

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

May 2012 Forecasts for Fiscal Year 2012

Report Date: April 26, 2012

Executive Summary

The U.S. Department of Agriculture (USDA) Forest Service (FS) is forecast to spend, with 80 percent confidence, between \$677 million and \$1.44 billion in Fiscal Year 2012, while the agencies of the Department of the Interior (DOI) are forecast to spend, with 80 percent confidence, between \$279 million and \$473 million. The median forecast for the FS is \$990 million, while the median forecast for DOI is \$363 million. Excluding costs associated with cost pools, the FS's median forecast for FY 2012 represents average costs compared to recent years (since 1995). Compared to the September 2011 forecast for FY 2012, conditions have become more favorable for active seasons in all regions, and this is partly attributable to cold central Pacific Ocean temperature (La Niña) related persistent drought conditions in the Southwest and below-normal precipitation and above normal temperatures in other parts of the West and parts of the East. The DOI agency expenditures are expected to be higher than average in FY 2012. The DOI forecast, like the recently released March 2012 forecast (median forecast of \$366 million), represents an upward shift from the September 2011 forecast (median forecast of \$183 million), primarily due to dry conditions in the Southwest. A secondary reason is the creation of a more accurate forecast system for DOI agencies, which relies primarily on drought information and a longer time series of historical observations.

Overview

The Rocky Mountain Research Station (RMRS) has provided monthly forecasts of annual FS 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 FS suppression expenditures in the fall and spring of the fiscal year. With the passage of the FLAME Act in 2009, both the FS 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.

Modeling

Modeling Framework for the May 2012 Forecast of FY 2012 Forest Service Expenditures

To meet the statutory requirements of the FLAME Act, the FS 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 historical costs and a set of predictor variables for a particular FS 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).

This forecast is the third forecast issued for FY 2012; previous reports were completed for the September and March report dates for the FLAME Act. Similar to these and previous year's forecast efforts, 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 (Southern Oscillation Index, Atlantic Multi-decadal Oscillation index, and the Pacific Decadal Oscillation index). No time trends were included in these equations.

Equation estimates are shown in Table A1, located in an Appendix to this report. This table shows that the models had moderate to high R^2 's, ranging from 0.21 (Region 2 and 3 aggregate) to 0.71 (Region 1 and 4 aggregate). This means that between 21 percent and 71 percent of the variation in the expenditures is explained by the variables included in the regressions. Durbin-Watson statistics, which measure the relationship of the unexplained portion of the expenditures between two consecutive years, 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 2011, 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. 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), we randomly sampled

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.

from equation error and coefficient distributions in ways that accounted for the uncertainties in the forecast. These Monte Carlo forecasts, which are repeated 5,000 times for the FS forecast, do not produce a precise estimate. Rather, they generate a distribution of estimates. This distribution can be summarized in many ways. The 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.³

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 2012 Current 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 FS as well as forecasts produced by the September Out-Year Forecast Model. Table A2 shows that the root mean squared error of the model used in this May 2012 forecast of FY 2012 expenditures, when applied to the 1995-2011 period, was \$251 million and that it had a negligible positive bias, tending to under-forecast by about \$7.6 million (1.03%). (This bias was not used to adjust the May 2012 forecast for FY 2012.) 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 FS 88.2 percent of the time—that is, in all but two of the years, 1995-2011. The predicted direction of change for FY 2012 compared to FY 2011 is slightly negative (-16 million in 2004 dollars; see Figure A1) when considered from the point estimate and slightly positive (+17 million in 2004 dollars) when considered from the median forecast excluding the Cost Pool (Figure 1).

Modeling Framework for the May 2012 Forecast of FY 2012 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 May 2012 Current Year Model covered Department-wide expenditures for Fiscal Years 1985-2011. 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 different from previous models, which related DOI expenditures to FS expenditure forecasts or to just the drought indices. One advantage of using Palmer indices

³ Region or regional aggregate random forecast values for the FS were constrained to be at least as large as spending recorded through April 9, 2012.

rather than FS forecast expenditures is that historical values of the Palmer H-indices were available for the entire length (1985-2011) of the DOI time series.⁴

The DOI suppression expenditure forecast equation is reported in Table A3. It included the Palmer H-index for Forest Service Region 3 March (t), Regions 1 and 4 Palmer H-index values for June of the previous year (t-1), Region 1 Palmer H-index for the most recent December (i.e., December 2011 values are used to forecast FY 2012 costs), lagged expenditures, and an intercept. The estimated equation explained 75 percent of the variation ($R^2 = 0.75$) in annual DOI suppression expenditures over the historical time period, 1985-2011. The Durbin H-statistic indicated no evidence ($p=0.43$) of residual autocorrelation in the model estimation errors.

