

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

March 2013 Forecasts for Fiscal Year 2013

Report Date: February 7, 2013

Executive Summary

The USDA Forest Service (FS) is forecast to spend, with 80 percent confidence, between \$621 million and \$1.409 billion in Fiscal Year (FY) 2013, while the agencies of the Department of the Interior (DOI) are forecast to spend, with 80 percent confidence, between \$157 million and \$385 million. The FS forecast includes \$45 million in expected contributions to the agency's Wildland Fire Suppression Cost Pool. The median forecast for the FS is \$985 million, while the median forecast for DOI is \$281 million. Excluding the Cost Pool, the Forest Service's median forecast for FY 2013 represents average costs compared to recent years (since 1995). Compared to the September 2012 forecast of FS costs for FY 2013, the lower March forecast is consistent with the shift in the El Niño/La Niña – Southern Oscillation from a possible El Niño, to neutral conditions. Further testing revealed instability in the logged and differenced equations used in the September forecast, and we have reverted to simpler linear models until we more fully understand the implications of using what should be statistically more consistent models. The DOI agency expenditures are forecasted to be lower in real dollar terms compared to the average observed expenditures over the last decade. The DOI forecast has also shifted lower since the September 2012 forecast, in part due to changes in forecast methodology.

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. The current report was produced in early February, 2013, in time for review and in compliance with the March 1, 2013, due date for this forecast for FY 2013.

Modeling

Modeling Framework for the March 2013 Forecast of FY 2013 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).

For this forecast, similar to the forecast issued in September of 2012 for FY 2013 and all 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 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 (North Atlantic Oscillation and the Atlantic Multi-decadal Oscillation). The equation for the Region 10 + RFS aggregate included a time trend.

Equation estimates are shown in Table A1, located in an Appendix to this report. This table indicates that most models had low to moderate R^2 's, ranging from 0.15 (Region 2 and 3 aggregate) to 0.65 (Region 8 and 9 aggregate). Durbin-Watson statistics, designed to detect serial autocorrelation in the residuals of estimated equations, 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 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 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 from equation error and coefficient distributions in ways that accounted for the uncertainties in the forecast. These Monte Carlo forecasts, which are repeated 50,000 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. These 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

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.

description of where the median forecast value fell 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 both graphically (Figure A1) and tabularly (Table A2). The graph shows how well the March 2013 FLAME 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 FLAME Forecast Model. Table A2 shows that the root mean squared error of the model used in this March 2013 forecast of FY 2013 expenditures, when applied to the 1995-2012 period, was \$260 million and that it had a negative bias, tending to under-forecast by about \$16 million (-2.06 percent). (This negative bias was not subtracted from the March 2013 forecast for FY 2013.) The model had a Mean Absolute Percent Error of about 34 percent, meaning that the typical forecast averaged 34 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 FS 76 percent of the time – that is, in all but four of the years, 1996-2012. The predicted direction of change is negative; the median 2013 forecast is expected to be roughly \$470 million lower than the observed 2012 expenditure (excluding cost pools).

Modeling Framework for the March 2013 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. Therefore, DOI suppression expenditure data used in the March 2013 FLAME Model covered fiscal years 1985-2012. 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 the same model that was used last March for forecasting DOI suppression expenditures. It differs from the September model with the inclusion of some more recent drought measures from December for regions 1 and 3 as well as lagged expenditures in place of a time trend.

The DOI suppression expenditure forecast equation is reported in Table A3. It included the Regions 1 and 4 Palmer H-index values for June of the previous year (t-1), Region 1 and 3 indices for the most recent December (i.e., December 2012 values are used to forecast FY 2013 costs), lagged expenditures, and an intercept. The estimated equation explained 73 percent of the variation ($R^2 = 0.73$) in annual DOI suppression expenditures over the historical time period, 1985-2012. The Durbin H-statistic ($p=0.15$) indicates there is no remaining residual autocorrelation in the model estimation errors.

