

**Federal Land Assistance, Management and Enhancement (FLAME) Act Suppression  
Expenditures for the U.S. Department of the Interior and  
the U.S. Department of Agriculture Agencies:**

*March 2013 Forecasts for Fiscal Year 2013*

**Report Date: February 7, 2013**

**Executive Summary**

The U.S. Department of Agriculture's (USDA) Forest Service is forecast to spend, with 80 percent confidence, between \$621 million and \$1.409 billion in fiscal year (FY) 2013, while the agencies of the U.S. Department of the Interior (DOI) are forecast to spend, with 80 percent confidence, between \$157 million and \$385 million. The Forest Service forecast includes \$45 million in expected contributions to the agency's Wildland Fire Suppression Cost Pool. The median forecast for the Forest Service is \$985 million, while the median forecast for DOI is \$281 million. Excluding the Cost Pool, the Forest Service's median forecast for FY 2013 represents average costs compared to recent years (since 1995). Compared to the September 2012 forecast of Forest Service costs for FY 2013, the lower March forecast is consistent with the shift in the El Niño/La Niña–Southern Oscillation from a possible El Niño, to neutral conditions. Further testing revealed instability in the logged and differenced equations used in the September forecast, and we have reverted to simpler linear models until we more fully understand the implications of using what should be statistically more consistent models. DOI agency expenditures are forecasted to be lower in real dollar terms compared to the average observed expenditures over the last decade. The DOI forecast has also shifted lower since the September 2012 forecast, in part due to changes in forecast methodology.

**Overview**

The Rocky Mountain Research Station (RMRS) has provided monthly forecasts of annual Forest Service suppression expenditures since FY 1998 and annual DOI suppression expenditures since FY 2005. In addition, starting in FY 2003, the RMRS and the Southern Research Station (SRS) have collaborated to provide “early warning” forecasts of annual Forest Service suppression expenditures in the fall and spring of the fiscal year. With the passage of the FLAME Act in 2009, both the Forest Service and the 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. The current report was produced in early February, 2013, in time for review and in compliance with the March 1, 2013, due date for this forecast for FY 2013.

## Modeling

### *Modeling Framework for the March 2013 Forecast of FY 2013 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 are generally specified as a system of equations. Each of the six equations contained in the current modeling system represents a statistical relationship between historical costs and a set of predictor variables for a particular Forest Service region or the sum of two regions. These equations are estimated simultaneously as a system but allowed to solve without constraints across equations within the system. For this reason, the estimation procedure is called Seemingly Unrelated Regression (SUR).

For this forecast, similar to the forecast issued in September of 2012 for FY 2013 and all previous FLAME Act forecasts, equations were specified for the following regions or regional aggregates: (i) Region 1 plus Region 4, (ii) Region 2 plus Region 3, (iii) Region 5, (iv) Region 6, (v) Region 8 plus Region 9, and (vi) Region 10 plus the National Interagency Fire Center, Washington Office, and research stations, which we label in this report as “RFS.” The statistical relationships that were identified with extensive research effort relate spending in the coming fiscal year to lagged measures of drought (Palmer indices), ocean temperatures (the Niño-3 sea surface temperature anomaly), and ocean pressure indices (North Atlantic Oscillation and the Atlantic Multi-decadal Oscillation). The equation for the Region 10 + RFS aggregate included a time trend.

Equation estimates are shown in Table A1, located in an Appendix to this report. This table indicates that most models had low to moderate R<sup>2</sup>s, ranging from 0.15 (Region 2 and 3 aggregate) to 0.65 (Region 8 and 9 aggregate). Durbin-Watson statistics, designed to detect serial autocorrelation in the residuals of estimated equations, were all within the acceptable (insignificant) range.

