

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

September 2012 Forecasts for Fiscal Year 2013

Report Date: August 30, 2012

Executive Summary

The USDA Forest Service (Forest Service) is forecast to spend, with 80 percent confidence, between \$1.048 billion and \$2.604 billion in Fiscal Year 2013, while the agencies of the Department of the Interior (DOI) are forecast to spend, with 80 percent confidence, between \$264 million and \$581 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 \$1.584 billion, while the median forecast for DOI is \$393 million. Excluding the Cost Pool, the Forest Service's median forecast for FY 2013 represents higher than average costs compared to recent years, and this is attributable to below normal live and dead fuel moistures as well as above normal Energy Release Components that cover much of the central-western United States. The emerging El Niño conditions in the central Pacific Ocean also would tend to raise expected wildfire activity in the northwest portion of the West. In spite of El Niño conditions, which are correlated with lower costs in the South (Region 8), the current dry conditions in parts of the South and neighboring regions explain an expectation of much higher costs in the eastern United States in the coming Fiscal Year. The DOI agency expenditures are also expected to be higher than average in FY 2013, due to an ongoing drought in portions of the West and to the increased likelihood of El Niño conditions, which would also tend to raise wildfire activity in northern portions of the West.

Overview

With the passage of the FLAME Act in 2009, both the Forest Service and DOI are required to produce forecasts of annual suppression expenditures three times during each fiscal year, in 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 late August of 2012, meeting the September 1, 2012, due date for the FY 2013 forecast. This continues ongoing forecasting efforts through collaboration among scientists in the Southern Research Station and the Rocky Mountain Research Station, dating to 2003, as well as North Carolina State University.

Modeling

Modeling Framework for the September 2012 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^{1,2}. 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 an annual cost and a set of predictor variables hypothesized to affect those costs for a particular Forest Service region or the sum of 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 and similar to 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 is labeled in this report as “RFS.” The statistical relationships 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 Atlantic Multidecadal Oscillation). The equations for Region 5 and the combined Region 10 plus RFS included a time trend. Equation estimates are shown in Table A1, located in an Appendix to this report.

Forecasts were made for region-level costs that excluded the contributions to the Cost Pool, which are held constant during the simulation and then added back to the costs for the Region 10 and RFS aggregate. Data for modeling were annual FY totals of expenditures, ranging from 1995 to 2011, the only FYs for which consistent region-level data could be assembled. To erase the effects of general price inflation in the statistical modeling, 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, forecast values were adjusted to current (forecast year) dollars. The 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), equation and coefficient error distributions were randomly sampled in ways that accounted for the uncertainties in our forecast. These Monte Carlo forecasts, which are repeated 15 thousand times for the Forest Service forecast, do not produce a precise forecast value. Rather, they generate a probability density distribution of forecast values. From the distribution are derived a graphical display of the 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.

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.

Model fitness is reported in the Appendix of this report and is described in a graph (Figure A1) and a table (Table A2). The graph shows how well the September 2012 Out-Year 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. Table A2 shows that the root mean squared error of the model used in this September 2012 forecast of FY 2013 expenditures, when applied to the 1995-2011 period, was \$304 million and that it had a positive bias, tending to over-forecast by about \$17 million (2 percent) – (This bias was not used to adjust the September 2012 forecast for FY 2013.) The model had a Mean Absolute Percent Error of about 40 percent, meaning that the typical forecast averaged 40 percent above or below expenditures actually incurred during the 1995-2011 period. Finally, this model correctly predicted the direction of change in suppression expenditures by the Forest Service 88 percent of the time – that is, in all but two of the FYs, 1995-2011.

Modeling Framework for the September 2012 Forecast of FY 2013 Department of the Interior Expenditures

The development of a forecast model for DOI was constrained by a lack of detailed regional expenditure data for the Department. The only DOI suppression expenditure data currently available for developing this forecast were annual DOI suppression expenditures for FY 1985 to FY 2011, Department-wide. Although geographical and agency disaggregations are available for recent years (since the early 2000’s), these are insufficient for developing reliable statistical models by geographic region or by agency within the Department. Instead, the entire Department’s expenditures are modeled with a parsimonious equation specification involving four Palmer H-indices. This is different from previous models, which have primarily related DOI expenditures to Forest Service expenditure forecasts³. One advantage of using Palmer indices rather than Forest Service forecast expenditures is that historical values of the Palmer H-indices were available for the entire length (1985-2011) of the DOI time series.

