Federal Land Assistance, Management and Enhancement (FLAME) Act Suppression Expenditures for Interior and Agriculture Agencies:

March 2015 Forecasts for Fiscal Year 2015

Supporting Documentation

Report Date: February 13, 2015

Executive Summary

In FY 2015, the U.S. Department of Agriculture Forest Service is forecast to spend:

Median forecast	$1.225 billion
90% confidence range of forecast	$794 million to $1.657 billion
Forecast tercile of historical expenditures since 1985	Upper
Previous median forecast (September 2014 FLAME)	$1.122 billion

These forecasts are reported in Tables 1-3 and Figure 1.

In FY 2015, the bureaus of the U.S. Department of the Interior are forecast to spend:

Median forecast	$382 million
90% confidence range of forecast	$275 million to $490 million
Forecast tercile of historical expenditures since 1985	Upper
Previous median forecast (September 2014 FLAME)	$356 million

The DOI forecasts are reported in Tables 4-5 and Figure 2.

Overview

With the passage of the FLAME Act in 2009, both the U.S. Department of Agriculture Forest Service (USDA) and the Department of the Interior (DOI) are required to produce forecasts of annual suppression expenditures three times during each fiscal year: March, May, and July, with a September outlook for the next fiscal year required when the next fiscal year budget is not approved by Congress and the President by that date. Scientists at the USDA Forest Service Southern Research Station provide these forecasts to both the Forest Service and the DOI.

Modeling

Modeling Framework for the March 2015 FLAME Act Forecast of FY 2015 Forest Service Expenditures

To meet the statutory requirements of the FLAME Act, the Forest Service developed statistical models based on peer reviewed research.[1,2] These models have been developed for several forecast horizons and are generally specified as a system of equations. Each of the nine equations contained in the current modeling system represents a statistical relationship between historical expenditures and a set of predictor variables for a particular Forest Service region. These equations were estimated using ordinary least squares regression (OLS).

This report is the second forecast issued for FY 2015. The current approach forecasts expenditures by individual Forest Service region. The expenditures made by the National Interagency Fire Center, Washington Office, and research stations continue to be modeled as an aggregate, which we label in this report as "RFS." This RFS category is combined with Region 10, Alaska, because there relatively few expenditures on suppression in Region 10. This report differs from previous March FLAME Act forecasts in two ways: (1) cost pools were included in the forecast rather than added in at the end, and (2) gross domestic product deflators consistent with the President's budget were used.[3]

The statistical models relate spending in the coming fiscal year to lagged measures of suppression expenditures, a dummy variable for structural change starting in FY 2000, lagged measures of drought (mean and minimum) from December of the current FY and May of the previous FY (Palmer indices), ocean temperatures (Niño-3 sea surface temperature anomaly), and ocean pressure indices (Pacific-North American teleconnection pattern). The models had moderate R^2's, ranging from 0.25 (RFS) to 0.62 (Region 4 and Region 8). Durbin-Watson statistics, designed to detect serial autocorrelation in the residuals of estimated equations, were all within the acceptable (insignificant) or inconclusive range.

Forecasts were made using the equation estimates shown in Table 6 for region-level expenditures. Data for modeling were annual fiscal year totals of expenditures, and ranged from 1995 to 2014, the only years for which consistent region-level data could be assembled. To erase the effects of general price inflation, all expenditures were deflated to the value of a dollar in 2014 using the gross domestic product deflator used in the President's budget—that is, models were estimated and expenditures were forecast in "real" dollar terms.

After the forecast, we adjusted the forecast values to put them in current dollars. When generating a forecast distribution (see Figure 1), we randomly sampled from equation error distributions in ways that accounted for the uncertainties in the forecast. These Monte Carlo

[1] Prestemon, J.P., K.L. Abt, and K. Gebert. 2008. Suppression cost forecasts in advance of wildfire seasons. Forest Science 54(4):381-396.
[2] Abt, K.L., J.P. Prestemon, and K. Gebert. 2009. Wildfire suppression cost forecasts for the US Forest Service. Journal of Forestry 107(4):173-178.
[3] http://www.whitehouse.gov/sites/default/files/omb/budget/fy2015/assets/hist.pdf

forecasts, which are repeated 50,000 times, do not produce a precise estimate. Rather, they generate a distribution of estimates. This distribution is summarized in many ways: a forecast density distribution, a table reporting a median forecast and the lower and upper bounds of likely observed expenditures,[4] and a table of not-to-exceed expenditures by probability levels. We also describe where the median forecast value for each region falls within the observed historical expenditures for other years, in real dollar terms.