Forecasts were made using the equation estimates shown in Table A1 for region-level costs that excluded the contributions to the Cost Pool, which are held constant in the simulation and then added back to the costs for the Region 10 and RFS aggregate. Data for modeling were annual fiscal year totals of expenditures, and they ranged from 1995 to 2012, the only years for which consistent region-level data could be assembled. To erase the effects of general price inflation, all costs were deflated to the value of a dollar in 2004 using the gross domestic product deflator—that is, models were estimated and costs were forecast in “real” dollar terms. After the forecast, we adjusted the forecast values to put them in current dollars. SUR estimates allowed for more precise identification of statistical relationships by using the correlations in estimation errors. When generating a forecast distribution (see Figure 1), we randomly sampled from

---

<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.

equation error and coefficient distributions in ways that accounted for the uncertainties in the forecast. These Monte Carlo forecasts, which are repeated 50,000 times for the Forest Service forecast, do not produce a precise estimate. Rather, they generate a distribution of estimates. This distribution can be summarized in many ways. These forecasts emanating from the Monte Carlo simulation produced a forecast density distribution, a table reporting a median forecast and the lower and upper bounds of likely observed costs, a table of not-to-exceed costs by probability levels, and a description of where the median forecast value fell within the observed historical costs for other years, in real dollar terms.

Model fitness is reported in the Appendix of this report and is described both graphically (Figure A1) and tabularly (Table A2). The graph shows how well the March 2013 FLAME Forecast Model 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 “jackknife”) compared with observed expenditures for the Forest Service as well as forecasts produced by the September FLAME Forecast Model. Table A2 shows that the root mean squared error of the model used in this March 2013 forecast of FY 2013 expenditures, when applied to the 1995-2012 period, was \$260 million and that it had a negative bias, tending to under-forecast by about \$16 million (-2.06 percent). (This negative bias was not subtracted from the March 2013 forecast for FY 2013.) The model had a Mean Absolute Percent Error of about 34 percent, meaning that the typical forecast averaged 34 percent above or below expenditures actually incurred during the 1995-2012 period. Finally, this model correctly predicted the direction of change in suppression expenditures by the Forest Service 76 percent of the time—that is, in all but four of the years, 1996-2012. The predicted direction of change is negative, the median 2013 forecast is expected to be roughly \$470 million lower than the observed 2012 expenditure (excluding cost pools).

#### *Modeling Framework for the March 2013 Forecast of FY 2013 Department of the Interior Expenditures*

The development of a forecast model for the DOI was constrained by a lack of detailed regional expenditure data for the Department. Therefore, DOI suppression expenditure data used in the March 2013 FLAME Model covered fiscal years 1985-2012. Although geographical and agency disaggregations were available for recent years (since the early 2000’s), there are insufficient data for modeling by geographic region or agency within the Department. We modeled aggregate DOI expenditures using a parsimonious model specification involving four Palmer H-indices from the West and the one-year lag of DOI expenditures. This is the same model that was used last March for forecasting DOI suppression expenditures. It differs from the September model with the inclusion of some more recent drought measures from December for regions 1 and 3 as well as lagged expenditures in place of a time trend.

The DOI suppression expenditure forecast equation is reported in Table A3. It included the Regions 1 and 4 Palmer H-index values for June of the previous year (t-1), Region 1 and 3 indices for the most recent December (i.e., December 2012 values are used to forecast FY 2013 costs), lagged expenditures, and an intercept. The estimated equation explained 73 percent of the variation ( $R^2 = 0.73$ ) in annual DOI suppression expenditures over the historical time period,

1985-2012. The Durbin H-statistic ( $p=0.15$ ) indicates there is no remaining residual autocorrelation in the model estimation errors.

Model fitness for the March FLAME Forecast Model for DOI is reported in Appendix Table A4. As in the case of the Forest Service March FLAME Forecast Model, the DOI March FLAME Forecast Model was evaluated by making jackknife forecasts of DOI expenditures. This March forecast model had a root mean squared error of about \$78 million, calculated over 1995-2012, \$73 million when calculated over 1985-2012. The model had a bias of about \$2 million (0.9 percent) calculated over 1995-2012 and \$6 million (2.5 percent) calculated over 1985-2012 (and these historical biases were not used to adjust the 2013 forecast.) The model had a Mean Absolute Percent Error of about 24 percent for the 1995-2012 period and 30 percent for the 1985-2012 period. It correctly predicted the direction of change in suppression expenditure for the agency from one year to the next about 78 percent of years 1995-2012 and 74 percent of years 1986-2012.