The DOI suppression expenditure forecast equation is reported in Table A3. It included the Regions 1, 3, 4, and 9 Palmer H-index values for June of the previous year (t-1) and an intercept. The estimated equation explained 77 percent of the variation ($R^2 = 0.77$) in annual DOI suppression expenditures over the historical time period, 1985-2011.

Model fitness for the September Out-Year Forecast Model for DOI is reported in Appendix Table A4. As in the case of the Forest Service September Out-Year Forecast Model, the DOI model was evaluated by making jackknife forecasts of DOI expenditures. The September DOI forecast model had a root mean squared error of about \$76 million, calculated over 1995-2011 and \$73 million when calculated over 1985-2011. The model had a bias of about \$423 thousand (0.14 percent) calculated over 1995-2010 and -\$230 thousand (-0.09 percent) calculated over 1985-2010 (and these biases were not used to adjust the 2013 forecast.) The model had a Mean Absolute Percent Error of about 18 percent for the 1995-2011 period and 25 percent for the

³ The H-indices were based on Forest Service regional geographic boundaries which allowed for at least a partial representation of how some DOI costs typically cover some Forest Service wildfires.

1985-2011 period. It correctly predicted the direction of change in suppression expenditures for the agency from one year to the next about 88 percent of FYs 1995-2011 and 85 percent of FYs 1985-2011.

Results

USDA Forest Service

The FY 2013 suppression expenditures are forecast to range, with 80 percent confidence, between \$1.048 billion and \$2.604 billion. The median forecast is \$1.584 billion. 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 \$774 million. In contrast, there is a 70 percent chance that these expenditures will fall below \$1.915 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, in total and for all regions except the Region 2 and Region 3 combination and Region 6, expenditures are expected to be in the upper tercile in 2013, when compared to the most recent 15 years and when compared to such expenditures since 1977. For FY 2013, the combination of Region 2 and Region 3 is expected to have average costs when compared to the last 15 years but expenditures are higher than average when compared to the last 35 years. Region 6 costs are expected to be average when compared since 1995 and since 1977.

Department of the Interior

The FY 2013 suppression expenditures for DOI are forecast to range, with 80 percent confidence, from \$264 million to \$581 million, with a median forecast of \$393 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 15 thousand Monte Carlo random forecasts, each generated by adding random errors to the forecast model. The 90 percent confidence band spans \$237 million to \$668 million. These forecast expenditures are projected to be more comparable in real dollar terms to the higher-than-average expenditures (equivalent to \$250 million and greater) observed in the first eight years of the 2000's.

Contact Information for this Report

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Table 1. September 2012 FLAME Act Forecasts of Fiscal Year 2013 Suppression Expenditures of the USDA Forest Service, by Region and in Total, Current (FY 2013) Dollars

	R1 + R4	R2 + R3	R5	R6	R8 + R9	R10 + RFS*	Total*
Millions of 2013\$							
Median	\$493	\$87	\$327	\$68	\$267	\$206	\$1,584
80% Confidence Lower Limit	194	42	152	39	161	131	1,048
80% Confidence Upper Limit	1,284	183	703	118	447	354	2,604
90% Confidence Lower Limit	147	34	121	33	139	117	940
90% Confidence Upper Limit	1,681	223	883	137	516	420	3,075
95% Confidence Lower Limit	114	28	99	29	123	107	859
95% Confidence Upper Limit	2,144	272	1,071	157	588	487	3,602

*Note: This table includes the FY 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. September 2012 FLAME Act Forecasts of Fiscal Year 2013 Suppression Expenditures of the USDA Forest Service, by Percentiles, Current (FY 2013) Dollars

Probability (%) of Falling Below Indicated Dollar Amount	Realized Amount (\$ Million 2013)
1	774
5	940
10	1,048
20	1,200
30	1,327
40	1,449
50	1,584
60	1,732
70	1,915
80	2,163
90	2,604
95	3,075
99	4,404

Note: This table includes the FY 2012 Wildland Fire Suppression contributions to the Wildland Fire Suppression Cost Pool, expected to be \$45 million.

