

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

*July 2018 Forecasts for Fiscal Year 2018*

*Supporting Documentation*

**Report Date: June 22, 2018**

**Executive Summary**

*USDA Forest Service July FLAME forecast for FY 2018 in \$2018 dollars<sup>1</sup>:*

Median forecast	\$1.650 billion
90% confidence range of forecast	\$1.212 billion to \$2.088 billion
Forecast tercile of historical expenditures since 1985	Upper

The Forest Service forecasts are reported in Tables 1-2, Tables 5-6, and Figures 1, 3 and 4.

*The Department of the Interior July FLAME forecast for FY 2018 in \$2018 dollars:*

Median forecast	\$489 million
90% confidence range of forecast	\$376 million to \$602 million
Forecast tercile of historical expenditures since 1985	Upper

The DOI forecasts are reported in Tables 3-4, Tables 7-8, and Figures 2 and 5.

**Overview**

With the passage of the FLAME Act in 2009, both the Forest Service and the Department of the Interior 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 only 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.

We tested models that included the most recent Palmer drought indices, the El Niño-Southern Oscillation (ENSO) anomalies, NASA annual global temperature and a time variable instead of, and in addition to, the shift variable. Based on our error and bias measures (as in Table 6 for FS, Table 8 for DOI), none of these models performed better than the selected models.

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<sup>1</sup> Without Base 8 expenditures and without cost pools for FY 2018.

## **Forecast**

### *USDA Forest Service*

The median forecast is \$1.650 billion, and the 80, 90 and 95 percent confidence bands around the median forecast are provided in Table 1. These forecasts exclude Base 8 expenditures. The forecast probability density is shown in Figure 1 and the not-to-exceed levels at a range of probabilities are reported in Table 2. Uncertainty surrounding the Forest Service forecast for FY 2018 is shown by the probability density graphic (Figure 1) developed with 50,000 Monte Carlo random forecasts. The median forecast expenditure from the Monte Carlo simulation for the FS is in the upper tercile of expenditures in real dollar terms compared to the observed expenditures since 1995.

In FY 2018, a change was made to the accounting protocol for the FS which makes the FS protocol similar to the DOI protocol. Expenditures made for the daily salaries of firefighters (with more than half their time spent in firefighting), which used to be paid out of the suppression fund (WFSU) are now being paid out of the preparedness fund (WFPR). Using historical data, we were able to correct the total FS expenditures from 2004 to 2017, and the regional expenditures from 2013 to 2016. Because we do not have adequate observations to estimate models without base 8 funding, we estimated our models using the original (with base 8) data for each of the regional aggregates. We then used the corrected (without base 8) 2004-2017 total FS data to correct the total FS and incorporated the uncertainty in these estimates into the Monte Carlo. Then we adjusted the regional aggregate based on the regional percentage of the total with base 8 to give us forecasts for FY18 for the regional aggregates that do not include base 8 expenditures.

### *Department of the Interior*

Table 3 shows the median FY 2018 suppression expenditure forecast for DOI (\$489 million in 2018 dollars), as well as the 80, 90, and 95 percent confidence bands. As in the Forest Service forecast, uncertainty surrounding the DOI forecast for FY 2018 is illustrated with the probability density graphic (Figure 2) developed with 50,000 Monte Carlo random forecasts. The median forecast expenditure from the Monte Carlo simulation for the Department is in the upper tercile of expenditures in real dollar terms compared to the observed expenditures since 1985.

## **Modeling**

To meet the statutory requirements of the FLAME Act, the Forest Service developed statistical

models based on peer-reviewed research.<sup>2,3</sup> This report is the fourth and final FLAME Act forecast issued for FY 2018.

### *Modeling Framework for the July 2018 Forecast of FY 2018 Forest Service Expenditures*

The current approach forecasts expenditures by Forest Service regional aggregates for West (Regions 1-6), and East (Region 8 and Region 9) and the Rest of the Forest Service (RFS). This RFS category includes Region 10 (Alaska) because there are relatively few suppression expenditures in Region 10.

