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

May 2015 Forecasts for Fiscal Year 2015

Supporting Documentation

Report Date: April 15, 2015

Executive Summary

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

Median forecast	$1.216 billion
90% confidence range of forecast	$810 million to $1.620 billion
Forecast tercile of historical expenditures since 1985	Upper
Previous median forecast (September 2014 FLAME)	$1.122 billion
Previous median forecast (March 2015 FLAME)	$1.225 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	$378 million
90% confidence range of forecast	$281 million to $475 million
Forecast tercile of historical expenditures since 1985	Upper
Previous median forecast (September 2014 FLAME)	$356 million
Previous median forecast (March 2015 FLAME)	$382 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 May 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 ten 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 third 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 May 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 and March 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 and Pacific Decadal Oscillation index). The models had moderate R^2's, ranging from 0.25 to 0.62.

To improve the performance of the RFS model, the model from the March FLAME forecast (V1) was averaged with an alternative model (V2) with time and the Pacific Decadal Oscillation index as independent variables resulting in a smaller forecast error for the total Forest Service compared to including either specification separately. 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. The March FY15 FLAME forecast models for Regions 1, 3, 6, 8 and 9 had lower Root Mean Square Errors than other models tested, and so were retained. The models for Regions 2, 4, 5 and RFS differ slightly from the March FY15 models, adding or deleting specific variables as predictors.

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[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

Data used for modeling were annual fiscal year totals of expenditures for 1995 to 2014, the only years for which consistent region-level data could be assembled. Total Forest Service expenditures are also available for 1985-1994, and some comparisons are made to this longer time series. 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 forecasts, which are repeated 50,000 times, do not produce a precise estimate. Rather, they generate a distribution of estimates. This distribution is summarized as: 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 May 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 May 2015 FLAME Act model, calculated over FY 1996-2014, was $204 million.

The forecast had a positive bias, tending to over-forecast each year, on average, by about $13 million (1.25 percent). We do not adjust the current forecast using this bias. The model had a Mean Absolute Percent Error of 17 percent, meaning that the typical forecast averaged 17 percent above or below expenditures actually incurred during the 1996-2014 time span. Finally, this model correctly predicted the year-over-year direction of change in suppression expenditures by the Forest Service 89 percent of the time. The median FY 2015 expenditures are forecast to be lower than the actual FY 2014 expenditures (Figure 3).

Modeling Framework for the May 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 May 2015 FLAME Act Model covered department wide expenditures for FY 1985-2014.[5] We modeled aggregate DOI

[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.

expenditures using a model specification that includes the Palmer Drought Severity Drought Indices corresponding to Forest Service Regions 2, 3, and 8, and a variable to represent years after 2000.

The DOI suppression expenditure forecast equation is reported in Table 8. The estimated equation explained 85 percent of the variation ($R^2 = 0.85$) in annual DOI suppression expenditures over the historical time period, 1985-2014. The Durbin Watson statistic indicated no evidence (1.92) 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.

Model fitness for the May FLAME Act forecast model for DOI is reported in Table 9. As in the case of the Forest Service forecast, the DOI May 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 May forecast model had a Root Mean Squared Error of $60 million when calculated over 1985-2014 and a small positive bias. As with the Forest Service, we do not adjust the forecasts for any historical prediction bias.

The typical forecast was off by 19 percent for the 1985-2014 time span (Mean Absolute Percent Error). The model correctly predicted the direction of change in suppression expenditure for the agency from one year to the next 83 percent of the time between 1986-2014 (Figure 4) [6]. The median FY 2015 expenditures are forecast to be higher than the actual FY 2014 expenditures.

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[7]. Both agencies median forecasts in this May FLAME Act forecast are in between the medians from the March and September FLAME Act forecasts. The difference between the September and May forecasts can be attributed to the inclusion of climate and drought measures that are not included in the September forecasts. Differences between the March and May can be attributed to the addition of two March drought measures and, mostly, to the averaging of the two RFS models.

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. The median and confidence

[6] Direction of change is calculated based on the change from the previous year's data, therefore, can only be calculated from 1986-2014 in the case of the Department of the Interior. The USDA Forest Service system contains a lagged dependent variable for RFS therefore reducing the years that we can forecast (and evaluate the forecast) to 1996-2014.