Model fitness is reported in Table 7 and Figure 3. Table 7 shows how well the March 2015 FLAME Act forecast model performs by measuring the errors developed from out-of-sample forecasts (produced by dropping the observation of the forecast year, and doing this iteratively over the historical data, a technique sometimes termed "cross-validation") compared with observed expenditures for the Forest Service. The Root Mean Squared Error of the model used in this March 2015 forecast of FY 2015 expenditures, when applied to the 1996-2014 period, was $268 million and that it had a positive bias, tending to over-forecast each year, on average, by about $27 million (3 percent). We do not adjust the current forecast using this bias. The model had a Mean Absolute Percent Error of 25 percent, meaning that the typical forecast averaged 25 percent above or below expenditures actually incurred during the 1996-2014 time span. Finally, this model correctly predicted the direction of change in suppression expenditures by the Forest Service 84 percent of the time. The predicted direction of change for FY 2015 compared to FY 2014 is positive (upward) when considered from the median forecast (Figure 3).

Modeling Framework for the March 2015 FLAME Act Forecast of FY 2015 Department of the Interior Expenditures

The forecast model for the DOI was based on departmental total expenditure data—i.e., aggregated across all agencies and geographic regions. The March 2015 FLAME Act Model covered department wide expenditures for FY 1985-2014.[5] We modeled aggregate DOI expenditures using a parsimonious model specification involving the Pacific-North American teleconnection pattern, the Niño-3 sea surface temperature anomaly, and a variable to represent years after 2000.

The DOI suppression expenditure forecast equation is reported in Table 8. The estimated equation explained 81 percent of the variation ($R^2 = 0.81$) in annual DOI suppression expenditures over the historical time period, 1985-2014. The Durbin Watson statistic indicated no evidence (1.95) of residual autocorrelation in the model estimation errors. As in the Forest Service forecast, uncertainty surrounding the DOI forecast for FY 2015 is illustrated with the probability density graphic (Figure 2) developed with 50,000 Monte Carlo random forecasts.

[4] It is possible for the lower bounds of the distribution to be less than or equal to zero when suppression expenditures are low and the sampled error is larger. Our interest is primarily on the upper end of the distribution.

[5] Although geographical and agency disaggregated data are available for recent years (since the early 2000's), there are insufficient data for modeling by geographic region or agency within the Department.

Model fitness for the March FLAME Act forecast model for DOI is reported in Table 9. As in the case of the Forest Service forecast, the DOI March FLAME Act Forecast Model was evaluated by making cross-validated forecasts of DOI expenditures, then generating the model evaluation diagnostics presented in Table 9. This March forecast model had a Root Mean Squared Error of $64 million when calculated over 1985-2014. The model had a bias of positive $404 thousand (0.14 percent) calculated over 1985-2014. As with the Forest Service, we do not adjust the forecasts for any historical prediction bias. The model had a Mean Absolute Percent Error of 20 percent for the 1985-2014 time span. It correctly predicted the direction of change in suppression expenditure for the agency from one year to the next of 79 percent, or 24 out of the 29 years, between 1986-2014 (Figure 4).

Results

Both the USDA Forest Service and the DOI are forecast to have fire suppression expenditures in the upper tercile since 1985 and middle tercile using data only since 1995. Both agencies median forecasts are higher in this March FLAME Act forecast than reported in the September FLAME Act forecast. The difference may be attributed to the inclusion of a relatively neutral Niño-3 sea surface temperature anomaly, localized measures of regional drought, and ocean pressure conditions compared to the September FLAME Act forecast that does not include climatic information.

USDA Forest Service

The median forecasts for each of the regions, and for the USDA Forest Service total, are reported in Table 1, along with the 80, 90 and 95% confidence intervals. Table 2 contains probabilities of falling below specific dollar amounts by region and in total. Table 3 reveals that, when compared to expenditures since 1995, Regions 1, 5, 6, 9, and the RFS aggregate are forecast to be in the upper tercile in 2015; Regions 3, 4, 8, and the USDA Forest Service total are expected to have expenditures in the middle tercile; and Region 2 is forecast to have suppression expenditures in the lower tercile. Using a longer time series since 1985 for the USDA Forest Service total indicates suppression expenditures are forecast to be in the upper tercile.

