions by addressing fuel loading and fuel bed depth. This report documents the development, methodology, testing and results, and conclusions of the LF DBFD.

Background

It is generally understood that as wildland fuels dry out, additional fuel materials are available for combustion and heat release. In terms of climate, drought can be used to express this relationship between dry conditions and increased fuel availability. Changing amounts of available fuel can be the result of seasonal trends, vegetation phenology, and changing water table levels, as well as long term climatological trends. While it can be difficult to capture this variation on a large scale, trends in increased fire spread potential with increased drought conditions are important factors to consider when modeling anticipated fire behavior. For this reason, the LF Program initiated MoD-FIS to capture these trends. As a starting point, the Southeast U.S. was chosen as the prototype area to test methods to capture this variation (Figure 1). This product is the first of its kind for the LF Program and its success will be used to inform future exploration to capture seasonal fuel model variability at various geographic scales due to regional conditions.

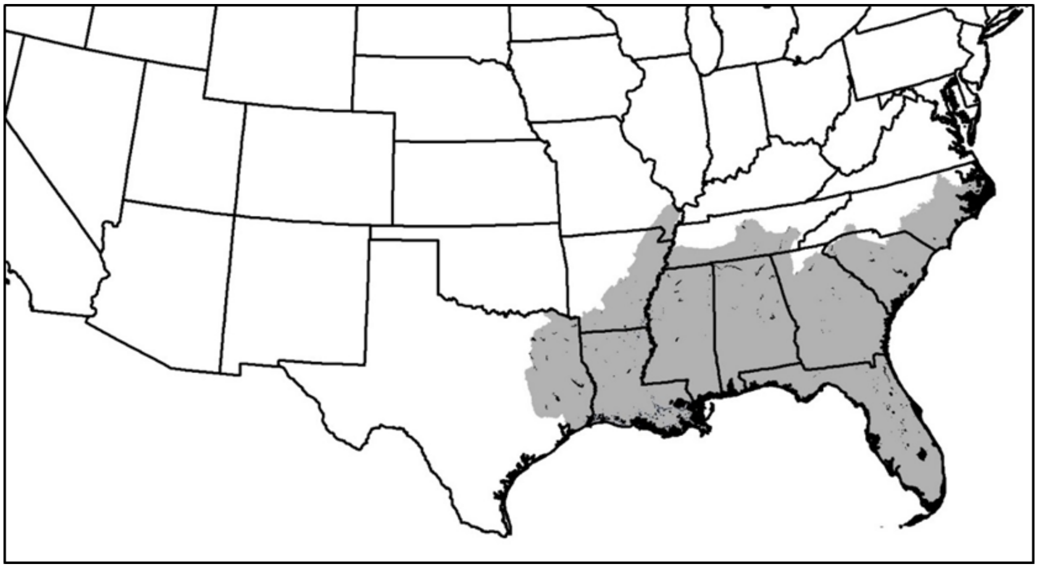


Figure 1: LANDFIRE Drought Based Fuel Dynamic prototype area in the Southeast U.S.

Methodology

LF developed the DBFD for the Southeast U.S. based on concepts founded and developed through the 1988 revisions of the National Fire Danger Rating System (NFDRS). The DBFD is comprised of three components including additive fuel weight by size class and fuel bed depth, vegetation type that influences the fuel model transitions, and drought increments that were applied to the transitions. Additive fuel weight by size class and fuel bed depth by fuel models were based on the NFDRS88 recommendations for severe drought, then proportioned by the Keetch Byram Drought Index (KBDI; Keetch and Byram 1968). The LF existing vegetation type (EVT) was used to influence the fuel model transitions. Lastly, the LF 2012 fire behavior fuel model 40 (FBFM40) was used to transition the fuel model depending on the EVT and drought increments.

LF DBFD Components

1988 revisions to the National Fire Danger Rating System

The 1988 revisions of the NFDRS (NFDRS88-Burgan 1988) addressed concerns raised by fuel experts in the Southeast, in particular how fuel moisture changes during periods of drought (Schlobohm and Brain 2002). In the 1988 revisions, there are descriptions of fuel bed characteristics for each fuel model, along with suggested fuel load additions based on severe drought conditions. Each fuel load addition has formulas that calculate fuel weight in proportion to the fuel time-lag size classes. These formulas also account for fuel bed depth, which increases along with fuel weight, to maintain the packing ratio of the fuel model.

Keetch Byram Drought Index

Keetch Byram Drought Index (KBDI) is a mathematical system for relating current and recent weather conditions to potential or expected fire behavior. KBDI was originally developed for the Southeast and is based primarily on recent rainfall patterns. It is one of the only drought indices specifically developed to equate the effects of drought with potential fire behavior. KBDI provides a number ranging from 0 to 800 that describes the moisture deficit of the top eight inches of soil. A drought index of 0 defines the point where there is no moisture deficiency and 800 defines maximum drought.

LF Data Products

LF EVT and FBFM40 were the data products used in the development of the LF DBFD. The LF EVT layer represents the species composition currently present at a given site. LF uses EVT in several subsequent layers, including the development of the fuel layers. The FBFM40 layer represents distinct distributions of fuel loading found among surface fuel components (live and dead), size classes, and fuel types. The FBFM40 data can be used within fire behavior modeling systems to predict wildland fires, prescribed fires, and fire use applications.

Methods

The NFDRS88 method to add fuel load by size class and fuel bed depth under drought conditions was used to generate a table of FBFM40 under four classes of drought condition: no drought, low drought, moderate drought, and high drought (Table 1). LF EVT and FBFM40 layers, along with the NFDRS88 fuel model map for the Southeast from the Wildland Fire Assessment System (WFAS) were visually compared to determine relevant combinations of EVT, FBFM40, and NFDRS88 fuel model to guide assignment of FBFM40 transitions. Next, a climatological assessment of KBDI was completed for all the map zones within the LF

Southeast GeoArea, in order to determine to which areas this method would apply. This was done using the Remote Automated Weather Station (RAWS) data when the 90th percentile KBDI value was reached within each zone. The 90th percentile values ranged from 574 in Northern North Carolina to 680 in Southern Florida (See Appendix A).

Table 1: KBDI index values from 0 to 800 divided into four drought classes, along with additional fuel load weight and fuel bed depth based on NFDRS88 fuel models.

KBDI Index	Drought Classes	NFDRS88 Fuel Models
0 – 200	No Drought	None (uses the LF 2012 FBFM40 fuel model)
201 – 400	Low Drought	20% of additional weight and depth added to fuel model
401 – 600	Moderate Drought	55% of additional weight and depth added to fuel model
601 – 800	High Drought	100% of additional weight and depth added to fuel model

For each NFDRS88 fuel model, the total fuel weight and depth for each drought class was calculated. An example of how the fuel models were calculated can be found in Appendix B. The additional fuel weight and depth were calculated proportionally by size class and fuel type and added to NFDRS88 models by drought increments. Then they were correlated to FBFM40 by total fuel load, 1 hr fuel load, live fuel load, fuel bed depth and moisture of extinction (MXT). A look-up-table (LUT) was developed, starting with the LF 2012 FBFM40 models, which then transitioned to either the same, similar, or a more aggressive fuel model depending on the EVT and drought class. The fuel model transitions were combined with the current KBDI layer provided by the WFAS to determine which fuel model best represents the drought condition for each pixel.

Testing and Results

The effects of the fuel model transitions on the modeled fire behavior were tested using several methods including NEXUS a fire behavior processor, the FARSITE simulator, and analyzing the relationships between KBDI and temperature.

NEXUS

A spatial version of the NEXUS fire behavior processor was used to produce several fire behavior characteristic maps at 30 meter resolution across the prototype area. The model was initiated with the same inputs and outputs for each LF map zone. The model inputs and outputs used in the NEXUS models are listed in Table 2.

Table 2: NEXUS model inputs and outputs.

Model Inputs	Model Outputs
90th Percentile Dead Fuel Moisture	Fire Type and Crown Fraction Burned
60% Herb – 90% Woody Fuel Moisture	Rate of Spread
20 mph 20 ft. Windspeed	Flame Length
	Torching Index and Crowning Index
	Effective Mid-flame Windspeed

The fire behavior characteristics were computed for each of the four drought classes using the LF 2012 FBFM40 layer corresponding to that drought level (Table 3). Figures 2 through 5 show the fire type output for each of the four drought classes. Note the gradual color change from blues and greens to more yellow and red.

Table 3: Drought class definitions and associated fire behavior fuel model layers.

