

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

September 2013 Forecasts for Fiscal Year 2014

Supporting Documentation

Report Date: August 15, 2013

Executive Summary

The U.S. Department of Agriculture (USDA) Forest Service is forecast to spend, with 90 percent confidence, between \$745 million and \$1.89 billion in Fiscal Year (FY) 2014, with a median forecast of \$1.32 billion. Excluding cost pools, the FY 2014 Forest Service median forecast is in the upper tercile of costs since both 1995 and 1977. The agencies of the U.S. Department of the Interior (DOI) are forecast to spend, with 90 percent confidence, between \$297 million and \$518 million, with a median forecast of \$408 million. The DOI expenditures are expected to be in the upper tercile of costs 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.

Modeling

Modeling Framework for the September 2013 Forecast of FY 2014 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 eleven 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. These equations are estimated using seemingly unrelated regression (SUR).

This report is the first FLAME forecast issued for FY 2014, and it includes some methodological changes compared to the reports issued in previous years. The current approach is to forecast

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.

total Forest Service suppression expenditures, along with the share of the total for each region. This differs from past early season forecasts that estimate region/regional aggregate suppression costs and then sum for the total. 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.” 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), lagged suppression costs (three years), time, and a year 2000 shift.

Equation estimates are shown in Table A1, located in an Appendix to this report. This table indicates that most models had moderate to high R^2 's, ranging from 0.20 (Region 1) to 0.61 (Total Forest Service). 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 A1 for region-level costs that excluded the contributions to the wildland fire suppression cost pool, which are added to the simulation results. Data for modeling were annual fiscal year totals of expenditures for 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 expected FY 2014 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 in many ways: a forecast density distribution, a table reporting a median forecast and the lower and upper bounds of likely observed costs³, and a table of not-to-exceed costs by probability levels. We also describe where the median forecast value for each region falls 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 in a graph (Figure A1) and a table (A2). The graph shows how well the September 2013 FLAME Act Forecast Model of FY 2014 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. Note that while the overall agency forecast has a high R^2 and a low RMSE, several of the region percentage regressions show a poor fit. Thus, the confidence interval on the total is much narrower than many of the confidence intervals on the individual region percentages.

Table A2 shows that the root mean squared error of the model used in this September 2013 forecast of FY 2014 expenditures, when applied to the 1995-2012 period, was \$278 million and that it had a negative bias, tending to under-forecast by about \$11 million (1.4 percent). (This

³ It is possible for lower bounds of the distribution to be less than zero noted by (0) in the table.

bias was not used to adjust the September 2013 forecast for FY 2014.) The forecast for the total Forest Service had a Mean Absolute Percent Error of 38 percent meaning the typical forecast averaged 38 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 78 percent of the time. The predicted direction of change for FY 2014 compared to FY 2013 is negative (downward) when considered from the median forecast excluding the cost pool (Figure 1).

Modeling Framework for the September 2013 Forecast of FY 2014 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 2013 FLAME Act Model for FY2014 covered department wide expenditures for fiscal years 1988-2012.⁴ We modeled aggregate DOI expenditures using a parsimonious model specification involving an April minimum Palmer H-indices, a three-year lag of DOI expenditures, and a variable to represent a still unspecified change in climate and/or policy (year 2000 onward dummy variable).

The DOI suppression expenditure forecast equation is reported in Table A3. It included the Palmer H-index for Forest Service Region 2 April minimum (t-1), lagged expenditures, time, year 2000 dummy variable, and an intercept. The estimated equation explained 81 percent of the variation ($R^2 = 0.81$) in annual DOI suppression expenditures over the historical time period, 1988-2012. The Durbin H-statistic indicated no evidence ($p=0.338$) of residual autocorrelation in the model estimation errors.

Model fitness for the September FLAME Act Forecast Model for FY2014 for DOI is reported in Appendix Table A4. As in the case of the Forest Service September FLAME Act Forecast Model, the DOI September FLAME Act Forecast Model was evaluated by making jackknife forecasts of DOI expenditures. This September forecast model had a root mean squared error of about \$67 million when calculated over 1988-2012. The model had a bias of positive \$5.1 million (1.7 percent) calculated over 1988-2012 (and these historical biases were not used to adjust the 2014 forecast). The model had a Mean Absolute Percent Error of about 22 percent for the 1988-2012 period. It correctly predicted the direction of change in suppression expenditure for the agency from one year to the next about 76 percent of years 1988-2012.

