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Master's Thesis

FOREST INVENTORY INFORMATION NEEDS IN NORTHWEST RUSSIA

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ABSTRACT

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This thesis applies the customer value hierarchy model to forestry in order to determine strategic options to enhance the value of LiDAR technology in Russian forestry.

The study is conducted as a qualitative case study with semi-structured interviews as a main source of the primary data. The customer value hierarchy model constitutes a theoretical base for the research. Secondary data incorporates information on forest resource management, LiDAR technology and Russian forestry.

The model is operationalised using forestry literature and forms a basis for analyses of primary data. Analyses of primary data coupled with comprehension of Russian forest inventory system and knowledge on global forest inventory have led to conclusions on the forest inventory methods selection criteria and the organizations that would benefit the most from LiDAR technology use. The thesis recommends strategic options for LiDAR technology's value enhancement in Russian forestry.

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Tässä diplomityössä sovelletaan asiakkaan kokeman arvon hierarkian mallia metsätalouteen. Mallia sovelletaan LiDAR teknologian strategisten vaihtoehtojen määrittämiseen Venäjän metsäinventoinnissa.

Diplomityö on laadullinen tapaustutkimus, jossa puolistrukturoituja haastatteluja käytettiin aineistonhankintamenetelmänä. Asiakkaan kokeman arvon hierarkian malli muodostaa tutkimuksen teoreettisen perustan. Sekundaariaineisto koostuu metsävarojen hallintaan, LiDAR teknologiaan sekä Venäjän metsätalouteen liittyvästä aineistosta.

Asiakkaan kokeman arvon hierarkian malli on operationalisoitu käyttäen metsätiedon kirjallisuutta ja toimii primaariaineiston analyysin perustana. Primaariaineiston analyysi yhdessä Venäjän metsäinventoinnin järjestelmän ja maailmanlaajuisen metsäinventoinnin tiedon kanssa oli johtanut diplomityön tuloksiin. Tutkimuksessa oli määritelty Venäjän metsätiedon käyttäjät, jotka hyötyvät eniten LiDAR teknologian käytöstä sekä oli määritelty metsäinventointiteknologien arvosteluperusteet. Diplomityössä esitetään strategiset vaihtoehdot LiDAR teknologian arvon kohottamisesta Venäjän metsäinventoinnissa.

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Writing this thesis has required putting a lot of thought and reading a wide range of literature in order to focus my research and get it to the present final form. I thank my family for being there for me, giving me all support that I needed.

My daughter Alisa has been my joy during all my studies and duration of the thesis. I thank you for all the moments that gave me forces and inspired me for the better.

Lappeenranta, 18 May 2015

Veronika Höök

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LIST OF ABBREVIATIONS

ARRISMF	All-Russian Research Institute for Silviculture and Mechanization of Forestry
C&I	Criteria and Indicators
DBH	Diameter at Breast Heigh
DCV	Desired Customer Value
GPS	Global Positioning System
IQ	Information Quality
IMU	Inertial Measurement Unit
HTLCB	Height To Live Crown Base
LiDAR	Light Detection And Ranging
Metla	The Finnish Forest Research Institute
NFI	National Forest Inventory
NORDI	Northern Dimension Research Centre
NPV	Net Present Value
PCV	Perceived Customer Value
PRF	Pulse Rate Frequency
Rosleshoz	Federal Forestry Agency
RMS	Root-Mean-Squire
RMSE	Root-Mean-Squared Error
VOI	Value Of Information

1. INTRODUCTION

1.1. Background of the study

This study is a part of a Finnish-Russian Forest Academy project at Northern Dimension Research Centre (NORDI) in Lappeenranta University of Technology. The aim of the project is a promotion of cooperation between Finnish and Russian firms in the forest industry. Arbonaut Ltd as a member of CONIFER - cooperation and networking platform for the Finnish and Russian Forest Sectors has requested a study that would clarify who are forest information users in Russia and determine what information these users value. Arbonaut Ltd is a leading Finnish company with an expertise in forest inventory and natural resource management information gathering and GIS solutions. The company has developed advanced software that is applied to analyze forest inventory data gathered by Light Detection And Ranging (LiDAR) - remote sensing method for forest inventory data acquisition. The research is needed in order to understand what could be LiDARs competitive advantage in Russia.

There are numerous frameworks that are centered on the concept of customer-focused competitive advantage (e.g., Day and Wensley, 1988; Day, 1990; Slater and Narver, 1995; Woodruff, 1997; Vargo and Lusch, 2004). It is crucial to understand the way in which customers judge and value a product or service in order to attain a competitive advantage (Graf and Maas, 2008). Customer value is a fundamental concept in managing customer behavior and determination of value for customers (Johnson et al. 2006; Kothari and Lackner 2006; Setijono and Dahlgaard 2007; Graf and Maas 2008). Customer value research strives to depict, analyze and transform the value that companies generate for their customers to be empirically measurable (Graf and Maas, 2008).

In forestry, information on forest resources is obtained through various inventory methods. This information is required to assist in a decision making process. According to Kangas (2010) forest decisions are produced on many different levels. Decisions on narrowest level are made by forest owners or forest leaseholders, depending on ownership of the forest in the country. These forest management decisions may be tactical, operative or strategic in nature. At higher level state draws decisions concerning the forest policy. Good quality information is needed for execution of all these decisions. (Kangas, 2010) Quality of information may be linked to customer's attribute-based satisfaction, which according to Woodruff (1997) is one of the levels of customer value hierarchy that constitutes the concept of desired customer value and may be a source of competitive advantage.

1.2. Research gap and research objectives, research questions and delimitations

Researches of customer value construct have focused their studies on its conceptualization. There are still multiple views and lack of agreement on what constitutes customer value. Customer value models may be categorized as perceived customer value (PCV) models and desired customer value models (DCV). Despite of their complexity, perceived customer value models are operationalised with straightforward product or service characteristics. Desired customer value (DCV) approach takes a broader perspective, but is mostly focused on benefits with little attention to the sacrifice aspects like the destruction of value. The biggest challenge is still a shortage of empirical research on construct of customer value with most empirical research done in category of PCV. (Graf and Maas, 2008; Graf and Maas, 2014) There is a general need on more research that is aimed on operationalisation of DCV concept. This research strives to operationalise DCV concept in the field of forest information in order to answer the main research problem and questions.

Value of forest information is addressed sparsely in the literature. There are certain difficulties in estimation of value of forest information as it incorporates besides economic, also environment and social issues. (Kangas, 2010) There is a lack of research on what Russian forest information users value as well as on perspectives of LiDAR technology in Russia. The main purpose of this study is identification of information needs of Russian forest inventory information users and, in particular, determination of the value that they expect from forest inventory information in order to understand perspectives of LiDAR technology in Russia.

The main research question of the study is: How to enhance LiDAR forest inventory method value in Russia?

In order to answer to this question a set of sub-questions should be set:

- How forest information users choose certain inventory methods for the inventory of forest in North-West Russia?
- What value criteria forest inventory information users have?
- Who would benefit the most from the LiDAR inventory method?

1.3. Theoretical framework

This thesis incorporates the definition of customer value from desired customer value (DCV) perspective that is according to Graf and Maas (2014) concerned with consequences and goals as abstract value dimensions derived from specific performance attributes.

Wodruff (1997) framework of customer value hierarchy is used in order to assess how forest information is valued on three levels. At the lowest level of abstraction are desired products and attributes that are assessed using Lee et al. (2001) information quality (IQ) attributes. At the next level of customer value hierarchy are desired or non-desired consequences that arise from customers' choices of certain attributes in specific use situations. The consequences in forestry may be accounted from perspective of sustainability that has ecological, economic and social aspects Kangas (2010). These consequences may be accounted on different managerial levels: tactical, operational and strategic. The highest level of hierarchy defines how well customers' goals and purposes are accommodated by service or product, at this level consequences are take in account in terms of their importance to achieve customer goals. The highest level of customer value hierarchy is translated to forestry in terms of sustainability – Kant (2003); Adamowicz (2003) with the examination of the level of forest management development in Russia. The research explores how close or far in the development forest management in North-West Russia in terms of sustainability. The framework for evaluation of Russian forest users' value preferences coupled with operationilization questions that lead the line of research inquiry is presented in Table 1, Woodruff's (1997) model operationalised to forestry is instrumental in learning customer value.

Table 1. Theoretical framework of the thesis

	Value-In-Use Woodruff (1997)	**Operationalisation of Value-In-Use to Forestry**	**Operationalisation Questions**
Learning customer value	Customer goals and purposes	Level of forest management development in Russia (Kant,2003; Adamowicz, 2003)	What objectives forest managers have? • Timber yield? • Sustainable timber yield (economic sustainability)? • Ecologic and social sustainability goals?
	Desired/non-desired consequences	Acknowledgement of decision making consequences in forestry (Kangas, 2010) with respect to the forest management level (Weintreb and Cholaky, 1991)	Sustainability consequences: ecological, economic? Are consequences accounted in tactical, operational, strategic level?
	Desired products attributes and attribute performance	Information quality (IQ) attributes (Lee et al., 2002)	How managers understand quality of information? What information quality attributes are the most important?
Delivering value to customers	**Service marketing perspective on value-in-use Grönroos (2011)**		

To translate learning about customer value to customer value delivery Grönroos (2011) value co-creation perspective has been employed as it is indicated in Table 1. Grönroos (2011) states that achievement of superior customer value presumes value co-creation with a customer. The co-creation of value is viewed from a service marketing perspective. Interactions between supplier and customer are regarded as crucial to generation of an exceptional customer value. The concept serves as a frame to generate recommendations of the study that are based on integration of information learned from primary data using Woodrruff (1997) model, secondary data and literature.

1.4. Research Methodology

1.4.1. Research strategy

A choice of research strategy is determined by the type of research question, the amount of control over those that are involved in the study and on degree of relevancy of studied issues, e.g contemporary or historical. (Yin, 2003) The form of research question of the present study may be suitable for different strategies such as experiment, history or case study. However, present study is focused on forest information users' perceptions and opinions and is contemporary in nature. The research strives to receive genial responses in natural, for those involved in the study, settings.

Additionally, it should be noted that studied forest inventory needs are needs that are fulfilled by different inventory methods with the information forming forest resource information system that is used by forest managers. Information needs should form a base for the system development. The needs are determined by a context in which they arise, in the present study context is Northwest of Russia. According to Benbasat et al. (1987) case study is advisable to use in the information systems' research due to the fast changing nature of the field that demands exploratory studies that would benefit from the knowledge of practitioners.

Bearing in mind present study’s question type, contemporary nature of the study with no control over the participants and the assumption that case study strategy is especially useful for information needs research and the study being carried in unique Russian context - the research strategy of the thesis was chosen to be a case study.

1.4.2. Data collection

Data was collected using primary and secondary sources of evidence. Articles in forestry scientific journals have provided valuable information on what influences decision makers in forestry and what forest variables are the most significant when considering the consequences of decisions based on less accurate information. The next authors are mentioned on the basis of their importance as authors of sources of secondary data for the present study. Especially research of Eid (2000); Eid et al., (2004) and Holmstrom et al. (2003) have been invaluable sources of secondary data in forestry. Lee at al. (2002) have provided the basis for the defining valuable for Russian forest leaseholders information quality attributes. Jabkowski et al. (2013) and Chen et al. (2012) provided data concerning LiDAR.

Documents composed by Russian authorities and All-Russian Research Institute for Silviculture and Mechanization of Forestry (ARRISMF) were used as a major source of a secondary data to understand the Russian forest inventory system and to identify potential market for LiDAR forest inventory method. The information on all key secondary data is compiled to Table 2.

Table 2. Key secondary data

Topic	**Sources of secondary data**	**Publisher**	**Used search words**	**Secondary data**
Selecting the data acquisition method in forestry;	scientific journals; government scientific journals	Royal Swedish Academy of Sciences The Finnish Society of Forest Science; Finnish Forest Research Institute (Metla);	forest inventory, decision making, accuracy	forest variables in decision making; factors to influence decision making
Attribute based value of information in forest management	scientific journals; government scientific journals	Elsevier; The Finnish Society of Forest Science; Metla;	information quality; analysis; uncertainty, forestry planning	information quality dimensions
Consequence based value of information in forest management	Scientific journals; government scientific journals	Taylor Francis Online; The Finnish Society of Forest Science; Metla;	decision making; forest management; net present value-losses	net present value losses in different forest stand types; inventory method by stand type
LiDAR	Scientific journals	Elsevier	Remote sensing; forestry; LiDAR; forest inventory	factors that influence cost of LiDAR inventory, forest inventory attributes
Russian forestry	Government public-cations; government act	ARRISMF; Russian Federal Forestry Agency; Ministry of Natural Resources and Environment of The Russian Federation; Roslesinforg; Metla	Russia, forestry, forest management, forest management planning, forest inventory	data on Russian forests; Russian forestry management structure, forest management planning

Primary source of evidence were chosen to be semi-structured interviews. Owning to exploratory nature of the study, in-depth interviews were presumed to be an appropriate method of data collection making this study qualitative. Collection of primary data through semi-structured interviews was conducted in cooperation with Mikhail Smirnov due to his participation to the Finnish-Russian Forest Academy project and writing thesis on the subject related to the topic of the present research. Firstly, each of the researches has designed own versions of the guide, after that the versions were combined resulting in many questions of the guide being the same in both of our studies. However, the responses to these questions are analyzed using different theoretical frameworks.

The geographical area or research was chosen to be Russian Northwest due to Finnish-Russian Academy project constrains and its geographic proximity to the researches. Based on identification of LiDAR's market drown from a secondary data and geographical areas of interest a list of one hundred fourteen (114) forest leaseholders was comprised. Additionally, a list of nine (9) private inventory companies was made; the small amount of firms is due to government inventory company Roslesinforg's leading position on the market. Government has been considered as an important market opportunity for LiDAR and included Roslesinforg, Federal Forestry Agency (Rosleshoz). Only thirteen (13) organisations have agreed to give their opinion on forest inventory in Russia, which may be due the lack of trust as there is a limited amount of master level students that would use interviews as a method to gather primary data.

The interviews were executed face-to-face and by phone. The respondents selected the most convenient for them mode of communication. Due to difficulties involved in getting in-depth interview opportunities from the managers, the interview guide has been sent to a part of respondents that may limit in-depth understanding of their answers. Interview guide was constructed based on Woodruff (1997) value hierarchy. There was a set of questions aimed to define the use situations of forest inventory technologies. Desired products attributes and attribute performance were operationalised through Lee et al. (2002) IQ dimensions resulting in questions that would inquire Timeliness and Free of Error IQ dimensions as well as question probing for other important to forest managers IQ dimensions. Desired/non-desired consequences were incorporated through questions that incurred on respondents opinions on economic and ecologic sustainability. Customer goals and purposes were reflected through questions on the intended use of information and measures to achieve economic and/or ecologic sustainability. One question was directed to probe on value co-creation meaning possible cooperation with Russian government. The process of construction of questions for the interview guide according to the theory is reflected in Appendix 1. Ready interview guide is presented in Appendix 2.

1.4.3. Data analyses

Interviews were recorded and transcribed in collaboration with Mikhail Smirnov. The shortest interview lasted 40 minutes and the longest was 140 minutes, the length of interview depended generally on respondent's willingness to share information, quantity and quality of answers varied significantly between the respondents. Four respondents chose to answer to the questions in a written form stating its convenience.

Deductive thematic analyses, based on Woodruff (1997) customer value hierarchy and primary data driven inductive analyses were chosen as an approach that would ensure theoretical assumptions on customer value applied to forestry and data-driven themes contribute to build a better understanding of the topic. Five theory based themes emerged: use situation, value co-creation, desired/non-desired product or service attributes; desired/non-desired consequences and customer's goals and purposes. The codes were developed in accordance with a theme and constructed operationalisation concept which is shown in Appendix 3. The codes were applied to the transcripted texts of the interviews and written respondents responses. Parts of the codes have not been found in primary data, these codes that have been found were incorporated into results under Russian forestry environment theme. The results have been arranged according to four preplanned themes and one emergent theme. Primary data findings were analyzed together with the secondary data findings and the answer to the research question and sub questions was found and presented in the discussion chapter.

Validity of the research was ensured through the integration of primary and secondary data into analyses. Additionally, forest leaseholders, government and to some extent private forest inventory companies have provided points of view to the same problem from different perspectives. The primary data was taken into analyses based on the formed common view on the problem and data quality.

1.4.4. Limitations of the study

The present study is a single case study and therefore the findings may be applied only to the case of Russia. However, suggested Woodruff (1997) customer value hierarchy operationalisation may be applied to forestry in general. During primary data gathering only one manager from each of the organizations was interviewed, therefore limiting the understanding of topic only from the point of view of one person in the organization. Four of the respondents out of thirteen have chosen to answer to the questions by e-mail thus limiting in depth understanding of the topic. Some reservations on a disclosure of information were observed as well, but due to the interview format these reservation had a minimal influence to results.

1.5. Structure of the thesis

In the introduction general research gap in applied research on desired customer value (Woodruff, 1997) is presented with the emphasis on the gap in application of the theory in forestry. The background of the study provides insights on why LiDAR forest inventory technology was chosen to be studied in forestry. Theoretical framework which was used for the construction of interview guide and analyses of data is presented as well. Introduction proceeds to methodology part which explains the choice of case study strategy owning to the form of research question and contemporary nature of the study. The overview of collected secondary data as well as primary data is presented and followed with information on executed analyses and limitation of study with the last subchapter of introduction outlining the structure of the thesis.

