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

May 2014 Forecasts for Fiscal Year 2014

Supporting Documentation

Report Date: April 16, 2014

Executive Summary

The U.S. Department of Agriculture (USDA) Forest Service is forecast to spend, with 90 percent confidence, between $1.222 billion and $1.996 billion in Fiscal Year (FY) 2014, with a median forecast of $1.547 billion. Excluding cost pools, the FY2014 Forest Service median forecast is in the upper tercile of expenditures since 1996 and since 1977. The Forest Service May forecast is higher than both the March 2014 median ($1.22 billion) and the September 2013 median ($1.32 billion). The agencies of the U.S. Department of the Interior (DOI) are forecast to spend, with 90 percent confidence, between $173 million and $419 million, with a median forecast of $296 million. DOI expenditures are expected to be in the middle tercile of expenditures since 1986. The May DOI forecast is lower than the March 2014 median ($336 million) and the September 2013 median ($408 million) for FY2014. The median values in this forecast are within the 90 percent confidence intervals provided in the previous two forecasts for both agencies.

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

FY 2014 suppression expenditures are forecast to range, with 80 percent confidence, between $1.287 million and $1.879 billion. The median forecast is $1.547 billion. These expenditures include $58 million in estimated cost pool contributions (Table 1). 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 states that there is a 1 percent chance that Forest Service suppression expenditures, including the cost pool, will fall below $1.103 billion. In contrast, there is a 70 percent chance that these expenditures will fall below $1.673 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 3, 5, 6, RFS and in total for the Forest Service are forecast to be in the upper tercile in 2014, while regions 4, 8, 9, and 10 are expected to have expenditures in the middle tercile. Regions 1 and 2 are forecast to have expenditures in the lower tercile. When compared with spending since 1977, expenditures are forecast to be in the upper tercile for all categories except regions 1, 2, 8, and 10 which are forecast to be in the middle tercile.

Department of the Interior

FY2014 suppression expenditures for the DOI are forecast to range, with 80 percent confidence, from $200 million to $392 million, with a median forecast of $296 million. The 90 percent confidence band spans $173 million to $419 million, while a 95 percent band spans $150 million to $442 million (Table 4). As in the Forest Service forecast, uncertainty surrounding the DOI forecast for FY 2014 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 within the middle tercile of expenditures since 1986.

Modeling

Modeling Framework for the May 2014 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 ten equations contained in the current modeling system represents a statistical relationship between historical expenditures and a set of predictor variables for a particular Forest Service region. These equations are estimated using ordinary least squares regression (OLS).

This report is the third forecast issued for FY 2014; previous forecasts for FY 2014 were issued for September 2013 and March 2014. 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." Data for modeling were annual fiscal year totals of expenditures, and they ranged from 1995 to 2013, the only years for which consistent region-level data could be assembled. To erase the effects of general price inflation, all expenditure data were adjusted to constant 2004 dollars, using the gross domestic product deflator. The statistical models that predict expenditures in the coming fiscal year were identified with extensive research effort. They relate spending to lagged measures of drought (Palmer indices), ocean temperatures (the Niño-3 sea surface temperature anomaly), and ocean pressure indices (Pacific-

[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.

North American teleconnection pattern, Arctic Oscillation index, and the Pacific Decadal Oscillation index).

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 0.28 (Region 3 and Region 9) to 0.71 (RFS). The exception is Region 10, Alaska, which has very few fires on Forest Service land hence very little expenditure on suppression. Durbin-Watson statistics, designed to detect serial autocorrelation in the residuals of estimated equations, were all within the acceptable (insignificant) or inconclusive range.

Using the equation estimates shown in Table A1 for region-level expenditures, we performed a Monte Carlo simulation that produced a probability distribution of forecast expenditures for each region and for the agency in total. After the simulation was completed, we adjusted the forecast values to put them in current dollars and then added the estimated contributions to the 2014 wildland fire suppression cost pool ($58 million).

