Knowledge in the Forest Planning Process

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Abstract

The main focus of this thesis is the use of knowledge in the forest planning process of large Swedish forest owning companies. The forest planning is conducted as a three step system: long-, medium- and short-term planning. In these steps, knowledge is created, stored, shared and applied – knowledge about the forest as well as other relevant knowledge. The studies have knowledge management theory linked to strategy theories as a base for description and analysis of the use of knowledge in the forest planning process. A draft for a changed planning process is presented which aims at a better management of knowledge in forest companies.

In Swedish forest owning companies the long-term forest plans are developed at top level and transferred down the organization over a number of steps. These steps involve the medium-term planning where planners prepare the compartments to be harvested and register them in the so called tract bank. The harvest managers use the compartments in the tract bank as a stock to meet delivery plans. This is where the forest plans meet harvest and delivery plans.

The interaction between the forest plans and the sales plans was studied. The results showed that sales managers tend to use other input data such as previous sales volumes, rather than what is found in the medium-term plan, due to what they considered as lack of precisions and detail in the forest plan. Also, the supply of compartments with desirable attributes in the tract bank is not always sufficient to meet the demand from the harvest managers. This could make the harvest managers to sidestep the forest plan altogether. It seems that forest plans do not always are followed.

In the light of these studies, a proposition for a bottom-up approach to an integrated planning process was developed. This approach was made with the purpose to stimulate the use of knowledge at local level to enhance the accuracy and applicability of the forest plans. With this approach employees at local level would hopefully be more involved in the planning process, leading to a higher adherence of the plan. This would in turn increase the association of realized plans with intended plans, thus improving the competitive position of the company.

Keywords: forest planning, knowledge management, tract bank, bottom-up planning, long-term planning, medium-term planning, knowledge, information, sales planning, timber supply

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Contents

List of Publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

I M Nilsson, D Staal Wästerlund, O Wahlberg, L O Eriksson (2012). Forest Planning in a Swedish Company – a Knowledge Management Analysis of Forest Information. *Silva Fennica* 46(5), 717-731.

II M Nilsson, D Staal Wästerlund, O Wahlberg, L O Eriksson. The use of forest information in timber sales planning (submitted manuscript)

III M Nilsson, L O Eriksson, D Staal Wästerlund. Perspectives on sustained competitive advantage in medium- and short-term forest planning in Swedish forest-owning companies (submitted manuscript)

IV L O Eriksson, O Wahlberg, P Wikström, M Nilsson. Questioning the contemporary forest planning paradigm: making use of local knowledge (submitted manuscript)

Paper I is reproduced with the permission of the publisher.

The contribution of Malin Nilsson to the papers included in this thesis was as follows:

I Designed the study in cooperation with the supervisors and planned and conducted the interviews. Performed the analysis of the material and wrote the major part of the manuscript.

II Designed the study in cooperation with the supervisors and planned and conducted the interviews. Performed the analysis of the material and wrote the major part of the manuscript

III Designed the study and developed the questionnaire. Performed the analysis of the material and wrote the major part of the manuscript. All activities were made in discussions with supervisors.

IV Designed and planned the study and the basis for the model in cooperation with the other authors. Prepared most of data. Wrote a minor part of the manuscript.

Abbreviations

DIK	Data - Information - Knowledge
KM	Knowledge Management
MBV	Market Based View
MO	Market Area
RBV	Resource Based View
SCTT	Self Contained Task Team
TB	Tract Bank

1 Introduction

Knowledge is a widely used word. When it is used in daily life, the meaning often changes. For example, 'knowledge' can be used to describe a skill, such as being able to make a wonderfully tasty dinner or it can be used to describe the information someone has read and that he or she is able to repeat and write down to score well in a test at school. These examples are just two different definitions of knowledge. There are many more ways to categorize and define knowledge, for example, the type of knowledge, how knowledge is used, how and where knowledge is found etc. Some of these different ways of explaining the concept of knowledge are presented in Table 1, together with concepts of knowledge management. This is, by no means, a complete list of definitions of knowledge or knowledge management, but demonstrates the large variety of meanings and gives the reader a short overview of what knowledge can be and how the word will be used in this thesis, when applied to the concept of forest planning within a large forest-owning company.

Table 1. *Overview of some concepts of knowledge and KM used in this thesis*

Knowledge Categories
Explicit; Tacit
General; Context-specific
State of mind; Object; Process; Access to information; Capability
Declarative (know-about); Procedural (know-how); Causal (know-why); Conditional (know-when); Relational (know-with)
Individual; Social
Knowledge Management Categories
Pull strategy; Push strategy
Creation; Storing/Retrieving; Transferring; Applying

1.1 Knowledge and knowledge management

Knowledge is often described by the data-information-knowledge relationship (DIK). Basically, the DIK relationship describes how data are meaningless numbers until they are given meaning, when they turn into information. Combined with other information and already acquired knowledge, this information turns into knowledge. Other authors do not hold this view of knowledge however; they consider data, information, structured information and other forms as different states of knowledge in decision-making (Holsapple, 2008; Van Lohuizen, 1986).

Knowledge can either be explicit or tacit. Explicit knowledge can be described. It is knowledge that the person is aware of, that it is possible to write down or to tell someone. Tacit knowledge resides within a person. This knowledge is a result of experience, either technical or cognitive. Technical tacit knowledge consists of acquired know-how, while cognitive tacit knowledge is formed by the mental understanding and internal construction a person has of the world (Nonaka, 1994). In the earlier example of cooking, some explicit knowledge is required in the form of how much of the ingredients to use and how long to keep the food in the oven; but to make a superb dinner, the chef also needs tacit knowledge, to know exactly when to put in the beans or how much pepper to add, depending on how soft the tomatoes are and when to add the pepper depending on the amount of water. The tacit knowledge here is the final touch that cannot be explained to a student, but can be learnt from a master.

Knowledge can also be divided into general and context-specific knowledge (Zack, 1999). An example of general knowledge could be to know how to read. As soon as you know how to read, you can read anywhere and anything. Still, there can be a lack of understanding if the reader lacks other knowledge, for example, if the text is very technical in an area where the reader does not have context-specific knowledge. Context-specific knowledge applies to a specific situation.