The second chapter on customer value concept introduces the main concept of desired customer value or value-in-use (Woodruff, 1997) that forms basis for the construction of interview guide and analyses, therefore is in effectively the base of the thesis. Value-in-use is examined further from the service marketing perspective and serves as means to translate learning on customer value to the delivery of the value to customers, it is used later in strategic recommendations.

The focus of the present research is forest managers' information needs concerning forest inventory. The third chapter presents the decision making process of forest managers in order to understand what customers value in forest inventory methods. Information on forest inventory needs of forest managers and their forest inventory choice criteria is instrumental in directing the understanding of these issues in Russian context.

In the fourth chapter Woodruff (1997) customer value hierarchy was applied to forestry forming customer value of forest information. Woodruff's (1997) customer goals and purposes are translated to forestry through incorporation of sustainability, focusing on ecologic and economic dimensions. The sustainability concept is especially suitable owning to LiDAR technology competitive strength in obtaining diverse data on forest that is invaluable in sustainable forest planning. Woodruff's (1997) desired/non-desired consequences were translated into forest management planning through the theory on consequences of decisions based on inaccurate information that result in additional costs that generally are not accounted by forest managers. Due to the focus of the research on information needs Woodruff's (1997) desired products attributes and attribute performance were incorporated through the theory on information quality (IQ) dimensions.

LiDAR technology is described in fifth chapter. The knowledge on the technology advantages and disadvantages is instrumental in answering the research question and sub-questions. Use of LiDAR in forestry is presented due to the leading concept of the present study being value-in-use and provides valuable insights on costs of LiDAR technology use in forestry.

The sixth chapter on Russian forestry provides context for the thesis. Understanding of Russian forest managers information needs requires the knowledge of Russian forest inventory system with the demands and limitations that it imposes on the managers. Organizations that participate in forest inventory are introduced with government inventory company Roslesinforg taking the central role with its monopoly in government inventory and leading position in local (for local forest leaseholders) inventory.

The seventh chapter is empirical chapter where is described the primary data gathering process through semi-structured interviews and by e-mail. The information on interviewed companies is given and the principles of interview guide construction are presented.

The eighth chapter presents results of primary data grouped by four original themes that were incorporated to the interview guide, the theme of desired/non desired consequences was excluded due to general (with some exceptions) short-term forest management planning in Russian forestry. Related to inventory government organizations gave valuable insight on what in their view might be important for forest managers. The input of private inventory organizations was minimal. Russian forestry environment theme has emerged from all gathered data.

The ninth chapter – discussion combines primary data results and knowledge gained from secondary data into analyses to produce a thorough understanding of forest managers information needs. Firstly research sub-questions are answered with the answer to the main question in the recommendations sub-chapter. The recommendation part is based on the theory and primary as well as secondary data analyses.

The tenth chapter provides a summary of the thesis where the stages of the research and the findings are presented. The thesis is evaluated and significance of findings is considered. The structure of thesis is shown in Figure 1.

INPUT	CHAPTER	OUTPUT
Background knowledge	Introduction	Research questions Methodology.
Research questions Literature on customer value concept	Customer value concept	Customer value hierarchy (value-in-use). Service marketing perspective on value-in-use
Decision making in forestry	Forest resource management	Use situations in forest management Information needs of forest managers globally
Literature on sustainability, forest management decision consequences and IQ attributes	Value of forest information	Operationization of customer value hierarchy in forest management.
Literature on forest inventory method LiDAR	Remote sensing method LiDAR	LiDAR advantages and disadvantages and it's use situations in forest management
Russian forest inventory system and methods	Russian forestry	Russian forest managers' environment conditions (forest inventory system) Limitations of novel forest inventory methods use
Respondents chosen based on geographical position and understanding of Russian forest inventory system	Empirical study	Description of respondents
Interviews transcripts and respondents' written answers	Results	Identification of Russian forest managers information needs

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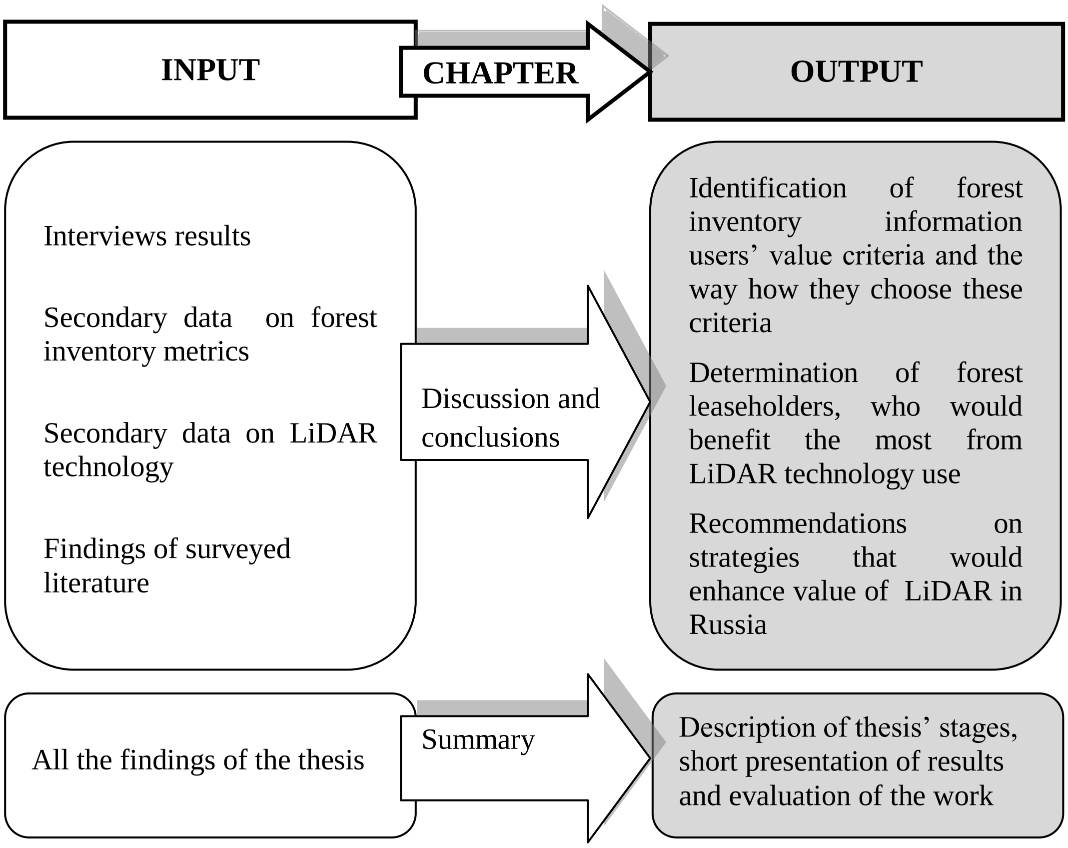

Figure 1. Structure of the thesis

2. CUSTOMER VALUE CONCEPT

Customer value concept has become one of the most significant constructs in the marketing literature (Ulaga and Chacour, 2001; Ravald and Grönroos, 1996). Strategy geared on providing superior customer value delivery is considered one of the possible ways to provide a sustainable competitive advantage of the firm (Woodruff, 1997). Interestingly, there is still no common understanding in the literature on what embodies "value" (Payne and Holt, 1999, p. 42). Marketing literature offers numerous definitions of value; however, it is possible to make general as well as more detailed classifications of value definitions in the literature. It should be noted that there are several value concept classifications as well.

According to Sánchez-Fernández and Iniesta-Bonillo (2007) ”perceived value" definitions can be categorized to uni-dimensional and multidimensional constructs. Zeithaml (1988) understanding of value as an attribute trade-off between quality and price is often citied and represents uni-dimensional value construct. On the other hand, many researches such as Babin, Holbrook, Mathwick have taken a broader view on the concept of value and argued that "perceived value" is a multidimensional construct in which perceived price, quality, benefits and sacrifice are all ingrained. (Sánchez-Fernández and Iniesta-Bonillo, 2007, p. 428) This value definitions in the consumer value literature has influenced value research in business content with Woodruff (1997) rooting his theory of value hierarchy in Zeithaml's consumer means-end theory.

According to Ulaga (2001, p.316) value research in business markets, traditionally, has been concentrated on the evaluation of value created by suppliers for their customers and on the customer's perceptions of delivered by supplier value in comparison with competing offers (the buyer's perspective). With a growing understanding on the role of customer as a strategic asset of the firm, the management of customer equity "as the total of the discounted lifetime values summed over all of the firm's current and potential customers" has become second major perspective of customer value (the seller's perspective)

(Ulaga, 2001, p.316; Rust et al., 2004, p. 110). The third perspective on value according to Ulaga (2001, p.316) is buyer-seller perspective, which stems from the idea that value created within networks of market players trough their relationships, alliances and partnering. This view is backed by Wilson (1995).
Figure 2 illustrates the concept of three perspectives on customer value according to Ulaga (2001, p.316)

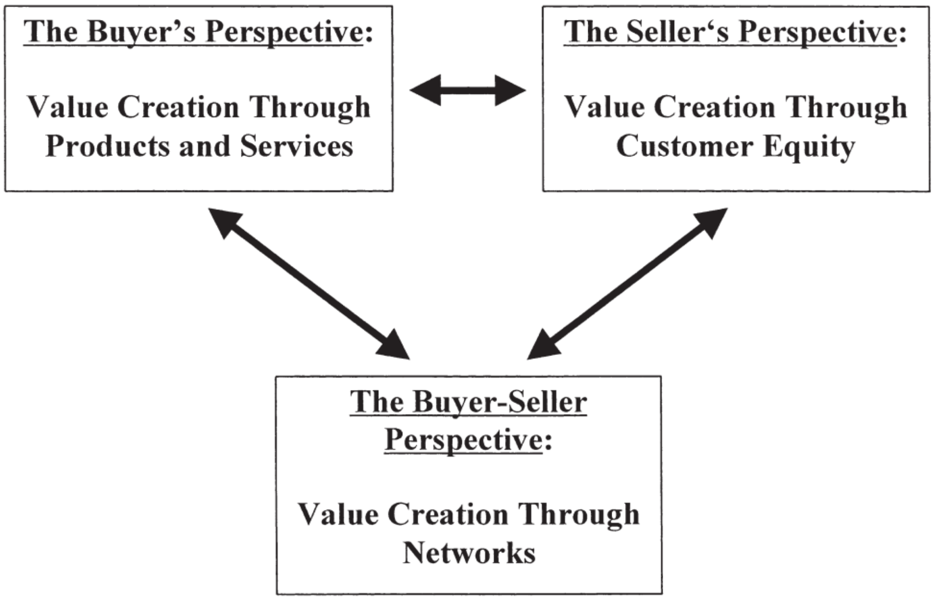

Figure 2. Three value concepts (Ulaga, 2001, p. 317)

This classification is very useful for the general understanding on value research streams in the literature. Seller perspective is broadened further by value classification offered by Woodruff and Flint (2006), according to them the sellers perspective incorporate as Ulaga's (2001) economic worth of a customer and also valued added concept.

According to Woodruff and Flint (2006), in value-added concept value is created by seller and the product or service has value independently of buyer's perceptions. This view has roots according to Vargo and Lush (2006, p.3) in classical and neoclassical economics. Nonetheless, with a marketing discipline that is concentrated on customer needs, value-added concept though focused on seller’s contributions, takes into account also customer perceptions (Woodruff and Flint, 2006). The product or service is viewed as a “bundle of attributes” that are seller’s controlled, possible customer feedbacks are assessed as well and based on them different combinations of attributes are created (Griffin and Hauser, 1993). Woodruff and Flint (2006) offer a critique of value-added concept arguing that seller’s concentration on attributes might obscure seller’s understanding of customers’ needs in concrete use situations.

Economic worth of the customer is one of the leading notions in customer relationship management (CRM) (Woodruff and Flint, 2006, p.185). Ulaga (2001, p.316) defines it as a customer equity. In this perspective seller’s concern is to extract biggest lifetime customer value by segmenting customers and applying strategy according to the segment with a highest value potential (Woodruff and Flint, 2006).

Woodruff and Flint (2006) have indicated two definitions of value from buyer perspective: “economic worth of a seller’s product/service offerings” and value-in-use. “Economic worth of a seller’s product/service offerings” refers to the stream of literature based on Zeithhaml (1988) work where customers understand value in monetary terms and value is often associated with a lower price. Though this concept might be successfully applicable to some business-to-business transactions, it is quite limited in understanding of the customer, because value might be considered by customer also in non economic terms. (Woodruff and Flint, 2006)

Fourth value definition as understood by Woodruff and Flint (2006, p.185) and Vargo and Lush (2004) is value-in-use defined as “a phenomenological experience perceived by a customer interacting with products/services bundles in use situations”. Value is not linked to the product; it is attached to the customer perceptions of the product or service combination of attributes in a concrete use situation Woodruff and Flint (2006). The definition has steamed from means-end theory (Vargo and Lush, 2004, p.9) and incorporates a broader view on customer value.

Woodruff and Flint (2006) customer value classification omits the third perspective that was mentioned by Ulaga (2001, p. 316) namely buyer-seller perspective, which is concerned with creation of value trough networks. According to Kothandaraman and Wilson (2001) the focus in customer value research has shifted from creating customer value by one seller to the creation of customer value by key players in value networks. Achievement of a superior customer value depends on the core capabilities of the firms involved in the network and also on the nature of relationships.

Present research is exploratory and attempts to take a broader look at the customer value in Russian forestry by inquiring customer perceptions of forest inventory methods. The research design leads to the natural choice of a seller perspective and subsequently choice of value-in-use as an appropriate value definition for the study. Next chapter is focused on the explanation of value-in-use that is used as a base for conducting the research.

2.1. Value-in-use

Woodruff (1997, p.142) in his article has proposed defining value as: "Customer value is a customer's perceived preference for and evaluation of those product attributes, attribute performances, and consequences arising from use that facilitate (or block) achieving the customer's goals and purposes in use situations." Value-in-use thus can be divided on received value, that customer has received and desired value, the value that customer would wish to receive. It is important to understand that this definition of value embodies not only attributes of a product or service at present that customer would want, but also it establishes what kind of expectations the customer has from a future offering and what consequences customer would wish to avoid or to have. Products/services are related to concrete use situations of the customer. (Woodruff, 1997, p.142) This definition has roots in Means-end theory, that was used to understand how customers classify information about the products in their memory (Gutman 1982; Woodruff and Gardial, 1996).

Woodruff (1997) has suggested a customer value hierarchy, which is shown in Figure 3, as a way to understand customer value, that can be applied to desired value as well as to received value. The value hierarchy is linked to particular use situation and differentiates according to the use situation in hand. According to the hierarchy the lowest level of hierarchy is attribute level, where customers value a product or a service according to attributes that are offered at present that leads to attribute-based satisfaction. The next level of the hierarchy is desired consequences- the customer prefers particular attributes that lead to desired consequences in specific use situations; result is consequence-based satisfaction. The next and highest level of the hierarchy is value that customer places on how product or service coincide with customers' goals and purposes, at this level consequences are classified according to their importance to achieve customer's goals (Clemons and Woodruff, 1992).