Model fitness for the March FLAME Forecast Model for DOI is reported in Appendix Table A4. As in the case of the (FS) March FLAME Forecast Model, the DOI March FLAME Forecast Model was evaluated by making jackknife forecasts of DOI expenditures. This March forecast model had a root mean squared error of about \$78 million, calculated over 1995-2012, \$73 million when calculated over 1985-2012. The model had a bias of about \$2 million (0.9 percent)

calculated over 1995-2012 and \$6 million (2.5 percent) calculated over 1985-2012 (and these historical biases were not used to adjust the 2013 forecast.) The model had a Mean Absolute Percent Error of about 24 percent for the 1995-2012 period and 30 percent for the 1985-2012 period. It correctly predicted the direction of change in suppression expenditure for the agency from one year to the next about 78 percent of years 1995-2012 and 74 percent of years 1986-2012.

Results

USDA Forest Service

FY 2013 suppression expenditures are forecast to range, with 80 percent confidence, between \$621 million and \$1.409 billion. The median forecast is \$985 million. 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 one percent chance that FS suppression expenditures, including the Cost Pool, will fall below \$419 million. In contrast, there is a 99 percent chance that these expenditures will fall below \$1.8 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 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 and the aggregate of Regions 8 and 9 are expected to have expenditures in the upper-tercile in 2013, the aggregate of Regions 2 and 3, Region 6, and the aggregate of Regions 10 and RFS are forecast to have average costs, while Region 5 is projected to have lower-tercile costs. On the other hand, when compared with spending since 1977, Regions 5 and 6 are expected to have average costs in 2013 while all other regions are expected to have higher than average costs.

Department of the Interior

FY 2013 suppression expenditures for DOI are forecast to range, with 80 percent confidence, from \$157 million to \$385 million, with a median forecast of \$281 million. The 90 percent confidence band spans \$127 million to \$409 million, while a 95 percent band spans \$107 million and \$426 million (Table 4). As in the FS forecast, uncertainty surrounding DOI forecast for FY 2013 can be appreciated by examining the probability density (Figure 2). This density distribution was developed using 50,000 Monte Carlo random forecasts, each generated by adding random errors to the forecast model. The median forecast expenditure for the DOI is lower in real dollar terms compared to the average observed expenditures over the last decade.

Contact Information for this Report

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

| | R 1&4 | R 2&3 | R 5 | R 6 | R 8&9 | R 10&13* | Total* |
|----------------------------|-----------------|-------|-----|-----|-------|----------|--------|
| | 2013 \$ Million | | | | | | |
| Median | 367 | 84 | 131 | 98 | 102 | 148 | 985 |
| 80% Confidence Lower Bound | 142 | 4 | 0 | 10 | 70 | 96 | 621 |
| 80% Confidence Upper Bound | 592 | 211 | 338 | 187 | 134 | 289 | 1,409 |
| 90% Confidence Lower Bound | 114 | 0 | 0 | 0 | 66 | 92 | 540 |
| 90% Confidence Upper Bound | 620 | 260 | 418 | 225 | 138 | 350 | 1,548 |
| 95% Confidence Lower Bound | 100 | 0 | 0 | 0 | 64 | 89 | 481 |
| 95% Confidence Upper Bound | 634 | 307 | 496 | 263 | 140 | 411 | 1,680 |

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

| Probability (percent) of Falling Below Indicated Dollar Amount | R 1&4 | R 2&3 | R 5 | R 6 | R 8&9 | R 10&13* | Total* |
|--|-------|-------|-----|-----|-------|----------|--------|
| 1 | 92 | 0 | 0 | 0 | 63 | 88 | 419 |
| 5 | 114 | 0 | 0 | 0 | 66 | 92 | 540 |
| 10 | 142 | 4 | 0 | 10 | 70 | 96 | 621 |
| 20 | 199 | 28 | 38 | 48 | 78 | 107 | 734 |
| 30 | 255 | 47 | 70 | 70 | 86 | 119 | 824 |
| 40 | 311 | 66 | 100 | 86 | 94 | 132 | 905 |
| 50 | 367 | 84 | 131 | 98 | 102 | 148 | 985 |
| 60 | 424 | 105 | 164 | 110 | 110 | 168 | 1,064 |
| 70 | 480 | 129 | 204 | 126 | 118 | 193 | 1,150 |
| 80 | 536 | 161 | 256 | 149 | 126 | 228 | 1,254 |
| 90 | 592 | 211 | 338 | 187 | 134 | 289 | 1,409 |
| 95 | 620 | 259 | 418 | 225 | 138 | 350 | 1,548 |
| 99 | 643 | 369 | 597 | 313 | 141 | 491 | 1,829 |

Note: This table includes the Fiscal Year 2013 contributions to the Wildland Fire Suppression Cost Pool, expected to be \$45 million.