Drought Class	KBDI Values	FBFM40 Layer
No Drought	0 – 200	LF2012 FBFM40
Low Drought	201 – 400	KBDI 2_4 FBFM40
Moderate Drought	401 – 600	KBDI_4_6 FBFM40
Severe Drought	601 – 800	KBDI_6_8FBFM40

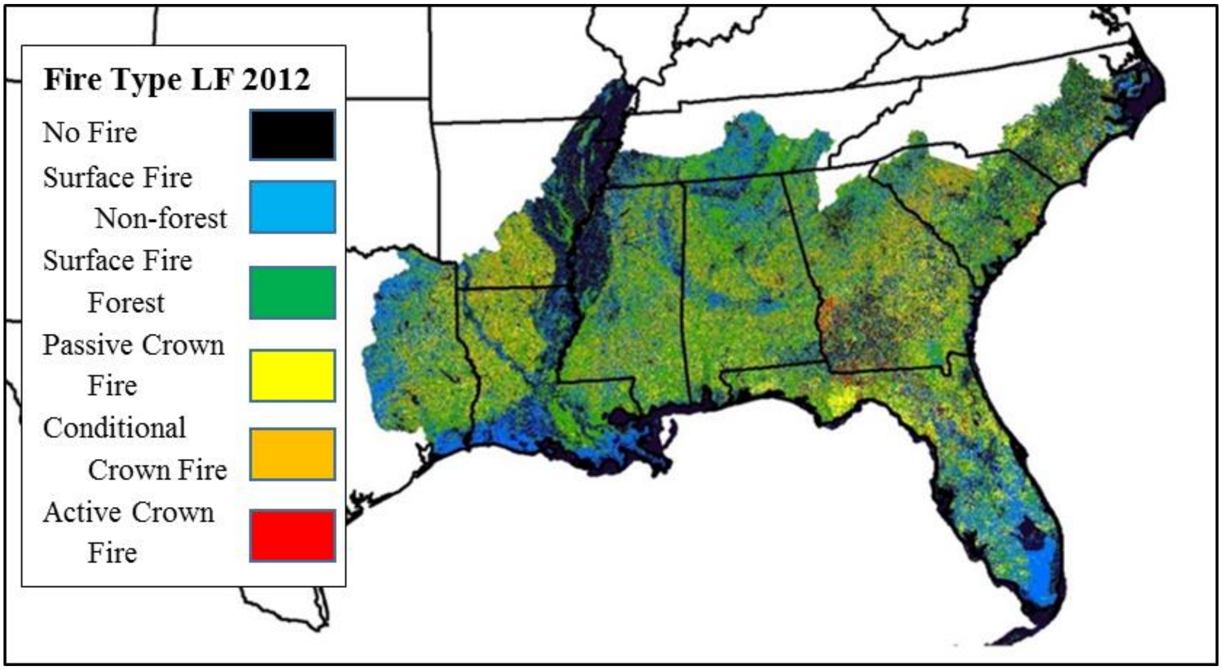


Figure 2: Fire type using LANDFIRE 2012 (LF 2012) FBFM40 (no drought).

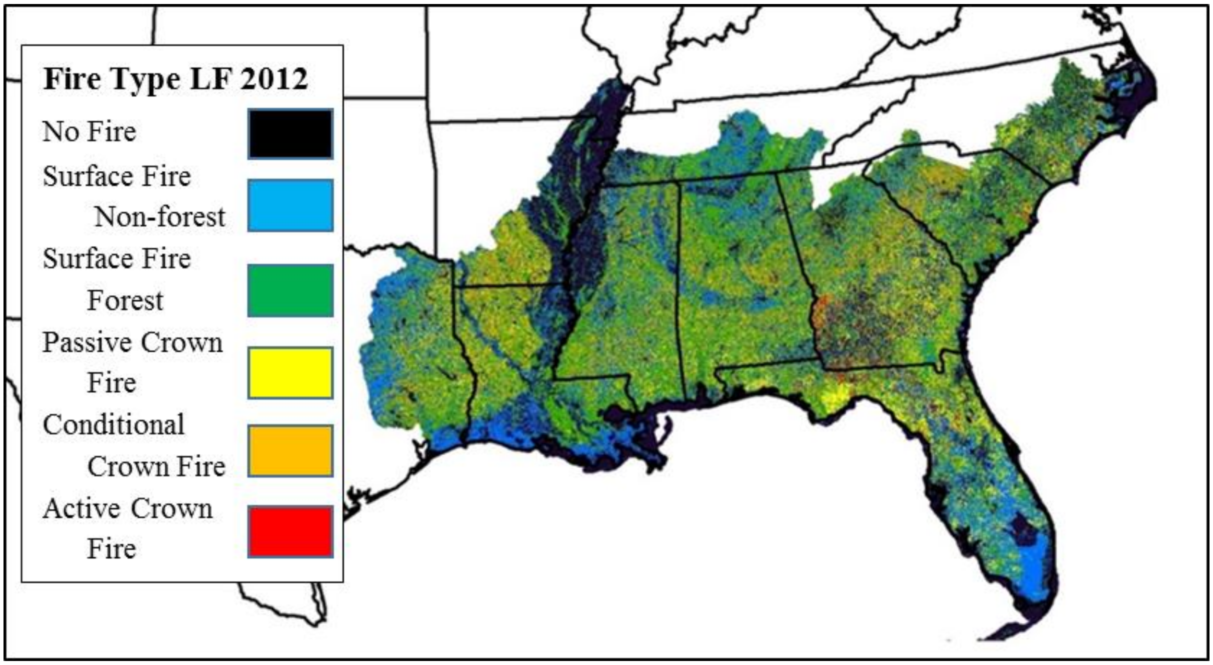


Figure 3: Fire type using KBDI 2_4 FBFM40 (low drought).

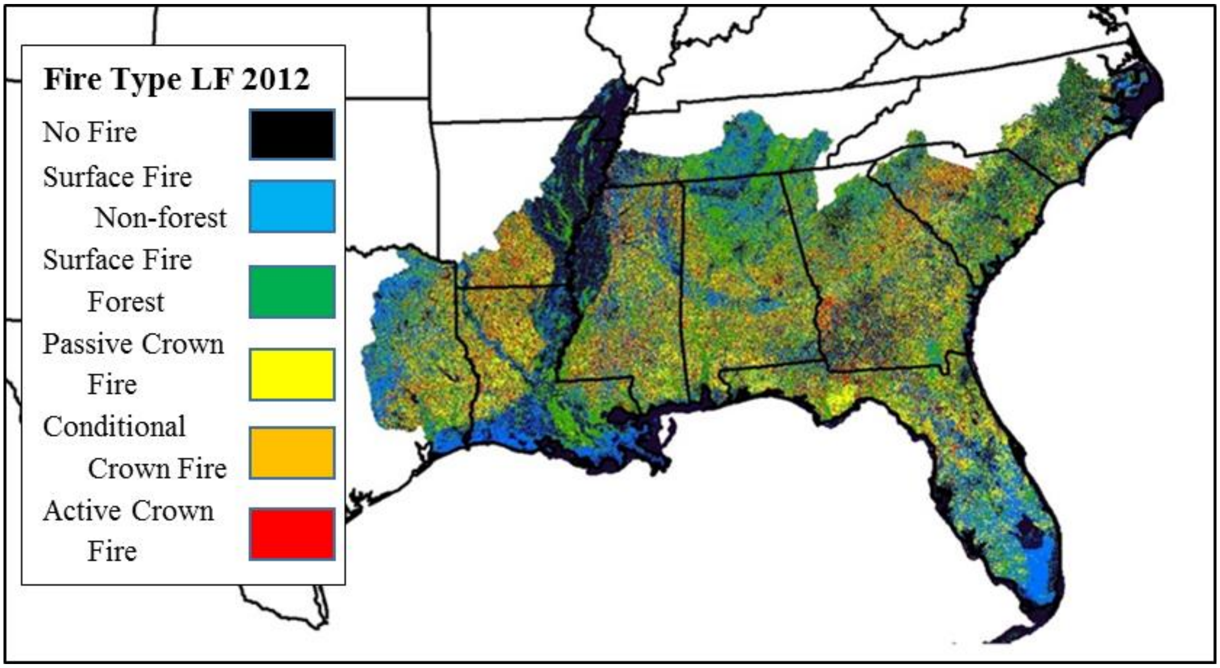


Figure 4: Fire type using KBDI 4_6 FBFM40 (moderate drought).

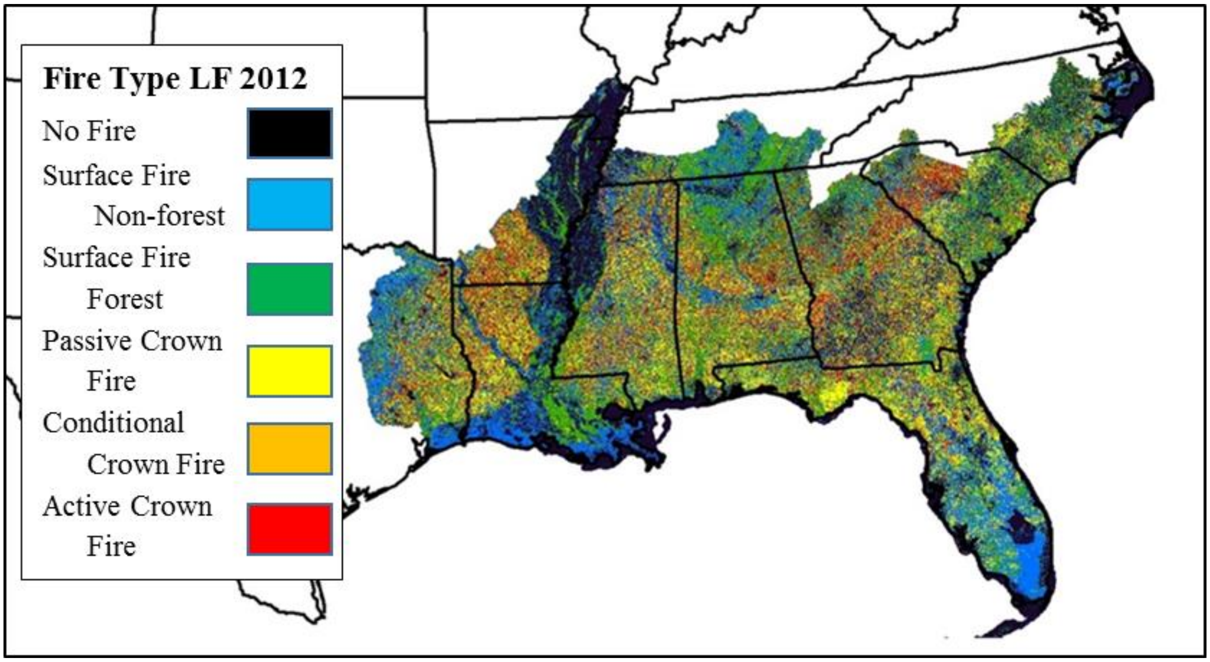


Figure 5: Fire type using KBDI 6_8 FBFM40 (severe drought).

The fire behavior characteristics maps are in grid format and their attribute values are available for statistical analysis. Tables 4 through 7 illustrate the gradual increase in fire behavior characteristics as the drought index values increase through the four increments.