Yet another way to look at knowledge is as different perspectives. Alavi and Leidner (2001) described five perspectives of knowledge. Knowledge can be seen as: a state of mind, an object, a process, access to information and as a capability. “State of mind” is about the knowledge that is located within the mind of an individual, things they have learnt through experiences or by reading. “Object” is a perspective that handles the knowledge as if it was a thing. It can be stored or used as if it is a tangible asset. “Process” views the

knowledge with knowing and acting together. “Access to information” focuses on the storage and potential to retrieve knowledge. In the “Capability” view, knowledge is seen as the ability to understand and interpret information in order to influence future decisions.

Knowledge in companies or groups can be either individual or social. The individuals in the group hold knowledge that is part of the group’s total knowledge. Groups create collective action patterns and communication: these common patterns are social knowledge.

Another way to categorize knowledge is to categorize it using five, more practical, groups**:** declarative (know-about), procedural (know-how), causal (know-why), conditional (know-when) and relational (know-with) (Alavi & Leidner, 2001; Zack, 1999).

So, knowledge can have many forms and be found in many ways and in many places. When studying knowledge and how to manage it in companies, a knowledge management (KM) strategy is needed.

The information and knowledge a company has most often needs to be shared within and outside the organization. For knowledge-sharing, the company can either choose a pull strategy or a push strategy. In a pull, or codification strategy, the knowledge is coded and the employees can use it when they need it. In the second strategy, the push or personalization strategy, the organization builds a web of experts with experience. When someone in the company needs specific information, they must ask for it and the knowledge is then shared, person to person (Hansen *et al.*, 1999).

Alavi and Leidner (2001) defined four basic processes of knowledge management. The four processes are: knowledge creation, knowledge storing/retrieving, knowledge transferring and, finally, knowledge applying. Knowledge creation within an organization is an interaction between people and their tacit and explicit knowledge (Nonaka, 1994). To avoid loss of knowledge and to secure access to knowledge and information, the organization needs to store its knowledge in a way that allows retrieval (Alavi & Leidner, 2001). Five possible ways to organize the storage are described, covering both tacit and explicit knowledge: written documents, information in databases, codified human knowledge stored in expert systems, documented organizational procedures and processes and, finally, tacit knowledge acquired by individuals. It is also important that relevant knowledge possessed by individuals or groups can be transferred to other individuals or groups, or to explicit sources, both within the company and to external recipients. Transfer in KM is built on the classic communication elements: to communicate you need a message, a channel, a sender and a receiver, transmission, encoding and decoding of the message and a meaning of the message (Krone *et al.*, 1987).

To apply knowledge, three mechanisms have been proposed to translate knowledge into organizational capability: directives, organizational routines and self-contained task teams (SCTT) (Grant, 1996).

In any company, a wide spectrum of knowledge types is used to keep daily work flowing. Knowledge is mostly treated as an object in this thesis, but will be highlighted if treated differently. Most of the categories of knowledge can be seen in a forest-owning and management company's daily work. When looking at the categories of "know-how" presented by Zack (1999), all of the categories can be found in the forest-owning company. The declarative category that includes "know-about", from a forest planning point of view, can be knowing that the optimization has happened and knowing most, or at least the important parts, of the outcome. The procedural category relates to knowing how to proceed with medium-term forest planning or how measurements should be carried out at the compartments. The causal knowledge category relates to an understanding that the harvested compartment is a consequence of the earlier steps in the forest planning system. In the same way, conditional knowledge informs the employees when to harvest a certain compartment and relational knowledge relates to when an employee realizes what will happen if a specific compartment is harvested using a certain harvesting team. The tacit-explicit pair of knowledge is also present: there is written - explicit - knowledge about the compartment in the database. The harvest manager might know by experience how to present an upcoming compartment for harvesting to a harvesting team. General knowledge can be the knowledge of which species of trees are present in Swedish forests, whilst context-specific knowledge might relate to the amount of spruce timber that is to be delivered to a specific sawmill. In the company, there is both individual knowledge, a planner know how to store the information about a compartment in the software and social knowledge, the group of employees know how the routines for the planning process are organized. All these categories are important to the company and in a KM strategy, they all need to be managed.

1.2 Management and planning of Swedish forests

1.2.1 Forests in Sweden

50% of the forest area in Sweden is owned by private owners, approximately 10% is owned by private companies and approximately 40% is owned by large companies (Skogsstyrelsen, 2013). A majority of these large companies also own industries (sawmills and pulp mills) or are owned by mill-owning companies. Some companies are pure forest-owning companies. There are four

larger forest-owner associations in Sweden. They operate in different areas of the country. These associations own mills and are also actors in the forestry market (LRF, 2008).

The wood industry is dependent on the quality of the logs. A sawmill needs to be able to sell a high quality product, which means that there are exacting requirements for the logs delivered from the forest. Since the mills have different requirements, the forest owner can sell the wood to different customers, depending on the quality and size of the stems in the stand to be cut. In 2011, the volume of the harvested forest in Sweden was 72.1 million m^3 solid volume under bark (m^3sub), of which 34.5 million m^3sub were saw logs. The area of felling in 2010 was 200,000 hectares final felling and 433,000 hectares thinning (Skogsstyrelsen, 2013).

1.2.2 Forest management

In traditional forest management in Sweden, there are a few stages that stands go through during their lifetime. When trees are cut, the felling site is planted or sown (possibly after scarification). The area is later inspected, to investigate if the seedlings are alive and healthy. After a couple of years, the trees are big enough for pre-commercial thinning. After a number of years, they are thinned again (most common is to thin once or twice during the stand's life-cycle**)** and then, after more years, the final felling takes place (and then the process starts all over again). The normal duration for this cycle is approximately 70 – 120 years from planting to final cutting. During this time, there is a good deal of information about the stands that is supposed to be stored and kept live within company. The areas are visited and planned a couple of times during the stand's life (here, planning is the inventory of the site, measuring the trees and delineating the borders and subareas to be left). A forest-owning company encounters several different obstacles in the process of managing forests and delivering the products (for example, timber and pulpwood).