Table 3. March 2013 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 |
|---------------------|---------------------------------------|--|
| R 1&4 | Upper | Upper |
| R 2&3 | Middle | Upper |
| R 5 | Lower | Middle |
| R 6 | Middle | Middle |
| R 8&9 | Upper | Upper |
| R 10&13 | Middle | 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. March 2013 FLAME Act Forecasts of Fiscal Year 2013 Suppression Expenditures of the Department of the Interior, Current (FY 2013) Dollars

| | 2013 Dollars (million) |
|--|------------------------|
| Median Estimate | \$281 |
| Lower Bound, 80 percent Confidence Limit | 157 |
| Upper Bound, 80 percent Confidence Limit | 385 |
| Lower Bound, 90 percent Confidence Limit | 127 |
| Upper Bound, 90 percent Confidence Limit | 409 |
| Lower Bound, 95 percent Confidence Limit | 107 |
| Upper Bound, 95 percent Confidence Limit | 426 |

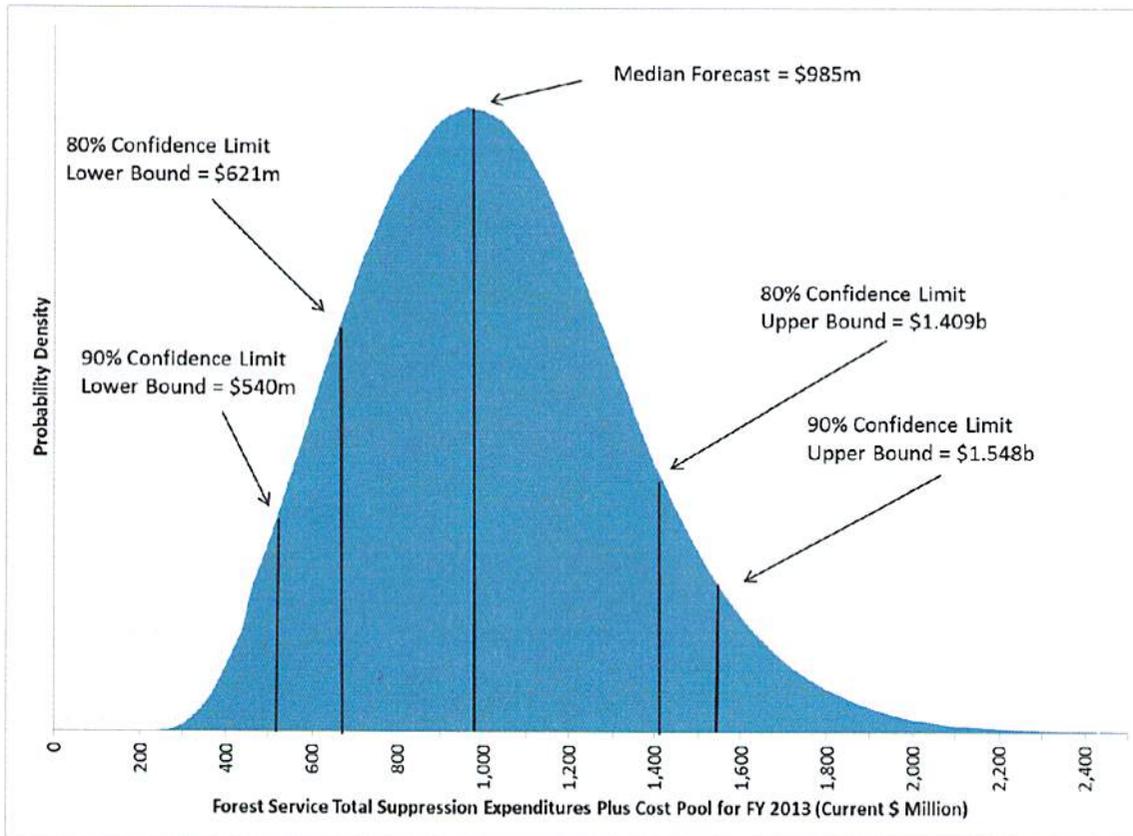


Figure 1. USDA Forest Service suppression expenditure forecast probability density, Fiscal Year 2013, March 2013 version of the March FLAME Forecast Model. (Note: Fiscal Year 2013 Wildland Fire Suppression Cost Pool expenditures are included at their expected level of \$45 million in this probability density display.)