Model fitness for the May Current Year Forecast Model for DOI is reported in Appendix Table A4. As in the case of the FS May Current Year Forecast Model, the DOI May Current Year Forecast Model was evaluated by making jackknife forecasts of DOI expenditures. This May forecast model had a root mean squared error of about \$76 million when calculated over 1995-2011, and \$70 million when calculated over 1985-2011. The model had a bias of -\$3.7 million (1.39%) calculated over 1995-2011 and \$1.5 million (0.64%) calculated over 1985-2011 (and these historical biases were not used to adjust the 2012 forecast). The model had a Mean Absolute Percent Error of about 23 percent for the 1995-2011 period and 27 percent for the 1985-2011 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 1995-2011 and 73 percent of years 1986-2011.

Results

USDA Forest Service

The FY 2012 suppression expenditures are forecast to range, with 80 percent confidence, between \$677 million and \$1.440 billion. The median forecast is \$990 million. These costs include \$47 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 FS suppression expenditures, including the Cost Pool, will fall below \$479 million. In contrast, there is a 70 percent chance that these expenditures will fall below \$1.144 billion.

An analysis of historical real dollar expenditures in suppression contains information about the likely financial magnitude of spending for FY 2012 (Table 3), by FS 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, Region 5, and the aggregate of regions 8 and 9 are expected to have expenditures in the middle tercile in 2012. The region 2 and 3 aggregate,

⁴ Although the H-indices that we used were based on FS regional geographic boundaries, this allowed for at least a partial representation of how some DOI costs typically cover some FS wildfires. Lagged DOI expenditures helped to limit autocorrelation of model residuals, which can introduce downward bias in standard errors of parameter estimates.

Region 6, and the Rest of the Forest Service are expected to have costs in the upper tercile. When compared with spending since 1977, all regions are forecast to have costs in the upper tercile in 2012.

Department of the Interior

The FY 2012 suppression expenditures for the DOI are forecast to range, with 80 percent confidence, from \$279 million to \$473 million, with a median forecast of \$363 million. The 90 percent confidence band spans \$259 million to \$508 million, while a 95 percent band spans \$244 million to \$545 million (Table 4). As in the FS forecast, uncertainty surrounding the DOI forecast for FY 2012 can be appreciated by examining the probability density (Figure 2). This density distribution was developed using 5,000 Monte Carlo random forecasts, each generated by adding random errors to the forecast model. The median forecast expenditure for the Department is comparable in real dollar terms to the observed expenditures of the first decade of the 2000's.

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

	R 1&4	R 2&3	R 5	R 6	R 8&9	R 10+RFS*	Total*
Millions of 2012 Dollars							
Median	\$121	\$151	\$302	\$146	\$54	\$190	\$990
80% Confidence Lower Limit	66	68	153	74	26	108	677
80% Confidence Upper Limit	223	334	452	291	83	271	1,440
90% Confidence Lower Limit	56	54	111	63	19	100	604
90% Confidence Upper Limit	265	416	491	346	92	294	1,599
95% Confidence Lower Limit	48	45	75	54	13	100	555
95% Confidence Upper Limit	302	505	518	393	98	312	1,748

* Note: This table includes the Fiscal Year 2012 contributions to the Wildland Fire Suppression Cost Pool, expected to be \$47 million, which are added to the Region 10 + RFS forecast and the agency-wide total.

Table 2. May 2012 FLAME Act Forecasts of Fiscal Year 2012 Suppression Expenditures of the USDA Forest Service, by Percentiles, Current (FY 2012) Dollars

Probability (%) of Falling Below Indicated Dollar Amount	Realized Amount* (Millions of 2012 Dollars)
1	\$479
5	603
10	677
20	773
30	849
40	921
50	990
60	1,063
70	1,144
80	1,254
90	1,440
95	1,599
99	2,018

* Note: This table includes the Fiscal Year 2012 contributions to the Wildland Fire Suppression Cost Pool, expected to be \$47 million.

