

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

*September 2014 Forecasts for Fiscal Year 2015*

*Supporting Documentation*

**Report Date: August 13, 2014**

**Executive Summary**

The U.S. Department of Agriculture (USDA) Forest Service is forecast to spend, with 90 percent confidence, between \$714 million and \$1.53 billion in Fiscal Year (FY) 2015, with a median forecast of \$1.12 billion. Excluding cost pools, the FY 2015 Forest Service median forecast is in the middle tercile of expenditures since 1995 and the upper tercile of expenditures since 1977.

The U.S. Department of the Interior (DOI) is forecast to spend, with 90 percent confidence, between \$247 million and \$466 million, with a median forecast of \$356 million. DOI expenditures are forecasted to be in the middle tercile of expenditures since 1995 and upper tercile since 1985.

**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 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.

**Forecast**

*USDA Forest Service*

The median forecast is \$1.12 billion and includes \$86 million in estimated cost pool contributions which are added to the forecast for the total Forest Service (Table 1). This table also includes the 80, 90 and 95 percent confidence bands around the median forecast. 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. As Table 2 shows, this model forecasts that there is a 1 percent chance that Forest Service suppression expenditures, including the cost pool, will fall below \$545 million. In contrast, there is a 70 percent chance that these expenditures will fall below \$1.25 billion.

We used the mean percent spent in each region to forecast the tercile of expenditures in each region (Table 3). When compared to expenditures since 1995, Regions 6, 9, and 10 are forecast

to be in the upper tercile in 2015, while the remaining regions, the Rest of Forest Service, and the Forest Service in total are forecast to have expenditures in the middle tercile. Table 4 provides the minimum, mean, median, and maximum regional percentages from 1995 to 2013, as well as the 2015 dollar amount for the average percent for each region based on the median forecast for the total Forest Service not including the cost pool.

### *Department of the Interior*

Table 5 shows the median FY 2015 suppression expenditure forecast for DOI (\$356 million in 2015 dollars), as well as the 80, 90, and 95 percent confidence band. As in the Forest Service forecast, uncertainty surrounding the DOI forecast for FY 2015 is illustrated with a the probability density graphic (Figure 2) developed with 50,000 Monte Carlo random forecasts. As Table 6 shows, this model states that there is a 1 percent chance that the Department of the Interior suppression expenditures will fall below \$201 million. In contrast, there is a 70 percent chance that these expenditures will fall below \$391 million. The median forecast expenditure from the Monte Carlo simulation for the Department is in the middle tercile of expenditures in real dollar terms compared to the observed expenditures since 1995 and the upper tercile since 1985.

## **Modeling**

### *Modeling Framework for the September 2014 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<sup>1,2</sup>. These models have been developed for several forecast horizons and the September FLAME forecast is the most challenging because climate and drought information are not available to forecast expenditures for the next fiscal year. Additionally, total FY 2014 data on suppression expenditures in total and by region will not be available until after the end of the FY. Therefore, this year the total departmental forecasts provided are the same as the outyear forecasts made available for long-term budgeting (2 to 10 years out).

This report is the first FLAME forecast issued for FY 2015, and it includes some methodological changes compared to the reports issued in previous years. The approach used here forecasts total Forest Service suppression expenditures using a time series model over data from 1977 to 2013. The statistical model relates expenditures in the coming fiscal year to lagged suppression expenditures (three years), time, and a year 2000 shift. Then, regional shares are calculated based on the average share over the data available (1995 to 2013) and the historical range is provided to show how much the shares have actually varied over the time frame. This differs from past September forecasts that either (1) estimated the total expenditures and regional shares using regression, or (2) estimated region/regional aggregate suppression expenditures and then

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<sup>1</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>2</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.

summed for the total. The expenditures made by the National Interagency Fire Center, Washington Office, and research stations are classified as the rest of the Forest Service, “RFS.”

Equation estimates are shown in Table 7. The model  $R^2$  is 0.74 indicating 74% of the variation in suppression expenditures is explained by the variables included in the model. Durbin-h statistic, designed to detect serial autocorrelation in the residuals of autoregressive equations (those that include lagged values of the dependent variable), was insignificant ( $p$ -value=0.15).