The effects of drought were as expected such that the drier the region in December of the current FY, the higher the suppression expenditures (all regions except Regions 1, 3, and RFS) while previous FY May values show an inverse relationship for Regions 3, 4, and 8 presumably because drought last May would lead to lower grassy fuels and thus lower expenditures this year The December positive value for ocean temperatures (Niño-3 sea surface temperature anomaly) reduced forecasted suppression expenditures in Regions 5 and 6 while the positive value for the ocean pressure index (Pacific-North American teleconnection pattern) increases expected suppression expenditures in Regions 1 and 6. Regions 1, 3, 4, and 9 had higher suppression expenditures in the years since FY 2000.. The net effect is that Regions 5, 6, and RFS are forecast to have suppression expenditures lower than in FY 2014 while the remaining regions are forecast to have higher suppression expenditures than in FY 2014.

Department of the Interior

The median forecast expenditure from the Monte Carlo simulation for the Department is in the upper tercile in real dollar terms compared to the observed expenditures since 1985 and the middle tercile since 1995. The outcome is the result from a positive but relatively neutral Niño-3 sea surface temperature anomaly (0.91), higher average expenditures since 2000, and slightly positive Pacific-North American teleconnection (0.37).

Table 1. March 2015 FLAME Act forecasts of FY 2015 suppression expenditures of the USDA Forest Service, by region and in total in current year (FY 2015) dollars.

	(Millions of 2015$)									
	R1	R2	R3	R4	R5	R6	R8	R9	RFS	Total FS
Median Estimate	147	11	73	97	359	152	43	15	328	1,225
80% Confidence Lower Limit	34	(33)	5	52	188	62	12	4	127	889
80% Confidence Upper Limit	260	56	140	141	530	242	75	26	529	1,560
90% Confidence Lower Limit	(15)	(53)	(24)	33	114	23	8	1	102	794
90% Confidence Upper Limit	308	76	169	160	604	281	79	29	555	1,657
95% Confidence Lower Limit	(64)	(72)	(53)	14	40	(16)	6	(1)	89	706
95% Confidence Upper Limit	357	95	198	179	678	320	81	31	567	1,738

Table 2. March 2015 FLAME Act forecasts of FY 2015 suppression expenditures of the USDA Forest Service by region and in total, probability of falling below specified amount in FY 2015 dollars.

	Realized amount by region and in total (Millions of 2015$)									
Probability (%) of falling below indicated dollar amount	R1	R2	R3	R4	R5	R6	R8	R9	RFS	Total Forest Service
1	(128)	(98)	(92)	(11)	(57)	(67)	4	(4)	82	604
5	(15)	(53)	(24)	33	114	23	8	1	102	794
10	34	(33)	5	52	188	62	12	4	127	889
20	82	(14)	34	71	261	101	20	8	177	1,003
30	111	(3)	51	83	304	123	27	11	228	1,084
40	131	5	63	91	335	140	35	13	278	1,158
50	147	11	73	97	359	152	43	15	328	1,225
60	162	18	82	103	383	164	51	17	378	1,292
70	182	26	94	111	413	181	59	19	429	1,363
80	211	37	111	122	456	203	67	22	479	1,447
90	260	56	140	141	530	242	75	26	529	1,560
95	308	76	169	160	604	281	79	29	555	1,657
99	421	120	237	204	775	371	82	34	575	1,846

Table 3. March 2015 FLAME Act forecasts of FY 2015 suppression expenditures of the USDA Forest Service, by tercile

Region	Tercile of Costs Expected, Since 1995
R1	Upper
R2	Lower
R3	Middle
R4	Middle
R5	Upper
R6	Upper
R8	Middle
R9	Upper
RFS	Upper
Total FS since 1995	Middle
Total FS since 1985	Upper

Table 4. March 2015 FLAME Act forecasts of FY 2015 suppression expenditures of the Department of the Interior in FY 2015 dollars.

	(Millions of 2015$)
	Total DOI
Median Estimate	382
80% Confidence Lower Limit	298
80% Confidence Upper Limit	466
90% Confidence Lower Limit	275
90% Confidence Upper Limit	490
95% Confidence Lower Limit	254
95% Confidence Upper Limit	510

Table 5. March 2015 FLAME Act forecasts of FY 2015 suppression expenditures of the Department of the Interior probability of falling below specified amount in FY 2015 dollars.

