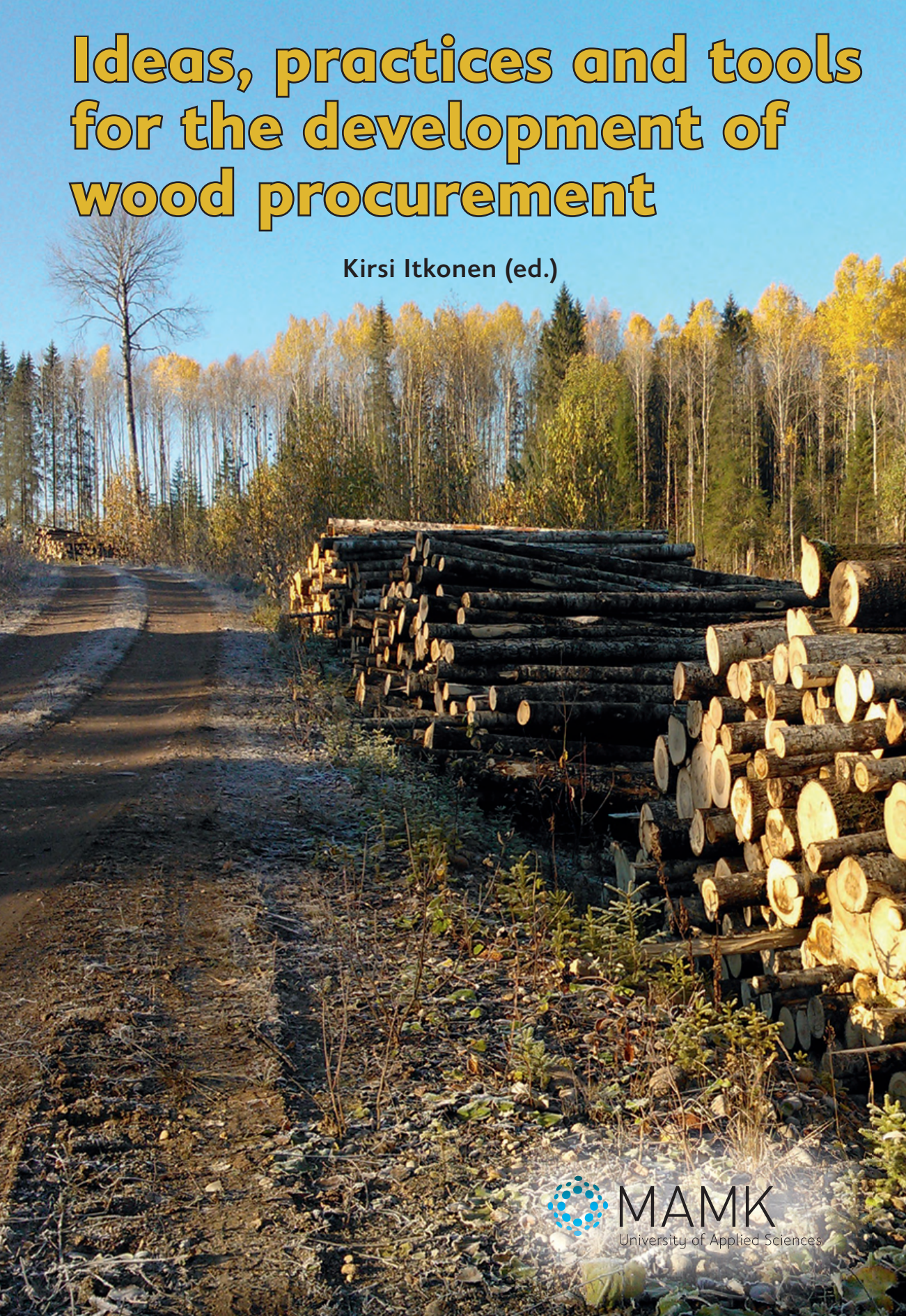
Ideas, practices and tools for the development of wood procurement

Kirsi Itkonen (ed.)



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IDEAS, PRACTICES AND TOOLS FOR THE DEVELOPMENT OF WOOD PROCUREMENT

Kirsi Itkonen (ed.)

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This publication has been made within the project WOPE – Wood Procurement Entrepreneurship, which has been carried out with the EU programme of South-East Finland – Russia ENPI CBC 2007-2013. The project has been co-funded by the European Union, The Russian Federation and the Republic of Finland.

The authors and contributors to the publication represent consortia institutions, including Mikkeli University of Applied Sciences (Finland), Aalto University School of Business Small Business Center (Finland), South Savo Education (Finland), Saint Petersburg State Forest Technical University after S. M. Kirov (Russia) and the Autonomous Public Institution of Secondary Vocational Education of Leningrad Oblast (Russia), and their partners in cooperation, including Forestry Development Centre Tapio (Finland), Finnish Forest Research Institute, South Savo Energy Ltd. (Finland) and Komatsu Forest Ltd. (Russia)

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CONTENT

Preface

Almost two years ago, in December 2012, a project called Wood procurement entrepreneurship (WOPE) started. The aim of the project has been to develop entrepreneurship in wood procurement in the Leningrad region and in Finland. The main activities have included tailor-made training programs for the personnel of wood harvesting companies, the teachers of the vocational forestry education in the Leningrad region as well as for the wood procurement companies in Finland. Three educational organisations from Finland and two from Russia have been involved in the project. These project partners were Mikkeli University of Applied Sciences Ltd., Aalto University School of Business Small Business Centre, South-Savo Education Ltd., Saint Petersburg State Forest Technical University and the Autonomous Public Institution of Secondary Vocational Education of Leningrad Oblast. The project has been carried out within the EU programme of South-East Finland – Russia ENPI CBC 2007-2013 and it has been cofunded by the European Union, The Russian Federation and the Republic of Finland.

The publication *Ideas, practices and tools for the development of wood procurement* is one of the outcomes of the WOPE project and it consists of a selection of articles that aim at developing wood procurement in Russia and Finland. It covers themes that were already dealt with during the project in the training courses both in Russia and Finland. In addition, the publication introduces completely new themes, and a traditional printed publication makes it possible to return to and recall the topics that were found relevant.

This publication covers both technical and financial issues connected with wood harvesting. The technical part comprises articles that deal with silvicultural topics such as thinning and choosing suitable logging technology. In addition, it includes articles on forest roads and machinery and their maintenance as well as an article discussing the possibilities to strengthen the soils and roads. There is also an article introducing energy wood procurement from Russia to Finland as a case example. The articles with financial topics concentrate on the cost calculation and profitability of wood harvesting, and the wood harvesting entrepreneurship in Finland. The last article of the publication deals with the risks that forest machine entrepreneurs could meet while operating in the Russian operating environment.

The structures, lengths and approaches of the articles differ from each other. A number of experts from the fields of education, RDI and working life have contributed to this publication as authors. Some of the articles are more detailed ones and have more or less scientific approach, and some of them are more practical in nature. The aim has been that a variety of writers with different backgrounds would provide the readers with a wider perspective on the topics at issue.

Some of the originally Finnish articles have been translated into English by different writers. Major part of the translation work was done by Pia Paakkulainen. In addition to this laborious translation task Pia also helped with good comments to improve the quality of the original texts.

Also Russian versions of these articles will be published with the hope of reaching more professionals and students involved in wood procurement in Russia. All in all, each article in the publication plays a role in providing an overview of the topics faced and discussed among the wood procurement professionals in North-West Russia and Finland. Based on the shared experiences, ideas, practices and tools within the WOPE project, the useful and beneficial cooperation hopefully continues in the field of wood procurement.

In Mikkeli, Finland, on 15 October 2014
Kirsi Itkonen

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Wope project in the development of wood procurement

Kirsi Itkonen & Svetlana Tereschenko

Background of the project

Almost two years ago a project called Wood procurement entrepreneurship (WOPE) started. The aim of this project has been to develop entrepreneurship in wood procurement in the Leningrad region and in Finland. This has been done especially by arranging tailor-made training programs for the personnel of wood harvesting companies, teachers of the vocational forestry education in the Leningrad region as well as for the employees of wood procurement companies in Finland.

Three educational organisations from Finland and two from Russia have been in charge of this project, which has been co-funded by the European Union, The Russian Federation and the Republic of Finland. The project has been carried out with the EU programme of South-East Finland – Russia ENPI CBC 2007-2013. The partners carrying out the project included Mikkeli University of Applied Sciences (Mamk), Aalto University School of Business Small Business Center (Aalto Biz SBC), South Savo Education (Esedu), Saint Petersburg State Forest Technical University after S. M. Kirov (FTU) and the Autonomous Public Institution of Secondary Vocational Education of Leningrad Oblast (Vyborg).

The purpose of this article and the entire present publication is to look back and consider the achievements of these past two years. What has been done? How have the activities succeeded? And, what have we learned during this project?

With training to development

The aims of the project were divided into two different levels, the overall objectives and the specific objectives. The overall objective of the project was to develop entrepreneurship in wood procurement in North-West Russia. The specific objectives of the project were:

- to improve, increase and to strengthen the know-how in wood harvesting, transportation, entrepreneurship and business operations among the Finnish and Russian enterprises as well as among the vocational forestry schools and logging companies in the Leningrad region.
- to improve and increase the skills and the motivation of the Finnish wood procurement enterprises to work in the Russian business environment.
- to strengthen and improve the risk management and business security of the Finnish companies working in wood procurement in North-West Russia.

Consequently, the project activities were planned so that they would serve as tools in achieving both the overall and specific objectives. Because the project partners involved were educational institutions, the main activities to reach these objectives have naturally been training and coaching. Altogether, the project partners have planned and arranged 13 different training programs and courses, including one study trip in Russia and a visit to FinMetko exhibition in Jämsänkoski, Finland. One of the field trips arranged during the project in Podporozhe, Russia, is going on in Picture 1.

PICTURE 1. Landing in Podporozhe, Russia (Itkonen 2013).

The information about the training courses, the target groups, the venues and the number of participants as well as the partners responsible for the implementation are presented in Table 1.

TABLE 1. The target groups, the duration of the training, the venue, the date, the number of the participants and the partners responsible for the training.

Target group	Duration days	Venue	Date	Participants	Partner
Owners and personnel of wood harvesting companies in the Leningrad Region	3 3 2 3	Podporozhe Mikkeli Jämsä Tihvin	Oct 2013 Apr 2014 Aug 2014 Oct 2014	15 10 13 13	Mamk FTU
Teachers of vocational forestry education, workers of logging companies in the Leningrad Region	5 5 5 5 2	Mikkeli Mikkeli Mikkeli Mikkeli Jämsä	Nov 2013 Nov 2013 Apr 2014 Apr 2014 Aug 2014	9 7 10 7 10	Esedu Vyborg
Entrepreneurs in wood procurement in Finland	2 1 1 2 3	Mikkeli Mikkeli Mikkeli Mikkeli Podporozhe	Apr 2013 Oct 2013 Oct 2013 Apr 2014 Oct 2014	11 9 26 7 10	Aalto Biz SBC

The contents and the themes of the training courses are presented in Table 2 below. In addition to the training courses there have also been other activities with the aim of helping wood harvesting companies in their business. Also a model has been created for the management of risks and the improvement of safety. It is aimed at Finnish and international companies operating in Russia at the moment or in the future. Moreover, an online service for entrepreneurship and business management of wood procurement enterprises will be available in the Finnish and Russian languages.

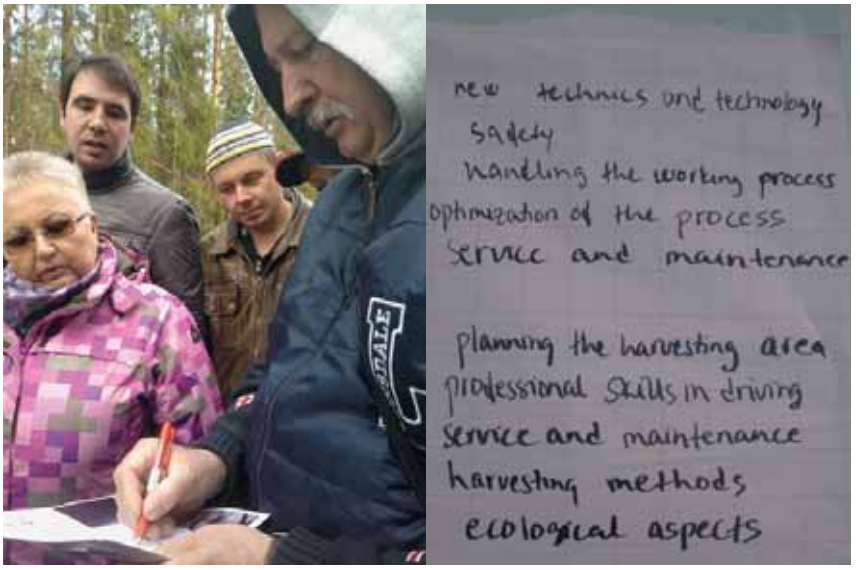
TABLE 2. Main contents of the training courses.

Outcomes	Contents
Training modules for wood harvesting companies in the Leningrad region	Thinning, forest road construction Investment planning Motivation and pricing Timber production: sawmilling, pellets, furniture
Training modules for teachers of vocational schools and employees of logging companies	Logging techniques Maintenance of machines Environmental issues in wood harvesting
Training modules for the Finnish wood procurement entrepreneurs	Management and business culture in Russia, establishing businesses in Russia, financing and taxation , contracts and customs clearance, risks and insurances, wood harvesting and transportation, forest road construction in Russia

One of the outcomes of the project is also the present publication. The aim of the publication is that its different articles could be used in the development of companies. The articles describe good practices and companies can think how the practices presented could be applied in their situation.

Cooperation and networking

During the two years the network of partners has strengthened. When working together in the project, useful experiences have been gained of coaching the companies as well as of working together (Picture 2). It is important to ensure that the network could have a possibility to exploit the project results. This would guarantee the sustainability of the activities after the project has ended. The competences of the network have increased resulting in better possibilities to arrange training in wood procurement at entrepreneurial, managerial and educational levels.