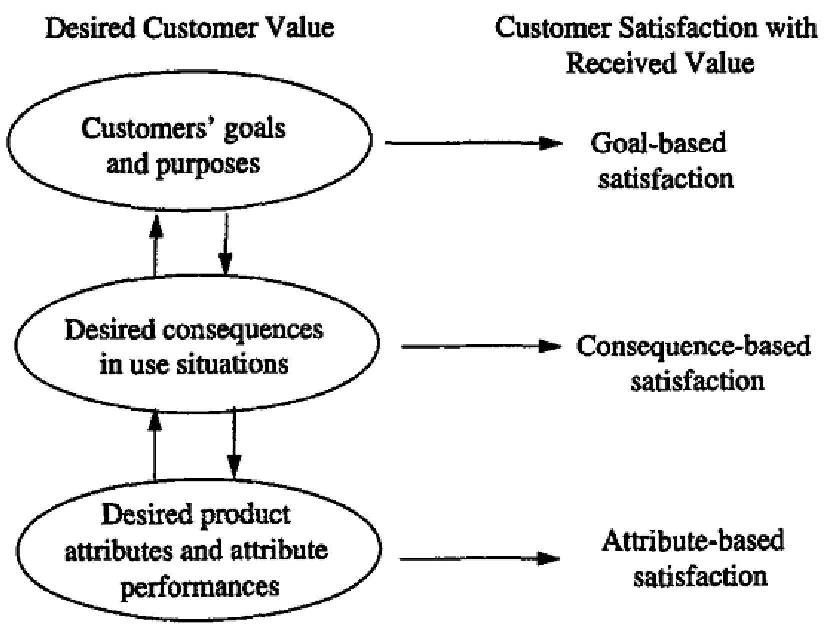

Figure 3. The customer value hierarchy (Woodruff, 1997, p. 142)

According to Woodruff (1997, p. 144) organizations tend to learn about their customers mostly on the lowest attribute level of value hierarchy. Organizations' focus on products/ services attributes is in line with a common view in marketing literature on value as simply a trade-off between quality and price. This focus is on the received value (Flint and Woodruff, 2001)

This vision is lacking in depth understanding of the customers. It is recommended to use more in depth interviews to uncover what consequences customer desire from the use of a product or service. Current practices to understand what customer values are too focused on the quantities dimensions of customer satisfaction and often lack the inside to answer why customer assess offerings in this particular way. (Woodruff , 1997, p. 145)

Flint and Woodruff (2001) notes that with customers' changing value perceptions, it is crucial to understand the change for the reason that prediction of customer desired value might be a source of a competitive advantage for the supplier. Flint et al. (1997) have expanded the concept of desired value negative consequences that steam from the use situations and that influence customers' value perceptions. Change in customers' value perceptions is influenced according to the study by customers' personal value, desired value and value judgments. Values are defined as people's core beliefs that are not influenced by use situations and can be held by individuals or organizations. They are the drivers of customers attribute preferences and influence evaluation of probable consequences of the choice, thus guiding customers' behavior to achieve set goals. (Flint et al., 1997)

Desired value differs from values concept by its strong linkage to specific use situation, customers desire benefits that will steam from the use of specific attributes of product or a service. Value judgments represent customers' assessment of received monetary on non-monetary benefits comparing to monetary or non-monetary sacrifices that customer had to make in a specific use situation. It is essential to monitor the changes in customer's perceptions to be able to incorporate these changes in the strategy. (Flint et al., 1997)

2.2. Value-in-use - service marketing perspective

Grönroos (2011) further classifies value-in-use to value creation and value generation. Value creation is defined a process of value creation by customer using available resources. Value generation is defined as much broader process that includes value creation and development, design, manufacture and delivery as well as firm's back-office and front-office activities (Grönroos, 2011, p. 242). In Grönroos's (2011) article customer is seen as a value creator who not always co-creates value, this point of view is different from the point made by Vargo and Lush (2004), where the customer is considered as co-creator of value in all situations, where value-in-use is created.

Grönroos and Ravald (2009) state that the most important goal of the business is reciprocal value creation, service being crucial factor in the process. Service is considered as means to create value not only for the customer but also for the supplier. Value-in-use can be facilitated by suppliers' provisions of necessary resources to the customers.

Supplier's interactions with the customer during offering's usage process opens an opportunity for a co-creation of value, thus supplier becomes not only value facilitator, but also a value co-creator (Grönroos, 2011, p.243). During the interactions in offering's use situations supplier and buyer influence each other perceptions and actions (Ballantyne and Varey, 2006). Co-creation of value through interactions might occur at any stage of offerings' design, manufacturing, sale, delivery, maintenance; in general during all the processes between supplier and buyer. During non-interaction fazes between supplier and buyer, supplier plays a role of a facilitator of value. (Grönroos, 2011, p. 244)

Figure 4 illustrates value-generating process from a production perspective and from a value creation perspective.

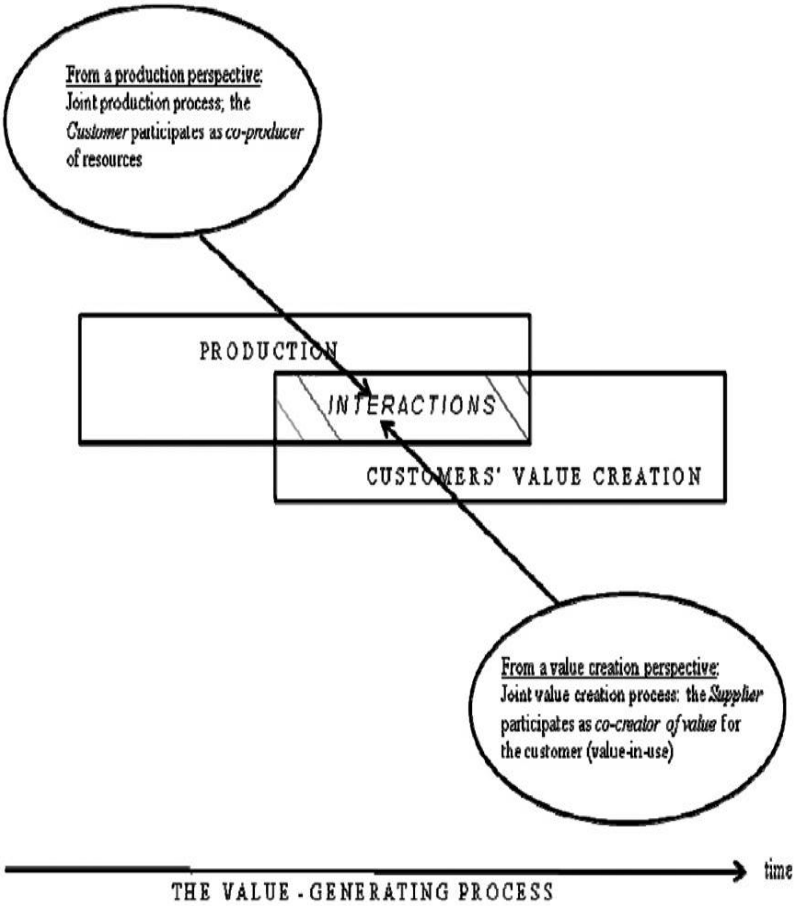

Fig. 2. Value creation and the phases of the value-generating process.

Figure 4. Value-generating process (Grönroos, 2011, p. 244)

Value production perspective perceives customer as co-producer of resources. Value creation perspective considers supplier's participation in joint value creation process as co-creator of value for customers. (Grönroos, 2011, p. 244) These perspectives differ in their focus, value production perspective is focused on value generation by supplier with some role of the customer in the process with value creation perspective being concentrated on the customer as a value creator with a supplier that support customer in value generation. Both perspectives endorse value co-generation through interactions. It should be noted that the possibility of value co-creation depends on the quality of interactions. Interactions should be seen as a base from where supplier might influence customer in different usage situations. (Grönroos, 2011)

Service logic of marketing implies that supplier needs to engage with customer's processes to be able to support customer's value creations. The logic coupled with the possibility of value co-creation through interactions might be successfully used also in non-service businesses. Value co-creation activities with customers might assist in building new extended market offerings and enable new earning logics. (Grönroos, 2011, p.245)

3. FOREST RESOURCE MANAGEMENT

Erdle and Sullivan (1998, p. 83) define forest management as a process that includes design and implementation of actions, which lead to achieving desired value in the set amount of time.

Forest resource managers have to make long-term and short-term decisions concerning forest use. Managers need to achieve timber production and revenue objectives, plan timber production according to the set goals, and manage ecological diversity. Their tasks include setting what trees to harvest and when, planning forest road network to provide efficient access to timber resources scheduling harvesting and reforestation, manage investments to maximize revenues, forecasting forest products demand and dealing with uncertainty. (Buongiorno and Gilless, 2003, p. 2)

According to Franklin (2001) forest management process can be categorized to four main elements:

- The definition of forest values, which are defined by Buongiorno and Gilless (2003, p. 113) as values of property including trees and land that represents the income that forest might produce over infinitive amount of time.
- The description of the forest (the inventory),
- The identification of treatment alternatives, and
- The description of the biological response to treatment

According to Fedkiw and Cayford (1999) cited by Franklin (2001) the forest management process has long-term nature that currently is not widely admitted. However, Kant (2003, p.40) argues that forest management has moved from sustainable timber yield management to sustainable forest management.

3.1. Decision making in forest management planning

Decision making process to achieve forest management plan has several stages that are: definition of management objectives, establishment of management objectives and finally the choice of preferred approach. It should be noted that this process is only meaningful when all stages of the process are supported by adequate information that would also enable forecasting of resource development under diverse management strategies. Decision-making is considerably influenced by decision-maker values and preferences thus being in a considerable part subjective. (Knoke et al., 2010)

The stages in decision-making for forest management planning, as it shown in Figure 5, form a process where monitoring and updating the management plan influences the goals, inventory concepts and definition of management alternatives. (Knoke et al., 2010)

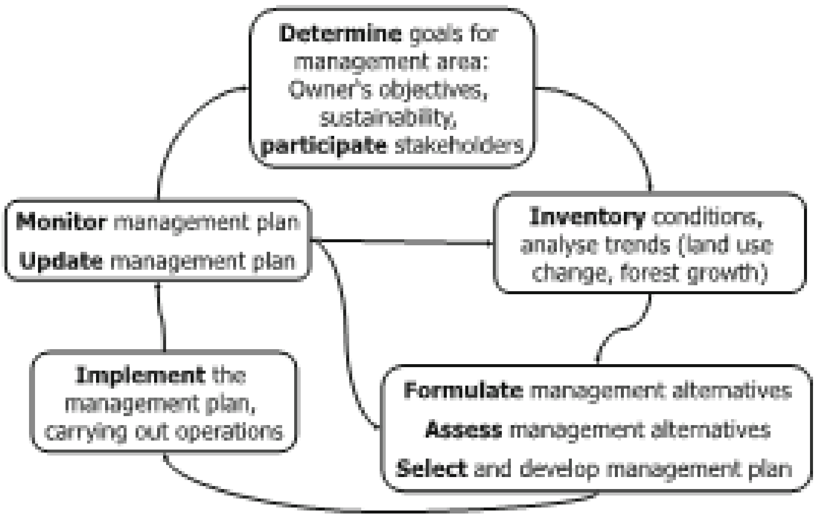

Figure 5. Decision-making in forest management planning (Bettinger et al. 2009; Knoke et al., 2010, p.772)

Decision-making process demonstrated in Figure 5 shows that forest management objectives might include sustainability concepts in addition to purely economic objectives. The process identifies different optimization approaches and related information needs to support high-quality decision-making. Monitoring and inventory assessments assist in decision making. (Knoke et al., 2010)

3.2. Information needs in forest management

Forest managers' information needs can be categorized to three levels: operational, tactical and strategic (Weintreb and Cholaky, 1991). Operational needs are local in nature and concern short-term harvesting decisions, scheduling and implementation of silvicultural treatments and finding certain forest structures such as old-growth stands. Knowledge of tree species distributions within different forest units is important. This level demands the biggest accuracy and commands the highest uncertainty; however the consequences of this uncertainty are deemed not too decisive considering the small size of areas in question. Areas are usually small homogenous stands and in some cases acceptably heterogeneous. (Weintreb and Cholaky, 1991)

At tactical level managers need information that covers broader areas of forest. It is acceptable that this level information is less detailed. The tactical level information might be used for road planning as well as for biodiversity management. (Weintreb and Cholaky, 1991). Tactical planning usually covers the period from several years to several decades and focused on satisfying temporal demands for timber through careful selection and sequencing of stands or homogenous parts of forest to cut. Earlier mentioned road planning is crucial for provision of timber access in harvest areas. Road planning is an important plan of management planes since transportation comprises up to 40% of the operational costs. (D'Amours et al., 2008)

Strategic level needs demand broader information to make decisions such as allocation of certain lands to timber production and other area to wildlife habitat. (Weintreb and Cholaky, 1991). Strategic level decisions are made on country level and can span several forest rotations, which means the establishment of plans that cover more than 100 years. These planes influence greatly forest values.

The decisions made on this level incorporate decisions linked to forest use and different socio-economic consequences. (D'Amours et al., 2008) Operational, tactical and strategic level information is often incorporated in various decision support systems and strongly influence forest managers' activities (Bachelord and Griffith, 1994).

Forest managers also have information needs that are related to sustainability. Sustainable forest management (SFM) has become a replacing concept to the earlier sustainable timber yield management with ecological and social aspects, present in SFM, differentiating them. Social aspects incorporate value of different stakeholder groups while ecological aspects concentrate on long-term eco-system sustainability. (Kant, 2003, p. 49)

C&I systems have enabled identification of related to sustainability information needs that forest managers have (Franklin, 2001), with forest productivity and health as well as ecosystem criteria being possible of high significance. Sustainable forest management calls for balancing multiple objectives connected to social, ecological and economical criteria. Consequently, forest managers need more accurate forest information. (Wulder et al., 2008, p. 814) In addition to earlier mentioned information needs that derive from ecological criteria of forest management there are crucial for forestry information needs that emerge from economic criteria.

3.3. Forest inventory

Forest management information needs to support decision making are satisfied by acquirement of information through forest inventories. During forest inventory the extent, quantity and condition of forests are assessed. (Penman et al., 2003) According to Köhl et al. (2006) "forest inventory is a process for obtaining information on the quality and quantity of forest resources and forms the foundation of forest planning and forest policy".

In developed countries forest inventory needs have been growing from need of information in timber supply to the broader information needs on multiple functions of forests (Köhl et al., 2006). Köhl et al. (2006) provide (Figure 6) a good example of growing forest planning information needs in USA.

					Nonforest lands, habitats, old growth and primary forests
				Ecosystems, biodiversity, NWGS	Ecosystems, biodiversity, NWGS
			Global warming	Global warming	Global warming
		Biomass	Biomass	Biomass	Biomass
	Multiple resources	Multiple resources	Multiple resources	Multiple resources	Multiple resources
Timber	Timber	Timber	Timber	Timber	Timber
1950s	1960s	1970s	1980s	1990s	2000+

NWGS nonwood goods and services

Figure 6. Growing forest planning information needs in USA (Köhl et al., 2006, p. 5.; after Lund and Smith, 1997)

These growing forest inventory information needs are in line with earlier mentioned development of forest management to be more sustainable.

There is a need for definite objectives with a set priority to successfully execute an inventory. Objectives should be well defined and measurable; cost, stuff and time constrains should be assessed as well. Generally inventories are not implemented to satisfy information need of just one stakeholder, it is advisable to find multiple stakeholders with an interest in information. These stakeholders might be, for example, forest authorities, land-use planning and environmental protection agencies, forest owners, the wood-processing industry, consumers of secondary forest products, wildlife organizations. All groups of users of inventory results should be involved in initial planning stages of inventory. After definition of objectives, desired attributes should be identified based on the inventory area from which samples will be taken, data type and error limits. (Köhl et al., 2006)

Forest inventory can be executed by remote sensing technologies or/and field assessments done on the ground (Köhl et al., 2006). A use of remote sensing technologies is especially beneficial in a case where there is a need to promptly access forest resources on large areas that are challenging to survey on the ground (Congalton et al., 1993). However, it should be noted that the number of attributes that might be obtained from remote sensing is quite limited, thus some amount of field assessments are still required for execution of good quality inventories (Köhl et al., 2006).

3.4. Selecting the data acquisition method in forestry

Decisions on information acquisition in forestry are often based on costs of information obtainment as well as accuracy of data. Traditionally, the accuracy of mean volume is often the most important measure concerning the data of quality. However, there is still a lack of knowledge in what forest variables have the highest value in decision making and consequently should have highest accuracy. The problem of accuracy prioritization complicates minimization of costs based on decision making as well (Kangas, 2010). Forest variables, for example, are volume, age, biomass, site quality, and field layer, ground moisture provide information that is extracted for each forest plot (Reese et al., 2003).

Inventory methods are generally evaluated by a level of error (Eid, 2000). This error is typically the percentage value of root mean square error (RMSE), that present difference between estimated and actually observed value. However, it should be noted that this traditional inventory method assessment does not support the use of measured information for decision making. (Kangas, 2010)

Long-term timber production analyses are often focused on forecasting timber prices/harvest costs, success of regeneration and growth/mortality of trees, however uncertainty related to inventory data is less accounted (Eid, 2000). In practice method of data acquisition is selected based on tradition, not on pursuit for optimal acquisition of information. In case of inventory execution to manage change in addition to assisting decision making in a certain period, selection of optimal inventory method is even more challenging. (Kangas, 2010)

It should be noted that higher accuracy and quality of data in general leads to higher costs. There is a trade-off between costs of acquiring accurate information and losses resulted by non-optimal decision making based on errors data. (Holmstrom et al., 2003)

On the other hand, forest management process requires forest management planning that according to Knoke and Weber (2006) requires integration of stakeholder economic interests and sustainability goals concerned with ecological and social facets has become a central goal of forest management planning. Forest management planning can be defined as a decision making process that results in management plan that includes all activities that are required to meet management's goals and objectives (Bettinger et al. 2010).

Buongiorno and Gilless (2003, p. 93) state that primary requirement of forest management plan is sustainability of forest as whole including sustainability of timber production that is linked to the amount of trees being harvested and sustaining biodiversity that depends on the growing stock. Therefore, sustainability incorporated into goals of forest management might be one of the factors of forest inventory method choice.

4. VALUE OF FOREST INFORMATION

4.1. Goal based value of information in forest management: sustainability perspective

In developed countries forest management practices have developed from practices concerned only with achieving continuous profit to sustainable forest management practices. In nineteen and first half of twenties century forestry businesses were only concentrated on maximization of profits from timber. The move to mores environment friendly practices has happened in 1970s in developed world. (Kant, 2003) The same period was a beginning of establishing more sustainability directed practices in developing world as a result of different pressure groups owning this development to freedom of thought (Kant and Berry, 2005).

Heal (1998, p. 14) argues that sustainability can be defined using tree axioms. Sustainability is determined as "a treatment of the present and the future that places a positive value on the very long run", "recognition of all the ways in which environmental assets contribute to economic well-being" concentrating on biodiversity's contribution to economic welfare and as "recognition of the constraints implied by the dynamics of environmental assets".