Table 3. September 2012 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
R1 + R4	Upper	Upper
R2 + R3	Middle	Upper
R5	Upper	Upper
R6	Middle	Middle
R8 + R9	Upper	Upper
R10 + RFS	Upper	Upper
Total	Upper	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. September 2012 FLAME Act Forecasts of Fiscal Year 2013 Suppression Expenditures of the Department of the Interior in Millions of 2013 Dollars

Millions of 2013 Dollars	
Median Estimate	393
80% Confidence Lower Limit	264
80% Confidence Upper Limit	581
90% Confidence Lower Limit	237
90% Confidence Upper Limit	668
95% Confidence Lower Limit	218
95% Confidence Upper Limit	718

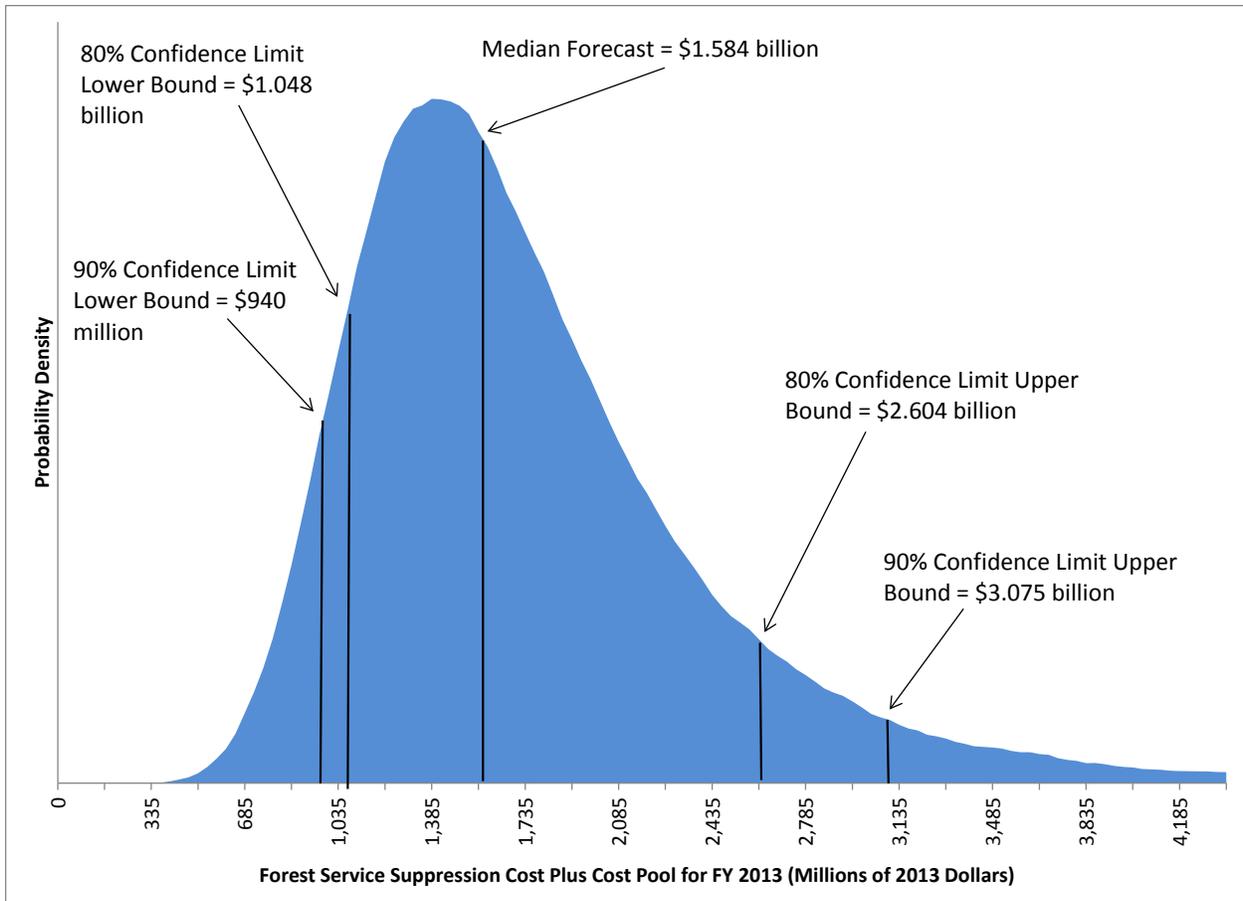


Figure 1. The USDA Forest Service suppression expenditure forecast probability density, FY 2013, September 2012 version of the September Out-Year Forecast Model. (Note: Fiscal Year 2013 Wildland Fire Suppression Cost Pool, an expected expenditure of \$45 million, in this probability density display.)

