Case Study 6: MPCA

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Recap of the Situation

The Minnesota Pollution Control Agency wishes provide volunteers that measure stream water turbidity the temporal trends in the turbidity of the streams that they have been measuring. The agency also desires to do statistical inference on the turbidity levels to see if a) there are trends in individual streams, b) there are useful comparisons to be made between streams, and c) to see if there is an overall trend across watersheds. Finally, they desire to have graphical representations of the trends and results of any analysis that are public friendly.

Statistical Analysis for Trends in Individual Streams

Several analysis methods are considered:

1) Simple Linear Regression: Probably the easiest for the public to identify with if it simplifies to a linear trend against one covariate. Start with response *turbidity* and covariates continuous *year*, factors *water level*, *season*, and their interactions. See if the analysis simplifies. To deal with the censored values, use a Bayesian approach and consider them missing data for imputation.

2) Time Series Analysis: Used mostly for forecasting based linearly on previously collected temporal data points, this approach generally requires a stationary process with ergodicity. In brief, it where you go next doesn't depend on how you got there and the averaged values settle down over time. There are methods that allow for seasonally stationary processes. Through this method, trends can be studied.

3) Survival Analysis: Use turbidity as the response in a proportional hazards model. This method accounts for censoring. Use covariates *time, water leve*l, and *season*. Put in *turbidity:time* interaction to check if we need to account for the change in tube lengths.

Reporting of Results for Individual Streams

It would be good to provide the volunteer with both the overall trend and current trend of their stream. Something as simple as various categories of improvement or decline would suffice.

It would also be nice to provide visual reports. This graph shows red for decline, yellow for consistency, and green for improvement based on the analysis.

A simple bar plot of time averaged turbidity would also be provided to give a sense of quantitative differences. Gradient graphs using shades to represent turbidity could be used in place of the bar graphs.

Statistical Analysis of Trends in the overall Watershed

The previously mentioned SLR or Time Series analyses could be performed on turbidity centered on their own mean and accounting for differences is stream variances.

A couple of other methods are considered:

1) Longitudinal Analysis: This approach is good for data that is data that is highly correlated within subgroups. You can then study general trends over time.

2) Tukey's Honestly Significant Difference: This approach can be used to test for differences in the trends between streams in the same watershed. Unequal sample sizes can be handled with further procedures.

Reporting overall Watershed Trends

A simple categorical grading of the health of a watershed could be provided. For example: frail, weak, steady, strong, and robust. Trend could be categorized as before.

Graphically, a plot of the watershed could be shown with color coding of trend. It could be done along streams, or over the entire watershed.

Here is an example of such a graph (topic completely arbitrary):