PICTURE 2. Training and training needs (Itkonen 2013, 2014).

As a result of the training courses a significant number of professionals have gathered together. During the project more than 60 different persons have participated in the training courses. This has been an extremely good possibility to share knowledge and good practices. Every time when professionals are together something new can be created – new contacts, shared knowledge, new practices. The list of advantages is long.

Conclusions

The objectives of the WOPE project have been reached through the activities and the outcomes of the project. The increased competences in business operations and wood procurement help in running the businesses in a new business environment, managing the enterprises, operating the machines on the forest sites and training the students in vocational education. Through training it will be easier for the entrepreneurs, managers, superiors and forest machine operators to apply the new know-how and research results.

On the other hand, there are several companies interested in expanding their businesses and in looking for opportunities for growth in Finland, which could eventually result in improved profitability. One way of achieving this could be by extending the operational area, especially, to Russia. It would be excellent, if as a result of the project, Finnish wood harvesting companies could consider harvesting in Russia (Picture 3). When Finnish companies' knowledge of the Russian business environment has increased, they will be better prepared to work in Russian conditions.

PICTURE 3. A group of entrepreneurs from Finnish wood harvesting companies on a study trip in Podporozhe (Mynttinen 2014).

The project and its results could also benefit local and regional economies in South Savo and the Leningrad Region, the professionals in the field of wood procurement and even the local and regional forest fire protection. Enterprises that are more profitable can expand their business operations, which can result in increasing employment possibilities at the local and regional level. However, it is challenging to measure these extensive effects and their impact at once, when the project is just ending.

It is important to think about the future after the project. What will happen afterwards, and what is the sustainability of the project? In this project a lot of emphasis and expectations have been put on strengthening and developing the training network. It is expected that the network will continue to operate in South-East Finland and North-West Russia by offering joint training courses. The network will enable the partners to offer eg joint training for the different levels of the customer organisations with strong emphasis on customer orientation. Valuable information has been received from the participants' feedback on the training programs and modules implemented during the project. This feedback has already been used in planning new training courses. A third additional training course for forwarder operators will be arranged in November 2014. The partners responsible for the implementation are Esedu, FTU, Vyborg and Mamk.

The participants of the training courses with their companies and networks will be an extremely important and useful resource for this training network. New ways to cooperate and develop wood harvesting and to increase the operations of wood harvesting companies have been created. It is important to improve the opportunities of harvesting companies to advance their competitiveness through networking and technological expertise in North-West Russia and South-East Finland.

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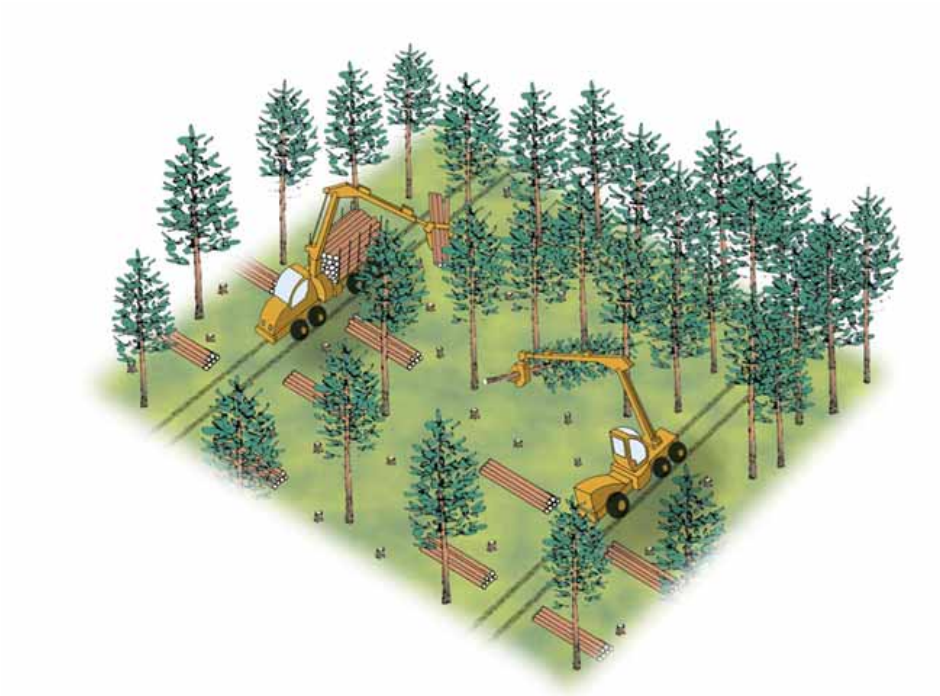
Thinning practices in Finland

Kati Kontinen, Evgeny Kutznetsov &Timo Antero Leinonen

Introduction

Thinning refers to a tree felling operation where some of the trees are felled in a forest stand which has passed the young stand stage. Most of the wood volume contained in the trees cut down during the thinning meet industrial criteria. Obviously, thinning operations should be financially profitable. Thinning also improves the vigour of the tree stand by improving the growth conditions of the retained trees.

Thinning is the most important silvicultural measure to be applied in stands that have reached the intermediate stage in their development. When thinning is carried out, the most vigorous and financially most valuable trees are usually retained. The majority of the trees removed in thinning meet pulpwood dimensions at least.



PICTURE 1. Thinning operations (Uusitalo 2011. 90).

Thinning reduces the competition for light, water and nutrients between the retained trees. The root systems of the retained trees have more space to grow and they begin to expand. Thinning mainly promotes the diameter growth of trees.

The trees grow in size and the competition between the trees once again increases, and also the shading within the stand begins to increase.

The first commercial thinning

The first commercial thinning is the first thinning in which industrial wood is harvested. From the silvicultural viewpoint the first commercial thinning is the most important thinning, but in an economic sense, it does not have a great significance in the entire rotation. When considering the stand's future development, the timing and intensity of the first commercial thinning are of crucial importance. The timing is determined by the state and by the condition of the stand.

The first commercial thinning must be done before the trees selected to be retained lose their vigour due to over-stocking. In pine stands the recommendation is that thinning should be done before the live crown is reduced to less than 40% of the height of the tree. In spruce stands and birch stands the corresponding minimum is 50%. The timing of the first commercial thinning depends on how the stand was treated in its young stand stage and on the quality of the growing stock. For example, in Southern Finland thinning can be carried out at the height of about from 12 to 17 metres depending on the tree species, the selected growing programme, and the quality of the growing stock.

Subsequent thinnings

The second thinning in a pine stand is usually necessary, because the objective is to fatten up the trees in a hope of getting a better price. The third thinning ensures that the diameter growth of the most valuable sawlog boles is sufficient before the regeneration felling. There are thinning models that have been developed as aids for determining the timing of subsequent thinnings. When following these thinning models the second thinning usually takes place between 10 to 25 years after the first commercial thinning, depending on site quality. The recommendation is then to retain 400–450 trees per hectare until the regeneration felling, which is due at an age of 40 to 50 years.

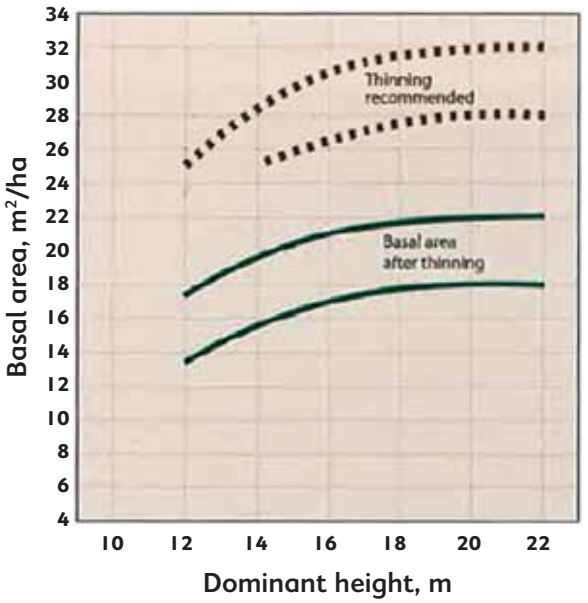
Types of thinning

The type of thinning refers to the principle applied when selecting the trees to be felled and those to be retained when carrying out thinning. Low thinning has been the traditional favourite in the Finnish forestry. This means that felling mainly concentrates on the smallest trees which have fallen behind as a result of competition.

Crown thinning focuses on felling some of the largest dominant trees in the stand along with the smallest trees assuming that a sufficient number of vigorous co-dominants can be retained. Thinning revenues are higher in crown thinning. The calculation of the current value of stumpage revenues when applying an interest rate of 4% makes crown thinning about 10% more advantageous to the forest owner than low thinning.

Thinning models

The thinning models presented in the Finnish silvicultural recommendations show the limits within which it is advisable to stay in terms of stand treatment. The models are presented by tree species and by the site types for Southern Finland, Central Finland and Northern Finland, and they show



PICTURE 2. An example of a thinning model (Hynynen 2011. 119).

the level of stocking to be retained in the stand at different stand heights after thinning. Picture 2 below introduces an example of a thinning model where the stand height is on the y axis and basal area on the x axis.

Once the stocking density of a forest stand reaches the zone illustrated by the pair of dashed lines in the thinning model, it is time to thin the stand. The lower pair of continuous lines shows the basal area range of the stand within which the stand's basal area should be after thinning. Thinning models based on basal area suit best for subsequent thinnings in advanced stands.

When dealing with the first commercial thinning in young stands, the recommendation is to carry out thinning by following the target stem numbers per hectare instead of using the thinning models. The target stem number vary according to tree species and site types. If the volume of the growing stock is thinned below the recommended level of the thinning models, the stand is deemed to be under stocked. After such heavy thinning the diameter increment of the trees is no longer able to compensate for the loss in the increment caused by the thinning.

Mechanized harvesting in thinning

Since the introduction of single grip harvesters in the end of the 1980s, thinning experiments have been done with harvesters. Practically all commercial thinnings in Finland are nowadays carried out by harvesters. There are two major challenges in using harvesting machines in thinnings. First, the machines can cause damage to the remaining tree stand resulting in weaker silvicultural quality. The second challenge appears if the harvested stems are small in size, which results in low productivity and further low profitability.

The standard procedure in mechanized thinnings is to use harvesters with a 10-metre crane and a striproad spacing of 20 metres, and the thinning models are adopted to this procedure. There are also procedures based on the use of small size harvesters (Picture 3). These harvesters are capable of moving between the retained trees and piling logs on desired locations. The striproads used for forwarding can be spaced even 40 metres apart.

Some rutting commonly occurs in harvesting and mainly it is caused by forwarders. On regeneration sites rutting is a visual defect. On thinning sites rutting can cause severe problems, as soil compaction and scars on roots, stumps and stems cause loss of future growth. They also decrease quality. The most effective methods to avoid rutting and scars on roots is to collect logging residues on striproads and to equip machines with appropriate tracks.

PICTURE 3. First thinning of a birch stand done by a medium sized single-grip harvester (Leinonen 2010).

The productivity of harvesters mainly bases on the stem size, ie volume per stem. In turn, the profitability of processing small stems can be improved by multi-stemming. This means processing two or more stems simultaneously. This technology is worth further study, if a company's operations concentrate on the first thinnings.

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Factors affecting the choice of logging technology

Timo Antero Leinonen, Vladimir Kaztadze & Ano Teittinen

This article lists and briefly discusses factors that should be considered when choosing logging technology, and especially forest machines. The first of these factors – ie terrain conditions, tree properties, industry requirements and silvicultural guidelines – are more constant in nature whereas the last four factors – ie finance, the availability of service, the availability of labour and its competence – can change fairly quickly. Also some differences between the Finnish circumstances and those of the Leningrad region are introduced, and the article ends with two charts that could be used as checklists when considering which logging technology would best suit a certain environment.

Terrain conditions

The applicability of wheeled machines is restricted to areas with modest slopes and fair bearing capacity. The performance of such machines on steep terrain can be increased and greatly improved by careful planning, especially by planning the locations of striproads. Notable improvement can also be achieved by tracks and winches. However, slopes exceeding an incline of 30 % are not suitable for wheeled machines at all. (Harstela 1998.)

In the boreal coniferous zone the low bearing capacity is a restricting factor on peatlands between spring and autumn. This is due to non-frozen

PICTURE 1. QR code to a boggie control video (Leinonen 2013).

ground. The performance of forest machines on peatlands can be improved by working in the winter, by gathering residues on striproads and by using special tracks, such as those of Olofsfors and their Baltic model. The attached video available through the QR code below in Picture 1 presents a more unique method called boggie control to improve forest machines' performance. This method is optional in some forwarders and it reduces rutting.

Tree properties

In terms of choosing logging technology and forest machines the most important tree property is dimension. The maximum opening of the harvesterhead must exceed the mean diameter of the processed trees. It is possible, but too slow, to process trees with a diameter greater than the maximun opening of the harvesterhead. Trees that are several centimeters bigger in diameter are impossible to process. In addition, deciduous trees are more difficult to delimb compared to conifers. The design and the number of delimbing knives can affect the delimbing result. (Uusitalo 2010.)

These aspects would be good to consider, for example, when choosing a suitable logging technology for the Leningrad region. Although the region mostly has the same tree species as Finland, the number of deciduous trees – the more challenging ones to delimb – is bigger (Picture 2). Also the average size of the trees is bigger, because harvesting has not traditionally been typical in the area. This sets requirements for the harvesterheads, for instance.

PICTURE 2. Birch is more difficult to delimb than conifers (Leinonen 2014).

Industry requirements

Which logging technology and what kind of machines are used, also affect bucking and delimbing and the resulting quality and dimensions. Sawmilling, plywood manufacturing and the production of ground pulp usually set strict demands on bucking and the accuracy of dimensions. Chemical pulping and energy production are more flexible. Similar division can be also seen in delimbing. Chainsaws as bucking tools usually meet the demands of all industrial users. There are also scissor-type cutting devices which break the wood when cutting. This breakage can be harmful in further processing. Typically only energy producers and some chemical pulpmills accept these logs. (Harstela 1998.)