The forecast was made using the equation estimates shown in Table 7 for total Forest Service expenditures that excluded the contributions to the wildland fire suppression cost pool, which is subsequently added to the simulation results. Data for modeling were annual FY totals of suppression expenditures from 1980 to 2013 (except the three year lagged suppression expenditure series uses data back to 1977). To erase the effects of general price inflation, all expenditures were deflated to the value of a dollar in 2004 using the gross domestic product deflator—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 expected FY 2015 dollars.

When generating a forecast distribution (see Figure 1), we randomly sampled from the equation error distribution to account for uncertainty in the forecast. This Monte Carlo forecast, which is repeated 50,000 times, does not produce a precise estimate. Rather, it generates a distribution of estimates. This distribution is summarized in many ways: a forecast density distribution (Figure 1), a table reporting a median forecast and the lower and upper bounds of likely expenditures (Table 1), and a table of not-to-exceed expenditures by probability levels (Table 2). We also provide each region’s forecasted expenditures based on the mean share evaluated at the median forecast value and describe where each region falls within the observed historical expenditures, in real dollar terms (Table 4). Regional shares are calculated using data from 1995 to 2013, the years when consistent regional level expenditure data is available. Descriptive statistics for each region’s share are provided to give an idea of the actual variability in shares over the time frame.

Model fitness is reported in Figure 3 and Table 8. The graph shows how well the September 2014 FLAME Act Forecast Model of FY 2015 forecasts out-of-sample using the leave-one-out cross validation method (produced by dropping the observation of the forecast year, and doing this iteratively over the historical data), compared with observed expenditures for the Forest Service. Table 8 shows that the root mean squared error of the model used in this September 2014 forecast of FY 2015 expenditures, when applied to the 1995-2013 period, was \$276 million and that it had a negative bias, tending to under-forecast by about \$470 thousand (0.07 percent). (This bias was not used to adjust the September 2014 forecast for FY 2015.) The forecast for the total Forest Service had a Mean Absolute Percent Error of 58 percent meaning the typical forecast averaged 58 percent above or below expenditures actually incurred during the 1995-2013 period. Finally, this model correctly predicted the direction of change in suppression expenditures by the Forest Service 82 percent of the time. The predicted direction of change for FY 2015 compared to the FY 2013 actual is negative (downward) when considered from the median forecast excluding the cost pool (Figure 3).

*Modeling Framework for the September 2014 Forecast of FY 2015 Department of the Interior Expenditures*

The forecast model for the Department of the Interior (DOI) is based on departmental total expenditure data—i.e., aggregated across all agencies and geographic regions. The September 2014 FLAME Act Model for FY 2015 covered department wide expenditures for fiscal years 1994 to 2013 (although DOI expenditure data back to 1985 was needed to produce the nine year lag).<sup>3</sup> We modeled aggregate DOI expenditures using a time series model specification involving a three year lag of DOI expenditures, a nine year lag of DOI expenditures, and time.

The DOI suppression expenditure forecast equation is reported in Table 9. The estimated equation explained 82 percent of the variation ( $R^2 = 0.82$ ) in annual DOI suppression expenditures over the historical time period, 1994-2013. The Durbin H-statistic indicated no evidence ( $p=0.15$ ) of residual autocorrelation in the model estimation errors.

Model fitness for the September FLAME Act Forecast Model for FY 2015 for DOI is reported in Table 10. As in the case of the Forest Service September FLAME Act Forecast Model, the DOI September FLAME Act Forecast Model was evaluated using the cross-validation procedure for the years 1994 to 2013. This September forecast model had a root mean squared error of about \$65 million. The model had a bias of negative \$2.9 million (0.8 percent and these historical biases were not used to adjust the 2015 forecast). The model had a Mean Absolute Percent Error of 18 percent. It correctly predicted the direction of change in suppression expenditure for the agency from one year to the next about 85 percent of years. The predicted direction of change for FY 2015 compared to the FY 2013 actual is negative (downward) when considered from the median forecast (Figure 4).

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<sup>3</sup> 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.

**Table 1. September 2014 FLAME Act forecasts of FY 2015 suppression expenditures of the USDA Forest Service, by in FY 2015 dollars.**

(Millions of 2015\$)	
Median Estimate	1,122
80% Confidence Lower Limit	804
80% Confidence Upper Limit	1,440
90% Confidence Lower Limit	714
90% Confidence Upper Limit	1,531
95% Confidence Lower Limit	636
95% Confidence Upper Limit	1,609

\* Note: This table includes the Fiscal Year 2015 contributions to the wildland fire suppression cost pool, projected to be \$86 million, which are added to the agency-wide total.