## **Results**

### *USDA Forest Service*

FY 2013 suppression expenditures are forecast to range, with 80 percent confidence, between \$621 million and \$1.409 billion. The median forecast is \$985 million. These costs include \$45 million in estimated Cost Pool contributions, held constant in the Monte Carlo simulation that generated the median and confidence limits, which are added to the Region 10 plus RFS forecasts (Table 1). Uncertainty can be appreciated by examining the forecast probability density (Figure 1) and the not-to-exceed levels at a range of probabilities (Table 2). As Table 2 shows, this model states that there is a 1 percent chance that Forest Service suppression expenditures, including the Cost Pool, will fall below \$419 million. In contrast, there is a 99 percent chance that these expenditures will fall below \$1.8 billion.

An analysis of historical real dollar expenditures in suppression contains information about the likely financial magnitude of spending for FY 2013 (Table 3), by Forest Service Region or region aggregate, and in total. An examination of this table reveals that, when compared to expenditures since 1995, the aggregate of regions 1 and 4 and the aggregate of regions 8 and 9 are expected to have expenditures in the upper-tercile in 2013, the aggregate of regions 2 and 3, region 6, and the aggregate of regions 10 and RFS are forecast to have average costs, while region 5 is projected to have lower-tercile costs. On the other hand, when compared with spending since 1977, regions 5 and 6 are expected to have average costs in 2013 while all other regions are expected to have higher than average costs.

### *Department of the Interior*

FY2013 suppression expenditures for the DOI are forecast to range, with 80 percent confidence, from \$157 million to \$385 million, with a median forecast of \$281 million. The 90 percent confidence band spans \$127 million to \$409 million, while a 95 percent band spans \$107 million and \$426 million (Table 4). As in the Forest Service forecast, uncertainty surrounding the DOI

forecast for FY 2013 can be appreciated by examining the probability density (Figure 2). This density distribution was developed using 50,000 Monte Carlo random forecasts, each generated by adding random errors to the forecast model. The median forecast expenditure for the Department is lower in real dollar terms compared to the average observed expenditures over the last decade.

**Authors**

<b>Karen L. Abt,</b> Research Economist	<b>Charlotte Ham,</b> Postdoctoral Economist	<b>Jeffrey P. Prestemon,</b> Research Forester
Forestry Sciences Laboratory, SRS USDA Forest Service	North Carolina State University SRS USDA Forest Service	Forestry Sciences Laboratory, SRS USDA Forest Service

**Table 1. March 2013 FLAME Act Forecasts of Fiscal Year 2013 Suppression Expenditures of the Forest Service, by Region and in Total, Current (FY 2013) Dollars**

	R 1&4	R 2&3	R 5	R 6	R 8&9	R 10&13*	Total*
	2013 \$ Million						
Median	367	84	131	98	102	148	985
80% Confidence Lower Bound	142	4	0	10	70	96	621
80% Confidence Upper Bound	592	211	338	187	134	289	1,409
90% Confidence Lower Bound	114	0	0	0	66	92	540
90% Confidence Upper Bound	620	260	418	225	138	350	1,548
95% Confidence Lower Bound	100	0	0	0	64	89	481
95% Confidence Upper Bound	634	307	496	263	140	411	1,680

\*Note: This table includes the Fiscal Year 2013 contributions to the Wildland Fire Suppression Cost Pool, expected to be \$45 million, which are added to the Region 10 + RFS forecast and the agency-wide total.

**Table 2. March 2013 FLAME Act Forecasts of Fiscal Year 2013 Suppression Expenditures of the Forest Service in Total and by Region, by Percentiles, Current (FY 2013) Dollars**

Probability (percent) of Falling Below Indicated Dollar Amount	R 1&4	R 2&3	R 5	R 6	R 8&9	R 10&13*	Total*
1	92	0	0	0	63	88	419
5	114	0	0	0	66	92	540
10	142	4	0	10	70	96	621
20	199	28	38	48	78	107	734
30	255	47	70	70	86	119	824
40	311	66	100	86	94	132	905
50	367	84	131	98	102	148	985
60	424	105	164	110	110	168	1,064
70	480	129	204	126	118	193	1,150
80	536	161	256	149	126	228	1,254
90	592	211	338	187	134	289	1,409
95	620	259	418	225	138	350	1,548
99	643	369	597	313	141	491	1,829

Note: This table includes the Fiscal Year 2013 contributions to the Wildland Fire Suppression Cost Pool, expected to be \$45 million.