Products from thinning and final cutting are timber, pulpwood and biofuel. The product mix is considerably more diverse than just three different products. The timber part is divided into many different assortments depending on type of tree, the diameter, the length and quality of the log. All these aspects are important for the sawmills. Larger mills in Sweden are specialized so different kind of timber must be sold and delivered to different buyers. Pulp mills are also specialized and the description of wood quality is precise. One pulp mill can use wood from both spruce and pine whilst another might want just wood from spruce and a third want wood from spruce, but smaller pieces than the other. There is a potentially large mix of assortments produced from a stand.

This division of the output from the stands makes the delivery complex. When producing for one customer, a number of other products are also produced and these also need a customer. In addition, producing one product limits the choices of which other products can be produced from the same stem. In addition to the mix of products, many other aspects must also be considered when selecting a stand to cut, for example, its location, its size and the ground conditions.

In this "producing process", different parts within the company are involved: for example, the person planning the stand, the business manager, the production manager, the harvesting team, the transportation manager and the truck drivers. Externally, the buyers are also involved. One person may hold more than one of these positions. With all these personnel involved, it is important to have a structured way of communicating information about the felling. In larger companies (where different people hold the positions), a software system is often used to manage the information flow.

In Sweden (most often), when the harvester fells the trees and cross-cuts them, information about length, diameter and quality of the produced logs is transferred to a data company, SDC. It is an independent actor that collects and shares data between different companies, buyers, sellers and entrepreneurs in the Swedish forest industry (SDC, 2008).

1.2.3 Forest planning

Forest management and silviculture consists of actions made over time in a forest stand. If the goal with the stand is to optimize the financial gain, these actions need to be done at certain times, depending on, for example, the tree species and site quality. Optimal forest management programs can be selected for each stand in the forest. Since forest owners have many stands, the goals differ from an optimal management program for each stand to an optimal management for the entire forest. A forest owner might want make a financial gain from the forest every year. They might prefer that this profit is similar every year, or that it does not decrease in any given year. As soon as this kind of goal is set, the optimal management program per stand becomes a sub-goal, but still very important in achieving a high financial gain.

For large forest owners, it is important to secure the continuous output of timber. Their forest plans are also made to safeguard sustainability, both regarding timber output and, depending on strategy and context, regarding environmental and social values. The large forest-owning companies in Sweden all have the similar planning structure for their activities in the forests: a hierarchical planning system with a long-term plan, a middle-term plan and a

short-term plan (Eriksson, 2008; Söderholm, 2002). This planning process is a sequence of decisions, where all decisions are made with respect to the former (Church, 2007; Epstein *et al.*, 2007; Gunn, 2007). The harvesting and delivery to mills follow the forest planning hierarchy.

The long-term plan is a harvest estimation for the forests. In this plan, the focus is on sustainability and economic optimization which is made from data on the forest holdings. These data come from exact inventories of selected sample stands. The selection is made by stratification of the stands in the stand register. The optimization also takes account of assumptions of prices and costs in the future as well as of the interest rate. Over the last three decades, most of the Swedish forest-owning companies have used the Forest Management Planning Package (Jonsson *et al.*, 1993), but now there has been a move to the Heureka systems. The outcome of the optimization is used as the base for the next level of the forest planning hierarchy.

The medium-term plan covers three to ten years. The base for this plan is the first part of the harvest estimation and it is made at a regional and local level. In this plan, the compartments to be harvested or thinned are identified. Within the frame set by the long-term plan, an allocation of compartments to be cut is made in order to keep low the costs for road construction or upgrading and for moving harvesting teams. Other plans are connected to the medium-term plan, for example, road construction plans, fertilizing plans and sales plans. The medium-term plan ends with a TB (tract bank), a register that stores the compartments available for harvest.

The short-term forest plan covers the immediate one to three months. This plan is a scheduling of harvesting resources and compartments to meet delivery plans and it is made at the local level of the companies. The compartments in the TB and the harvesting resources are input into this plan. The aim is to harvest volumes of the right assortments in an even flow to meet the delivery plans. Deliveries go either to mills owned by the corporation or to customers' mills. Costs, weather and ground conditions are also aspects to take into consideration in this planning. The outputs from this planning are timber logs and pulp wood to be delivered to mills.

Through the forest planning literature runs the discussion of how to acquire data about the forest, the core data source of most forest planning systems. Forest owners face the problem that verification of the exact state of the forest can be expensive or even impossible It is a matter of balancing the cost of available techniques against the potential gain (Kangas, 2010; Duvemo & Lämås, 2006). It is also a matter of which information that is collected, when, and of what quality to support specific decisions. (Duvemo *et al.*, 2012) Data collection is a parameter that influences the planning system as such.

1.3 Company Strategies and theories

As in any market, forest companies compete to gain advantage and, in the end, to survive. To grow, the company needs to gain a competitive advantage that keeps it in business. To do this, the manager needs a strategy.

1.3.1 Strategies

The word strategy can refer to different processes and characteristics in business planning. Mintzberg et al (2009) described the different meanings of the word with five Ps: Plan, Pattern, Ploy, Position and Perspective. Using the first two meanings, strategy as a plan and as a pattern, it does not only refer to the plans that the management of a company makes and implements within that company, but also to the pattern formed by the actions and decisions made in the company. The main difference between these concepts of strategy is that one (plans) is a view into the future whilst the other is a view back in time (patterns) (Mintzberg and Waters (1985). The intended strategy, the plan, which is communicated to the employees and implemented by the company, can be compared to the outcome, the realized strategy. Along the way, some of the intended strategies will not be realized due to changes in conditions or because of assumptions that proved to be incorrect. Through these changes, new strategies will emerge and actions will become the realized strategy (Mintzberg *et al.*, 2009)

There are different ways to form strategy. The choice is dependent on, for example, the industry, the company, the owners or the employees. Some strategies are not formed by a manager but grown from inside the company. These forms of strategy are just forms. They do not have any content i.e. what to plan or how the vision is formulated (Furrer *et al.*, 2008; Mintzberg & Waters, 1985).

1.3.2 MBV & RBV

There are different ways to look at a company's potential to gain competitive advantage and survive the competition. There are two dominating views that deal with this: the market-based view (MBV) (Porter, 1979) and the resource-based view (RBV) (Furrer *et al.*, 2008; Barney, 1991; Wernerfelt, 1984).