Probability (%) of falling below indicated dollar amount	Realized amount (Millions of 2015$)
1	230
5	275
10	298
20	327
30	348
40	366
50	382
60	399
70	417
80	437
90	466
95	490
99	534

Table 6. Ordinary least squares regression equation estimates used in the March 2015 forecast of FY 2015 suppression expenditures of the USDA Forest Service.

Dependent variable	Independent variables	Coefficient	Standard error	t-statistic	P-value	R^2	Durbin-Watson statistic
Region 1 Expenditures	Constant	48,735,922	45,954,147	1.06	0.3057	0.42	2.28
	Region 1 Expenditures (t-1)	(0.352)	0.213	(1.65)	0.1187		
	Years 2000 on	104,720,626	53,794,102	1.95	0.0705		
	Pacific North American Oscillation December (t-1)	57,288,093	20,862,647	2.75	0.0150		
Region 2 Expenditures	Constant	10,293,596	13,016,307	0.79	0.4399	0.47	2.42
	Region 2 December Palmer M-Index Minimum (t-1)	(8,825,316)	3,671,534	(2.40)	0.0279		
	Region 2 December Palmer X-Index (t-1)	(15,817,518)	8,892,762	(1.78)	0.0932		
Region 3 Expenditures	Constant	48,509,000	23,345,968	2.08	0.0532	0.45	1.52
	Years 2000 on	87,957,560	28,318,137	3.11	0.0064		
	Region 3 May Palmer M-Index (t-1)	13,788,994	4,826,680	2.86	0.0109		
Region 4 Expenditures	Constant	(19,723,650)	23,891,418	(0.83)	0.4212	0.62	1.51
	Years 2000 on	94,150,186	25,716,401	3.66	0.0021		
	Region 4 May Palmer H-Index (t-1)	18,785,872	4,956,910	3.79	0.0016		
	Region 4 December Palmer S-Index Minimum (t-1)	(11,007,032)	5,939,080	(1.85)	0.0824		
Region 5 Expenditures	Constant	256,367,779	30,441,695	8.42	<.0001	0.49	1.52
	Niño-3 SSTA December (t-1)	(51,258,031)	22,869,158	(2.24)	0.0386		
	Region 5 December Palmer S-Index (t-1)	(51,551,281)	15,599,327	(3.30)	0.0042		
Region 6 Expenditures	Constant	91,972,892	28,653,673	3.21	0.0055	0.41	1.64
	Niño-3 SSTA December (t-1)	(26,510,377)	14,635,290	(1.81)	0.0889		
	Pacific North American Oscillation December (t-1)	37,955,778	19,160,817	1.98	0.0651		
	Region 6 December Palmer H-Index Minimum (t-1)	(22,518,805)	10,438,621	(2.16)	0.0465		
Region 8 Expenditures	Constant	87,115,446	18,007,248	4.84	0.0002	0.62	1.57
	Region 8 May Palmer X-Index Minimum (t-1)	15,332,109	5,788,122	2.65	0.0169		
	Region 8 December Palmer S-Index (t-1)	(14,458,360)	2,762,633	(5.23)	<.0001		
Region 9 Expenditures	Constant	7,197,458	3,388,804	2.12	0.0487	0.36	1.63
	Region 9 December Palmer X-Index (t-1)	(5,299,050)	1,829,911	(2.90)	0.0101		
	Years 2000 on	7,863,497	4,049,467	1.94	0.0689		
RFS Expenditures	Constant	103,576,939	54,499,923	1.90	0.0745	0.25	2.48
	Region 1013 Expenditures (t-1)	0.519	0.217	2.39	0.0285		

Note: The dependent variable is the annual total real dollar suppression expenditures for each region.

Table 7. Cross-validation of the ordinary least squares regression model used in the March 2015 FLAME Act forecast of FY 2015 suppression expenditures of the USDA Forest Service calculated over data from 1996-2014 in FY 2015 dollars.

	Millions of 2015 dollars	Percent
Root mean square error	268	-
Bias	27	-
Percent bias	-	3
Mean absolute percent error	-	25
Percent correct direction of change	-	84

Table 8. Equation estimates used in the March 2015 FLAME Act forecast of FY 2015 suppression expenditures of the Department of the Interior.