**Table 2. September 2014 FLAME Act forecasts of FY 2015 suppression expenditures of the USDA Forest Service, probability of falling below specified amount in FY 2015 dollars.**

Probability (%) of Falling Below Indicated Dollar Amount	Realized Amount (Millions of 2015\$)
1	545
5	714
10	804
20	913
30	992
40	1,059
<b>50</b>	<b>1,122</b>
60	1,185
70	1,253
80	1,331
90	1,440
95	1,531
99	1,700

\* Note: This column of totals includes the Fiscal Year 2015 contributions to the wildland fire suppression cost pool, projected to be \$86 million.

**Table 3. September 2014 FLAME Act forecasts of FY 2015 suppression expenditures of the USDA Forest Service, by tercile\***

Region	Tercile of Expenditures Projected, Since 1995
1	Middle
2	Middle
3	Middle
4	Middle
5	Middle
6	Upper
8	Middle
9	Upper
10	Upper
RFS	Middle
Total	Middle

**Table 4. Descriptive statistics for regional percentages and the mean regional expenditures based on the median Forest Service forecast (1995-2013).**

Region	Minimum	Mean	Median	Maximum	Mean
	%	%	%	%	Millions of FY2015\$ (Mean% * median \$1,036 million)
1	2	9	6	36	93
2	1	4	3	12	37
3	4	11	9	32	109
4	4	9	9	19	89
5	7	30	26	60	306
6	7	14	14	24	147
8	<1	5	5	18	50
9	<1	2	1	4	16
10	<1	<1	<1	2	4
RFS	2	17	17	33	178

**Table 5. September 2014 FLAME Act forecasts of FY 2015 suppression expenditures of the Department of the Interior in FY 2015 dollars.**

(Millions of 2015\$)	
Median Estimate	356
80% Confidence Lower Limit	271
80% Confidence Upper Limit	442
90% Confidence Lower Limit	247
90% Confidence Upper Limit	466
95% Confidence Lower Limit	226
95% Confidence Upper Limit	487

**Table 6. September 2014 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	201
5	247
10	271
20	300
30	321
40	340
<b>50</b>	<b>356</b>
60	373
70	391
80	413
90	442
95	466
99	511

**Table 7. Ordinary least squares regression equation estimates used in the September 2014 forecast of FY 2015 suppression expenditures of the USDA Forest Service.**

<b>Variable</b>	<b>Parameter estimate</b>	<b>Standard error</b>	<b>T value</b>	<b>Significance level</b>
<b>Intercept</b>	-43,807,205,896	13,933,429,755	-3.14	0.0037
<b>Year</b>	22,235,948	7,019,421	3.17	0.0035
<b>Forest Service Costs (t-3)</b>	-0.4578	0.1435	-3.19	0.0033
<b>If year&gt;1999</b>	474,452,822	141,440,152	3.35	0.0022
<b>R<sup>2</sup></b>	0.74			
<b>Adjusted R<sup>2</sup></b>	0.71			
<b>Durbin-h</b>	1.93			
<b>(significance level)</b>	0.15			
<b>Number of obs.</b>	34			

**Note:** The dependent variable is the annual total real dollar suppression expenditures.

**Table 8. Cross-validation of the ordinary least squares regression model used in the September 2014 Forecast of FY 2015 suppression expenditures of the USDA Forest Service calculated over data from 1980-2013 in FY 2015 dollars.**

	<b>Millions of 2015 dollars</b>	<b>Percent</b>
<b>Root mean square error</b>	276	-
<b>Bias</b>	-0.47	-
<b>Percent bias</b>	-	-0.07
<b>Mean absolute percent error</b>	-	58
<b>Percent correct direction of change</b>	-	82

**Table 9. Equation estimates used in the September 2014 Forecast of FY 2015 suppression expenditures of the Department of the Interior.**