According to the MBV theory, the success of a company depends on how it handles the environment and how it can adjust to and gain advantage from that environment. The company must survive the competition and find a place where it can grow. Porter (1985) described five forces of competition that define the industry in which the company is located. The five forces of competition are: i) threats of new entrants, ii) threats of substitutes, iii) bargaining power of buyers, iv) bargaining power of suppliers and v) rivalry

among existing competitors. To survive this competition a company can use one of three generic strategies. (Porter, 1980): i) cost leadership, where the company cut costs to be able to sell the product at the cheapest price, ii) differentiation strategy, where the product is specialized to fit the customers' needs better so the price can then be higher and iii) focus strategy, where the product is sold to a target group, which the company learns to understand and so develops the product according to the group's needs. In addition to this a product is subject to different activities within the company. Each of these activities adds value to the product and are either primary or support activities. Value drivers and costs are identified for each of them. The product's value chain is part of a value system which includes the value chains of suppliers and buyers (Porter, 1985).

According to the RBV theory, resources *within* the company can be the source of competitive advantage rather than solely from comparison with other firms in a specific industry. These resources are defined in several ways in literature. For example, Wernerfelt (1984) wrote "By a resource is meant anything which could be thought of as a strength or weakness of a given firm. More formally, a firm's resources at a given time could be defined as those (tangible and intangible) assets which are tied semipermanently to the firm." Another way to look at this can be that the resources and competences that are superior to the resources of competitors can be the basis of competitive advantage (Peteraf, 1993). Conner and Prahalad (1996) wrote that knowledge within the company can also be a resource, if that knowledge can only be learnt through personal experiences. Barney (1991) defined the resources of a firm as "all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by a firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness." These resources are categorized into three groups: physical capital resources, human capital resources and organizational capital resources. These resources must fulfill four conditions to create sustained competitive advantage. They need to be i) valuable, the resource needs to improve efficiency, ii) rare, not all firms in the industry can have the resource if it is going to be a source to competitive advantage, iii) "imperfectly imitable", the resource must be hard to imitate and iv) the organization must be able to use the resource, according to the VRIO framework (*Figure 1*) (Barney, 1991).

When testing planning systems in the framework, a formal strategy can be a valuable, rare resource, but it is unlikely to be non-imitable and the strategy is not a sustained competitive resource (Barney, 1991). A valuable informal strategy, on the other hand, can be a pattern, based on, for example, experience or social complexity within the company and can, depending on its non-

imitability and rareness, be a sustained competitive resource. Zack (1999) described knowledge as a resource thus: “The firm’s advantage comes from being able to absorb external knowledge and integrate it with their internal knowledge to develop new insights faster than the competition.” Putting them together this means that management of knowledge is an important resource in gaining competitive advantage.

Valuable?	Rare?	Costly to Imitate?	Exploited by Organization?	Competitive implications	Economic performance
No	---	---	No	Competitive disadvantage	Below normal
Yes	No	---		Competitive parity	Normal
Yes	Yes	No		Temporary competitive advantage	Above normal
Yes	Yes	Yes	Yes	Sustained competitive advantage	Above normal

Figure 1. The VRIO framework (from J. Barney, “Gaining and sustaining competitive advantage” (Table 5.2, page 173), (Barney, 2002)).

The forest plan can be seen as a strategy – as a plan. This plan, along with strategic decisions for the coming years, is implemented by the company. The knowledge used to realize the forest plan is managed in order to carry out each task at the right time. When the plan is realized, it probably differs from the intended plan. Decisions made in everyday work will create a pattern that becomes the realized forest plan. Forest knowledge is essential in developing the plans and then carrying them out. The management and organization of the forest knowledge can thus form a resource that, according to the VRIO framework, is valuable, rare and hard to imitate. The management of the forest knowledge would then give sustained competitive advantage.

1.4 Objectives of the thesis

The main objective of this thesis is to investigate how knowledge in the forest planning process is managed and then suggest a different approach for organizing forest planning. The perspective is that of the large forest-owning companies in Sweden (*Figure 2*) with forest planning and forest knowledge in the studies especially focused on knowledge related to timber production. To illustrate the use of forest knowledge and knowledge of the forest plans in other activities in the company, one study examined the connection between the medium-term forest plan and sales planning (paper II). The studies included in this thesis are case studies based on interviews with employees in one forest-owning company (papers I & II), a questionnaire study representing three forest-owning companies (paper III) and finally a discussion paper about how to apply a greater knowledge utilization in a bottom-up approach of forest planning in a forest-owning company (paper IV).

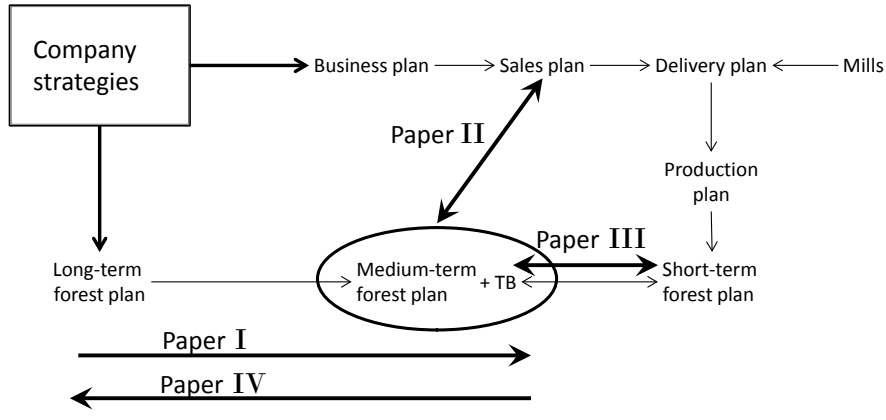

Figure 2. A map showing which parts of the forest planning process were examined in the studies.

The objectives of each of the papers I - IV are:

Paper I: The objective was to characterize, utilizing KM as an analysis tool, how data and information about the forest are managed as knowledge and used in the forest planning process of a large forest company. It is limited to long-term and medium-term planning and focuses on KM applied to forest information.

Paper II: The objectives were to describe and understand the way in which a large forest-owning company currently uses forest information in sales planning and to see what other forms of more sophisticated forest information are desirable or might prove useful.

Paper III: The objectives were to explain how the intended long-term and short-term strategies are realized in the work with the TB and to analyze their consequences on the competitive advantage of the companies.

