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

March 2014 Forecasts for Fiscal Year 2014

Supporting Documentation

Report Date: January 31, 2014

Executive Summary

The U.S. Department of Agriculture (USDA) Forest Service is forecast to spend, with 90 percent confidence, between $897 million and $1.57 billion in Fiscal Year (FY) 2014, with a median forecast of $1.22 billion. Excluding cost pools, the FY 2014 Forest Service median forecast is in the upper tercile of costs since both 1995 and 1977. The Forest Service March forecast is lower than the September 2013 forecast for FY 2014 median ($1.32 billion). The agencies of the U.S. Department of the Interior (DOI) are forecast to spend, with 90 percent confidence, between $244 million and $427 million, with a median forecast of $336 million. DOI expenditures are expected to be in the middle tercile of costs since 1985. This DOI forecast is lower than the September 2013 median ($408 million) for FY 2014.

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, July, 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 March 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

[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.

costs 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 second forecast issued for FY 2014. The current approach is to forecast costs by individual Forest Service region, while in past efforts equations were sometimes specified for aggregations of two regions. 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 (Niño-3 sea surface temperature anomaly), and ocean pressure indices (Pacific-North American teleconnection pattern, Atlantic Multidecadal Oscillation index, North Atlantic Oscillation index, and 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 1) to 0.69 (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.

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 not included in the simulation and then added to the total costs from the simulation. 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 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. 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 costs[3], 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 March 2014 FLAME Act 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 March 2014 forecast of FY 2014 expenditures, when applied to the 1995-

[3] It is possible for the lower bounds of the distribution to be less than or equal to zero when suppression expenditures are low and the sampled error is larger, as is the case in Regions 1, 8, 9, and 10. Our interest is primarily on the upper end of the distribution.

2013 period, was $261 million and that it had a negative bias, tending to under-forecast by about $15 million (1.55 percent). (This bias was not used to adjust the March 2014 forecast for FY 2014.) The model had a Mean Absolute Percent Error of 32 percent, meaning that the typical forecast averaged 32 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 74 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 March 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 March 2014 FLAME Act Model covered department wide expenditures for fiscal years 1985-2013.[4] We modeled aggregate DOI expenditures using a parsimonious model specification involving the Pacific-North American teleconnection pattern, the Niño-3 sea surface temperature anomaly, and a variable to represent years after 2000.

The DOI suppression expenditure forecast equation is reported in Table A3. The estimated equation explained 82 percent of the variation ($R^2 = 0.82$) in annual DOI suppression expenditures over the historical time period, 1985-2013. The Durbin Watson statistic indicated no evidence (1.78) of residual autocorrelation in the model estimation errors.

Model fitness for the March FLAME Act Forecast Model for DOI is reported in Appendix Table A4. As in the case of the Forest Service March FLAME Act Forecast Model, the DOI March FLAME Act Forecast Model was evaluated by making jackknife forecasts of DOI expenditures. This March forecast model had a root mean squared error of $67 million when calculated over 1995-2013, and $64 million when calculated over 1985-2013. The model had a bias of negative $1.8 million (-0.5 percent) calculated over 1995-2013 and positive $711 thousand (0.2 percent) calculated over 1985-2013 (and these historical biases were not used to adjust the 2014 forecast). The model had a Mean Absolute Percent Error of 17 percent for the 1995-2013 period and 21 percent for the 1985-2013 period. It correctly predicted the direction of change in suppression expenditure for the agency from one year to the next in about 79 percent of years 1995-2013 and 1986-2013.

[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.

Results

USDA Forest Service

FY 2014 suppression expenditures are forecast to range, with 80 percent confidence, between $968 million and $1.49 billion. The median forecast is $1.22 billion. These costs include $48 million in estimated cost pool contributions, which are not included in the Monte Carlo simulation that generated the median and confidence limits, but then added to the forecast total (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 $750 million. In contrast, there is a 70 percent chance that these expenditures will fall below $1.32 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 and since 1977, Regions 1-6, RFS, and the total for the Forest Service are forecast to be in the upper tercile in 2014, while Region 10 is expected to have expenditures in the middle tercile. Region 8 is forecast to have suppression costs in the middle tercile since 1995 and lower tercile compared since 1977. Region 9 is forecast to have suppression costs in the upper tercile since 1995 and middle tercile compared since 1977.