<b>Variable</b>	<b>Parameter estimate</b>	<b>Standard error</b>	<b>T value</b>	<b>Significance level</b>
<b>Intercept</b>	-44,210,620,323	4,946,766,753	-8.94	<.0001
<b>Year</b>	22,332,904	2,483,623	8.99	<.0001
<b>DOI Costs (t-3)</b>	-0.2372	0.1287	-1.84	0.0838
<b>DOI Costs (t-9)</b>	-1.0535	0.1237	-8.52	<.0001
<b>R<sup>2</sup></b>	0.82			
<b>Adjusted R<sup>2</sup></b>	0.79			
<b>Durbin-h</b>	2.23			
<b>(significance level)</b>	0.15			
<b>Number of obs.</b>	20			

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

**Table 10. Cross-validation of the equation used in the September 2014 Forecast of FY 2015 suppression expenditures of the Department of the Interior calculated over FY 1994-2013.**

	<b>Millions of 2015 dollars</b>	<b>Percent</b>
<b>Root mean square error</b>	65	-
<b>Bias</b>	-2.87	-
<b>Percent bias</b>	-	-0.82
<b>Mean absolute percent error</b>	-	18
<b>Percent correct direction of change</b>	-	85

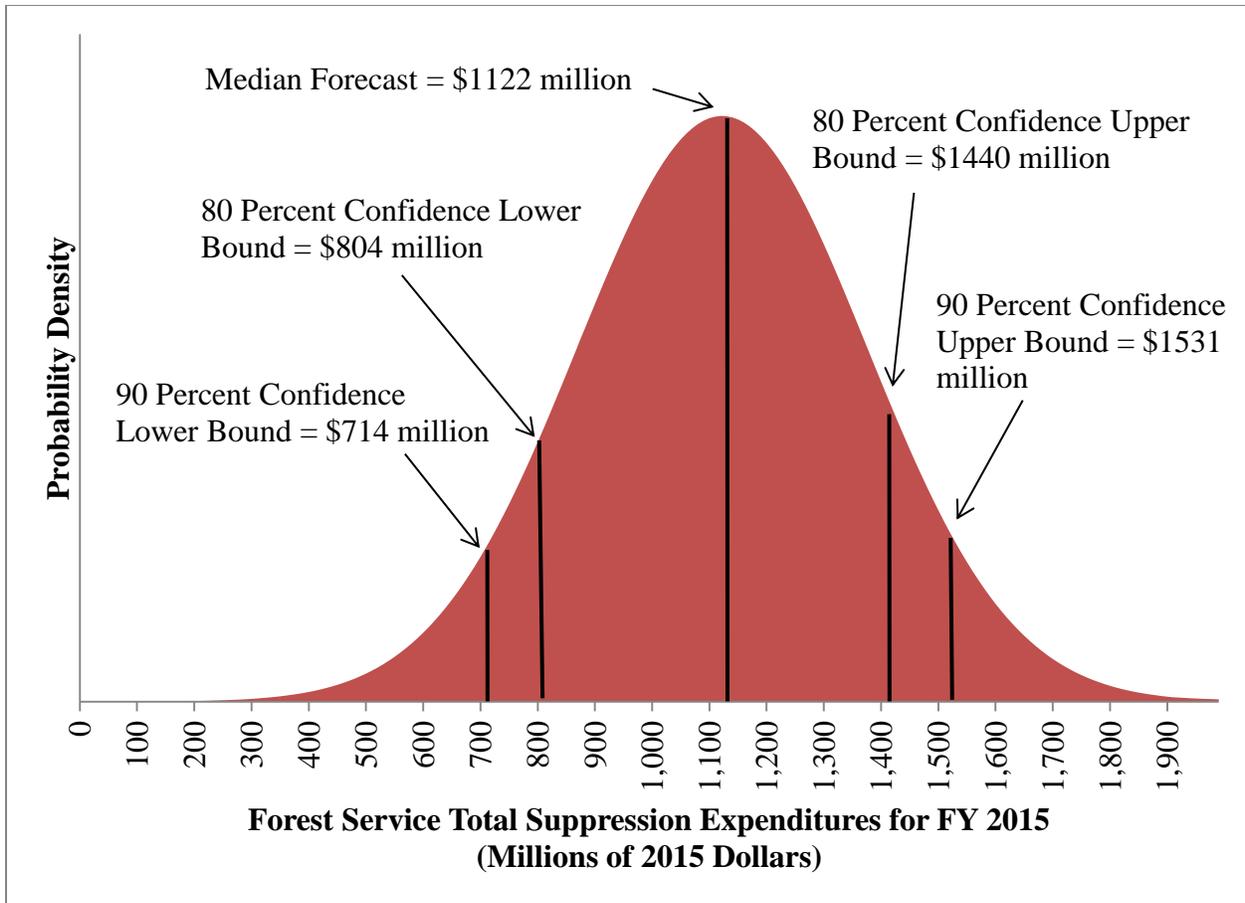


Figure 1. USDA Forest Service suppression expenditure forecast probability density, FY 2015, September 2014 FLAME Act Forecast Model. (Note: FY 2015 wildland fire suppression cost pool expenditures are included at their projected level of \$86 million in this probability density display.)