Silvicultural guidelines

The last constant factor influencing technology choices involves silvicultural guidelines which can include regulations that have bearing on technological solutions, too. An example could be given from Finland where thinnings are typical as logging operations and following the requirements of silvicultural guidelines result in challenges in terms of the machinery used. In case thinning is involved in the logging operation there are two choices for the forest machines used: either specific thinning machines or the so called all-purpose machines for thinning and regeneration fellings. The silvicultural thinning models set requirements for the latter types of machines in terms of allowed crane reach and machine width. As the distance between two striproads should not be less than 20 meters, working with a machine whose crane cannot reach far enough can result in some areas being left unthinned.

This dilemma becomes even more complicated when the bearing capacity of soil and the stability of machine must be considered. The so called 10^3 idea has been presented as a solution. It involves a machine with a 10-meter crane which is reachable enough. The stability needed can be achieved with a machine tara of 10 tons, and a chassis of this size is appropriate for carrying a load of 10 tons both in case of harvesters and forwarders. And, in Finland the machines utilized today are commonly heavier than 10 tons. (Uusitalo 2010.)

Silvicultural guidelines also set requirements for the forest damages allowed. And, different technology alternatives can be considered in terms of avoiding damages, too. There are two kinds of forest damages: soil damages and tree damages. Soil damage is called rutting and it can cause erosion on slopes. It also compacts soil and makes it difficult for roots to grow, which may result in lower growth. Rutting also increases the risk of wind-falls. Rutting can be minimized, for example, by choosing good tracks for the forest machines.

Tree damages can be divided into three groups depending on which part of the tree is affected, ie upper part of stems, lower part of stems and root-necks. The damages on the upper parts of stems are caused by felled trees. Damages on the lower parts of stems and root-necks are caused by felled stems, logs, cranes, frames of machines or wheels. Tree damages lower the quality of timber and decrease the growth, and they can be minimized by making professional use the technical devices and machinery chosen. The following pictures illustrate the different kind of possible damages caused by harvesting.

PICTURE 3. Rutting (Leinonen 2014).

PICTURE 4. A damaged root and a matchbox as a scale (Leinonen 2014).

PICTURE 5. A damaged stem and a matchbox as a scale (Leinonen 2014).

Changing factors

The last four factors that affect logging technology choices and are introduced here involve finance, the availability of service and labour and the competence of labour. These are factors whose features and influence on logging technology can change, and the changes can also take place quickly. For example, modern forest machines are expensive and their pay-back period is several years. That is why, uncertainty of employment or financial stability can make second-hand machines more attractive alternatives for entrepreneurs than buying new machines. The Nordic countries have a well-developed aftermarket for forest machinery. (Uusitalo 2010.)

Also the availability of service plays a role in choosing the logging technology. Efficient service is a requirement for the forest machines' degree of utilization, as introduced in another article of this publication titled Cost calculation and profitability in wood harvesting. And, it may prevent entrepreneurs from choosing specific equipment if the manufacturers are not able or willing to arrange the service. (Uusitalo 2010.)

Obtaining a high degree of utilization also requires that a necessary number of skilled forest machine operators are working. Modern machines set high demands on the operators' skills, and the availability of labour is not only a question of labour availability in quantity, but both in quantity and quality. The ability to pay wages to operators is set by the open market mechanism.

Employers should guarantee good working conditions to keep the skilled labour satisfied. (Uusitalo 2010.)

A further way of introducing factors that play a role in choosing a suitable logging technology is available below in two charts. The first one of them Chart 1 presents factors and features that are relevant in terms of technical and ecological environment. Chart 2, in turn, aims at describing the points to consider in terms of economic environment.

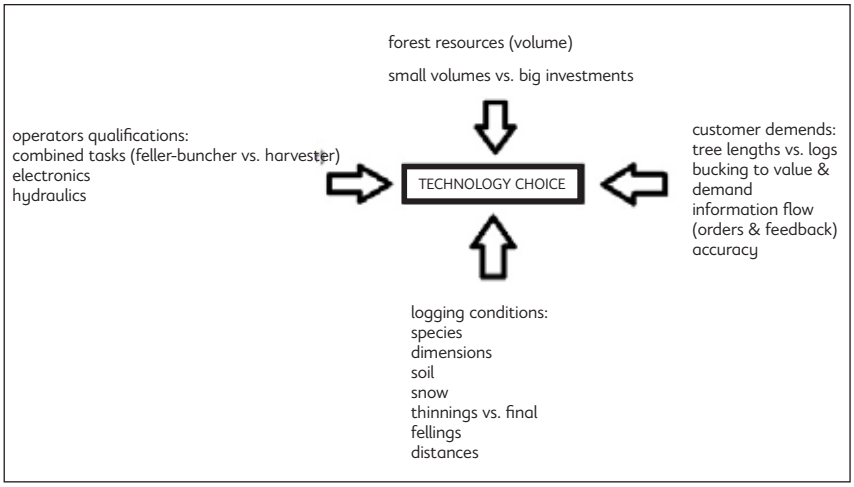

CHART 1. Technical and ecological environment in choosing logging technology.

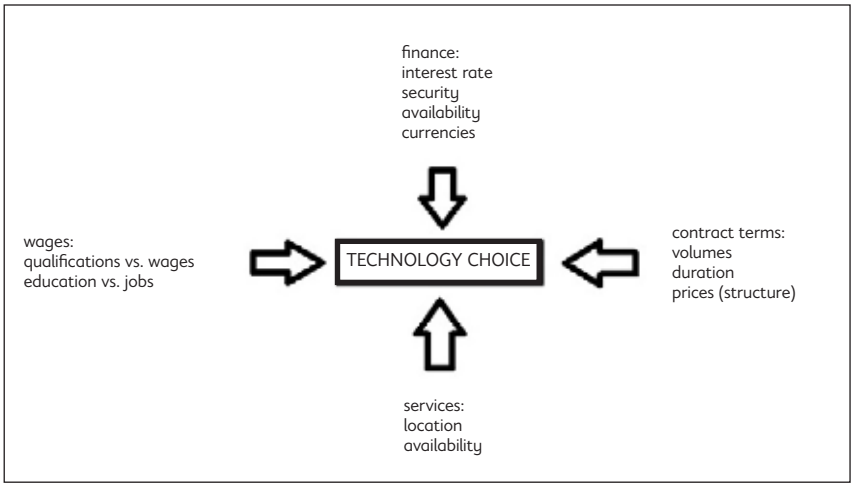

CHART 2. Economic environment in choosing logging technology

The charts and their information could be used as checklist when choosing logging technology. Harvesting companies can typically invest in one new machine only. Therefore, it is important to consider not only the features of the new machine, but also how well it will work as part of the entire existing forest machine fleet.

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The importance of forest machine maintenance in the challenging Russian conditions

Altti Laiho & Ano Teittinen

Russian logging and its operating environment

The developing Russian market for forest machines and the related after sales infrastructure bases on the growth of forestry in Russia. The Russian parliament's, the Duma's, forecast for the increase of logging is huge: The volume of logging is predicted to rise to 250 million cubic metres by the year 2020 and to 350 milllion cubic metres by 2025. These volumes do not match the reality, as the only possibility for the growth is increasing export, which is not realistic with the current speed. For example, there are currently no paper or pulp mills under construction in Russia. Logging volumes are nevertheless growing, and the share of the Cut-to-length method is increasing annually by a couple of percent. This way the market for forest machines is growing steadily. The total volume of imported new forest machines seems to reach the number of approximately 340 units in 2014. The number for second-hand machines appears to be about 200 units. These numbers account for the overall imports of all manufacturers.

When forest machine business was done in the former Soviet Union in the end of the 1980s, customers wanted the quotations for the machines to include spare parts for the machines' entire lifetime. It is impossible to predict the number of the spare parts, and that is why their separate sales was started. This was not typical in the country.

Nowadays all established forest machine manufacturers have warehousing for spare parts and service units around the Russian forest areas. Forest machines are developed continuously according to the Scandinavian requirements and this improves their operational reliability and productivity. The drawback, however, is the machines' increasing dependence on computers, and that way their greater vulnerability to damages in heavy conditions.

The importance of service in the maintenance of high technology forest machines

The profitability of forest machine investments is guaranteed by advance service to achieve the best rate of utilization. Customers must understand that it is more affordable to have the machines maintained in time before they break. The implementation and right execution of routine maintenance give a basis for productive forest machine contracting. Being prepared and timing the services so that the time suits the logistic operations help to prevent useless downtime in the use of the machines. It is advisable to keep advance orders and a reasonable stock for spare parts that wear frequently always available at the logging site. The most typical spare parts are usually available from the manufacturers' stock in the warehouses of their service units. Other service and repair supplies must be ordered from the manufacturers' central warehouses. There is case-related variation in the delivery times, and for example distances and the routes available influence them (Picture 1).

PICTURE 1. Transportation of workers to a logging site beyond Lake Onega (Laiho).

How to improve the quality of service work

Carefulness and cleanliness play a key role in service and repair work. For example, over 80 % of the malfunctions in hydraulics may be caused by impurities entering the system for instance during the changing of hoses when the surroundings of the machine under service have not been cleaned carefully enough according to recommendations. The overall cleaning of machines and washing the target areas before the service guarantee the machines' problem-free operation. This also emphasises the use of a pneumatic pressure compressor in cleaning in the forest conditions. This compressor can be acquired as an additional device and pneumatic pressure can be used, for instance, when cleaning the cooling system cells of the engines and hydraulics. Pressure cleaner, in turn, is a good solution in forest machine depots. The best cleaning results are achieved with an efficient steam pressure cleaner. However, its use in an environment with electrical components and connectors requires skills and carefulness.

Details requiring special attention in the different areas of forest machines' service and repair work

Engines

The beginning of the 21st century and the diesel engine technique that had developed with the international pollution regulations brought engines with the commonrail injection also to the Russian market. In the beginning there were great problems with the quality of fuel. The local fuel is not poor as such, but it's a question of distribution. The fuel is first loaded into a railroad car, after that into a tank truck and then into a smaller tank truck, after which it is transferred into a tank in the forest or directly into a forest machine's tank. There is no one to guarantee the cleanliness of the tanks and that they are free of water, which results in damages in the injector nozzles and pumps. Picture 2 illustrates a fuel tank in the forest.

PICTURE 2. Fuel tank beyond Lake Onega (Laiho).

The fuel culture has improved, but there is still a lot of room for development in the handling of fuel (Picture 3). For example, the Komatsu forest machines include electrical filler pumps both for fuel and hydraulic oil as standard. In addition, the standard machines are equipped with a separator for additional water.

PICTURE 3. A fuel tank of a harvesting site in Karelia (Laiho).

Power transmission devices

The endurance of the transmission devices must be good, when the transportation distances are long due to lack of forest roads. Forest machine manufacturers, such as Komatsu, have arranged a couple of training sessions in building forest roads at a customer's site and with the customer's machine. Picture 4 presents an example of finished base for a forest road.

PICTURE 4. A finished base for a forest road in Perm (Laiho).

The forests also lack ditching, and machines must transport wood in endless mud (Picture 5). This causes the power train sealing to wear quickly resulting in oil leakages.

PICTURE 5. Problems by Lake Ladoga (Laiho).

The forest machine operators play a major role when working in this kind of conditions. If the machines are driven embedded in mud, they must be greased often enough to keep the seals operational. For example, the Komatsu forest machines do not have central lubricant systems in the Russian area, because their use in the winter is difficult. The quality of oils and greases is sufficiently good in Russia. The forest machine manuals introduce the quality requirements for oils which are a condition for the validity of warranty.

Hydraulics

Repairing hydraulics in the forest is demanding, and this emphasised constantly to the mechanics and forest machine operators. Repairs in the forest must be avoided and for example seals must be changed in a service truck. Each logging site must have a service trailer or storage, and it must be tidy. Picture 6 below presents a proper service storage where for instance the spare hydraulic hoses must be stored plugged. Many bigger logging sites have their own hose clamp for making connections. The hoses are often changed carelessly without cleaning the connectors, which allows impurities to enter the system.

PICTURE 6. A proper storage for spare parts in a Karelian logging site (Laiho).

Electrical devices and information technology

In the winter forest machines are used even in temperatures of minus 40, when endurance is required for instance of electric devices. In addition, the service of batteries is difficult in the forest and batteries are used more, too. Especially jump starting and its wrong execution result in computer malfunctions. Also repair welding puts computers at risk. Welding is usually carried out as quickly as possible, and devices are damaged, because some of the computerized units have not been disconnected. In such cases, urgency and rush did not promote the continuous payment of salaries.

If they are necessary, the software updates for the forest machines' control systems are made during routine maintenance. The most common malfunctions result from the forest machine operators' wrong changes to the adjustments that they cannot undo, and service mechanics are needed for the job.

Skills in adjusting and calibrating the length and thickness sensors is not at a professional level, but on the other hand, the quality requirements in measuring length are not as high in Russia as in Scandinavia. In Russia wood purchasers, such as forest industry companies, measure most of the wood and machine measurement is needed for paying the forest machine operators' salaries that base on cubic metres. This aspect, in turn, is a burden: operators want to achieve as many cubic metres as possible.

Accessories: chains, tracks and cranes

As mentioned above, the distances in Russia are long and the terrain is often covered by liquid sand that makes the tracks and chains to wear quicker as usual. It's typical in Russia that the tracks are repaired, they receive new links and link hooks, and after that they can be used for the next 5 000 hours.

Cranes are often used to load trucks on the roadside landing, which stresses them too much. In addition, their use in the winter in low temperatures results in cold shortness and through that in damages. It's usually the lack of greasing that results in cranes wearing too early and requiring general maintenance. To ensure sufficient lubrication the use of more liquid greases should be started in the autumn well before the really cold temperatures so that the less liquid grease used in the summer has time to wear away from the lubrication system.

Details relating to winter use and service

Using forest machines in temperatures of minus 40°C causes problems (Picture 7). As additional heaters do not help in starting the machines in such temperatures, the guideline is that the machines should be used all the time, so that there is no need to start them. Accordingly, the machines are normally used in Russia for 20 hours per day, seven days a week, which makes working in such cold temperatures possible. However, damages do occur.