Different environment groups have influenced government forest policies in developed and developing countries. Criteria and indicators (C&I) systems as well as Helsinki and Montreal processes form a base for definition of sustainable forest management. (Kant, 2003, p. 49) C&I systems are currently widely used for measurement of sustainability in forest management. Early international C&I driving processes such as the Helsinki process and the Montreal process were a base for establishing national sustainability indicator systems such as Canadian Council of Forest Ministers (CCFM) C & I Framework. These C&I systems have influenced establishment of certification systems. (Adamowicz, 2003, p. 33)

Typically, sustainability goals and guidelines are first incorporated to Codes of Forest Practice. These guidelines assist in achieving certain environment goals within current economical constrains (Smith and Raison, 1998). Codes of Forest Practice include statements on recreation, ecological health, biodiversity, wildlife habitat, water regimes and timber values. (Erdle and Sullivan, 1998). The Codes of Forest Practice are implemented through local management prescriptions that influence resulting forest values (Erdle and Sullivan, 1998). Implementation of management prescriptions should be monitored trough various criteria and indicators (Smith and Raison, 1998). These forest management practices, aimed to ensure sustainability, are illustrated bellow in Figure 7.

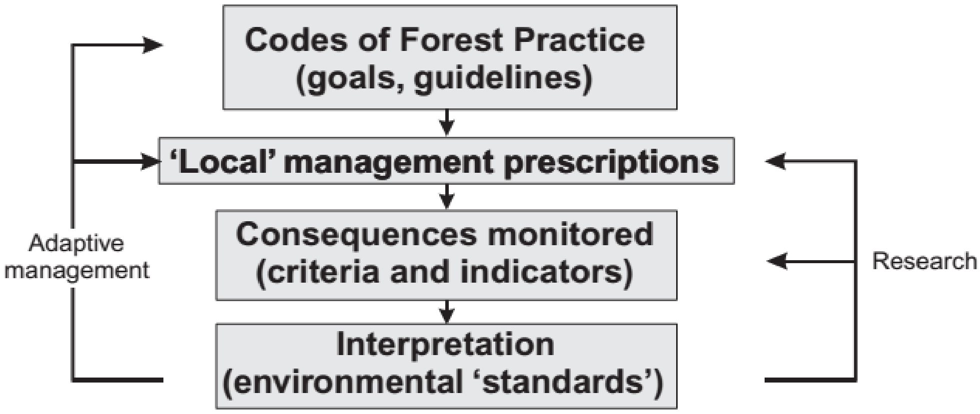

Figure 7. Building sustainable forest management (Smith and Raison, 1998)

There are numerous sets of sustainability indicators that differ in forest management and economics literature. Indicators in economic literature tend to integrate ecological and economical information while indicators used in forest management practices are commonly separated. (Adamowicz, 2003, p. 28)

Economic sustainability literature is focused on setting economic measures to sustainability and has a common understanding on definition of sustainability. The main notion is - "ecological relationships are critical for the development of economic accounts". Currently there are several problems in assessing sustainability using economic measures. Evaluation if sustainability in limited scope of forest industry is one of these challenges. (Adamowicz, 2003, p. 32) Indicators that are set in the limits of individual sectors might not demonstrate an accurate measure of sustainability (Nordhaus and Kokkelenberg 1999). Spatial scale issue is another matter that is challenging to implement in economic sustainability assessment, as well as accounting of nonmarket goods and services. (Adamowicz, 2003, p. 32)

Adamowicz (2003, p. 33) classifies C&I to several general criteria that might combine in various ways. These C&I systems incorporate: legal, policy and institutional framework; ecosystem services (carbon, water, soil); socio-economic benefits; forest health or integrity; biological diversity and forest productivity. All of the above mentioned criteria are categorized to economic, social and ecological criteria with ecological being critical to determination of economic sustainability.
C&I systems will likely be used by firms to assess performance, for example through certification, as well as to develop management practices and policies. With good quality indicators firms might progress into the direction of sustainable forest management. (Adamowicz, 2003, p. 37) In order to direct their businesses toward sustainability forest sector firms need to change their business models, technologies, organizational forms, scale of operations and performance objectives. Trough this change strategies of renewing resource base for future generations might be fulfilled. Sustainable companies require a use of new "knowledge-based" technologies that enable to create value from fewer selected tree compared to present non-sustainable forestry technologies that necessitate clear-cut big areas in order to achieve minimal productivity levels. (Sharma and Henriques, 2005, p.160)

It is indicated in this subchapter that there are three dimensions of sustainability: ecological, social and economic. These dimensions are often reflected in identification of objectives during forest management planning process. Knowledge-based technologies might assist in capturing information to fulfill sustainability goals. The value of information might be accessed through C&I criteria.

4.2. Consequence based value of information in forest management

In decision making there is a certain amount of uncertainty either it is market uncertainty or event uncertainty. In forestry market uncertainty might be connected to future timber prices and demand for timber, event uncertainty might be, for example, the amount of timber that will be achieved in future cuttings influenced by such possible events as, for example, fire or insects attacks. Perceptions and preferences of decision makers are also inevitably to certain degree are subjective, for example, concerning trade-offs between attributes. (Kangas et al., 2010)

The decision making goal is maximization of payoffs trough a set of actions; payoffs might be tangible such as profit, revenue, and output or less tangible such as satisfaction or utility. Investments in information acquisition reduce uncertainty in payoffs; however payoffs are also diminished as a result of information cost. There must be made a choice on using existing information for decision making or on investing in additional information acquisition that reduces uncertainties and is valuable enough to justify an investment. (Wilson, 2015)

Opportunity costs that are often not accounted such as consequences (costs) of suboptimal decisions concerning harvesting times together with direct costs such as, for example, costs due to the late delivery timber to the factory are result of poor quality information (Kangas et al. 2010).

4.2.1. Cost-plus-loss analyses

Cost-plus-loss analyses is used in assessing trade-offs between information acquisition and analyses costs and economic losses due to non-optimal decision making. Analyses aims at minimizing total information costs. (Eid, 2004)

Cost-plus-loss analyses take into account costs that follow as a consequence of misguided by inaccurate information decision making, these costs are added to the total costs of forest inventory (Hamilton, 1979). The biggest challenge of the analyses is calculation of possible misguided decisions consequences – losses. Generally they are calculated in terms of net present value (NPV), as it is assumed that forest managers are guided in their decisions by the notion of NPV maximization. (Holmstrom et al., 2003)

Eid (2000) indicates that costs inquired by errors in different forest variables are varied in amount. Errors in assessment of site quality and age lead to higher NPV-looses with age having the highest impact compared to basal area and height. Subsequently, more efforts should be put in inventory of age and site quality. Expected NPV-losses differ according to forest stand types. Losses for stands that are close to maturity are significantly higher than in the oldest stands (relative maturity > 120 %). Inventory design should reflect the value of information with stands that have potentially larger NPV-losses be inventoried more intensively than stands with lower losses.

Holmstrom et al. (2003) have noted that the choice of inventory method to optimize costs should depend on the stand type with application of more sophisticated and accurate methods to larger mature stands, while in small stands with less value – more simple methods use is preferable. Comparison of photo-interpretation and laser scanning (two large-area inventory methods) in Eid et al. (2004) study has identified that thought laser scanning inventory costs were twice higher than photo-interpretation costs, the final laser scanning costs that accounted losses associated with consequences of incorrect harvest decisions were twice lower than photo-interpretation costs. The scale of NPV-losses is influenced by the harvest timing with longer periods generating higher losses as well as stand maturity (Eid et al., 2004). Kangas (2010) has noted that NPV-losses might be higher in long-term then stated in Eid et al. (2004) and Holstrom et al. (2003) studies indicate due to simplifications such as exclusion of deterioration of data through time among others.

4.2.2. Multi-criteria decision analysis

Multi-criteria analyses strive to incorporate ecological and social sustainability criteria in addition to economic to valuate forest inventory information. Nonmarket goods' value of information is challenging to determine due to the goods non-monetary nature (Kangas 2010; Kangas et al., 2010). Analyses strive to calculate the value of information (VOI) to assist in the choice of optimal method of inventory.

Value of information (VOI) can be defined as the expected gain from reducing uncertainty through data collection. In case of "wrong decisions" the expected loss is calculated as probability of "wrong" decision multiplied by quantified average consequence of "wrong" decision (the opportunity loss) or equivalently, in case of "good decisions", the expected gain from reducing uncertainty. (Wilson, 2015) Thus it should be concluded that the scale of decision consequences directly influence the value of information.

Kangas (2010) that VOI depends on information quality as well as the costs of acquiring such data thus optimal policy in data acquisition is maximization of VOI. This approach is similar to cost-plus-analyses in terms of data acquisition solution with the biggest difference being accounting for the value of previous information which is not done on cost-plus-losses analyses. Value of existing information may influence the choice of inventory method revealing cases when obtainment of new inventory information is not profitable.

VOI in multi-criteria analyses is calculated, principally, in the same way as calculations done for cost-plus-loss analyses (Kangas, 2010). Difference between cost-plus-loss analyses and multi-criteria is an inclusion of multiple sustainability criteria in multi-criteria analyses and calculations. It should be noted that interpretation of results from multiple-criteria analyses is difficult due to difficulties in assigning relative values for the criteria (Kangas, 2010).

4.3. Attribute based value of information in forest management

Generally, forest inventory data is used in forest planning as input for decision support systems (Jonsson et al., 1993). This data is further used for forecasting growth and timber yield to make optimal management decisions and the treatment schedules that aligned to management objectives. Forecasts' quality depends on the accuracy of data thus forest planning based on accurate data results in better planning decisions. (Holmstron et al., 2003)

Accuracy is only one of quality dimensions of information. Lee et al. (2002) further classifies quality of information stating that there are four information quality (IQ) categories: intrinsic IQ, contextual IQ, representational IQ, and accessibility IQ. All categories have multiple IQ dimensions that differ between researches. Intrinsic IQ is quality dimension that is associated with accuracy and reliability. Information quality must be considered within the context of the task (contextual IQ) thus it must be relevant, complete, timely and appropriate in terms of amount. Representational and accessibility IQ refer to consistent and concise representation of information that is easy to understand and interpret as well as securely access and manage. (Lee et al., 2002) These dimensions can be incorporated to different IQ categories for various authors. Lee et al. (2002) further expanded IQ dimensions; drawing from their list of dimensions' measures it is possible to form a general understanding of IQ dimensions as it shown at Table 3.

Table 3. Information Quality Dimensions (Lee et al., 2002, p. 143)

IQ Dimension	Meaning
Accessibility	Information is quickly accessible when required
Appropriate Amount	Amount of information is sufficient for current information needs
Believability	Information is trustworthy
Completeness	Information has sufficient breadth and depth for the task (includes all necessary values)
Concise Representation	Compact presentation of information

Consistent Representation	Consistent presentation of information in the same format
Ease of Operation	Information is easy integrate with other information
Free of Error	Information is accurate and reliable
Interpretability	Easiness with which is possible to interpret information
Objectivity	Objective collection of based on facts information
Relevancy	Information usefulness for the task
Reputation	Reputable sources of information
Security	Information accessible only by authorized people
Timeliness	Information is sufficiently up-to-date for the task
Understandability	Easily understandable information

Collection of a good quality information requires knowledge of value of data in decision making (Kangas, 2010).

5. REMOTE SENSING METHOD LIDAR

Remote sensing might assist in the presentation and reporting on sustainable forestry criteria and indicators (C&I) (Berry and Ripple, 1996). Remote sensing includes acquisition of data as well as data analyses and modeling (Buongiorno and Gilless, 2003, p. 83). Digital remote-sensing images might be acquired by use of satellite, airborne and field-based platforms. These methods may be complimentary in executing forest analyses and modeling (Buongiorno and Gilless, 2003, p. 85).

According to Junttila et al. (2013) prediction of forest variables reduces decision related uncertainties that should be considered in forest management and in forest policies. These large-scale and small-scale estimates may be achieved by using a combination of field assessment on the ground and remote sensing methods such as LiDAR - Light Detection And Ranging. (Junttila et al., 2013) LiDAR is an active sensor that emits laser pulses and measures the backscattered signal. (Suárez et al., 2005)

5.1. LiDAR systems

LiDAR systems may be classified to airborne, space borne and ground based according to the platforms they are placed on, on the method with which returned signals are recorded (discrete return or waveform) and on the footprint size that may differ from small that is about one meter or less to larger footprints that may account for tens of meters. (Kelley and Tommaso, 2015) The main difference between discrete return and full waveform systems is the way with which forest canopy's three-dimensional is sampled vertically and horizontally. Discrete systems record one (first or last), two (first and last) or few return signals. Full waveform systems record return signals for a series of equal time intervals. Laser footprint details grow with the increase of the time intervals amount. Full waveform method allows to indicate a forest structure: top of the canopy and understory volume. Discrete return systems characterized by small footprint of 0,2 to 0,9 meters. (Lim et al., 2003) Waveform systems' footprint differs between 10 to 70 meters (Means, 1999). Full waveform systems with bigger footprints allow to gather information on forest canopy and multiple forest elements with discrete return systems that can record only a limited portion of forest elements (Lim et al., 2003). It should be, however, noted that both systems are capable to drive canopy height, which is used in definition of other forest parameters (Lefsky et al., 2001). Most commercial applications are discrete return systems due to the very large volume and complexity of full waveform data that severely increase processing time (Kelley and Tommaso, 2015).

Small-footprint discrete return sensors' ability to achieve multiple returns - "to penetrate beyond the first reflective surface of the canopy" is a crucial characteristic for forestry applications with the most LiDAR commercial systems achieving from two to five returns (Lim et al, 2003, pp. 93). The recordings form a three-dimensional point cloud that represents the vegetation and topography of the surveyed plot (Kelley and Tommaso, 2015).

Currently, small-footprint, discrete return laser scanners positioned on airplanes are the most commonly used LiDAR systems. Airborne laser scanning systems consist of four main components: a laser scanning unit, a global positioning system (GPS), an inertial measurement unit (IMU) and a computer to store data (Kelley and Tommaso, 2015). GPS supplies the coordinates of the laser source (plane) and the IMU the direction of laser pulse. The system is able to attain high vertical and horizontal accuracies with 15-20 centimeters Root-Mean-Squire (RMS) vertically and 20-30 centimeters horizontally. (Suárez et al., 2005) The RMS is usually acquired by comparison of the measured data against an absolute reference (Ussyshkin et al., 2007).   The onboard control computer functions is system set-up, monitoring, data recording and access to laser control, the GPS and IMU. The computers are located in separate compartment from the sensor and commonly constructed from VME or Ethernet based commercial hardware with a use of specifically made for the sensor software. Processing of LiDAR data constitutes extraction and geo-coding of the acquired by sensor data using proprietary software and classifying and analyzing the data with proprietary or third-party software. The processing of the data is executed on standard workstations. (Lim et al., 2003)

Large-scale forest inventory may be performed with small-footprint LiDAR data in the scale of individual trees and at the plot or stand scale. On the individual tree level LiDAR is able to delineate separate trees, which has been proven by Chen et al. (2006) for heterogeneous and complex forests and by Li et al. (2012) for mixed-conifer stands. On the plot or stand scale level regression between field data and LiDAR metrics derived from the point cloud such as height and height profiles and percentages is required with measures of uncertainty such as root-mean-squared error (RMSE) and "overall goodness-of-fit" measures such as correlation coefficient R2 (Kelley and Tommaso, 2015). Discrete return LiDAR on the plot level is capable to estimate many canopy structure metrics such as canopy height, canopy base height, canopy cover and basal area well (Jakbowski et al., 2013).

5.2. LiDAR use in forest management

It should be noted that there are several limitations of the method include the cost of the data, the shortage of common standards or the low amount of processing algorithms commercially available (Suárez et al., 2005). However, forest managers might reduce the cost of data by choosing appropriate for their purposes size of the surveyed plot and LiDAR pulse density. The accuracy of measurements are linked to the pulse density with higher pulse densities producing more accurate results. Higher pulse densities are achieved by repeated airplane flights, decrease in the flight altitude, the speed of the plane or by independent increase of pulse rate frequency (PRF) and scanning rate. The pulse density dependence on the flight time may increase significantly data acquisition costs. In general there are economies of scale with costs per hectare decreasing with an increase of surveyed plots areas size (Jabkowski et al., 2013)

Figure 8 illustrates a trade-off between data costs, coverage and pulse density.