Dependent variable	Independent variables	Coefficient	Standard error	t-statistic	P-value	R^2	Durbin-Watson statistic
DOI Expenditures	Constant	190,574,357	15,241,062	12.50	<.0001	0.81	1.95
	Niño-3 SSTA November (t-1)	(31,465,502)	10,045,659	(3.13)	0.0043		
	Years 2000 on	194,939,731	21,732,746	8.97	<.0001		
	Pacific North American Oscillation December (t-1)	48,468,367	11,098,345	4.37	0.0002		

Note: The dependent variable is the Department's annual real dollar suppression expenditures.

Table 9. Cross-validation of the equation used in the March 2015 FLAME Act forecast of FY 2015 suppression expenditures of the Department of the Interior calculated over data from 1985-2014 in FY 2015 dollars.

	Millions of 2015 dollars	Percent
Root mean square error	64	-
Bias	0.40	-
Percent bias	-	0.14
Mean absolute percent error	-	20
Percent correct direction of change	-	79

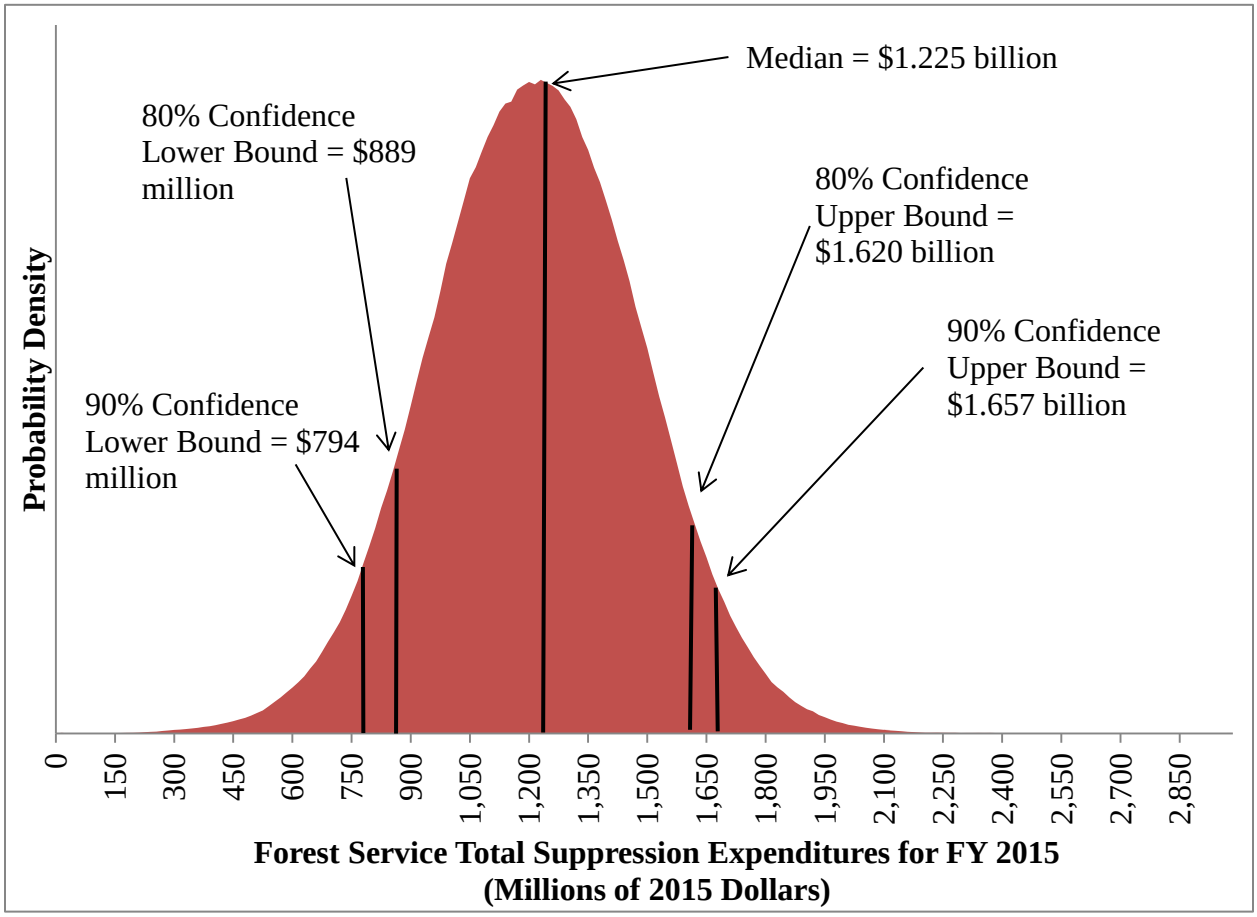

Figure 1. USDA Forest Service suppression expenditure forecast probability density, FY 2015, March 2015 FLAME Act forecast model.