Table 4: Area of each fire type class for each drought increment in acres.

Fire Type	**No Drought LF_2012 FBFM40**	**Low Drought KBDI 2_4 FBFM40**	**Moderate Drought KBDI 4_6 FBFM40**	**Severe Drought KBDI 6_8 FBFM40**
Non-burn	63,304,766	63,304,766	63,304,766	63,304,766
Surface Non-forest	59,707,132	59,707,132	59,707,132	59,707,132
Surface Forest	83,678,176	83,288,681	68,661,722	61,911,204
Passive Crowning	22,133,383	22,522,878	37,149,842	43,900,354
Conditional Crowning	29,553,949	29,472,074	11,197,840	1,382,890
Active Crowning	3,892,251	3,974,126	22,248,356	32,063,310

Table 5: Area of each fire type class for each drought increment in percent.

Fire Type	**No Drought LF_2012 FBFM40**	**Low Drought KBDI 2_4 FBFM40**	**Moderate Drought KBDI 4_6 FBFM40**	**Severe Drought KBDI 6_8 FBFM40**
Non-burn	0.241	0.241	0.241	0.241
Surface Non-forest	0.228	0.228	0.228	0.228
Surface Forest	0.319	0.318	0.262	0.236
Passive Crowning	0.084	0.086	0.142	0.167
Conditional Crowning	0.113	0.112	0.043	0.005
Active Crowning	0.015	0.015	0.085	0.122

Table 6: Area of each rate of spread class for each drought increment in acres.

Rate of Spread	No Drought LF_2012 FBFM40	Low Drought KBDI 2_4 FBFM40	Moderate Drought KBDI 4_6 FBFM40	Severe Drought KBDI 6_8 FBFM40
Non-burn	63,304,766	63,304,766	63,304,766	63,304,766
0.22 to 5.0 ch/hr	77,399,287	76,370,339	53,520,220	31,061,139
5.1 to 10.0 ch/hr	6,489,088	7,021,307	10,188,610	20,512,523
10.1 to 20.0 ch/hr	19,498,204	20,056,180	9,605,420	9,971,008
20.1 to 40.0 ch/hr	19,671,342	19,128,086	28,825,562	25,763,401
40.1 to 60.0 ch/hr	61,897,689	62,379,519	80,198,554	70,013,448
60 + ch/hr	14,009,280	14,009,460	16,626,530	41,643,372

Table 7: Area of each flame length class for each drought increment in acres.

Flame Length	No Drought LF_2012 FBFM40	Low Drought KBDI 2_4 FBFM40	Moderate Drought KBDI 4_6 FBFM40	Severe Drought KBDI 6_8 FBFM40
0	63,304,766	63,304,766	63,304,766	63,304,766
0.2 to 4 ft.	99,803,180	99,487,957	63,987,895	21,637,514
4.1 to 8.0 ft.	32,441,217	32,700,389	50,300,571	56,633,952
8.1 to 12.0 ft	14,995,269	14,434,401	12,162,010	35,033,610
12.1 to 20 ft.	9,209,514	9,788,937	19,994,530	14,879,208
20.1 to 40 ft.	9,422,297	9,411,048	15,895,553	27,806,112
40,1 to 60 ft.	27,185,571	21,358,012	15,325,983	12,706,795
60 + ft.	5,907,841	11,784,145	21,298,353	30,267,699

FARSITE

FARSITE was used to model fire perimeters for known fires using the LF 2012 FBFM40 first, and then the LF 2012 DBFD FBFM40 layer based on the KBDI drought level at the local RAWS. The simulations that used the DBFD FBFM40 layers more closely represented the actual fire spread, compared with those that used the LF 2012 FBFM40 files. Some of the fuel model transitions were modified based on these modeling results to better reflect expected fire behavior. The final LUT is shown in Appendix C.

Moore Branch Fire, East Texas, 2000

The Moore Branch fire burned near Newton, Texas in 2000. The fire burned 13,900 acres over a 5 day period, September 1 - 5, during very dry conditions. The KBDI for the Sabine South RAWS was over 700 prior to and during the fire event. The FARSITE simulations below display the modeled fire extent for the LF 2012 landscape and a landscape file created with the severe drought FBFM40 layer from LF DBFD. All model inputs were the same for both simulations:

- Dead and live fuel moistures from South Sabine RAWS from the dates of the fire
- 10 minute average hourly wind speeds from South Sabine RAWS all given a northerly direction
- Simulation settings for spotting ignition frequency, conditioning, duration, and burn period were the same.

Canopy cover and canopy height from LF 2001 (pre-fire) were used in both the LF 2012 and DBFD simulations in order to best replicate the vegetative and environmental conditions at the time of the fire. Figure 6 shows the progression of the Moore Branch Fire from September 1 - 5.

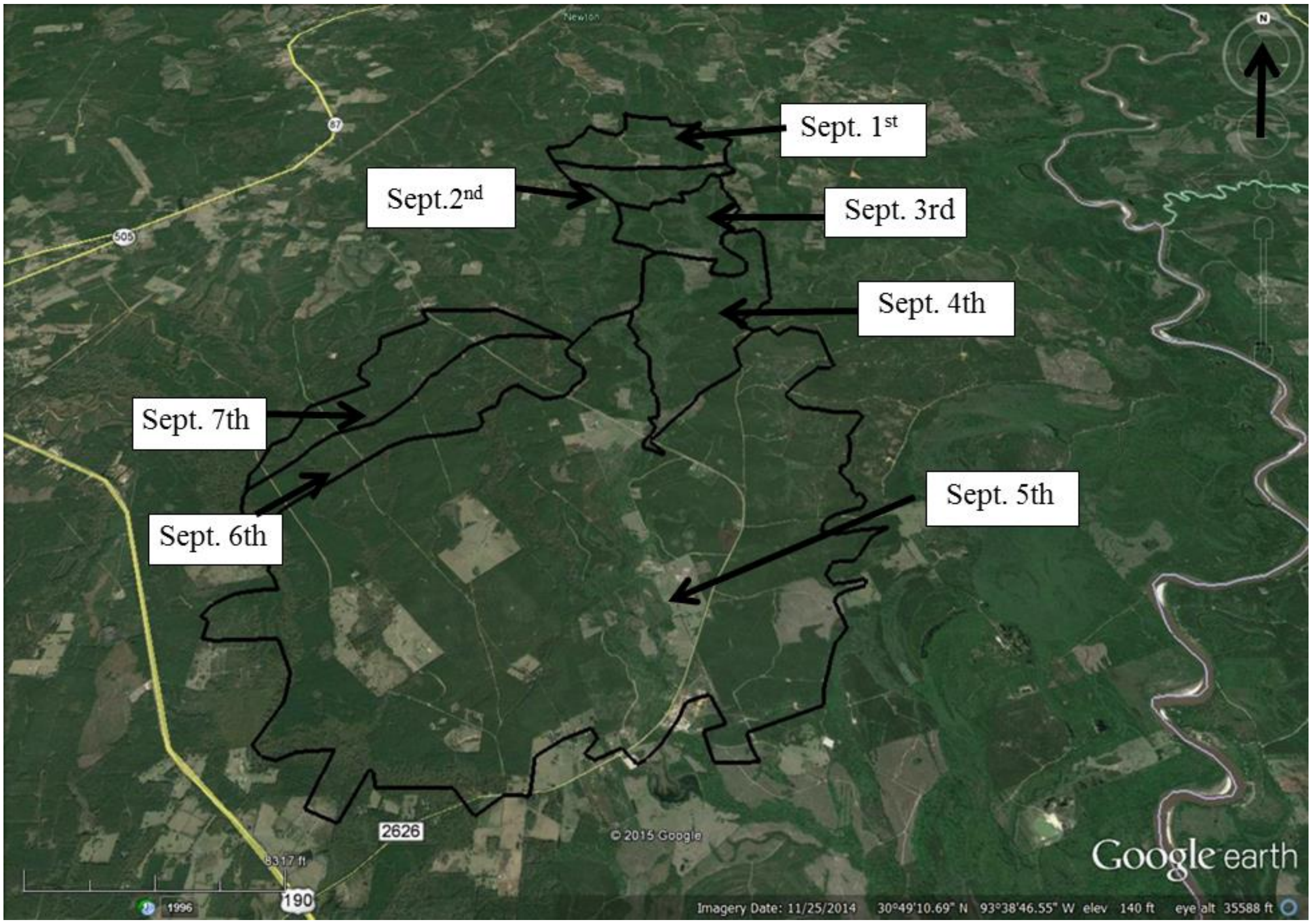


Figure 6: Progression of the Moore Branch Fire from September 1 - 5, 2000.

Suppression activities modified the actual fire progression for each day, though they were not accounted for in the simulations. The results of the simulations using LF 2012 fuel layers are shown in Figure 7 below.