[7] The USDA Forest Service models use data only since 1995 as regional level data are not adequate prior to that date. Total USDA Forest Service expenditures are available, and considered reliable, so we do the comparison.

intervals for regions 1, 3, 8, and 9 are identical to the March FLAME values. Region 6, which used an identical model, differs slightly because a different error distribution was chosen for the simulation. 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, and 9 are forecast to be in the upper tercile in 2015; Regions 3, 4, 8, the RFS aggregate, 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 drought conditions in March (Regions 2 and 5) and last December (Regions 6, 8 and 9) increased the expenditures, as expected[8]. Drought conditions last May in Regions 2, 3, 4 and 8 decreased expected suppression expenditures this year. This is somewhat consistent with results recorded in the literature where conditions the previous year are assumed to lead to less fine fuels and thus fewer acres burned.[9]

The positive Niño-3 sea surface temperature anomaly (December 2014) and the positive Pacific Decadal Oscillation (December 2014) reduced forecast suppression expenditures in Regions 6 and RFS while the positive value for the ocean pressure index (Pacific-North American teleconnection pattern) increased forecast suppression expenditures in Regions 1 and 6. Regions 1, 3, 4, and 9 had higher suppression expenditures in the years since FY 2000. The overall effect is a small reduction in the total Forest Service forecast expenditures compared to the March FLAME forecast.

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 of drought conditions in the central and southeastern United States and higher average expenditures since 2000.

[8] Westerling, A.J., A. Gershunov, D.R. Cayan, T.P. Barnett. 2003. Long lead statistical forecasts of area burned in western U.S. wildfires by ecosystem province. Int. J. Wildl. Fire 11(3– 4):257–266; Littell, J.S., D. McKenzie, D.L. Peterson, and A.L. Westerling. 2009. Climate and wildfire area burned in western U.S. ecoprovinces, 1916–2003 19(4): 1003-1021.

[9] Littell, J.S., D. McKenzie, D.L. Peterson, and A.L. Westerling. 2009. Climate and wildfire area burned in western U.S. ecoprovinces, 1916–2003 19(4): 1003-1021.

Table 1. May 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	8	73	87	474	166	43	15	204	1,216
80% Confidence Lower Limit	34	(35)	5	34	340	76	12	4	38	898
80% Confidence Upper Limit	260	51	140	140	607	256	75	26	369	1,532
90% Confidence Lower Limit	(15)	(54)	(24)	16	283	46	8	1	18	810
90% Confidence Upper Limit	308	69	169	158	664	286	79	29	390	1,620
95% Confidence Lower Limit	(64)	(72)	(53)	(1)	226	16	6	(1)	7	733
95% Confidence Upper Limit	357	87	198	175	721	316	81	31	400	1,701

Table 2. May 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)	(96)	(92)	(24)	150	(22)	4	(4)	1	632
5	(15)	(54)	(24)	16	283	46	8	1	18	810
10	34	(35)	5	34	340	76	12	4	38	898
20	82	(17)	34	54	398	109	20	8	80	1,005
30	111	(6)	51	67	431	131	27	11	121	1,084
40	131	2	63	77	455	150	35	13	162	1,153
50	147	8	73	87	474	166	43	15	204	1,216
60	162	14	82	97	492	183	51	17	245	1,282
70	182	21	94	107	516	201	59	19	287	1,347
80	211	32	111	120	549	223	67	22	328	1,424
90	260	51	140	140	607	256	75	26	369	1,532
95	308	69	169	158	664	286	79	29	390	1,620
99	421	112	237	198	797	354	82	34	407	1,794

Table 3. Tercile forecasts of FY 2015 suppression expenditures from the May 2015 FLAME Act model.

