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U.S. House of Representatives
Committee on Resources Subcommittee on Forests and Forest Health
Congressional Oversight Hearing: *Scientific Research and the Knowledge-base concerning Forest Management Following Wildfires and Other Major Disturbances*, 24 February 2006 Medford, OR

March 9, 2006

Honorable Members of Congress,

I am respectfully submitting my comments concerning the Congressional Oversight Hearing entitled *Scientific Research and the Knowledge-base concerning Forest Management Following Wildfires and Other Major Disturbances*, held February 24, 2006 in Medford, Oregon. I am a consulting statistician with the Department of Forest Science at Oregon State University. Although two of the authors (Messrs. Donato and Fontaine) on the publication in the journal *Science* that precipitated this hearing consulted with me regarding study design prior to data collection, I was not consulted regarding data analysis or interpretation of the data after collection.

On March 3, Mr. Donato asked me to provide an independent analysis of his data in order to assess the validity of his approach from a statistical point of view. I did so using a slightly different approach than he and his coauthors used. **I had two primary objectives: to analyze the data from a different, yet statistically sound and ecologically relevant perspective in order to compare my results with theirs for consistency; and to investigate the potential influence of measurements made on any single plot to assess the robustness of the results.** I have described my methods in detail below. As with all statistical analyses, statistical significance of results may or may not represent biologically meaningful differences in the context of the study. That interpretation is left up to the authors and is not an issue I am qualified to address.

Even though my analysis addressed a slightly different question than Donato et al (2006) aked, my results regarding seedling density and fine fuels are consistent with the conclusions they draw and their analysis appears to be quite robust. My results concerning coarse fuels were consistent with Donato et al's but I found that some individual plots had slight influence on the magnitude of the results.

In my analysis, I focused on the salient question of the research for each of the three measures: seedling density, fine fuels and coarse fuels. I asked **"Is there statistical evidence that, on**

average, stands that were logged between 2004 and 2005 changed more than stands that were not logged over the same interval?" As annual variation can lead to changes in these three measures between these two years, regardless of the human intervention, I felt it was important to frame the research question in a way that incorporates the potential inherent change in these measures from year to year. Donato et al also addressed this issue but in a slightly different way. They asked two sequential questions "Is there statistical evidence of significant differences between logged and unlogged stands in 2004, before logging was implemented?" Once they established that the two groups (logged and unlogged) had no initial differences, they then asked "Is there evidence of significant differences after logging, in 2005?" Both approaches are valid, but are estimating slightly different things. I deliberately approached this analysis from a different perspective in order to assess the consistency of their results. **My independent analysis of the data indicates the answer to my question above to be clearly "Yes" for seedling density and fine fuels and a "qualified yes" for coarse fuels.**

Methods I used a parametric approach with these data, using $\log_e$-transformed values. This transformation is very common in natural resources and is often used when effects are multiplicative rather than additive. If a factor acts additively, as opposed to multiplicatively, it would cause a change of a fixed number of units, no matter how many were there to start with. For example, a certain factor may induce an average change of 10 units, so that a plot starting with 200 units or a plot starting with 50 units are both expected to change by 10 units after this factor has acted. A factor that acts multiplicatively would cause a change of a fixed percent, no matter how many there were to start with. For example, if a factor induces a 10% decrease, a plot starting out with 200 units would be expected to decrease by 20 units, whereas a plot starting out with 50 units would be expected to decrease by only 5 units. When factors act multiplicatively, the distribution of the data is often skewed with some few, very large numbers. In this case, the median is often a better measure of central tendency than the mean. The median represents the half way point in the distribution of the data, i.e. half the values can be expected to be above the mean, half below. It is much more stable than the mean and is not influenced by few large values. The mean in a skewed distribution, on the other hand, is highly influenced by a few large values and will be pulled toward them. It will not be representative of the half-way point in the distribution. In the Donato et al. study, seedling density, fine fuels and coarse fuels appeared to be acting on a multiplicative scale, so the $\log_e$ transformation was applied to all three measures and median values (and 95% confidence limits) are reported.

In statistical analyses, we can never make such precise estimates as those just stated (e.g. 10 unit decrease or 10% decrease). We place 95% confidence limits or bounds on these estimates of change or difference that can be interpreted as having a 95% chance that the true change or difference is somewhere within the bounds, so rather than a 10% decrease we would estimate somewhere between a 7% and 14% decrease, for example.