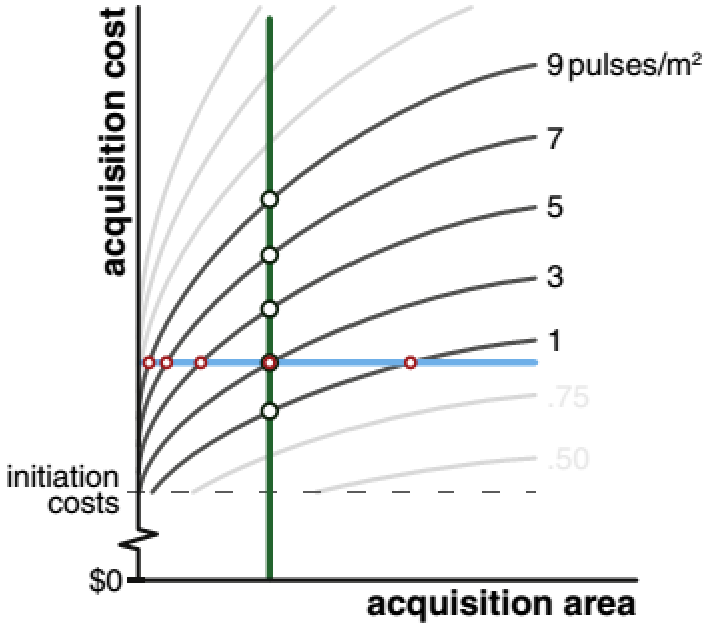

Figure 8. Trade-off between cost, data density and area surveyed (Jabkowski et al., 2013, pp. 246.)

The blue and green lines on Figure 8 represent decision ranges within a set budget or alternatively within a set forest plot to be inventoried. The blue horizontal line represents the range of decision choices for forest managers within a set budget to spend on forest inventory. The forest area inventoried within the set budget increases with a choice of a lower pulse density (less amount of flights). Vertical green line represents the range of decisions within a set plot to be surveyed. The data acquisition costs decrease with a choice of a lower pulse density. (Jabkowski et al., 2013)

Jabkowski et al. (2013) state in their study on relation of forest metrics accuracy to the pulse density within a topographically complex mixed-conifer forest stated that it is possible to obtain relatively reliable and accurate tree height (mean and max), total basal area, tree's diameter at breast height (DBH) (mean and max), and shrub height (less accurate) with pulse densities that decrease to 1 pulse/m^2. Metrics related to coverage: tree density, canopy cover, and shrub cover, and mean height to live crown base (HTLCB) require much higher pulse densities that are more than 1 pulse/m^2. It may be concluded that forest managers that have a constrained forest inventory budget may choose lower pulse densities and still obtain relatively reliable and accurate tree height (mean and max), total basal area, DBH (mean and max) with less accurate, but acceptable, shrub height. (Jabkowski et al., 2013)

It should be noted that the amount of forest inventory attributes that can be directly measured by LiDAR is limited. It is strongly recommended to use remotely sensed optical data such as, for example, aerial photography to increase the number of assessed inventory attributes, particularly vegetation types. (Wulder et al, 2008; Chen et. al, 2012)

On the other hand, there are several advantages to using LiDAR in forestry. Lidar performs better in terms of accuracy than other remote sensing systems for prediction of forest structural attributes such as mean tree height. There is a possibility of fully three-dimensional analyses of forest data acquired by LiDAR. (Suárez et al., 2005) Vertical forest structure information is the most valuable for forest managers due to it being used as a source for determination of other biophysical parameters such as, for example, volume and above ground biomass that are used for description of the function and productivity of forest ecosystems. (Lim et al., 2003; Dubayah and Drake, 2000) LiDAR is especially useful in the determination of economical and ecological forest variables such as forest biomass (Junttila et al., 2013).

LiDAR's capacity to produce detailed tree-level characterizations is well suited for a strategic level forest management where sustainability goals are considered. However, there is still a need for a provision of refined forest attributes that could effortlessly been used in the support of practical strategic forest decisions. (Wulder et al, 2008)

Usage of LiDAR forest inventory method is advisory especially in medium-scale operational inventory that comprises forest areas that have a size at most of million hectares. LiDAR's use on forest areas over one million hectares is not recommended due to the better benefit- cost ratio offered by satellite imagery based remote sensing methods that have lower costs and lesser accuracy compared to LiDAR. (Junttila et al., 2013) Additionally, LiDAR's accurate elevation data may result in related to road-building and harvest planning cost savings. LiDAR supplemented by current data acquisition approaches might provide greater value for forest managers. (Wulder et al., 2008)

5.3. Arbonaut Ltd

Arbonaut Ltd is the initiator of this study through the CONIFER network that has been created as a result of Finnish-Russian Forest Academy project. Arbonaut is a leading company in a development of software solutions for forest inventory and natural resource management with a base in Joensuu, Finland (Arbonaut, 2015a). The company provides integrative information solutions that incorporate all aspects of forest information collection and data management (Arbonaut, 2015b). Arbonaut has developed a proprietary software - ArboLiDAR, that is used for processing of obtained by LiDAR data on forest resources (Arbonaut, 2015b; Arbonaut, 2011).

ArboLiDAR is designed to process data obtained by small-footprint discrete return sensors (Minguet, A., 2015). ArboLiDAR incorporates a combination of LiDAR, CIR imagery, and GPS ground control plots with non-parametric estimation methods. The delineation of forest stands is done by combination of LiDAR and color infrared data to obtain a composite image of stand – defining layers. Segmentation of stands may be done based on the composite image using proprietary to Arbonaut segmentation tool. ArboLiDAR databases are designed to enable efficient forest management through the functions that allow to plan locations of felling sites based on defined by managers criteria. (Arbonaut, 2011)

6. RUSSIAN FORESTRY

6.1. Forests in Russia

Russia is a world leader in terms of forest area with 20, 1% of world total forest area. In terms of available timber volume Russia has 83 106 million meter3 and is in the second place after Brazil. In terms of timber felling Russia has forth position worldwide after USA, Brazil and Canada. (All-Russian Research Institute for Silviculture and Mechanization of Forestry (ARRISMF), 2013)

Russian forests are owned by the Russian Federation. Majority of Russian forests belongs to the forest fund (lesnoy fond), forests that do not belong to the forest fund account for less than 3 % and are either protected areas or belong to armed forces and municipalities. (Karvinen et al., 2011, p. 7) Figure 9 displays forest cover of Russia in %.

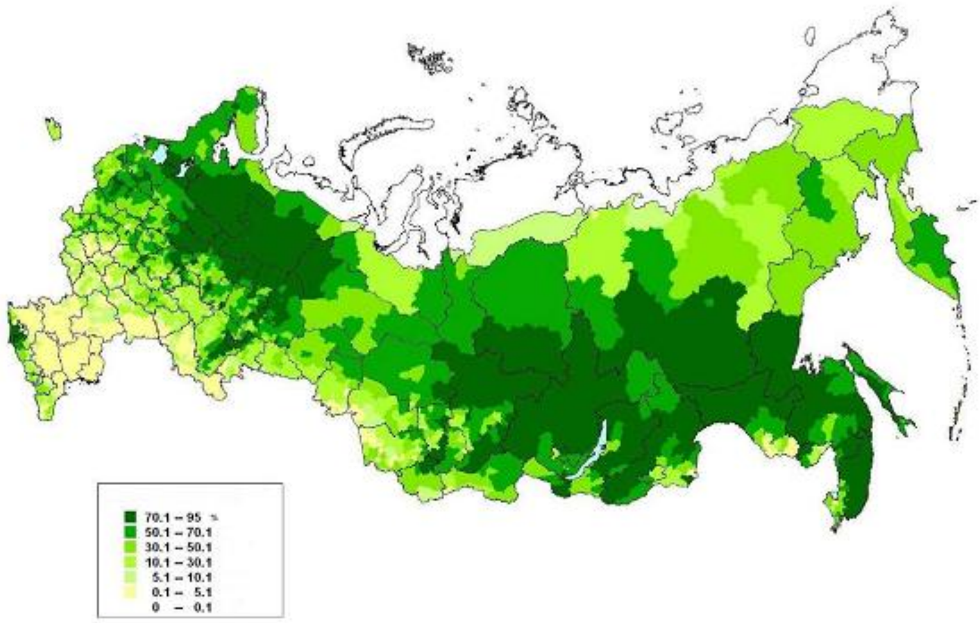

Figure 9. Forest cover of Russian Federation in % (ARRISMF, 2013, p. 9)

Russia's forests consist mostly of boreal forests (88%). Main forest-forming tree species are larch, pine, spruce, cedar, fir, birch and aspen. These tree species constitute over 98 % of forest land. Larch trees represent 35,8 %; pine constitutes 15,6 %; and birch represented by 15,0 % of forest land. In overall, tree species of the coniferous group account for 68,4 %. Distribution of forest – forming tree species is shown in Figure 10. (ARRISMF, 2013)

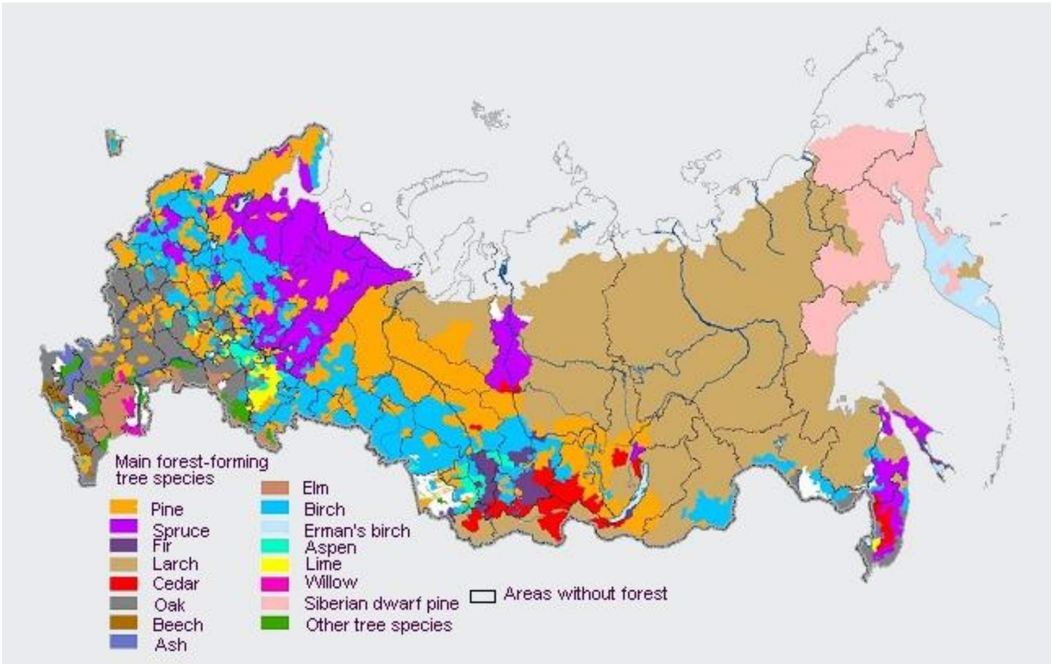

Figure 10. Distribution of forest-forming tree species in Russian Federation (ARRISMF, 2013, p. 11)

6.2. Government forest management in Russia

There are two levels of government management of forests in Russia: federal and regional. The main decision making powers concerning the use, protection and regeneration of forests are given to federal subjects of Russia or regional level. (ARRISMF, 2013, p.27) Utilization of forests is regulated by the Forest Code (Karvinen et al., 2011, p. 7).

Federal level of government management is mainly responsible for developing government politics, policymaking, legal regulations, control of federal subjects decision making, forest plots registers support, government inventory of forests and forest fire protection (ARRISMF, 2013, p.28).

Tasks of Ministry of Natural Resourses and Environment of The Russian Federation are in legislation (State Council of Russian Federation, 2013). The Federal Forestry Agency (Federalnoye agenstvo lesnogo khozyaistva), shortly “Rosleskhoz” works directly with executive authorities of the subjects of Russian federation. (ARRISMF, 2013, p.28) Figure 11 shows government structure at federal level.

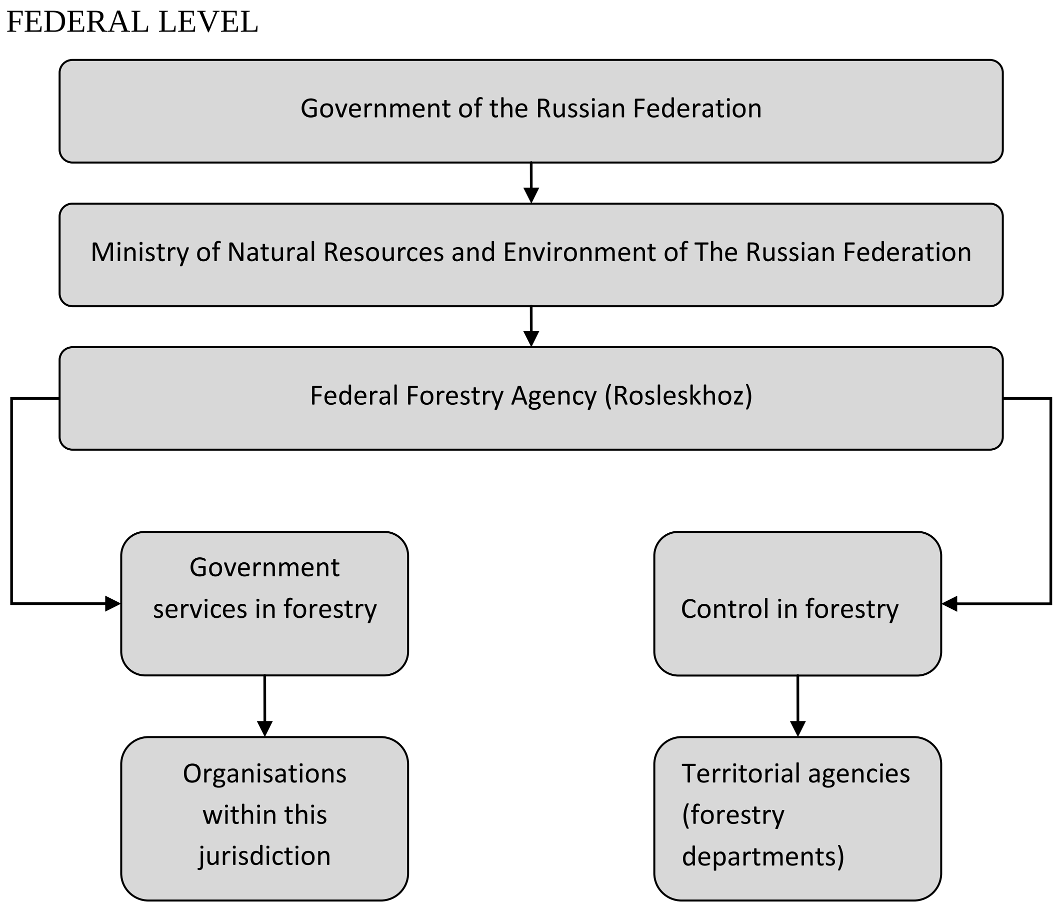

Figure 11. Forestry federal level management structure in the Russian Federation (State Council of Russian Federation, 2013)

After new Forest Code was introduced in 2006 giving Federal Subjects more functions to manage forests, each Federal Subject has set own set of forest management institutions. As a result regional level of forest government differ in various Federal Subjects with some of them having executive agencies in forestry as a part of different regional government structures that may regulate ecology, nature management and environment protection, agriculture and energy. In others Federal Subjects executive agencies in forestry are independent and may have different names such as ministries of forestry, forestry departments, forestry committees, forestry administration and even government forest service. (State Council of Russian Federation, 2013)

Figure 12 shows general government forest management structure at regional level without indication of executing agencies names.

REGIONAL LEVEL

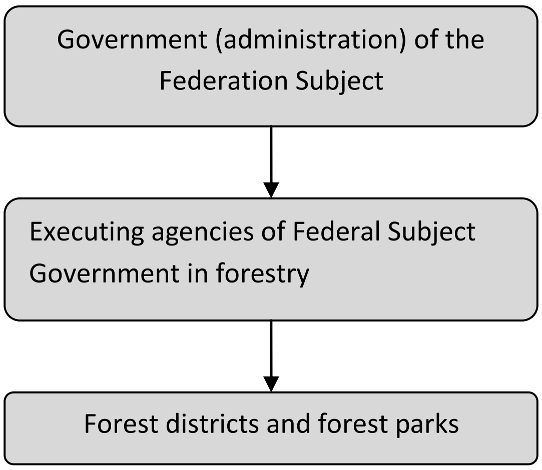

Figure 12. Forestry regional level management structure in the Russian Federation (adapted from State Council of Russian Federation, 2013)

Forest districts and forest parks are the main territorial management units for forest use, protection and reproduction. Presently there are 1468 forest districts and parks in Russia, these territorial units are further divided into 7379 smaller forest rangers. (ARRISMF, 2013) Forest districts functions vary in different Federal Subjects of Russian Federation. The main difference is the level of day-to-day control of forestry operations and the measures to ensure forest protection. (State Council of Russian Federation, 2013) Utilization of forests is regulated by the Forest Code (Karvinen et al., 2011, p. 7).

6.3. Forest management planning

Forest management planning is the base for the use of forests and is needed to provide sustainable development of forests. There is multilevel system on forest management planning in Russian federation (ARRISMF, 2013, p. 29).

There are three main planes in Russian forest management: forest plan (lesnoy plan) and forest districts' silvicultural regulations (lesohozjaistvenny reglament), are composed by the Federal Subject parties; forest management plan is composed by forest lessee. The planes are made for ten years period. (ARRISMF, 2013, p. 30)

Forest plan is made for all the Federal Subjects of Russian Federation and holds general guidelines on the use, protection and regeneration of forests as well as information on transport infrastructure and zoning (ARRISMF, 2013, p. 30). The plane is composed by a third party, chosen by regional highest authority, and is based on existing forest management planning and inventory data (Karvinen et al., 2011, p. 13). Forest plan determines the Federal Subject forest management expenditures (ARRISMF, 2013, p. 30). This plan sets objectives and indicators for silvicultural regulation (lesohozjaistvenny reglament) (Karvinen et al., 2011, p. 13).