**Table 3. March 2013 FLAME Act Forecasts of Fiscal Year 2013 Suppression Expenditures of the USDA Forest Service, by Tercile.**

Region or Aggregate	Tercile of Costs Expected, Since 1995	Tercile of Costs Expected, Last 35 Years
R 1&4	Upper	Upper
R 2&3	Middle	Upper
R 5	Lower	Middle
R 6	Middle	Middle
R 8&9	Upper	Upper
R 10&13	Middle	Upper
Total	Middle	Upper

Note: Historical Wildland Fire Suppression Cost Pool expenditures are assumed to be zero in all year expenditure totals used in these rankings. Comparisons across years are in real (2004) dollars.

**Table 4. March 2013 FLAME Act Forecasts of Fiscal Year 2013 Suppression Expenditures of the Department of the Interior, Current (FY 2013) Dollars**

	2013 Dollars (million)
Median Estimate	\$281
Lower Bound, 80 percent Confidence Limit	157
Upper Bound, 80 percent Confidence Limit	385
Lower Bound, 90 percent Confidence Limit	127
Upper Bound, 90 percent Confidence Limit	409
Lower Bound, 95 percent Confidence Limit	107
Upper Bound, 95 percent Confidence Limit	426

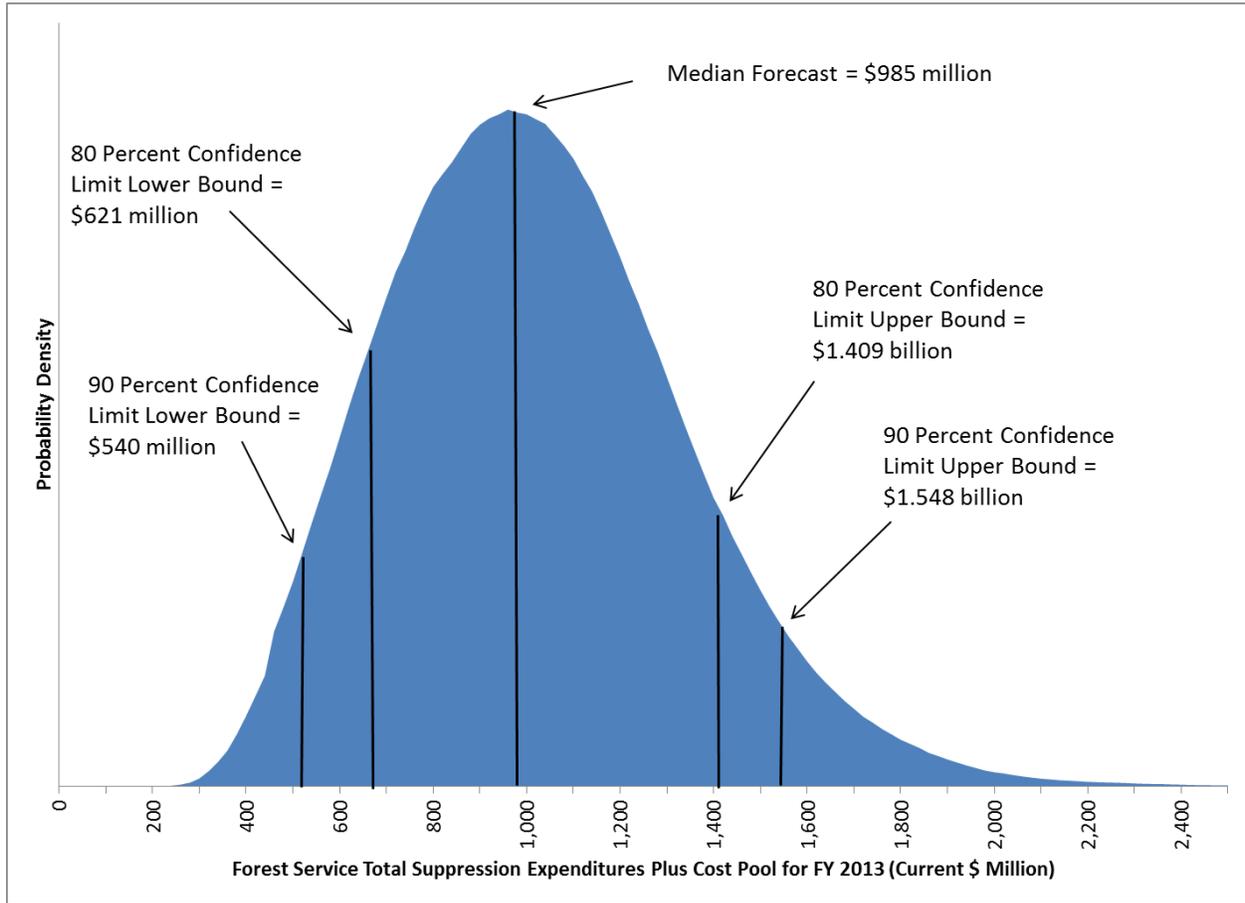


Figure 1. Forest Service suppression expenditure forecast probability density, Fiscal Year 2013, March 2013 version of the March FLAME Forecast Model. (Note: Fiscal Year 2013 Wildland Fire Suppression Cost Pool expenditures are included at their expected level of \$45 million in this probability density display.)

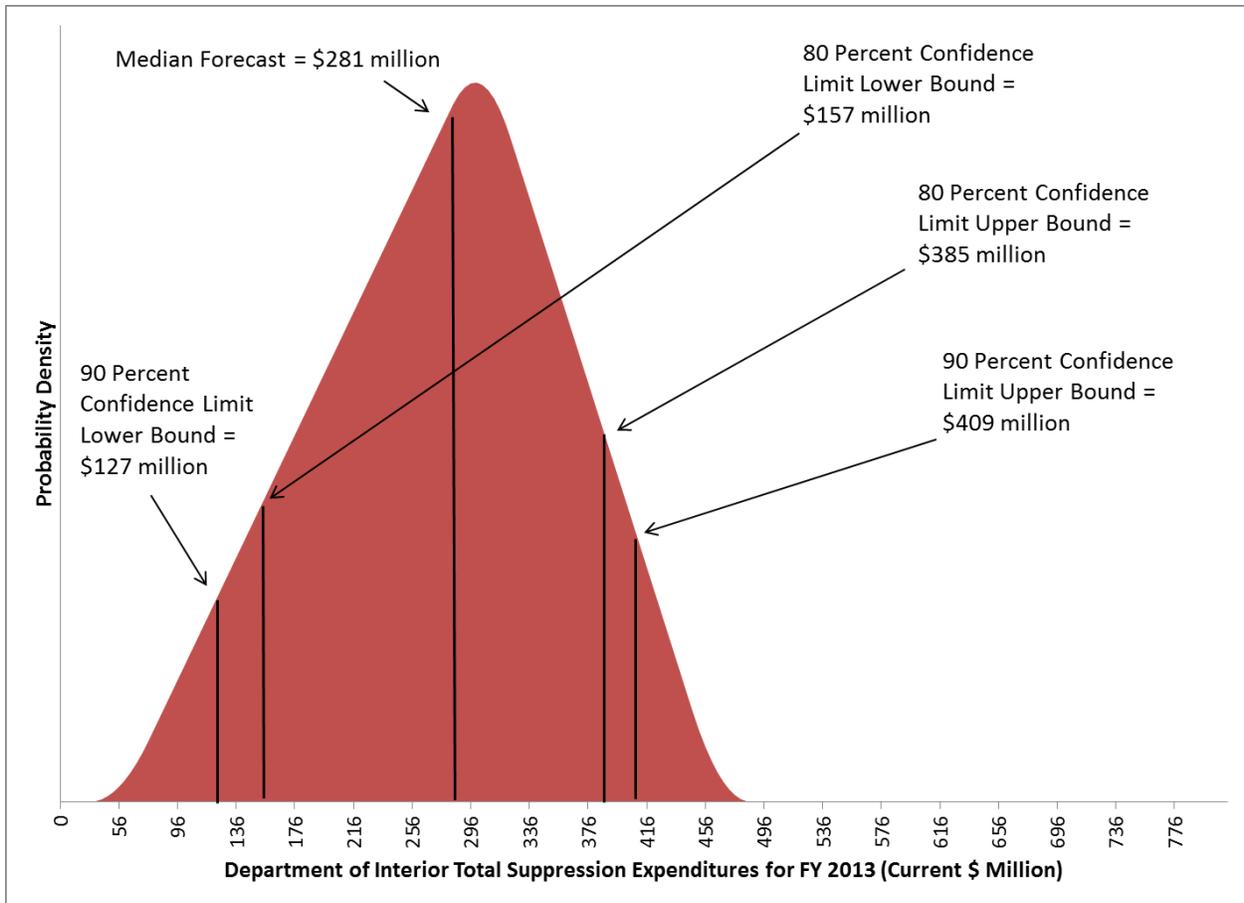


Figure 2. Department of the Interior suppression expenditure forecast probability density, Fiscal Year 2013, March 2013 version of the March 2013 FLAME Forecast Model.