Results

USDA Forest Service

FY 2014 suppression expenditures are forecast to range, with 80 percent confidence, between \$872 million and \$1.77 billion. The median forecast is \$1.32 billion. These costs include \$58 million in estimated cost pool contributions which are added to the forecast for the total Forest Service (Table 1). The forecast probability density is shown in Figure 1 and the not-to-exceed

⁴ 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.

levels at a range of probabilities are reported in 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 \$507 million. In contrast, there is a 70 percent chance that these expenditures will fall below \$1.5 billion.

An analysis of historical real dollar expenditures in suppression contains information about the likely financial magnitude of spending for FY 2014 (Table 3), by Forest Service region and in total. An examination of this table reveals that, when compared to expenditures since 1995, regions 1, 2, 5, 6, 8, 9, and the total for the Forest Service are forecast to be in the upper tercile in 2014, while regions 3, 4, and the Rest of Forest Service are expected to have expenditures in the middle tercile. Region 10 is the exception in that it is forecast to have expenditures in the lower tercile. When compared with spending since 1977, costs are forecast to be in the upper tercile in total and for all regions except region 10 (lower tercile) and the Rest of Forest Service (middle tercile).

Department of the Interior

The FY 2014 suppression expenditures for the DOI are forecast to range, with 80 percent confidence, from \$325 million to \$490 million, with a median forecast of \$408 million. The 90 percent confidence band spans \$297 million to \$518 million, while a 95 percent band spans \$270 million to \$545 million (Table 4). As in the Forest Service forecast, uncertainty surrounding the DOI forecast for FY 2013 is illustrated with a 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 higher in real dollar terms compared to the observed expenditures since 1988.

Table 1. September 2013 FLAME Act Forecasts of Fiscal Year 2014 Suppression Expenditures of the USDA Forest Service, by Region and in Total, Current (FY 2014) Dollars

<i>Millions of 2014\$</i>	R1	R2	R3	R4	R5	R6	R8	R9	R10	RFS	Total*
Median	\$142	\$48	\$104	\$91	\$513	\$138	\$62	\$14	\$1	\$96	\$1,319
80% Confidence Lower Limit	42	14	37	46	299	70	23	5	0	0	872
80% Confidence Upper Limit	275	94	191	147	781	235	105	27	7	215	1,767
90% Confidence Lower Limit	10	4	17	34	246	57	7	2	0	0	745
90% Confidence Upper Limit	330	113	221	165	866	263	122	32	9	248	1,894
95% Confidence Lower Limit	0	0	0	22	203	47	0	0	0	0	635
95% Confidence Upper Limit	383	134	251	182	945	287	137	36	12	275	2,004

* Note: This table includes the Fiscal Year 2014 contributions to the wildland fire suppression cost pool, expected to be \$58 million, which are added to the agency-wide total.

Table 2. September 2013 FLAME Act Forecasts of Fiscal Year 2014 Suppression Expenditures of the USDA Forest Service, Probability of Falling Below Specified Amount, Current (FY 2014) Dollars

Probability (%) of Falling Below Indicated Dollar Amount	Realized Amount (\$ Million 2014)
1	507
5	745
10	872
20	1,025
30	1,136
40	1,231
50	1,319
60	1,408
70	1,503
80	1,613
90	1,767
95	1,894
99	2,132

* Note: This column of totals includes the Fiscal Year 2014 contributions to the wildland fire suppression cost pool, expected to be \$58 million.

Table 3. September 2013 FLAME Act Forecasts of Fiscal Year 2014 Suppression Expenditures of the USDA Forest Service, by Tercile*

Region	Tercile of Costs Expected, Since 1995	Tercile of Costs Expected, Since 1977
1	Upper	Upper
2	Upper	Upper
3	Middle	Upper
4	Middle	Upper
5	Upper	Upper
6	Upper	Upper
8	Upper	Upper
9	Upper	Upper
10	Lower	Lower
RFS	Middle	Middle
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 2013 FLAME Act Forecasts of Fiscal Year 2014 Suppression Expenditures of the Department of the Interior, Current (FY 2014) Dollars

	(Millions of 2014\$)
Median Estimate	408
80% Confidence Lower Limit	325
80% Confidence Upper Limit	490
90% Confidence Lower Limit	297
90% Confidence Upper Limit	518
95% Confidence Lower Limit	270
95% Confidence Upper Limit	545

