Statistical Budget Prediction Model Forecasts of Suppression Expenditures
FYs 2007 & 2008
An Alternative to the 10-Year Moving Average for Out-year Budget Projections

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Executive summary

In August 2005, researchers at the Rocky Mountain Research Station (RMRS-4802) and the Southern Research Station (SRS-4851) reported on an investigation of statistical alternatives to the 10-year moving average for out-year budget projections of Forest Service wildland fire suppression expenditures. This investigation was in response to a request by the General Accounting Office (now the Government Accountability Office) [1] to explore methods for estimating annual wildfire suppression costs because "improved methods would more effectively account for annual changes in costs and the uncertainties associated with wildfires, so that funding needs for wildfire suppression can be predicted with greater accuracy." Additionally, the Strategic Issues Panel on Large Fire Costs [2] recommended that the Forest Service and DOI investigate the possibility of allocating suppression funds on a regional basis as a move towards increasing accountability. [3] It was not felt that the 10-year moving average would provide sufficient information to implement this recommendation.

This report is an update to that provided in August 2005. It provides forecasts of Forest Service wildland fire suppression expenditures two years out (2-YO model) and three years out (3-YO model) from the current fiscal year using the Statistical Budget Prediction Model (i.e., forecasts for fiscal years 2007 and 2008). The Statistical Budget Prediction Model is based on weighted averages of past regional costs and time trends and substantially reduces the error rate of forecasts, as opposed to the 10-year moving average.[4]

Using the Statistical Budget Prediction Model, the 2-YO median forecast of fiscal year (FY) 2007 suppression expenditures is $1,096 million (in 2007$) with the 95% confidence interval ranging from $436 to $2,904 million. The 3-YO median forecast of FY 2008 expenditures (in 2008$) is $1,262 with the 95% confidence interval ranging from $567 to $3,179 million. The remainder of this report provides details of the Statistical Budget Prediction Model forecasts for FYs 2007 and 2008.

[1] United States General Accounting Office. 2004. Wildfire suppression: funding transfers cause project cancellations and delays, strained relationships, and management disruptions. General Accounting Office Report GAO-04-612, June 2004. 62 pages.

[2] Strategic Issues Panel on Fire Suppression Costs. 2004. Large fire suppression costs: strategies for cost management. A report to the Wildland Fire Leadership Council. [www.fireplan.gov/reports/2004/costmanagement.pdf], 59 pages.

[3] The Department of Interior remains committed to the 10-year moving average for the near-term.

[4] In the August 2005 report, we reported that using the Statistical Budget Prediction Model, the forecast of costs two years in advance (2-YO) has a mean error that is 43 percent lower, while a forecast of costs three years in advance (3-YO) has a mean error that is 48 percent lower than the 10-year moving average. In this report, we used a jackknife (bootstrapping) technique to evaluate out-of-sample performance. This shows that shows that the 2-YO and 3-YO models have more modest (roughly 10 percent) gains in explanatory power over the 10-year moving average over the period 1990-2005; since 2000, however, the 3-YO provides a 24 percent gain over the 10-year moving average.

Model Development and Evaluation

We developed our agency-wide suppression cost forecasts using available suppression cost data for fiscal years 1977-2005. Our suppression cost data are based on expenditures charged to the WFSU fund code and include the work activities associated with suppression, rehabilitation, and severity, but do not include economic efficiency, "other" expenditures, or reimbursables. These data were obtained from the Forest Service financial system and are updated and maintained by the Rocky Mountain Research Station with some adjustments made to the raw financial data to account for changes in the financial systems and work activities over time.

The 2-YO and 3-YO Statistical Budget Prediction Model forecasts are based on weighted averages of past regional costs and time trends. Costs are forecast at the Forest Service Region level and then summed up across Regions to provide an agency-wide forecast using data available at the beginning of the fiscal year. Therefore, using data available in October 2005 (start of fiscal year 2006), we made forecasts for costs in fiscal year 2007 and fiscal year 2008.

For reference purposes, forecast performance of the 2-YO and 3-YO models are shown in Table 1, compared to that of the 10-year moving average. The forecast error rate is measured by the size of the root mean squared error of forecasts made "out-of-sample."[5] For example, for the 3-YO model out-of-sample cost forecast for 2000, only data through 1997 are used. The 10-year is based on historical data, with each previous year weighted equally.

Table 1. Forecast out-of-sample prediction performance comparison for the 10-year moving average, 2-YO and 3-YO Statistical Budget Prediction Models, 1990-2005.

Forecast model	**Percent Decrease in Error compared to the 10-year Moving Average, 1990-2005**	**Jackknife R^2, 1990-2005**	**Percent Decrease in Error compared to the 10-year Moving Average, 2000-2005**	**Jackknife R^2, 2000-2005**
10-year moving average	NA	0.64	NA	0.65
2-YO (AR+trend System) [1]	11	0.69	10	0.77
3-YO (AR+trend System) [1]	10	0.70	24	0.80

[1]AR+trend System is the seemingly unrelated regression system estimate of autoregressive models that include trend variables.