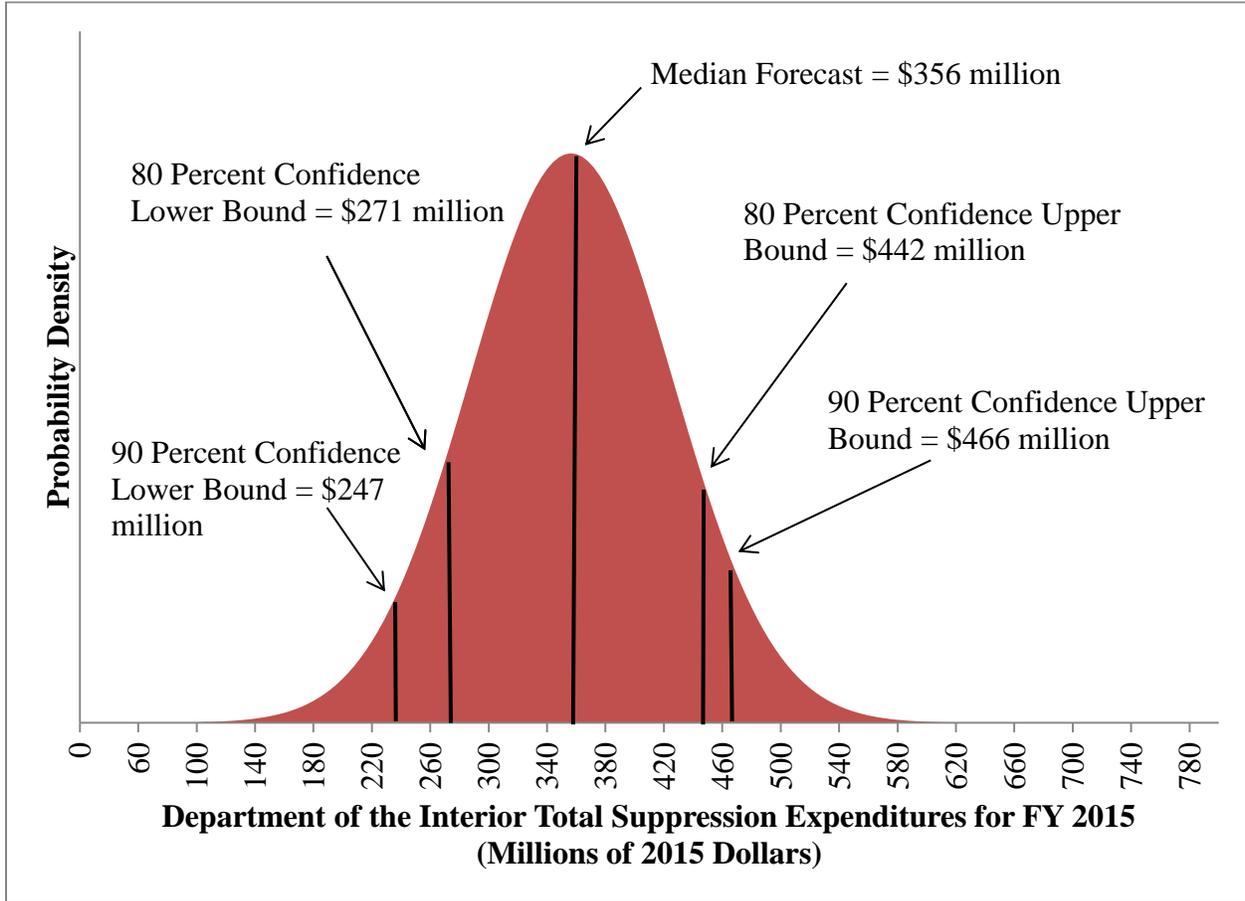


Figure 2. Department of the Interior suppression expenditure forecast probability density, FY 2015, September 2014 FLAME Act Forecast Model.