In addition to answering the above research question, I explored the possibility that results were based on an unusual sample of data, and that perhaps only one plot with an extreme measured value was actually responsible for the results. So, I reanalyzed the data, leaving out one plot at a time (16 separate analyses) to see if the results would change. If taking out a single point causes the conclusions to change, then the results of this study would not be considered to be robust. It would be extremely tenuous to interpret as general effects, those that are unduly influenced by measurements at only one point. However, if the conclusions were qualitatively unchanged by removal of any plot, then the results would be interpreted as robust and the effects measured would be considered representative of a general pattern in the data. Visual representations of the results of this analysis are presented in Figures 3, 6 and 9. In each of the these, if the plotted interval includes 1, then there is no statistical evidence of difference between logged and unlogged stands. If all intervals exclude 1, then the conclusions are robust and there is statistical evidence of a difference between logged and unlogged stands.

I found that the results derived from Donato's sample were robust for seedling density and fine fuels and even leaving any one plot out did not change the essential interpretation of the results. Coarse fuel measures were extremely variable and **there was some evidence that the coarse fuels estimates would change slightly if only one point were removed.**

Analysis Results Based on All Data

Seedling density

Seedling densities in 2004 ranged from about 300 to 2400 in 2004, with (to be) logged plots having about the same range as (to be) unlogged plots (Figure 1). Seedling density of most stands declined between 2004 and 2005 (9 out of 9 logged, 5 out of 7 unlogged). However, **the magnitude of the decline was, on average, greater in logged stands than in stands that were not logged** (Figure 2). While seedling density in unlogged plots was estimated to decline 20% from 2004 to 2005, seedling density in logged plots was estimated to decline by 61% over this same time period. The 95% confidence limits for the estimated percent change in seedling density in unlogged stands extend from a decline of 48% to an increase of 23%, indicating that the evidence is equivocal as to whether the average density decreased, increased or remained unchanged in these stands. The 95% confidence limits for the estimated percent change in logged stands, however, extend from a decline of 43% to a decline of 74%, indicating that there is strong evidence of a decline over that period, with uncertainty only in the magnitude of the decline. **Logged stands were estimated to have, in 2005, between 27% and 86% of the proportion of seedling density remaining in unlogged stands in 2005.**

Fine Fuels

Fine fuels ranged from 0.5 to 2.9 Megagrams per hectare in 2004, with (yet to be) logged plots having about the same range as (to be) unlogged plots, and well interspersed (Figure 4). In 2005, after logging, the fine fuel load of every logged plot was greater than that of every unlogged plot (Figures 4 and 5). Fine fuels in unlogged plots were estimated to increase by 8% from 2004 to 2005, whereas fine fuels in logged plots were estimated to increase by 370% over this same time period. The 95% confidence limits for the estimated percent change in fine fuels in unlogged stands extend from a decline of 31% to an increase of 68%, indicating that the evidence is equivocal as to whether the average fine fuel load decreased, increased or remained unchanged in these stands. The 95% confidence limits for the estimated percent change in logged stands, however, extend from an increase of 222% to an increase of 607%, indicating that there is strong evidence of an increase in fine fuels over that period, with uncertainty only in the magnitude of the increase. **The change in fine fuels in logged stands from 2004 to 2005 was estimated to be between 2.4 to 8 times the change in fine fuels in unlogged stands over this same period.**

Coarse Fuels

Coarse fuels ranged from 1 to 81 Megagrams per hectare in 2004, with (yet to be) logged plots having a bit larger range as the (to be) unlogged plots (Figure 7). The two largest values and the two smallest values were measured in plots that were later logged. In 2005, after logging the coarse fuel load of every logged plot was greater than that of every unlogged plot (Figures 7 and 8). The two plots with the smallest coarse fuel load in 2004 each had dramatic increases in coarse fuel load after logging. Coarse fuels in unlogged plots were estimated to decrease by 34% from 2004 to 2005, whereas coarse fuels in logged plots were estimated to increase by 240% over this same time period. The 95% confidence limits for the estimated percent change in coarse fuels in unlogged stands extend from a decline of 63% to an increase of 19%, indicating that the evidence is equivocal as to whether the average coarse fuel load decreased, increased or remained unchanged in unlogged stands. The 95% confidence limits for the estimated percent change in logged stands, however, extend from an increase of 7% to an increase of more than 1000%, indicating that the data are highly variable but there is fairly strong evidence of an increase in coarse fuels over that period, with a lot of uncertainty in the magnitude of the increase. **The change in coarse fuels in logged stands from 2004 to 2005 was estimated to be between 1.4 and 19.2 times the change in coarse fuels in unlogged stands over this same period.**