Region	Forecast Tercile
R1 (since 1995)	Upper
R2 (since 1995)	Lower
R3 (since 1995)	Middle
R4 (since 1995)	Middle
R5 (since 1995)	Upper
R6 (since 1995)	Upper
R8 (since 1995)	Middle
R9 (since 1995)	Upper
RFS (since 1995)	Middle
Total FS (since 1995)	Middle
Total FS (since 1985)	Upper
Total DOI (since 1985)	Upper

Table 4. May 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	378
80% Confidence Lower Limit	302
80% Confidence Upper Limit	454
90% Confidence Lower Limit	281
90% Confidence Upper Limit	475
95% Confidence Lower Limit	262
95% Confidence Upper Limit	494

Table 5. May 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	240
5	281
10	302
20	328
30	347
40	363
50	378
60	393
70	409
80	428
90	454
95	475
99	515

Table 6. Ordinary least squares regression equation estimates used in the May 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	0.2906	0.42	2.28
	Region 1 Expenditures (t-1)	(0.3518)	0.2126	(1.65)	0.1000		
	Years 2000 on	104,720,626	53,794,102	1.95	0.0534		
	Pacific North American Oscillation December (t-1)	57,288,093	20,862,647	2.75	0.0068		
Region 2 Expenditures	Constant	(35,084,380)	19,769,944	(1.77)	0.0780	0.49	2.46
	Region 2 March Palmer S-Index Minimum	(22,134,460)	5,596,128	(3.96)	0.0001		
	Region 2 May Palmer S-Index (t-1)	9,448,428	4,209,710	2.24	0.0263		
Region 3 Expenditures	Constant	48,509,000	23,345,968	2.08	0.0394	0.45	1.52
	Years 2000 on	87,957,560	28,318,137	3.11	0.0023		
	Region 3 May Palmer M-Index (t-1)	13,788,994	4,826,680	2.86	0.0049		
Region 4 Expenditures	Constant	4,803,308	21,268,001	0.23	0.8216	0.54	1.55
	Years 2000 on	110,436,299	25,841,278	4.27	<.0001		
	Region 4 May Palmer H-Index (t-1)	14,641,377	4,730,015	3.10	0.0023		
Region 5 Expenditures	Constant	270,123,827	31,340,208	8.62	<.0001	0.41	2.02
	Region 5 March Palmer S-Index	(47,184,947)	13,289,703	(3.55)	0.0005		
Region 6 Expenditures	Constant	91,972,892	28,653,673	3.21	0.0016	0.41	1.64
	Niño-3 SSTA December (t-1)	(26,510,377)	14,635,290	(1.81)	0.0721		
	Pacific North American Oscillation December (t-1)	37,955,778	19,160,817	1.98	0.0494		
	Region 6 December Palmer H-Index Minimum (t-1)	(22,518,805)	10,438,621	(2.16)	0.0326		
Region 8 Expenditures	Constant	87,115,446	18,007,248	4.84	<.0001	0.62	1.57
	Region 8 May Palmer X-Index Minimum (t-1)	15,332,109	5,788,122	2.65	0.0089		
	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	0.0353	0.36	1.63
	Region 9 December Palmer X-Index (t-1)	(5,299,050)	1,829,911	(2.90)	0.0043		
	Years 2000 on	7,863,497	4,049,467	1.94	0.0540		
RFS Expenditures V1	Constant	103,576,939	54,499,923	1.90	0.0593	0.25	2.48
	Region 1013 Expenditures (t-1)	0.5195	0.2171	2.39	0.0180		
RFS Expenditures V2	Constant	(25,395,669,281)	8,456,214,714	(3.00)	0.0031	0.56	1.46
	Year	12,762,875	4,219,210	3.02	0.0029		
	Pacific Decadal Oscillation December (t-1)	(81,542,352)	26,736,739	(3.05)	0.0027		

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 May 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	204	-
Bias	13	-
Percent bias	-	1.25
Mean absolute percent error	-	17
Percent correct direction of change	-	89

Table 8. Equation estimates used in the May 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	219,199,666	15,459,357	14.18	0.0000	0.85	1.92
	Region 2 March Palmer S-Index	(17,610,849)	5,955,284	(2.96)	0.0067		
	Region 3 March Palmer S-Index	(10,515,157)	4,777,428	(2.20)	0.0372		
	Region 8 March Palmer S-Index	(27,365,152)	8,128,490	(3.37)	0.0025		
	Years 2000 on	111,436,017	26,238,210	4.25	0.0003		