PICTURE 7. A bit colder weather in the Sakha Republic (Laiho).

The hydraulics system includes a thermostat that works cold so that the oil will heat up as quickly as possible. And when the oil is warm, the thermostat keeps it in the right temperature. It's important to remember to make advance services already in the early autumn to be ready for the winter. For example, oils used in the summer must be changed to winter oils in time, and vice versa. The same applies to fuel, and there is well fuel available for the winter and arctic conditions.

Benefits achieved in service work through forest machines' monitoring systems
The operation of forest machines in the forest sites can be monitored with satellite systems. For example, at the moment Komatsu uses their Maxifleet satellite monitoring system in about hundred machines in Russia. The system produces information about the forest machines for the customers' use. Two or more machines operate in the same WLAN network and the machines exchange information with each other whenever they are closely located. One of the machines sends the information to the Komatsu server through a satellite antenna, and the customer can access the server and study the real-time information and the location of the machines on the map.

Customers receive information, for example, on the hours and rate of utilization, fuel consumption and the results. Komatsu receives information to help in planning the service and this makes it possible for the service point mechanics to make preparations for the general services and to reserve the necessary supplies in time. The maps show the locations of the machines and the machines' control systems which provide error codes and printouts from the machines' computers that help the mechanics to survey the condition of the machines and to find out the reasons for the malfunctions.

Work safety and accidents in service work
Most accidents in forest machine operations in Russia typically result from falling, slipping and flesh wounds. When arranging training for the forest machine operators and mechanics special attention must be paid to supporting the machines correctly during service and repair work to prevent accidents where the machines either fall on somebody or cause somebody to get squeezed. Protective measures against exposure to chemical substances must also be remembered.

The specific development targets in the forest machines' service and repair work in Russia

Accidents and wrong service methods can be reduced through training, but achieving this is difficult, when there is no time to participate in training. Finland had the same problem earlier in between the 1950s and 1960s, when the use of chainsaws and mechanical forest transportation became more common. Occupational accidents were a major problem when working with new tools without training. The solution to the problem was that forest companies hired travelling instructors who gave advice for safer and more rational working methods. The first proper schools for forest and forest machine work were established in Finland in the 1960s.

Travelling instructors provide one good method for the development of forest work safety in Russia. Service point mechanics should be trained to be

instructors, because they visit the forest machines regularly and could train the personnel on site (Picture 8). The basic training in mechanical engineering should cover more of machine manufacturers' involvement, because the current basic training does not provide enough information on the technical aspects of the latest machines.

Conclusions

The maintenance of high technology harvesters and forwarders requires a sophisticated service organisation and forest professionals of a new generation. This requires a lot of training, and it's also a challenge to develop the maintenance logistics to suit the demanding Russian conditions. The distances between the warehouses and logging sites and long, and a lot of time is spent in delivering spare parts, even though they would be available from stock. In the customers' opinion the spare part deliveries always take too much time.

The key problems of servicing forest machines in the Russian conditions can be listed as follows: distances, lack of road network and operators with basic skills, waste of time, low results, lack of advance planning – repairing only when something breaks – neglect of general maintenance, users' indifference and the use of insufficient service supplies. Machines are often repaired only when they stop, and the reason is the machine operators' payroll system. If there are no cubic metres, there is no salary.

PICTURE 8. Mechanic training in The Komi Republic (Laiho).

One of the important issues is training the companies' operational managers to meet the requirements of forest machine maintenance. Also the operational management has a big role, when 50 000 cubic metres per each harvesting system, including a harvester and a forwarder, must be delivered to the roadside landing, so that the machines can be financed.

Comparison calculations between the costs and the rate of utilization of well-serviced and neglected forest machines must be made for the customers to motivate companies to invest in the service operations. This is a constant topic in sales negotiations so that the forest machine owners would understand the importance of service to their companies' finances.

PICTURE 9. An up-to-date service unit in The Komi Republic (Laiho).

Despite all the challenges there has been huge development in the Russian maintenance operations during the past 25 years. There are service units and training facilities that meet the Scandinavian standards around the country (Picture 9). Customers are interested in full service agreements, which gives completely new possibilities for the development of service. The cooperation of forest machine manufacturers and educational institutions should be increased further. This increases the amount of information and promotes the development of a service culture.

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Forest roads in Finland: Practices for the development of forest roads in Russia

Ilppo Greis & Kati Kontinen

Introduction

A road network that is extensive enough and in good condition is essential for the wood procurement of Finnish forest industry. Most of the raw wood used in the factories comes directly from the forest by trucks. In addition, the road network is important for rural areas. (Uusitalo 2003.) Forest roads are important in keeping the costs of wood harvesting and transportation competitive as they help forest owners to get a better price for the sold timber. The forest roads also enable the forest industry to acquire the raw material needed around the year. (Metsätiet ja metsäluonto 2003.) Picture 1 presents a typical forest road in Finland.

PICTURE 1. A typical forest road in Finland (Niemelä).

During the last decade the annual harvesting volumes in Finland have been 40–50 million cubic metres, and the aim in the future is 70 million cubic metres (Kansallinen metsäohjelma 2015 2011). Because of the increase in the size and number of forest trucks and that of frost heave, the structural

condition and bearing capacity of private forest roads need to be better. The condition of private forest roads has become worse during the last 20 years. The funding for the maintenance of the roads has decreased by 70 percent. This happened after the depression in 1990, when the responsibility for funding was transferred from the government to the municipalities. In 2014 the government subsidises the building of the forest roads by EUR 5 million. The decrease in the subsidies has resulted in the government's non-involvement in the maintenance of private roads.

The conditions for constructing forest roads in North-West Russia are difficult compared to the situation in Finland. It is difficult to find places with bearable soil for forest roads and natural gravel or stony soils to crush for road pavements. The plain terrain and the lack of drainage systems make the water drainage difficult. Therefore, timber has traditionally been transported along winter roads in Russia, and the permanent forest road network compared to Finland is sparse.

However, the long-term forest leases have currently started to include a condition requiring leaseholders to build a permanent forest road on the area. In case of long-term leases such investments in forest roads start to be affordable for the leaseholders. In addition, the increasing silvicultural activities need permanent forest roads

Finnish forest roads

The building of Finnish forest roads started in the 1930s in the forests owned by the forest industry companies and the state. The building of roads in private forests started after 1948, when the state started to support forest road construction. Nowadays most of the forest roads have already been built and the existing network is also supplemented by spur roads (Niemelä 2002). The road network is so dense and of such good quality that an average hauling distance from the felling site to the roadside landing in Southern Finland is only 200 meters.

The road network has practically been completed and today's building concentrates on the construction and development of the existing road network. Because of the changes in the weight and length of the trucks the roads, and especially the bridges, need to be reinforced. The length of the road network in Finland is about 450 000 kilometers. About 3/4, that is 350 000 kilometers, are considered as private and forest roads. There are 26 000 kilometers of street network and 78 000 kilometers of road network maintained by Finnish Transport Agency, an organization operating under

the Ministry of Transport and Communications. The length of the forest road network built especially for forestry purposes is almost 160 000 kilometers. More than 60 % of these roads are located in private forests, 20 % in the state forests and 15 % on the land of forest companies.

The so-called shareholders of a road maintenance association own the private forest roads. The shareholder is a person who owns an estate in the area where the road is situated. All the landowners who own land in the surroundings of the road belong to the road association. The rule is that the members take care of the road and its maintenance as well as its reconstruction. The state is not responsible for maintaining private roads, although it can provide financial support for the maintenance.

Profitability of forest roads

When estimating how profitable a forest road would be different advantages and costs should be considered. The most important factor is the volume of the harvested timber. The maximum calculation period is 20–30 years, equaling the technical lifetime of the road. Also, the resulting benefits should be achieved by that time. (Niemelä 2002.) Especially the support provided through public funds increases the profitability of the road investment a lot. For example in Finland, the Act of the Financing Sustainable Forestry, called KEMERA, provides subsidies to support road building. Subsidies are available for the planning and implementation. In addition, the Centres for Economic Development, Transport and the Environment, called ELY Centres, support the construction of forest roads, because they are responsible for the regional implementation and development tasks of the central government. Also cities and municipalities are supporting the road maintenance more and more. (Lepola 2009.)

A shorter haulage is an advantage for the timber buyers, forest owners and timber transporters. When the roads are in good condition, the planning of harvesting is easier, the forest owners get better prices for the timber as the cost of harvesting decreases, and finally the efficiency of harvesting increases. Forest owners can have a landing on their own land along the forest road and this way avoid paying rent for the landing. In addition, travelling, for example for planting, clearing and thinning, is easier as well as travelling for recreational purposes. When the roads are also available during the summer time and frost heave, the transportation of the timber is possible all year round. The building of new forest roads can make the truck transportation shorter in some cases. In addition, the fire control and rescue operations are easier and more effective when the roads exist. (Metsäteho 2011.)

Requirements for forest roads

Most of the forest roads are more than 20 years old. The total weight of trucks, including the truck and its load, has increased. In 1961 the biggest accepted weight was 30 tons, in 1982 the number was 48 tons and in 1993 already 60 tons. At the moment the maximum weight of the truck and load can be 76 tons, if the truck has nine axles. There is a transfer period of five years going on and during this time the normal weight of the truck can be 64 tons. (Liikenne- ja viestintäministeriö 2012.)

The most important aim in road construction is to build a road with enough bearing capacity. The target bearing capacity can be defined by estimating the timber volumes the road should bear. Achieving the bearing capacity needed requires information about the ground soil, and information on bearing capacity, in turn, is needed when forming and sizing the road body. There are different bearing capacity classes that have their own measurements for the road body. There is also variation in the width of the area where the trees are removed, in the width of the road body and in the depth of the ditches.

Proper drainage of the road body increases the bearing capacity of the road a lot. The material for the road body comes from the soil dug out from the side ditches. This way, the road becomes high and the water goes down from the road area. Proper pavement consists of the layers of soil placed on the road body, and it is very important for the bearing capacity and the usability of the road. The pavement material can be crushed rock, gravel, moraine or pit-run gravel. The end of the forest road must have a proper turnaround where the trucks can turn easily. A couple of turnarounds with the right size should also be placed along the forest road. Because most forest roads have only one lane turnarounds for the trucks should be frequent. In addition, harvesters and forwarders should have enough exits from the forest road into the forest to avoid breaking the road and ditches.

Developing the planning and construction of forest roads in Russia

The Finnish Forestry Development Centre Tapio has developed forest road planning, construction and its processes in North-West Russia with Finnish and Russian companies for several years. Tapio has cooperated with Mondi Syktyvkar, Investlesprom, Cherepovetsles, Metsä Svir and Stora Enso Ruskij Les and Olonetsles. In addition, there has been cooperation with the Russian governmental forestry authorities in Nizhny Novgorod where Tapio has built a model road. The emphasis has been in developing the forest road network and its construction, in training when planning single roads as well as in implementing techniques in constructing forest roads in theory

PICTURE 2. A new forest road in Komi Republic (Greis).

and practice. The training has included the renovation of old road and their maintenance and responsible use. There is an example of a new forest road in Komi Republic presented in Picture 2.

There are certain basic principles in road construction that must be in order when building a permanent forest road. Despite the more difficult conditions in Russia compared to Finland the experiences show that the same principles can also be applied in Russian conditions.

Building a forest road body and drainage and searching for stony material

The most important factor for the bearing capacity of the forest road is proper drainage. The drainage can be achieved by choosing the right place for the road, digging proper ditches – usually on both sides of the road – by using the right size culverts on a right place, and finally by digging proper drain ditches to get the water off the road area. The right technique in placing ditches and culverts also prevents the road from erosion. Erosion can damage the body of the road and do harm to the conservation of water in the fine soils of Russia.
The right techniques in building, isolating and reinforcing the road body help to keep the road dry and bearable. Local soil that is dug from the side ditches is used to build the road body. All mineral soils are suitable in a road body as long as the road body remains dry. The drainage of road body is presented in Picture 3.

PICTURE 3. Drainage of a road body in Tikhvin (Greis).

It's possible to prevent the water from reaching the road structures by gathering logging residue and humus as a mat between the road and the freezing ground. The heavy-duty wooden structures are used only in the areas with the lowest bearing capacity such as peatlands and soils of silt clay, because they are expensive and do not last long. Properly applied geo-textiles and geo-nets of the right size and density can be a good solution for that problem.

It is also important to put an effort in finding good material for pavements. The local tradition, geological experts and technical devices are useful in this task. Sometimes stony materials can be found under a thick layer of clay which can been seen in Picture 4.

Planning, timing of work and responsible use of roads

The proper planning of both the road network and one single road is essential for the successful result. After planning the road network, the planning of each single road has to be done in the summer without snow and frost in the field. This way it is possible to find the best possible bearing capacity available. In addition, the road is cheaper to build. It is important to avoid placing the road along the straight borders of quartals which often go through unbearable land.

PICTURE 4. Stony material for road pavement under a two-meter layer of clay (glina) in Tikhvin (Greis).

Timing the planning and the construction of the roads correctly according to the season of the year is also important. The road building process takes from one to two years. The suggested schedule could be as follows:

- first summer: planning and field work
- early next summer: basic construction in order to get the road body dry
- the following winter when there is already frost: pavement laid

This two-year process must be taken into consideration when planning the logging and wood transportation operations in the forest. No vehicle can use the road under construction when there is unfrozen soil (Picture 5). All the possible road users should be informed of this and they should comply with this.

Forest roads are extremely important for effective and profitable wood procurement. As an investment, their construction is expensive, but it should be considered as a long-term investment. It is a matter of great relevance that a right kind of road is built in the right place, and that the use of the road – in order to transport wood – starts immediately.

PICTURE 5. Driving on a road under construction is not allowed. Olonets (Greis).

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Possibilities to improve the bearing capacity of soils and roads

Kati Kontinen

This article introduces the possibilities to improve the bearing capacity of soils and roads. In order to test different kind of materials and techniques a study was carried out in Mikkeli University of Applied Sciences (Mamk) between the years 2008 and 2010. The study was part of Mamk's RDI activities, and it involves testing the usability, the costs and the technique of four different kinds of solutions to increase the soil bearing capacity during timber harvesting and transportation. The tested techniques included driving bridges, rubber blasting mats and duckboard mats. The results of the study (Kontinen 2014) are presented in this article after summarising the background of the study.