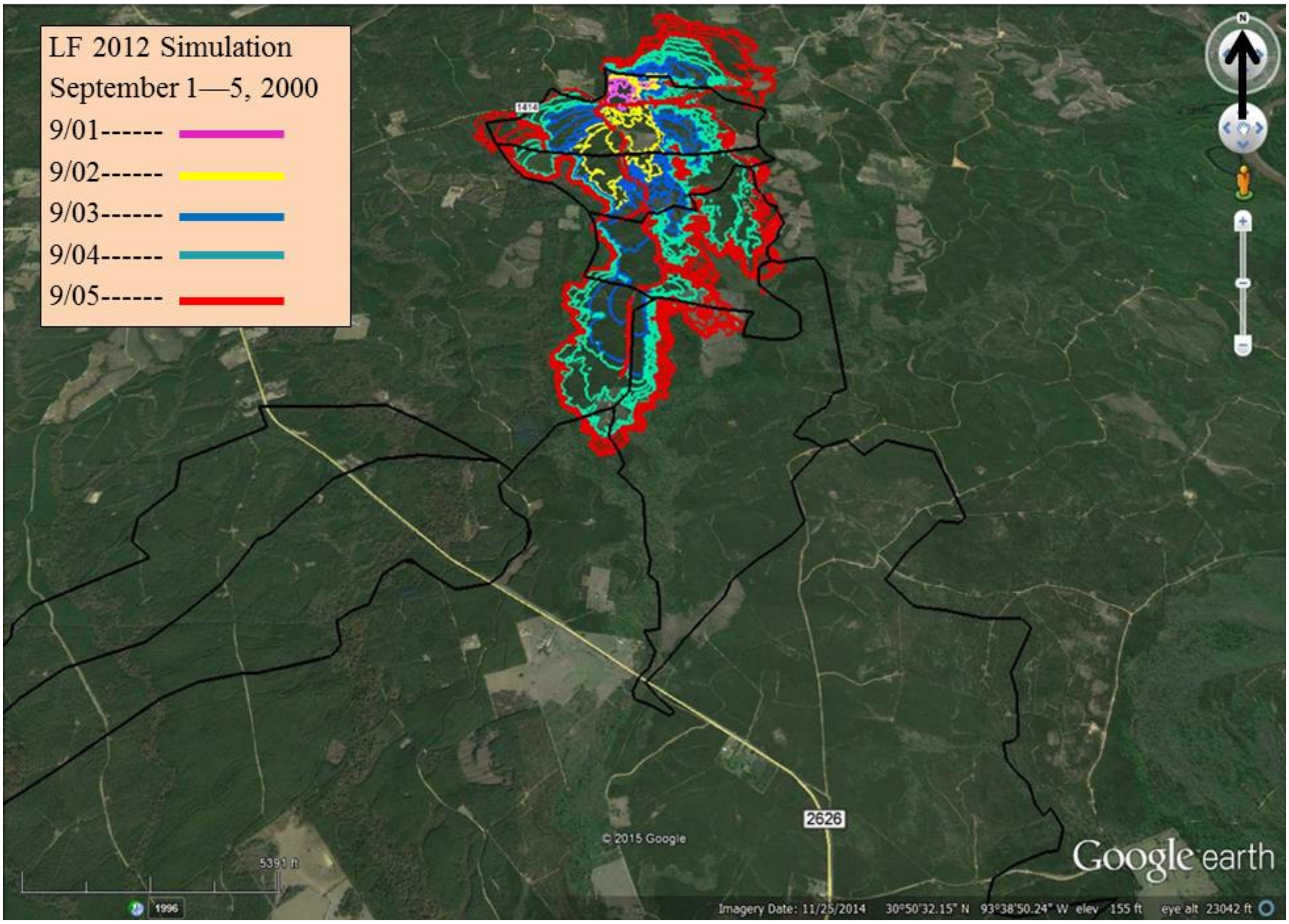


Figure 7: Moore Branch Fire simulation using LF 2012 landscape.

The daily spread rate in the LF 2012 simulation follows the fire perimeters for the first three days of the event. By day four, the extent of the fire is much larger than the simulated outcome. On day five, which was the windiest day in the weather record, the simulation showed very little fire spread due to the surface fuel models within the landscape.

The results of the simulations using KBDI 6_8 fuel layers are shown in Figures 8 through 10. KBDI 6_8 (severe drought) was chosen because the KBDI value at South Sabine RAWS was over 700 during the corresponding time period. Figure 8 shows the full five day simulation, Figure 9 shows only days 1 and 2, and Figure 10 shows days 1 through 4.

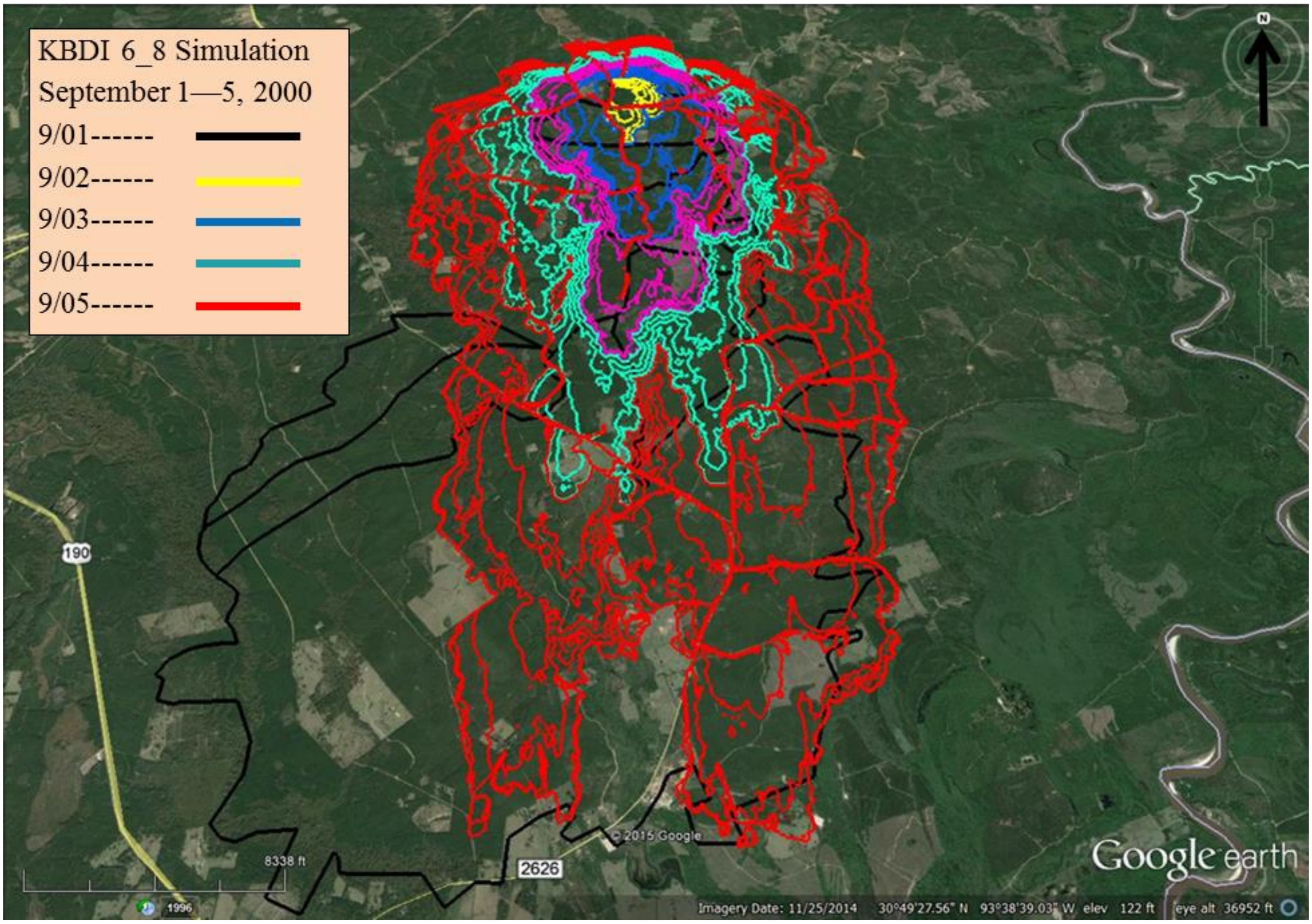


Figure 8: Moore Branch Fire simulation using KBDI 6_8 landscape (severe drought).

The daily fire extent in Figure 9 compares the forward spread of day 1 (yellow) to the actual day 1 fire line (black). On day 2, the breadth of the fire was retained, but it burned to the fire line of day 3 (blue). On simulation day 3, the fire burned into actual day 4 fire spread. On simulation day 4, the fire spread close to the actual day 4 fire perimeter. Figure 8 depicts simulation day 5, which represents the forward extent of the actual fire. With adjustments to the wind file to more northeasterly winds instead of just north, more of the fire perimeter would have been modeled as burned.

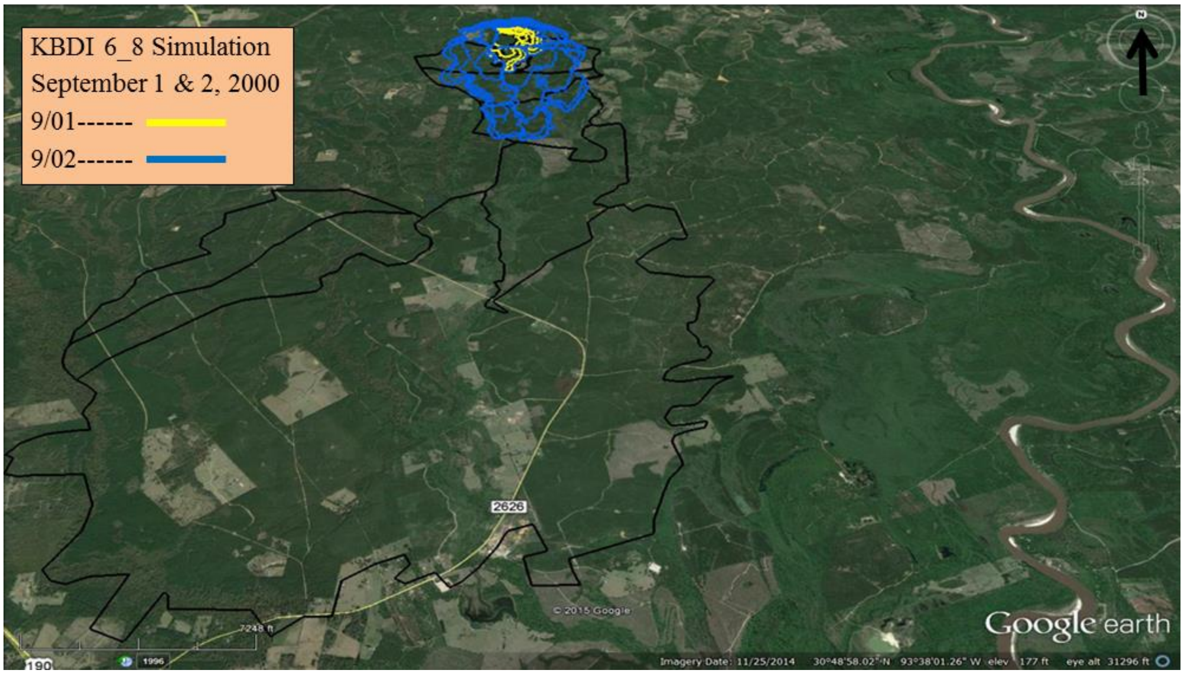


Figure 9: Moore Branch Fire simulation using KBDI 6_8 landscape (severe drought) for days 1 and 2.