The root mean square error is a gauge of how accurate the forecast model is compared to the observed costs. During the period 1990-2005, the root mean squared error in the forecast for the 10-year moving average is $413 million, while those provided by the 2-YO and 3-YO models are, respectively, 11 and 10 percent smaller than this. These results show that the 2-YO and 3-YO models can explain about 70 percent of the variance in annual emergency suppression costs, as measured by the out-of-sample (jackknife) R^2. Since 2000, in a period of significant volatility in costs, the 3-YO model performs even better, reducing forecast error compared to the 10-year moving average by 24 percent, producing a jackknife R^2 of 0.80. Modeling improvements are continuous, with advances expected with each new year

[5] The root mean squared error is calculated as the square root of the sum of squared forecast errors divided by the number of forecasts evaluated.

of data and the introduction of new modeling techniques, such as the one newly implemented that seeks to reduce bias.[6]

Statistical Budget Prediction Model Forecast Results for FY 2007 and FY 2008

The forecasts for fiscal years 2007 and 2008 are shown below (Tables 2 and 3; Figures 1 and 2). In the tables, the forecasts are displayed in both constant 2003$ and inflated to reflect current dollars for the year being forecast (i.e., 2007 or 2008 dollars).

Best 2 -YO models

Table 2 shows the 2007 forecast, using the Statistical Budget Prediction Model and data available in early October, 2005. The median forecast of FY 2007 FS suppression expenditures, implying a 50 percent chance that expenditures will exceed the value, is $1,096 million (in 2007$) with the 95% confidence interval ranging from $436 million to $2,904 million. The probability-weighted (expected or mean) forecast expenditure is $1,242 million, while the most likely single value (point forecast) is $1,015 million.

Table 2. Confidence interval table for forecast of total Forest Service emergency suppression expenditures for fiscal year 2007.

	Total Fiscal Year 2007	**Total Fiscal Year 2007**
	Millions of 2003 Dollars	Millions of 2007 Dollars
Point Forecast	907	1,015
Mean	1,111	1,242
Median	980	1,096
95% Confidence Interval Lower Bound	389	436
95% Confidence Interval Upper Bound	2,596	2,904
90% Confidence Interval Lower Bound	453	507
90% Confidence Interval Upper Bound	2,208	2,469

[6] Karlberg, F. 2000. Population total prediction under a lognormal superpopulation model. Metron 58(3/4):53-80.

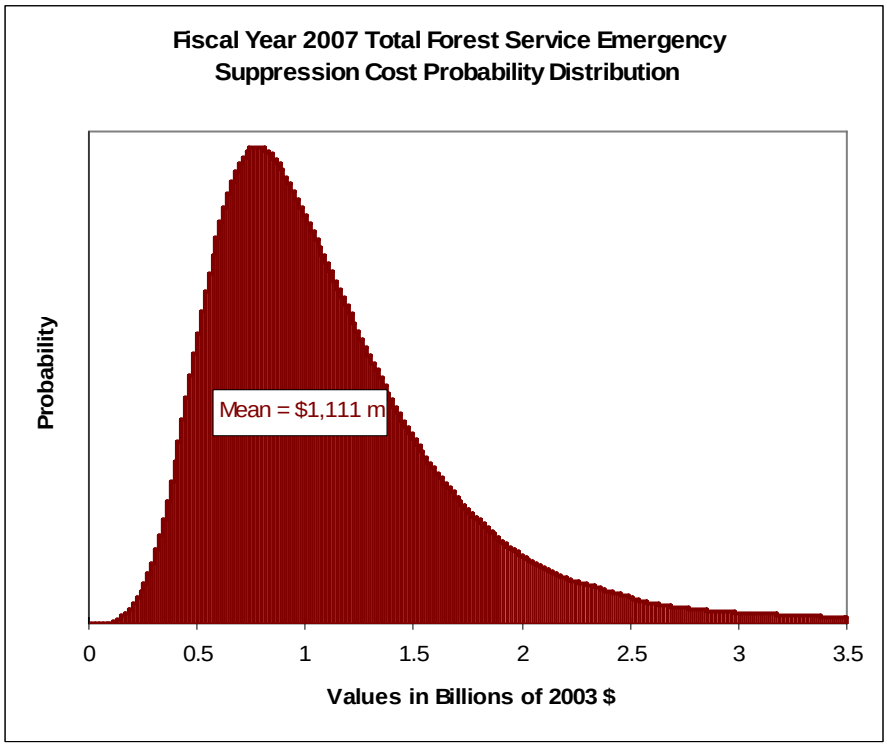

Figure 1. Empirical forecast total Forest Service emergency suppression cost distribution for fiscal year 2007, in constant (2003) dollars.