Silvicultural regulation is based on the forest districts' and forest parks' forest management materials and it further sets forest usage volumes and restrictions to the composed by leaseholder forest management plan (proyekt osvoyeniya lesov) (Karvinen et al., 2011, p. 13). The plan defines the main parameters and limitations of forest usage, as well as forest protection and regeneration requirements to forest leasers within the limits of concrete forest district (ARRISMF, 2013, p. 30). Forest plan and silvicultural regulations are composed by private companies (Karvinen et al., 2011, p. 13).

Forest management plan, made by a leaseholder, is based on the forest leasing contract, silvicultural regulations, forest register and territorial planning documents. The plan consists of information on the leased wood plot, organization of forest usage as well as planned forest protection and forest regeneration activities. (ARRISMF, 2013, p. 30)

Forest management plan is a base for forest declaration (lesnaya deklaratsiya), that is leaseholder’s final operative plan for the next year (Karvinen et al., 2011, p. 13). Earlier described system of Russian forest management planning is shown on the next Figure 13.

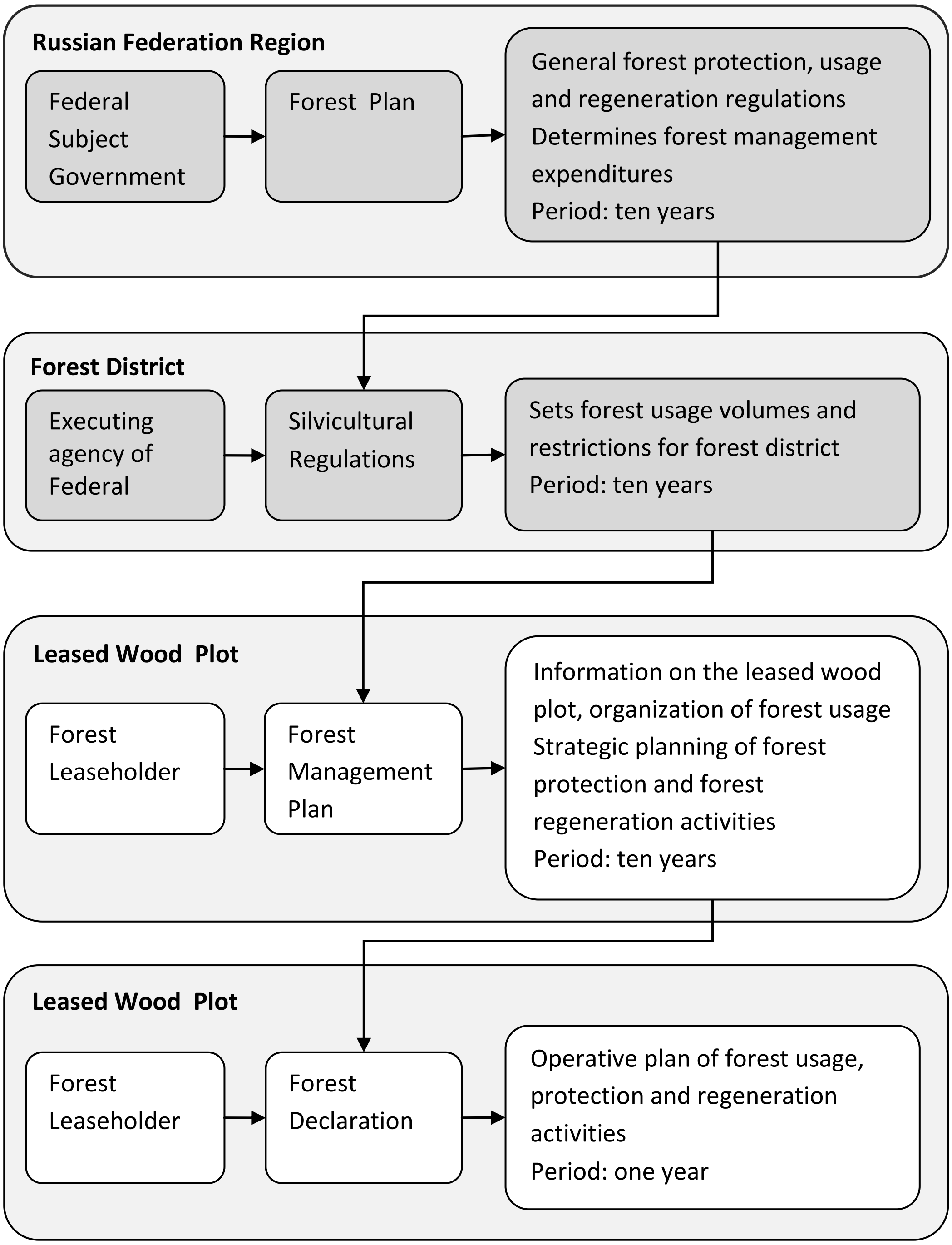

Figure 13. Russian forest management planning system

6.4. Forest inventory in Russia

Federal Forestry Agency provides government services in forest inventory through subordinated state company – Roslesinforg that is responsible for execution of National Forest Inventory (NFI). Forest leaseholders contribute to the assessment of forest resources trough the production of Forest Management Plans. National Forest Inventory is focused on provision of forest information on national level, while Forest Management Plan supply with more detailed information on forest resources of leased forest areas. (Karvinen et al., 2011)

Data on forest resources is placed to Forest Resource Register (gosudarstvenny lesnoy reestr), which accommodates official statistics of Russian forests. Forest Resource Register is managed by Roslesinforg, which put there two sets of data on national, regional and local level. National forest inventory data is attained though NFI. Regional authorities gather data from local forest districts and send it to Roslesinforg that input it to the register. Local forest district get forest inventory data partly by themselves and partly through forest leasers. (Karvinen et al., 2011) Local forest districts ensure also government control function of the forest use by gathering information on forest use infringements and sending it further to regional and federal authorities (Roslesinforg, 2013).

6.4.1. National Forest Inventory (Inventarizatsiya)

NFI includes several types of measures: remote monitoring of forests; determination of forest state; valuation of measures directed to forest protection, reproduction, and use; forming of federal information resources. Valuation of measures directed to forest protection, reproduction, and use is executed annually by no less than 10% of forest districts predominantly by field assessments. Forest districts are rotated though years.   Remote monitoring of forests is done annually by Roslesinforg as well as determination of forest state and forming federal information resources. Determination of forest state, its quantity and quality characteristics, is done by combination of field and remote inventory methods. (Roslesinforg, 2013)

According to the Government Program of Russian Federation “Forestry development 2013-2020” a share of remote monitoring, executed as a part of NFI, of leased forests should grow from 63 % in 2010 to 89 % in 2020. There is definitely a need for promotion of faster remote sensing inventory methods due to amount of outdated forest inventory information. According to the Government Program of Russian Federation “Forestry development 2013-2020” currently 70% of forest assessment is more than recommended 10 years old with 3 million hectares not assessed at all.

6.4.2. Local Forest Inventory (Taksatsiya)

Composition of Forest Management Plan does not demand from forest leaseholders to update forest inventory information, as it may be prepared using old forest inventory data. This fact may influence the quality of Forest Management Plan. Forest users have an option of Forest Management Plan based on up-to-date information. According to the Forest Code assessment of forest resources that may be included to Forest Management Plan may be executed by any organization that provides forest inventory services. Several companies offer forest inventory and planning services, Roslesinforg competes with them on the market of forest inventory planning services. (Karvinen et al., 2011)

Forest Management Instruction (Lesoustroitelnaya instruktsiya) is a document that in accordance with the Forest Code defines forest management practices. Forest Inventory information that is declared in Forest Management Plan must be acquired in accordance with forest inventory methods that are stated in the instruction. Forest Management Instruction (2011) asserts four main methods of forest inventory: ocular estimation, field measurements, remote sensing and data updating. All forest inventory methods have specific methodologies that must be followed. Remote sensing is limited only to the use of aerial and satellite images in accordance with Appendix 9 of Forest Management Instruction (2011).

7. EMPIRICAL STUDY

7.1. Data collection

Semi-structured interviews were the most valuable source of primary data providing insights to Russian forestry. The process of obtaining agreement to interviews began with a sending of invitations to each of possible respondent organizations with none responding to them. The next step was to phone the organizations with a request for the interview. There were considerable difficulties in getting firms to cooperate as there are strong trust issues that influence the decision to participate. Finnish-Russian Forest Academy project manager – Anu Honkanen has assisted greatly in getting first three respondents to participate. Additionally, ten organizations agreed to participate in the research with four agreeing to response only in a written form.

In overall, six interviews have been conducted in working environments of respondents with two interviews from the same enterprise, but from different organizations within it. Additionally, three interviews have been executed by phone and four in written form with the interview guide sent by e-mail. From the group of respondents nine were forest leaseholders and therefore primary users of forest inventory information, two companies were private inventory organizations and two has represented government forest inventory company and government forest inventory information investor.

Forest leaseholders were companies from Vologda, Arkhangelsk, Karelia and Leningrad region, six companies' main activity was timber harvesting, two enterprises were big pulp and paper enterprises, one firm's activity was construction of wood buildings. Two private inventory companies had North-West as a region of their business that consisted in information services to forest leaseholders, they make a competition to Roslesinforg that provides these services as well and has participated in the research. Federal Forestry Agency influences and controls the choice of forest inventory methods used by Roslesinforg and therefore was included into the list of respondents. There were attempts to contact region government executing agency which agreed to the interview, however the manager that was suggested to have interview with was an employee of Roslesinforg, therefore the interview has not been conducted due to the earlier interview with Roslesinforg that took place.

Interviews were scheduled over a period of three months and were executed as semi-structured with an interview guide to make the interview easier to lead.

7.2. Interview guide

The interview guide has included three parts. In order to get deeper insights to the problem questions were open-ended with the exception of couple of questions in the first part. The first part was introductory, in this part questions related to the company size were asked to relate it later into the analyses with companies goals, their ability and willingness to achieve these goals. The second part constituted questions related to desired product or service attributes; attribute-based and consequence-based satisfaction. The third part was concerned with customer goals and purposes.

There were two questions in second and third parts on cooperation in order to relate them later to value co-creation. Questions about a decision maker role in the company and about the forest inventory method chosen were done in order to relate them later with a notion of how information needs are satisfied in the company. The second and third parts of interview guide were constructed based on Woodruff (1997) customer value hierarchy. Desired product attributes were operationalised using Lee et al. (2001) information quality (IQ) dimensions. Due to LiDAR's strength lying in provision of accurate and reliable data faster than traditional forest inventory methods, questions based on Free of Error IQ and Timeliness IQ were asked. Four questions to assist in definition of to use situation were asked as well. One additional question was linked to LiDAR possible usage in Russian Forestry. Woodruff's (1997) desired consequences and desired goals were applied to the research through sustainability notion, taking into account only economic and ecologic dimensions of sustainability.

The notion of sustainability aroused from analyses of LiDAR strength that in addition to accuracy and speed constituted the scope of information that may provide invaluable tools for sustainable forest management. To assess the level of Russian forest management, it's affinity to sustainability; questions related to sustainability were on purpose not specific in order to attain Russian forest management understanding of sustainability.

Interview guide was modified for government and private forest inventory companies, due to the many questions directed specifically to forest leaseholders. These specific questions were removed from the interviews.

7.3. Interviewed companies

Two private forest inventory companies has participated in the research, the companies were small in size and had a large geographical area of operations. The companies were LLC Research And Production Center "Lesnoe Delo" and LLC "Orbita Les Servis". The information on private inventory company companies' managers is limited as well.

Interviews of government and forest leaseholders have proved to be a reach source of information. Government organizations Rosleshoz and Roslesinforg are large with a high level of technical knowledge on forest inventory. Interviewed there managers had many years of experience and considerable knowledge of the subject and gave valuable insights on Russian forest inventory.

All interviewed leaseholders had long-term lease contracts with the lease term being 49 years. Only two companies had also lease contracts for shorter lease terms. All companies leased forest area was more than fifty thousand hectares, with seven organizations' areas being more than one hundred thousand hectares.

Four companies had annual forest harvesting of more than one million cubic meters, one company had annual forest harvesting of more the one hundred, another considerably less and data for three other companies concerning annual forest harvesting is unavailable. Four companies had access to foreign markets and five were supplying local Russian market. Five companies had different degrees of foreign ownership, two – Russian and two have not disclosed this information. The managers of interviewed companies were managers with many years of experience and technical knowledge of forest inventory processes.

The information on interviewed leaseholders is compiled to Table 4 on the next page. The area of leased forestland is given in thousand hectares. Two metrics are presented to indicate company's size: annual harvest in thousand cubic meters and number of employees in the interviewed company. It should be noted that, at first only number of employees metric was planned to indicate the size of the company, however during the course of interviews it has been understood that annual harvest can much better illustrate the scale of operations due to a high degree of outsourcing in the companies with a foreign capital. During two of the interviews the questions on the size of leased forest land and questions related to company size were not answered, instead it was advised to take this numeric information from the companies' websites; references to companies websites are provided in the table.

Table 4. Interviewed forest leaseholders

Participant organization	**Region**	**Organization's Business**	**Lease Term**	**Leased Forestland** (ths. ha)	**Company size** Annual harvest Employees (empl.)	**Customers**	**Ownership**
The Holding company "Cherepovetsles"	Vologda	Timber harvesting, timber processing	49	> 550 (Cherepovetsles 2015b)	1 200 ths m^3 (Cherepovetsles 2015b) 1023 empl.	Russia, Europe, China, Afrika (Cherepovetsles 2015a)	no available information
OJSC "Ilim Group"	Arkhangelsk Irkutsk	All cycle from forest regeneration till pulp and paper	49	5 700	≈ 9 000 ths m^3 ≈ 20 000 empl.	China, Europe, Russia	50% Russia 50% Foreign
LLC "Metsa Forest Podporozhye"	Leningrad	Timber harvesting and procurement	49	≈270	≈ 150 tha m^3 ≈250 empl.	Russia	100% Foreign
LLC "Nikolsk Forest "	Vologda	Timber harvesting, sawn wood production, construction	49	50-100	50-500 empl.	Russia	100% Russia
"Novatorsky LPK", PJSC	Vologda	Construction of wood buildings	49	50-100	50-500 empl.	Russia	Russian and Foreign
Stora Enso Ladenso	Karelia	Timber harvesting	49 25	150	4-4,5 ths m^3 < 50 empl.	Russia,Finland	Foreign 98 %

Participant organization	**Region**	**Organization's Business**	**Lease Term**	**Leased Forestland** (ths. ha)	**Company size** Annual harvest Employees	**Customers**	**Ownership**
LLC "Titan Group"	Arkhangelsk	Timber harvesting, sawn wood production	49	no available information	1 500 ths. m^3 (Titangroup, 2011) >1000 empl.	Russia	Russian
"Ust-Pokshensky" logging enterprise (LLC "Titan Group")	Arkhangelsk	Timber harvesting	49	> 100	350 empl.	Russia	Russian
Big logging company	Vologda	Timber harvesting, sawn wood, consulting	15-49	> 100	≈1 250 ths. m^3; >1000 empl.	Russia Europe	no available information

8. RESULTS

It should be noted that the answers of interviewed managers reflect in part forest management planning in their organizations and on other part reflect their opinion on the level of forest management planning in Russian forestry as a whole. Results incorporate forest mostly forest leaseholders' and government organizations' opinions with lesser influence of private inventory companies due to more general and shorter answers. The most amount of information is obtained from semi-structured interviews, while information gained from interview guides is of lesser amount and quality. Semi-structured interviews have proved to be a very good source of information. The questions in the interview guide have guided the interviews; furthermore some respondents have extensively elaborated on the most important characteristics and limitations of Russian forest management planning and therefore have provided invaluable expert opinions on the matter.

The interviews were analyzed according to theoretical themes that were constructed based on operationalised to forestry Woodruff (1997) customer value hierarchy model. Opinions that were repeated in most of interviews and/or were sufficiently supported have been included to the separate theme. Finally, results were grouped according to four based on the theory themes and one theme that has emerged during analyses.

Results regarding to value co-creation (8.1.) are based on value co-creation theme (Appendix 3) which has grounds in Grönroos (2011) service perspective on value-in-use. The concept is instrumental for understanding how customer desired value may be translated into the actual delivery of this value to the customer. Value co-creation was chosen as means of value-in-use delivery to the customer and therefore has begun a theoretical base for strategic recommendations. Therefore it was important to get knowledge of possible value co-creation that already exists between organizations in Russian forest inventory.

Results regarding Russian forestry environment (8.2) are based on Russian forestry environment theme which has emerged during the course of analyses and includes codes related to Russian forest, Russian forest management and Russian government. The theme is important in assuring validity of the study with the data confirming the information presented in Russian forestry chapter. Furthermore, the knowledge of environment is necessary for making strategic recommendations.