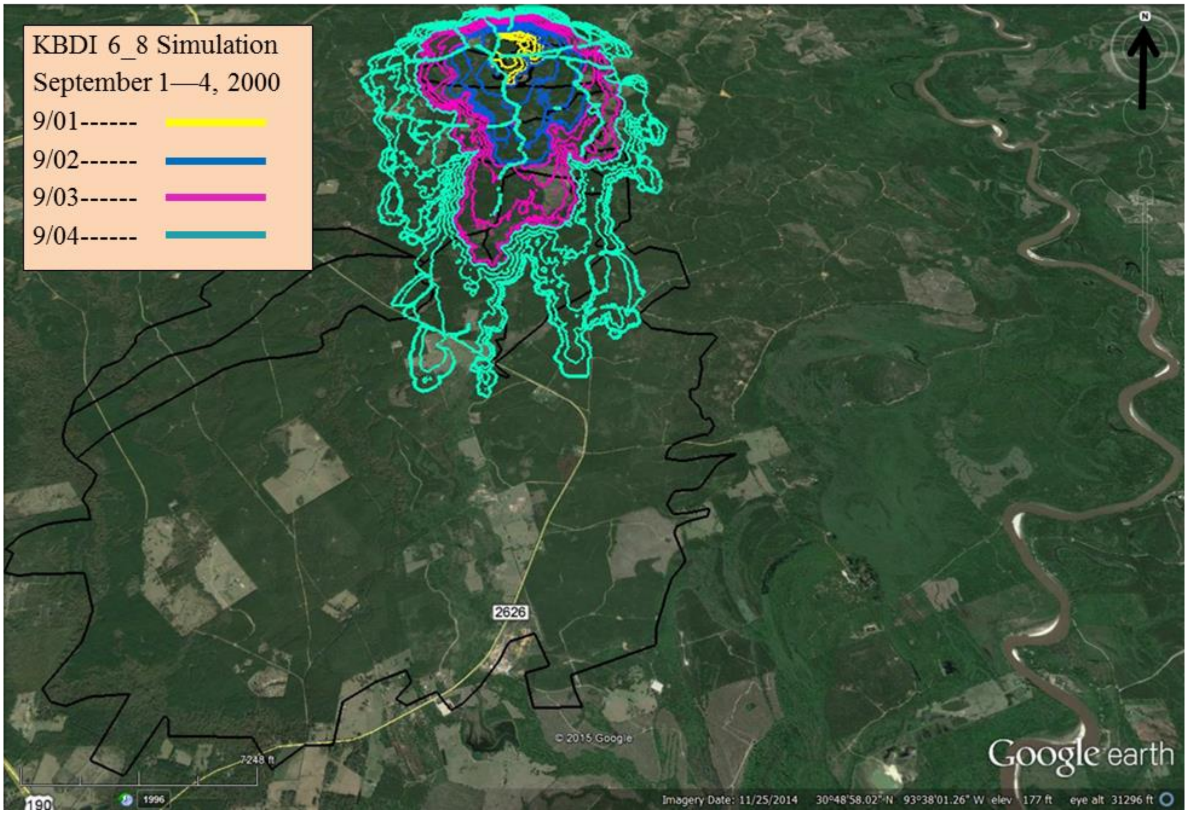


Figure 10: Moore Branch Fire simulation using KBDI 6_8 landscape (severe drought) for days 1 through 4.

In the LF 2012 landscape, the north portion of the fire area had much of the area in slow burning Timber Litter models within the riparian areas. The simulated fire was not able to burn through these riparian areas and into the faster spreading fuel models. In the KBDI 6_8 landscape, the Timber Litter models transitioned due to added fuel loading and depth to Timber Understory models, which spread through the riparian areas at approximately the same rate as the actual fire.

Bugaboo Swamp Fire

The first significant infrared perimeter for the Bugaboo Swamp fire was collected on May 7, 2007. The fire occurred in the Okefenokee National Wildlife Refuge and eventually combined with the Big Turnaround Fire, and others to burn the whole Okefenokee Swamp area in the 2007 fire season. This fire also burned under severe drought conditions; the KBDI value was over 700 at the time of the fire according to the Jones Island RAWS near the origin and the Waycross RAWS north of the fire.

In this analysis, FARSITE was used to simulate the first two days of significant spread from the fire origin (May 7- 8, 2007). Simulations using the LF 2012 and the LF DBFD fuels were used to compare the modeled effects. The KBDI 6_8 surface fuel layer was used to replicate the severe drought (KBDI 600-800) in the LF DBFD landscape. All other inputs into the model were the same for each simulation. Data from three RAWS: Waycross, Jones Island, and Eddie Tower (describing weather, fuel moisture, and wind conditions) were analyzed for the simulations. Waycross and Jones Island were similar, with Waycross having the best wind direction for the way in which the fire spread. For this evaluation, a compilation of values for 10 minute average windspeeds, live and dead fuel moisture, and burn period calculations were derived from these two weather stations.

The 11.7 mile fire run on May 8 was due to gusty wind conditions. The wind gusts ranged from mid-20 mph to low 30 mph throughout the day. This evaluation only used the 10 minute average windspeeds from the Waycross station. The LF 2012 surface fuel layer contained fast burning Grass and Shrub models (GR3 and SH7) within the fire perimeter, but they were interspersed and dominated by slow burning Timber Litter models (TL2). The results of the simulations are illustrated in Figures 12 and 13.

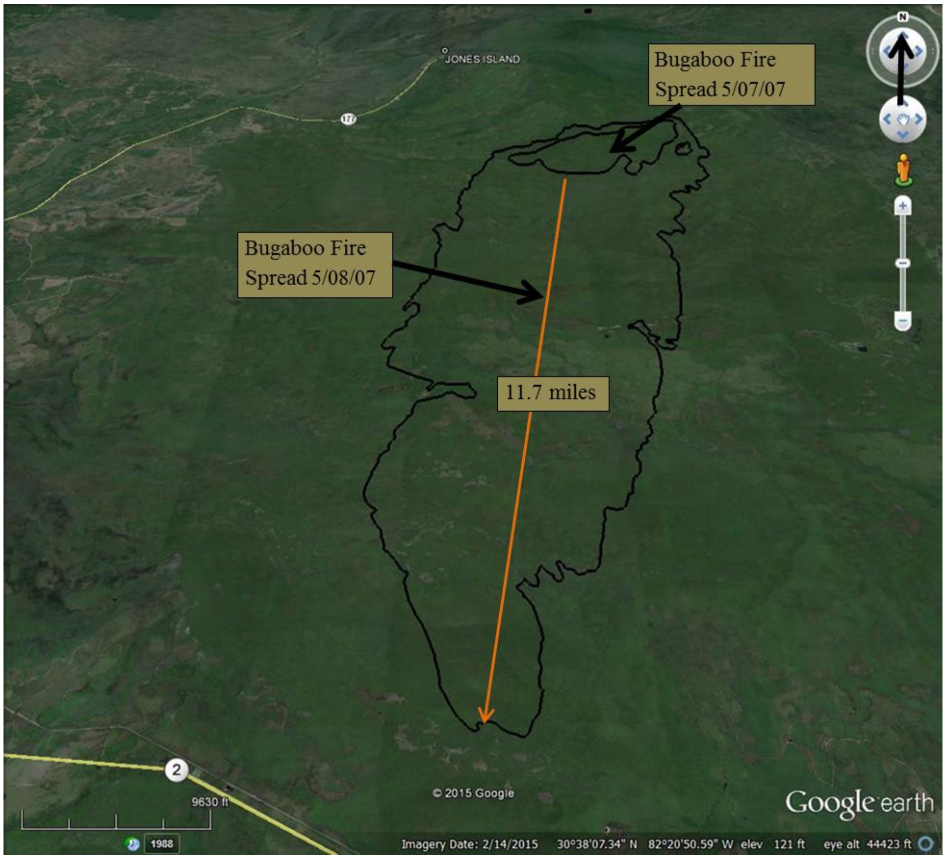


Figure 11: Bugaboo fire perimeters from May 7- 8, 2007.

