EMBEDDEDNESS STUDIES

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Embeddedness is the percentage an average cobble in the streambed is packed in the sands and silts of the river bottom. At 100% the cobble is completely covered with the fine material; at 0% the cobble is free from sediments and water circulates freely around it. Embeddedness is important to the animals living in a stream. Trout cannot reproduce in areas where the embeddedness is higher than 40-50% because the packed fine materials smother their eggs. Some types of stream insects are adversely affected by high levels of embeddedness. On the other hand, the eastern pearlshell mussel seems to do best when the embeddedness is between 20-45%. It's an ill wind that bloweth no man to good.

Embeddedness field work began in 1993 and continued through 1997. During that time, BRASS measured embeddedness in 133 specific sites at 29 different locations on the river. The sites were selected for easy access, and to be representative of water velocities used by trout and salmon when spawning in the spring. If we wish to compare data from the sites, we need to leave out 1993 (embeddedness values were measured in ranges rather than specific values), and remove those sites where there was artificial disturbance (e.g., gravel removal and deepening the river for fire fighting) or where there were other complications.

Therefore, for comparison we are left with 82 specific sites over four years, with average embeddedness as follows:

1994	42%
1995	38%
1996	34%
1997	35%

If we look at the embeddedness of individual sites, rather than averages of all sites, some sites are consistently higher in embeddedness than others. Why? We have recorded certain site conditions that may help us answer the question. For instance, we know the velocity of the water at the time of sampling, also the depth, and during 1997 we measured the slope of the streambed at each site.

In a situation like this, where you suspect there might be a relationship between two variables, the easiest way to get a quick answer is to plot a scatter diagram. You put one variable along each axis of a graph. Each site, with its combination of the two variables, becomes a point on the scatter diagram. Now you ask if the points make a pattern, but those for embeddedness vs slope–and embeddedness vs velocity (see below)–seem to show a pattern. You can draw with your mind's eye a curved line that expresses a sort of consensus of all the points. As velocity becomes greater, the embeddedness falls rapidly from very high values to moderate values, and then falls more slowly to slow embeddedness values at the highest velocities. A similar pattern occurred for the slope.

So, we can relate either velocity or slope to embeddedness. Sites with high slopes or with high water velocities seem to have lower embeddedness. This leads to another question: Are the patterns we see just random clusters of dots that fool us into thinking there is a pattern? And, if there really is a pattern, how much of the variability does the relationship account for?

These are statistical questions, and the test we use for an answer is called a linear regression. Basically, the statistics draw the best line through the points, then describe how close to the line the points are. The only catch is the test assumes the line will be straight, and our graphs plotted more like curves. Therefore, we must transform the data in some way to make it lie on a straight line. The method that works best in this example is to take the logarithm of the embeddedness value and use that in the statistical analysis. This gives a good straight line relationship.

With a slope vs log embeddedness test, the relationship is shown to be real, not random, with a greater than 99% probability. And, the slope accounts for 66% of the variability in the embeddedness.

With a velocity vs log embeddedness test, the relationship is shown to be real, with a greater than 99% probability. The slope accounts for 63% of the variability in the embeddedness.

So, both are real patterns which account for a lot of the variability. The next question is: Do both slope and velocity directly control the embeddedness, or are they just interrelated in some more indirect fashion?

Actually, there is a statistical test called stepwise regression for determining which of the variables controls the other. For this, we use slope vs log embeddedness regression (where we found that slope controls 66% of the variability) and do a second regression, on top of the first, to see how much additional variability velocity can account for. Under these circumstances, velocity is still a statistically significant factor, but accounts for only an additional 3% of the variability (for a total of 69%).

From the work of other scientists, we know that slope generally controls the velocity of a stream (the greater the slope, the faster the water moves), and that velocity affects the amount of embeddedness (the faster the water movement, the lower the embeddedness tends to be). But, the BRASS studies were conducted during times of low discharge and slow water movement, not during spring run-off and storm events. This probably explains why slope is a better predictor in our data (accounting for 66%) than velocity (accounting for 63%). The slope, which determines the velocity and therefore embeddedness during storm events, is a better predictor of embeddedness than velocity during the low waters of summer.