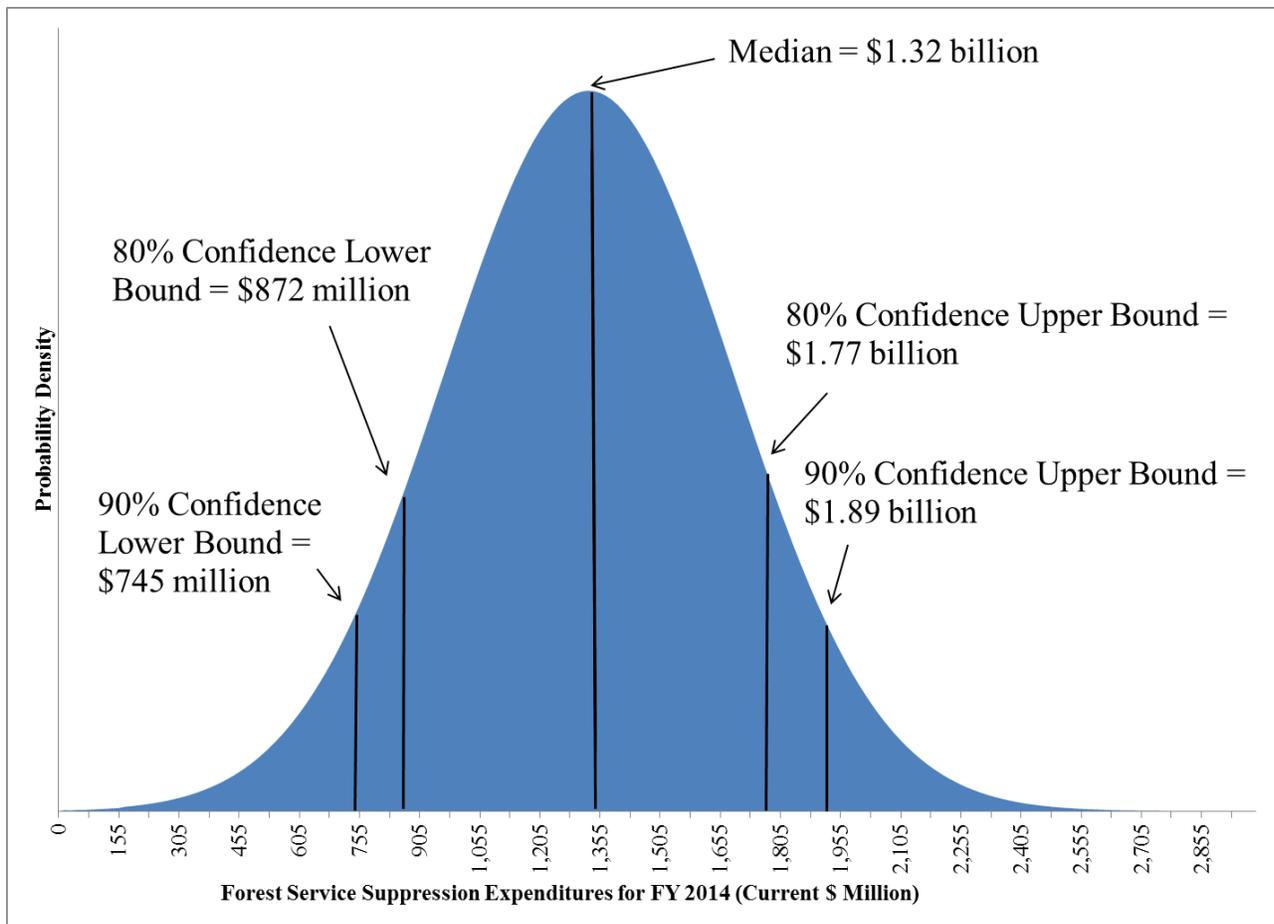


Figure 1. USDA Forest Service suppression expenditure forecast probability density, Fiscal Year 2014, September 2013 FLAME Act Forecast Model. (Note: Fiscal Year 2014 wildland fire suppression cost pool expenditures are included at their expected level of \$58 million in this probability density display.)