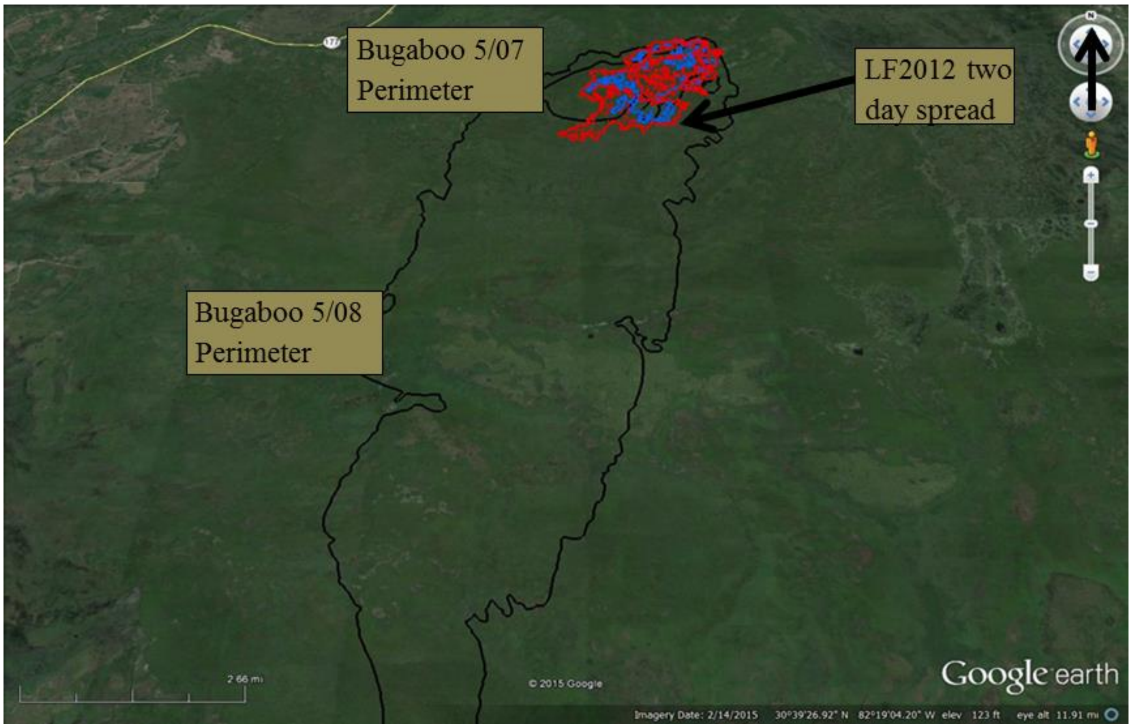


Figure 12: Bugaboo fire simulation using LF 2012 landscape.

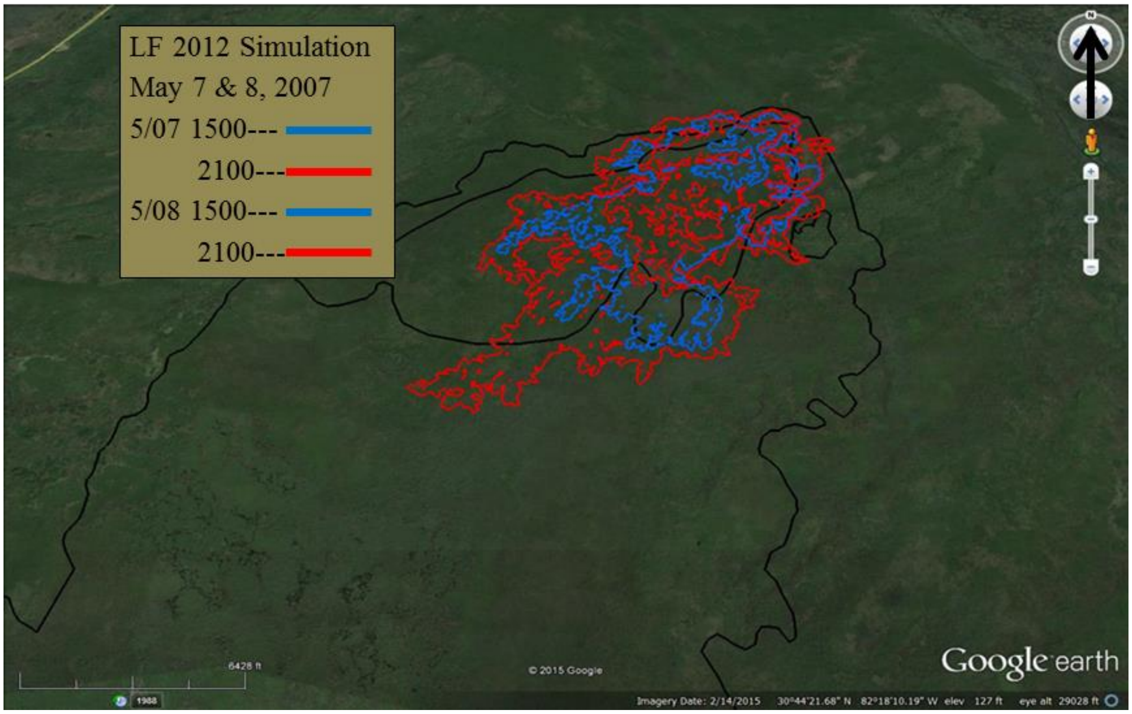


Figure 13: Closer view of the Bugaboo fire simulation using LF 2012 landscape.

Much of the area described by Timber Litter fuel models in LF 2012 was transitioned to a fast burning Shrub model (SH9) in the severe drought case. The results of the simulations using the severe drought surface fuel layer are illustrated in Figure 14.

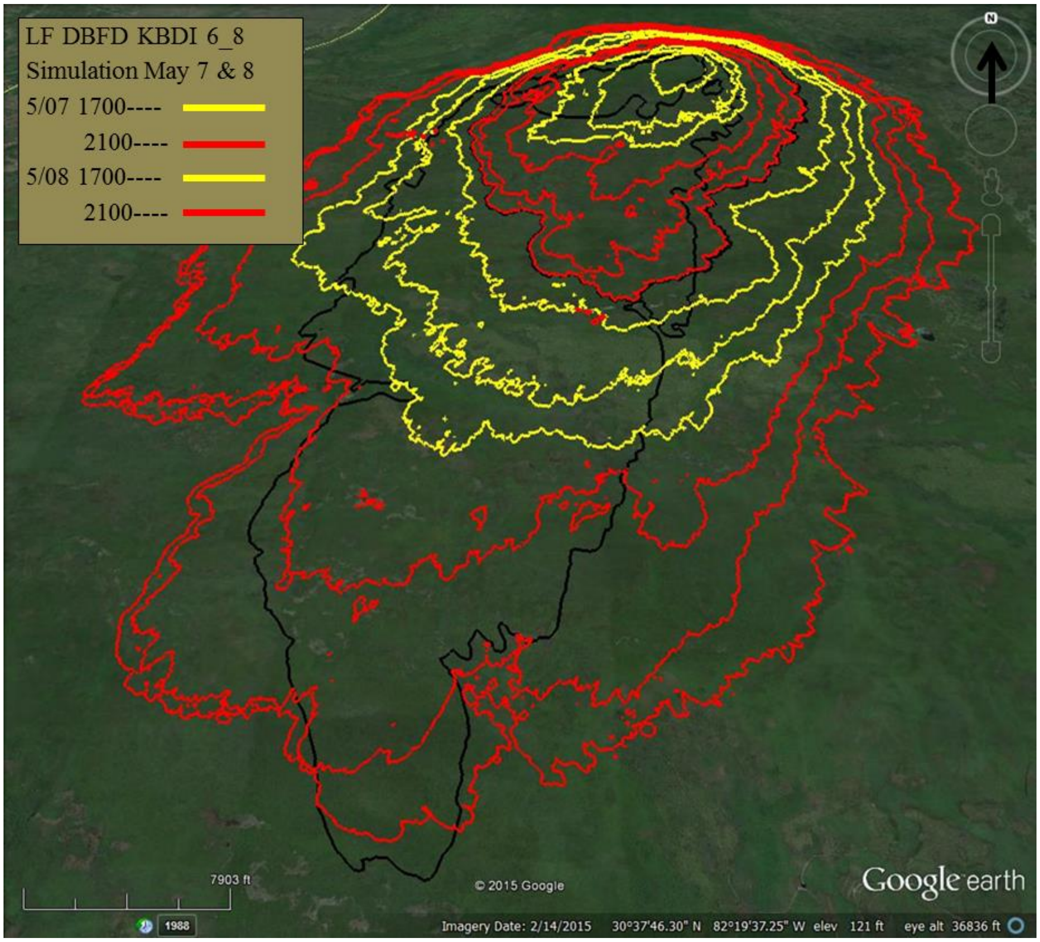


Figure 14: Bugaboo fire simulation using KBDI6_8 landscape.

Due to gusty winds on May 8, the actual fire perimeter covers most of the two day extent on that day. Using 10 minute average winds, the LF DBFD landscape takes both days to reach the approximate forward extent of the actual perimeter. In the simulation, the fire travels further on May 7 than the actual fire, but on May 8 the forward extents end at a similar point. The 10 minute average wind speeds also caused the wider breadth of the simulated fire compared to the actual fire.

Modeling the extents of the Bugaboo and Big Turnaround Fires from 2007 helped define the fuel model transitions for swamp areas in the LF DBFD. In the case of the Bugaboo Fire, EVT 2480 (Gulf and Atlantic Coastal Plain Swamp System) was assigned a Timber Litter model (TL2) in this area based on the typical moisture level; however this model slowed the LF 2012 simulation down. In the severe drought scenario, where EVT 2480 was a TL2 in the swamp areas, the LF DBFD transitioned the TL2 model to a Heavy Humid Climate Shrub (SH9) model. The SH9 model generally has a lower rate of spread than the Dry Climate Shrub (SH7) model that was used for this EVT in areas that were typically drier. However, the SH9 had the closest rate of spread comparison to SH7 and was able to sustain burning in higher humidity, which represents fire more favorably than other dry climate shrub models. Therefore, an effort was also made to transition the SH7 dry climate fuel models to the SH9 humid-climate fuel models using the LF DBFD.

KBDI and Temperature

In the course of review for the LF DBFD, concerns were raised about the ability of KBDI to remain as an indicator of dryness when temperatures fall, particularly in the autumn and winter months. Eight RAWS from across the Southeast area were analyzed to chart the effects of temperature on KBDI. Figure 15 depicts weather from the Congaree RAWS near Gadsden, South Carolina, from August 1 through December 31, 2004. Note the fluctuation of temperature from October 3 through the end of November. For that time period, the KBDI showed a steady increase even though the temperature varied on a daily basis (10 to 15 degrees) and there were some minor precipitation events. The only time KBDI dropped significantly was when there was substantial precipitation. All eight weather stations were examined for fall and winter/spring time periods through several years and this relationship remained the same with each evaluation.