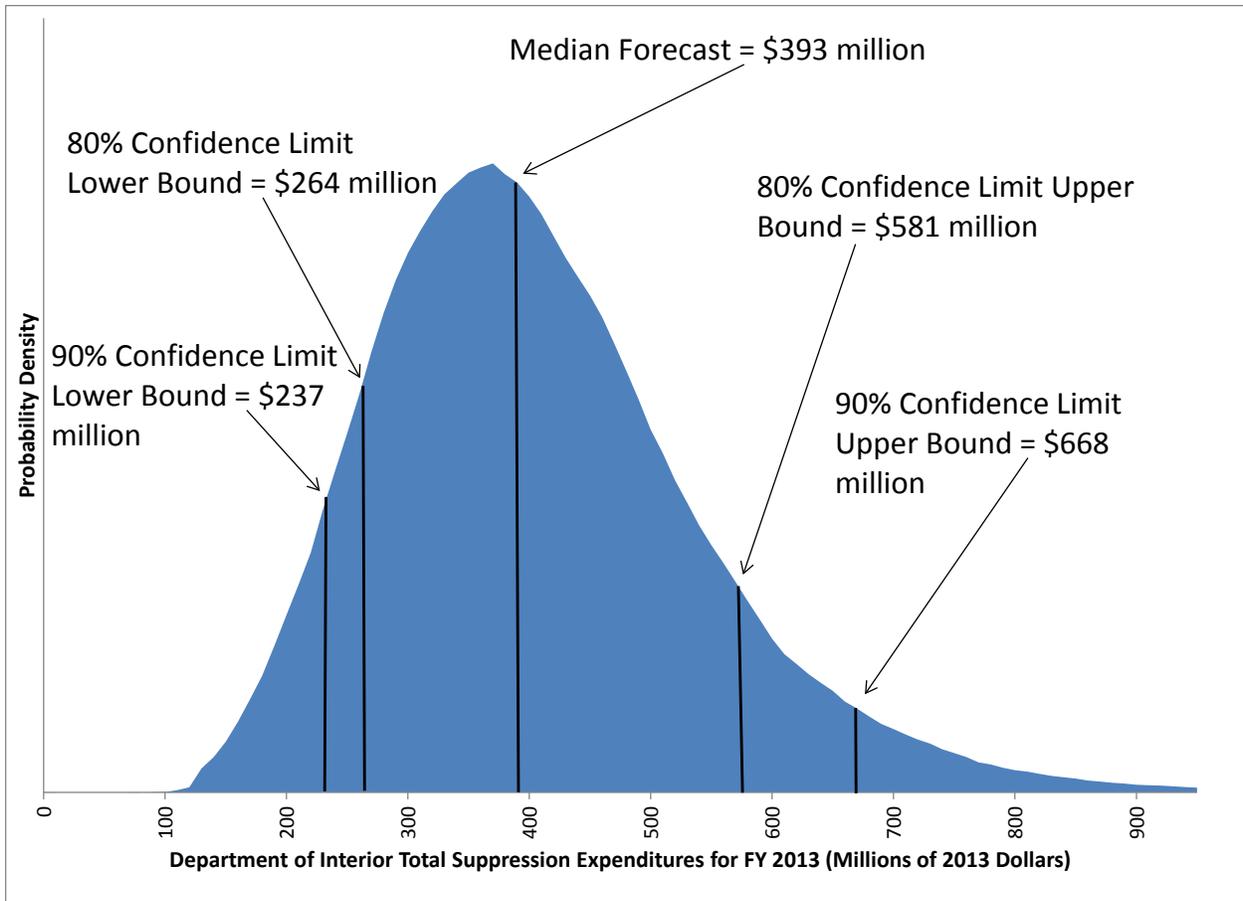


Figure 2. The DOI suppression expenditure forecast probability density, FY 2013, September 2012 version of the September Out-Year Forecast Model.