Background for the study

The peatland forests account for 34 % of the total forested area in Finland. In turn, the volume of peatland forests accounts for 20 % of the total volume of the growing stock. The growth of Finnish peatland forests covers 26 % of the total forest growth. This translates into about 20 million cubic metres, and it is the outcome of decades of investment in peatland forests. A remarkable amount of mires were ditched in the 1960s and the 1970s in Finland. As a result there is a lot of potential growing stock in the peatland forests. It has been estimated that 15 to 20 million cubic metres more could be harvested annually. The timber in peatlands is harvested in winter, when the ground is frozen, and snow protects the soil. There are also a lot of peatlands and soils with fine earth in North-West Russia. The harvesting conditions in soils with fine earth can be considered the same as in peatlands.

Possibilities studied to strengthen the bearing capacity

By strengthening the bearing capacity of soil, it is possible to improve the drivability of forest machines and to diminish the damages to the soil. The

bearing capacity of soil can be strengthened by adding extra elements or materials onto logging trails. This way, the pressure caused by the wheels of forest machines is distributed over a larger surface. When the area under surface contact grows in size, the surface pressure on the ground caused by forest machines decreases (Lassila 2002).

Traditionally logging trails have been strengthened with logging residue and timber. Sometimes, such as in the summer, this is not enough when operating in peatlands. Severe damage on the soil can appear even after few times of driving. Big problems with bearing capacity are rare, occurring only in some sections of logging trails during peatland operations. The critical places can be watery and short, ie lowlands, crossovers of ditches, brooks, or tracks leading to roadside landings. It is important to know beforehand, if there are places with low bearing capacity, or if the timber loads are big. Then it is possible to strengthen the logging trails with different alternatives such as by placing coniferous logging residue on the trails, building pulpwood reels over ditches, by using transportable driving bridges or the so-called light bridges.

The use of different possibilities to strengthen the soil bearing capacity was studied in the Nikkarila research forest in Pieksämäki, Finland. The study was carried out by Mikkeli University of Applied Sciences in the years 2008 to 2010 and it involved testing the usability, the costs and four different products to increase the soil bearing capacity during the timber harvesting and transportation. One of the techniques tested, the so-called duckboard mats, included two different products. Also the costs of all these different possibilities were surveyed with the method of time investigation.

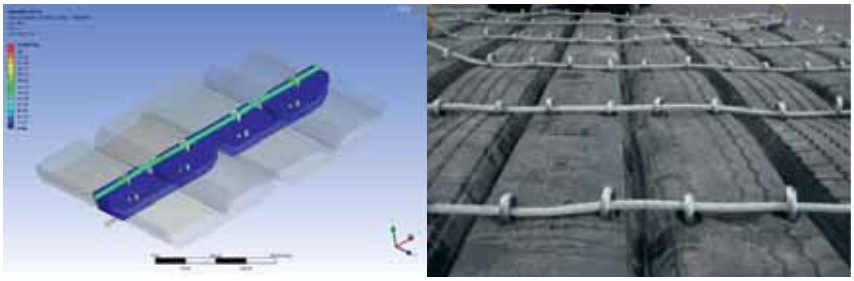
The products tested in the study

The technical solutions tested included driving bridges, rubber blasting mats and duckboard mats that comprised two different products. All these products were tested on logging trails in the summer or in autumn conditions on non-frozen ground. In addition, the rubber-blasting mats were also tested in strengthening a winter road.

The driving bridges tested in the study were four metres long, one metre wide and 12.5 centimetres thick. They were bolted together with steel bars drilled through in three points. The tested driving bridges were made of shore pine (*Pinus contorta*). Their tested bending strength was about 140 kN (kilonewton). Picture 1 presents the tested wooden driving bridge.

PICTURE 1. Tested wooden driving bridges (Jääskeläinen 2009).

Fortecta rubber blasting mats tested were produced of recycled truck tires. The size of the mat was 3 x 5 metres, and it weighted one ton. The blasting mats were bound together with two cables: The first one binds the tire treads together, and the second straight cable is inserted through the loop formed by the first cable. This can be seen in Picture 2.



PICTURE 2. Tested Fortecta rubber blasting mat (Fortecta 2010, Kontinen 2010).

The first tested duckboard mat was made of sawn and drilled pinewood. The mats used are presented in Picture 3, and they were 11 metres long, 110 centimetres wide and 10 centimetres thick. The width of one piece of wooden plate was 15 centimetres. The entire mat weighed 0.5 tons, and a steel cable attached the pieces of wooden plates together.

PICTURE 3. The first tested duckboard mat (Kontinen 2010).

The second tested duckboard mat had been produced by placing round pieces of timber next to each other and attaching them together with steel cables, as shown in Picture 4. There were three different kinds of binding techniques in the mats that were tested. The first pair was bound together both from above and on the side. The second pair was bound from the side and drilled through the timber. Finally, the third pair was bound from the sides. The raw material of the mats was spruce timber and the measurements covered a width of 120 centimetres, length of 800 centimetres and thickness of approximately 23 centimetres. The entire weight of the combination was one ton.

PICTURE 4. The second tested duckboard mat (Suorsa 2011).

The machine used in the tests was Valmet 838 forwarder with eight tires. The other equipment in the forwarder were Marttiini thinning tracks planned especially for peatland conditions and thinning operations. The width of the grouser shoe was 90 millimetres. There were ECO Magnum

tracks with the width of the grouser shoe of 150 millimetres in the back of the forwarder. This kind of tracks are useful while operating on extremely soft and easily damaged soils and on thinning sites. The total loaded weight of the machine was 22 tons, and without the load, but including the tracks 16 tons.

The implementation and results of the study

The first part of the study surveyed the costs of using the rubber blasting mats on the forest road. After that, the second part of the study concentrated on strengthening the logging trails with all the different alternatives tested, ie rubber blasting mats, driving bridges and duckboard mats. The sections below introduce the most relevant findings for all of these products. As also the time spent in loading, unloading and installing the mats and bridges was investigated, Table 1 first presents the relevant times for each product tested.

TABLE 1. Use of time for each technique to improve the soil bearing capacity.

Improvement technique for improvement of soil bearing capacity	Loading into the machine, pcs	Installation pcs	Loading into the machine, pcs	Unloading in the landing, pcs	Total
	in the loading	in the forest	in the forest		
Driving bridge	12 s	18 s	12 s	12 s	54 s
Duckboard mat 1	15 s	3 min 1 s	2 min 30 s	15 s	6 min1 s
Duckboard mat 2	2 min 38s	3 min 47 s	2 min 38 s	2min 38s	11 min 41 s
Rubber blasting mat	35 s	2 min 10 s	53 s	35 s	4 min 13 s

When continuing with the rubber blasting mats, the area under testing was a recently completed straight winter road that had been built on peatland and there had not been any driving yet. The test proceeded in the following way: Eight mats were placed on the road lengthwise and two mats cross-wise. This way, the total test area covered 46 metres. The comparison road that was not strengthened covered 50 metres. The test truck used was SISU 380E displayed in Picture 5. The speed of the truck was kept low, 5–10 kilometres per hour. The weight of the loaded truck was 27 tons.

PICTURE 5. The logging truck on the rubber blasting mats (Kontinen 2010).

Results of rubber blasting mats on non-frozen ground and on winter roads
The handling cost of one rubber blasting mat was approximately five euros. When strengthening the length of 50 metres the cost was high – EUR 183 – because the number of the mats needed was the highest compared to the other possibilities tested. Moreover, the purchasing price was the biggest with the price of EUR 133 per one metre, when compared to the prices of the other alternatives. However, the testing situation encountered so big problems that it was impossible to measure the damages caused to the logging trails and the testing was stopped. One reason for stopping the testing was that attachment cables got constantly stuck with both the grouser shoes and the spikes.

When turning to the results on winter roads, the handling of the rubber blasting mats was relatively quick. The handling cost for one mat was only one euro on the winter road. When strengthening 50 metres of road the cost resulting from the use of time was 22 euros. The price of the mat was high – EUR 133 euros – but the mat can be used for 10 to 15 years. The rubber blasting mats improved both the driveability and the bearing capacity of the winter road. Moreover, the road remained undisturbed. Especially, when the mats were placed lengthwise and the machine was driving forward, the result was good. Equally, the mats installed crosswise were useful on places where the machine needed to reverse, ie on the spur trail to the landing.

Results of driving bridges
When thinking about the use of time in the handling of the driving bridges the results can be considered good. The driving bridges were the quickest to handle of all the techniques tested. The cost for handling one pair of bridges

was less than three euros. In addition, the trail remained practically undisturbed. The material and production costs of the driving bridges was the second cheapest – EUR 51 per metre. When considering the costs resulting from the use of time the driving mats were the cheapest – EUR 122. This result was received when 50 metres of logging trail were strengthened.

The use of driving bridges caused only minor damage on the logging trail. The surface pressure of the machine on the ground was very small when the forwarder was driving on the bridges. The calculated surface pressure was 12 kPa, when the forwarder with a total mass of 22 tons was on top of the four bridges. In addition, the driving bridges prevented the trees on the side of the logging trail from leaning towards the forwarder. This, in turn, prevents the stems and roots of trees remaining along the trail from damages.

Results of the first and the second duckboard mats
The handling of the first duckboard mat took a remarkable amount of time. Especially, gathering and loading the mats back to the forwarder was not without problems and took time. However, the mats reduced the damage on the logging trail, and would be therefore suitable for increasing the bearing capacity. When thinking about the material and production costs the duckboard mats were the cheapest alternative – EUR 40 per metre. When 50 metres of logging trail were strengthened, the cost was EUR 170 euros, which was the second cheapest of all the possibilities tested. The weight of the first duckboard mat was 0.5 tons.

The time spent in handling and the resulting costs were the highest when using the second duckboard mat – EUR 30 per the pair of mats. Likewise, the cost of strengthening 50 metres of trail was EUR 316. This exceeded even three times the costs of driving bridges. When thinking about the material and production costs these mats cost two times more than the driving bridges – EUR 92 per metre.

There were some problems when using the second type of mats. The lifting lug cables got stuck into the tracks during driving. As a result, the mats started to roll with the machine. Moreover, the traction of the machine was not very good when driving on the mats. The reason for this was that the wooden mats were too slippery for the machines track equipment. The forwarder slipped off from the mats and the mat stuck between the wheels started to roll with the machine. The duckboard mats were not stable enough and this made the machine to slide off the mats. One solution to diminish the weight of the mats would be to make them from split timber. In addition, the duckboard mats were difficult to handle because they are 8 metres long, twice as long as the driving bridges.

Conclusions

An important matter when thinking about the purchase and use of the different possibilities to improve soil bearing capacity is the total harvesting volume in the area: The bigger the harvested volume is on the stand the more profitable the investment will be. The recommendation for the harvested volume could be 5000–10 000 cubic metres. It is also important to train the professionals and to demonstrate the use of the different techniques. This way it could be possible to change the attitudes towards the techniques for improving the soil bearing capacity introduced here.

The summary of the usability of the different techniques to increase the soil bearing capacity is presented in the Table 2. The table clearly shows the best techniques to increase the soil bearing capacity in terms of the use of time, the costs of production and handling as well as the damages caused to the tracks.

TABLE 2. The summary of the best techniques to increase the soil bearing capacity.

Technique	Use of time	Cost of production	Cost of handling	Damage to the track
Driving bridge	x		x	x
Duckboard mat 1		x		
Duckboard mat 2				
Rubber blasting mat				

At present the soil bearing capacity is improved used in harvesting in North-West Russia, too, especially on forest roads. The rubber blasting mats could be useful, because they are strong and transportable. Furthermore, the use of driving bridges could be considered in Russian conditions. The purchase price of the bridges is moderate and using them is rather easy. The methods of improving soil bearing capacity will become current in Russia, if the quality assessment of logging operations and the resulting damages start to receive more attention.

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Energywood procurement in the Tikhvin region – case ESE

Lasse Lahtinen & Timo Antero Leinonen

Background

A Finnish electricity company ESE – Etelä-Savon Energia (South Savo Energy) – has a powerplant in Pursiala, Mikkeli. The nominal capacity of the powerplant is 223 MW, and the plant consists of three units: Pursiala 1 with the nominal capacity of 95 MW, Pursiala 2 with the nominal capacity 98 MW and FLK2 with the nominal capacity of 30 MW. ESE's powerplant is a combined heat and power plant supplying the City of Mikkeli with heat and electricity, together with seven peak stations. ESE also has several smaller plants supplying smaller communities and the industry. The utilization of fuels was 1 000 GWh in the year 2013. Wood-based fuels made 73 %, that is 730 GWh, of the total use. (Etelä-Savon Energia Oy 2013). Picture 1 presents transportation of energywood in the Tikhvin region.

PICTURE 1. Transportation from an upper landing to a lower landing in the Tikhvin region, Russia (Lahtinen).

Between the years 2006 and 2008 the price of electricity was high in Finland and powerplants were producing condensing power. This production caused an increased demand for energywood in Finland. The increased demand caused higher prices of energywood and uncertainty of supplies.

In the year 2007 a project called Wood-Center was established to develop the energywood resources. The project was organized by ISBE – Itä-Suomen Business-edustusto, East Finland Business Representative – and it project included research of energywood resources in the Leningrad region and the development of an operational organization.

The model developed in the Wood-Center project involved:
1. collecting wood from several logging companies
2. selling pulpwood and sawlogs to other companies
3. importing energywood for own use in Finland.

Based on the results of the Wood-Center project (Wood Center esiselvityshanke 2007), ESE decided to establish a company called OOO ESE in the year 2008. OOO ESE is a holding, R&D and logistics company in ESE's organization. In the year 2011 ESE established a branch office in Tikhvin. This unit operates as a holding company. Also another company, OOO Russkij Les, must be mentioned at this point. It was founded in the year 1998 and operated as an independent company until the year 2004, when it was merged to Stora Enso plc. In the year 2010 Stora Enso sold OOO Russkij Les to ESE.