Analysis Results Based on Subset of the Data

I examined the potential influence of each point on these results by removing one point at a time (16 possible) and rerunning each analysis. I evaluated the effect on inference by plotting the 95% confidence intervals around the estimate of the change in logged stands relative to the change in unlogged stands from 2004 to 2005.

Seedling density

Figure 3 represents the 95% confidence intervals around the ratio of percent seedlings remaining in logged stands relative to percent seedlings remaining in unlogged stands in 2005. For example, if density in logged stands in 2005 was 60% of what it was in 2004, but in unlogged stands it was 80% of what it was in 2004, the ratio of the percent remaining in logged to unlogged stands would be .6/.8=0.75=75%. This ratio takes into account the possibility that densities in all stands decreased between the two years. **When the seedling density data were reanalyzed after having removed one of the plots, none of the 95% confidence limits of this ratio included 1, indicating that the results were robust and the measured effect was representative of a general pattern in the data (Figure 3).**

Fine fuels

When the fine fuels data were reanalyzed after having removed one of the plots, none of the 95% confidence limits of this ratio included 1, indicating that the results were robust and the measured effect was representative of a general pattern in the data (Figure 6). In fact, this ratio was never less than 2, indicating at least a doubling of fine fuels in logged plots relative to unlogged.

Coarse fuels

When the coarse fuels data were reanalyzed after having removed one of the plots, 4 out of 16 of the 95% confidence limits of this ratio included 1, indicating that the results were not very robust and the measured effect might not be representative of a general pattern in the data (Figure 9). Although in all cases the estimate itself indicated an increase in coarse fuels, removal of some of the plots caused the 95% confidence interval around the estimate to include 1, providing equivocal evidence of a general change. In addition, all the 95% confidence intervals were extremely large, reflecting the high variability in this measure.

Literature Cited

Donato, D.C., J.B. Fontaine, J.L. Campbell, W.D. Robinson, J.B. Kauffman, B.E. Law, 2006. Post-wildfire logging hinders regeneration and increases fire risk. Science 311: 352.

Figures

Figure 1. Seedlings per hectare in each plot in 2004 and in 2005. Logged plots are indicated with an asterisk and solid line connecting the two measurement dates, unlogged plots are indicated with a square and a dashed line connecting the two measurement dates.

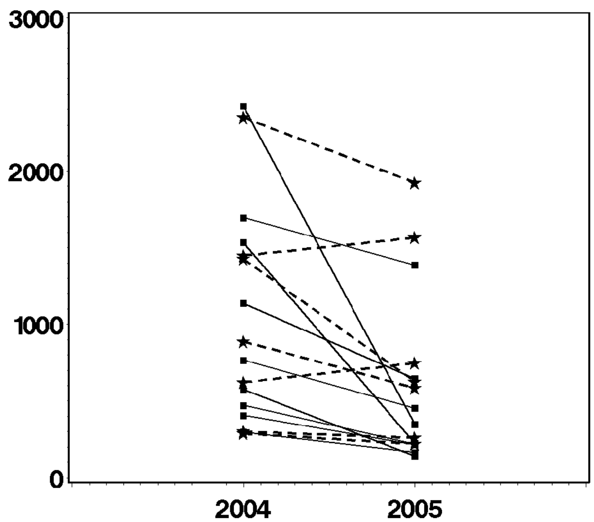

Figure 2. Estimated median seedlings per hectare in each plot in 2004 and in 2005 with 95% confidence limits. Logged plots are indicated with an asterisk, unlogged plots are indicated with a square.

