Abstract template for the conference "A century of national forest inventories – informing past, present and future decisions"

Dear author. This is a two-page template that in the first page will ask for information on presenter name, topic, and preferred presentation form.

On page two, you are asked to fill in your abstract in the format and font size indicated. Please remember to include authors affiliation information in the footer section of page two. The length of the abstract may not be more than one page including references.

Abstract title:		Local difference estimators of variance in systematic sampling
Take-home message:		*SRS-based estimator for the standard errors in systematic sampling can lead to serious overestimation. Estimators based on local differences are less biased but still conservative under mild assumptions, as we illustrated through simulation in this presentation.*
Presenter name:		Juha Heikkinen
Presenter contact info:		Natural Resources Institute Finland (Luke) location: Latokartanonkaari 9, FI-00790 HELSINKI mail: PO Box 2, FI-00791 HELSINKI e-mail: juha.heikkinen@luke.fi
General topic, see website: (please double click on the check box and activate the relevant one)	X	Improving future NFIs by learning from the past
	☐	NFIs today and in the future
	☐	Cutting edge and futuristic inventory techniques and technologies
Preferred presentation form:	X	Oral presentation
	☐	Poster
Abstracts will be reviewed by members of our scientific committee and you will be given information on decisions in due time after the submission deadline has passed.		

Local difference estimators of variance in systematic sampling

Juha Heikkinen[1] and Lauri Mehtätalo[2]

Introduction: Systematic sampling is commonly used in national forest inventories (NFI). Total and mean values of populations with spatial or temporal trends are more precisely estimated than with random sampling. The problem is that all population units included in one systematic sample are determined by one randomly selected starting unit. From the design-based point of view, we thus have zero degrees of freedom left after estimating the total or mean, and unbiased variance estimation is impossible. In practice, sampling error of estimators of population parameters is often assessed using the conservative variance estimator associated to simple random sampling (SRS). As a result, population parameters are, in fact, estimated more precisely than the reported standard errors suggest.

The problem of assessing the precision of estimators computed from systematic samples has been discussed from the very beginning of NFIs. In Finland, mathematical statistician J. W. Lindeberg worked on this topic on 1920's, when the first NFI was being planned as a line survey. He proposed a variance estimator based on local differences between successive inventory lines. When NFIs abandoned line surveys, Bertil Matérn presented a simple generalization to the adopted spatially systematic design, a square grid of sampling units. These developments took place in a close contact to the operational NFIs, and Matérn's estimator is still in everyday use. However, it appears to be widely unfamiliar, and unnecessarily conservative SRS estimator is still too often used in the context of systematic sampling.

This talk demonstrates the superiority of local difference estimators both with real NFI data and through simulations. We also present a (to our knowledge) previously unreported case, where sampling variance can be underestimated due to edge effects, along with a simple bias correction.

Materials and methods: We first review results from the 9th NFI of Finland, the latest one that used a strict square grid of sample plot clusters. Temporally systematic sampling is then illustrated through simulation from a time series of cow behaviour, including the activity (chewing, sleeping, drinking, doing nothing) in 1-second intervals over a day. The aim is to estimate the proportion of time spent for a given activity. The spatial simulation experiment is based on a large mapped forest stand, which is sampled using a square grid design of sample plots to estimate standing volume.

Results: The use of SRS-estimator can lead to severe overestimation of the variance in the presence of strong temporal or spatial trends in the population. The estimators based on local differences are less biased but still conservative under very mild assumptions. Edge effects may cause underestimation, but that can be easily corrected. This leads to a surprising resolution of a 100 years old quarrel.

Conclusion: We should not forget the good old works. Often they also lead to something new.

References:

Heikkinen, J. 2006. Assessment of uncertainty in spatially systematic sampling. In Kangas, A. and Maltamo, M (editors) Forest inventory - methodology & applications. Springer.

Lindeberg, J. W. 1924. Uber die Berechnung des Mittelfehlers des Resultates einer Liniertaxerung. Acta Forestalia Fennica 25.

Matern, B. 1947. Methods of estimating the accuracy of line and sample plot surveys. Meddelanden från Statens Skogforskningsinstitut 36.1. (In Swedish with English summary).

1. Natural Resources Institute Finland (Luke), P.O. Box 2, 00791 Helsinki, Finland. juha.heikkinen@luke.fi
2. University of Eastern Finland, School of Computing, P.O.Box 111, 80101 Joensuu, Finland.