



Comparison of remote sensing based RFID and standard tree marking for timber harvesting



Gerhard Pichler^{a,*}, Jose Alejandro Poveda Lopez^b, Gianni Picchi^c, Enda Nolan^d, Maximilian Kastner^a, Karl Stampfer^a, Martin Kühmaier^a

^a Institute of Forest Engineering, Department of Forest and Soil Sciences, University of Natural Resources and Life Sciences, Vienna, Peter-Jordan-Straße 82/3, 1190 Vienna, Austria

^b Treemetrics Limited, Anglesea Business Suites, 2nd floor, 11 Anglesea Street, Cork, Ireland

^c CNR Consiglio Nazionale delle Ricerche - IVALSA Istituto per la Valorizzazione del Legno e delle Specie Arboree; Via Madonna del Piano 10, 50019 Sesto Fiorentino, Italy

^d Coastway Surveys, The Grainstore, Singletons Lane, Bagenalstown, Co Carlow, Ireland

ARTICLE INFO

Article history:

Received 16 December 2016

Received in revised form 23 May 2017

Accepted 27 May 2017

Keywords:

Tree marking

TLS

UAV

RFID

Technology integration

ABSTRACT

Forest inventory is the basis for creating forest management plan. In Europe, forest inventory data is usually collected manually by standard survey methods based on sampling procedures. The information from forest management plan to execute silvicultural and harvesting treatments is transferred to the field by standard tree marking methods e.g. marking spray, marking tape, chalk, bark blazer and plastic shim. A new computer-aided approach based on UAV (Unmanned Aerial Vehicle) and TLS (Terrestrial Laser Scanner) technology was developed to generate a 3D forest model, which replaces standard survey procedures and is the basis for tree marking with RFID (Radio Frequency Identification)-tags. The goal of the developed survey and tree marking method was to increase timber harvesting efficiency in mountain forests by implementing a higher degree of mechanization, automation and intelligent technologies. The objective of this study was to analyse the practical applicability and the advantages and disadvantages of standard and innovative procedures as well as performing a comparison based on requirements, efforts and costs. For this purpose, tree marking was executed for a negative selective thinning in a forest stand in Austria. The costs for marking the trees with RFID tags amounted to 1.55 € per tree. In comparison to that standard tree marking of the same trees with spray by experienced forester amounted to 0.36 € per tree. The results had shown that the new tools were already applicable from a technological point of view, but efforts and costs are still high, especially survey costs. Therefore, further improvement has to be made to transform the innovative method into a marketable and competitive tool.

© 2017 Elsevier B.V. All rights reserved.

1. Introduction

The utilisation of forests in an efficient way can be improved by creating a forest management plan and by transferring the necessary information to the field, i.e. to define how the silvicultural and harvesting operations have to be carried out by forest workers. For the information transfer, tree marking is a commonly used approach. Necessary information about how to perform the forest operations, definition of harvesting area, cable corridors and skid trails, identification of trees to be harvested are usually marked in the forest using a variety of equipment (e.g. marking spray,

marking tape, chalk, bark blazer and plastic shim). The markers are normally placed on the tree, on the soil or on small wooden posts. Forest management plan is mainly based on forest inventory data and determines forest management for a ten-year period. The information is compiled in tables describing stand characteristic (species, stem number, volume, basal area...), maps, aerial photos, plan for silvicultural treatments and economic goals. A forest management plan is usually organised into three parts: cartography (e.g. age-class map), tables (e.g. forest stand data like area, species, age, number of trees, volume, species proportion, yield class) and a technical report (e.g. description of the goals and how to reach them).

Forest inventory is a procedure for collecting measurable, appreciable, or countable forest data, which are analysed and evaluated with mathematical-statistical methods and outputting the results with their errors or confidence intervals (Akça, 2001). So the means and totals for measures of forest characteristics were

* Corresponding author.

E-mail addresses: gerhard.pichler@boku.ac.at (G. Pichler), jpoveda@treemetrics.com (J.A. Poveda Lopez), picchi@ivalsa.cnr.it (G. Picchi), endanolan@coastway.net (E. Nolan), maximilian.kastner@boku.ac.at (M. Kastner), karl.stampfer@boku.ac.at (K. Stampfer), martin.kuehmaier@boku.ac.at (M. Kühmaier).

estimated, which happens for a specific forest area (Kangas and Maltamo, 2009). The generated information can be classified in external information (e.g. ownership structure, market, physical circumstances), direct information (e.g. area, volume, growth, damages, quality) and operative information (household, goals, rights) (Akça, 2001). The standard methods of forest stand inventory are complete enumeration by calipering, sampling methods (sample areas with constant size, distance procedures and angle-count sampling) and estimation of proportions (Kramer and Akça, 2008). For the survey of large forests, sampling is often used because less time and lower costs are needed for gaining the information in comparison to a complete enumeration (Husch et al., 2003). One of the most frequently applied methods is the angle count sampling method developed by Bitterlich (1952). The mentioned standard methods are commonly used in Europe.