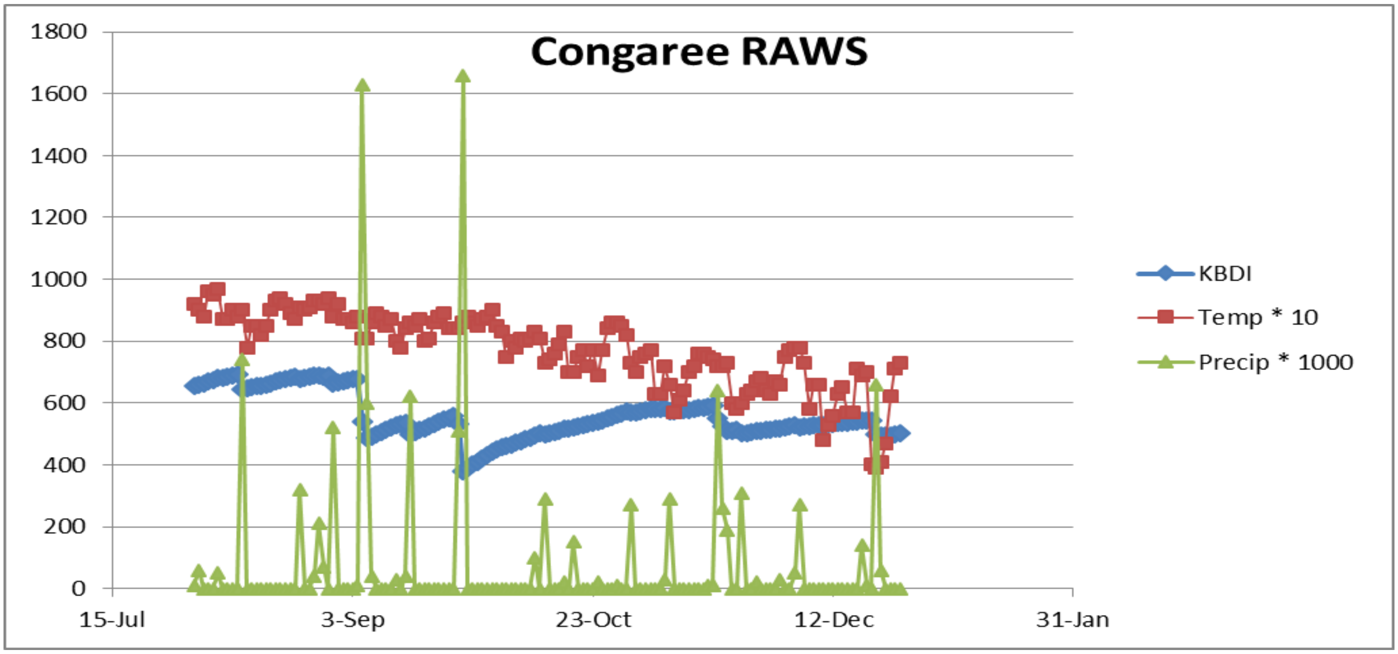


Figure 15: Relationship between KBDI, temperature, and precipitation from August 1 through December 31, 2004 at the Congaree RAWS, South Carolina.

Conclusion

In a static fuel model system, the fuel models in the Southeast U.S. were found to be inconsistent with actual fire behavior. Therefore, the MoD-FIS LF DBFD, which was comprised of three components, including, additive fuel weight by size class and fuel bed depth, vegetation type that influences the fuel model transitions, and drought increments that are applied to the transitions, was developed. This dynamic system was created to adjust fuel models based on environmental conditions, which in the Southeast are most notably affected by drought. The DBFD testing results were found to improve the functionality of the fuel products for fire behavior modeling by transitioning the landscape to classes that more favorably represented actual fire behavior.

Future Development

A couple issues affecting the drought based transition of surface fuel models in the Southeast still require additional research. First, areas with muck soils that transitioned fuel models are low enough in elevation to retain water, especially in moderate drought, and thus should not be transitioned. Additional data sets including lidar-based, high-resolution elevation data, National Wetlands Inventory, SSURGO soils data, and layers depicting muck soils are being investigated for their ability in identifying these areas. If the areas of concern can be adequately identified, additional combinations will be added to the LUT to account for these characteristics and the fuel model transitions adjusted accordingly.

The second issue relates to the relationship of fire behavior and leaf-on versus leaf-off condition of deciduous vegetation in the Southeast. LF calibrated FBFM40 data assumes a leaf-on condition. The reduction in cover and the additional leaf litter available during leaf-off periods could have serious effects on the fire behavior characteristics of these sites. Phenological transitions of surface fuel models are being investigated as an addition to the drought-based fuel transitions, but will require different data and processes to capture these changes.

References

Burgan, Robert E. 1988. 1988 revisions to the 1978 national fire-danger rating system. Research Paper SE-273. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 144 pp.

Keetch, John J., and Byram, George. 1968. A drought index for forest fire control. Research Paper SE-38. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 32 pp.

Schlobohm, Paul, and Brain, Jim. 2002. Gaining an understanding of the National Fire Danger Rating System. Boise ID: National Wildfire Coordinating Group, Fire Danger Working Team. 82 pp.

Contact Information

Please contact the LANDFIRE Help Desk with any questions.

Appendix A

Climatology based on 90th percentile KBDI

Table 8 is a listing of the RAWS used for the climatological assessment in each map zone along with the state they reside in and the LF mapping zone number. Using the KBDI as a surrogate for dryness, ten years of daily weather observations for each station were sorted from lowest to highest to assess the percentile KBDI values that represent critical dryness. The 90th percentile KBDI value from each station was used to assess how the stations related to one another in terms of dryness and how that relationship would associate to a KBDI of 600, which is the threshold for severe drought in the LF DBFD. It was found that RAWS with a 90th percentile KBDI value between 550 and 680 represented the majority of the Southeast, and that the percentile values at these stations of KBDI 600 was within a range of 75-95%.

This climatology analysis covers a large geographic area from east to west and north to south with many variations in soil types and other variables that affect the KBDI computation. In general, the LF DBFD assures that an area is not classified as severe drought until it has reached at least its 75th percentile dryness as determined by KBDI, on the high end. On the low end, the process generally assures that the area represented by the weather station does not exceed its 95th percentile dryness as determined by KBDI before it reaches the severe drought stage. This process placates the largest portion of the area with reasonable breakpoints for no, low, moderate, and high drought conditions, though local variations do exist that impact the relative dryness at which the drought class thresholds are met (e.g. LkWales, FL).

Table 8 - RAWS both used and excluded for climatological analysis of KBDI, showing the 90th percentile KBDI values and the percentile value at KBDI 600, 400, and 200.

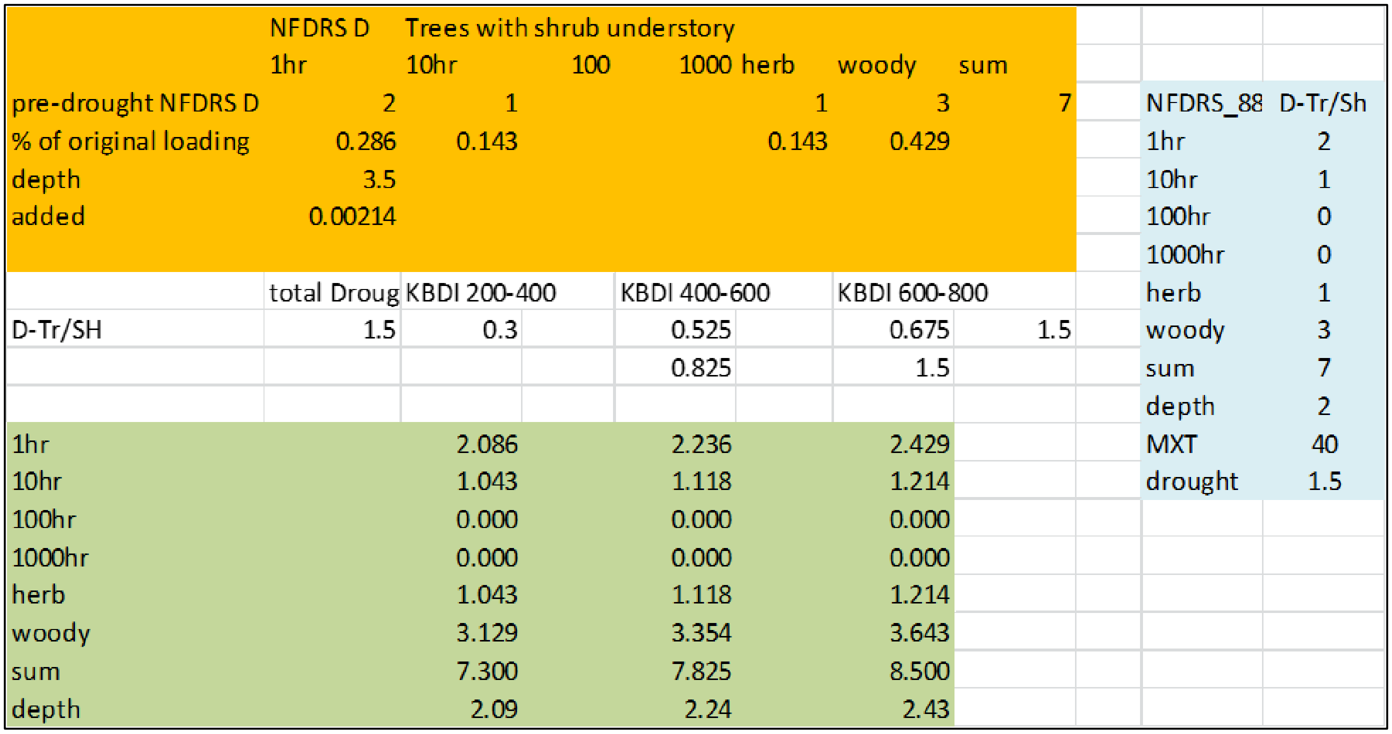
Station Name	State	Map Zone	90th Percentile KBDI Value	Percentile value at KBDI 600	Percentile value at KBDI 400	Percentile value at KBDI 200
Southeast GeoArea						
Bankhead	AL	48	575	92	67	43
Dayton	TX	37	658	84	62	37
JonesOkee	GA	55	624	86	49	20
LkWales	FL	56	680	76	35	12
Oconee	GA	54	581	92	60	35
Whiteville	NC	58	574	92	67	32
Winborn	MS	45	678	82	55	38
Others nearby						
BigSpr	MO	44	539	95		
Flatwood	WV	61	391	99		
MIO	MI	51	154	N/A		
Tomilson	WV	62	356	99		

Appendix B

Fuel weight and depth change due to drought level in NFDRS88 fuel model- D

Figure 16 demonstrates the process of proportionally adding additional fuel weight and depth attributes from NFDRS88 fuel model D to each dead fuel size class and live fuel class for each drought level. This process was completed for each NFDRS88 Fuel Model that linked to a LF EVT/FBFM40 combination.

