Comments on the Montana Headwaters Wildfire Cost Study Technical Report Dated August 8, 2008

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SUMMARY

This paper reviews the methodology, conclusions and policy suggestions of the Montana Headwaters Wildfire Cost Study Technical report dated August 8, 2008, prepared by Headwaters Economics (the "Headwaters Wildfire Cost Study"). The conclusions of the Headwaters Wildfire Cost Study are based on a statistical analysis employing a complex and seldom-used methodology. After correcting the errors, the conclusions of the statistical analysis are too unreliable to support policy decisions.

The Headwaters Wildfire Cost Study conclusions are based on statistical estimates of three crucial parameters correlating housing proximity and fire fighting costs. These parameters either have unacceptably high statistical errors or are incorrectly interpreted and hence are unreliable for policy decisions. In addition, the Headwaters Wildfire Cost Study ignores other research and uses questionable and insufficiently documented statistical methods. The Headwaters Wildfire Cost Study does not appear to be peer-reviewed. The peer review process is an integral part of the scientific method and a prerequisite for publication in professional journals.

Other peer reviewed research reports mixed conclusions with respect to housing proximity and fire fighting costs. This means that the scientific process is not yet complete, and there still are significant research issues to be resolved before the findings can be reliably applied to policy. Specifically, further research is required to determine more precisely the relationships between values at risk (housing is one of many) and fire fighting costs. The peer reviewed research also identifies a number of other factors that influence fire suppression costs, which were not included in the Headwaters Wildfire Cost Study.

The Headwaters Wildfire Cost Study reported a number of key findings. Contrary to claims, the statistical analysis **DOES NOT SUPPORT** the following conclusions of the Headwaters Wildfire Cost Study:

- The study does not support the claim that, "Firefighting costs are highly correlated with the number of homes threatened by a fire."
- The study does not support the claim that, "The pattern of development (dense vs. spread out) is an important contributing factor."
- The study does not support the claim that, "When large forest fires burn near homes, costs related to housing usually exceed $1 million per fire."

- The study does not support the claim that, “As few as 150 additional homes threatened by fire can result in a $13 million increase in suppression costs in a single year.”

- The study does not support the claim that, “For all agencies involved in fire suppression in Montana, the estimated annual costs related to home protection for 2006 and 2007 were approximately $55 million and $36 million respectively.”

- The study does not support the claim that, “If current development trends continue, fires (sic) seasons similar to 2006 and 2007 could cost $15 to $23 million more by 2025, bringing total fire suppression costs associated with home to between $51 and $79 million dollars (sic). Adjusted for inflation, future costs could be as high as $124 million in 2025.”

- The study does not support the claim that, “A conservative estimate is that 25% of all costs of protecting homes from wildfires within Montana are paid for by the state. Therefore, Montana’s costs for home protection in 2006 and 2007 are estimated to have been $13.9 and $9.2 million, respectively. By 2025, Montana’s future costs, adjusted for inflation, could be as high as $31 million.”

- The study does not support the claim that, if the Montana Legacy Project fails, these parcels could be subdivided into “160 acre lots, as few as 150 homes distributed across these lands could have added $13 million in costs to 2007’s fire suppression bill.”

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THE HEADWATERS WILDFIRE COST STUDY

Three estimated parameters are crucial to the conclusions of the Headwaters Wildfire Cost Study. Despite the extended discussions concerning forecasting and choosing the “best model,” the study conclusions are not based on predictions or forecasts of suppression costs. Instead, three estimated parameters underlie all of the study’s conclusions and each is either unreliable for policy analysis or is interpreted incorrectly. Also, the extended discussions of model choice in sections 2 and 3 do not add confidence to these three parameters (Mac Nally 2000).

The Homes1 Model. The Headwaters Wildfire Cost Study estimates the increase in suppression costs for each additional home within one mile of a wildfire to be $7,933. This value was derived from the Homes1 model by multiplying the estimated coefficient on Homes1 (344.90) by the average number of days a home is within a mile of the fire perimeter (23). That is, 344.90 X 23 = 7,932.7. The study never mentions the error margin associated with the $7,933; both the coefficient and the average number of days have associated standard errors. But, as will be shown below, this estimated coefficient (344.90) is not statistically reliable and the product ($7,933) is not appropriate for policy analysis.