Paper IV: The objectives were to illustrate how a bottom-up oriented forest planning process of the large forest owning organization could function and deduce potential advantages and drawbacks of the approach.

2 Summary of Papers

The papers in this thesis relate to three main themes: Knowledge, Forest Planning and Strategies. As seen in *Figure 3*, all three themes are referenced in all the papers, but the main perspective is on two of the themes, except in the paper IV, where all the themes interact.

Figure 3. The themes which are the basis for this thesis.

In the papers, different types of knowledge are discussed. Paper I, discusses very specific knowledge that originates from forest data, forest knowledge. This kind of knowledge is also discussed in paper IV together with other more general knowledge, mostly company-specific but also universal. In papers II and III, knowledge about the forest plans is discussed and, paper III also examines knowledge about other company plans, especially timber delivery/production plans.

2.1 Forest Planning in a Swedish Company – a Knowledge Management Analysis of Forest Information (Paper I)

Forest-owning companies in Sweden make their long-term forest plans as economic optimizations. Data used in the optimizations come from stratifications of stands in the stand registers. The outcome of the optimization is a volume to cut in the coming years and the first period is the base for the medium-term forest plan. Over several stages, the volume to be cut is broken down to specific areas and stands as well as season and year. All the way through this process, forest knowledge is used to make decisions. Paper I presents how the knowledge about the forests is managed in the planning process. The purpose of the study in paper I was to characterize, utilizing KM as an analysis tool, how data and information about the forest is managed as knowledge and used in the forest planning process of a large forest company.

The study is based on interview data from Sveaskog in Sweden. It is limited to long-term and medium-term planning and only concerns the planning of timber production, even if most parts of the forest planning process do not separate assortments. The study focuses on KM applied to forest information in the forest planning with little attention being paid to information from other sources. In paper I, the definition of knowledge is as an object and it is explicit. The studied knowledge is limited to the knowledge built on forest data.

By using the four KM processes of creation, storage/retrieving, transferring and applying, the forest knowledge was tracked through the forest planning process, as shown in *Figure 4*.

At each step in *Figure 4*, the forest knowledge is processed in different ways and new knowledge is created. This new knowledge is stored and transferred to the next step in the organization of the forest planning. Since the studied knowledge is explicit, it is present in all the steps, either stored in documents or in databases. The channels used to transfer the knowledge to the next step are personal meetings, e-mails and graphical user interfaces. Formal minutes were also found as a channel in one transfer process. The application of the knowledge mainly happens through organizational routines.

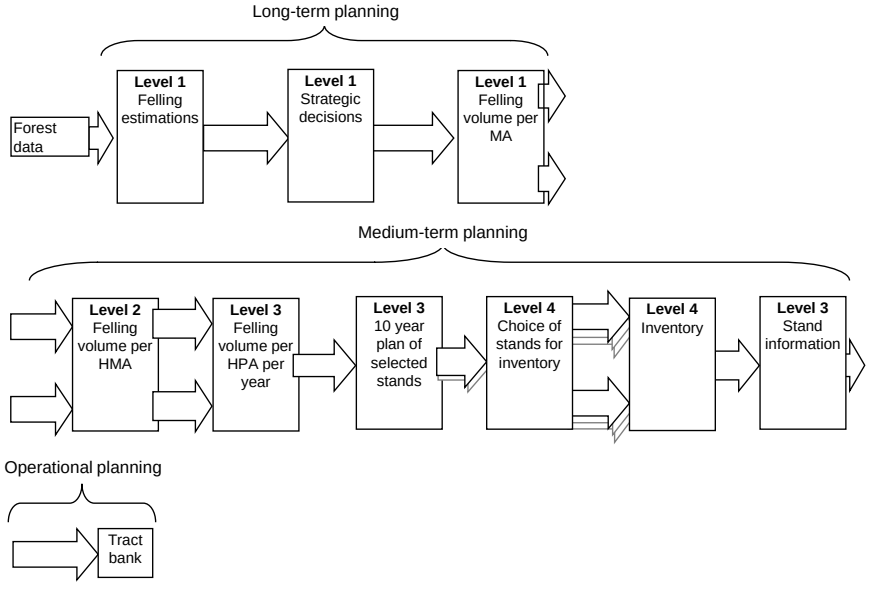

Figure 4. The flow of forest knowledge through the organization of forest planning and the level at which decisions are made. (Separate multiple arrows denote distribution to different geographical units; overlaid multiple arrows denote repeated activity at the same geographical unit during the long-term planning cycle.)

The entire planning process, with the exception of the initiation of the planning process, is conducted as a push strategy, where knowledge is coded and available to use. The process is also very hierarchical in a top-down way, with each decision being built on an earlier decision at a higher level.

2.2 The use of forest information in timber sales planning (Paper II)

The purpose of the study reported in paper II was to describe and understand the way in which a large forest-owning company currently uses forest information in sales planning and to see what other forms of more sophisticated forest information are desirable or might prove useful. Data were gathered by conducting interviews at a large forest company in Sweden.

The results show how medium-term forest planning is carried out and how forest knowledge is used in the sales planning. The medium-term forest plan, or medium-term plan, is a ten year plan for forest compartments with a total volume to cover the harvests over ten years. The TB (tract bank, the register that stores the compartments available for harvest) is divided into four parts.

The part closest to the "now" is the TB, where the compartments are ready to be harvested either for final felling or for thinning. The part just before the TB covers compartments that are ready to have their harvesting planned. Compartments in areas with consultations, for example, with the Sami people have been consulted. The third part covers compartments that are ready to be consulted on and, in the fourth part, furthest away from "now", are compartments still receiving silvicultural treatments. Together, the parts are supposed to cover compartments with a volume equal to that described by the plan over ten years. This volume is meant to be fairly evenly distributed over the four parts, which should produce a TB for compartments lasting approximately two years, but the interviews revealed that it was rather uncommon with a TB of that size.

The company studied was divided into four geographical areas, MOs, each with one sales manager. In the study, three of them were interviewed. The sales managers described their planning in different ways, but they all said that they do not really use the information in the medium-term plan when they plan their sales. They look back on previous deliveries and use this historical information instead. One sales manager said that using forest plan information instead would only be possible if it was presented in a useful way and if the information was totally reliable.