The aggregate West Region statistical model relates expenditures in the coming fiscal year to the Palmer M-index of Region of May, the Pacific-North American teleconnection of last December, and a shift variable to represent years from 2000 onward. The aggregate East Region model has lagged East expenditures, and the RFS model includes a dummy variable for structural change starting in FY2011. Durbin-Watson statistics, designed to detect serial autocorrelation in the residuals of estimated equations, were all within acceptable or inconclusive ranges. Durbin-H statistics were calculated when there is a lagged variable in the model (East Region). None of the models had statistically significant residual autocorrelation.

Equation estimates shown in Table 5 do not include the aviation cost pool but include base 8 salaries (and the associated cost pool for salaries and unemployment compensation insurance). Data for modeling were annual FY totals of suppression expenditures and ranged from 1995 to 2017, the only years for which consistent regional-level data could be assembled (with base 8 expenditures included—see the discussion in the Forecast section) 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 from the President’s budget—that is, models were estimated and expenditures were forecast in “real” dollar terms.<sup>4</sup> Forecasted values were then converted to expected FY 2018 dollars.

When generating a forecast distribution (see Figure 1), we randomly sampled from the equation error distribution from 1998 to 2017 and base 8 percentages over the year 2004 to 2017 to account for uncertainty in the forecast. This Monte Carlo forecast, which is repeated 50,000 times, does not produce a single forecast of fiscal year expenditures. Rather, it generates a distribution of expenditure predictions. This distribution is summarized as a forecast density distribution (Figure 1), a table reporting a median forecast and the lower and upper bounds of

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<sup>2</sup> Prestemon, J.P., K.L. Abt, and K. Gebert. 2008. Suppression cost forecasts in advance of wildfire seasons. *Forest Science* 54(4):381-396.

<sup>3</sup> 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.

<sup>4</sup> Deflator source: <https://www.whitehouse.gov/omb/historical-tables/> and Table 10.1—Gross Domestic Product and Deflators Used in the Historical Tables: 1940–2022

likely expenditures (Table 1), and a table of not-to-exceed expenditures by probability levels (Table 2).

Model fitness is reported in Figure 3 and Table 6, and include the base 8 expenditures. The graph shows how well the July 2018 FLAME Act Forecast Model of FY 2018 forecasts out-of-sample using the leave-one-out cross-validation method (produced by dropping one observation, estimating the model parameters, and predicting the left out year's value, and then repeating for all observations), compared with observed expenditures for the Forest Service.

Table 6 shows that the root mean squared error of the model used in this July 2018 forecast of FY 2018 expenditures, when applied to the 1998-2017 period, is \$259 million (\$2014). The model has a negative bias of \$2 million (-0.18 percent), meaning that, on average, actual expenditures are lower than those predicted using the July 2018 FLAME model. This bias was not used to adjust the forecast for FY 2018.

The forecast for the total Forest Service 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 1998-2017 period. Finally, this model correctly predicted the direction of change in year-over-year suppression expenditures by the Forest Service 74 percent of the time. The FY 2018 forecasted median is lower than the FY 2017 actual expenditures (Figure 3).

#### *Modeling Framework for the July 2018 Forecast of FY 2018 Department of the Interior Expenditures*

The forecast model for the Department of the Interior (DOI) is based on departmental total expenditures each fiscal year—i.e., aggregated across all bureaus and geographic regions – and so involved estimation of a single equation. The July 2018 FLAME Act Model for FY 2018 covered department-wide expenditures for fiscal years 1985 to 2017. We modeled aggregate DOI expenditures using a parsimonious model specification, as a function of the Pacific-North American teleconnection from last December, the Niño-3 Sea Surface Temperature Anomaly from last November, and a shift variable to represent years from 2000 onward. This is the same model as was used for the May FLAME Act forecast for FY 2015-2017 and for the July FLAME Act forecast for FY 2017. Because none of the variables changed since April 2018, the results and forecasts are identical to those presented in the May 2018 forecast document.