Department of the Interior

FY 2014 suppression expenditures for the DOI are forecast to range, with 80 percent confidence, from $264 million to $407 million, with a median forecast of $336 million. The 90 percent confidence band spans $244 million to $427 million, while a 95 percent band spans $226 million to $445 million (Table 4). As in the Forest Service forecast, uncertainty surrounding the DOI forecast for FY 2014 is illustrated with 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 in the middle tercile in real dollar terms compared to the observed expenditures since 1987.

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

	Median	80% Confidence Interval Lower Bound	80% Confidence Interval Upper Bound	90% Confidence Interval Lower Bound	90% Confidence Interval Upper Bound	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
R1	94	-2	190	-43	231	-84	272
R2	45	27	96	24	123	23	153
R3	122	66	178	42	202	18	226
R4	105	51	160	36	175	22	189
R5	394	271	517	229	559	188	600
R6	195	127	263	104	286	82	308
R8	13	-10	36	-16	42	-22	48
R9	10	1	18	-1	20	-3	22
R10	1	0	10	0	19	0	36
RFS	172	65	280	51	293	44	300
Total*	1,219	968	1,486	897	1,572	831	1,652

* 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. March 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

Probability (%) of Falling Below Indicated Dollar Amount	R1	R2	R3	R4	R5	R6	R8	R9	R10	R13	Total*
1	-139	21	-14	7	136	53	-28	-6	0	40	750
5	-43	24	42	36	229	104	-16	-1	0	51	898
10	-2	27	66	51	271	127	-10	1	0	65	968
20	39	31	90	70	316	152	-2	4	0	92	1,055
30	64	35	104	83	346	169	4	6	0	118	1,116
40	81	40	114	95	371	182	8	8	1	145	1,169
50	94	45	122	105	394	195	13	10	1	172	1,219
60	107	51	130	116	417	208	17	11	1	199	1,269
70	124	60	140	128	442	221	22	13	2	226	1,323
80	148	72	154	141	472	238	28	15	4	253	1,389
90	190	96	178	160	517	263	36	18	10	280	1,486
95	231	123	202	175	559	286	42	20	19	293	1,572
99	327	200	258	204	652	337	54	25	74	304	1,760

* 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. March 2014 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
R1	Upper	Upper
R2	Upper	Upper
R3	Upper	Upper
R4	Upper	Upper
R5	Upper	Upper
R6	Upper	Upper
R8	Middle	Lower
R9	Upper	Middle
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. March 2014 FLAME Act Forecasts of Fiscal Year 2014 Suppression Expenditures of the Department of the Interior, Current (FY 2014) Dollars

Median	80% Confidence Interval Lower Bound	80% Confidence Interval Upper Bound	90% Confidence Interval Lower Bound	90% Confidence Interval Upper Bound	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
336	264	407	244	427	226	445