Appendix: Model Estimates and Forecast Evaluation Statistics

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

Dependent Variable	Independent Variables	Coefficient	Std. Error	t-Stat.	P-Value	R2	Durbin-Watson
Ln(Region 1 + Region 4 Cost)	Constant	17.4940	0.3192	54.8015	0.0000	0.2473	1.6124
	AMO October (t-2) to February (t-1) Mean	2.1617	0.8312	2.6006	0.0111		
	NAO October (t-2) to February (t-1) Mean	0.6422	0.1992	3.2238	0.0018		
	Region 1 + Region 4 June Palmer Z-Index, Weighted Average (t-1)	-0.2543	0.0909	-2.7971	0.0065		
Ln(Region 2 + Region 3 Cost)	Constant	18.2278	0.1389	131.1904	0.0000	0.3414	1.5959
	Region 1 June Palmer H-Index (t-1)	-0.1550	0.0479	-3.2356	0.0018		
	Region 3 June Palmer H-Index (t-1)	0.0645	0.0374	1.7264	0.0882		
Ln(Region 5 Cost)	Constant	-617.8900	322.0218	-1.9188	0.0586	0.5665	1.8833
	Niño-3 SSTA March (t-1) to July (t-1) Mean	-0.6172	0.2285	-2.7009	0.0085		
	Region 5 September Palmer Z-Index, Weighted Average (t-2)	0.9001	0.2275	3.9570	0.0002		
	Region 5 December Palmer Z-Index, Weighted Average (t-2)	-0.2017	0.1267	-1.5916	0.1155		
	log(year)	83.9197	42.3520	1.9815	0.0510		
Ln(Region 6 Cost)	Constant	18.1722	0.0995	182.6256	0.0000	0.6920	1.8743
	Region 1 June Palmer H-Index (t-1)	-0.3633	0.0583	-6.2262	0.0000		
	Region 4 June Palmer H-Index (t-1)	0.1422	0.0495	2.8712	0.0052		
Ln(Region 8 + Region 9 Cost)	Constant	17.8982	0.0969	184.6883	0.0000	0.7856	2.8859
	Niño-3 SSTA October (t-2) to February (t-1) Mean	-0.3626	0.0746	-4.8573	0.0000		
	Region 9 June Palmer H-Index (t-1)	-0.8536	0.0859	-9.9411	0.0000		
	Niño-3 SSTA March (t-1) to July (t-1) Mean	1.2636	0.1863	6.7820	0.0000		
Ln(Region 10 + RFS Cost)	Constant	-977.8545	333.7730	-2.9297	0.0044	0.6058	2.5678
	Region 2 June Palmer H-Index (t-1)	0.1155	0.0362	3.1922	0.0020		
	log(year)	130.9181	43.9219	2.9807	0.0038		
	Regions 8 & 9 March Palmer Z-Index, Weighted Average (t-1)	-0.3070	0.1309	-2.3464	0.0215		

Table A2. Jackknife Forecast Evaluation of the Seemingly Unrelated Regression Model Used in the September 2012 Forecast of FY 2013 Suppression Expenditures of the USDA Forest Service, Calculated over 1995-2011

Diagnostic	Calculated 1995-2011
Root Mean Squared Error, (2013 \$)	304,208,620
Bias, Predicted Minus Actual (2013 \$)	16,842,020
Bias (%)	2
Mean Absolute Percent Error	40
Correct Direction of Change %	88

Table A3. Equation Estimate Used in the September 2012 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 (2004) Dollar Expenditures

Variable	Coefficient	Standard Error	t-Statistic	Probability
Intercept	-507.0544	110.2966	-4.5972	0.0002
Log of Year	69.2292	14.5130	4.7702	0.0001
Palmer H Index Region 1, June 2012	-0.1994	0.0424	-4.7060	0.0001
Palmer H Index Region 3, June 2012	-0.0653	0.0219	-2.9831	0.0071
Palmer H Index Region 4, June 2012	0.1494	0.0369	4.0525	0.0006
Palmer H Index Region 9, June 2012	-0.1242	0.0462	-2.6894	0.0137
Observations	27			
R-squared	0.77			
Equation Error	0.27			
Durbin-Watson Statistic	2.41			