The DOI suppression expenditure forecast equation is reported in Table 7. The estimated equation explained 81 percent of the variation ( $R^2 = 0.81$ ) in annual DOI suppression expenditures over the historical time period, fiscal years 1985-2017, and it had a Durbin-Watson test statistic of 1.72, which indicates no significant residual autocorrelation in the model estimation errors.

Model fitness measures of the July FLAME Act Forecast Model for FY 2018 for DOI are reported in Table 8. The DOI July FLAME Act Forecast Model was evaluated using the cross-validation procedure for the years 1985 to 2017. This forecast model had a root mean squared error of \$62 million (\$2014). The model had a bias of \$0.1 million (0.03 percent), meaning that, on average, the actual DOI suppression expenditures have been higher than predictions, but this historical bias was not used to adjust the 2018 forecast. The model had a Mean Absolute Percent Error of 19 percent. It correctly predicted the direction of change in suppression expenditures for the agency from one year to the next in 24 out of 30 years (about 81 percent). The FY 2018 forecast median is 6% lower than the FY 2017 actual expenditures (Figure 4).

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**Table 1. July 2018 FLAME Act forecasts of FY 2018 suppression expenditures of the USDA Forest Service, in FY 2018 dollars (excluding base 8 and cost pools).**

	Total FS	West	East	RFS
Median Estimate	1,650	1067	76	503
80% Confidence Lower Limit	1,309	796	35	368
80% Confidence Upper Limit	1,991	1338	117	638
90% Confidence Lower Limit	1,212	720	23	330
90% Confidence Upper Limit	2,088	1415	129	667
95% Confidence Lower Limit	1,128	653	13	297
95% Confidence Upper Limit	2,172	1482	139	710

**Table 2. July 2018 FLAME Act forecasts of FY 2018 suppression expenditures of the USDA Forest Service, the probability of falling below the specified amount in FY 2018 dollars (excluding base 8 and cost pools).**

Probability (%) of Falling Below Indicated Dollar Amount	Total FS	West	East	RFS
1	1,030	576	1.9	258
5	1,212	720	23	330
10	1,309	796	35	368
20	1,426	889	49	415
30	1,510	957	59	448
40	1,582	1,014	68	477
50	1,650	1,067	76	503
60	1,717	1,121	84	530
70	1,789	1,178	93	559
80	1,874	1,245	103	592
90	1,991	1,338	117	638
95	2,088	1,415	129	677
99	2,269	1,559	151	748

**Table 3. July 2018 FLAME Act forecasts of FY 2018 suppression expenditures of the Department of the Interior in FY 2018 dollars.**

	DOI
Median Estimate	489
80% Confidence Lower Limit	401
80% Confidence Upper Limit	577
90% Confidence Lower Limit	376
90% Confidence Upper Limit	602
95% Confidence Lower Limit	355
95% Confidence Upper Limit	623

**Table 4. July 2018 FLAME Act forecasts of FY 2018 suppression expenditures of the Department of the Interior, the probability of falling below the specified amount in FY 2018 dollars.**

Probability (%) of Falling Below Indicated Dollar Amount	DOI
1	329
5	376
10	401
20	418
30	453
40	472
50	489
60	507
70	525
80	545
90	577
95	602
99	649

**Table 5. Ordinary least squares regression equation estimates used in the July 2018 forecast of FY 2018 suppression expenditures of the USDA Forest Service.<sup>a</sup>**