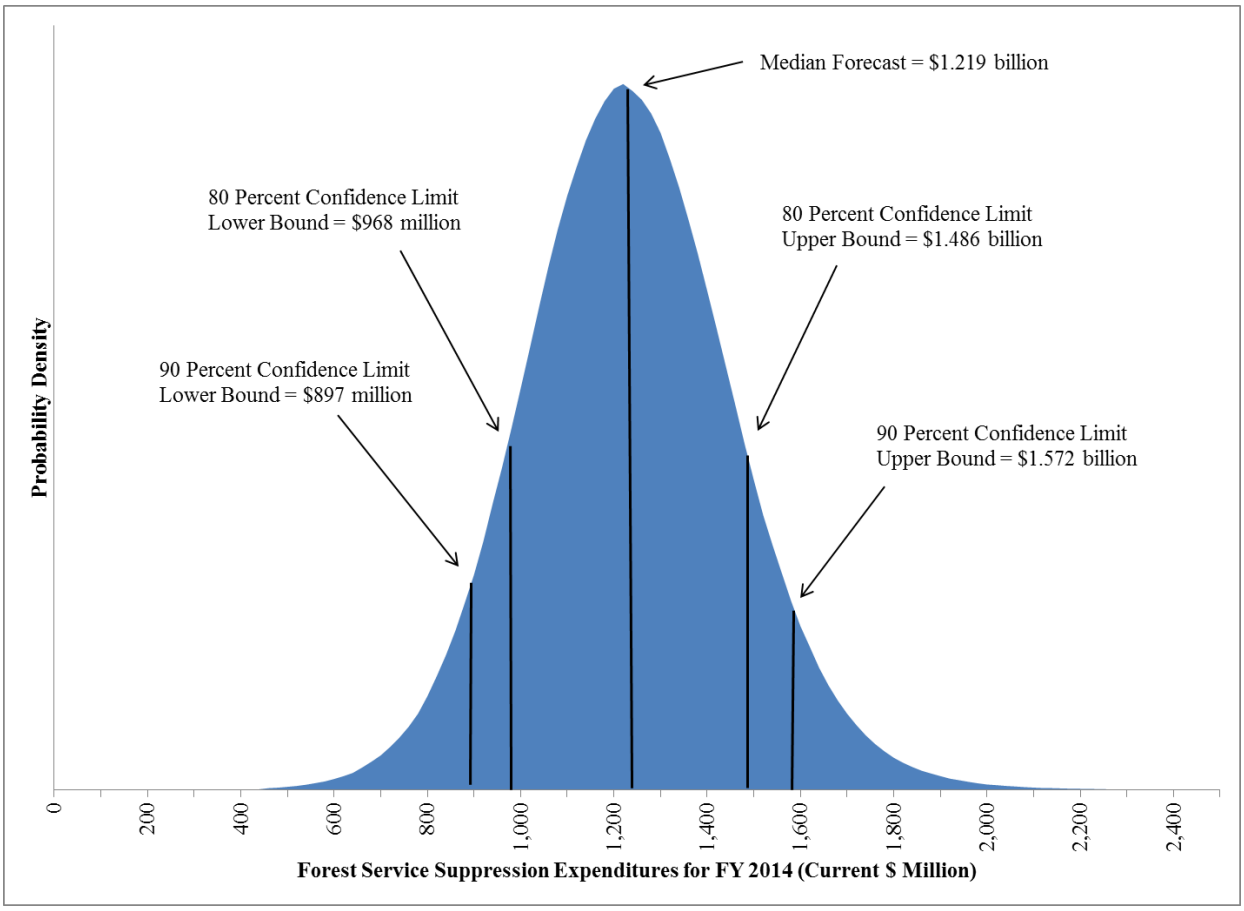

Figure 1. USDA Forest Service suppression expenditure forecast probability density, Fiscal Year 2014, March 2014 FLAME Act Forecast Model. (Note: Fiscal Year 2014 wildland fire suppression cost pool expenditures are included at their expected level of $58 million in this probability density display.)

