Quality aspects in intensive forest monitoring

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Abstract: Under the umbrella of the Convention on Long-range Transboundary Air Pollution (CLRTAP), the intensive forest monitoring program has been recording data on up to 88 intensive monitoring plots (Level II) in Germany. Parameters recorded are numerous and changes in manuals have not ceased to entail challenges. These cover all aspects from the design to sample collection, from lab procedures to data validation. Here we present an overview over arising problems and future strategies.

1. Introduction

The International Co-operative Program [ICP10] Forests was initiated under the umbrella of the CLRTAP of the UNECE [Bu01] to gain a better understanding of the phenomenon 'Waldsterben' in the 1980s. In 1995 the intensive forest monitoring (so-called Level II monitoring) became a fundamental part of forest ecology research in Europe [DRV03]. Data was measured in a wide range of fields on about 860 permanent plots in Europe, 88 of which were in Germany; aspects included soil, soil solution, deposition, tree growth, and crown condition, to name only a few. Millions of individual values which have to be measured, observed, and recorded. It is a long way and very often you cannot see the proverbial forest for the trees. Trees die and need to be replaced to maintain arrogated numbers, cutting off valuable time series; unseen and only detected much later insects change the chemistry of soil solution [PVB10], birds use measuring equipment as a meeting place causing a change in chemical composition with their droppings [As82] or it just bad luck and the sampler falls over. There is a sheer endless list of possible errors and yet: the intensive monitoring is still going today and is seen as a valuable and irrepressible aspect on the way to understand our forest ecosystems.

However, during evaluations problems emerge whether an exceptional high nitrogen value is based on a contaminated deposition sample or the variation between investigators for e.g. defoliation estimates or crown condition or cover degrees of ground vegetation. Methodological differences and those in sampling equipment have already been shown [In88]. There are different levels of experience and differences between site accessibility and layout. Not even starting with the difference between species composition, soil conditions, water availability, age structure, and climate. Looking at this high amount of variability, it seems to be a great challenge to compare all these sites, to gain valuable information, results, and increase our knowledge.

Being aware of those problems we have to consider the whole moulding process along the chain from data collection out in the forests to data input low-level aggregations after e.g. laboratory work and finally transmission to the international data centre at the Project Co-ordinating Centre (PCC) of ICP Forests (not to mention even higher hierarchies e.g. at the European Environmental Agency (EEA)); from there leaving again to a university or research station. Criss-crossing around Europe being analysed and interpolated until the individual tree is not recognisable anymore. It is not surprising that problems appear along this way. Therefore we have to accept that our smallest data block can get lost or changed in the wrong way. It is therefore an undeniable fact that we need to have check-posts and adequate feedback mechanisms along the way.

Summarized under the topic of quality assurance (QA) and quality control (QC) numerous ways were found to verify monitoring data [HH09]. But how effective are these controls? And nearly more importantly what problems are caused by wrong data?

2. Levels of quality assurance in complex monitoring programs

There are several levels of possible errors connected to any research or monitoring program [Fe11]. The lowest level is the design of the research, the sample plot and the field equipment. The ICP-Forests manual has implemented a high standard of control to allow for inter-plot comparisons on a European level in its newest version. However, even here samplers and their position within forest stands vary [HH09] and it is important that every step is recorded to allow for later control, corrections, and considerations. The next level is the collection of samples and documentation of observations in the field. After this the laboratory analysis is of extreme importance. The last levels are the analysis of the data and later various syntheses. The most important question is: how can quality aspects be effectively included within the database?

Quality assurance can never be done on one level or aspect alone. More than this it has to be done on all levels. For the successful evaluations of the data and plausible syntheses several factors such as knowledge of data quality, consistency and comparability as well as availability of meta information have to be fulfilled.

However, these minimum requirements are often not fulfilled and the effects are difficult to estimate as an unknown problem of data quality might hardly, or only with quite sophisticated approaches [SB11], be detectable. It is therefore a necessity to introduce additional quality parameters which include first-hand information from the field and continue through further analysis. As such quality parameters are widely lacking for the current Level II data; quality can only be assessed in retrospective approaches [FSi.p.]. Therefore several tests are in place, checking for compliance, conformity and uniformity [HH09]. Range tests are often the first step to evaluate the data. While range tests are certainly useful they can only detect values which are most likely wrong as they are outside the range defined plausible. This on the one hand causes the problem of despising values which might very well be true but are outside current experiences on the other hand values can be within the range and still wrong.

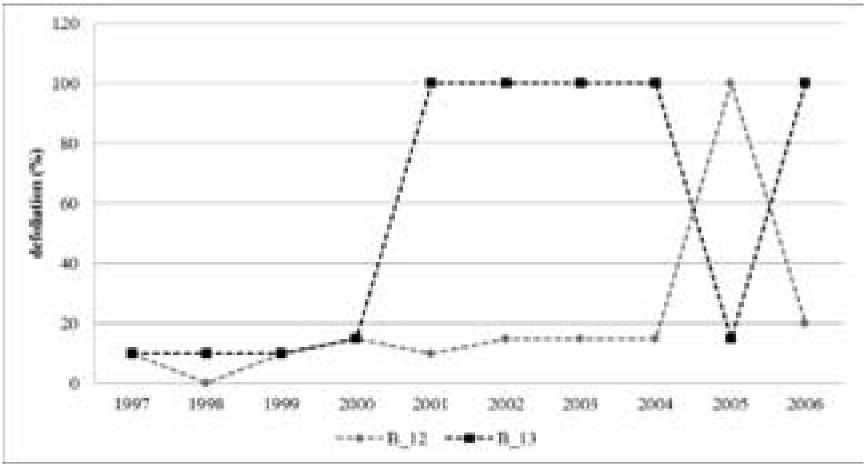

Figure 1: Simple example for change in defoliation on two individual spruce trees on one plot over the years.

While the values for both trees in the year 2005 are clearly possible, the comparison with previous and following years show that they are wrong – in this case the mistake is most likely in confounding these two trees. These errors can only be detected using consistency checks over time series. Nevertheless this causes the problem that some errors e.g. defoliation in year 2005 for tree B_12 can only be detected as wrong after 2006. The sudden jump from 20% to 100% would be possible and be taken as a severe worsening of the crown condition. To the contrary the error regarding the defoliation of tree B_13 in 2005 can be labelled wrong immediately as it is impossible for a spruce to produce enough needles in one year to go from 100% (dead) to 20%. Apart from this, tree B_13 cannot be alive after so many years without needles.

3. Conclusions

There are two main outstanding actions: i) the development of a continuous system of quality parameters connected to each value or at least its aggregates, ii) an easily accessible documentation of meta-information from the sampling design and equipment for each plot and survey over methods of gap-filling algorithms and the aggregation of data. For the meteorological survey a completeness parameter is given for each daily values; similar should be introduced for chemical analyses. Parameters assessed visually like defoliation of tree crowns or cover in vegetation surveys, deviation scores of the evaluating team achieved in cross calibration courses could be given. Apart from these elements, which have to be largely developed in the near future, errors discovered in retrospect during evaluations have to be corrected within the existing database and flagged.

However, even this simple exercise sounding task is not trivial in view of the complex organisation structure of one of the world's largest monitoring system.

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