OOO Russkij Les holds concessions for 75 000 ha with an annual allowable cut of 79 000 m^3 per year in the Tikhvin region. The company also has the FSC certificate for its wood. Since the year 2012 OOO Russkij Les has continuously supplied chipped energywood to its owner in Finland. In picture 2 there is transportation of energywood going on in the Tikhvin region.

Present and future

Logging operations in the Tikhvin region are carried out by a partner contractor, and pulpwood and sawlogs are sold to this same partner. Harvested aspen and dead conifers are used as energywood. Energywood is also bought from external suppliers. The following pictures describe the chipping and transportation process of energy wood chips from the production site to the power plant.

PICTURE 2. Transportation from a lower landing to the terminal in the Tikhvin region, Russia (Lahtinen).

PICTURE 3. A mobile chipper at the terminal in Tikhvin, Russia (Lahtinen).

PICTURE 4. Loading railway wagons in Tikhvin, Russia (Lahtinen).

PICTURE 5. Transfer from a railway wagon to a truck in the Kurkvuori terminal, Finland (Lahtinen).

PICTURE 6. Terminal in Kurkvuori, Finland (Lahtinen).

Energywood is transported by Ural-trucks to better roads. On the better roads semi-trailers are used. Chipping is carried out at the terminal close to the railway station in Tikhvin, and the chips are loaded to railway wagons and transported to Kurkvuori terminal in Imatra, Finland. The railway wagons are unloaded there, and the chips are stored for further transport. Transport from Kurkvuori to Pursiala is done by trucks.

For all of the production and transport activities OOO Russkij Les has nine employees, chippers, vehicles and railway wagons, and the company supplies about 5 % of ESE's total energy demand. This is a strategic resource for ESE for example for the following reasons:

1. The quality of the Russkij Les chips is high, and they can be mixed to improve the quality of other chips.
2. The storage of chips in the Kurkvuori terminal also creates a reserve supply.
3. The supply from OOO Russkij Les can be increased if needed.

There are also risks involved in this operation, as for instance, the exchange rates cause uncertainty with loans and prices.

The activities of OOO Russkij Les in Tikhvin are now established. This creates a strategic resource that is separated from the Finnish wood market. The energywood procurement in the Tikhvin region continues on the steady level, and the volumes may grow depending on the overall market situation.

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Cost calculation and profitability in wood harvesting

Timo Antero Leinonen & Yury Zementzky

Introduction

This article bases on the contents of a lecture delivered within the WOPE project in Podporoze, Russia, in October 2013. The article concentrates on the most typical features that affect the profitability of logging companies, and it lists both methods to increase the prices and volumes and to decrease costs. The terminology applied both in the lecture and in this article has been determined by Uusitalo (2010). The topic is discussed from the viewpoint of Finnish practices and the examples used base on Finnish circumstances. For example, Figure 1 below shows how the use of different types of forest machines has developed during the past decades in Finland according to Metsäteho. Metsäteho is a joint RDI organisation of Metsähallitus, ie state forest enterprise, and the major Finnish forest industry companies and certain forestry organisations.

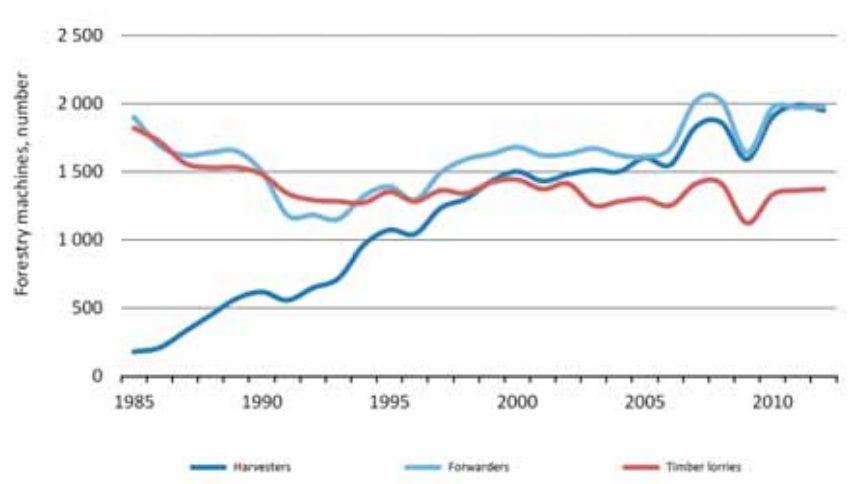

FIGURE 1. Number of forest machines by Metsäteho (Strandström 2014).

Better profit interests all logging companies and it can be improved either by increasing earnings or decreasing costs. Piece rate is commonly applied in logging operations, and therefore either increasing volume or the price per piece, ie per cubic metre, improves the profit. The price per piece is generally determined by the open market mechanism, and one enterprise has no possibility to raise or lower the price. Figure 2 shows the prices per cubic metre in Finland for different types of logging operations in the beginning of the 21st century. It's worth observing the differences in costs between first thinnings and regeneration fellings.

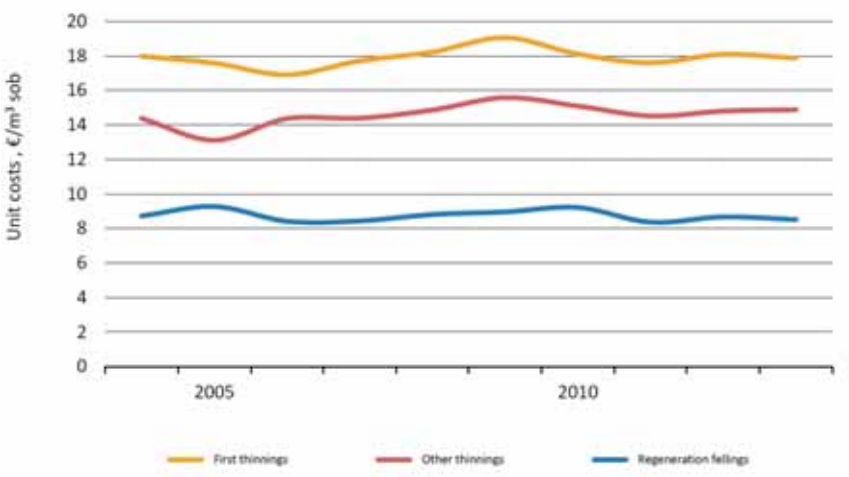

FIGURE 2. Unit Costs in Mechanised Harvesting by Felling Method from 2004 to 2013 by Metsäteho (Strandström 2014).

When moving on to list possible ways of improving piece rate and increasing volume, the quality of work, silvicultural requirements and the recovery level must be introduced. After that the article ends by introducing methods to decrease costs.

Methods to improve piece rate and recovery

In case the quality of work and timber is superior, a higher piece rate may be obtained. This superior quality refers to accuracy in dimensions, qualities, deliveries and to the silvicultural status of logging sites. (Uusitalo 2010.) The desired silvicultural status and the relevant requirements are determined in the silvicultural guidelines. There are not many requirements for regeneration fellings, and the requirements for thinning are discussed in another article of this publication called *Thinning practices in Finland*.

When turning to ways of increasing volume, the theoretical maximum volume is determined by natural conditions at the logging site. That is why the maximum volume can never be achieved in practice. However, the recovery level can be improved in everyday operations. The volume harvested can, for example, be increased by the careful utilization of stems. This means cutting stumps as low as possible and bucking the tops of the trees as precisely as possible. Achieving this requires a combination of operators' skills and motivation. Also, continuous control of the measuring device is needed. (Harstela 1993.)

Harvester operators must have accurate and up-to-date information about the industry needs. This means dimensions, qualities, delivery volumes and timing. Colour marking can be used to help forwarder and timber truck operators to recognize the assortments and to keep them separated. (Harstela 1996.) The attached video available through the QR code below (Picture 1) demonstrates colour marking.

PICTURE 1. QR code to a video about Color marking (Leinonen 2013).

Compared to the loss caused by harvester greater losses are often caused by timber that is lost in forwarding. Partly this loss is due to natural conditions, darkness and snow, but the human factor is also present. Harvester and forwarder operators should work in teams. In winter the time gap between felling and forwarding should be short. On the other hand, this time gap allows the soil to freeze and strengthen. Trails have been made with GPS-aided systems to track the timber piles made by harvesters. To avoid mixing the assortments during the forwarding and long distance transport, the landings must be planned so that they allow enough storage area per each assortment. (Uusitalo 2010.)

Methods to decrease costs

When moving on to decreasing costs, a general point to make is that operators should concentrate on work which produces results. For example, the relocation of machines creates expenses and decreases earnings. This can be avoided by planning the relocations well in advance. Thorough pre-plan-

ning of work and services and careful selection of equipment and machinery also help to reduce costs. And, advance planning should cover all of these factors in combination. (Uusitalo 2010.)

The factors that are relevant in choosing suitable machinery are discussed in the article titled *Factors affecting the choice of logging technology* elsewhere in this publication. Figure 3, in turn, helps to illustrate how significant seasonal fluctuations are in logging operations. They cause costs, because the capacity is set according to the maximum demand, not the average demand. The figure below could be considered together with Figure 1 above that showed the number of forest machines in Finland. Figure 3, instead, describes how much these machines are used monthly in a year. It shows that all the machines are not working evenly throughout the year, ie their capacity is not fully used.

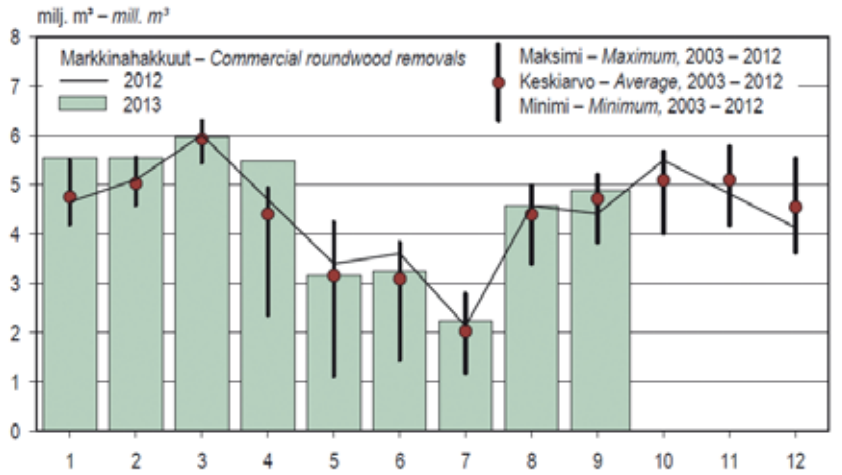

FIGURE 3. Commercial roundwood removals by month (Finnish Forest Research Institute 2013).

This kind of fluctuation can be reduced through good planning and by developing the ability to work throughout the year or at least lengthen the working period in the spring, summer and autumn. This is a matter of expertise, planning, machinery selection and working methods, and the challenge can be considered from two points of view: in terms of logging and in terms of road transportation. (Uusitalo 2010.)

When starting with the logging point of view, logging sites must be carefully studied and classified according to their bearing capacity. Larger areas can be divided into smaller uniform compartments. The compartments with the lowest bearing capacities must be processed during winter. The compartments with modest bearing capacities can be improved by logging residues or bridges on striproads. Machines can be equipped with tracks, and flexible

methods can be utilized, for example, by transporting smaller loads, adapting to weather conditions, and by switching between coarse and fine soils. Commonly forwarders are the heaviest units in the harvesting system, and typically one challenging area is restricting the logging of the entire compartment. In such cases it could be considered, for example, if avoiding this single point or lightening the forwarder is possible. (Harstela 1991.)

Also road transportation is often restricted by only one badly bearing section of the road. It may bring good profit to fix this section. For example, geotextiles or geogrids can be utilized. It is also possible to log and store timber alongside the badly bearing road and wait until winter. When planning this kind of long term storage, the quality requirements of industry wood must be kept in mind. (Uusitalo 2010.)

To conclude, it can be claimed that all logging companies are interested in improving profitability. The degree of utilization (%) and productivity (m^3/h) are then key factors. Mathematically profitability is the end-product of the degree of utilization and productivity. Single-minded maximization of one these factors may result a decrease in the end-product. The qualifications of forest machine operators are vital in this improvement process.

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Wood harvesting entrepreneurship in Finland

Sinikka Mynttinen

Background

Entrepreneurship is a very multifaceted phenomenon. As a person, an entrepreneur is generally associated with personality traits such as independence, goal orientation, tolerance for risk, persistent, optimism etc. Entrepreneurship can also be described as processes. When establishing and managing a successful company, an entrepreneur should be proficient in many skills, including social skills, professional skills, and business know-how. He or should also have financial capital or the possibility to acquire financing when necessary. In the current networking economy, an entrepreneur also needs plenty of social capital in order to be able to create connections and to engage in confidential co-operation with different entities. Renowned economist Schumpeter (1934) suggested that an entrepreneur is an innovator who seeks financial gain in a competitive market by developing new products, services and business models. Entrepreneurship is currently viewed as a multifaceted, heterogeneous and multi-level phenomenon that should be studied in each of its contexts. The goal is to understand how, and by whom, business opportunities are discovered, created and utilized and with what consequences. An entrepreneur is a person who bears the risk related to the business opportunity and strives to make a profit with his or her business operation. (Venkataraman & Shane 2000)

Forestry companies in Finland operate across a wide range, in forestry services, wood harvesting and transportation. As a group, forest machine entrepreneurs or contractors are an important link in the timber supply, bioenergy production and forestry management of the forest industry, but as individual contractors they are quite small.