When generating a forecast distribution (see Figure 1), we randomly sampled from actual out of sample 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 expenditure estimate for any region or in total. 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 expenditures, and a table of not-to-exceed expenditures by probability levels. We also describe where the median forecast value for each region falls within the observed historical expenditures 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 May 2014 FLAME Act Forecast Model 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, as well as forecasts produced by the September and March FLAME Act Forecast Models. Table A2 shows that the root mean squared error of the model used in this May 2014 forecast of FY 2014 expenditures, when applied to the 1995-2013 period, was $272 million and that it had a negative bias, tending to under-forecast by about $34 million (-4 percent). (This bias was not used to adjust the May 2014 forecast for FY 2014.) The model had a Mean Absolute Percent Error of about 37 percent, meaning that the typical forecast averaged 37 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 89 percent of the time—that is, all years except 1998 and 2008. The predicted direction of change for FY 2014 compared to FY 2013 is positive (upward) when considered from the median forecast excluding the cost pool (Figure A1).

Modeling Framework for the May 2014 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 May 2014 FLAME Act Model covered department wide expenditures for fiscal years 1985-2013.[3] We modeled aggregate DOI expenditures using a parsimonious model specification involving three Palmer H-indices from the West and the one-year lag of DOI expenditures.

The DOI suppression expenditure forecast equation is reported in Table A3. It included the Palmer H-index for Forest Service Region 3 March (t), the Region 4 Palmer H-index values for June of the previous year (t-1), the Region 1 Palmer H-index for the most recent December (i.e., December 2013 values are used to forecast FY 2014 expenditures), lagged expenditures, 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, 1986-2013. The Durbin H-statistic indicated no evidence (p=0.25) of residual autocorrelation in the model estimation errors.

Model fitness for the May FLAME Act Forecast Model for DOI is reported in Appendix Table A4. As in the case of the Forest Service May FLAME Act Forecast Model, the DOI May FLAME Act Forecast Model was evaluated using a cross-validation procedure. This May forecast model had a root mean squared error of about $79 million when calculated over 1995-2013, and $73 million when calculated over 1986-2013. The model had a bias of negative $1.5 million (-0.44 percent) calculated over 1995-2013 and negative $2 million (-0.69 percent) calculated over 1986-2013 (and these historical biases were not used to adjust the 2014 forecast). The model had a Mean Absolute Percent Error of about 23 percent for both the 1995-2013 and the 1985-2013 periods. It correctly predicted the direction of change in suppression expenditure for the agency from one year to the next about 79 percent of years 1995-2013 and 1986-2013. The predicted direction of change for FY 2014 compared to FY 2013 is negative (downward) when considered from the median forecast (Figure A2).

[3] 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. May 2014 FLAME Act Forecasts of Fiscal Year 2014 Suppression Expenditures of the USDA Forest Service in Total, Current (FY 2014) Dollars in Millions

Median	$1,547
80 Percent Confidence Lower Limit	1,287
80 Percent Confidence Upper Limit	1,879
90 Percent Confidence Lower Limit	1,222
90 Percent Confidence Upper Limit	1,996
95 Percent Confidence Lower Limit	1,167
95 Percent Confidence Upper Limit	2,113

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. May 2014 FLAME Act Forecasts of Fiscal Year 2014 Suppression Expenditures of the USDA Forest Service, Probability of Falling Below Specified Amount, Current (FY 2014) Dollars in Millions

Probability (Percent)	Total
1	$1,103
5	1,222
10	1,287
20	1,370
30	1,433
40	1,491
50	1,547
60	1,607
70	1,673
80	1,754
90	1,879
95	1,996
99	2,275

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

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

Region	1996-2013	1984-2013
R1	Lower	Middle
R2	Lower	Middle
R3	Upper	Upper
R4	Middle	Upper
R5	Upper	Upper
R6	Upper	Upper
R8	Middle	Middle
R9	Middle	Upper
R10	Middle	Middle
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. May 2014 FLAME Act Forecasts of Fiscal Year 2014 Suppression Expenditures of the Department of the Interior, Current (FY 2014) Dollars in Millions

Median	$296
80% Confidence Lower Limit	200
80% Confidence Upper Limit	392
90% Confidence Lower Limit	173
90% Confidence Upper Limit	419
95% Confidence Lower Limit	150
95% Confidence Upper Limit	442