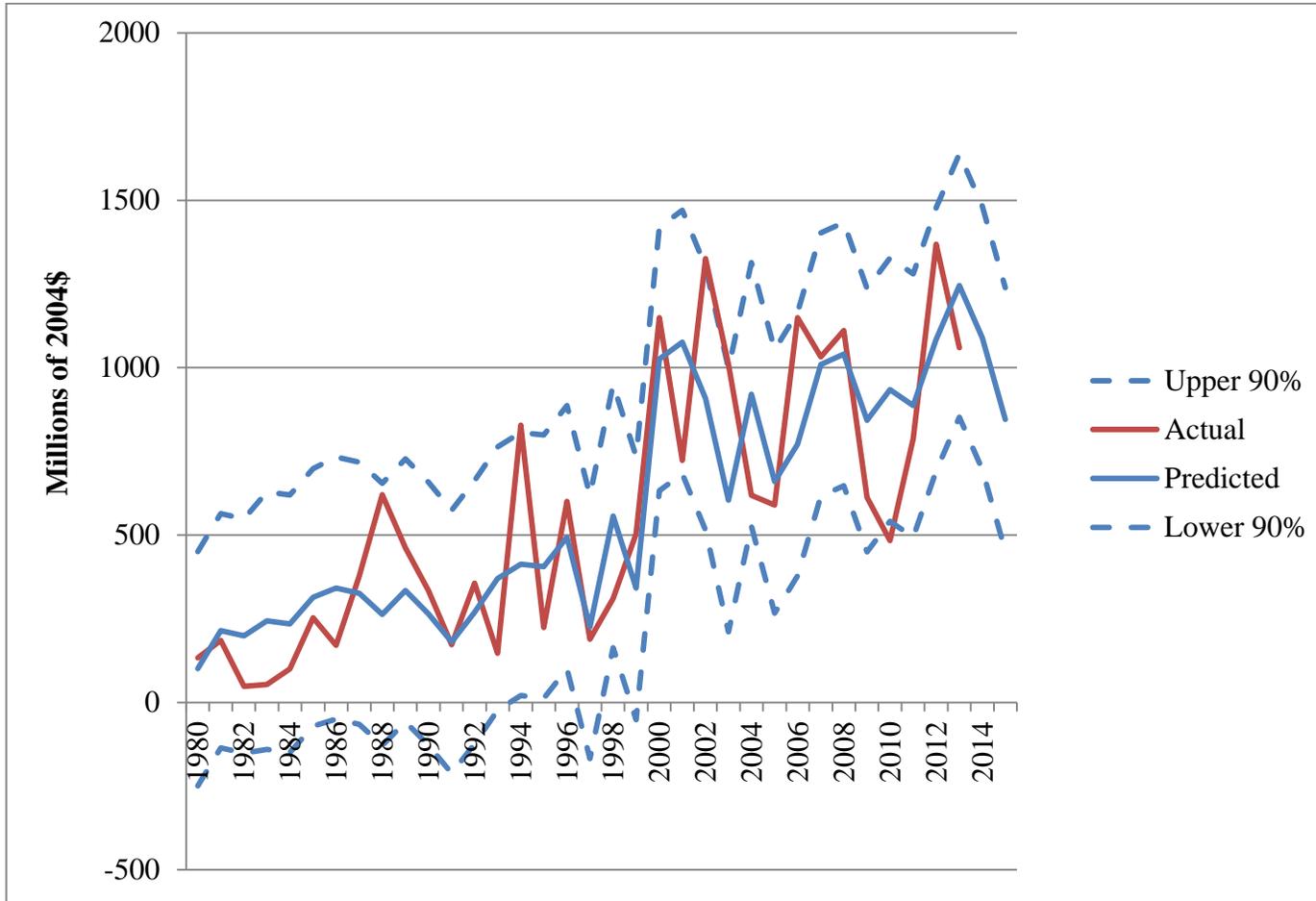


Figure 3. Observed historical USDA Forest Service suppression expenditures (1980-2013) and the forecasts of these expenditures (1980-2015) using the September 2014 FLAME Act forecast model. All forecasts for each FY are the point estimates generated with a cross-validation procedure. (Note: values are in constant 2004 dollars and exclude the wildland fire suppression cost pool expenditures.)