The results are evaluated and discussed in the context of the Forest Information Usage Model (*Table* 2), focusing on reasons why forest information is either not used or not considered useful in some cases.

Table 2. The Forest Information Usage Model.

Forest information is used today	Y/Y	Y/N
Forest information is not used today	N/Y	N/N
	New information is considered useful	New information not considered useful

In the analysis, the MOs were located within the model. One MO was located in the Y/N state, since they used forest data to simulate different scenarios, but this sales manager said that, after a while, he understood what would happen and the simulations were not carried out anymore. Forest information is used,

but new information would not be useful. The other two MOs were located in both the N/Y and N/N states. None of these MOs used forest information at that time, but they were open to using forest information if they knew it was new better information, reliable and adapted to suit their needs.

2.3 Perspectives on sustained competitive advantage in medium-term and short-term forest planning in Swedish forest-owning companies (Paper III)

Forest-owning companies in Sweden have two comprehensive objectives: a) to yield a good short-term rate of return on their forest and b) to maintain a high long-term rate of return by managing the forests sustainably thus maintaining the production of wood-based products. When creating the long-term forest plan, these two objectives are taken into account. In the medium-term forest plan, a selection of compartments to be harvested is made by the forest planners. The harvesting managers work with the short-term forest plans and need to focus on delivery plans that are drawn up according to sales of the wood-based products. The long-term rate of return is therefore dependent on the forest planning system whereas the short-term rate of return is mainly dependent on sales plans and deliveries. These objectives may raise potential conflicts on how to use the forest resources. The two planning hierarchies, forest planning and sales planning, meet in the tract bank (TB) the register of stands ready for harvesting. The objective of this study is to explain how the intended long-term and short-term strategies are realized in the work with the TB and to analyze the consequences on the competitive advantage for the organizations.

The study took the form of a web-based questionnaire survey, sent out to planners and harvest managers at three large forest-owning companies in Sweden. The results show that even if the TB is supposed to be the last activity of the medium-term forest plan, the forest planning system is not always the only perspective of the TB; the delivery plan is also often a main factor in determining the content of the TB. The delivery plan might even be the only strategy that directs the input to the TB. Many of the respondents expressed an opinion that the TB is too small and that the balance of compartments it stores could be better. This means that there are difficulties in finding compartments with certain rare attributes, for example, compartments that can be harvested during the spring when the ground conditions are bad.

Another opinion shown in the results is that there are problems trusting the information in the TB and the medium-term forest plan. The harvest managers said that they could not rely on information about whether there was a road to

the compartment, or whether the volume or tree species mix was correct. Also, the planners have problems with the information in the medium-term forest plan. However, the results show that planners and harvest managers think that the use of the TB actually works well in many units in the companies studied.

In the paper, it is argued that the way the companies organize their work with the TB can be a resource to gain competitive advantage as shown in the VRIO framework. The TB, as such, is not that type of resource, since all the companies have one or easily can get one, but the way in which a company organizes its work around the TB is a way to create competitive advantage. The way to use the TB is then valuable, rare and hard to imitate since it is embedded in organizational routines.

2.4 The contemporary forest planning paradigm questioned: Making use of local knowledge (Paper IV)

The purpose of the study was to illustrate how a bottom-up oriented forest planning process of the large forest owning organization could function and deduce potential advantages and drawbacks of the approach. The study is conducted as a simulated planning process with data from Sveaskog AB. The study includes both a planning model with the simulated planning results at the data set from Sveaskog, as well as an organizational example of how this planning can be conducted.

The organizational planning approach is assuming a two level planning organization. To stretch the planning process to one extreme, the top level management only gives a few directives about financial, environmental and silvicultural concerns. A medium-term plan is then made at regional level involving aspects on both deliveries and road upgrade and maintenance. These medium-term plans are then consolidated into a company level plan. This is followed by discussions between top- and regional-management to determine how the medium-term plans fit in a long-term perspective and what synergies can be found between regions.

The approach relies on the existence of a planning system that can incorporate harvest, road planning and sales planning. The Heureka system is used for this purpose. The planning model maximizes the net present value of forest operations, including costs for road upgrade and maintenance. The medium-term planning horizon covers 10 years with three seasons per year. The seasons (thaw, bare ground and winter) are attached with costs depending on the ground conditions both for roads and compartments. Each compartment is assigned to a specific road segment that can be either a public road or a forest road. The first time a forest road segment is used an upgrade cost is

activated. Forest-road segments also carry a maintenance cost per season used. The public-road segments that compartments can be assigned to, are given a fixed “turning-space cost”. In addition, a number of restrictions are given to the model, for example the proportion of thinning, or the non-decreasing cut volume. Table 3 shows an example of the outputs of the medium term plan that relates to the use of stands with different ground conditions.

Table 3. *Distribution of harvest activity (ha) on different ground condition classes (class 1, best; class 5, worst) during different seasons for district 3.*

	Season								
	Thaw			Bare ground			Winter		
Year	1	2	3	1	2	3	3	4	5
1	7	3		35	175	39	47	31	43
2	10	2	1	32	170	49	100	5	27
3	8	4		34	189	54	49	33	40
4	13	2		29	212	28	42	25	62
5	10	1		32	213	12	74	19	33
6	13			30	214	15	60	31	30
7	14	0	2	28	181	23	88	12	34
8	9	2		33	201	28	49	44	49
9	15	2		27	212	37	79	29	27
10	11	0		31	214	8	78	9	28
Total	*110*	*15*	*3*	*311*	*1,982*	*292*	*666*	*238*	*373*

The gains of this approach would be increased data quality and organizational commitment. It should also promote coordination, at least within the region. All three aspects gain from better conditions for knowledge creation and better utilizing of knowledge, both knowledge about the state of the forest as well as other kind of knowledge that can be used in the forest planning process.

3 Discussion and Conclusion

KM theories give an understanding of how data, information and knowledge can be managed to improve corporate performance. With a process view of KM, it needs to be considered how knowledge is, or can be, created, how it should be stored, retrieved and transferred and, finally, what means should be put in place to apply the knowledge. To make KM work**,** it is important to have appropriate channels, senders and receivers that understand and are motivated, occasions to gain tacit knowledge where it cannot be codified and codifying schemes where it can be (Krone *et al.*, 1987). KM also concerns the content of the knowledge, for example, its reliability and how long the information can be kept and used before it is outdated.