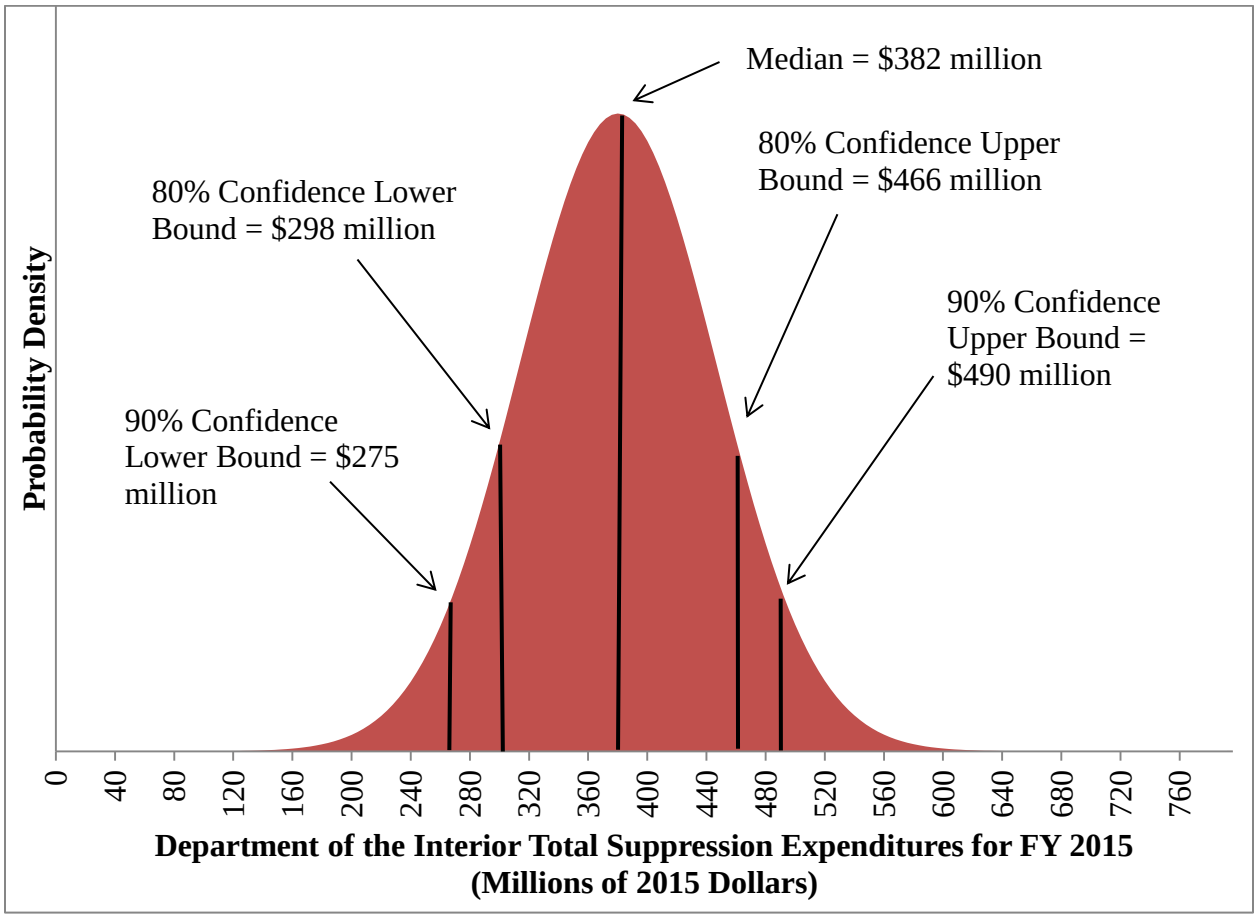

Figure 2. Department of the Interior suppression expenditure forecast probability density, FY 2015, March 2015 FLAME Act forecast model.