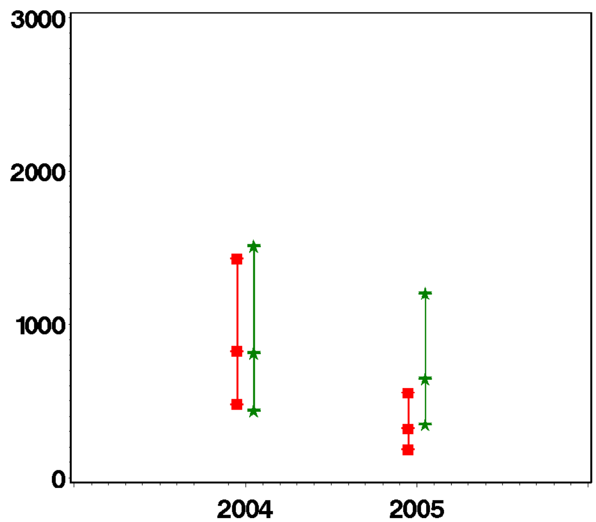

Figure 3. Ratio of percent seedlings remaining (and 95% confidence limits) in logged plots relative to unlogged plots in 2005, after having removed one point at a time from the data. None of the confidence limits include 1.

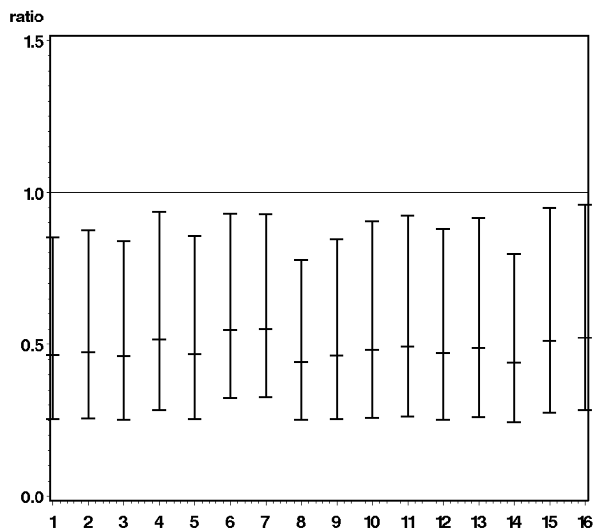

Figure 4. Fine fuel (Megagrams) per hectare in each plot in 2004 and in 2005. Logged plots are indicated with an asterisk and solid line connecting the two measurement dates, unlogged plots are indicated with a square and a dashed line connecting the two measurement dates.

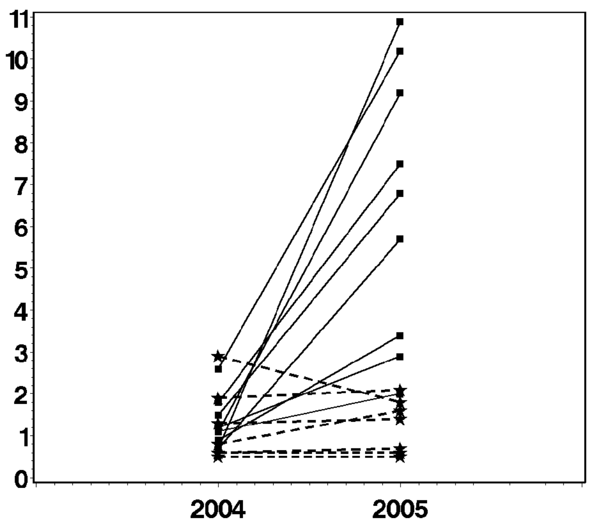

Figure 5. Estimated median fine fuel (Megagrams) per hectare in each plot in 2004 and in 2005 with 95% confidence limits. Logged plots are indicated with an asterisk, unlogged plots are indicated with a square.

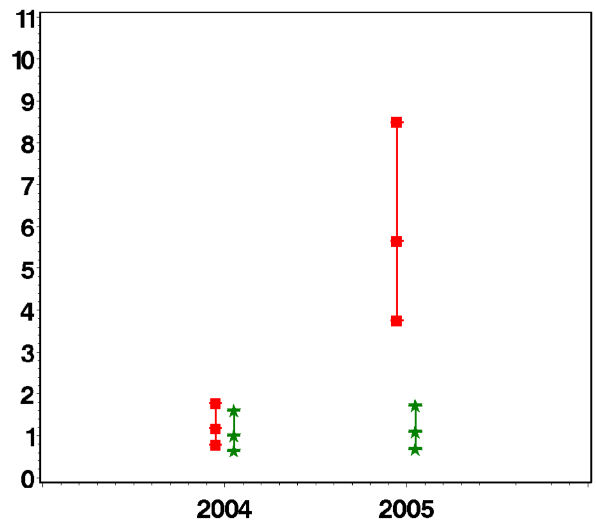

Figure 6. Ratio of percent fine fuels remaining in 2005 (and 95% confidence limits) in logged plots relative to unlogged plots, after having removed one point at a time from the data. None of the confidence limits include 1.