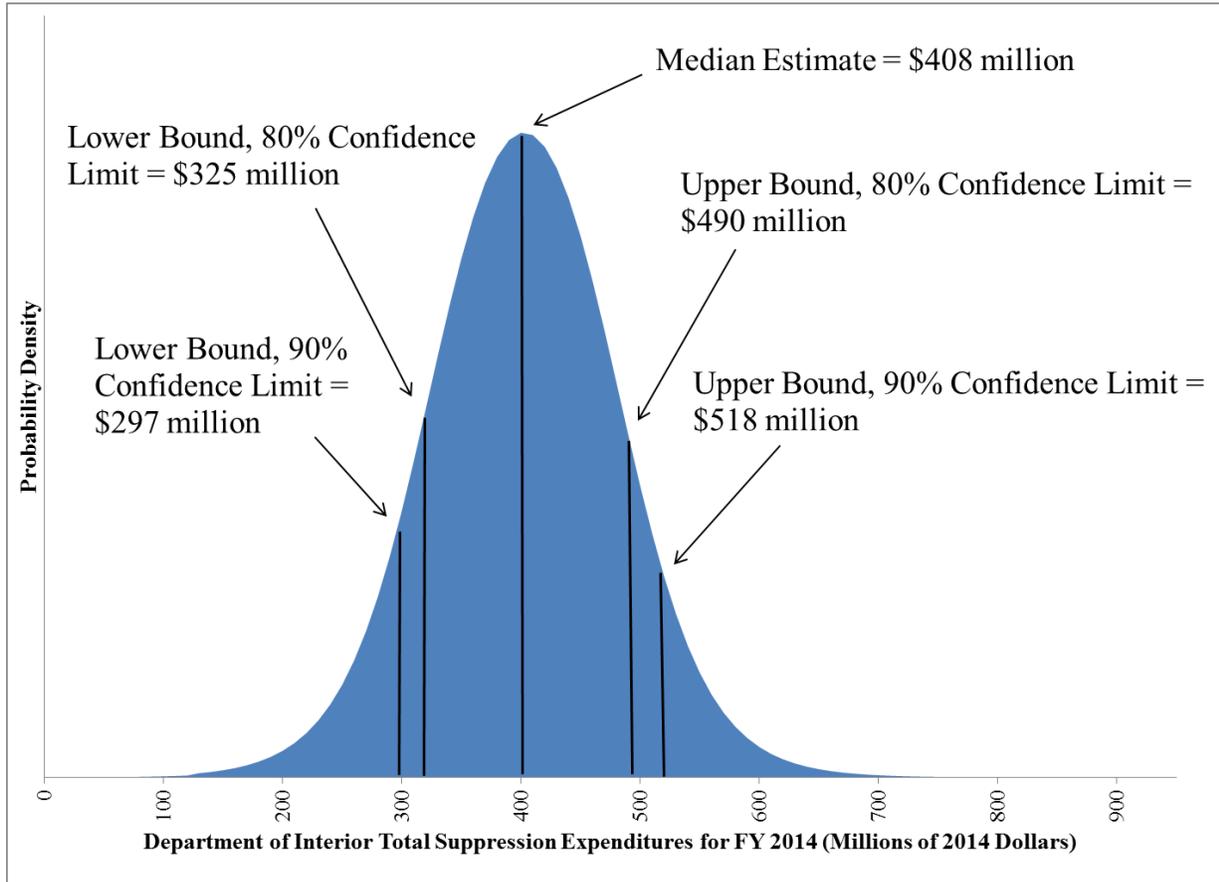


Figure 2. Department of the Interior suppression expenditure forecast probability density, Fiscal Year 2014, September 2013 FLAME Act Forecast Model.

Appendix: Model Estimates and Forecast Evaluation Statistics

Table A1. Seemingly Unrelated Regression Equation Estimates Used in the September 2013 Forecast of FY 2014 Suppression Expenditures of the USDA Forest Service. Note: The dependent variables in the regional models are percentages of total expenditures while the total Forest Service equation dependent variable is the annual total real dollar suppression expenditures.