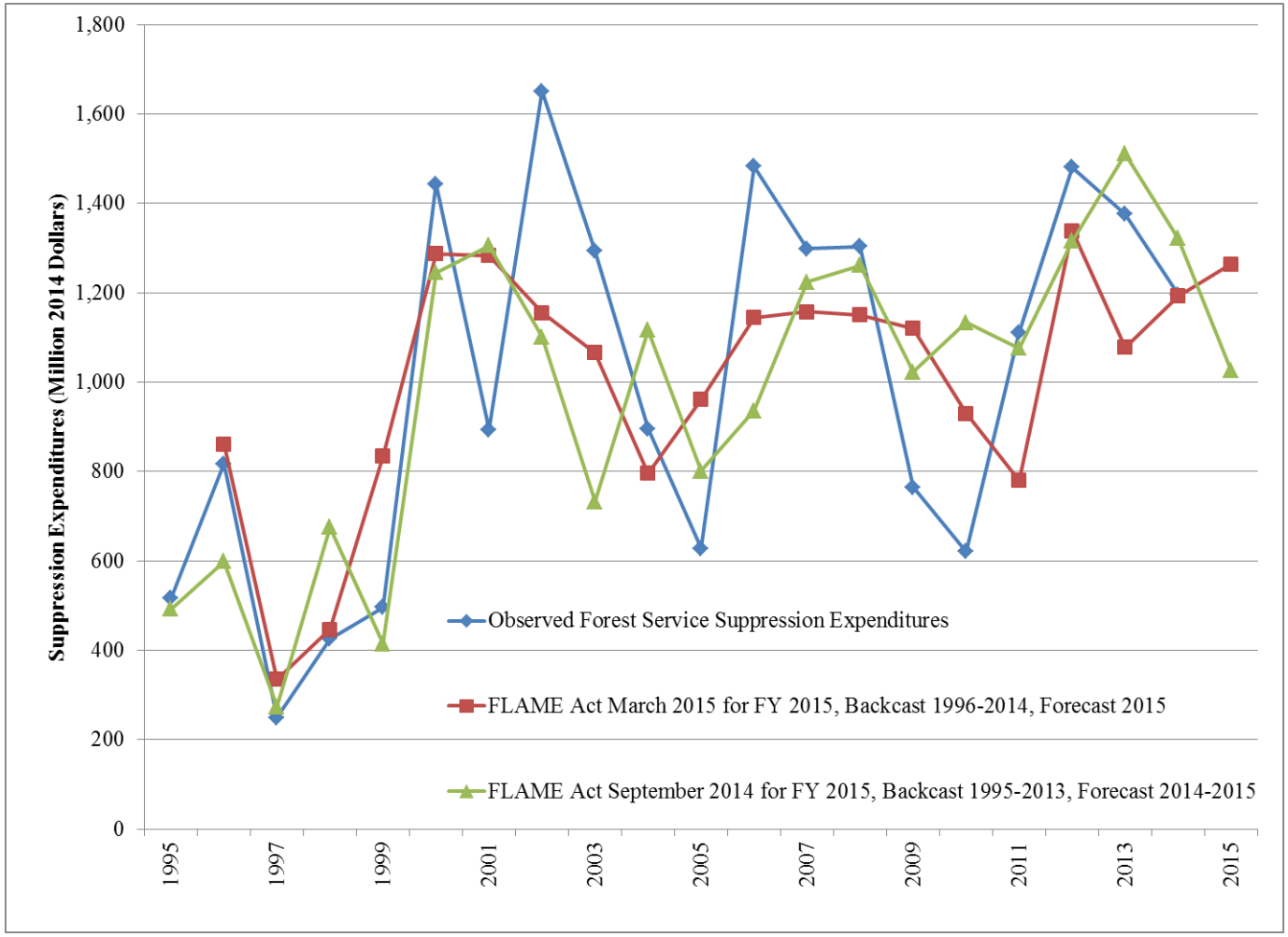

Figure 3. Observed historical USDA Forest Service suppression expenditures and the forecasts of these expenditures (1995-2015), using the March 2015 FLAME Act Forecast Model. All forecasts for each fiscal year are sums across the point estimates of each region's expenditures generated with a cross-validation procedure. (Note: values are in constant 2014 dollars and include the wildland fire suppression cost pool expenditures.)