Dependent variable	Independent variables	Coefficient	Standard error	T value	P-value	R <sup>2</sup>	Durbin Statistic
Suppression Expenditures	Intercept	268,291,670	98,665,857	2.72	0.0136	0.67	1.80
	Palmer R3 May M-index	(56,725,583)	19,801,230	(2.86)	0.0099		
	Pacific-North American teleconnection December (t-1)	111,665,100	47,694,438	2.34	0.0303		
	Year 2000 on	484,457,159	112,955,920	4.29	0.0004		
Suppression Expenditures	Intercept	98,899,549	13,447,156	7.35	<0.0001	0.40	0.71 <sup>b</sup>
	East Expenditures (t-3)	-0.7449	0.216	-3.45	0.0029		
Suppression Expenditures	Intercept	162,902,624	26,144,076	6.23	<0.0001	0.75	2.23
	Year 2011 on	376,154,250	47,390,163	7.94	<0.0001		

Suppression Base 8 expenditures

White-Hall Statistic



**Table 6. Cross-validation of the ordinary least squares regression model used in the July 2018 Forecast of FY 2018 suppression expenditures of the USDA Forest Service, calculated over data from 1998-2017 in FY 2018 dollars.<sup>a</sup>**

	Millions of 2014 dollars	Percent
Root mean square error	259	-
Bias	-2	-
Percent bias	-	-0.18
Mean absolute percent error	-	17
Percent correct direction of change	-	74

<sup>a</sup> Including Base 8 expenditures

**Table 7. Ordinary least squares regression equation estimates used in the July 2018 forecast of FY 2018 suppression expenditures of the Department of the Interior.**

Dependent variable	Independent variables	Coefficient	Standard error	T value	P-value	R <sup>2</sup>	Durbin-Watson Statistics
Department of the Interior	Intercept	176,167,493	15,531,688	11.34	<0.0001	0.81	1.72
	Niño-3 SST Anomaly November (t-1)	-28,138,900	9,041,596	-3.11	0.0041		
	Year 2000 on	207,447,431	20,782,474	9.98	<0.0001		
	Pacific North American Oscillation December(t-1)	45,188,917	11,080,036	4.08	0.0003		

**Table 8. Cross-validation of the equation used in the July 2018 Forecast of FY 2018 suppression expenditures of the Department of the Interior calculated over FY 1985-2016.**

	Millions of 2014 dollars	Percent
Root mean square error	62	-
Bias	0.1	-
Percent bias	-	0.03
Mean absolute percent error	-	19
Percent correct direction of change	-	81

**Table 9. July 2018 FLAME Act forecasts of FY 2018 suppression expenditures of the USDA Forest Service and the Department of the Interior, by tercile.<sup>a</sup>**

	Tercile of Expenditures Expected, Since 1985
Forest Service	Upper
Department of the Interior	Upper