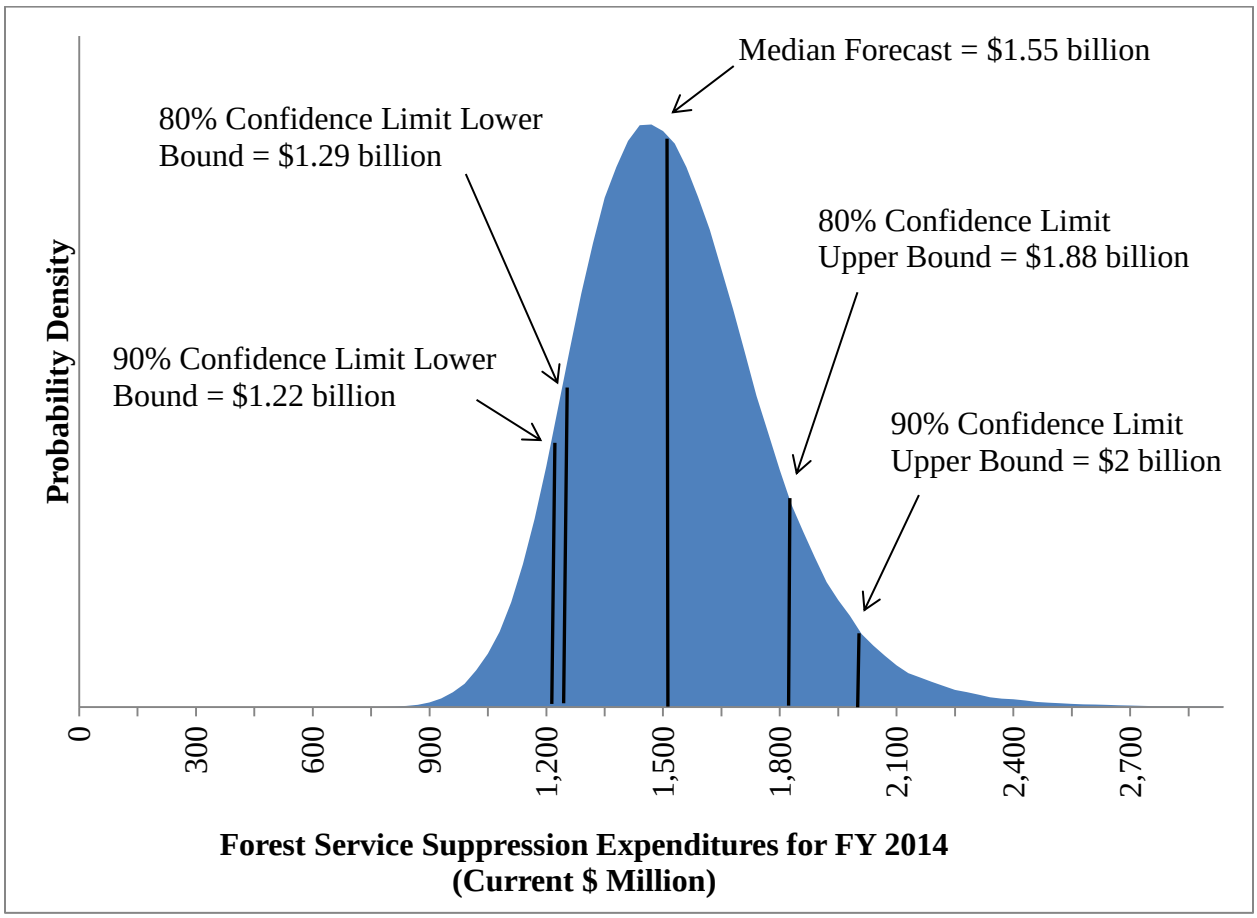

Figure 1. USDA Forest Service suppression expenditure forecast probability density, Fiscal Year 2014, May 2014 FLAME Act Forecast Model. (Note: Fiscal Year 2014 wildland fire suppression cost pool expenditures are included at their expected level of $58 million in this probability density display.)