The Homes6 Model. The estimated coefficient on Homes6 (53.92) was combined with the average number of days a home is within a mile of the fire perimeter (23) to derive the increase in suppression costs (53.92 X 23 = 1,240) for homes within six miles of wildfire. This may be inappropriate. With the variable Homes6, it may be appropriate to use the average number of days a home is within six miles of the fire perimeter. The error margin of the product is not discussed, even though the estimated coefficient and the average number of days (either one) have an associated standard error. In any case, as will be shown below, this estimated coefficient is not statistically reliable and this calculation is meaningless.

The Acres1 Model. This model is not comparable to the Homes1 or Homes6 models, and the estimated coefficients of Acres1 do not corroborate the findings of the Homes1 and Homes6 models. Specifically, the Acres1 model does not include the independent variable Acres, and therefore the coefficient on Acres1 is not comparable to those in the Homes1 and Homes6 models because it does not explicitly account for the size of the fire (Ramsey and Schafer pp. 274-275). The Headwaters Wildfire Cost Study (p. 11) states the “average lot size of homes threatened by the 18 fires in our sample was 12 acres, and if you multiply the cost per acre ($644) by 12 acres, you get roughly $8000 (the cost per home).” This calculation compares apples with oranges and is meaningless. The coefficient on Acres1 (28.88) co-mingles the effects of the Acres1 and Acres variables.

Numerous re-estimations invalidate traditional statistical tests and reduce the usefulness of the findings for policy decisions. In an attempt to identify the "best model" at least 31 regressions were estimated using the same data. This implies that the crucial coefficients reported in Table 6 do not meet commonly accepted statistical standards. There are 31 AICs (Akaike Information Criterion) reported and each is associated with a separate regression. There may have been more regressions estimated. The AIC is analogous to the R bar squared except that lower values indicate a better model.

As early as 1927 it was recognized that "a competent statistician, with sufficient clerical assistance and time at his command, can take almost any pair of time series for a given period and work them into forms which yield coefficients of correlation exceeding +/- .9" (Mitchell pp. 266-7). This conclusion has been stated and re-stated in numerous forms over the decades (Friedman 1940, Christ 1993, Jingling 2008). In this case, a high correlation or statistical significance does not support the model (or coefficient) because the model (or coefficient) was chosen because it **yielded** a high correlation. The usual statistical tests (such as the "t test") can be computed, but they do not have the distribution associate with the test. That is, the "t test" does not have the "Student's t" distribution and one cannot determine the level of statistical significance (or the p-value) in the usual manner.

A peer-reviewed article published in 1983 provides a method to quantify the overestimate of confidence resulting from estimating and *re-estimating* a model (Lovell 1983). Table 1 provides the coefficient estimates and their associated p-values reported in Table 6 along with the corrected p-values which take the re-estimations into account. If more than 31 regressions were run on this data, the corrected p-values would be even greater.

Table 1
Original and Corrected P Values

Model	Coefficient	Reported p-value	Corrected p-value
Homes1	344.90	.0223	.4125
Homes6	53.92	.0150	.2812

P-values measure the statistical confidence associated with an estimated parameter. Lower p-values imply greater statistical confidence that the coefficients are not zero and, therefore, greater applicability for policy analysis. The reported p-values for the Homes1 and Homes6 coefficients are both in the "moderate" range—indicating some but not convincing evidence that the coefficients are not zero (Ramsey and Shafer, p. 47). The corrected p-values are both in the "definitely reject" range, which implies they should not be used for policy analysis (Ramsey and Schafer, p. 47).

Cross Validation on the Best Model does not support the conclusions of the Headwaters Wildfire Cost Study. The only real tests of a model's accuracy are predictions that utilize data not available when the model was constructed (Christ 1993, Mac Nally 2000). The method ("cross validation") of excluding certain observations and then re-estimating the model has been explicitly criticized in recent literature (Christ p. 74). Cross validation (cross assessment is the preferred term) received decidedly mixed reviews even in the Headwaters Wildfire Cost Study citation (Stone 1974). The reviewers' comments are peppered with phrases such as "(cross validation procedures) should be resorted to only when we are driven (p.134)" and "Professor Stone seems to be attempting to bend statistics without touching them. My attitude to (that) is one of open-minded skepticism. I do not believe in (it). (p. 138)" A good example of using out-of-sample analysis of wildfire suppression costs is found in Gebert, et. al. 2007, see especially pp. 194-196.

The Headwaters Wildfire Cost Study conclusions are based on a complex and little-used statistical method. The Continuous Autoregressive model (CAR) is not widely used. It is not described in any of the sources cited in the Headwaters Wildfire Cost Study. The CAR is not available in the often used and vetted statistical packages such as SPSS, SAS and TSP. A computer assisted literature search identified only one other reported application in peer reviewed journals; a study concerning a time series of aircraft concentration in thirty-one air traffic sectors (Polhemus 1980).