Results regarding information quality criteria (8.3.) are based on Woodruff (1997) desired/non-desired product or service attributes (Appendix 3), which are operationalised using Lee et al. (2002) IQ attributes. The theme is needed for a determination of information attributes which are considered by Russian forest managers during a forest inventory selection. The relative importance of different attributes explains what managers value in forest inventory technology and therefore influence the final choice of the technology. It should be noted that from the wide range of possible attributes only three attributes have emerged during the interviews. These attributes are the most important criteria of forest inventory choice in terms of information quality.

Results regarding the use of information in Russian forestry (8.4.) are based on the use situation theme (Appendix 3). The theme has emerged from Woodruff (1997) customer value hierarchy theory where it is stressed that desired customer value is determined in concrete use situations. Understanding of what information is needed in Russian forest management and for what purposes, how forest inventory information is used, what methods are currently in use and the opinion of managers on LiDAR possible use as a forest inventory is needed for the definition of strategic directions to attract customers.

Results regarding sustainability goals in Russian forest inventory (8.5.) are based on customer's goals and purposes theme based on Woodruff 's (1997) theory and reflects the crucial issues of how long-term are forest managers' goals. The planning time period is important to take into account considering the fact that one of the most significant advantages of LiDAR technology is the ability to get a wider then usual range of forest metrics with a part of the metrics necessary for short-term forest management planning and part of the metrics that may be used in planning of long-term forest sustainable management. The ability of LiDAR to obtain these additional metrics necessary for the long-term sustainability planning (taking into account ecologic and economic aspects of sustainability) may be an additional advantage in competing with other forest inventory technologies. Therefore, it is essential to understand the current level of forest management level in Russia in regards to the time frame of forest management planning.

8. 1. Results regarding value co-creation

Value co-creation with government is extremely rare. Just one non-government company from the respondents stated that there was cooperation with government forest inventory company - Roslesinforg on inventory execution in form of co-financing to get the information faster. Documentation on information was attained only after seven years even with the existence of this cooperation. Government finances own forest inventory program with inventory done every ten years, however the program cannot cover in time all forest areas resulting substantial delays that are counted in years and therefore less-accurate information on forest resources.

8.2. Results regarding Russian forestry environment

Russian forest

In Russia there are ten times bigger units of forest planning than, for example, in Finland and forest is heterogeneous. Inventory variables differ significantly in Russian forest; there is a high variety of tree species.

According to Russian forest managers forest stands in Russia are bigger and even if they are divided to smaller plots of 2-3 hectares there are difficulties in identification of borders between these homogenous parts of the forest. There is a forest mosaic (tree species and height, diameter - especially in spruce forest) within each small plot resulting in difficulties in forest assessment by remote sensing method with spatial variability being a big issue.

Forest management

Forest management scale is bigger in Russia, unit of planning is bigger. Activities that are deemed to be non-critical are outsourced in bigger forest leaseholders with a foreign capital. It should be noted that the outsourcing is a tendency, with a lower degree of outsourcing in other companies that have foreign capital. Main processes that are concerned with forest management planning such as road planning and control are done in-house. Russian forest leaseholders with wholly Russian capital tend to do most of the activities in-house.

When a company makes lease contract, it is responsible to compose forest management plan in which forest procedures are included, that are done according to forest legislation. From all leased stands leaseholder chooses felling sites of this year, next year, next ten years. This may be done blindfolded, using official forest inventory materials – engineer makes division of felling sites after that employee in field defines felling site borders, calculates volume, and compiles forest inventory description that will be a base for forest declaration.

Government

Regional Roslesinforg branches execute inventories for government and for business. Government forest inventory is done exclusively by Roslesinforg in accordance with a contract that is made between Roslesinforg and executing agency of Federal Subject (name depends on the region e.g. ministry, committee). Business forest inventory may be executed by any organization in accordance with a contract between a forest inventory company and a forest leaseholder.

There is a lack of trust between forest business and government due to different goals and different planning terms, e.g. short-term, long-term.

8.3. Results regarding information quality criteria

State of information in terms of TimelinessIQ (up-to-date)

There is freely available government forest inventory information of various timeliness that serves as a base for forest declaration and forest management plan. The timeliness of information is ideally ten years, however in many areas information is not up-to-date and may be twenty years old. The information updating forest method of inventory is documentation based and is needed only for formalities. In order to get up-to-date information business may buy forest inventory acquisition from Roslesinforg, that has almost monopoly place in the market, or its competitors. There are delays in forest information acquisition by government; in some regions this information may be not up-dated by actual inventory methods for 20-30 years.

Businesses that have long-term sustainability goals need up-to-date information on young forest stands. Forest inventory attribute of the most significance for these companies are height, stand density and location relative to roads, the most important density and tree species composition and degree of spatial variability. Identification of the most potentially commercially valuable young stands in terms of tree species composition and variability needs to be done in time in order to avoid costs that arise from the thinning of overgrown trees.

Additionally, forest information for operational forest management needed annually with the need for information needed to compose forest management plan once in ten years. It should be noted that there is no requirement to use for the plan information obtained by actual forest inventory method with the possibility of “up-dated” (aktualisatisya) forest information use.

State of information in terms of AccuracyIQ

Financial resources on hectare are smaller than in Finland, as a result information details are lower. Forest management uses lower quality of information for forest planning. Government is short of financial and human resources to provide more accurate information. Government may not be interested in more accurate information due to the threat that accurate information might illuminate mistakes that were done by government forest management.

According to forest managers a high volume of mature forest does not demand very accurate information due to the abundance of commercial forest. When there are many felling sites forest inventory information mistakes will be compensated, therefore an average error of less than 20% is not influencing their business significantly. This managerial opinion on information accuracy insignificance for large mature stands is in contradiction with Holmstrom et al. (2003) findings that constituted special importance of information accuracy in large mature stands in term of costs that rise from decision making based on less accurate information.

According to forest managers' accuracy improves with the smaller size of the forest unit from where information is acquired, however the smaller unit means also additional costs of information acquisition, which are deemed to be not justified comparing to the benefits more accurate information brings. Accurate forest inventory methods may be beneficial in identification of objects locations by generation of relief maps.

Another notion stated by managers is that in Russia there are areas of mature forest that may be the size of thousand hectares, therefore in these areas information accuracy is not important, it will not significantly affect operations. Forest information tolerated error is 10% (RMSE); 20% (RMSE) is not acceptable for total growing stock. Businesses with long-term goals need more accurate information.

State of information in terms of ReliabilityIQ

There is a discrepancy between documented and factual values of total growing stock. Factual value may be higher than documented therefore making a part of forest resources not accounted. Big forest leaseholders with a foreign capital may not exploit this flow in the system, however smaller leaseholders with limited financial resources may use the flow making acquisition or reliable and accurate information not to be in their interests. Forest fund information on forest resources is not reliable. May be big differences between what tree species in official government documents and tree species that in reality grow. Government tries to solve the problem of forest inventory information reliability through legislation that would control forest turnover, not through acquisition of accurate information.

There is a contradiction of official forest inventory information on forest resources to actual forest resources state. There is a contradiction in situation of main geographical objects such as roads, streams e.g., forest compartments borders. The right identification of borders is important due to forest compartment being a unit of forest land that forms basis for forest operations: such as planting, logging, road construction. All forest planning operations such as felling sites border definition, road construction are done in accordance with forest compartments; therefore the reliable information on the borders is important.

Official forest inventory information on forest compartments may be not reliable due to the fact that outdated information was transferred over and over again from one document to another. Government controls forest use applying this often non-reliable forest compartments information to assessment of felling sites assigned by forest leaseholder. Accurate information acquired by a new for Russia forest inventory method may define forest compartments differently. The usage of this up-dated information may cause problems with government officials, demanding co-operation before the usage of information with forest districts authorities or discard of new information on forest compartments.

The biggest discrepancy of information – tree species discrepancy due to the fact that amount of conifer forest is an indicator of government forest management success and the death of these species is therefore not reported as well as the fact that their value as a commercial timber is decreased due to other tree species such as aspen growing over (aspen grows much faster – forest needs to be treated periodically).

8.4. Results regarding the use of information in Russian forestry

Method to acquire information

Government uses own based on aerial and satellite images forest inventory technology and field inventory. There is a considerable effort to develop further based on aerial images forest inventory technology in order to improve accuracy of forest inventory information. The technology has improved, however can not detect trees undergrowth.

Business generally uses official forest inventory information and own field (on-site) forest inventory. Official forest information consists of remote sensing methods (aerial and satellite images), field inventory and up-dating of information (aktualizatsiya).

Businesses may buy information acquisition that should be executed in accordance with methods identified in Forest Management Instruction (Lesoustroitelnaya instruktsiya) in order for information to have a legal status and therefore allowed to be used in the forest management plan. Information obtained by non-approved by government forest inventory methods may be used only internally.

The main method to acquire information is field inventory (ocular-measuring method). Satellite imaginary is the most used method after the field inventory in private forestry. Satellite images may be of varied quality with a use of commercial and open-source satellite imaginary. New forest inventory methods based on GPS are coming to usage but are not yet used in a big scale.

Forest inventory information use

Forest inventory materials form a base for the forest management plan and forest declaration; however it is less valuable on operational level of forest planning.
Government forest inventory documentation is used for reporting and for forest management planning to plan felling sites. Forest inventory information is used as

a support for decisions on forest treatments and road construction. Information needs are determined by the need for certain tree species.

Forest inventory information is needed to compose a forest management plan that is required by forest lease contract. In operational forest management the choice of felling sites may be done based on official forest inventory government documentation that may include outdated information. The outdated information causes substantial field work to identify felling sites. New forest inventory methods may be used to decrease field work, the benefits should outweigh field work costs.

In operational forest management planning information is used to limit potential forest areas to the most valuable in terms of age and tree species composition without loss of time and financial resources on less-valuable forest areas.

LiDAR possible usage in an organization or in the market

According to the most of responded forest manager LiDAR use for forest management planning may not be suitable due to the high price of acquired by this method information that may be currently used only internally. The use of the method should offer substantial benefits in forest management operational planning. High accuracy is not needed in operational planning for the next year felling sites. Government is focused on development of own more accurate forest inventory technology and will to contemplate substitute of the technology to LiDAR.

Needed information in forest management

It is important to know for Russian forest managers if there is spruce under aspen or not, to see spruce understory layer. Differentiation of birch from aspen on all stages of forest development is another information need. These information needs it is difficult to fulfill with aero and satellite images. Information needs differ according to the organization goals, with higher information needs for organizations that have strategic long-term sustainability goals. Organizations with long-term economic sustainability goals need information to efficiently plan forest treatments. The information needs in this case differ in accordance with forest age. The needed information in young forest stands are height, density, tree density, spatial structure. Information needed for middle-aged forest stands is total growing stock, density, diameter of amplitudes with smaller amplitude being a preference, in mature stands - spatial variability and understory layer with the identification of under layer conifer tree species.

8.5. Results regarding sustainability goals

Russian government states long-term sustainable development of forest to be a priority and notices that the goals of the business may differ.

Currently, there are short-term economic goals of Russian business, no concern for long-term ecologic or economic sustainability. Russian forest management is characterized by really short term forest management planning -1-2, maximum 5 years despite the fact that only long-term planning (50 years minimum) may ensure efficient use of resources for different economic and ecologic goals. Forest management investments to ensure biomass growth – good productivity of forest - are seen generally as expenditures due to short-term forest management planning, which results in low investments and low productivity of forest.

In general, there are investments on roads construction, but no investments to forest regeneration as they are seen only as expenditure due to short-term planning. Road planning is done mostly based on short-term goals to attain maximum timber yield for the next few years. Bigger leaseholders that have foreign capital strive to plan road construction in accordance with long-term goals of sustainable timber yield. Forest treatments are often executed formally as a necessity due to government demands that come from government official sustainable forest management goals. Only some companies see these treatments as an investment to attain sustainable timber yield.

One of Russian government goals in forestry is to ensure sustainable forest management, however concrete actions done by business are not encouraged due to bureaucracy reasons. Business initiatives to exclude certain forest areas to protect biodiversity of forest are not supported due to the government official difficulties in making changes to the records of forest fund.

All of the forest leaseholders are required by government to do forest planting with them complying with the requirements at least on paper. All of the respondents of this research actually comply to these requirements with one of the respondents substantially investing to forest planting.

In summary it may be said that Russian forest management planning is done generally on operational level with the planning period of at most of five years, as a result only short-term goals of ensuring temporal timber supply are considered. Only some bigger companies, usually with foreign capital, have planning also on tactical and strategic levels with long-term goals to ensure sustainable timber supply, biodiversity is considered rarely. Government as an owner of forests is interested in sustainable development of forests; however internal problems originated in Soviet Union system of forest inventory are still present.

9. DISCUSSION AND CONCLUSIONS

9.1. Key findings

Russian forest inventory information needs differ according to the goals set by the management. Businesses with long-term goals, usually bigger companies with foreign capital, have higher information needs. Accurate, reliable and up-to date information is more appreciated by this type of business comparing with businesses that have only short-term goals. In general, the businesses do not strive for the most accurate or reliable information stating that the degree of accuracy and reliability should be decided based on benefits to costs ratio. Only costs associated with the purchase of information are generally taken into account, costs that are a result of decisions based on inaccurate information are generally not accounted. There was no mention of tools that would calculate these costs.

The next two figures are simplifications of the main issues that form attitudes towards accuracy of information in forestry and simplification of forest managers needs. Figure 14 illustrates the main issues that form attitudes towards accuracy of information in forestry. The meaning of symbols : "-" the source of negative attitudes; "+" the source of positive attitudes.

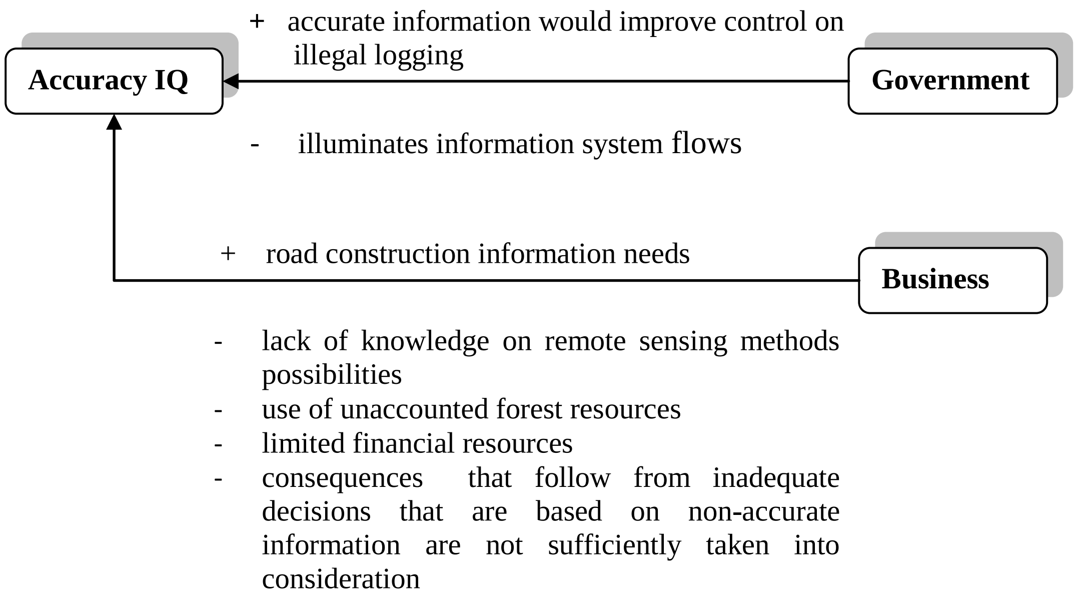

Figure 14. Attitudes towards accuracy of information in forestry

The next Figure 15 shows information needs of Russian forest leaseholders.

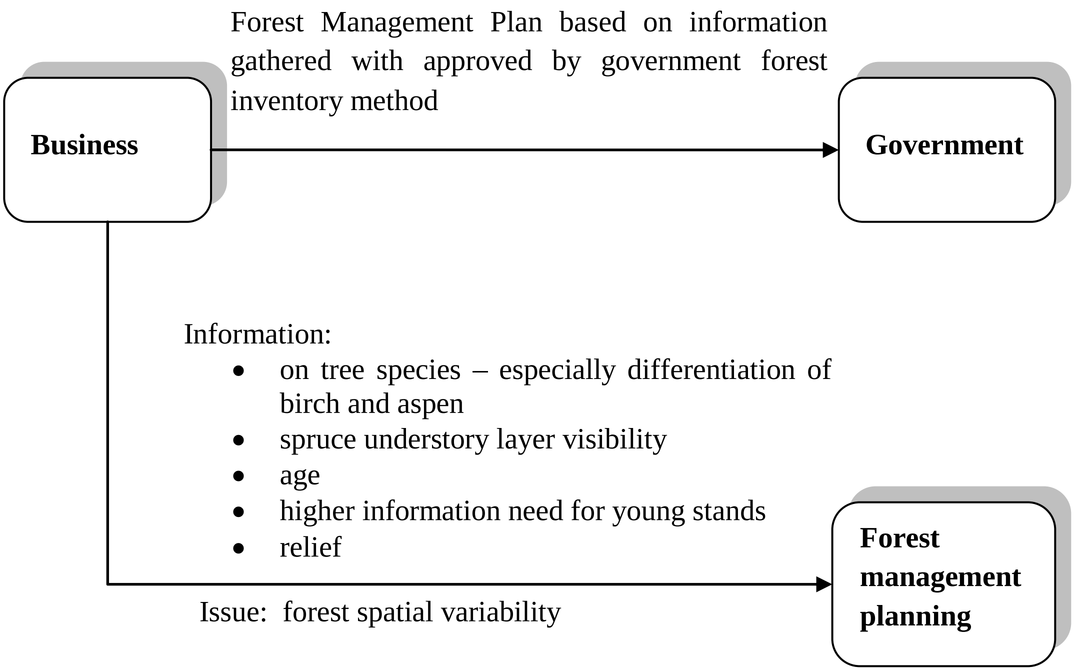

Figure 15. Information needs of Russian forest leaseholders

Business with short-term goals is concerned only with temporal timber yield to satisfy current needs. These companies are generally not interested in more accurate and reliable information provided by state-of –the-art forest inventory methods such as LiDAR. Government has long-term goals of sustainable forest development and may be interested in more accurate and reliable methods. Currently Russian forest inventory company Roslesinforg is actively improving aerial images remote sensing method to be more accurate and reliable, however the method is not capable to "see" undergrowth which is possible to do with LiDAR. Private forest inventory companies are small players on the market of forest information and have little influence on the decisions of forest leaseholders.