<sup>a</sup> USDA Forest Service comparison excludes Base 8 Salary

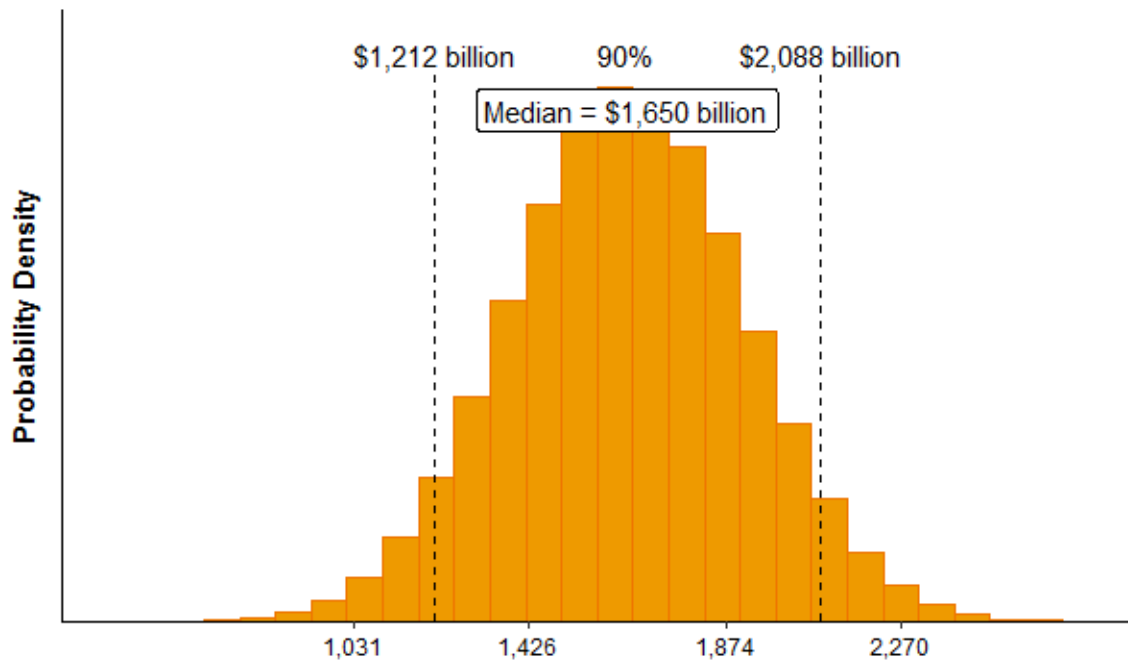


Figure 1. USDA Forest Service suppression expenditure forecast probability density, FY 2018, July 2018 FLAME Act Forecast Model, excluding the Base 8 expenditures.