CAR appears to be a form of time series analysis. The primary purpose of time series models is to incorporate regular patterns (i.e. monthly, quarterly and so forth) into accurate forecasts. The Headwaters Wildfire Cost Study does not make forecasts, but uses the estimated coefficients of time series models to make cost calculations. The methods for selecting an appropriate time series model may not yield regression coefficients appropriate for other analysis (Mac Nally 2000).

In recent years a number of noted statisticians have written about the use of statistically derived estimates for important policy conclusions. In general, they have concluded that the simpler the statistical method, the more reliable are the findings (Mac Nally 2000). Nobel Prize winner and noted economist Milton Friedman states, "I have been extremely skeptical of relying on projections from a multiple regression, however well it performs on the data from which it is derived; and the more complex the regression, the more skeptical I am" (Friedman 1991 p.49). The noted econometrician Carl Christ said, "Other things being equal, the simple model is preferred to a complex one" (Christ 1993 p.75).

OTHER WILDFIRE COST RESEARCH

The Headwaters Wildfire Cost Study is not the only research examining the recent increase in suppression costs. This section summarizes other studies of wildfire costs, which used a variety of research methods. A complete citation is provided in the **Sources** for this document. For simplicity, they are denoted here by their lead author.

1. **Donovan**. This is a USDA Forest Service General Technical Report; a publication that receives rigorous internal and external review. The authors analyzed data from 58 fires during 2002 in Washington and Oregon using a simple correlation-regression model. The primary purpose of the research was to examine the role of housing on fire suppression costs; other variables included fire size, fire terrain and the number of other uncontained fires burning in Washington and Oregon on the day the fire started. The authors concluded "Results fail to show a relationship between either total housing or housing density and suppression costs." Only fire size and extreme terrain were statistically significant determinants of fire suppression costs.

2. **Gebert**. This peer reviewed journal article examined 1,550 fires greater than 100 acres reported nationwide by the USDA Forest Service from FYs 1995 to 2004. A multiple regression model was estimated and then compared to data for 2005. The authors found that suppression costs reported in the USDA accounting system were "largely inaccurate and should not be used for analysis," and they recomputed them. The authors also adjusted for costs associated with fire complexes (a group of fires administratively treated as one fire). Independent variable categories included fire environment (slope, fuel, elevation etc), values at risk (private land, public infrastructure, high valued timberlands, etc.) resources available (number of other fires burning in the area and delay in starting suppression). Approximately 15 variables were statistically significant in the model for western states. The variable measuring total housing value within 20 miles of ignition was statistically significant, but the corresponding variable for 5 miles was not.

3. **Liang**. This is a peer reviewed journal article. The authors examined 100 wildfires greater than 121 ha. suppressed by the USDA Forest Service in Montana and Idaho from 1996 to 2005. They utilized the suppression cost estimate method of Gebert as the dependent variable and 16 potential non non-managerial factors as independent variables in a regression model. They found that only fire size and percentage of private land within the burned area were statistically significant predictors of suppression costs. But the impact of private land impact was not linear, "for the average fire, expenditures first increased with the percentage of private land within the burned area, but as the percentage exceeded 20% expenditures slowly declined."

4. **Canton-Thompson**. This is a peer reviewed journal article that uses interview methods to identify human factors and pressures which incident management team leaders thought affected their decisionmaking. The authors began by believing that the Incident Management Team (IMT) had substantial control over wildfire suppression costs. The interviewees subsequently reported that their ability to influence costs were

mostly outside their control. In particular they mentioned risk aversion (i.e. safety issues), interaction with the agency administrators, the plethora of regulations, the availability of resources, and the threat of litigation for IMT members as among the major factors affecting suppression costs.

These studies have important implications for the data and methods used in the Headwaters Wildfire Cost Study. Specifically:

- Unaudited fire cost data may not be reliable.
- Project fires need to be identified and analyzed appropriately.
- The 18 Montana fires during 2006 and 2007 considered by the Headwaters Wildfire Cost Study may be insufficient to incorporate impacts of differences in terrain, geography and time periods.
- There values at risk in addition to homes—such as high value timberland, national parks and wilderness areas.
- Incident Management Teams may not have control over all fire cost suppression factors.
- Fire fighter safety may impact suppression costs.

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