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

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Abstract title:		Using radio positioning for mapping trees on sample plots
Take-home message:		*Radio positioning provides sample plot tree positions accurately with minimal extra work*
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General topic, see website: (please double click on the check box and activate the relevant one)	☐	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:	☐	Oral presentation
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Using radio positioning for mapping trees on sample plots

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Introduction: Inventories for forest management planning as well as National Forest Inventories rely on extensive field reference. Large numbers of sample plots are measured inside inventory areas. Plots are usually fixed radius circular plots. Normally the only information about the tree location is that its trunk is inside plot radius. Many new approaches have been under study, for example using ultrasound distancing and digital compasses for tree positioning. Terrestrial Laser Scanning (TLS) has been a promising candidate for the goal of automating sample plot measurement. TLS can eventually also produce diameter and stem curve measurements. We have been searching for a method for getting accurate tree positions using traditional calipering and chose radio positioning as the method for this study. Our goal for location accuracy (planar) was 10-20 cm, or at least better than 50 cm.

Materials and methods: An experimental measurement system was built by the authors using available components. The system consists of 16 base stations and a rover, which is attached to an electronic caliper. During seasons 2017 and 2018 ca 18 ha of area and ca 16 000 trees were measured using the system. Areas were 1000-2000 m^2 polygons. During the measurement the base stations determine the distances to other base stations repeatedly. When the tree is calipered, the rover measures its distance to every base station it can hear, and the location of the rover is calculated using trilateration. The rover attitude (measurement compass direction and tilt angles) is recorded and used for adjusting the location difference between rover antenna and the trunk centre. The transformation between the local coordinate system and the map coordinate system is calculated from 2-4 common points, which are measured with multiple frequency GNSS receiver using static post-processing. All calculations can be done in 2D (simple and robust) or 3D, which allows more variation in terrain elevation, but requires more careful placement of the base stations.

Results: The basic distance accuracy seems to be around 5 cm. The planar RMS error of the base station locations was 10 cm and the RMS error of tree positions in local coordinate system 13 cm. There were some coarse errors of several meters in rare occasions between the rover and an individual base station, but these can be eliminated manually or automatically, as there are normally 10-15 good measurements available. Studying absolute location accuracy requires tedious reference measurements with GNSS and tacheometer methods and is left to a later study. Yet we believe that the goal of 10-20 cm accuracy is quite realistic with this approach. Biggest problems were caused by high water content in tree branches blocking radio waves during and after rain. Very dense forest limits the distance between base stations.

Conclusion: The home-made prototype system proved operational and produced satisfactory accuracy. We intend to refine the methods further and hope that better sample plot measurements will help us in improving the inventories in near future.

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