**Appendix: Model Estimates and Forecast Evaluation Statistics**

**Table A1. Seemingly Unrelated Regression Equation Estimates Used in the March 2013 Forecast of FY 2013 Suppression Expenditures of the USDA Forest Service. Note: The Dependent Variable in All Cases is the Indicated Region or Region Sum of Annual Real Dollar Expenditures (1995-2012)**

Dependent Variable	Independent Variables	Coefficient	Std. Error	t-Stat.	P-Value	R <sup>2</sup>	Durbin-Watson Statistic
Region 1 + Region 4 Cost	Constant	-22,783,928	0.3130	55.5830	0.0000	0.41	1.66
	AMO October (t-2) to February (t-1) Mean	547,127,064	136,807,356	3.9993	0.0001		
	NAO October (t-2) to February (t-1) Mean	81,215,141	31,775,791	2.5559	0.0123		
Region 2 + Region 3 Cost	Region 1 + Region 4 June Palmer Z-Index, Weighted Average (t-1)	-42,876,844	13,863,153	-3.0929	0.0027	0.15	1.23
	Constant	89,136,039	17,856,089	4.9919	0.0000		
	Region 2 + Region 3 September Palmer H-Index, Weighted Average (t-1)	10,467,340	5,746,171	1.8216	0.0720		
Region 5 Cost	March PDSI, Westwide, Weighted Average (t-1)	-25,831,634	5,968,445	-4.3280	0.0000	0.42	1.24
	Constant	321,085,847	93,554,268	3.4321	0.0009		
	Niño-3 SSTA October (t-1)	-61,266,774	18,876,918	-3.2456	0.0017		
	Region 5 December Palmer Z-Index, Weighted Average (t-1)	-42,795,588	19,748,032	-2.1671	0.0330		
Region 6 Cost	Region 5 September Palmer Z-Index, Weighted Average (t-2)	110,245,075	50,650,699	2.1766	0.0323	0.50	1.41
	Constant	106,216,113	12,289,814	8.6426	0.0000		
	Region 1 June Palmer H-Index (t-1)	-30,696,899	5,925,284	-5.1807	0.0000		
Region 8 + Region 9 Cost	Region 4 June Palmer H-Index (t-1)	11,907,539	5,734,499	2.0765	0.0408	0.65	1.55
	Constant	64,324,529	4,327,225	14.8651	0.0000		
	Niño-3 SSTA October (t-2) to February (t-1) Mean	-13,103,118	2,597,362	-5.0448	0.0000		
	Region 9 June Palmer H-Index (t-1)	-10,381,265	2,758,158	-3.7638	0.0003		
Region 10 + RFS Cost	Region 3 June Palmer H-Index (t-1)	2,880,002	1,253,761	2.2971	0.0240	0.57	1.61
	Region 9 December Palmer H-Index (t-1)	-12,468,970	2,571,274	-4.8493	0.0000		
	Constant	-172,134,965,519	22,362,447,466	-7.6975	0.0000		
	Region 2 September Palmer H-Index (t-1)	13,841,936	4,108,770	3.3689	0.0011		
	Ln(Year)	22,657,107,625	2,941,390,942	7.7029	0.0000		

**Table A2. Jackknife Forecast Evaluation of the Seemingly Unrelated Regression Model Used in the March 2013 Forecast of FY 2013 Suppression Expenditures of the USDA Forest Service, Calculated Over Data from 1995-2012**

Diagnostic	Calculated 1995-2012
Root Mean Squared Error, 1995-2012 (Real 2004 \$)	259,941,688
Bias, 1995-2012, Predicted Minus Actual (Real 2004 \$)	-15,563,279
Bias (percent)	-2.06
Mean Absolute Percent Error, 1995-2012	34.34
Correct Direction of Change percent, 1996-2012	76.47