Paper I traces the processes that are associated with the forest information in long-term and medium-term forest planning. The general mode of forest planning is top-down and the KM strategy is based on a push strategy. This is not surprising, considering the long tradition of using the current strategy of forest planning among Swedish forest companies. It is characterized by efficiency and managers along the line know where to find information. Concerns can be raised about the long chain of transmissions that knowledge travels down and what this means for the preservation of the meaning of the message. The top-down nature of the process and the relatively long time between meetings of the different levels in the organization about long-term forest planning may raise concerns about how well the local knowledge in the organization is promoted and utilized.

Paper II traces in more detail how forest medium-term planning and sales planning are conducted and how the latter is supported by the former. The main finding is that the sales managers do not use information in the forest plan to plan their sales. You would expect that sales are based on what products you have in the plan, but this is not usually the case. The sales managers said that they preferred to use historical sales data they have collected and managed themselves instead of using data from the forest plan

when they planned their sales. They know the origin of the data and what has been done to it. They also have knowledge of relevant changes in the environment since the data were captured. The sales managers expressed distrust of the plans for several reasons. One reason was that they had experienced the unreliability of the information. One other possible source of distrust, described in paper III, is that they may expect information not to be reliable since the compartments that are actually harvested are not always found in the plan. If the forest information was more reliable, the willingness to use the planned harvesting volumes for sales planning might increase. Another reason is that the information was presented in an unsuitable way. This could be due to difficulties to find the information, either because it is stored in a database the sales manager is unfamiliar with or because the sales managers' needs as users were not addressed when developing the software applications. Furthermore, there is a turbulent environment where the customers are expected to change their requirements, sometimes at very short notice.

This distrust or lack of understanding is something that can also be found in the results of paper III. In this study, the focus is on forest planners and harvest managers and the way they interpret the information in the forest plans and in the TB. The delivery plans and changes in customer demands are ever-present issues for the harvest manager. The harvest managers have to work with the stock of compartments in the TB, which is the result of the long- and medium-term planning process. From the long-term perspective, it is important to follow the forest planning decisions that produce the TB, but from a short-term perspective, it might be more important to meet the demands of customers or mills. The material from the study confirms this description; forest planners and the harvest managers often approach and think about the TB in different ways. The problem with this is expressed in different ways, for example, by the feeling that the TB is too small or that the harvest managers actually say that they do not trust the information supplied by the forest planners in the TB. This may then lead to a reduction in willingness to follow the plans thus forming a vicious circle. There are also planners and harvest managers that express the opposite opinion, that using the information in the TB works as intended. This suggests that, with a well adapted KM strategy, the mistrust of the different parts of the forest planning process could be overcome.

Thus, the deliberate top-down push strategy that is exercised in Swedish forest companies has its drawbacks from a KM perspective. The problems are of different natures. The problem with the link to sales planning seems to be that sales planners are left out of the planning process. In KM terms, the transferring process has not been adapted to fit the sales managers as receivers

of the knowledge from the planning process and, thus, they do not have easy access to the information.

The problems of linking long-term and medium-term forest plans with the short-term forest plan are generally related to the perspectives of the knowledge suppliers to the TB, the forest planners and the consumers of that knowledge, the harvest managers. This is in agreement with Storey et al. (2012), that a problem in information quality can be found if one unit is collecting information and another is using the information for decision-making. According to Storey et al. (2012), when one unit in a company collects information and another uses the information to make decisions, those who collect the information are influenced mainly by their own costs and not by what is beneficial for the entire company. Storey et al. (2012) suggested that the decisions should be moved to the units that collect the information to let the entire company gain from decisions about information collection. In forest planning, another idea could be to move the decisions on information collection and which compartment to select into the TB, to the harvesting managers. The cost for information collection would then be closely related to the harvesting profit (if any). The main benefit would be that the compartments in the medium-term plan had to be visible to the harvesting managers and so the harvest managers would gain knowledge about the medium-term plan. When making the selection into the TB, the harvest managers would be aware of available compartments in the medium-term plan and they would have to handle rare attributes over seasons and years. However, this scheme requires additional procedures that ensure that the long-term plans of the company are respected.

Another phenomenon that could occur when linking long-term and short-term plans has to do with emergent changes of strategies. Even though forest planners discuss with the harvest managers which compartment to select into the TB, the end result is often that the TB is overlooked and the selection made from outside it and maybe even from outside those defined in the medium-term forest plan. According to Mintzberg and Waters (1985), this behavior is emergent and it pushes the realized strategy away from the intended strategy. A more deliberate strategy is not necessarily more successful than an emergent strategy: "...the degree of deliberateness is not a measure of the potential success of a strategy." (Mintzberg & Waters, 1985). A company with a poor strategy will probably be better off if the strategy becomes more unrealized, than if the strategy is completely deliberate. If the strategy pattern adapts to the environment or to (maybe new) capabilities in the company, the strategy is emergent, but it is probably also more successful, than the planned strategy. The risk is that the emergent behavior makes the management lose its control

to special interests within the company. However, "... emergent strategy does not have to mean that management is out of control, only – in some cases at least – that it is open, flexible and responsive, in other words, willing to learn."(Mintzberg & Waters, 1985).

There is, therefore, a need to meet the requirements of the different levels of the company and to use more knowledge in the plans. By using more accurate information and assumptions when planning, the realized plan can be closer to the intended plan. Still, the company needs to learn in order to be able to achieve competitive advantage and that will require that emergent strategies are put into the plan. When planning the forests, the company possesses knowledge that could be useful but currently unutilized in the top-down planning hierarchy. One way to approach these requests of using knowledge within the company could be the use of a more bottom-up oriented planning process. This is discussed in paper IV. The idea is to integrate knowledge from all levels of the company to secure better data, commitment and coordination. The context is a two layered company, the top-level and the district level. The process is to follow a conventional top-down-bottom-up procedure consisting of (i) the top-level setting the value of some general parameters, (ii) each district forming its medium-term plan with a medium-term horizon where employees with different areas of expertise form teams for this task and (iii) the district plans being consolidated into a company plan for discussion between district and top-level managers. The latter two steps could, of course, be iterative if necessary.