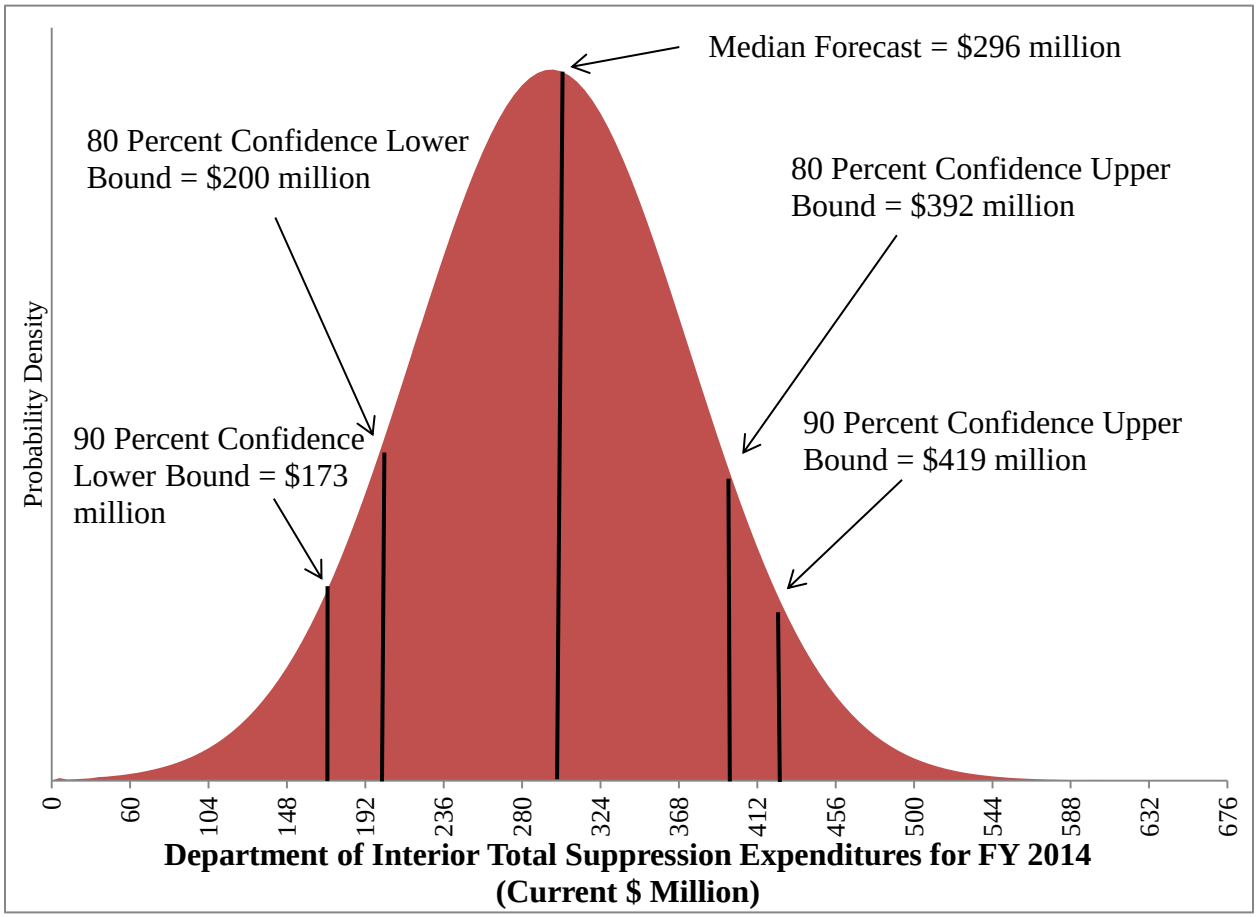

Figure 2. Department of the Interior suppression expenditure forecast probability density, Fiscal Year 2014, May 2014 FLAME Act Forecast Model.

Appendix: Model Estimates and Forecast Evaluation Statistics

Table A1. Ordinary Least Squares Regression Equation Estimates Used in the May 2014 Forecast of FY 2014 Suppression Expenditures of the USDA Forest Service. Note: The Dependent Variable in All Cases is the Indicated Region Annual Real Dollar Expenditures