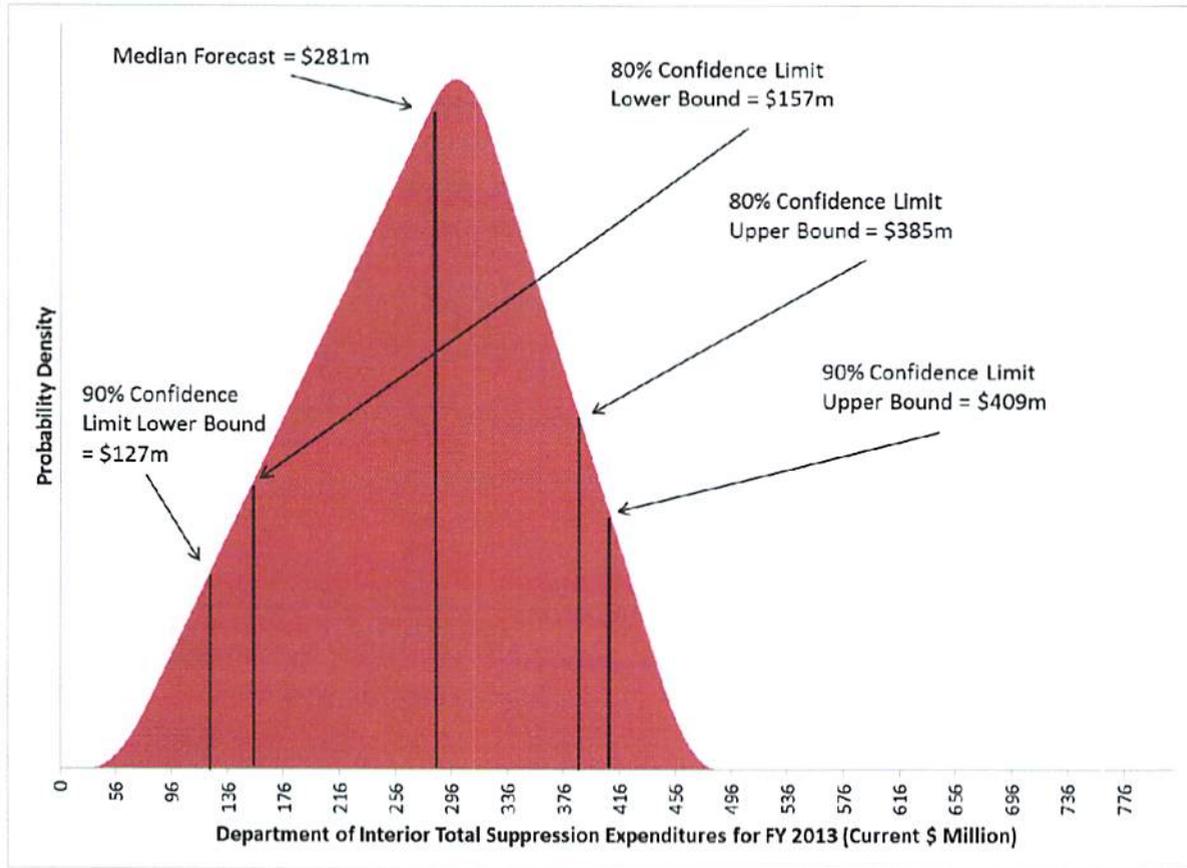


Figure 2. Department of the Interior suppression expenditure forecast probability density, Fiscal Year 2013, March 2013 version of the March 2013 FLAME Forecast Model.

Appendix: Model Estimates and Forecast Evaluation Statistics

Table A1. Seemingly Unrelated Regression Equation Estimates Used in the March 2013 Forecast of FY 2013 Suppression Expenditures of the USDA Forest Service. Note: The Dependent Variable in All Cases is the Indicated Region or Region Sum of Annual Real Dollar Expenditures (1995-2012)