Forest inventory and tree marking have a long tradition in forestry and have been carried out for decades according the same principles and methods. A new and innovative computer-based approach should now replace existing procedures and improve the efficiency in forest inventory and management. This innovative forest inventory system is based on surveying forest stands with unmanned aerial vehicle (UAV) and terrestrial laser scanner (TLS) for the acquisition of georeferenced 3D data on standing trees. Such techniques are capable of returning the position of each single tree, as well as a number of inventory data such as DBH (Diameter at Breast Height), stem profile, crown height and other characteristics. Computer-based technologies have been described in several studies (e.g. Moskal and Zheng, 2012; Wallace et al., 2012; Newnham et al., 2015; Puliti et al., 2015; Liang et al., 2016; White et al., 2016). The main focus was on remote sensing technologies, like UAV and TLS, for forest inventories. The focus of the present study goes one step further because it uses the data of these innovative remote sensing technologies to implement a new tree marking technology. The gained data can be fed into commercial software for returning the optimal bucking (Dassot et al., 2011), thus maximizing the value of the extracted timber according to the specific and up to date market requirements. The balance among high productivity and the number of grades and sorts that a logging operation is expected to produce is often regarded as incompatible or at least colliding. To meet domestic and export market demands and to maximize returns a wide range of log products has to be produced. A higher number of grades and sorts makes the harvesting operations more complex and time consuming. This regards bucking, sorting, loading, transport and unloading (Nurminen et al., 2009; Tolan and Visser, 2015). This is even more evident in mountain forest operations, where the reduced size of storage areas makes it necessary to clear the landing shortly, which calls for fast and well synchronized harvesting and transport (Spinelli et al., 2014).

Logistic problems can be solved, at least partially, by means of a traceability system. For this purpose, several solutions have been used for marking of trees and logs in forest operations or timber logistics, such as barcodes, QR codes and RFID technology (Tzoulis and Andreopoulou, 2013). The latter seemed to be the most promising tool. Compared to common colour marks, which provide very basic information (essentially indicate which trees have to be felled and which not), RFID tags have the potential to link the actual trees with the inventory database, making available the related information. Picchi et al. (2015) was testing in a study two tag models and two fixing modalities during three hauling and one transport operation. The reliability in these tests was good. Just 5 of 239 tracked tags were lost. RFID tags ensure a tracking of trees and assortments along the supply chain (marking, felling, extracting, storing, transport). Furthermore, take over and sorting at the customer should be possible. Murphy et al. (2012) also underlined the importance of an efficient log tracking method in the supply

chain for competitiveness and cost control in a global market. RFID systems can be a solution to reduce illegal logging. They provide also a direct financial benefit to the forest industry because of real-time information provided to managers, both in the forest and in manufacturing facilities. Such systems are widely used in many other industries for purposes such as quality management, safety, and financial control, and they can provide the same benefits to the forest industry (Dykstra et al., 2002). This technology can also be used for tree protection and management in cities (Luvisi and Lorenzini, 2014). Ravazzolo et al. (2015) used RFID tags in combination with GPS tracker devices for tracking log displacement during floods. RFID technology is also an important issue in agriculture (Luvisi, 2016) and other areas of life e.g. container yard management, hospital patient identification, mine worker identification, public library customer service, beer keg distribution control, airline luggage tracking, fashion boutique management and many more (Ferrer et al., 2010). Korten and Kaul (2008) showed that the application of RFID in the timber supply chain is technically feasible. It was possible to mark logs manually and several tag types could be read out in motor-manual harvesting. It was also possible to integrate RFID-tagging into highly mechanized timber harvesting systems (tag fixing device for harvester heads, automatic reading during the loading process, etc.). Björk et al. (2011) estimated that the implementation of RFID-based tracking systems in industrial wood procurement may lead to cost reductions in the range of 70% compared to the current practices. Due to the relative novelty of these applications in commercial forestry, very little information is available about the economic savings or the added value that the innovative system may generate.

The first aim of the present study was to analyse the practical applicability of the new forest inventory and tree marking system based on UAV survey, TLS survey and RFID tagging as well as the identification of advantages and disadvantages in comparison to the standard approach. The second aim was the comparison of the conventional system and the new system based on requirements, efforts and costs. The third aim was to make a comparison of the collected forest stand data (species, stem number, mean diameter at breast height, mean height, basal area and volume) derived from remote sensing based forest inventory and conventional inventory system.

2. Material and methods

2.1. Survey area and working chronology

The study site was located in the Austrian province Salzburg, near the village Annaberg im Lammertal. The survey area Promberg (47°29'45.0"N 13°25'17.6"E) has an altitude between 905 m

Table 1
Characteristics of the harvesting area.

Area	0.42 ha
Direction	NW
Measurements (horizontal distance)	140 × 30 m
Slope range	60–100%
Small flatter part in the upper sector	30–60%
Extraction distance (slope distance)	180 m
Age of the forest stand	80 years
Norway spruce	91%
Silver fir	8%
Larch	1%
Number of stems	345
Mean diameter at breast height	33.7 cm
Lorey mean height	30.2 m
Basal area	34.8 m ²
Volume	466 m ³

Download English Version:

<https://daneshyari.com/en/article/6458590>

Download Persian Version:

<https://daneshyari.com/article/6458590>

[Daneshyari.com](https://daneshyari.com)