Analysis of effectiveness of alternate strategies for sampling of stream habitat.

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1. INTRODUCTION

The condition of the physical environment of running water ecosystems can be assessed at various scales. The most detailed level of observation which is currently achievable is often called micro-scale approach and can be visualised as “fish-perspective”. Physical variables may be measured at the scale relevant to aquatic organisms (microhabitat) and generalised to a scale relevant for development planning. Although the variables measured during such detailed survey are generally always the same, there is wide variation in the methods employed to sample and assessing the data.

Until now, there has been no objective method for the comparison of the effectiveness of different sampling strategies, in the context of environmental assessment or physical habitat modelling. The goal of presented study is not only to accomplish this but also to develop methodological framework for such evaluation.

2. MATERIALS AND METHODS.

Four general categories of strategy for sampling of riverine physical habitat can be distinguished. The first three are based on statistical principles of **systematic** (or equidistant), **random** and **stratified random** sampling. They assume a particular distribution fitting statistical models (for review see PARASIEWICZ & DUNBAR in press). In all this methods specific grids or stratas are superimposed over the study reach. There is however considerable variation between the designs and the results obtained. The **Geodesically Based Irregular Systematic** (GBIS) technique is based on geodetic principles of linear distribution of variables between measured verticals, adapting techniques from digital terrain modelling (GROßMANN & KAHMEN, 1988, PARASIEWICZ, 1996).

The accuracy and efficiency of various designs from these four categories are evaluated using a very detailed hydro-morphological dataset collected in 1993 on the river Wagrainer Ache in Austria. This fourth order river is located in the county of Salzburg, has a catchment area of 130 km² and was sampled 1993 for a minimum flow assessment study. The average width is 9 m, the mean annual flow at the study site varies between 2 and 5 m³/s. One 49 m long and five 20 m long representative sites were sampled at a mean annual low flow conditions (1.2m³/s) using a constant grid of 1 m² (1007 verticals). The topography and mean column velocity were measured and substrate composition estimated at every vertical.

This high density sample was considered as a reference for testing other sampling designs, which were simulated by removing cross-sections and verticals from data set.

Altogether 21 sampling strategies were tested and distributions of morphological and hydraulic attributes were compared to the original. The accuracy, replicability, analytical power of data and effort of each strategy were compared in the final assessment.

2.1 Accuracy:

In order to take account for the spatial distribution of measured variables such as depth or mean column velocity within cross-sections and also to reduce the number of components in the analysis, two cross-sectional parameters were calculated from the dataset: mean velocity and maximum depth. The first one is used for analysis of the overall accuracy of method and second to examine its sensitivity to measured extreme values.

A major problem for statistical evaluation is the underlying distribution of the analysed data. Some samples were and some were not normally distributed. Furthermore they are highly dependent and the number of cases in each sample is different. This excludes most of the statistical tests for either in- or dependent data. Finally two evaluation approaches are chosen: one statistical one analytical. Both methods are still under development and it was hoped that they would give consistent results.

2.1.1 Statistical analysis:

The precondition for comparison of means of dependent data is the assignment of corresponding measurements to each other, consequently the same number of samples in both sets. The parameter values for cross-sections which were removed from original data set to simulate particular strategy are interpolated (only in case of stratified random strategy the values of cross-sections remaining in the simulation set are assigned to all other within represented strata). The analysis is accomplished comparing only the values computed for removed cross-sections with those corresponding in original data set. Since even these samples are highly dependent ($r \approx 0.7$), statistical methods which assume independence are unsuitable. Only the means can be compared with the help of paired t-test. The analysis of variances can be however accomplished by analysing the correlation coefficient between the differences and sum of corresponding values. According to PITMAN 1938 this is the measure for differences of variances and equal to zero if the variances are equal. Since variances are thought to have higher ecological significance than means (e.g. JUNGWIRTH, 1988), the following categorical classification of accuracy was applied to the results. Class 1 is given to the methods having the variances and means equal to the original, class 2 to those differing only at the means, class 3 where by equal means the variances are different and class 4 to remaining methods.

2.1.2 Distribution analysis:

In this approach the absolute deviation of cumulative frequencies (DCF) is used as the assessment criterion. In order to define how far the measurement error influences the DCF, various systematic errors were added and substracted to mean column velocity data measured on the Wagreinerach. Clear correlation between introduced error and mean as well as maximums of DCF could be shown. For relatively small errors the maximum value of DCF was almost equal to the error value. Assuming that systematic error represents the worse case scenario of field sampling four accuracy classes categories of sampling designs are defined as presented in the table 1.

2.2 Replicability

The sensitivity of the statistic approaches to the relocation of the superimposed grid was taken under consideration, particularly for the systematic sampling strategies. The same approaches and criteria as above are used to compare both samples.

2.3 Analytical power

The possibility of using of variously sampled data for different kinds of analysis (descriptive statistics, quantitative and spatial distribution) is estimated and 3 classes of analytical power distinguished (high, mid and poor) respectively.

2.4 Effort

The necessary effort was estimated comparing the number of verticals sampled in each strategy with the original data. The methods reducing this number for more than 85% are classified as requiring low, for 75% as moderate and those reducing it by less than 50% as a very high effort.

The final assessment is accomplished analysing all four estimates for both parameters. The effective, acceptable, ineffective-accurate and inaccurate designs are defined. The results obtained from both approaches are compared and analysed.

3. RESULTS

Both approaches lead to very similar conclusions. The systematic methods provide very high overall accuracy only at the very dense designs. The major handicap is their low replicability occurring already at the grid density higher than one third of a river width. The analytical power is relatively high for this methods but closely related to grid density. The overall accuracy of random sampling methods depends on number of samples only and is not higher than class 2 conditioned by missing extreme values. The random methods are also relocation sensitive. The major disadvantage is poor analytical power of the method. Sampled data can be used only for descriptive statistics analysis and do not take into account spatial distribution of variables. The necessary effort for random sampling is however relatively low. Stratified random sampling has good overall accuracy, low sensitivity to extreme values and is location insensitive. The analytical power is limited but effort is very low. The GBIS technique provides good overall accuracy, is replicable and have high analytical power. It is excellent for measurement of extremes. The effort required is less than 30% of that for the high density grid.

4. CONCLUSIONS

The GBIS method is the most effective one. The stratified random sampling as well as dense random methods can be classified as acceptable. The other methods are either ineffective or inaccurate.

The analysis of DCF of generated parameters proved to be very adequate approach for methods evaluation. The advantage of it is that calculation is simpler than those of statistic counterpart. It provides quantitative measure of inaccuracy allowing direct comparison of the approaches and definition of their accuracy limits.

5. REFERENCES

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