GROUP 2 : Sampling Design

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Specific design recommendations cannot be made without first defining the specific information needs. For example, design requirements for monitoring forest area differ from those necessary for monitoring forest biomass and environmental quality. The funds available and the precision required may also influence the sampling design. Thus, we first need to resolve what we want to monitor, what for, and how precise our estimates should be.

Some form of randomized sampling is necessary to provide estimates of statistical precision. However, randomized samples are more expensive than subjective samples selected for ease of access (e.g. satellite scenes that already are interpreted, or field plots that are next to a road, or rare forest categories whose location is already known). The increased costs of randomized sampling are offset by the benefits of diminished risk of bias and the ability to calculate the precision of the estimates.

One advantage of systematic sampling is that it offers uniform and complete coverage, which is useful when there is no prior information to assist in stratification. However, there are costs with this approach : it increases travel costs and includes a risk of bias (e.g. if you always visit your staff at lunch time, you may think that they never do any work). Users of systematic sampling must ensure that it does not coincide with some natural periodicity in the environment.

In theory, efficiency in estimating anticipated trends is enhanced by using permanent plots and by varying the sampling intensity according to probability of change. However, in practice, it may be difficult to define durable strata. For example, a region that has a high rate of deforestation today might have a low rate of deforestation 10 years hence because most of the suitable forest will have already been cleared.

Ecosystem quality is difficult to define and expensive to measure. Baseline measurements of forest condition are needed to interpret ecosystem quality, and future changes in quality. Undisturbed ecosystems could be used for this baseline, but such ecosystems may no longer exist. In practice, establishment of baseline ecosystem conditions may be possible only with subjective samples of undisturbed and protected sites. Vulnerable areas may pose some special problems. Many permanent plots may be disturbed before they are remeasured, and this may make it difficult to collect data on natural processes in these forests. However, change due to anthropogenic effects can still be assessed. Vulnerable areas can be monitored efficiently with pre-stratification and random sampling, but this requires estimates of vulnerability for an entire region, or for a randomized sample within the region.

The global carbon cycle is currently a fertile area for scientific research, and whilst the consumption of fossil fuels can be accurately quantified, considerable uncertainty surrounds current estimates of global biomass, and its rate of change. Should global biomass assessment and monitoring form the primary objective of cooperative global monitoring efforts, or should some other objectives have equal priority? Whilst biomass is correlated with fuelwood and forest quality, alternative sampling strategies may be favoured if they become the primary objective of our efforts.

A global data base can be assembled by aggregating data from a natural framework, and with cooperation and coordination to avoid duplication, this can provide very efficient assessment and monitoring. There are some obstacles, e.g. classifications and definitions vary, and cooperation is not universal. International institutions can monitor those regions that do not support suitable data at the national level. However, such institutional efforts must also be coordinated to effectively support national monitoring efforts and help improve environmental monitoring. Conflicting estimates may arise because of incompatible definitions, and we should try to avoid these. They may also arise because of different assumptions or differences in sampling design, and in such cases, major differences may reveal invalid assumptions or poor designs, and should be investigated further. Different estimates derived at successive points in time may be due to any of these previous reasons, or may be due to real changes in the environment. Thus it is important that we can determine the cause of differences in estimates.

Multistage sampling offers a flexible way to monitor at the global level. Such a design could use stratified random sampling with high-resolution satellite data (e.g. Landsat), aerial photographs, and field plots. The first stage could be a random sample of Landsat scenes, with pre-stratification based on ecoclimatic zones. Permanent samples may be provided by new images (e.g. recorded every 4 to 10 years). Either visual ordigital interpretation can provide forest area estimates. Deforestation and serious degradation can be detected using images recorded at different times. These samples could also serve to calibrate area estimates derived from AVHRR images.

The second stage could comprise randomly selected air photos. Local knowledge or further sub-sampling may be necessary to identify some land uses (e.g. recent reforestation). The second stage data also provides estimates for areas that cannot be reliably determined from the first stage data (e.g. areas of recent reforestation or afforestation). Satellite data enable pre-stratification of aerial photographs based on stable parameters (e.g. physiography, permanent land use, or potential natural vegetation). For monitoring change, a permanent time series of air photos should be used.

Ground plots should provide the third stage. Stratified random or systematic sampling could be based on strata derived from the aerial photographs. Strata may be based on existing state or on anticipated rate of change. An independent sampling frame (e.g. list sampling) could be employed for rare, isolated (e.g. plantations, wetlands, or lakes), or linear features (e.g. streams or tree windbreaks). In regions of rapidly changing land use, temporary plots would be satisfactory, although permanent plots provide more efficient estimates of change. Field plots may be deliberately selected to reduce costs, but this introduces some risks and the ability to estimate precision is lost.

For certain objectives, an independent sampling frame might be used. For example, a list of protected or reserved areas might be used for sampling this type of forest. Purposive sampling might be used for intensive monitoring of forest processes that affect forest health, for modelling, or testing new measurement techniques.

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