**Table A3. Equation Estimate Used in the March 2013 Forecast of FY 2013 Suppression Expenditures of the Department of the Interior. Note: The Dependent Variable is the Natural Log of the Department's Annual Real Dollar Expenditures**

Variable	Coefficient	Standard Error	t-Statistic	Probability
Intercept	9.7835	3.7711	2.5943	0.0169
Palmer H-Index, Region 1, June (t-1)	-0.0883	0.0421	-2.0965	0.0483
Palmer H-Index, Region 4, June (t-1)	0.1820	0.0350	5.2020	0.0000
Palmer H-Index, Region 3, December (t-1)	-0.0612	0.0266	-2.3008	0.0318
Palmer H-Index, Region 1, December (t-1)	-0.0935	0.0426	-2.1968	0.0394
Ln[DOI Expenditures (t-1)]	0.4884	0.1979	2.4682	0.0223
Observations	27			
R-squared	0.73			
Equation Error	0.29			
Durbin-H Statistic (F-Test, 1, 19)	2.3*			

\* Not significant at 0.15.

**Table A4. Jackknife Forecast Evaluation of the Equation Used in the March 2013 Forecast of FY 2013 Suppression Expenditures of the Department of the Interior, Calculated over 1995-2012 and 1985-2012**

Diagnostic	Calculated 1995-2012	Calculated 1985-2012
Root Mean Squared Error (Real 2004 \$)	77,701,029	72,611,187
Bias (Real 2004 \$)	2,345,097	5,811,435
Bias (percent)	0.9	2.5
Mean Absolute Percent Error (percent)	24	29
Direction of Change Prediction (percent Correct)	78	74