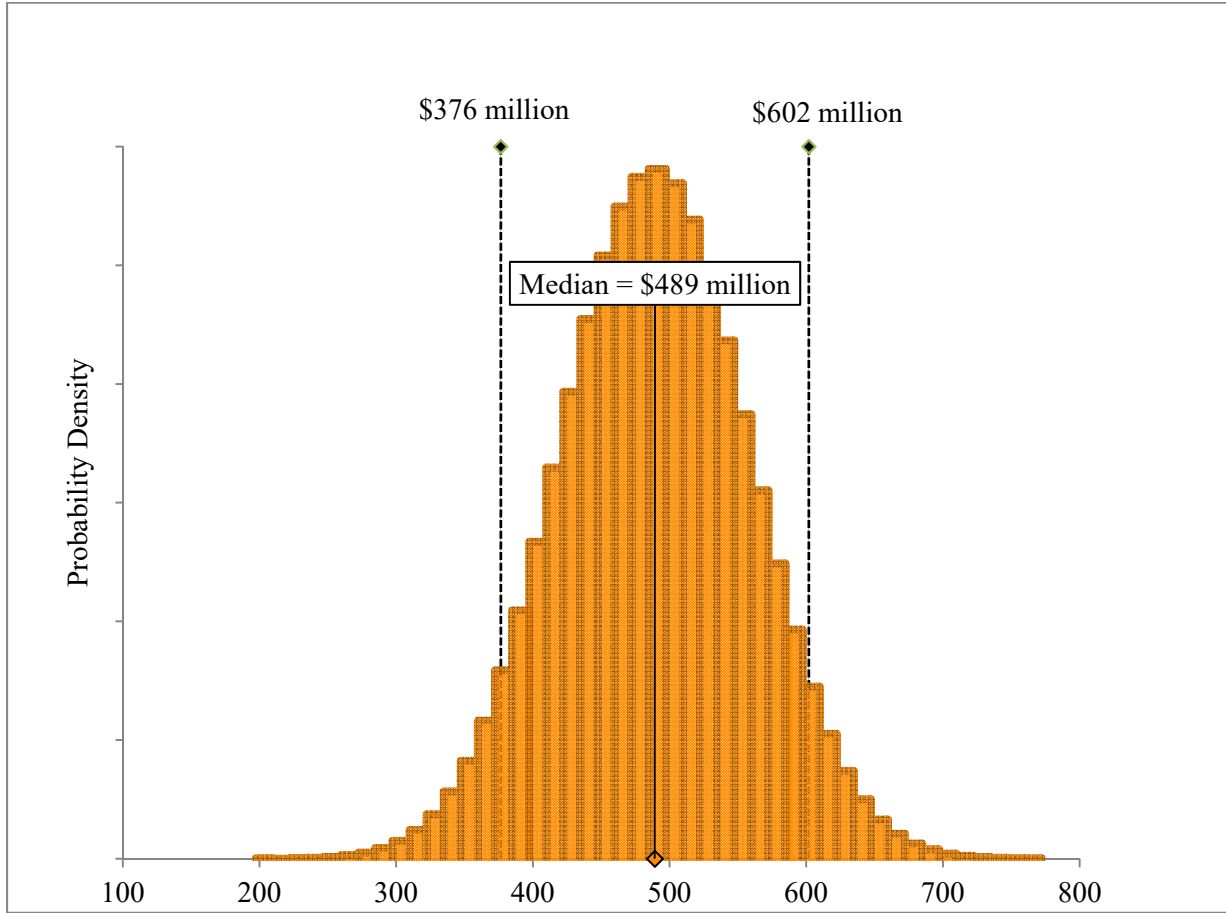


Figure 2. Department of the Interior suppression expenditure forecast probability density, FY 2018, July 2018 FLAME Act Forecast Model.

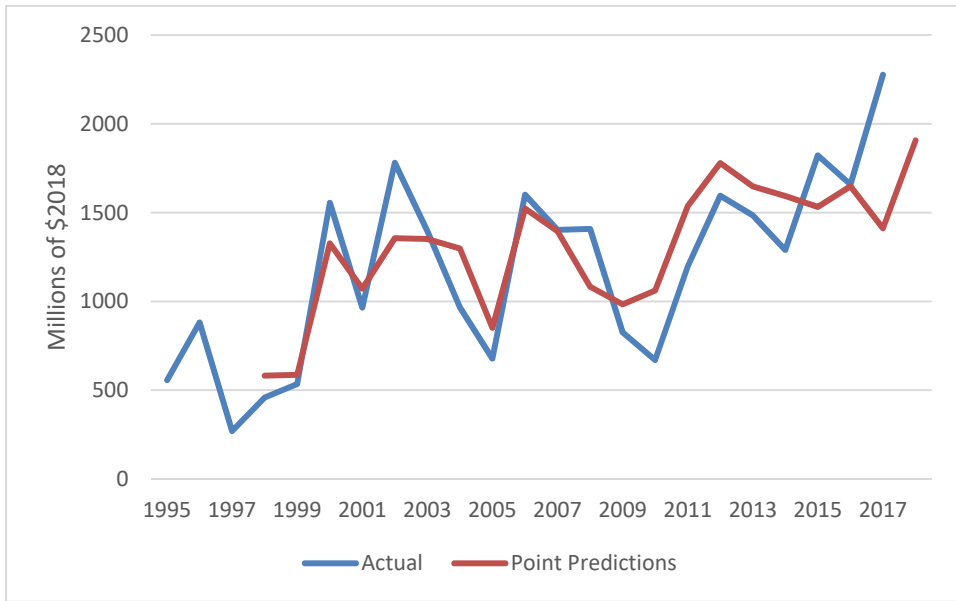


Figure 3. Observed historical USDA Forest Service suppression expenditures (1985-2017) and the predicted expenditures (1998-2018) using the July 2018 FLAME Act forecast model. All forecasts for each FY are the point estimates generated from the cross-validation procedure. (Note: values shown in the figure are in constant 2018 dollars, and **include Base 8 expenditures.**)