- To the right in the chart are two columns (with blue shading) showing the default NFDRS88 fuel attributes for fuel model D with the last line indicating the suggested weight (in tons per acre) of additional available fuel in severe drought.
- At the top of the chart (with orange shading), are the same NFDRS88 fuel attributes with the calculation for the proportion of each size class of dead fuel, live fuels, and fuel bed depth.
- The center of the chart (white), calculates the amount of the additional loading for each drought class from the total weight being added.
- The bottom section (green), calculates the proportion of additional fuel for each fuel class based on the percentage of each drought class. It also calculates the additional fuel bed depth by drought class. These are the fuel attributes compared to the FBFM40 fuel attributes for defining fuel model transitions by drought level.



	NFDRS D	Trees with shrub understory								
	1hr	10hr	100	1000	herb	woody	sum			
pre-drought NFDRS D	2	1			1	3	7		NFDRS_88	D-Tr/Sh
% of original loading	0.286	0.143			0.143	0.429			1hr	2
depth	3.5								10hr	1
added	0.00214								100hr	0
									1000hr	0
	total Droug	KBDI 200-400		KBDI 400-600		KBDI 600-800			herb	1
D-Tr/SH	1.5	0.3		0.525		0.675	1.5		woody	3
				0.825		1.5			sum	7
									depth	2
1hr		2.086		2.236		2.429			MXT	40
10hr		1.043		1.118		1.214			drought	1.5
100hr		0.000		0.000		0.000				
1000hr		0.000		0.000		0.000				
herb		1.043		1.118		1.214				
woody		3.129		3.354		3.643				
sum		7.300		7.825		8.500				
depth		2.09		2.24		2.43				

Figure 16: Example worksheet for calculation of additional fuel weight and depth for NFDRS88 fuel model D by drought class.

Appendix C

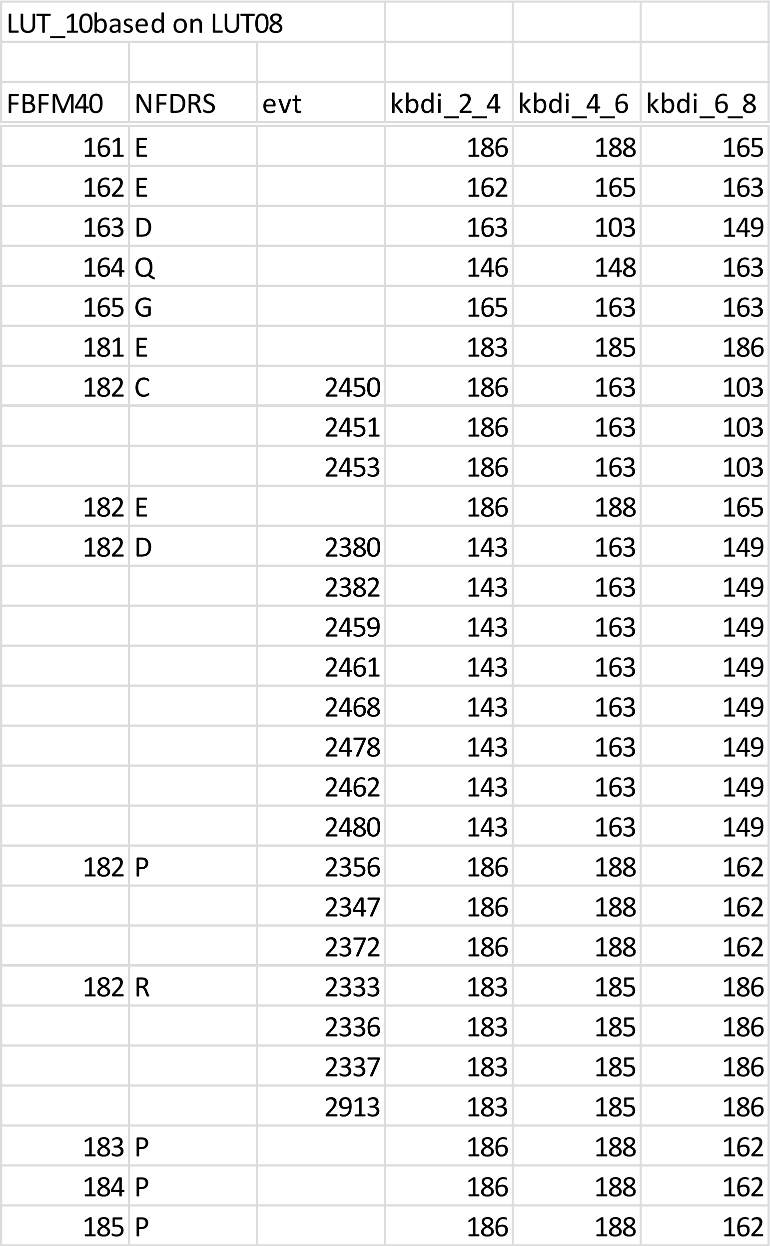
Look-up Table for Fuel Model Transitions

The final LUT for the Southeast GeoArea, which specifies the fuel model transitions for each drought class based on combinations of FBFM40, NFDRS88 fuel model, and EVT.

LUT_10based on LUT08					
FBFM40	NFDRS	evt	kbdi_2_4	kbdi_4_6	kbdi_6_8
101	L		101	102	103
101	A	2916	101	102	102
		2966	101	102	102
		2967	101	102	102
		2417	101	102	102
102	L		102	102	103
		2960	102	102	103
		2966	102	102	103
		2967	102	102	103
102	C	2194	102	103	105
103	N		103	105	106
103	D	2582	103	103	105
		2584	103	103	105
		2584	103	103	105
		2585	103	103	105
		2367	103	103	105
		2367	103	103	105
		2368	103	103	105
		2371	103	103	105
		2372	103	103	105
		2527	103	103	105
		2546	103	103	105
		2586	103	103	105
		2587	103	103	105
		2378	103	103	105
		2588	103	103	105
		2589	103	103	105
		2455	103	103	105
		2590	103	103	105
		2591	103	103	105
		2458	103	103	105

LUT_10based on LUT08

FBFM40	NFDRS	evt	kbdi_2_4	kbdi_4_6	kbdi_6_8
104	L		104	104	107
105	N		105	106	108
105	D	2406	105	105	106
		2488	105	105	106
		2556	105	105	106
		2557	105	105	106
		2377	105	105	106
106	N		106	106	108
107	T		107	107	107
108	N		108	108	109
109	N		109	109	109
121	L		121	122	123
121	L	2917	121	121	102
122	E		122	122	123
122	D	2936	122	123	123
123	D		123	124	103
124	O		124	103	149
141	E		142	143	186
142	E		143	185	165
143	E		186	188	165
143	D	2194	143	146	148
		2349	143	146	148
		2473	143	146	148
		2480	143	146	148
		2535	143	146	148
		2550	143	146	148
		2551	143	146	148
		2552	143	146	148
		2553	143	146	148
		2527	143	146	148
		2546	143	146	148
144	D		144	146	149
145	D		145	145	106
146	D		148	163	149
147	D		147	149	145
148	O		148	163	149
149	O		149	149	145



LUT_10based on LUT08

FBFM40	NFDRS	evt	kbdi_2_4	kbdi_4_6	kbdi_6_8
161	E		186	188	165
162	E		162	165	163
163	D		163	103	149
164	Q		146	148	163
165	G		165	163	163
181	E		183	185	186
182	C	2450	186	163	103
		2451	186	163	103
		2453	186	163	103
182	E		186	188	165
182	D	2380	143	163	149
		2382	143	163	149
		2459	143	163	149
		2461	143	163	149
		2468	143	163	149
		2478	143	163	149
		2462	143	163	149
		2480	143	163	149
182	P	2356	186	188	162
		2347	186	188	162
		2372	186	188	162
182	R	2333	183	185	186
		2336	183	185	186
		2337	183	185	186
		2913	183	185	186
183	P		186	188	162
184	P		186	188	162
185	P		186	188	162

LUT_10based on LUT08

FBFM40	NFDRS	evt	kbdi_2_4	kbdi_4_6	kbdi_6_8
186	E		188	162	163
186	D	2461	144	146	163
		2468	144	146	163
		2501	144	146	163
186	C	2346	186	163	103
		2348	186	163	103
		2349	186	163	103
		2358	186	163	103
		2450	186	163	103
		2451	186	163	103
		2453	186	163	103
		2454	186	163	103
186	P	2372	162	146	163
		2535	162	146	163
		2550	162	146	163
		2551	162	146	163
		2552	162	146	163
		2553	162	146	163
187	E		186	188	165
188	P		162	146	163
189	E	2448	165	162	163
189	P		162	146	163
201	K		201	165	202
202	K		202	202	203
203	J		203	203	204
204	I		204	204	204