Table 3. May 2012 FLAME Act Forecasts of Fiscal Year 2012 Suppression Expenditures of the USDA Forest Service, by Tercile*

Region or Aggregate	Tercile of Costs Expected, Since 1995	Tercile of Costs Expected, Since 1977
R 1 + R4	Middle	Upper
R 2 + R3	Upper	Upper
R 5	Middle	Upper
R 6	Upper	Upper
R 8 + R9	Middle	Upper
R 10 + RFS	Upper	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. May 2012 FLAME Act Forecasts of Fiscal Year 2012 Suppression Expenditures of the Department of the Interior, Current (FY 2012) Dollars

	Millions of 2012 Dollars
Median Estimate	\$363
80% Confidence Lower Limit	279
80% Confidence Upper Limit	473
90% Confidence Lower Limit	259
90% Confidence Upper Limit	508
95% Confidence Lower Limit	244
95% Confidence Upper Limit	545

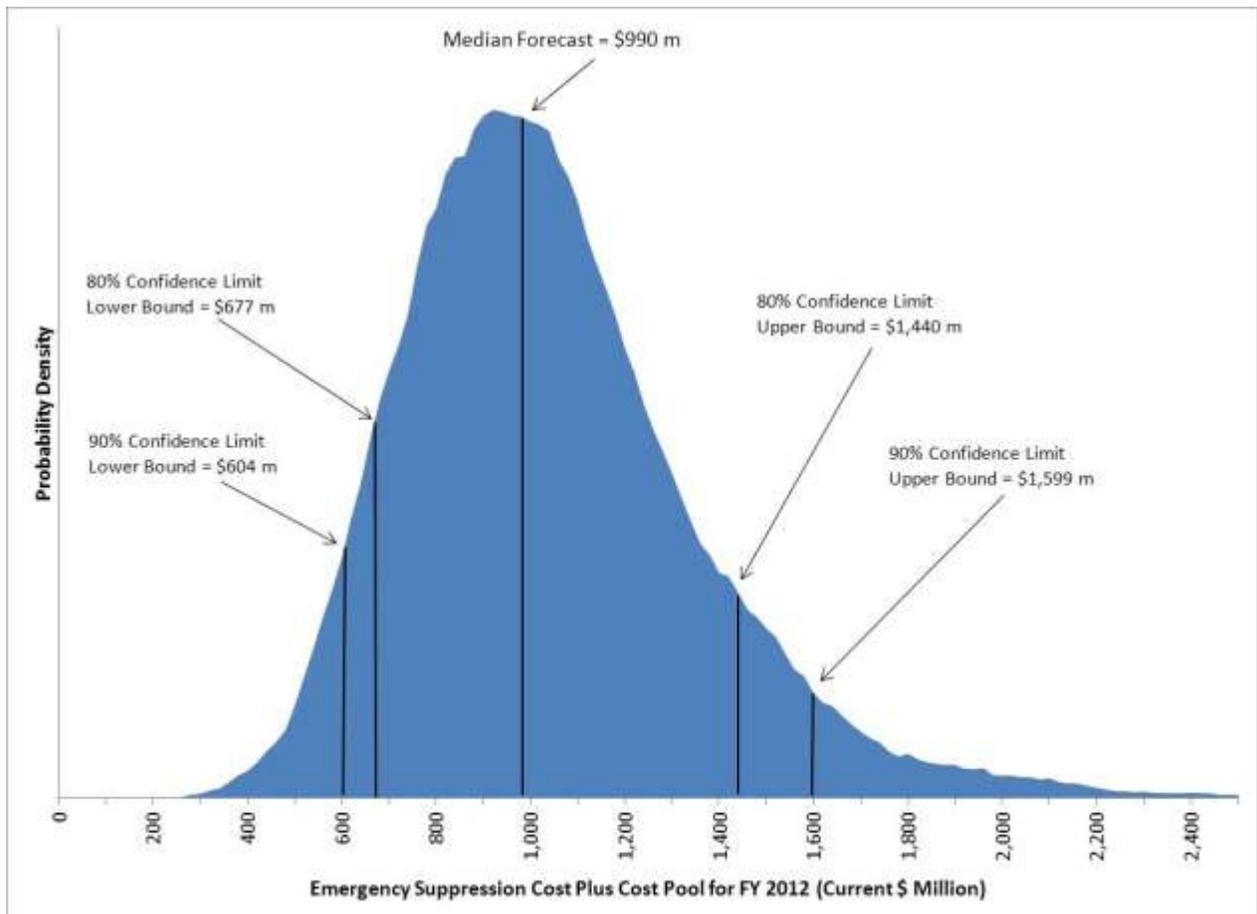


Figure 1. The USDA Forest Service suppression expenditure forecast probability density, Fiscal Year 2012, May 2012 version of the May Current Year Forecast Model. (Note: Fiscal Year 2012 Wildland Fire Suppression Cost Pool expenditures are included at their expected level of \$47 million in this probability density display.)