Table A4. Jackknife Forecast Evaluation of the Equation Used in the September 2012 Forecast of FY 2013 Suppression Expenditures of the Department of the Interior, Calculated over 1995-2011 and 1985-2011

Diagnostic	Calculated 1995-2011	Calculated 1985-2011
Root Mean Squared Error, (2013 \$)	76,286,269	73,105,788
Bias, Predicted Minus Actual (2013 \$)	423,492	-229,598
Bias (%)	0.14	-0.08
Mean Absolute Percent Error	17	25
Correct Direction of Change %	88	85

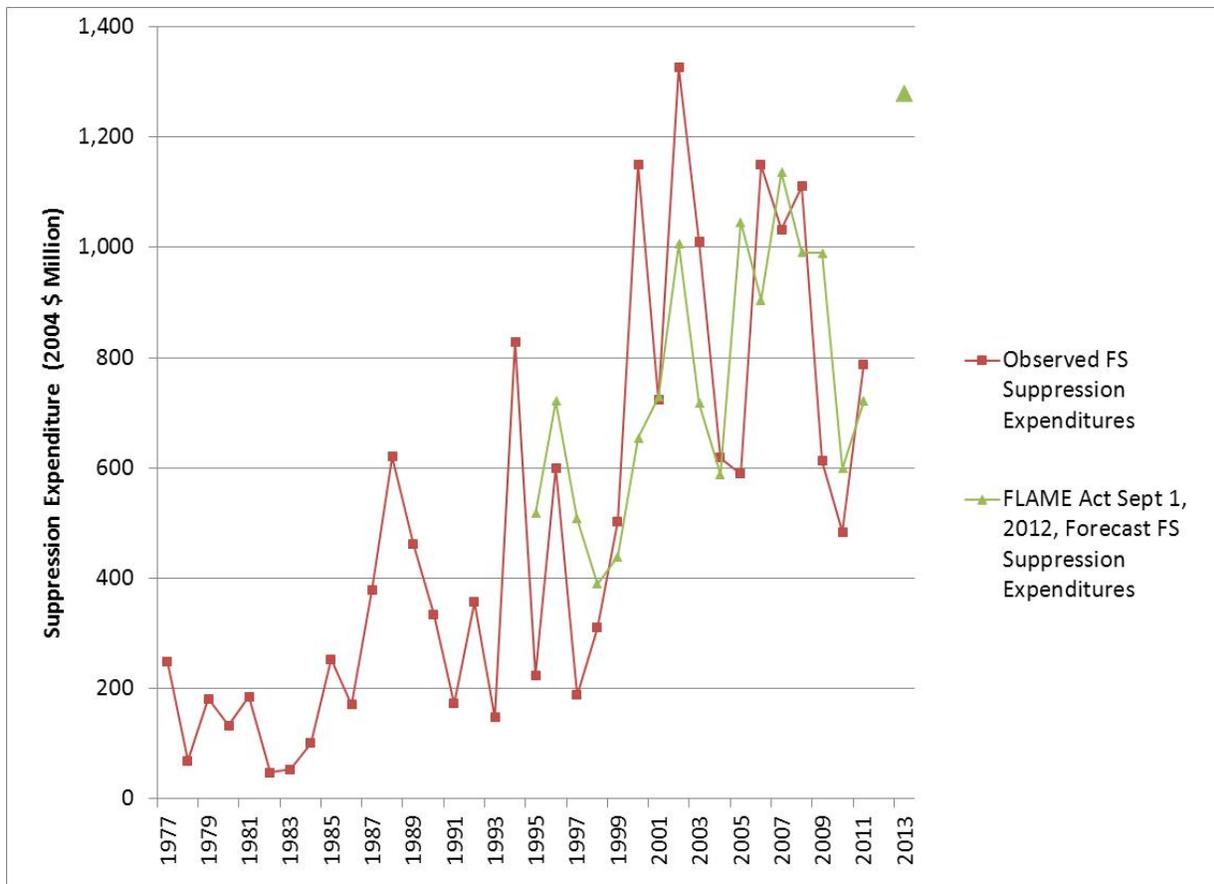


Figure A1. Observed historical USDA Forest Service suppression expenditures (1977-2011) and the forecasts of these expenditures (1995-2013) using the September 2012 version of the September Out-Year Forecast Models. All forecasts of those expenditures for each FY are sums across the point estimates of each region or region aggregate's costs generated with a jackknife procedure. Expenditures for FY 2012 are not included because they have not been finalized as of the date of this report. (Note: values are in constant 2004 dollars and exclude the Wildland Fire Suppression Cost Pool expenditures.)