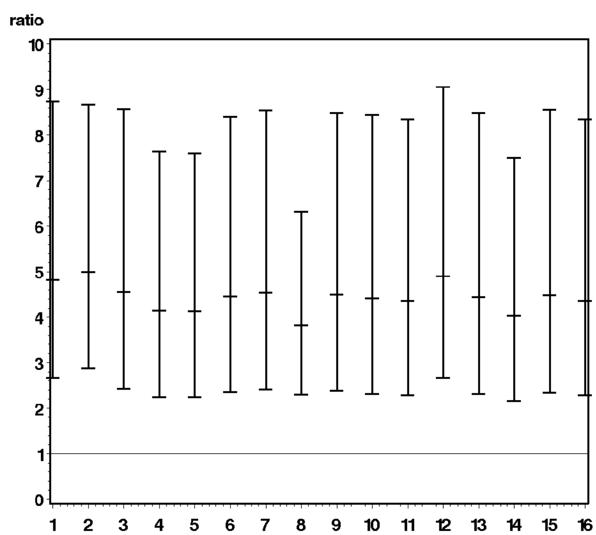

Figure 7. Coarse fuel (Megagrams) per hectare in each plot in 2004 and in 2005. Logged plots are indicated with an asterisk and solid line connecting the two measurement dates, unlogged plots are indicated with a square and a dashed line connecting the two measurement dates.

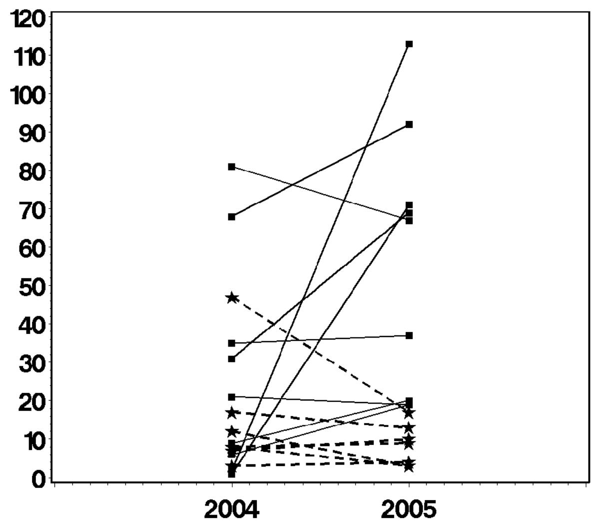

Figure 8. Estimated median coarse fuel (Megagrams) per hectare in each plot in 2004 and in 2005 with 95% confidence limits. Logged plots are indicated with an asterisk, unlogged plots are indicated with a square.

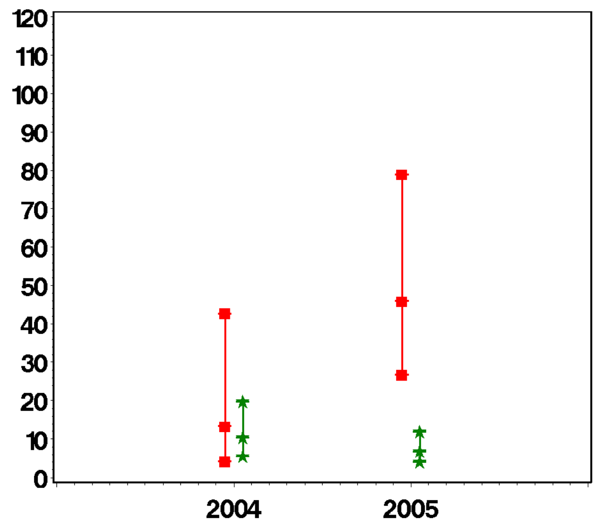

Figure 9. Ratio of percent coarse fuels remaining in 2005 (and 95% confidence limits) in logged plots relative to unlogged plots, after having removed one point at a time from the data. Some of the confidence limits include 1.