Forest machine companies in Finland - Important link in the supply of wood

A typical forest machine company is a family business that operations in the countryside and whose main service sold is the harvesting and transportation of timber intended for processing and energy production. Other services include the digging of stumps intended for energy production and the collection of crown mass left over from logging (branches, tops). Some companies also have soil tillage operations to enhance forest regeneration, mechanized sowing and planting. There are about 1,650 wood harvesting companies, of which 500 are also engaged in the harvesting of energy wood. About 1,000 companies make 90% of the turnover of the industry. Forest machine enterprises are the largest employers of forest industry workers, for they employ about 4,500 – 5,000 machine operators in addition to themselves. (Koneyrittäjien liitto)

Forest machine companies are responsible for nearly 100 percent of the harvesting work of industrial and energy wood, as well as forest transport to the side of the road for further transportation. Companies' equipment typically consists of a harvester and forwarder, as well as the necessary maintenance building and service car, along with a vehicle for transporting the machine and various other equipment. Companies owned about 2,000 harvesters and a slightly higher number of forwarders. With the introduction of new contracting models, a growing number of companies have excavators for digging stumps, planting, soil tillage and small-scale earthworks.

Forest machine contractors in Finland are nearly always involved in harvesting energy wood. Other companies that participate in the harvesting of energy wood include chipping and crushing companies as well as transport companies. The goal in Finland is to increase the use of wood chips to 13.5 million m^3 by 2020. Wood chips are chipped or crushed wood intended for energy production and derived from the logging residues and stumps of forest regeneration areas, from the thinnings of a young forest, or other forestry fuels intended primarily for energy production. In 2012 about 8.2 million m^3 of wood chips were harvested for energy usage. Increasing the quantity that is harvested to a level that corresponds to usage offers machine contractors significant business opportunities, but requires substantial investments in wood chip harvesting technology. The business models of the industry are undergoing a period of strong change in the field, and players must engage in networking and collaboration on multiple levels and directions in order to have development and growth in material flows of wood-based fuels. (Koneyrittäjien liitto)

The most important and largest groups of customers of forest machine companies are major forest industry companies (UPM, StoraEnso, Metsä Group), Metsähallitus, regional users of wood such as private sawmills (including Versowood Oy, Keitele Timber Oy, Pölkky Oy, Kuhmo Oy, Koskitukku Oy) and forest management associations. Nearly 90% of the services of forest machine companies are sold to the forestry industry and Metsähallitus. Companies also offer their services directly to private forest owners.

A diverse set of skills are required of forest machine entrepreneurs and operators. The value of the amount of wood processed annually by a harvester and a couple of forwarders varies greatly, but at best it can be several million euros. A machine operator has a great responsibility for the wood he or she makes, as well as the condition of the forest after the harvest, as well as the environment more broadly. Employees are required to have technical know-how, machine operating skills, forest management skills, basic IT skills, the ability to work independently and social skills.

The labor productivity of the Finnish forest machine industry is world class. One factor that has improved total productivity compared to competitor companies is that timber can be made into desired dimensions already in the forest, while simultaneously measuring the cubic volume. Data is transferred using modern telecommunications solutions electronically and wirelessly. The result has been major savings in employee expenses over the years and an improved efficiency in logistics. Finnish forest machine entrepreneurs work in wood harvesting jobs overseas as well; in Germany, Russia, Sweden and France. (Koneyrittäjien liitto)

Company forms and business models of forest machine enterprises ‘

Forest machine companies are typically owned by one person, but corporations have also become more popular as companies grow larger and the professionalism of the operations develops. For example, individual forest machine contractors can operate under a common umbrella organization that handles logistics and administration. In most cases a harvesting company offers only harvesting services, and has a contractual relationship with forest owners or forest industry companies. Some harvesting contractors have a purchasing agreement for subcontracting services with a woodcutter or forestry service entrepreneur.

Business models of companies engaged in wood harvesting are:

- Independent regional/key entrepreneur
- Regional/key entrepreneur who has subcontractors (network of entrepreneurs)

- Joint venture
- Traditional single entrepreneur or partial entrepreneur

Throughout the ages, forestry contractors in Finland have worked mainly for one strong customer – for industry or for Metsähallitus. More recently a new model for organizing work has emerged in forestry contracting. The model is called regional entrepreneurship, key entrepreneurship, or contracting of larger entities. Regional or key entrepreneurship means a growth in agreement entities and a diversification of tasks in machine and vehicle contracting related to wood procurements. It also means that contracting relationships are entered with fewer entrepreneurs. One the one hand, the result is a growth in the size of companies and an increase in the number of subcontracting agreements between entrepreneurs. The new business model is demanding, particularly for someone who is becoming a regional entrepreneur. The situation is also new for machine entrepreneurs carrying out subcontracts. Management of larger entities requires new know-how and a new kind of attitude compared to traditional contracting. (Rummukainen et al. 2006)

In addition to larger company size, another trend seen in the industry is an increase in information technology and automation. This is due to faster delivery times, cleaner raw materials, and order-specific wood-sorting dimensions demanded by the international wood processing industry. In order to satisfy these demands, as well as the problems incurred by rising wages, entrepreneurs are trying to increase the utilization rate of their harvesting machines and forwarders in order to keep capital costs, among others, reasonable, and to improve the harvesting performance per machine. As a result of mechanization, the number of employees is reduced, but the need for training rises. Effective training systems are needed in order to recruit and train machine operators and service personnel. (Rummukainen et al. 2006)

There are several players in the operating environment of Finnish forest machine entrepreneurs who use harvesting companies as subcontractors, compete with them for job offers, or offer supplementary services. Some of the players are statutory bodies and some are for-profit companies such as large forest companies and smaller wood buyers. (Markkula 2005)

Forest machine contractors have strong professional skill in their own core activity, but the level of their business know-how is inadequate, particularly in the areas of business economics, administration and marketing. This causes flaws or deficiencies in the development of entrepreneurship and business operations in the long term. Another common feature is the seasonality of work, which affects not only the utilization rate of machinery and thereby also the profitability of companies, but also the year-round employment of operators. Furthermore, because the industry has a low attractive or appeal

factor, there is a labor shortage as few young people enter the sector. Additionally, dependence on one or a few customers creates uncertainty in the continuity of operations. In particular, subsidies granted in forest energy companies for forest management and harvesting are an important prerequisite for entrepreneurship, although changing the conditions for aid create uncertainty. Opening up forest resource data equally for all players improves the operating conditions for entrepreneurship in the forestry sector. In other ways, decisions on forest policy and entrepreneurship at the national level, as well as the market trend of the forest products, are reflected in the entire forest industry. (Rummukainen et al. 2006)

Operating costs have grown significantly in recent years, especially fuel. This affects the profitability of business operations unless it is possible to adjust the price during the period of the tender or contract. Therefore contracts should include one or more cost index adjustment during the contract period. The rapid development of equipment and optimization of operations has increased productivity in the wood harvesting and transportation industry. However, production efficiency in small wood harvesting companies is often lower than in larger competitors because investment in the most efficient possible production equipment is rarely possible. A lower productivity is reflected in lower price competitiveness or profitability of operations. This further reduces opportunities to obtain financing. Studies indicate that the average financial situation of wood harvesting companies is tight. Capital costs are typically over one third of the company's costs. In addition to that, companies' solvency, that is, their ability to absorb losses, and ability to cope with commitments in the long term, has been weakened in many cases. When machine companies make investment decisions, the attention has always tended to focus on depreciation and thereby the minimization of taxes, instead of focusing on the additional capital tied up by the investment and the yield from it. The numbers indicate that on the one hand, there is a need in the industry for precision in the planning of income and cost structure, and drawing up contract agreements, and on the other hand in the development of profitability monitoring systems and the training of the entrepreneur and staff members. (Penttinen et al. 2009; Rummukainen et al. 2006)

The market situation of forest machine entrepreneurs is characterized by the strength of the buyers:

- Customers try to enter partnership agreements with forest machine entrepreneurs, in which case the customers become familiar with the cost structure of entrepreneurs
- The tender procedure used by many customers leads to a high market pressure
- Imbalance of bargaining power between one large customer and several small wood harvesting entrepreneurs

Competition between forest machine entrepreneurs and cost pressures in the global forest industry keep profits from wood harvesting operations low. Furthermore the customers have the bargaining power, either due to the tendering system or due to an imbalance from size differences in direct negotiations. From the perspective of the entrepreneur's capacity, finding enough customers can also be a problem. Harvesting operations have been outsourced by forest industry companies and by the state to forest machine entrepreneurs, who bear the risk. The manufacturing of forest machinery is mainly concentrated in a few large international companies. (Penttinen et al. 2009; Rummukainen et al. 2006)

Forest machine contractors are small, and as a result, the owner/manager has trouble handling both operative problems related to business activity and strategic issues, and still work as the machine operator in addition to that. The result is limited possibilities for developing operations. Table 1 presents methods to develop forest machine companies.

TABLE 1. Methods to develop forest machine companies (Rummukainen et al. 2006).

Method of development	**Features / Benefits**
Grow the business ➢ Bargaining power (customers, machine purchases, fuel and spare parts purchases and service)	Better bargaining position: ✓ Purchasing the business operations of others ✓ Establishing a service company: negotiations with customers, planning, allocation of resources ✓ Cooperation with subcontractors
Upgrading of skills ➢ Coping with the challenges introduced by growing external demands and business growth	Areas of expertise to be developed: ✓ Business know-how ✓ Leadership skills ✓ Know-how in communication and public relations
Improvement of working conditions ➢ Getting a qualified workforce	✓ Individual solutions in place of general terms and conditions ✓ Training and continuing education must be developed
Services, competition and market positioning ➢ Discovering new opportunities and the marketing of old strengths	Expansion of services may offer new possibilities: ✓ Market niches ✓ New sources for generating revenues (planning and forest management services) Customers need increasingly specialized companies with a wide range of services
Protection of interests ➢ Promoting the interests of forest machine companies (influencing invitations to tender so they include quality of work, environmental perspective and reliability in addition to price)	Associations of forest machine entrepreneurs can support entrepreneurs and act as intermediaries with different stakeholders

One channel of growth is co-operation and networking between companies. Joint ventures have been established in the forest energy sector, where there is strong competition for raw materials and customers. These ventures have been found to enable a light organizational structure, to offer efficiency and flexibility in the management of production chains and acquisition of raw materials, to bring economies of scale based on adequacy of machine capacity, and to increase the reliability of deliveries. As forest companies require wood harvesting entrepreneurs to provide increasingly large service packages, a growing number of the largest companies in the industry have set out to boost their market share and/or the market areas in which they operate. They have coped with the increased workload by purchasing new equipment and hiring more employees, and increasing the amount of subcontracting. More and more small suppliers have indeed become subcontractors. Internationalization has provided the opportunity for small companies to expand the market areas in which they operate through business co-operation. There has also been networking among some wood harvesting and trucking entrepreneurs in order to provide increasingly comprehensive services to the forest industry. Some wood harvesting companies have also expanded the services they offer to a new sector that supports their actual business. It has been found to improve the utilization rate, employment, and the profitability of companies by reducing the number of stoppages during thaws. (Niemi 2010; Penttinen et al. 2009; Rummukainen et al. 2006)

Conclusions

As Schumpeter (1934) noted, identifying new business opportunities is one of the most important questions in entrepreneurship. There are often larger development forces or competition vacuums behind these opportunities. The dynamics of the operating environment of the forest sector currently involve several drivers of change: large forestry companies are concentrating the purchasing of services, political goals favor the production of wood energy, approaching generational changes of ownership, growing costs, reforms to be carried out in public forest organizations, trends in the end-use of forest products, development of technology, expansion of the availability of forest resource data, and changes in the structure of private forest ownership. It is conceivable that some of the changes will manifest themselves as even greater challenges to entrepreneurship, some will bring about improvements to the operating conditions, but some will offer the opportunity to seize new strategic choices, develop new business models or produce new services or service packages. Above all, many of the drivers of change will offer small forestry companies the opportunity to grow as the conditions for entrepreneurship improve.

There appears to be a trend in forestry entrepreneurship from self-employing entrepreneurship or lifestyle entrepreneurship toward business operations that require sophisticated business-know, and in some cases toward growth entrepreneurship. For small, barely profitable companies, merely increasing sales is not enough, however, because there is a big risk that growth will further weaken the company's situation. Studies indicate that a company's financial situation before growth has a major impact on the profitability of growth. It has also been discovered that a small and profitable company can, in some cases, be the most viable option, whereas in some cases growth improves profitability and the financial situation over the long term. The ability to plan and develop business operations by also utilizing intangible factors of production such as strategic expertise, management skills and business know-how is particularly pronounced in high-cost countries. However, it has been often found that in these respects, business management is inadequate in small companies, not to mention the skills required by internationalization. In order for forest machine enterprises to cope with the growing challenges and to be able to benefit from new business opportunities, it is important to develop entrepreneurial and business know-how with regard to both tangible as well as intangible factors of production.

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Finnish forest machine entrepreneurs' risks in Russia

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Introduction

Russia is a challenging operating environment for forest machine contracting. When operating in Russia the meaning of risk management increases, and risks must be assessed when considering starting any kind of business operation. This article describes risks relating to forest machine contracting that are typical in the Russian operating environment. The article bases on a study (Karvinen et al. 2014) made among Finnish forest machine entrepreneurs. The list of risks below is not all-inclusive, but it introduces the most relevant ones based on the experiences of Finnish entrepreneurs that were interviewed for the study.

The study made also involved a case study where an example company was analysed and the results used to survey the most relevant risks and to suggest practical measures for eliminating or reducing these risks. These are summarised in this article, but the results cannot be generalized and directly applied to other companies. Instead, the results and their presentation below aim at serving as companies' tools when they identify risks, plan their own risk management processes and improve their skills in operating in the Russian market. The authors of this article shall have no responsibility for any damages possibly arising out of the use of this article.

Definition of risks

All business operations involve risks, ie when achieving targets is influenced by uncertainty and unexpected circumstances. There are several methods for risk management, such as the risk management process of the ISO 31000 standard, according to which companies can survey risks with the following questions:

- What can happen and why?
- What are the consequences?
- How feasible is it that the consequences take place?
- How can the feasibility and the consequences be minimised?

Risk management models are always detailed, and their adoptation must account for the company's size, resources and management methods. In order to avoid damages and losses risks should be identified, analysed and monitored constantly. The most relevant internal risks for forest machine contractors involve the personnel, machinery and materials. In addition, the risks can relate to management, agreements, finances, such profitability, liquidity, financing and production, such as to planning the work and work sites. External risk factors include customers, subcontractors, labour and its availability, technological development, the market and public sectors as well as interest groups. (Nippala & Sauni, 2004a, 2004b.)