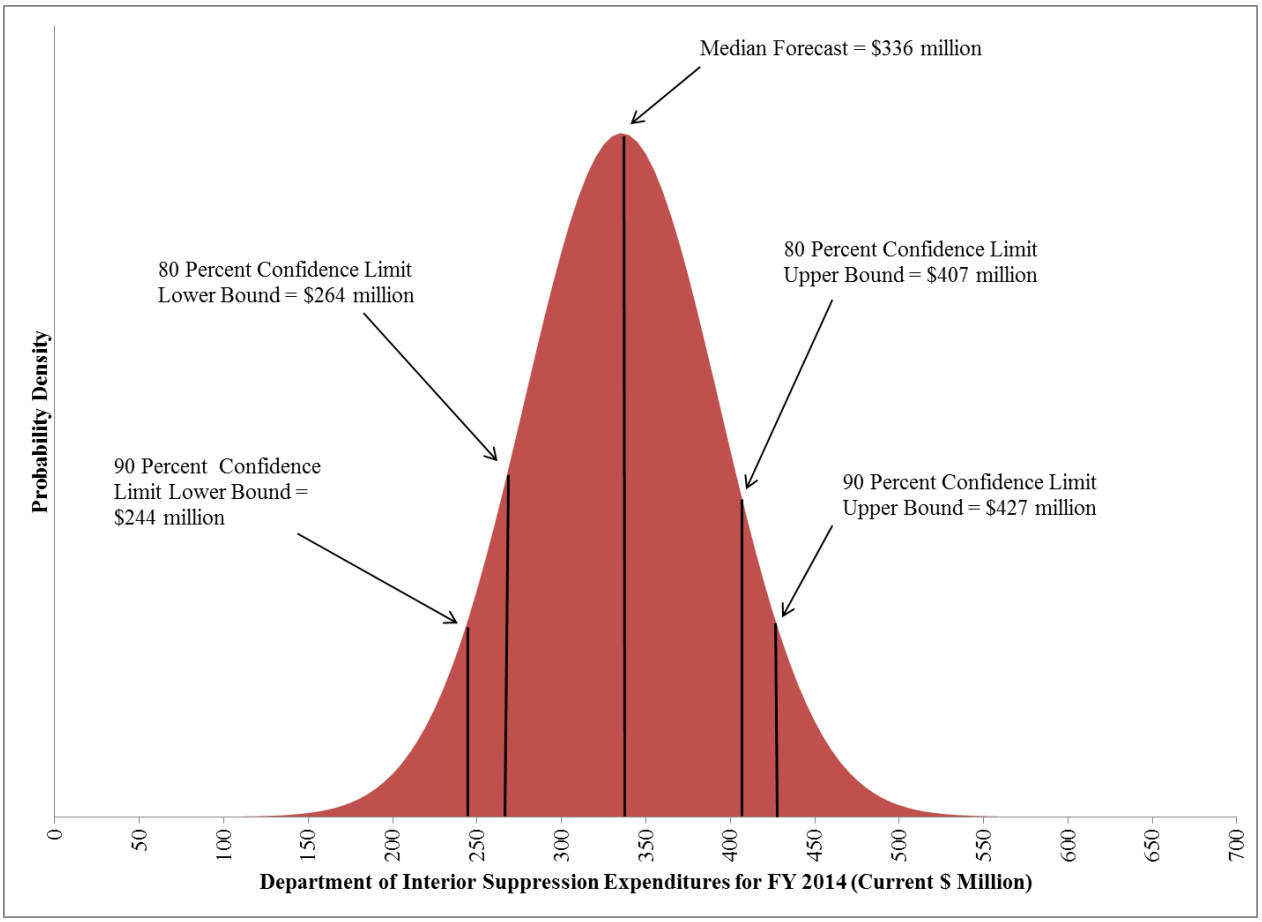

Figure 2. Department of the Interior suppression expenditure forecast probability density, Fiscal Year 2014, March 2014 FLAME Act Forecast Model.

Appendix: Model Estimates and Forecast Evaluation Statistics

Table A1. Ordinary Least Squares Regression Equation Estimates Used in the March 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 Variables	Coefficient	Std. Error	t-Stat.	P-Value	R^2	Durbin-Watson Statistic
Region 1 Cost	Constant	48,817,567	21,981,065	2.2209	0.0278	0.28	1.96
	AMO October (t-2) to February (t-1) Mean	338,948,385	141,160,089	2.4012	0.0175		
	NAO October (t-2) to February (t-1) Mean	47,751,732	29,657,829	1.6101	0.1094		
Region 2 Cost	Constant	-4,191,967,118	2,850,469,398	-1.4706	0.1434	0.32	2.22
	Region 2 December Palmer Z-Index, Weighted Average (t-1)	-22,275,335	8,245,485	-2.7015	0.0077		
	Year	2,107,194	1,422,315	1.4815	0.1405		
Region 3 Cost	Constant	54,992,575	13,869,202	3.9651	0.0001	0.35	1.92
	Region 5 December Palmer S-Index, Weighted Average (t-1)	-13,045,611	6,910,206	-1.8879	0.0609		
	Westwide March Palmer H-Index, Weighted Average (t-1)	-12,531,817	7,374,675	-1.6993	0.0913		
	Pacific Decadel Oscillation December (t-1)	-21,035,077	12,422,104	-1.6934	0.0924		
Region 4 Cost	Constant	-6,637,566,456	3,336,738,994	-1.9892	0.0484	0.52	1.03
	Region 4 December Palmer S-Index (t-1)	-14,804,681	5,439,876	-2.7215	0.0072		
	Region 4 March Palmer H-Index (t-1)	14,411,251	4,885,035	2.9501	0.0037		
	Year	3,346,615	1,665,299	2.0096	0.0462		