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

Table 9. Cross-validation of the equation used in the May 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	60	-
Bias	0.145	-
Percent bias	-	0.05
Mean absolute percent error	-	19
Percent correct direction of change, 1986-2014	-	83

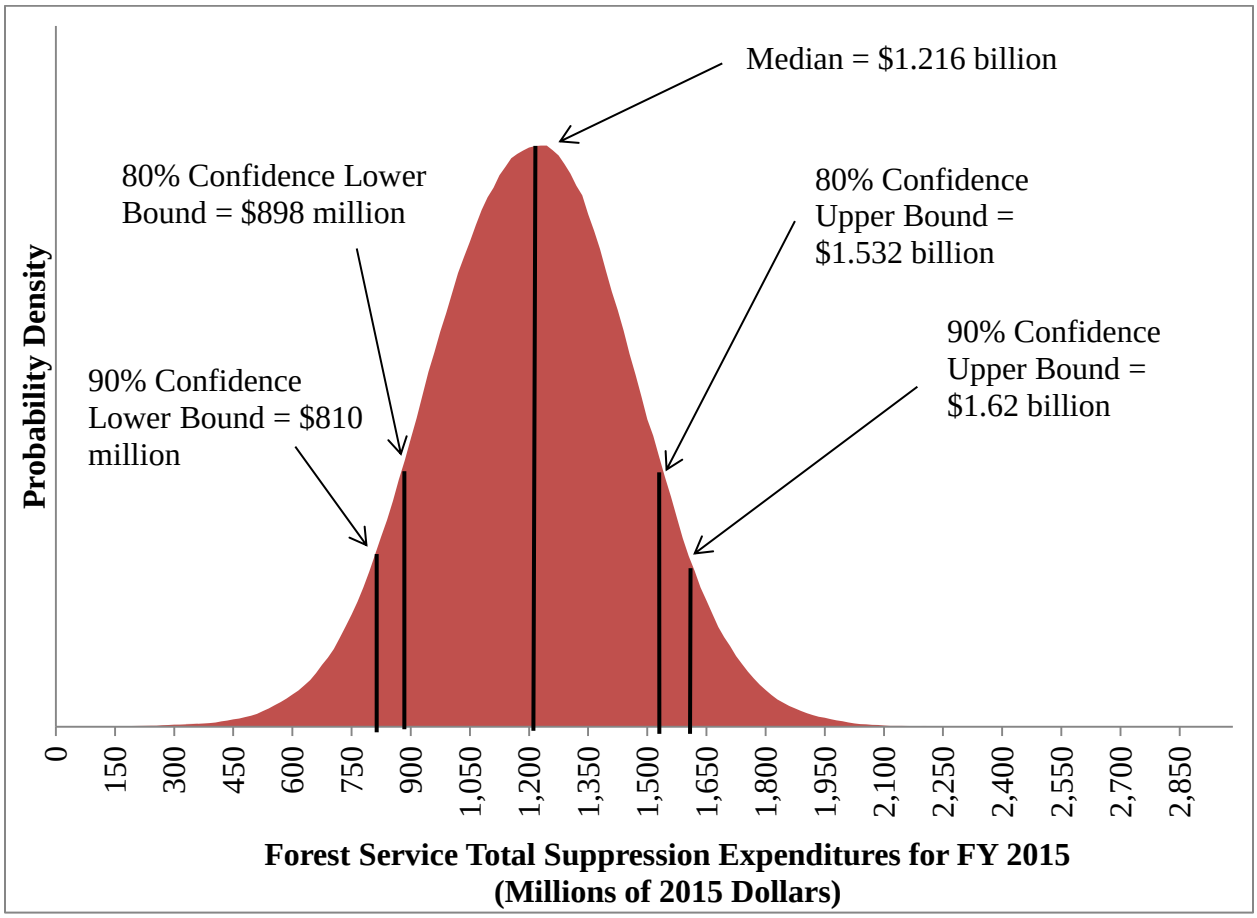

Figure 1. USDA Forest Service suppression expenditure forecast probability density, FY 2015, May 2015 FLAME Act forecast model.