Dependent Variable	Independent Variables	Coefficient	Std. Error	t-Stat.	P-Value	R ²	Durbin-Watson
Region 1 (%)	Constant	0.0894	0.0165	5.4302	0.0001	0.20	2.51
	Region 2 June Palmer Z-Index (t-1)	-0.0113	0.0060	-1.8874	0.0608		
Region 2 (%)	Constant	-0.0011	0.0071	-0.1525	0.8789	0.29	1.46
	Region 2 January Minimum Palmer Z-Index (t-1)	-0.0172	0.0025	-6.8570	0.0001		
Region 3 (%)	Constant	0.1638	0.0238	6.8907	0.0001	0.26	1.30
	Region 3 April Minimum Palmer Z-Index (t-1)	0.0245	0.0090	2.7069	0.0075		
Region 4 (%)	Constant	0.0367	0.0171	2.1529	0.0327	0.22	2.66
	Region 2 March Minimum Palmer Z-Index (t-1)	-0.0168	0.0054	-3.1181	0.0021		
Region 5 (%)	Constant	0.4862	0.0442	11.0001	0.0001	0.50	1.32
	Niño-3 SSTA June (t-1) Mean	-0.1104	0.0227	-4.8612	0.0001		
	Region 5 % of Total FS Suppression Costs (t-3)	-0.5786	0.1183	-4.8906	0.0001		
Region 6 (%)	Constant	0.1407	0.0080	17.6190	0.0001	0.54	1.98
	Region 1 June Palmer H-Index (t-1)	-0.0169	0.0020	-8.2573	0.0001		
Region 8 (%)	Constant	0.0907	0.0159	5.6919	0.0001	0.30	1.88
	Region 8 May Minimum Palmer S-Index (t-1)	0.0123	0.0044	2.8270	0.0053		
Region 9 (%)	Constant	0.0279	0.0027	10.5327	0.0001	0.47	1.32
	Region 9 January Minimum Palmer H-Index (t-1)	0.0041	0.0007	5.8386	0.0001		
Region 10 (%)	Constant	0.0052	0.0012	4.5033	0.0001	0.22	1.35
	March Westwide Average Palmer H-Index (t-1)	0.0013	0.0004	3.4459	0.0007		

Dependent Variable	Independent Variables	Coefficient	Std. Error	t-Stat.	P-Value	R²	Durbin-Watson
Rest of Forest Service (%)	Constant	0.1650	0.0159	10.4113	0.0001	0.32	0.87
	Region 2 June Palmer Z-Index (t-1)	0.0181	0.0038	4.8196	0.0001		
Total Forest Service (\$)	Constant	-30,421,036,599	21,085,542,656	-1.4427	0.1509	0.61	2.03
	Total FS Suppression Costs (t-3)	-0.4007	0.1007	-3.9805	0.0001		
	2000 onward	551,289,157	126,857,812	4.3457	0.0001		
	Time	15,506,325	10,577,606	1.4660	0.1445		

Table A2. Jackknife Forecast Evaluation of the Seemingly Unrelated Regression Model Used in the September 2013 Forecast of FY 2014 Suppression Expenditures of the USDA Forest Service, Calculated Over Data from 1995-2012.

	R1	R2	R3	R4	R5	R6	R8	R9	R10	RFS	Total
Root Mean Squared Error, 1995-2012	0.0966	0.0290	0.0657	0.0380	0.1223	0.0403	0.0398	0.0082	0.0058	0.0788	278,403,995
Bias, 1995-2012	-0.0045	-0.0018	-0.0002	0.0001	0.0027	-0.0005	-0.0007	0.0001	0.0000	0.0001	-10,741,643
Bias (%)	-4.94	-5.11	-0.22	0.15	0.92	-0.38	-1.37	0.92	-0.40	0.07	-1.40
Mean Absolute Percent Error, 1995-2012	95	65	46	37	44	22	78	65	993	66	38
Correct Direction of Change %, 1995-2012	67	67	67	83	83	61	78	83	61	78	78

Table A3. Equation Estimate Used in the September 2013 Forecast of FY 2014 Suppression Expenditures of the Department of the Interior. Note: The dependent variable is the Department's annual real dollar suppression expenditures

Variable	Coefficient	Standard Error	t-Statistic	Probability
Intercept	188,619,023	27,966,576	6.7444	0.0001
2000 onward	211,283,179	27,624,060	7.6485	0.0001
DOI Costs (t-3)	-0.5571	0.1304	-4.2733	0.0003
Palmer H Index Region 2 Minimum, April (t-1)	-14,323,699	6,311,661	-2.2694	0.0339
Observations	25			
R-squared	0.81			
Equation Error	50,200,268			
Durbin-Watson Statistic	1.48			
Durbin-H Statistic	0.98	(p=0.338)		

Table A4. Jackknife Forecast Evaluation of the Equation Used in the September 2013 Forecast of FY 2014 Suppression Expenditures of the Department of the Interior, Calculated over 1988-2012