| Dependent Variable | Independent Variables | Coefficient | Std. Error | t-Stat. | P-Value | R ² | Durbin-Watson Statistic |
|--------------------------------|--|------------------|----------------|---------|---------|----------------|-------------------------|
| Region 1 + Region 4 Cost | Constant | -22,783,928 | 0.3130 | 55.5830 | 0.0000 | 0.41 | 1.66 |
| | AMO October (t-2) to February (t-1) Mean | 547,127,064 | 136,807,356 | 3.9993 | 0.0001 | | |
| | NAO October (t-2) to February (t-1) Mean | 81,215,141 | 31,775,791 | 2.5559 | 0.0123 | | |
| | Region 1 + Region 4 June Palmer Z-Index, Weighted Average (t-1) | -42,876,844 | 13,863,153 | -3.0929 | 0.0027 | | |
| Region 2 + Region 3 Cost | Constant | 89,136,039 | 17,856,089 | 4.9919 | 0.0000 | 0.15 | 1.23 |
| | Region 2 + Region 3 September Palmer H-Index, Weighted Average (t-1) | 10,467,340 | 5,746,171 | 1.8216 | 0.0720 | | |
| | March PDSI, Westwide, Weighted Average (t-1) | -25,831,634 | 5,968,445 | -4.3280 | 0.0000 | | |
| Region 5 Cost | Constant | 321,085,847 | 93,554,268 | 3.4321 | 0.0009 | 0.42 | 1.24 |
| | Niño-3 SSTA October (t-1) | -61,266,774 | 18,876,918 | -3.2456 | 0.0017 | | |
| | Region 5 December Palmer Z-Index, Weighted Average (t-1) | -42,795,588 | 19,748,032 | -2.1671 | 0.0330 | | |
| | Region 5 September Palmer Z-Index, Weighted Average (t-2) | 110,245,075 | 50,650,699 | 2.1766 | 0.0323 | | |
| Region 6 Cost | Constant | 106,216,113 | 12,289,814 | 8.6426 | 0.0000 | 0.50 | 1.41 |
| | Region 1 June Palmer H-Index (t-1) | -30,696,899 | 5,925,284 | -5.1807 | 0.0000 | | |
| | Region 4 June Palmer H-Index (t-1) | 11,907,539 | 5,734,499 | 2.0765 | 0.0408 | | |
| Region 8 + Region 9 Cost | Constant | 64,324,529 | 4,327,225 | 14.8651 | 0.0000 | 0.65 | 1.55 |
| | Niño-3 SSTA October (t-2) to February (t-1) Mean | -13,103,118 | 2,597,362 | -5.0448 | 0.0000 | | |
| | Region 9 June Palmer H-Index (t-1) | -10,381,265 | 2,758,158 | -3.7638 | 0.0003 | | |
| | Region 3 June Palmer H-Index (t-1) | 2,880,002 | 1,253,761 | 2.2971 | 0.0240 | | |
| | Region 9 December Palmer H-Index (t-1) | -12,468,970 | 2,571,274 | -4.8493 | 0.0000 | | |
| Region 10 + RFS Cost | Constant | -172,134,965,519 | 22,362,447,466 | -7.6975 | 0.0000 | 0.57 | 1.61 |
| | Region 2 September Palmer H-Index (t-1) | 13,841,936 | 4,108,770 | 3.3689 | 0.0011 | | |
| | Ln(Year) | 22,657,107,625 | 2,941,390,942 | 7.7029 | 0.0000 | | |

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

| Diagnostic | Calculated 1995-2012 |
|--|----------------------|
| Root Mean Squared Error, 1995-2012 (Real 2004 \$) | 259,941,688 |
| Bias, 1995-2012, Predicted Minus Actual (Real 2004 \$) | -15,563,279 |
| Bias (percent) | -2.06 |
| Mean Absolute Percent Error, 1995-2012 | 34.34 |
| Correct Direction of Change percent, 1996-2012 | 76.47 |

Table A3. Equation Estimate Used in the March 2013 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 Dollar Expenditures

| Variable | Coefficient | Standard Error | t-Statistic | Probability |
|--|-------------|----------------|-------------|-------------|
| Intercept | 9.7835 | 3.7711 | 2.5943 | 0.0169 |
| Palmer H-Index, Region 1, June (t-1) | -0.0883 | 0.0421 | -2.0965 | 0.0483 |
| Palmer H-Index, Region 4, June (t-1) | 0.1820 | 0.0350 | 5.2020 | 0.0000 |
| Palmer H-Index, Region 3, December (t-1) | -0.0612 | 0.0266 | -2.3008 | 0.0318 |
| Palmer H-Index, Region 1, December (t-1) | -0.0935 | 0.0426 | -2.1968 | 0.0394 |
| Ln[DOI Expenditures (t-1)] | 0.4884 | 0.1979 | 2.4682 | 0.0223 |
| Observations | 27 | | | |
| R-squared | 0.73 | | | |
| Equation Error | 0.29 | | | |
| Durbin-H Statistic (F-Test, 1, 19) | 2.3* | | | |

* Not significant at 0.15.