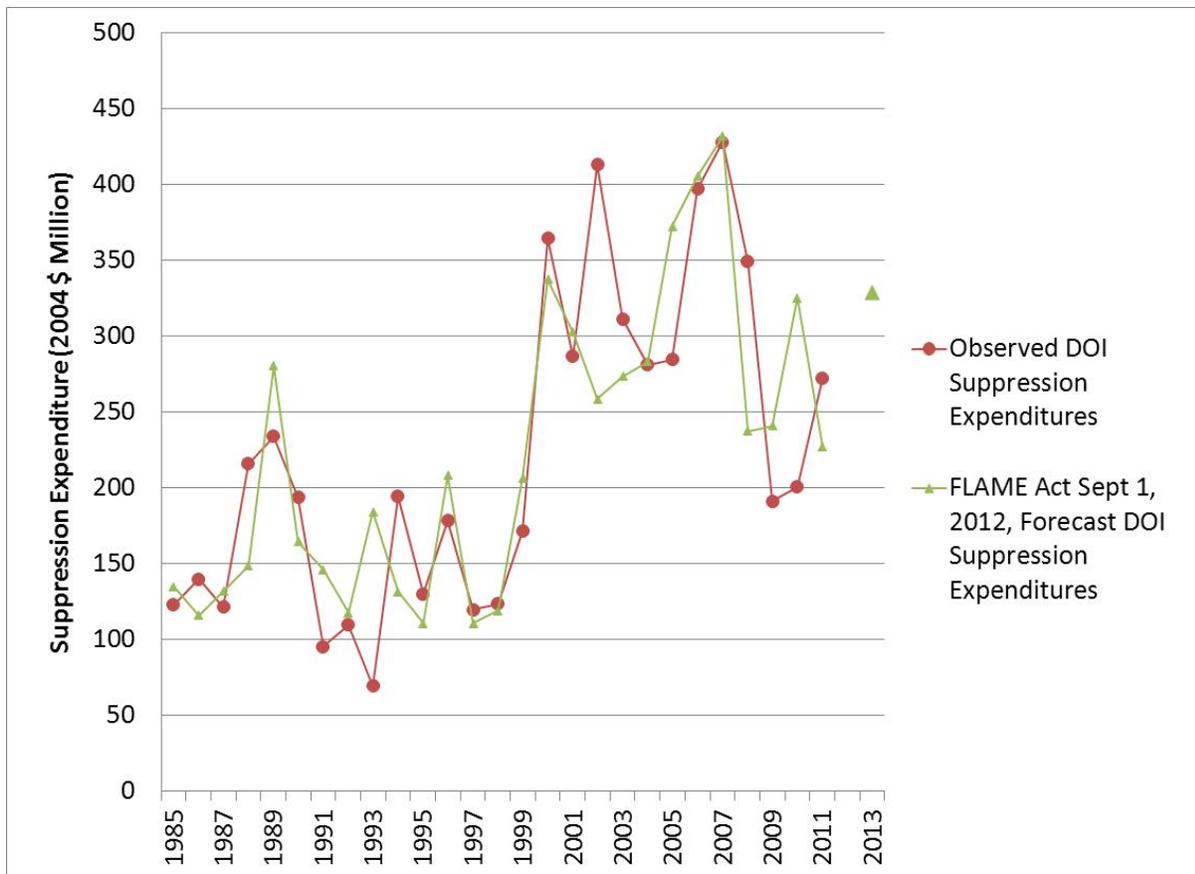


Figure A2. Observed historical DOI suppression expenditures (1986-2011) and the forecasts of these expenditures (1986-2013), using the September 2012 version of the September Out-Year Forecast Model. All forecasts of those expenditures for each FY are the point estimates generated with a jackknife procedure. Expenditures for FY 2012 are not included because they have not been finalized as of the date of this report. (Note: values are in constant 2004 dollars.)