Diagnostic	Calculated 1988-2012
Root Mean Squared Error, (2014\$)	66,694,001
Bias, Predicted Minus Actual (2014\$)	5,100,787
Bias (%)	1.74
Mean Absolute Percent Error	22
Correct Direction of Change (%)	76

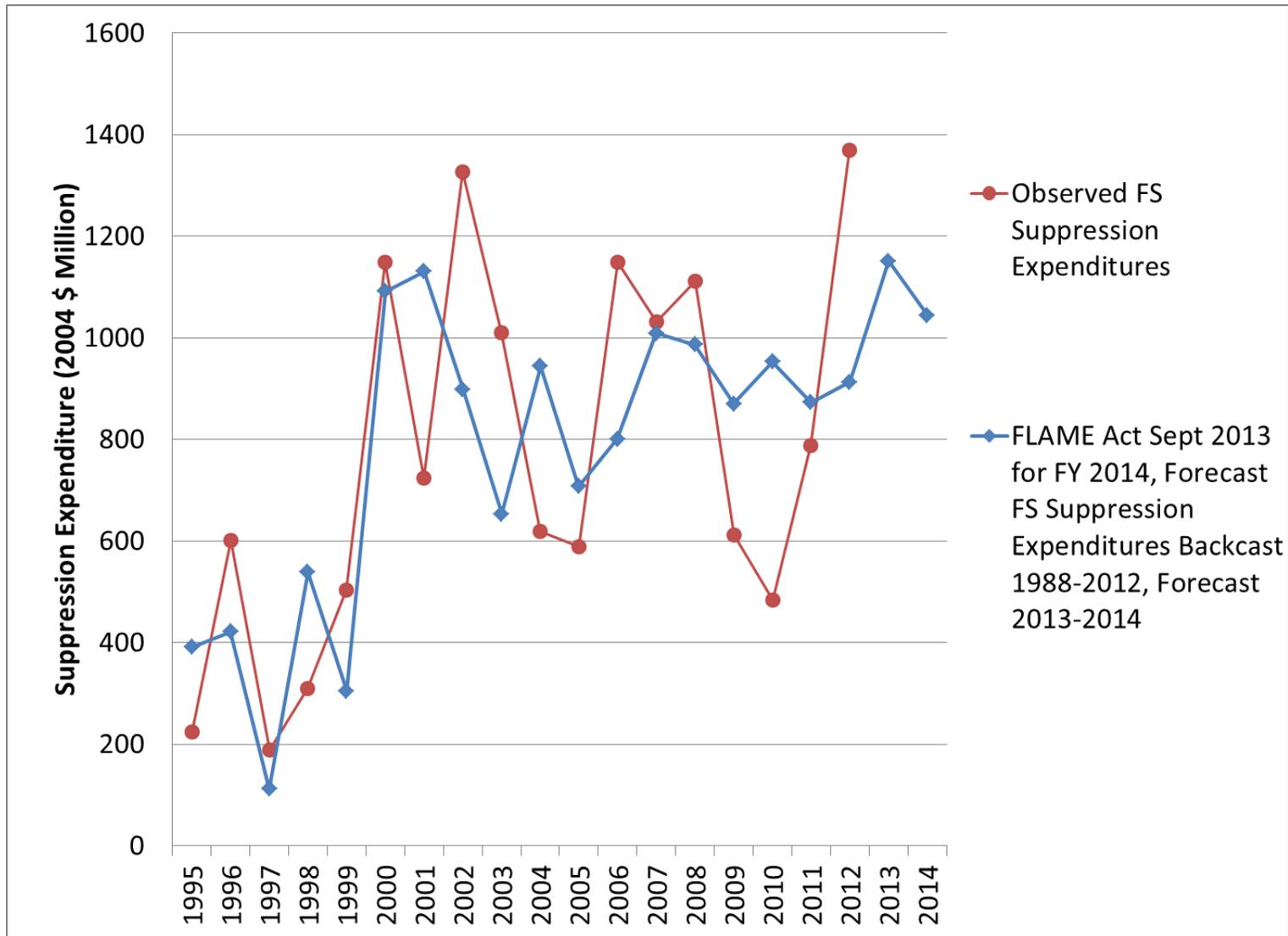


Figure A1. Observed historical USDA Forest Service suppression expenditures (1995-2012) and the forecasts of these expenditures (1995-2014) using the September 2013 FLAME Act Forecast Model. (Note: values are in constant 2004 dollars and exclude the wildland fire suppression cost pool expenditures.)