Dependent Variable	Independent Variables	Coefficient	Std. Error	t-Stat.	P-Value	R^2	Durbin-Watson Statistic
Region 5 Cost	Constant	-17,290,866,713	8,392,892,630	-2.0602	0.0411	0.64	2.18
	Niño-3 SSTA November (t-1)	-50,081,141	17,820,363	-2.8103	0.0056		
	Region 5 December Palmer S-Index Minimum (t-1)	-39,776,834	13,989,374	-2.8434	0.0051		
	Region 5 September Palmer Z-Index Minimum (t-2)	128,019,459	53,340,118	2.4001	0.0176		
	Year	8,782,846	4,191,640	2.0953	0.0378		
Region 6 Cost	Constant	52,571,665	25,178,180	2.0880	0.0384	0.55	1.81
	Region 6 December Palmer H-Index Minimum (t-1)	-17,159,609	6,645,367	-2.5822	0.0107		
	Pacific North American Oscillation December (t-1)	38,728,302	14,409,733	2.6876	0.0080		
	Niño-3 SSTA December (t-1)	-23,797,103	10,625,204	-2.2397	0.0265		
Region 8 Cost	Constant	64,826,156	11,991,284	5.4061	0.0001	0.57	2.00
	Region 8 December Palmer H-Index (t-1)	-12,815,097	3,061,147	-4.1864	0.0001		
	Niño-3 SSTA December (t-1)	5,797,672	3,773,649	1.5364	0.1265		
	Region 8 July Palmer H-Index Minimum (t-1)	7,206,958	2,975,532	2.4221	0.0166		
Region 9 Cost	Constant	-6,967,112	6,795,810	-1.0252	0.3069	0.43	1.77
	Region 9 December Palmer H-Index Minimum (t-1)	-4,030,666	1,690,783	-2.3839	0.0183		
	Pacific Decadel Oscillation November (t-1)	-2,276,903	1,439,162	-1.5821	0.1157		
	Region 9 November Palmer H-Index (t-1)	3,729,056	2,198,195	1.6964	0.0918		
Region 10 Cost	Constant	2,173,957	638,317	3.4058	0.0008	0.00	1.10

Dependent Variable	Independent Variables	Coefficient	Std. Error	t-Stat.	P-Value	R^2	Durbin-Watson Statistic
Region 13 Cost	Constant	-22,838,146,885	5,749,160,039	-3.9724	0.0001	0.69	2.46
	Year	11,469,125	2,868,279	3.9986	0.0001		
	Westwide July Palmer H-Index, Weighted Average (t-1)	34,686,486	11,255,523	3.0817	0.0024		
	Region 2 December Palmer H-Index (t-1)	-24,058,819	10,833,384	-2.2208	0.0278		

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

Root Mean Squared Error, 1995-2013 (2014 $)	261,233,320
Bias, 1995-2013, Predicted Minus Actual (2014 $)	-14,614,829
Bias (%)	-1.55
Mean Absolute Percent Error, 1995-2013	32
Correct Direction of Change %, 1995-2013	74

Table A3. Equation Estimate Used in the March 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	Standard Error	t-Statistic	Probability
Intercept	152,077,320	9,747,798	15.6012	0.0001
Niño-3 SSTA November (t-1)	-24,896,118	7,754,826	-3.2104	0.0036
Years 2000 and after	162,512,906	19,080,210	8.5174	0.0001
Pacific North American Oscillation December (t-1)	37,786,429	9,671,247	3.9071	0.0006
Observations	29			
R-squared	0.82			
Equation Error	48,378,853			
Durbin-Watson* (2, 29)	1.78			

* Not significant: dl=.988, du=1.42.