Dependent Variable	Independent Variable	Coefficient	Std. Error	t-Statistic	Prob.	R2	Durbin Watson
Region 1	Constant	100,989,449	19,305,673	5.23	0.0001	0.35	2.12
	PDO Dec (t-1)	51,279,570	19,647,294	2.61	0.0099		
	AO Jan	33,073,875	15,249,026	2.17	0.0315		
Region 2	Constant	-7,685,991	16,019,957	-0.48	0.6320	0.37	2.39
	PDSI R2 H-index Feb Min	-9,282,500	3,298,100	-2.81	0.0055		
	AO Feb	10,288,404	5,280,047	1.95	0.0531		
Region 3	Constant	-5,549,060,582	4,265,162,211	-1.30	0.1951	0.28	1.86
	PDSI R3 M-index Jan	-11,311,221	6,474,772	-1.75	0.0825		
	Year	2,803,526	2,128,878	1.32	0.1897		
Region 4	Constant	66,268,245	10,308,437	6.43	0.0001	0.32	1.29
	PNA Dec (t-1)	27,113,808	10,689,991	2.54	0.0121		
	Nino-3 SSTA Mar	-31,293,290	17,890,781	-1.75	0.0822		
Region 5	Constant	442,173,744	95,670,429	4.62	0.0001	0.62	1.31
	Nino-3 SSTA Oct-Feb	-36,626,763	21,204,281	-1.73	0.0860		
	PDSI R5 X-index Sep (t-1)	157,114,161	57,726,976	2.72	0.0072		
	PDSI R5 South H-index Mar	-32,625,501	8,735,634	-3.73	0.0003		
Region 6	Constant	86,156,602	15,715,705	5.48	0.0001	0.39	1.85
	PDSI March Westwide	-22,539,050	6,851,438	-3.29	0.0012		
Region 8	Constant	61,071,138	11,531,995	5.30	0.0001	0.54	1.99
	PDSI R8 H-index Mar	-11,276,970	2,662,857	-4.23	0.0001		
	PDSI R8 H-index Jul (t-1)	7,272,759	2,903,629	2.50	0.0132		

Dependent Variable	Independent Variable	Coefficient	Std. Error	t-Statistic	Prob.	R2	Durbin Watson
Region 9	Constant	1,706,307	3,637,110	0.47	0.6396	0.28	1.47
	PDSI R9 H-index March Min	-2,904,592	1,123,783	-2.58	0.0106		
Region 10	Constant	2,173,957	638,317	3.41	0.0008	0.00	1.10
RFS	Constant	-22,556,038,947	4,907,394,562	-4.60	0.0001	0.71	1.46
	Year	11,314,183	2,449,117	4.62	0.0001		
	PDO Dec (t-1)	-50,850,111	14,373,460	-3.54	0.0005		

Table A2. Cross-Validation Evaluation of the Ordinary Least Squares Regression Model Used in the May 2014 Forecast of FY 2014 Suppression Expenditures of the USDA Forest Service, Calculated Over Data from 1995-2013

	May FLAME Act Forecast Model
Root Mean Squared Error, 1995-2013 (2014 $)	271,918,012
Bias, 1995-2013, Predicted Minus Actual (2014 $)	-34,263,187
Bias (percent)	-3.68
Mean Absolute Percent Error, 1995-2013	37
Percent Correct Direction of Change, 1995-2013	89

Table A3. Equation Estimate Used in the May 2014 Forecast of FY 2014 Suppression Expenditures of the Department of the Interior. Note: The Dependent Variable is the Department's Annual Real Dollar Expenditures

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Intercept	102,341,349	32,720,197	3.13	0.0047
Palmer H-Index, Region 3, March (t)	-10,867,734	5,312,184	-2.05	0.0524
Palmer H-Index, Region 4, June (t-1)	29,811,628	5,547,290	5.37	0.0001
Palmer H-Index, Region 1, December (t-1)	-29,624,335	6,621,166	-4.47	0.0002
Expenditures, (t-1)	0.5593	0.1520	3.68	0.0012
Observations	28			
R-squared	0.77			
Equation Error	55,074,595			
Durbin-H Statistic	1.49	(p=0.25)		

Table A4. Cross-Validation Evaluation of the Equation Used in the May 2014 Forecast of FY 2014 Suppression Expenditures of the Department of the Interior, Calculated over 1995-2013 and 1985-2013

	1995-2013	1985-2013
Root Mean Squared Error (2014 $)	78,674,402	73,372,720
Bias, Predicted Minus Actual (2014 $)	-1,479,066	-1,985,211
Bias (Percent)	-0.44	-0.69
Mean Absolute Percent Error	22.43	22.93
Percent Correct Direction of Change	78.95	78.57