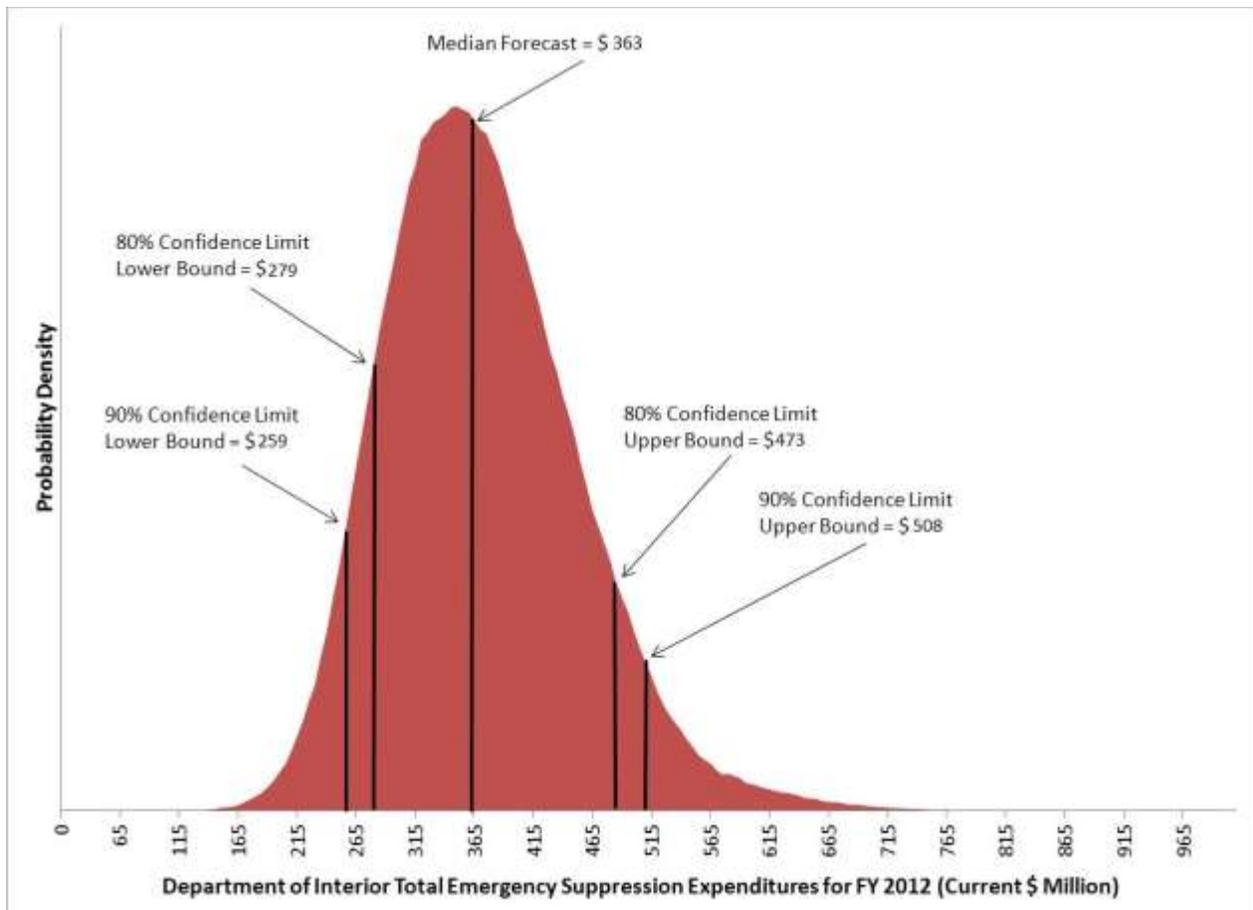


Figure 2. Department of the Interior suppression expenditure forecast probability density, Fiscal Year 2012, May 2012 version of the May 2012 Current Year Forecast Model.