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

Diagnostic	Calculated 1995-2013	Calculated 1986-2013
Root Mean Squared Error (2014 $)	67,348,666	64,450,949
Bias (2014 $)	-1,754,713	711,075
Bias (%)	-0.5	0.2
Mean Absolute Percent Error (%)	17	21
Direction of Change Prediction (% Correct)	79	79

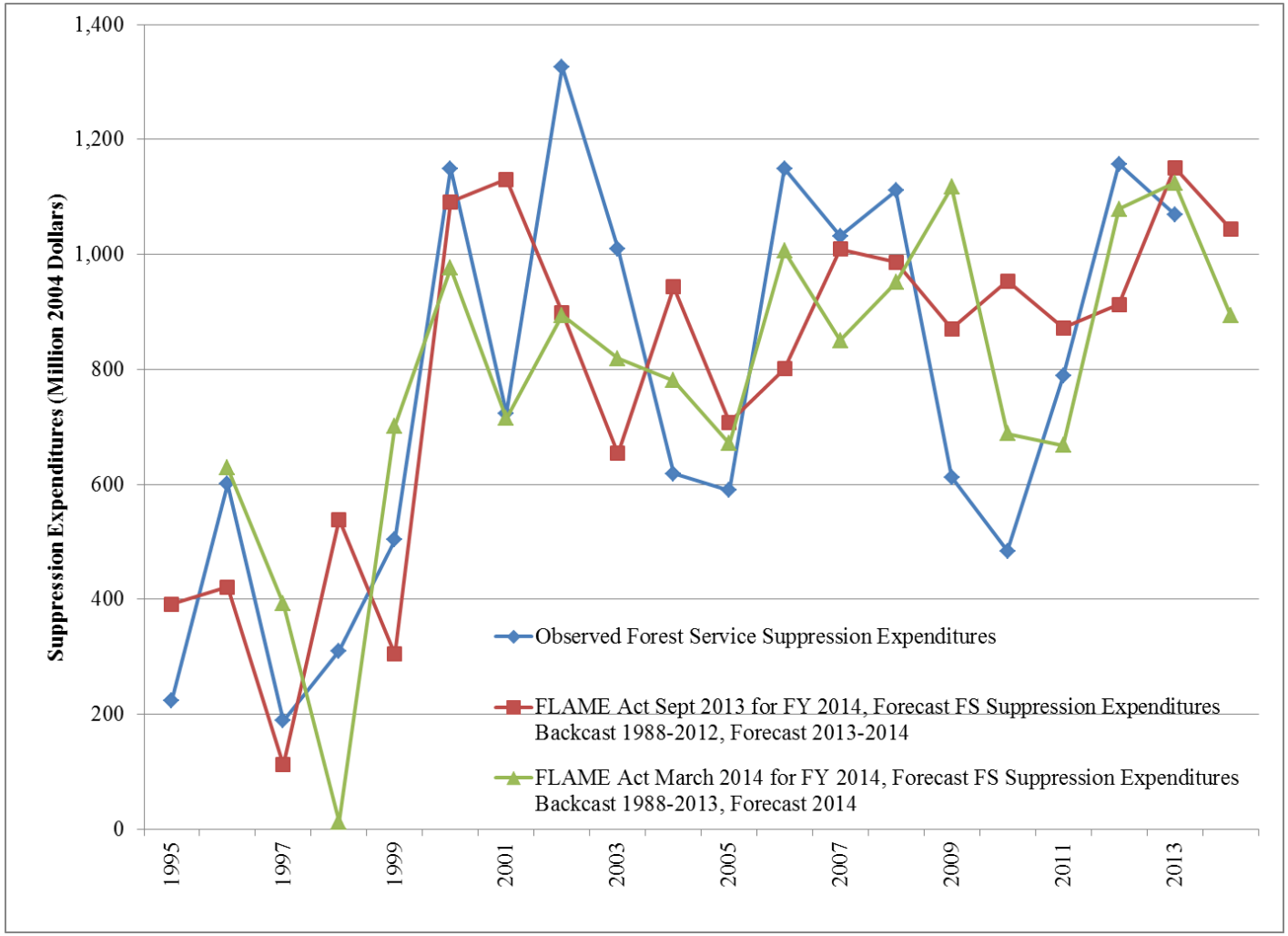

Figure A1. Observed historical USDA Forest Service suppression expenditures and the forecasts of these expenditures (1995-2014) using the March 2014 FLAME Act Forecast Model. All forecasts for each fiscal year are sums across the point estimates of each region's costs generated with a jackknife procedure.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