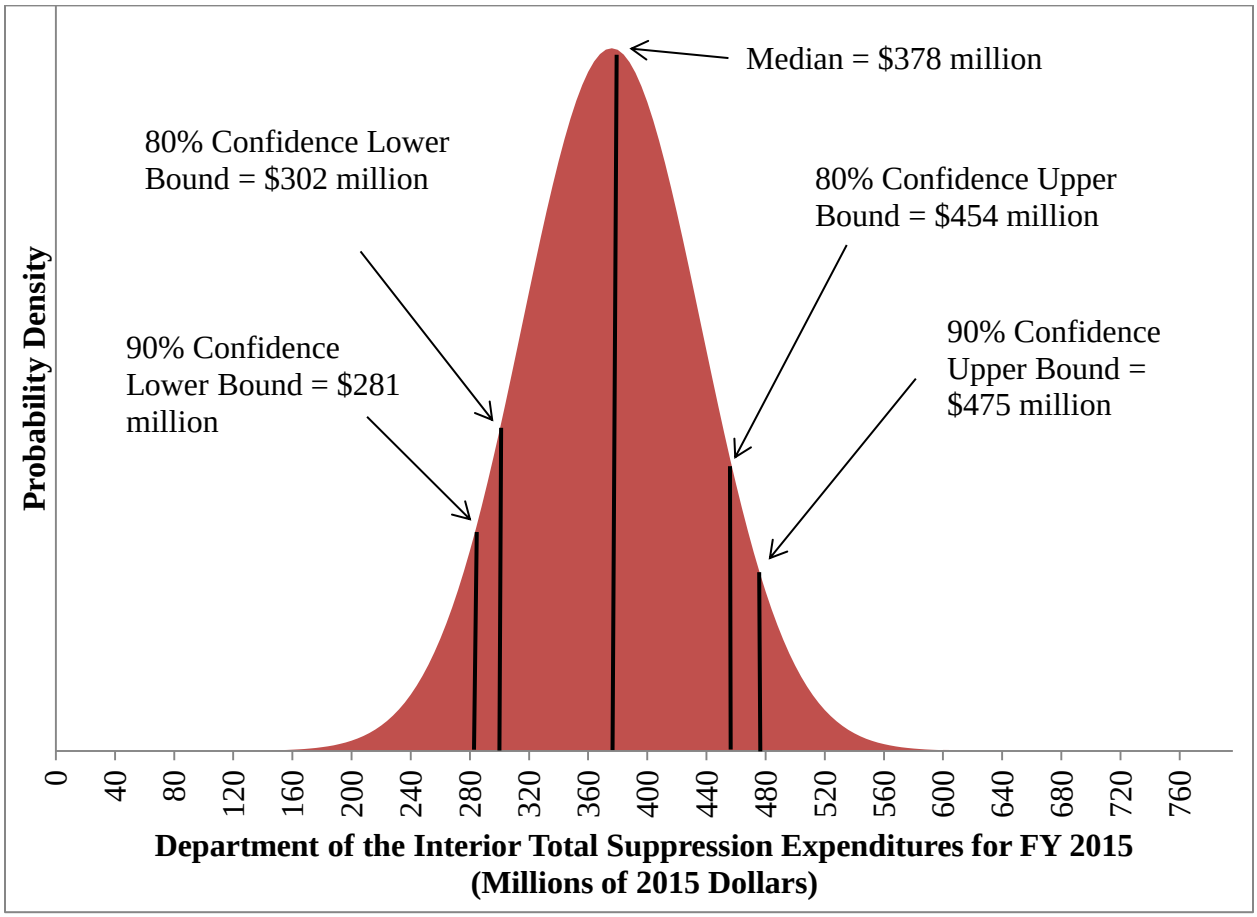

Figure 2. Department of the Interior suppression expenditure forecast probability density, FY 2015, May 2015 FLAME Act forecast model.