Appendix: Model Estimates and Forecast Evaluation Statistics

Table A1. Seemingly Unrelated Regression Equation Estimates Used in the May 2012 Forecast of FY 2012 Suppression Expenditures of the USDA Forest Service. Note: The Dependent Variable in All Cases is the Natural Log or the Change in 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	R ²	Durbin-Watson Statistic
Ln(Region 1 + Region 4 Cost)	Constant	17.6264	0.1402	125.7662	0.0000	0.71	1.80
	SOI August (t-1)	-0.3413	0.0909	-3.7545	0.0003		
	AMO Mean October (t-2) to February (t-1)	1.9465	0.4859	4.0062	0.0001		
	Niño-3 SSTA Forecast Mean March (t) to September (t)	-0.6469	0.1137	-5.6884	0.0000		
	Westwide Palmer H-Index Weighted Mean March (t) x 1 if < 0 (0 otherwise)	-0.2866	0.0523	-5.4756	0.0000		
Ln(Region 2 + Region 3 Cost)	Constant	18.0894	0.1561	115.8750	0.0000	0.21	2.09
	Niño-3 SSTA Mean October (t-1) to February (t)	-0.1441	0.0877	-1.6424	0.1044		
	Westwide Palmer H-Index Weighted Mean March (t)	-0.1574	0.0594	-2.6493	0.0097		
Region 5 Cost	Constant	422,818,327	74,715,752	5.6590	0.0000	0.61	1.61
	Niño-3 SSTA Mean October (t-1) to February (t)	-46,485,502	16,689,976	-2.7852	0.0067		
	Region 5 Palmer Z-Index Weighted Mean September (t-1)	125,234,311	44,173,042	2.8351	0.0058		
	Region 5 Palmer H-Index March (t)	-30,442,006	8,781,194	-3.4667	0.0008		
Ln(Region 6 Cost)	Constant	18.0428	0.1333	135.3913	0.0000	0.51	2.69
	Westwide Palmer H-Index Weighted Mean March (t)	-0.2782	0.0538	-5.1729	0.0000		
Region 8 + Region 9 Cost	Constant	46,130,187	4,397,383	10.4904	0.0000	0.55	2.13
	Region 8 Palmer H-Index March (t)	-15,225,782	2,426,670	-6.2744	0.0000		
	Niño-3 SSTA Mean October (t-1) to February (t)	10,865,810	3,638,868	2.9860	0.0037		
Region 10 + RFS	Constant	87,844,297	14,776,305	5.9449	0.0000	0.42	2.24
	Niño-3 SSTA Mean October (t-1) to	-33,336,980	10,120,188	-3.2941	0.0015		

Cost	February (t) Niño-3 SSTA Mean October (t-1) to February (t) x PDO Mean October (t-1) to February (t)	15,998,639	8,587,565	1.8630	0.0661
	Westwide Palmer H-Index Weighted Mean March (t-1)	-9,276,248	4,985,475	-1.8607	0.0664

Table A2. Jackknife Forecast Evaluation of the Seemingly Unrelated Regression Model Used in the May 2012 Forecast of FY 2012 Suppression Expenditures of the USDA Forest Service, Calculated Over Data from 1995-2011

	Calculated 1995-2011
Diagnostic	
Root Mean Squared Error (Real 2004 \$)	251,270,625
Bias (Real 2004 \$)	-7,553,583
Bias (%)	-1.03
Mean Absolute Percent Error (%)	40.47
Direction of Change Prediction (% Correct) (from 1995-2011)	88.24

Table A3. Equation Estimate Used in the May 2012 Forecast of FY 2012 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	10.3632	3.0682	3.3776	0.0030
Palmer H-Index, Region 3, March (t)	-0.0639	0.0281	-2.2737	0.0342
Palmer H-Index, Region 1, June (t-1)	-0.0866	0.0496	-1.7463	0.0961
Palmer H-Index, Region 4, June (t-1)	0.1386	0.0419	3.3107	0.0035
Palmer H-Index, Region 1, December (t-1)	-0.0792	0.0505	-1.5684	0.1325
Ln[DOI Expenditures (t-1)]	0.4567	0.1612	2.8338	0.0103
Observations	26			
R-squared	0.75			
Equation Error	0.27			
Durbin-H Statistic (F-Test, 3, 14)	0.89†			

†Not significant (p=0.46)