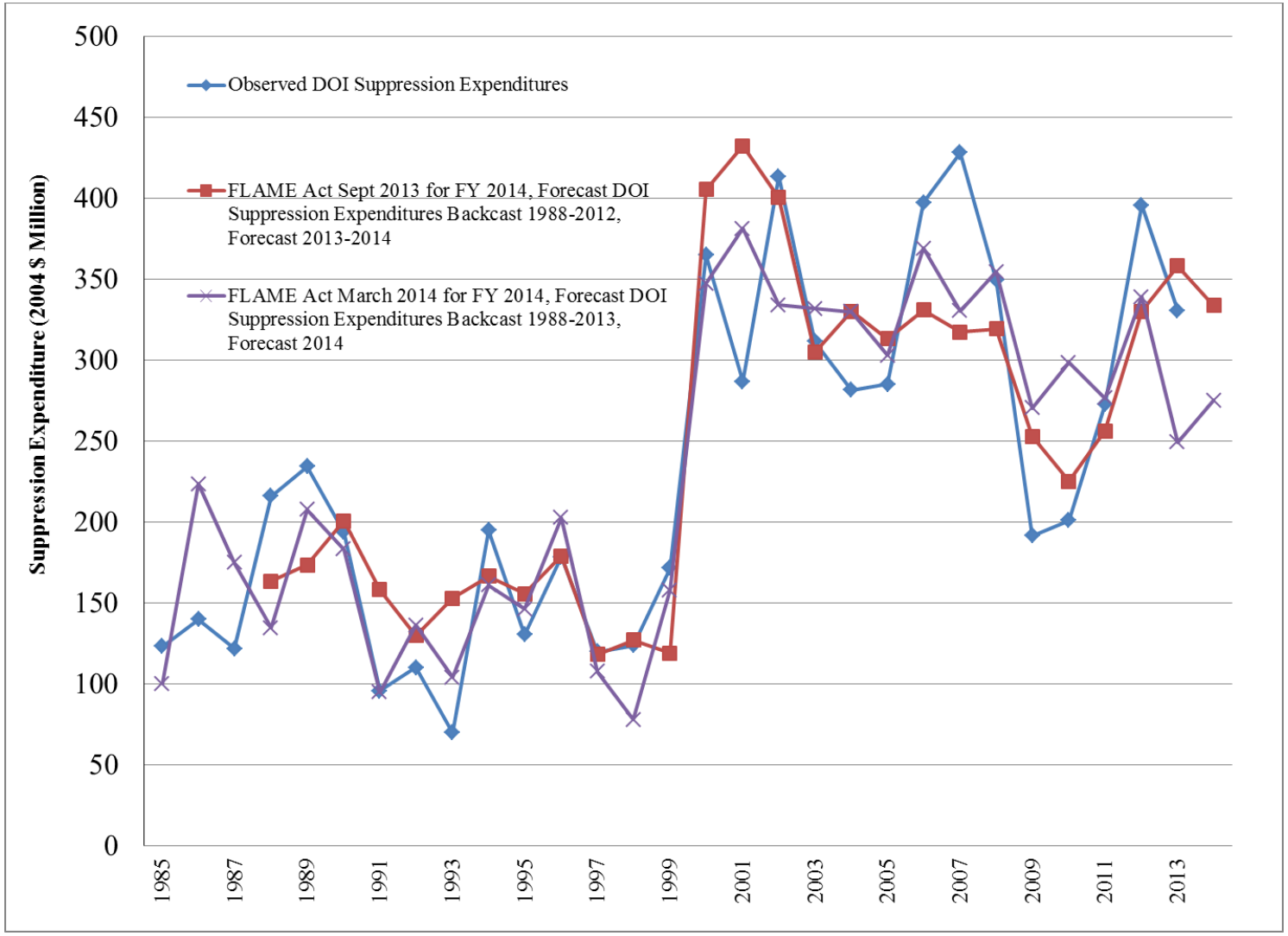

Figure A2. Observed historical Department of the Interior suppression expenditures and the forecasts of these expenditures (1985-2013), using the March 2014 version of the March FLAME Act Forecast Model. All forecasts for each fiscal year are the point estimates generated with a jackknife procedure.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