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

| Diagnostic | Calculated 1995-2012 | Calculated 1985-2012 |
|--|----------------------|----------------------|
| Root Mean Squared Error (Real 2004 \$) | 77,701,029 | 72,611,187 |
| Bias (Real 2004 \$) | 2,345,097 | 5,811,435 |
| Bias (percent) | 0.9 | 2.5 |
| Mean Absolute Percent Error (percent) | 24 | 29 |
| Direction of Change Prediction (percent Correct) | 78 | 74 |

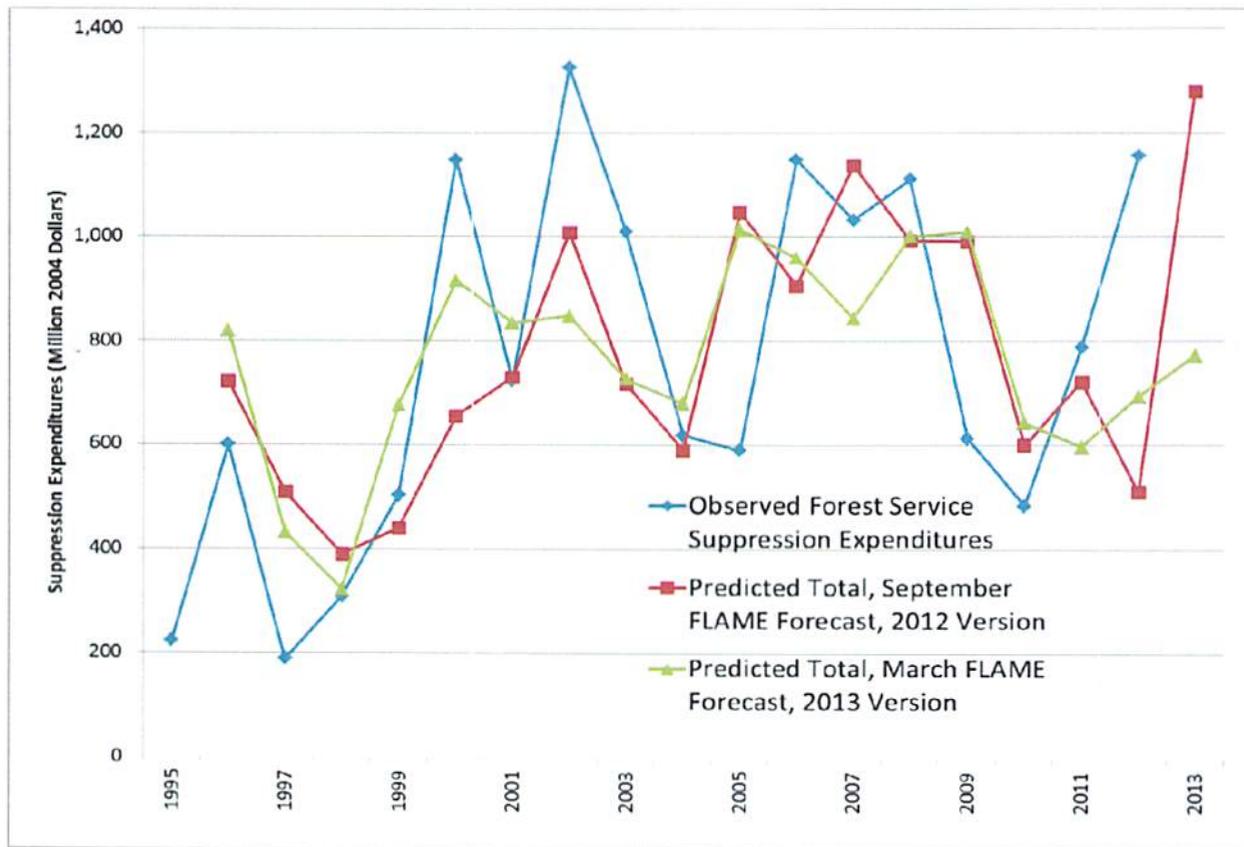


Figure A1. Observed historical USDA Forest Service suppression expenditures (1995-2012) and the forecasts of these expenditures (1996-2013) using the March 2013 FLAME Forecast Model and the September 2012 FLAME Forecast Model (1996-2013). All