As mentioned above, knowledge can, among other things, be divided into tacit or explicit knowledge, general or specific knowledge and into individual or social (Alavi & Leidner, 2001; Zack, 1999; Nonaka, 1994). For the purpose of examining the knowledge needed in the forest planning process and its management, it may help to divide knowledge into three operational categories, all treating knowledge as an object: i) forest knowledge, ii) other company-specific knowledge and iii) all other knowledge. This categorization could be made more detailed with subcategories. Forest knowledge is the explicit, situation-specific knowledge that can be stored in databases. It is consequently mostly social. This knowledge could be handled in a bottom-up planning situation in a way that increases the reliability of the plan. The employees at the district level know specific things about the forests and can thus add to the existing forest knowledge. The differences from the top-down planning would be limited, though.

The next operational category of other company-specific knowledge is harder to define since it is more complex. In Paper II, two parts of knowledge from this category are examined: sales knowledge and knowledge *about* the

forest planning. This category contains all knowledge used for developing forest plans that is about, or connected to, a company. This knowledge is specific since it is only applicable within this specific company, but within the company context, it can be seen as either specific or general. The category contains everything in and about the company, from its internal routines and guidelines to how to use the company-specific software or what products that must be delivered to what mill. This knowledge can thereby be both tacit and explicit, as well as both individual and social. If implementing a bottom-up planning perspective for the forest plans, this category of knowledge would be better utilized. Here is company specific knowledge that can be hard to transfer to the company top level, or that would be hard for top level management to process. This knowledge will be possible to use in a bottom-up process. This type of knowledge, with its origin at district level, will be new gained knowledge for the planning process.

The last operational category of knowledge used in a forest-owning company is the largest and most undefined: all other knowledge. This knowledge is general in the sense that it includes all "everyday knowledge". This knowledge can also be specific, but then specific in a context that is not related to the company, for example, specific knowledge of forest management that is common among foresters in Sweden. This third kind of knowledge is also either tacit or explicit, since it covers any kind of knowledge and it is largely individual**,** with most of the social knowledge within a company being found in the first two operational categories. In this last category, social knowledge can be found, but this is social in other groups rather than the company itself. Using this knowledge in a bottom-up planning process would improve the plan. The employees' knowledge of local conditions can be of great importance when developing a valuable forest plan.

In a company, the operational category of forest knowledge contains different explicit knowledge depending on what task an employee has. Here, focus has been on forest planning, hence the forest knowledge. The fact that different groups of employees have different knowledge in the first operational category makes the management of the knowledge somewhat more complex. When thinking in KM terms, this knowledge must be defined and stored in a purposeful way. Everyone who needs it must be able to reach it in a way that suits their task and the knowledge must contain useful parts that can be trusted by different users. Knowledge in the next operational category, other company-specific knowledge, is more complex to manage than forest knowledge. Attention must be paid to knowledge in this category, such as how directives are followed and which routines are used in the company. Knowledge in the last operational category is undefined – it is everything else. When identifying

important knowledge from this category, again, the task perspective is needed, as the knowledge in this category is explicit and tacit, general and context-specific knowledge as well as individual and social. This knowledge includes, for example, emergent developments in the environment, which could be highly valuable to bring into the planning process at an early stage, either it is market or technical turnarounds or the attitude of local stakeholder groups. A bottom-up oriented approach could pose advantages in this respect compared with the current procedure.

The VRIO perspective tells us that the way a forest company organizes the knowledge resource could give it sustained competitive advantage. Data sources and planning procedures have been stable over decades, but the situation is changing. To adapt to the constantly changing forest-related markets and the inflow of new technologies, the company must be a learning company, not just to gain competitive advantage but also to avoid losing to competitors. This thesis has pointed to some difficulties facing forest companies in this respect. It has also described some opportunities to deal with those issues, the value of KM analyses in general and the use of such analyses for forest planning in particular.

4 Future Research

This thesis has identified a number of problems related to current forest planning procedures and suggested an alternative, bottom-up oriented, approach. The discussion of future research topics will focus on the new approach, recognizing that much research is still to be done within the current planning paradigm.

If a bottom-up approach to forest planning were applied, a new organization around the planning process is needed in the forest owning companies. A first step would be to investigate what management at different levels would think of the benefits and drawbacks of the bottom-up approach? The study conducted here is more of a thought experiment and does not go into the actual aspirations and motives of those involved. From a top level perspective, the benefits could be that using knowledge from lower levels in the organization would increase the trustworthiness of the plan and the willingness of following it. At the same time, initiative and control is moved down the line in a way that could be controversial. The employees at regional and local level would be affected of this approach. Their thoughts about this planning process, where their knowledge is utilized in another way, are an interesting issue for future studies. Which benefits and drawbacks do they see in this approach? Will the usage of compartments from outside the TB decrease with this participating planning approach? Will they gain better insight into what data is available? Will they see a value in spending time with other specialists in the district when developing the plan?

There are a lot of research issues concerning the bottom-up approach that needs to be elaborated before it can be implemented. One issue concerns the relation between the organizational levels. In the illustration of the approach in study IV one could trace a lack of guidance from top to middle managers. The amount and form of instructions given by top level management is probably a critical element that needs further studies.

The forest plans are the basis of several other plans. It seems that these different plans, for example, the sales plan, the purchase plan and the road plan, are made one by one with the current forest plan as one input. A holistic perspective of the planning in the forest owning companies would be favorable in order to get all plans depending on each other a common base. How would these plans be planned, in accordance with the medium-term forest plan, in a superior way? Even with a holistic perspective there is a need for structure to keep the planning problem manageable.

If incorporating the other plans in the bottom-up planning of the forests, the forest planning process would increase in time and a large amount of additional work would be needed to complete the planning. Would the total amount of planning time also increase, or would this integrated approach actually decrease the total planning volume and the time needed for planning activities?

From study IV it is obvious that the forest DSS needs to be developed further. The system does not adequately address certain issues concerning road construction and use. Furthermore, the research instrument used for producing the plans needs to be made operational. The process of developing the software as part of the planning process should stimulate a lot of research.

Once the premises for the approach has been clarified and a more specified planning process developed the nest step of the approach would of course be to try out the bottom-up procedure on a factual case. Only with a practical application, the many research questions raised above can be truly put to test.

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