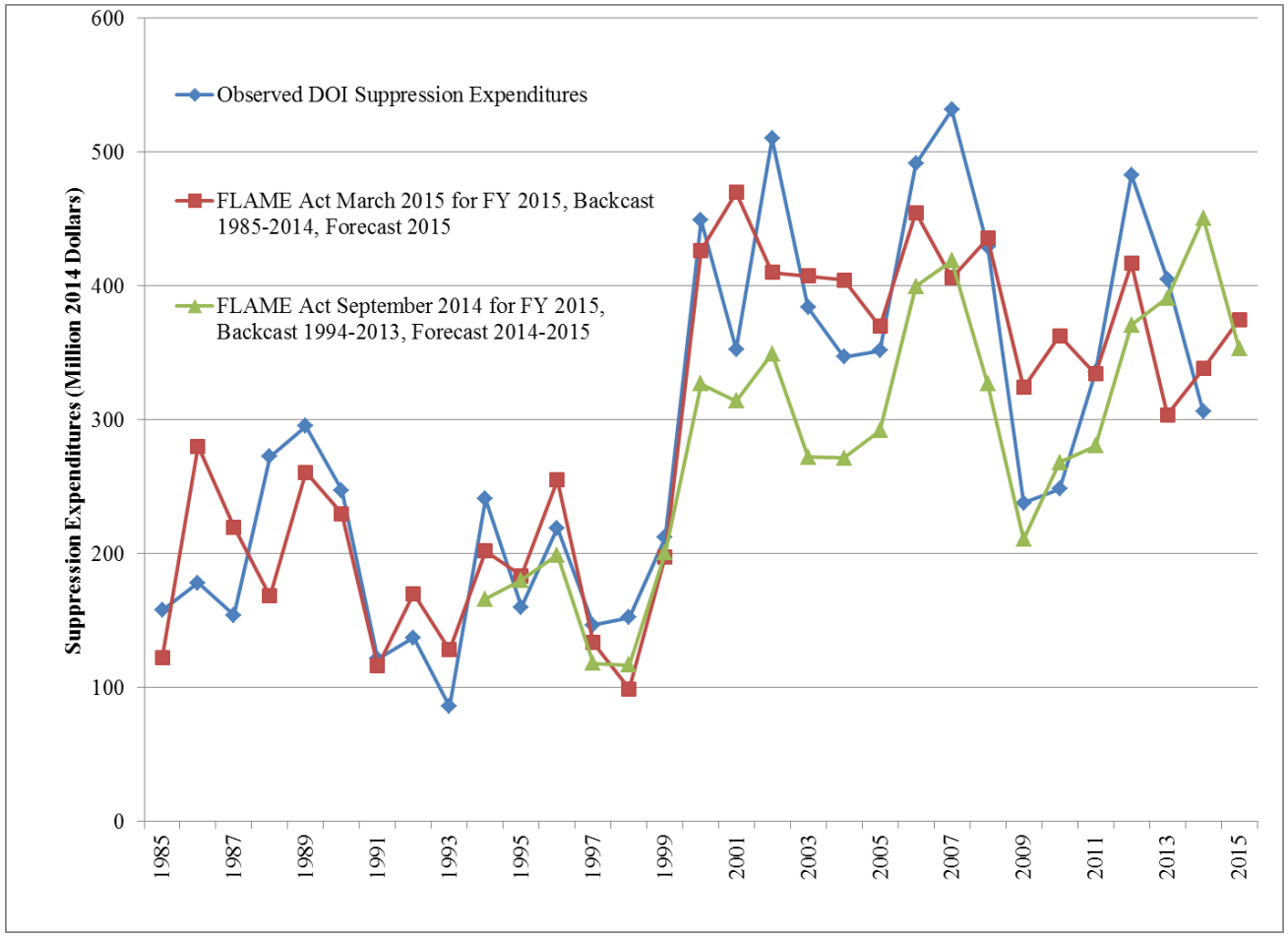

Figure 4. Observed historical Department of the Interior suppression expenditures and the forecasts of these expenditures (1985-2014), using the March 2015 version of the March FLAME Act Forecast Model. All forecasts for each fiscal year are the point estimates generated with a cross-validation procedure. (Note: values are in constant 2014 dollars)