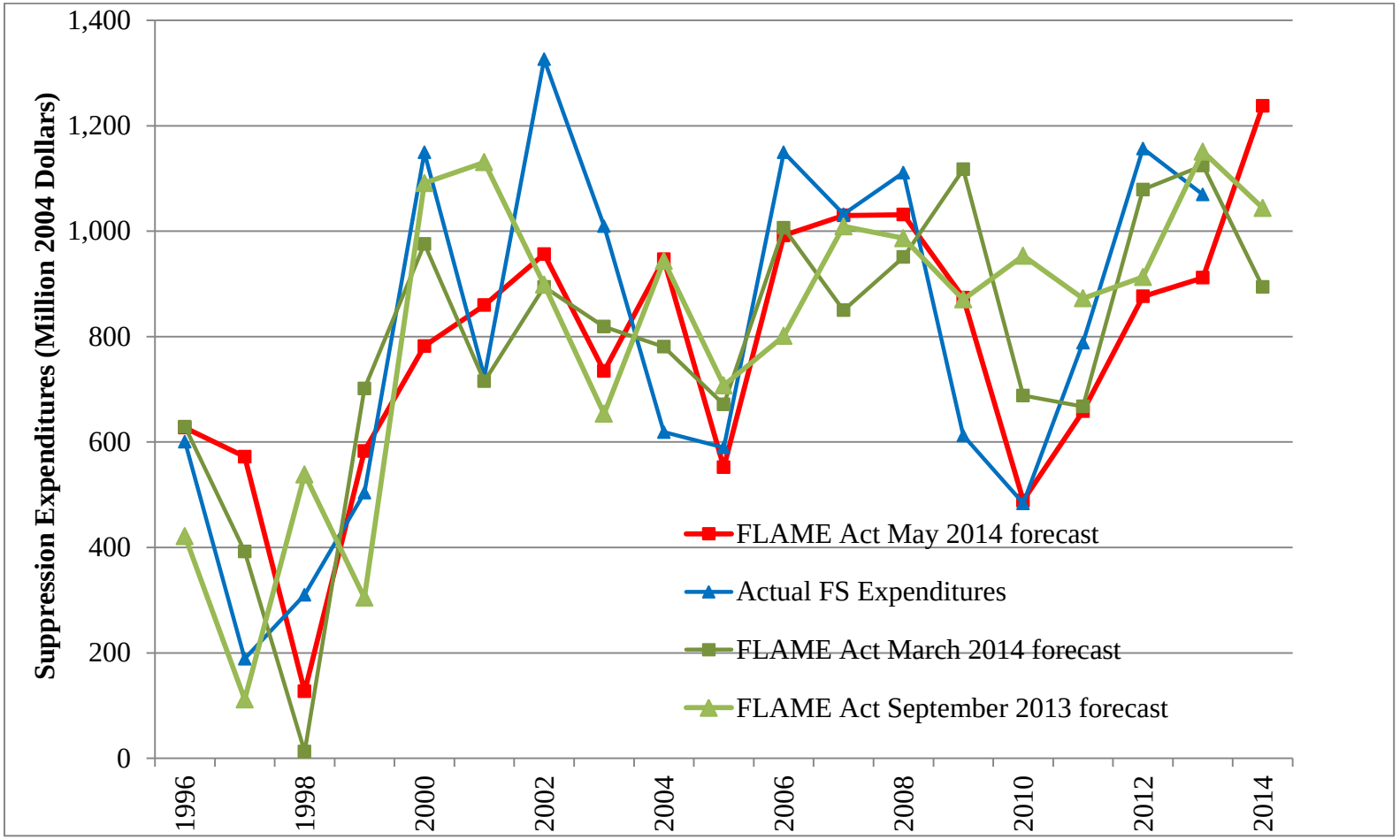

Figure A1. Observed historical USDA Forest Service suppression expenditures and the forecasts of these expenditures (1995-2014) using the May 2014 FLAME Act Forecast Model. All forecasts for each fiscal year are sums across the point estimates of each region's expenditures generated with a cross-validation procedure. (Note: values are in constant 2004 dollars and exclude the wildland fire suppression cost pool expenditures.)