forecasts of those expenditures for each fiscal year are sums across the point estimates of each region or region aggregate's costs generated with a jackknife procedure. (Note: values are in constant 2004 dollars and exclude the Wildland Fire Suppression Cost Pool expenditures.)

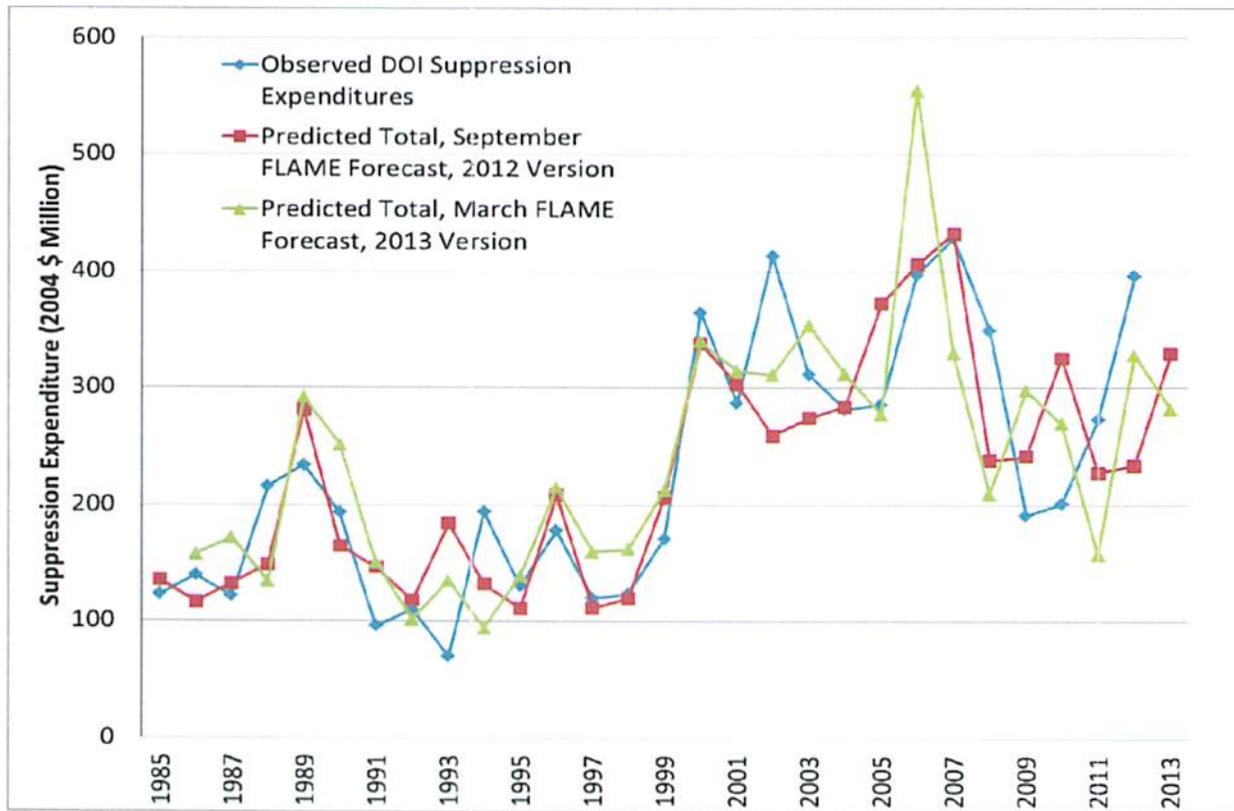


Figure A2. Observed historical Department of the Interior (DOI) suppression expenditures (1985-2012) and the forecasts of these expenditures (1986-2013), using the March 2013 version of the DOI March FLAME Act Forecast Model. All forecasts of those expenditures for each fiscal year are the point estimates generated with a jackknife procedure. (Note: values are in constant 2004 dollars.)