The main question of the thesis was "How to enhance LiDAR forest inventory method value in Russia?" with several sub questions to assist in answering it. These questions were: (1) How forest information users choose certain inventory methods for the inventory of forest in North-West Russia?; (2) What value criteria forest inventory information users have? and (3) Who would benefit the most from the LiDAR inventory method?

These sub questions are addressed in the next paragraphs with the answer to the main question following.

Forest managers typically need forest inventory to serve as a base for a composition of a forest management plan which determines forest usage volumes and restrictions set by government for the forest leaseholders. The period of forest managers' decision making on the composition of a forest management plan is crucial for the choice of forest inventory method.

Forest inventory methods are selected in accordance with the level of forest management planning that dictates the level of goals – short-term or long-term goals. This explanation is in line with Woodruff (1997) customer value hierarchy with the most abstract goals level of hierarchy influencing the total value that customer perceives in product or service. The consequences level is tightly interlined with the goals level. However consequences of the product or service use are not fully considered by Russian managers, therefore this component of value is missing in Russian context.

Attributes are considered in relation to the goals with accuracy, reliability and timeliness information quality attributes are of different value for businesses with long-term and short term goals. These attributes are of bigger value for companies with long-term goals which in forestry context means economic and ecologic sustainability. The businesses that strive to achieve sustainability are concerned more with economic aspect of sustainability which may be translated as a sustainable timber yield.

The main value criteria to choose a forest inventory method is benefits to costs ratio for companies with long-term goals and price for companies with short-term goals. The companies with long-term goals would benefit the most from LiDAR forest inventory method due to the quality and scope of information it provides that may be used for operational, tactical and strategic forest management planning. Forest age should be taken into account when defining potential LiDAR forest method users. According to Eid (2000) economic losses for maturing stands are substantially higher than in over mature stands. Forest leaseholders with a high degree of maturing stands may benefit the most from the use of LiDAR technology in order to reduce the economic losses that are result of decisions made based on inaccurate information. Forest leaseholders with a lease on forests with a high degree of over mature stands may not get a high value from the use of LiDAR technology due to the fact that the costs of the use will not cover the benefits. The use of LiDAR to acquire information on young stands of forest may produce a good value for leaseholders due to the need to get the information fast in order to avoid additional costs that arise from the delay in form of forest treatment costs.

The goal of government is long-term forest sustainability. There is a strong opinion on achievement of this goal only through the use of own forest inventory technology which is logical considering significant Roslesinforg efforts into development of own aeroimages based forest inventory technology. The fact that employees drift between Roslesinforg and Rosleshoz makes position of Rosleshoz similar to the opinion of Roslesinforg. The legislation (Forest Management Instruction, 2011) supports this opinion by demanding from leaseholders the use of gathered by officially approved forest inventory methods information for construction of forest management plan, which together with a lease agreement forms a base of relationship between government and forest leaseholders.

There may be different options that may be considered in order to enhance the value of LiDAR in Russia. These options are explored in the next subchapter – recommendations. The approach to generate these propositions is originates from Grönroos (2011) view on value enhancement through value co-creation with customers with the service perspective of marketing being central.

9.2. Recommendations

Value co-creation with forest inventory companies

Bearing in mind the opinion of forest leaseholders on LiDAR’s need to reduce price due to it being additional technology to currently in use due to legislation it seems sensible to introduce cost-plus-losses analyses as a way to include consequences based costs into forest managers consideration.

Cost-plus-loss analyses (Kangas, 2010) may be used to make an offer of LiDAR forest inventory method to forest leaseholders. The analyses are focused on calculation of economic losses due to decisions based on inaccurate information. The calculations must be made using available modeling tools for each forest inventory method applied to the forest of each potential customer. The calculation of these losses may prove that LiDAR is more beneficial for the leaseholder comparing to other forest inventory methods.

Value co-creation with forest leaseholders

According to Jabkowski et al. (2013) the costs of forest inventory per hectare decrease with the growth of surveyed areas size. Taking into account the opinion of forest leaseholders on LiDAR’s costs and Jabkowski et al. (2013) observations on relation of costs and area size there is a point to introduce service of connecting forest leaseholders reduces costs of forest inventory made by LiDAR. Timeliness, accuracy and reliability of information will stay at the same level due to LiDAR technology characteristics. Provision of this service would demand work with a leaseholder to identify possible cooperation opportunities to make bigger plots for inventory. Cooperation with leaseholder on the needed forest inventory metrics may additionally help to reduce costs due to the choice of optimal pulse density. This suggestion is based on Jabkowski et al. (2013) research and preferences of Russian forest managers as well.

Value co-creation with government

Wulder et al. (2008) and Chen et al. (2012) recommend the use of LiDAR together with aerial imaginary to increase amount of forest inventory attributes measured by LiDAR. Roslesinforg has intensive development of aerial imaginary forest inventory method. LiDAR and Roslesinforg aerial imaginary method may complement each other producing a superior value for private customers and for Russian government.

9.3. Suggestions for further research

The thesis identifies forest inventory users in Russia, who would benefit the most from the use of LiDAR forest inventory method, the users should have long-term planning goals and leased plots with a high degree of maturing stands. There is a need in further research in the determination of types of forestry companies that may with a higher probability have long-term forest management planning goals. Is there influence of company size, ownership, leased forest type, geographical position, and the timeliness of forest inventory documentation on the planning period of forest leaseholders? The answer to this question requires further research on the topic, which may be executed as a quantitative survey study.

According to the findings of this study, the main criterion of forest inventory method choice in Russia is price for short-term planning forest leaseholders and benefits cost ratio for long-term planning businesses. Forest inventory is in a tool for forest managers in planning their operations. It would beneficial to know for forest inventory technology development what forest inventory metrics forest managers value the most in their planning activities. The answer might lead to recommendations on customization of offered to Russian market technologies that would provide necessary for planning forest inventory metrics at lower cost. The other direction of the research would be studying possibilities of integration of novel for Russian market forest inventory technologies with generally used forest management planning software in order to create a higher technology value for the users.

10. SUMMARY

Present study explores forest inventory information needs in North-West Russia order to answer the main research question of the thesis: How to enhance LiDAR forest inventory method value in Russia?

Woodruff (1997) customer value hierarchy forms a theoretical basis of research. The framework is operationalised to forestry using information of global forest resource management. The operationalisation of the framework closes a research gap in applied research on desired customer value (Woodruff, 1997) in forestry. In order to answer the main research question secondary and primary data is gathered and analyzed. The main sources of secondary data are literature on forest management, information on LiDAR technology and Russian Forestry.

Information on Russian forest inventory system shows the presence of two types of forest inventory in Russia showing the forest leaseholders ordering forest inventory mainly from government inventory organization Roslesinforg and to much lesser extents from private inventory organizations. National forest inventory is done exclusively by Roslesinforg.

These findings coupled with geography constrains have formed the basis for the choice of respondents. The major part of respondents are forest leaseholders, there were interviewed only two private forest inventory companies owning to their small number. Russian government forest inventory company Roslesinforg holds a leading position in private forest inventory and monopoly in national forest inventory with Russian Federal Forestry Agency (Rosleshoz) executing the control over the organization. Both government organizations – Roslesinforg and Rosleshoz were interviewed. The central position of Roslesinforg in Russian forest inventory was confirmed by primary data.

The interview guide was constructed for specific use situation – forest inventory in Russian forestry using operationalised Woodruff (1997) theory as a base. Only secondary data related to LiDAR has become the basis for the research

conclusions owning to the little to no knowledge of the technology in Russian forestry.

Recommendations presented in the Discussion chapter answer the main research question with cooperation being the main strategy to enhance LiDAR value in Russia. Primary data shows that forest management planning in Russia is predominantly short-term with economic and ecologic sustainability dimensions rarely taken into account, as such technology direct costs is the biggest forest inventory choice criteria for forest leaseholders.

LiDAR technology perceived as too expensive due to the fact that results from LiDAR inventory can not be currently used as a base to make reports to the government due to the legislation and therefore the technology may be used only in combination with other forest inventory technologies currently in the market. This notion was proved by secondary and primary data results. Government is interested in the promotion of own aero image forest inventory technology in which it heavily invested with a desire for improvements.

The following recommendations are lead from the secondary data and primary data available. As direct technology costs being the most important criteria for Russian forest leaseholders the recommendations draw on the cost-plus-loss analyses to show Russian forest managers costs that arise as a result of decisions based on inaccurate information and reduce the direct costs of LiDAR technology through a service of connecting forest leaseholders together and therefore reducing inventory costs through execution of inventory on bigger forest plots.
The government desire of own forest inventory technology improvement makes possible only a complimentary use of LiDAR technology together with Russian government forest inventory technology. Additionally, secondary data provides a notion on the necessity of aero images forest inventory method and LiDAR in order to get a wider range of forest inventory metrics therefore making the complimentary use of LiDAR technology together with aerial images recommended.

The study has direct managerial implications to planning a strategy of LiDAR technology promotion in Russia, furthermore the study accomplishes an operationalisation of customer value hierarchy in forestry closing thus an existing research gap.

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APPENDICES

Appendix 1: Theory themes incorporated into the interview guide

Question	Theoretical construct	Measuring
What is your organization's role in inventory process?	Value co-creation	Value co-creation with government
How frequently do you need to acquire an up-to-date information about forestland?	Desired/non-desired product or service attributes	IQ Dimension Timeliness: Information is sufficiently up-to-date for forest management planning
What methods do you (your suppliers) apply in forest inventory?	Use situation	Method to acquire information
What inventory information does your organization need for forest management planning?	Use situation	Needed information in concrete use situation - forest management
What are criteria of forest inventory method choice? What could be the most important criterion of choice?	Desired/non-desired product or service attributes	New IQ Dimension identification through definition of forest inventory choice criteria
What are, in your opinion, benefits of the forest inventory method(s) your organization currently uses?	Desired/non-desired product or service attributes	Benefits of forest inventory method in use
What are disadvantages of the used forest inventory methods?	Desired/non-desired product or service attributes	Disadvantages of forest inventory method in use
How (for what purposes) do you utilize obtained information?	Customers' goals and purposes	Customer goals and purposes related to information use
How do you process forest inventory data?	Use situation	Forest inventory information use

(continues)

(Appendix 1 continues)

Question	Theoretical construct	Measuring
Do you think the currently applied forest inventory methods are up-to-date?	Desired/non-desired product or service attributes	Attribute-based dissatisfaction
Are you familiar with airborn scanner LIDAR forest inventory method? In your opinion, is it suitable for Russian market conditions? Is it suitable for your company's purposes?	Use situation	LiDAR possible usage. Possibilities to fulfill information needs of the company and market
What issues related to inventory need to be dealt with in the area of quality, methods and services?	Desired/non-desired product or service attributes	new IQ Dimension identification though definition of forest inventory method problems
What, in your opinion, could effect on reliability of forest inventory method? How do you assess reliability of the used methods?	Desired/non-desired product or service attributes	IQ Dimension Free of Error: Information is accurate and reliable
In your opinion, how can possible forest inventory errors (human factor) affect long-term sustainability?	Desired/non-desired product or service consequences	Sustainability ecologic and economic consequences
Has your organization made investments/purchases to ensure sustainability? Do you plan make investments in this or some other area of interest? What kind of investments?	Customer goals and purposes	Investments to ensure economic and ecologic sustainability

(continues)

(Appendix 1 continues)

Question	Theoretical construct	Measuring
How does your organization cooperate with other organizations? Cross-border cooperation?	Value co-creation	Value co-creation with business
Could you name the most discussed forest management problems in your organization?	Desired/non-desired consequences	Forest management problems

Appendix 2: Interview guide

Introductory questions

- What is your organization’s business?
- For how long your organization has leased the forestland?
- What is the size of forestland that you lease?

  1. less than 1000 ha
  2. 1-10 ths ha
  3. 10-25 ths ha
  4. 25-50 ths ha
  5. 50-100 ths ha
  6. more than 100 ths ha
- What types of customers your organization has?
- How many employees does your organization have?

  1. less than 50
  2. 50-500
  3. 500-1000
  4. more than 1000
- What is geographical area of your organization business interests?
- Does your organization have Russian or foreign ownership or is it joint venture?

Forest management and forest inventory methods related questions

- What is your organization’s role in inventory process?
- How frequently do you need to acquire an up-to-date information about forestland?
- What methods do you (your suppliers) apply in forest inventory?
- What inventory information does your organization need for forest management planning?
- What are criteria of forest inventory method choice?
- What could be the most important criterion of choice?
- What are, in your opinion, benefits of the forest inventory method(s) your organization currently uses?
- What are disadvantages of the used forest inventory methods?
- How (for what purposes) do you utilize obtained information?

(continues)

- How do you process forest inventory data?
- What precision is required for your purposes? Are you satisfied with precision of the methods in use?
- Do you think the currently applied forest inventory methods are up-to-date?
- Are you familiar with airborn scanner LIDAR forest inventory method? In your opinion, is it suitable for Russian market conditions? Is it suitable for your company's purposes?
- What issues related to inventory need to be dealt with in the area of quality, methods and services?
- What, in your opinion, could effect on reliability of forest inventory method? How do you assess reliability of the used methods?

Sustainability related questions

- What kind of measures have you undertaken or plan to undertake to improve sustainability?
- In your opinion, how can possible forest inventory errors (human factor) affect long-term sustainability?
- Has your organization made investments/purchases to ensure forest sustainability? Do you plan make investments in this or some other area of interest? What kind of investments?
- How does your organization cooperate with other organizations? Cross-border cooperation?
- Could you name the most discussed forest management problems in your organization?

Appendix 3: Theory themes incorporated into analyses

Themes	Codes	Explanation
Value co-creation	VALUEco-creat-GOV	Value co-creation with government
	VALUEco-creat-Business	Value co-creation with business
Desired/non-desired product or service attributes	TimelinessIQ	Information is sufficiently up-to-date for forest management planning
	RelevancyIQ	Relevancy: Information usefulness for forest management planning
	InventChoiceCRITERIA-newIQ	New IQ Dimension identification through definition of forest inventory choice criteria
	AccuracyIQ	Information is accurate and reliable
	ReliabilityIQ	Free of Error: Information is accurate and reliable
	AccessibilityIQ	Information is quickly accessible when required
	Appropriate AmountIQ	Amount of information is sufficient for current information needs
	BelievabilityIQ	Information is trustworthy
	CompletenessIQ	Information has sufficient breadth and depth for the task (includes all necessary values)
	CompactPresentIQ	Compact presentation of information
	FormatIQ	Consistent presentation of information in the same format
	IntegrateIQ	Information is easy integrate with other information
	InterpretationIQ	Easiness with which is possible to interpret information

(continues)

(Appendix 3 continues)

Themes	Codes	Explanation
	ObjectivityIQ	Objective collection of based on facts information
	ReputationIQ	Reputable sources of information
	SecurityIQ	Information accessible only by authorized people
	UnderstabilityIQ	Easily understandable information
	BenefitsCurrentMethodUse	Benefits of forest inventory method in use
	DisadvantCurrentMethodUse	Disadvantages of forest inventory method in use
	CurrentMethodSatisf	Attribute-based dissatisfaction
	InventoryProblem	new IQ Dimension identification through definition of forest inventory method problems
Use situation	InfoNeed	Needed information in forest management
	InfoUse	Forest inventory information use
	LiDARUse	LiDAR possible usage in organization or in the market
	DecisionMaker	Who selects forest inventory method
	Method-Get-INFO	Method to acquire information
Customer's goals and purposes	PurposeInfoUse	Customer goals and purposes related to information use
	SustainGoals	Concrete actions or no-actions to achieve long-term economic and ecologic sustainability goals
	InvestmentsSustainability	Investments to ensure economic and ecologic sustainability

(continues)

(Appendix 3 continues)

Themes	Codes	Explanation
Desired/non-desired consequences	ProblemsForestManagement	Forest management problems
	SustainConsequences	Sustainability ecologic and economic consequences