Table A4. Jackknife Forecast Evaluation of the Equation Used in the May 2012 Forecast of FY 2012 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 (Real 2004 \$)	76,357,410	70,059,544
Bias (Real 2004 \$)	-3,672,576	1,450,640
Bias (percent)	-1.39	0.64
Mean Absolute Percent Error (percent)	22.93	26.99
Direction of Change Prediction (percent Correct)	76.47	73.08

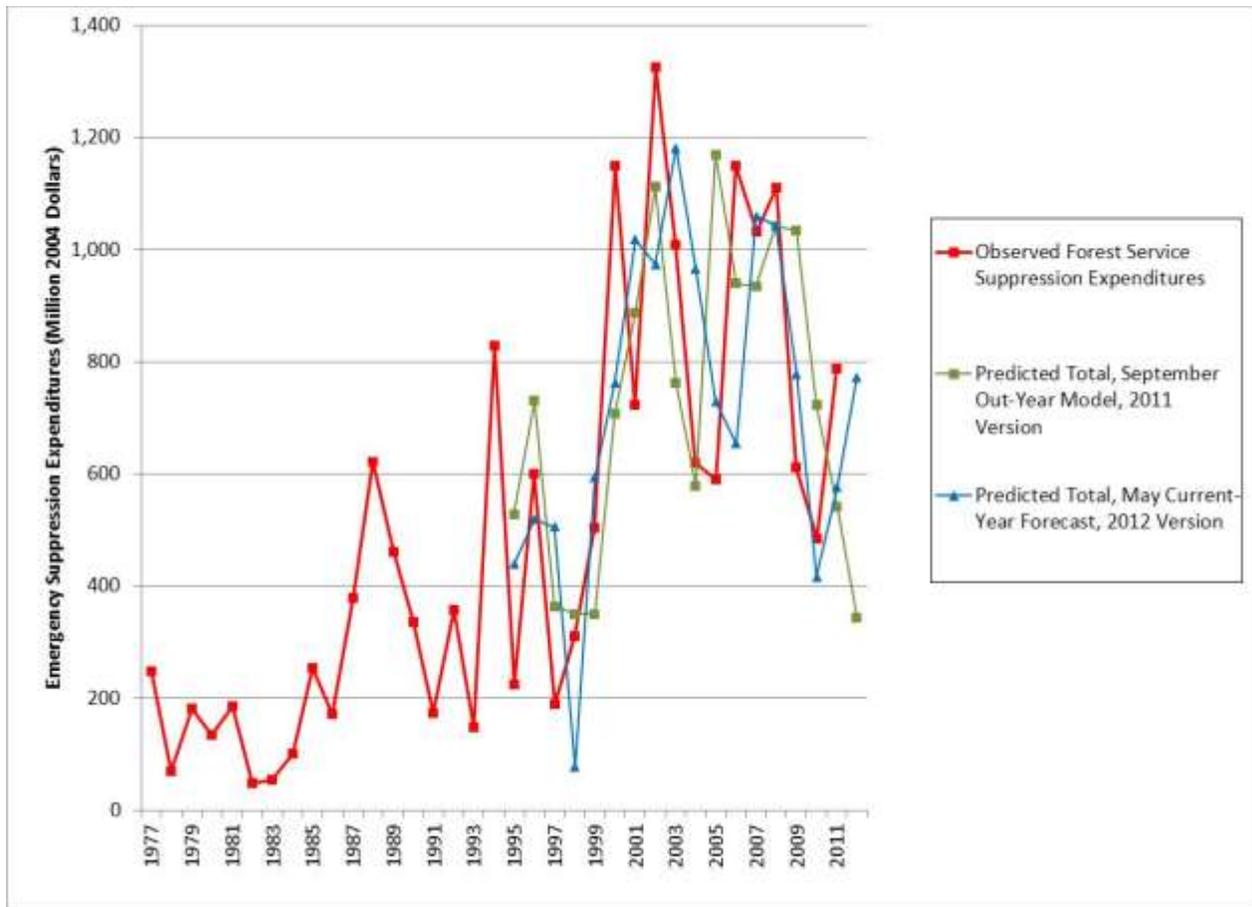


Figure A1. Observed historical USDA Forest Service suppression expenditures (1977-2011) and the forecasts of these expenditures (1995-2012) using the May 2012 Current Year Forecast Model and the September 2011 Out-Year Forecast Model. All forecasts of those expenditures for each fiscal year are sums across the point estimates of each region or region aggregates costs generated with a jackknife procedure. (Note: values are in constant 2004 dollars and exclude the Wildland Fire Suppression Cost Pool expenditures.)