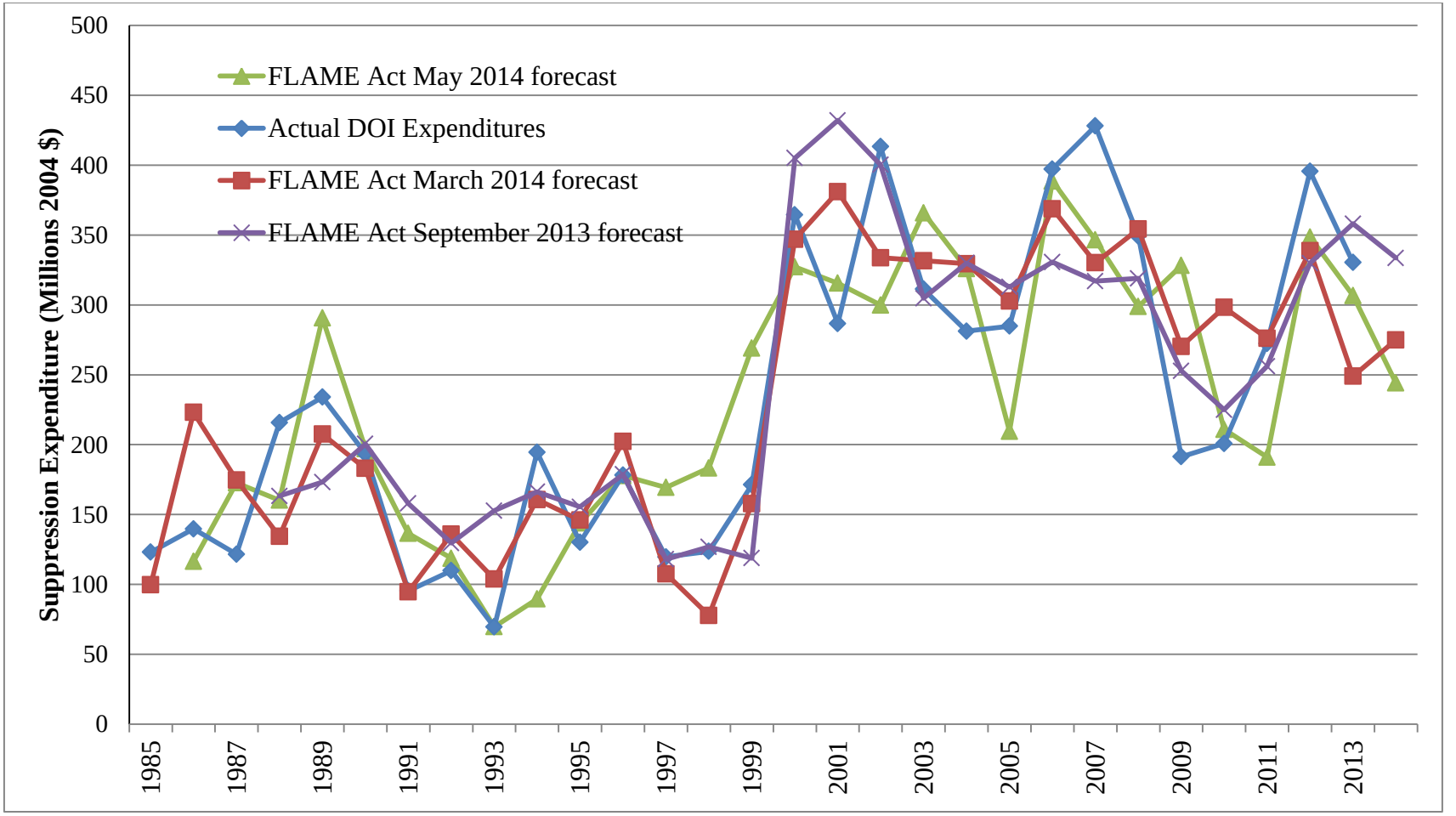

Figure A2. Observed historical Department of the Interior suppression expenditures (1985-2013) and the forecasts of these expenditures (1985-2014), using the May 2014 version of the May FLAME Act Forecast Model. All forecasts for each fiscal year are the point estimates generated with a cross-validation procedure. (Note: values are in constant 2004 dollars)