Best 3 -YO models

Table 3 shows the 2008 forecast using the Statistical Budget Prediction Model and data through early October, 2005 as the input data set. The median forecast of FY 2008 FS suppression expenditures is $1,262 million with the 95% confidence interval ranging from $567 to $3,179 million. The mean forecast is $1,417 million, while the most likely single value is $1,197 million.

Table 3. Confidence interval table for forecast of total Forest Service emergency suppression expenditures for fiscal year 2008.

	Total Fiscal Year 2008	**Total Fiscal Year 2008**
	Millions of 2003 Dollars	Millions of 2008 Dollars
Point Forecast	1,039	1,197
Mean	1,230	1,417
Median	1,096	1,262
95% Confidence Interval Lower Bound	493	567
95% Confidence Interval Upper Bound	2,760	3,179
90% Confidence Interval Lower Bound	556	641
90% Confidence Interval Upper Bound	2,345	2,701

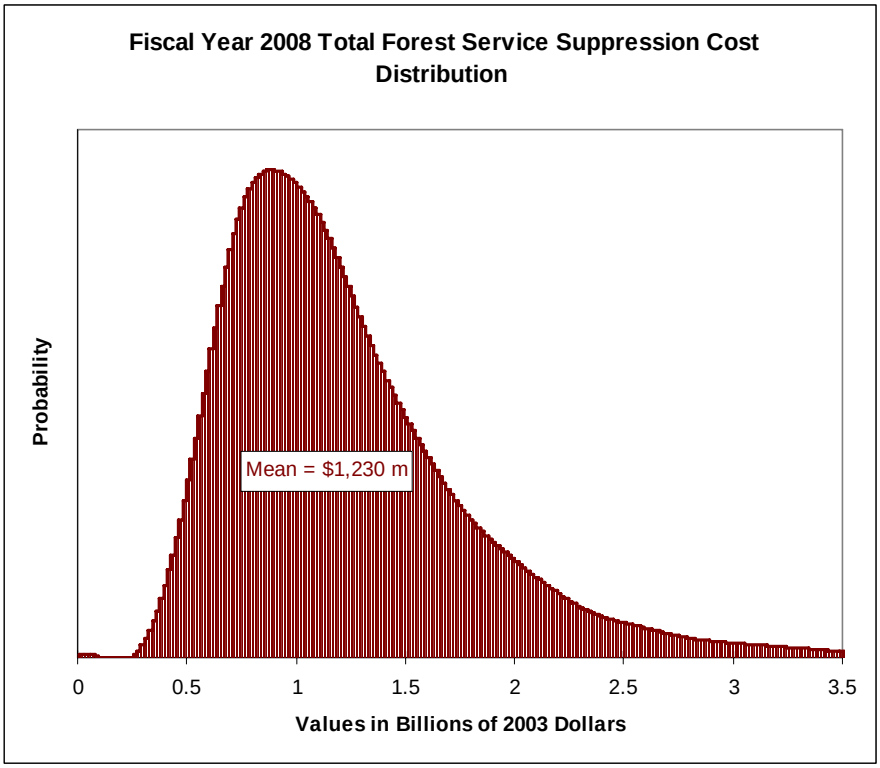

Figure 2. Empirical forecast total Forest Service emergency suppression cost distribution for fiscal year 2008, in constant (2003) dollars.

Conclusion

The error bands associated with the 2-YO and 3-YO forecasts are very large. This reflects the large amount of uncertainty when trying to forecast wildland fire suppression expenditures two to three years in advance, given the extreme amount of variation from year to year. Forecasts with a shorter time horizon, such as those produced at the beginning or middle of the fiscal year (see Prestemon, Gebert, and Abt, November 2005)[7] are able to take advantage of climate forecasts (such as sea surface temperatures and/or PDSI) for the upcoming fiscal year and, therefore, produce forecasts with smaller error bands. Unfortunately, climate forecasts two to three years in advance of a fire season are not available.

As noted in the discussion above, however, the forecasts provided in this report reflect an improvement over the 10-year moving average, if the goal of the forecast is to improve forecasting accuracy (as measured by the decrease in the root mean square error). If other goals predominate (such as budget stability for wildland fire management), then a less accurate, but more stable, forecast, such as the 10-year moving average, might be preferable.

Finally, the analysis detailed in this report is based on a relatively short time series of data, thus improvements in forecast errors can be expected with the addition of each year of new data, typically

[7] Prestemon, Jeffrey P., Gebert, Krista, and Abt, Karen. November 28, 2005. Fiscal Year 2006 Forest Service Suppression Cost Forecasts and Simulation. Unpublished report prepared for USDA Forest Service, Fire and Aviation Management, Washington DC.

available in October. We anticipate that the addition of new data to our already extensive data set and the development and testing of new methods for forecasts and probability distribution simulations will yield continued improvement in the quality and usefulness of our forecasts. If longer-term climate forecasts become available, we may be able to improve the 2-YO and 3-Y0 forecasts by incorporating this information in our modeling.