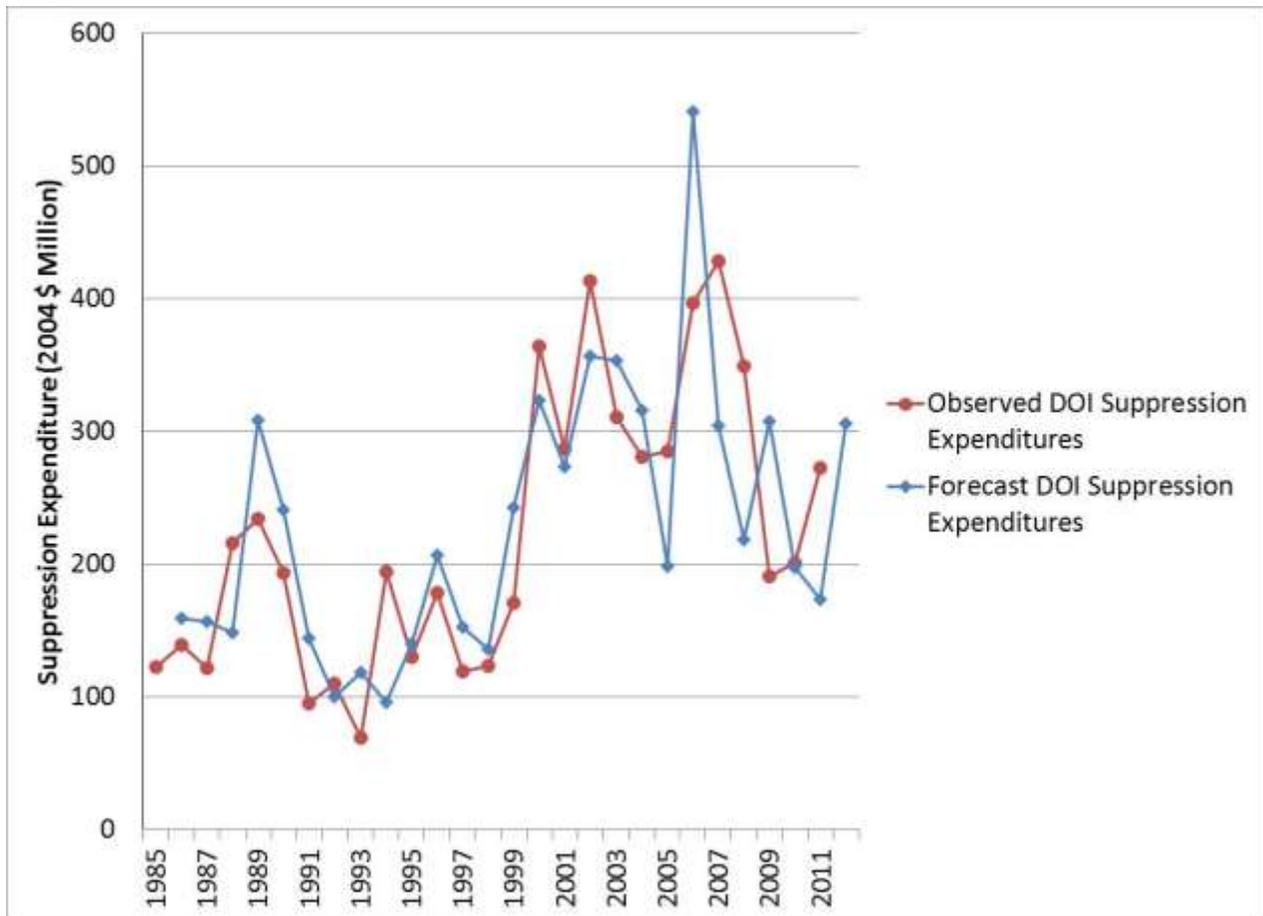


Figure A2. Observed historical Department of the Interior suppression expenditures (1985-2011) and the forecasts of these expenditures (1985-2012), using the May 2012 version of the May Current Year Forecast Model. All forecasts of those expenditures for each fiscal year are the point estimates generated with a jackknife procedure. (Note: values are in constant 2004 dollars.)