Operating environment in harvesting in Russia

In Russia the state owns the forests that rented for companies to harvest for 10 to 49 years. There are numerous companies operating in harvesting, and the biggest ones usually belong to larger forestry groups (Karvinen et al 2011).Traditionally harvesting is the least profitable sector of Russian forestry, and the harvesting companies face several problems (Doklad 2013; Karvinen et al 2011). Harvesting in Russia is seasonal, as fellings mostly take place in the winter due to the lack of roads that could be used around the year (Goltsev et al 2011; Suhanov 2014). The sparse road network of poor condition is a risk for forest machine entrepreneurs, because in the worst cases the harvesting sites cannot be reached at all, or the machines remain in the forest for the frost heave period (Šegelman & Lukaševitš 2011).

In addition to poor infrastructure, the weaknesses and threats for harvesting in Russia involve the lack of knowledge of forest resources, the low productivity of local labour, poor working culture, high level of accident risks, lack of skilled employees, corruption, unhealthy business practices and changing regulations (Gerasimov & Karjalainen 2008). The political risk of Russian forestry results from governmental regulations and from the political situation (Golovko & Oganezova 2013). The possibility of corruption is increased by complex bureaucracy and the authorities' nontransparent practices (Katkova 2012). Detailed guidelines must be followed in harvesting in Russia. The most important ones include silvicultural guidelines and regulations for felling, forest fires and forest health. In addition, there are guidelines relating to work safety, and the state also controls the measurement, transportation and sales of timber with a specific system that monitors the origin of the wood (O vnesenii izmenenij 2013). This system is deployed in stages between 2014 and 2015, and based on it, for instance, the transportation of wood requires an obligatory dispatch note (O soprovoditelnom dokumente 2014). Russian harvesting companies' further risks, in addition to road network and authorities' activities, involve forest damages, such as

forest fires and insect damages, changes in the foreign trade regulations, increases in costs, the quality of forest resources, poor weather conditions, lack of skilled labour and work safety (Golovko & Oganezova 2013; Katkova 2012).

Finnish forest machine entrepreneurs' risks in Russia

As mentioned earlier, the risks of forest machine contracting in the Russian operating environment were surveyed by interviewing Finnish forest machine entrepreneurs that had operated in Russia. These risks can be classified based on their feasibility and consequences, for instance. This was done in the study when analysing the risks of the example case company. In other words, the risks of the case company were surveyed by combining the feasibility – ie how often certain risks take place - and the consequences of the risks – ie how seriously the risks affect the company's business operations.

It must be considered in case of each company which risks are the most feasible and severe ones and require actions to be taken. Some of the risks can be outsourced, for instance, by insuring the machines and devices. Table 1 summarises Finnish forest machine contractors' possible risks in Russia. Below the table these risks are introduced in more detail by estimating their feasibility and by suggesting measures to minimize the risks.

Finance-related risks
Highly probable or feasible finance-related risks appear more than once a year. These can be breaches of contract which for example include differences in measurement, delays in payments and contract negotiations. If a company has just one customer, the financial risk is significant when making new contracts. The entrepreneur's negotiation position is weaker than that of an established customer, and the prices can remain at a disadvantageous level from the entrepreneur's viewpoint resulting in declining profitability. For example, if the price per cubic metre is lowered by one euro, for companies harvesting 300 000 cubic metres, the loss is equally many euros. If the customer, in turn, faces difficulties, the financial damage can be great. This is due to being forced to interrupt the operations for months and looking for a new customer.

Financial risks also result from disagreement on measurements. Differences in measurement results come up, for instance, because of the following factors:

- There are malfunctions in the harvesting machines' measurement devices.

TABLE 1. Finnish forest machine entrepreneurs' risks in Russia.

FINANCES
Customers' breaches of contract and failures in payment
Dependence on certain customers due to their limited number
Profitability of operations (challenges in making profit, eg due to too low pricing and competitors' undercut prices)
MACHINERY, FACILITIES AND PRODUCTION
Availability of skilled service
Major variation in production volumes resulting in challenges in planning and in achieving profitability
Problems in operative planning and in planning the harvesting system
Availability of spare parts
Thefs of machinery and supplies
Fires (machines, maintenance and storage facilities)
PERSONNEL AND OPERATIONAL CULTURE
Entrepreneurs' insufficient know-how and skills in the Russian conditions
Employees' insufficient professional skills and lack of skills in independent working
Difficulties in management due to differences in thinking (ideas of right and wrong, agreeing on decisions and procedures, respecting others' property)
Misunderstandings due to interpretation between languages
Lack of attention to the safety of one's own and others
Use of alcohol during working hours
MARKET FACTORS
Sensitivity to economic fluctuations according to general economic situation
Lack of financing
Competitors with undercut prices
POLITICS AND AUTHORITIES' PRACTICES
Unexpedted and nontransparent practices of the authorities (the interpretations of legislation and waiting for the inspections)
Quick and sudden changes of laws and regulations
Rigid practices in the application for permits
INFRASTRUCTURE AND NATURAL CONDITIONS
Long frost heave seasons cause downtime.
Roads are not ploughed during winter and the harvesting sites cannot be reached.
The forest structures vary, and the time consumption and the resulting volumes cannot be estimated.

- All transportation documents do not reach the customers' invoicing officers.
- There is loss of wood between the harvesters' and the customers' measurements due to following reasons: Forest machine operators leave trees in the forest. Forest truck drivers leave the last stems in the woodpiles in the roadside landings. Wood is sold illegally to other parties, or stolen from the forest.
- The measurements at the receiving end are inaccurate due to following reasons: The measurement method is inaccurate. Volumes are reduced intentionally, or the receiving inspectors lack professional skills.

Also delays in receiving payments can be a significant risk. In other words, it's common that contractor receive less payment than was agreed. In addition to differences in measurements the reasons for payment problems can involve customers' bookkeeping mistakes, general disagreement on the contract terms or the customers' financial problems due to economic fluctuations or strategic decisions. In terms of the contracts the risks can result from different interpretations of the contents, changes in the customers' operation practices due to changes in management or the customers' attempt to even out losses caused by the forest machine entrepreneurs' low production.

How to act:
Payment-related risks can be prevented by ensuring the condition of the measurement devices and by improving the forest machine operators' working methods in the forest. It is difficult to influence the reasons caused by the customers' activities, but risks can be prevented by detailed contracts and by carefully considering the choices between different customer companies. To prevent delays in payments the contacts can include interest for late payment that is charged immediately, when the first delay takes place. Working for more than one customer reduces the financial consequences.

Financial risks resulting from the dependence on one customer and from the uneven negotiation position between customers and forest machine entrepreneurs can be diminished by defining contract periods that favour entrepreneurs and by arranging the negotiations for the autumn. This is when customers have the greatest need for harvesting services. Forest machine entrepreneurs can strengthen their negotiation position through flexibly transportable machinery and adequate labour reserves. Dependence on one customer only can cause a significant risk as downtime, because solving problem situations requires finding new customers or interrupting operations altogether in the worst case. This kind of consequences can be overcome by continuously exploring new potential customers and the operators of the field and by building as extensive networks as possible.

Spare parts and service
The spare parts and service of the forest machines are feasible risks for forest machine entrepreneurs. It's possible that more than once a year spare parts and service mechanics are not available quickly enough. Financial damages can nevertheless remain small and downtime short. Thefts of spare parts and supplies, in turn, can take place several times a year resulting in financial damage.

How to act:
Forest machine entrepreneurs can prepare for this kind of risks by minimising the need for service through training their own employees and adequate stocking of spare parts. The storage of spare parts and supplies should be sized and placed correctly, as thefts can cause moderate financial risks.

Harvesting system
Annual risks in the operative planning can relate to malfunctioning harvesting systems, when harvesting sites are not available continuously. The aim is that forest machines are in full use, but customers' operations without enough planning can cause downtime in production.

How to act:
Inadequately planned harvesting systems can result in moderate risks in terms of finances and downtime, as forest machines are not in full use. Because customer companies are in charge of making decisions on the harvesting sites and on the order in which they are harvested, the forest machine entrepreneurs' possibilities to manage such risks are limited. This kind of risks can be reduced by carefully meeting the contract obligations and by cooperating closely with the customer companies' operative personnel in charge.

Fires
Fires are not that feasible risks, but if they occur, the consequences can be severe. In the worst cases, for example, fires in break rooms can result in death. And, fire damages of the machinery can cause significant financial losses.

How to act:
Fire alarms and extinguishers installed in break rooms can save lives in case of fires. The use of the alarms and extinguishers are requirements for diminishing such risks. The fire damages of forest machines can be prevented by accounting for the guidelines of fire safety and regular cleaning. Fire damages are also prevented through employees' training.

Personnel
Risks relating to personnel and operating culture can be common. More than once a year the lack of employees' professional skills may cause machinery damages that are financially severe. The operations can be interrupted for a long time. Further risks relating to personnel can involve employees'

different ways of thinking, which causes challenges for the management of work, and declining motivation to work, which can cause major financial losses. In addition, the employees' use of alcohol during working hours can be very likely result in minor losses in production and minor accidents.

How to act:
This kind of risks can be removed by drawing up recruitment strategies, anticipating problem situations and by taking care of good management of work and clear guidelines. Work motivation can be improved through salary bases and incentives, and overall responsibility through making the employees committed to the company. The easiest way of achieving this is to hire local employees.

Market factors
In terms of the market factors possible risks can result from unhealthy competition that can cause significant financial risk. Reduction in prices can be caused by competitors' undercut prices and situations where the customers' own harvesting units compete for the same work.

How to act:
It is difficult to change external factors influencing operations, but it is possible to prepare for such risks by taking care of the company's own competitiveness and reputation. This can be achieved by maintaining good operational reliability as well as the quality and efficiency of work.

Politics and authorities' practices
Politics and authorities' practices can cause forest machine operators risks more than once a year as varying interpretations of laws and regulations which often result in fines. Rigid and slow practices in permit applications can annually cause some financial loss. It is also possible that authorities' inspections interrupt companies' operations for example every five years, or that changes in legislation result in unexpected payments causing financial harm.

How to act:
As the cause of the risks cannot be removed, actions should be taken to minimise the negative consequences. The first measure involves negotiations with the authorities and in severe cases resorting to experts' help. Expert advice is worth using continuously to ensure company operations.

Infrastructure
Poor infrastructure and condition of roads cause long downtime periods during the frost heave seasons of both spring and autumn. This results in minor financial losses, but the time lost as downtime can be several months. This way, poor infrastructure can cause unbearable downtime risks for companies and the downtime during frost heave mean moderate financial risks.

How to act:
If the forest machine entrepreneurs are not able to build forest roads by themselves, this kind of risks can be reduced through the following measures: Forest machine entrepreneurs can try to choose customers whose harvesting sites are conveniently located. Entrepreneurs should also try to have long-term terms plans for their own operations.

Harvesting sites
Forest machine companies that operated in Russia for a long time know how to estimate the time needed and the resulting volumes. For newcomers estimating the additional costs caused by the forest structure and different tree species, such as aspen, is difficult and the average price does not necessarily cover the costs of poor harvesting sites. As a result, the risks on profitability can be highly probable and amount to significant financial damage.

How to act:
Forest machine entrepreneurs must be familiar with the natural conditions and the forest structure to be able to better manage pricing.

Conclusions

As mentioned above, this article introduced some of the main results of a case study where the risks of an example Finnish forest machine entrepreneur operating in Russia were studied and analysed. In case of this example company the major risks related to the profitability of operations and customers. A limited number of customers, dependence on one major customer and weak negotiation positions are problems in Finland, too, and therefore, these challenges are not typical of Russia only, but features of the forestry field in general. The challenges typical of Russia involve breaches of contract, disagreement on wood measurements, especially, and delays in payments.

Services relating to forest machines' maintenance and spare parts cause moderate risks in Russia, but the machine manufacturers' service networks

have developed remarkably during the recent years. Risks relating to safety, such as fires in break rooms and thefts of supplies, are specific to the Russian operating environment.

Risks relating to the personnel are somewhat different in Russia from similar risks in Finland. In Russia the forest machine operators' lack of professional skills can be a problem, because the training system is not efficient enough. Managing and leading employees is more challenging due to differences in operating cultures, and therefore, management skills are relevant. In Finland, changes in the personnel challenge productivity whereas in Russia the employees' varying motivation can result in problems. It's important for the forest machine entrepreneurs to adapt to the changing operating environments and maintain their business know-how and skills at high level both in Finland and Russia.

According to the interviews made for the study that this article summarises the external factors challenging forest machine entrepreneurs operations in Russia include especially the following: unhealthy competition in the market and the nontransparency and unexpectedness of authorities' practices. The seasonal nature of harvesting declines forest machine entrepreneurs' profitability both in Finland and Russia, but the problem is emphasised in Russia due to poor network of forest roads and longer downtime periods. The availability of tree stands suitable for harvesting is a challenge for the forest machine entrepreneurs' profitability on both sides of the border.

To conclude some notions on the study this article referred to and its reliability must be introduced. Qualitative risk analysis based on expert opinions is very subjective in nature, and therefore, the results can vary a lot according to the experts' backgrounds and experiences. In addition, how the risks are defined and dealt with is influenced by each organisation's operational environment and readiness to take risks. As a result, the risks analysis examples introduced above cannot be directly applied in other companies, but the risk management model must always be tailored for each case company.

Furthermore, it cannot be assumed that all the risks relating to the Russian operating environment would have been identified. The features introduced in the study and summarised above should, however, cover most of entrepreneurs' major risks in forest machine contracting in Russia. The risks analysis made in the case company did not account for the common, interrelated, consequences of different events and circumstances that can significantly affect the seriousness of the risk.

Companies must carefully consider which risks are the most feasible and serious ones in their own operations. Special attention must be paid on it that risks are not classified as too irrelevant ones and ignored. Cooperation with other companies and customers is recommendable when identifying risks.

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