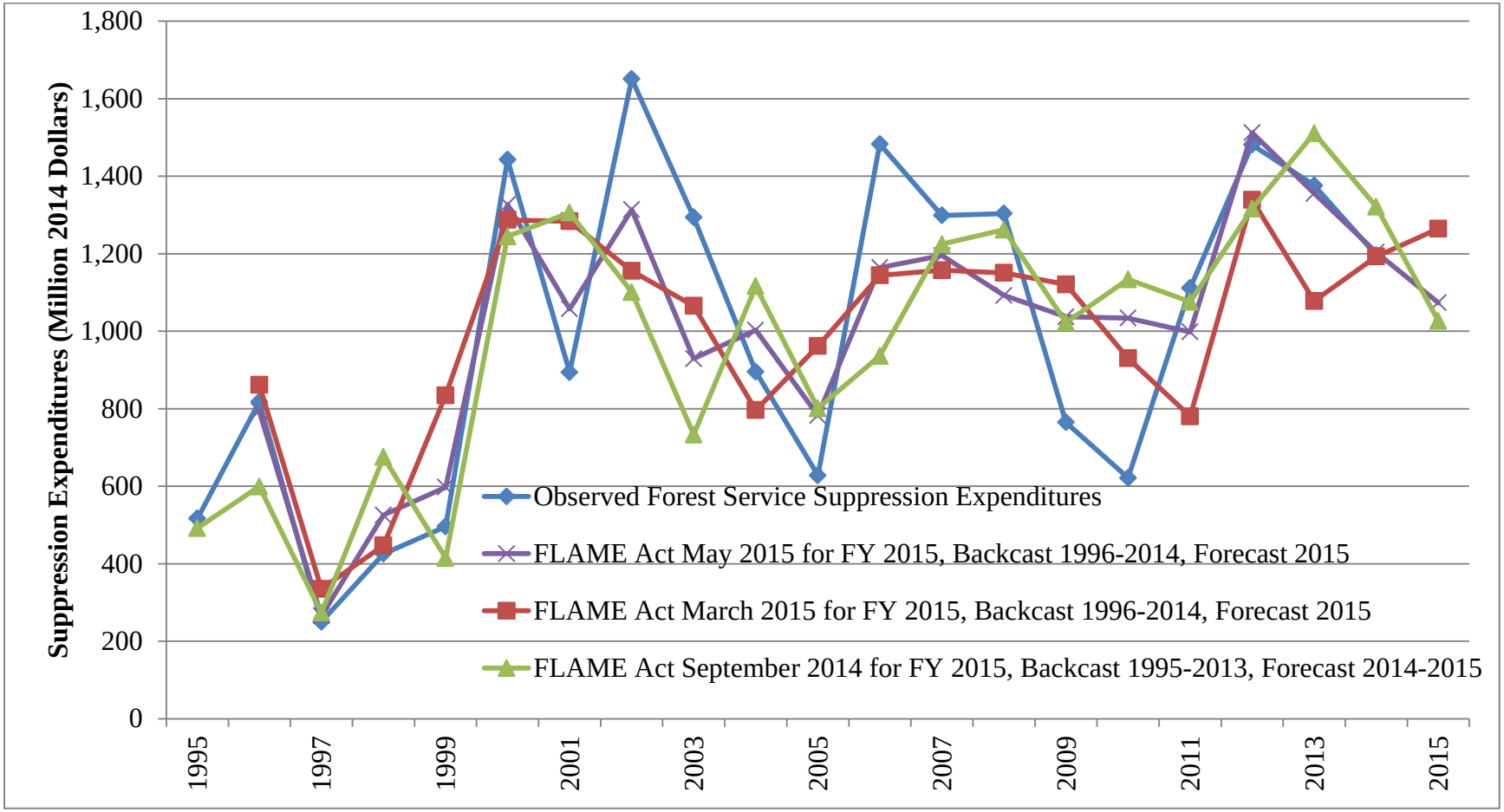

Figure 3. Observed historical USDA Forest Service suppression expenditures and the forecasts of these expenditures (1995-2015), using the May 2015 FLAME Act Forecast Model. All forecasts for each fiscal year are sums across the point estimates of each region's expenditures generated with a cross-validation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