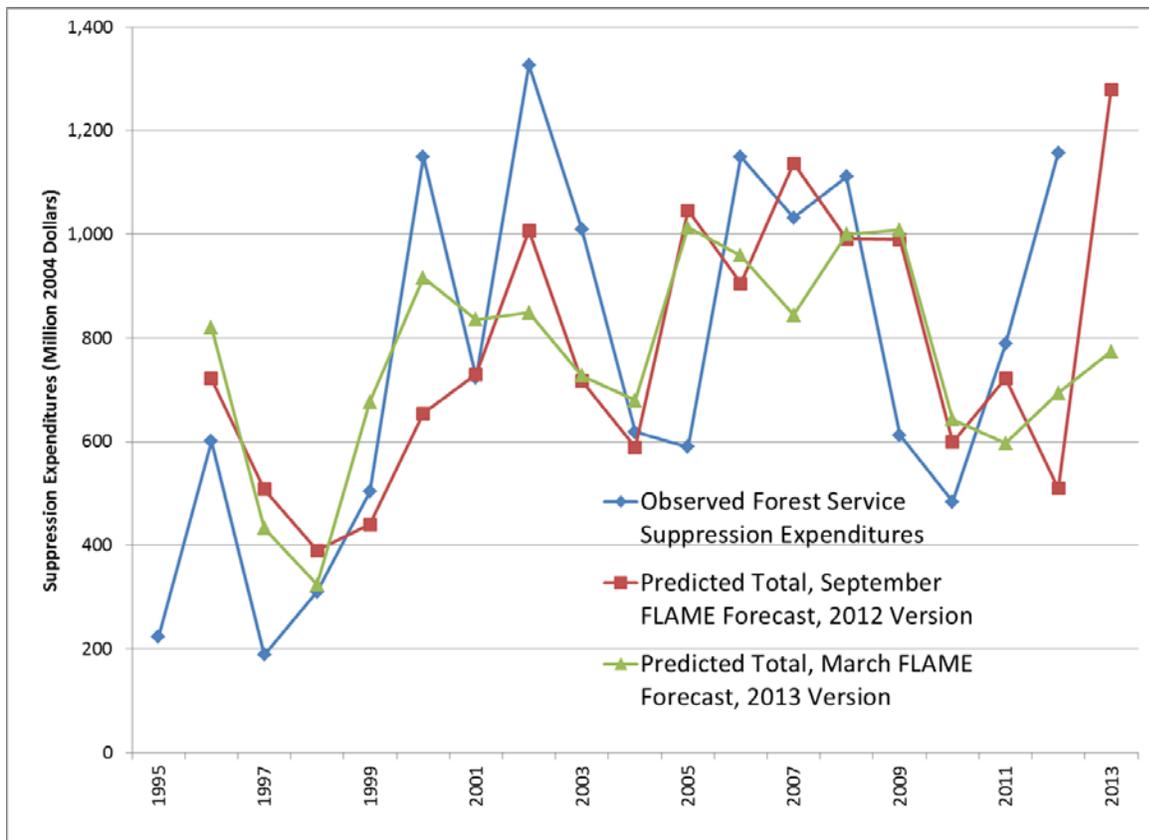


Figure A1. Observed historical Forest Service suppression expenditures (1995-2012) and the forecasts of these expenditures (1996-2013) using the March 2013 FLAME Forecast Model and the September 2012 FLAME Forecast Model (1996-2013). All forecasts of those expenditures for each fiscal year are sums across the point estimates of each region or region aggregate's costs generated with a jackknife procedure. (Note: values are in constant 2004 dollars and exclude the Wildland Fire Suppression Cost Pool expenditures.)

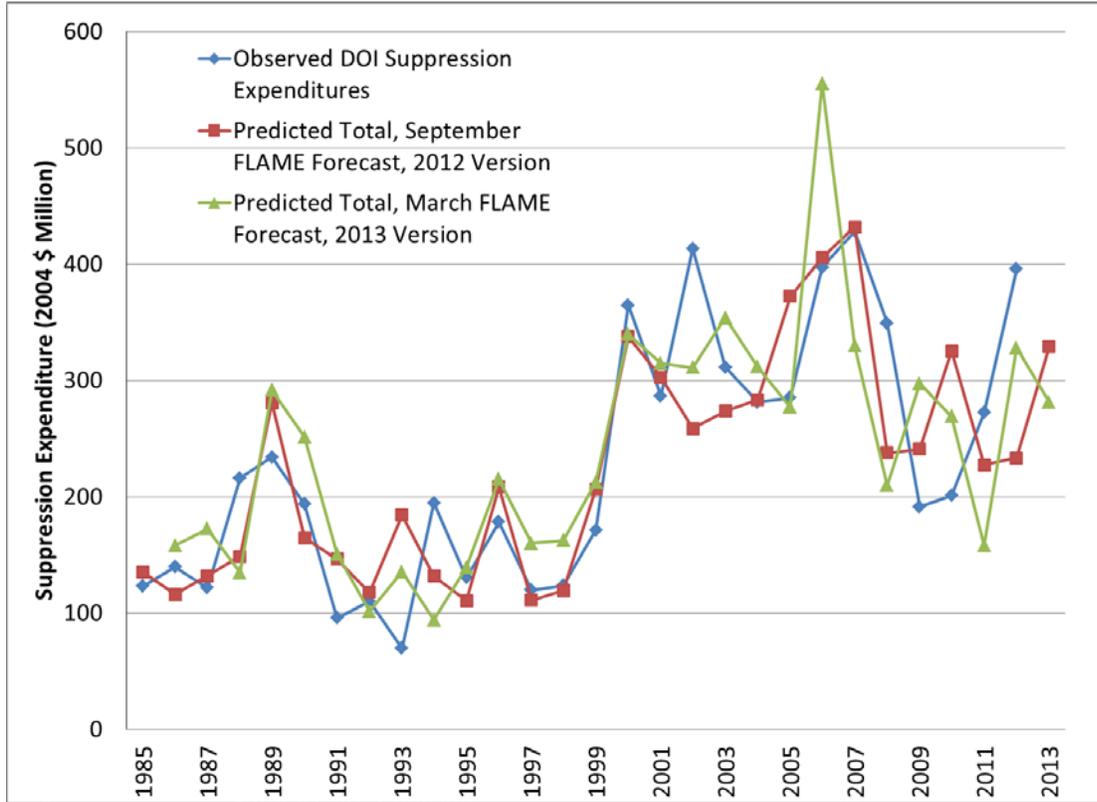


Figure A2. Observed historical Department of the Interior suppression expenditures (1985-2012) and the forecasts of these expenditures (1986-2013), using the March 2013 version of the DOI March FLAME Act Forecast Model. All forecasts of those expenditures for each fiscal year are the point estimates generated with a jackknife procedure. (Note: values are in constant 2004 dollars.)