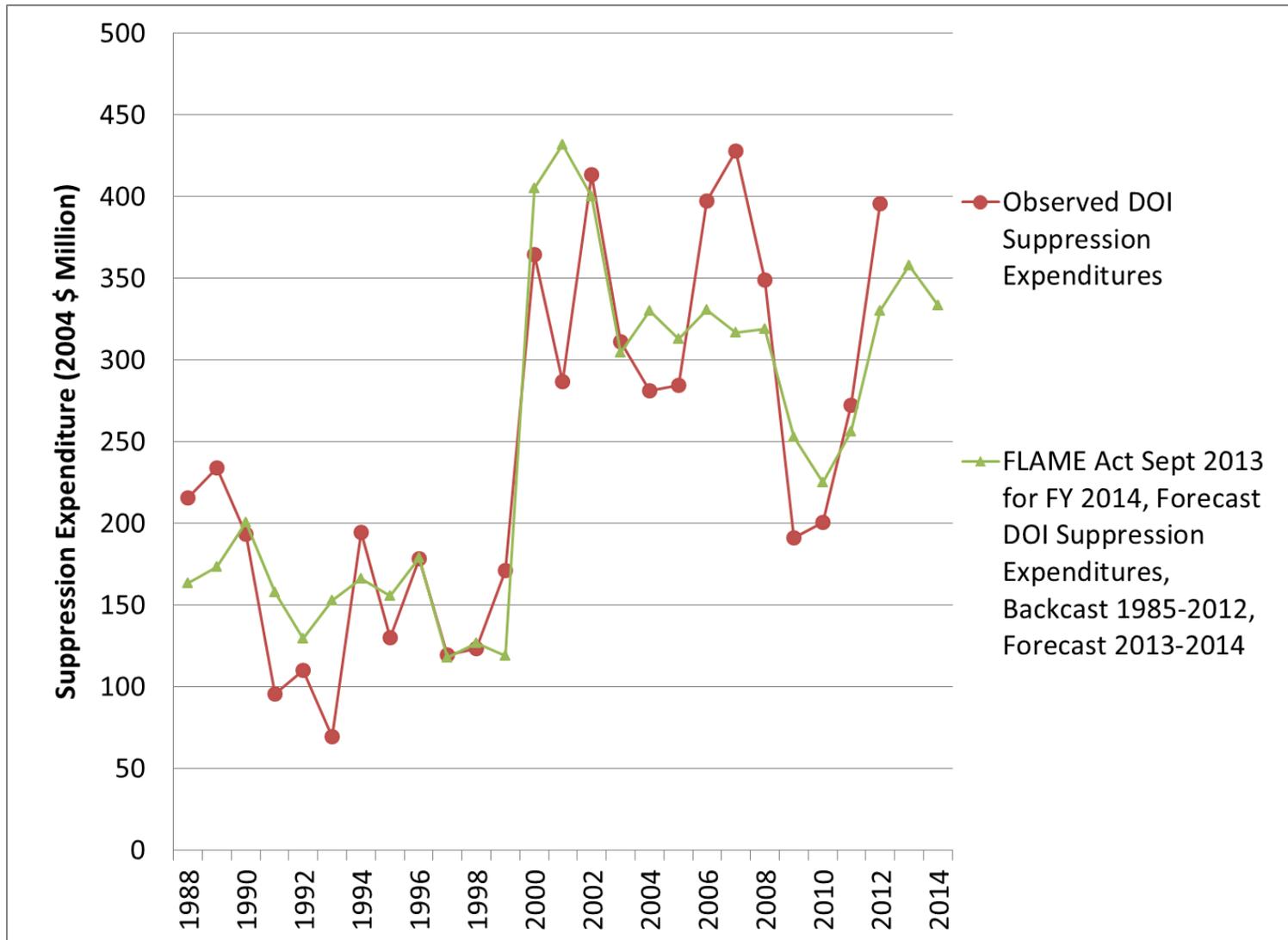


Figure A2. Observed historical Department of the Interior suppression expenditures (1988-2012) and the forecasts of these expenditures (1988-2014), using the September 2013 version of the September FLAME Act Forecast Model. All forecasts for each fiscal year are the point estimates generated with a jackknife procedure. (Note: values are in constant 2004 dollars)