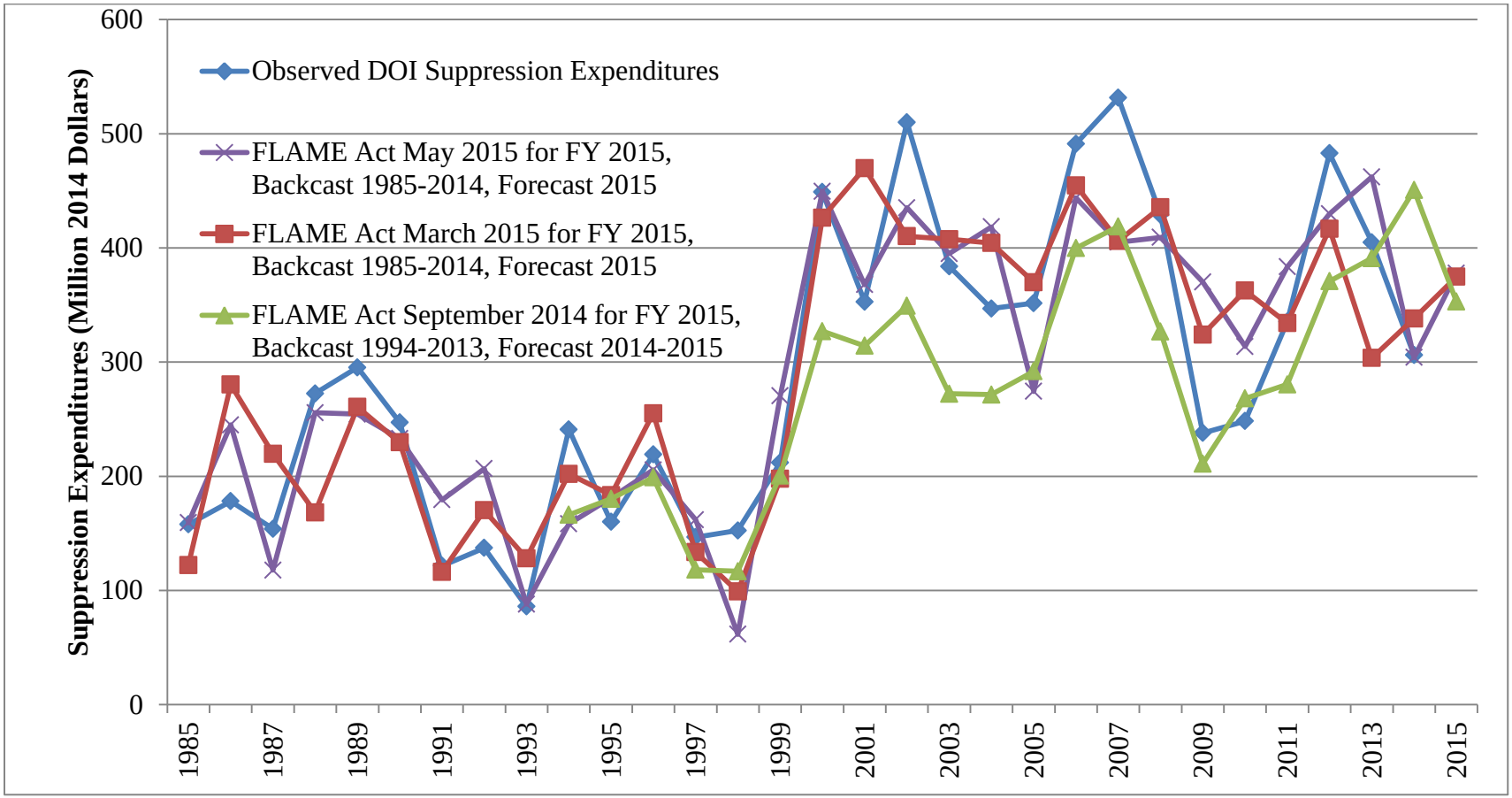

Figure 4. Observed historical Department of the Interior suppression expenditures and the forecasts of these expenditures (1985-2014), using the May 2015 FLAME Act Forecast Model. All forecasts for each fiscal year are the point estimates generated with a cross-validation procedure. (Note: values are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