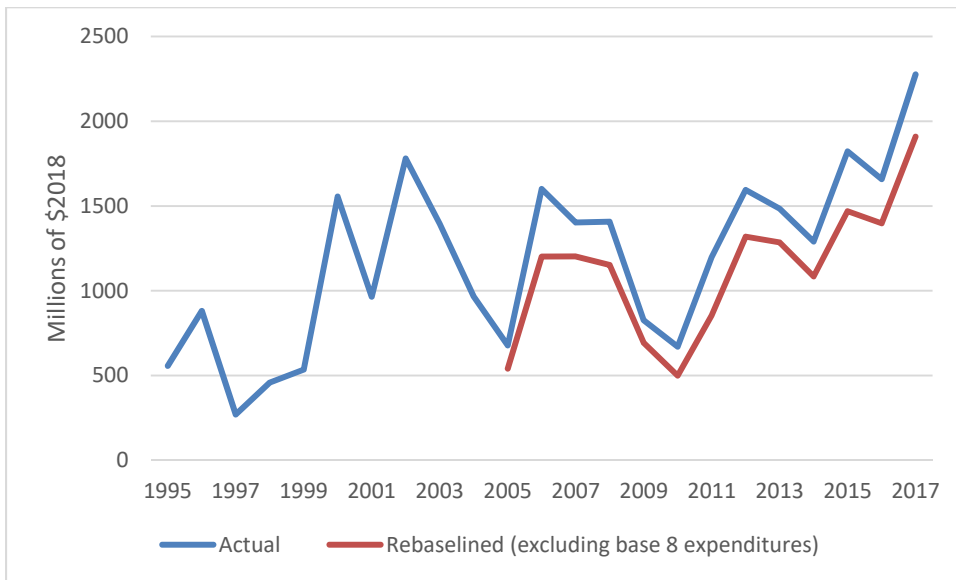


Figure 4. Observed historical USDA Forest Service suppression expenditures (1985-2017 including Base 8) and suppression expenditures (2004 -2017 excluding estimated Base 8 expenditures). (Note: values shown in the figure are in constant 2018 dollars)

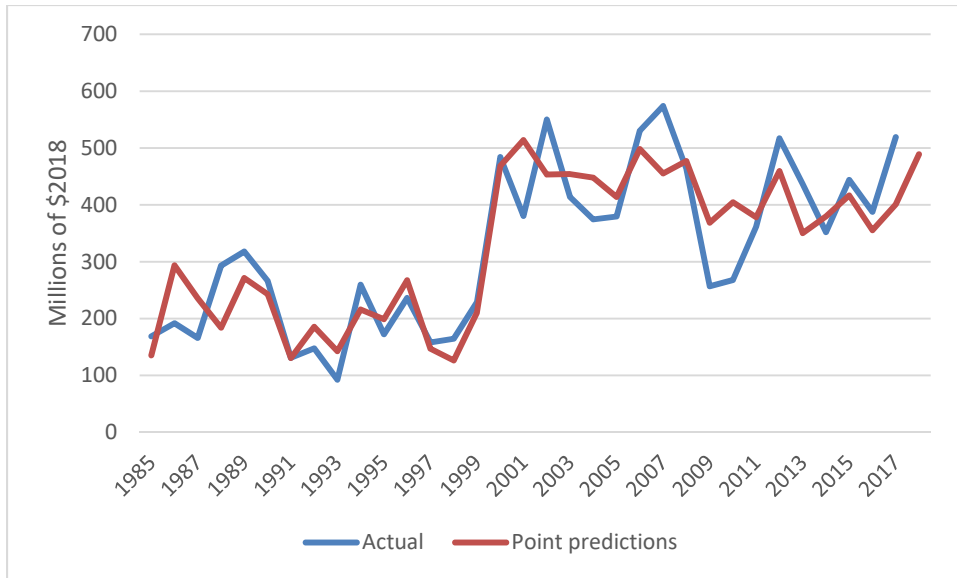


Figure 5. Observed historical Department of the Interior suppression expenditures (1985-2017) the predicted expenditures (1998-2018) using the July 2018 FLAME Act forecast model. All forecasts for each FY are the point estimates generated from the cross-validation procedure. (Note: values are in constant 2018 dollars)