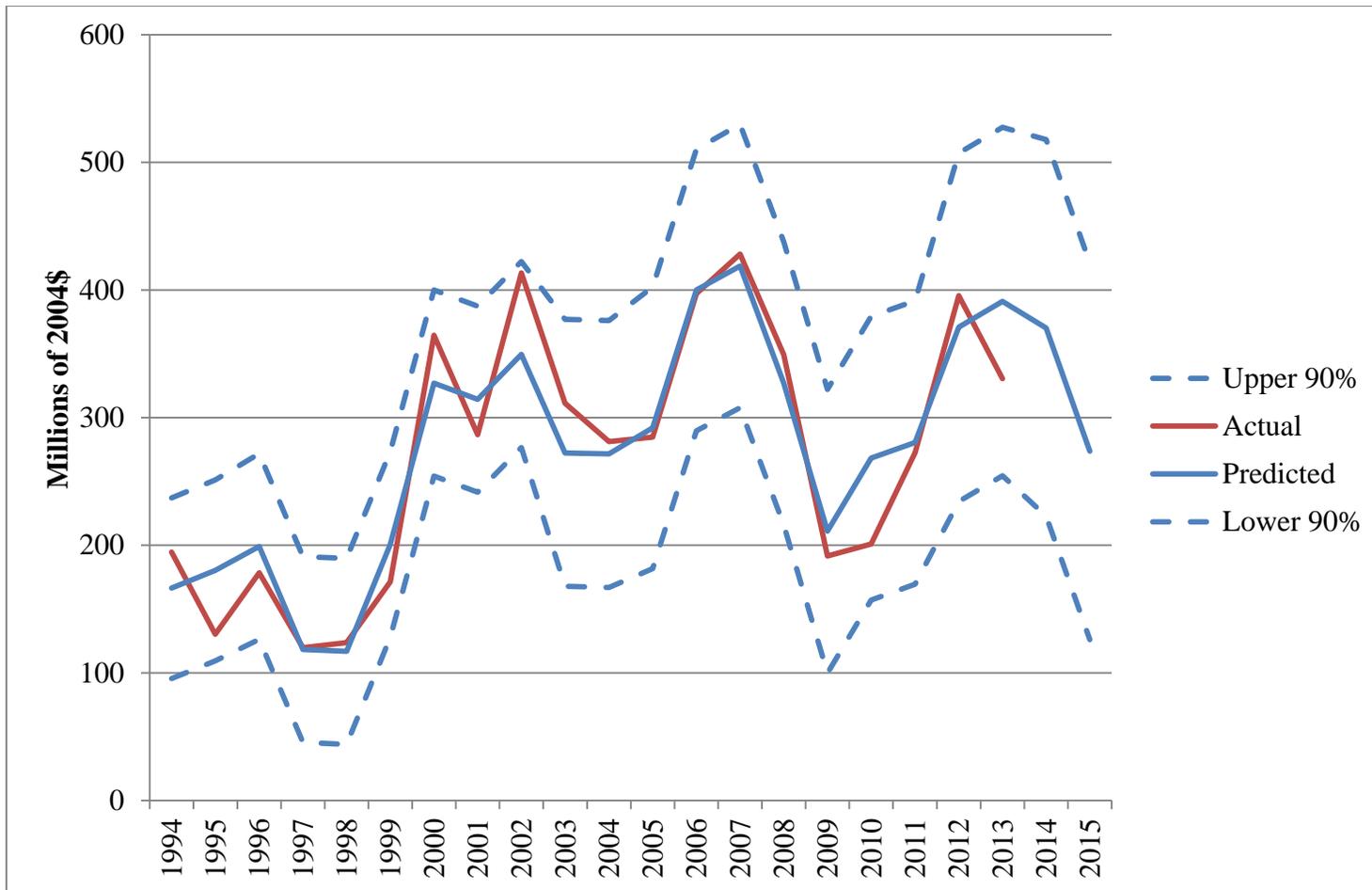


Figure 4. Observed historical Department of the Interior suppression expenditures (1994-2013) and the forecasts of these expenditures (1994-2015), using the September 2014 version of the September FLAME Act Forecast Model. All forecasts for each FY are the point estimates generated with a cross-validation procedure. (Note: values are in constant 2004 dollars)