

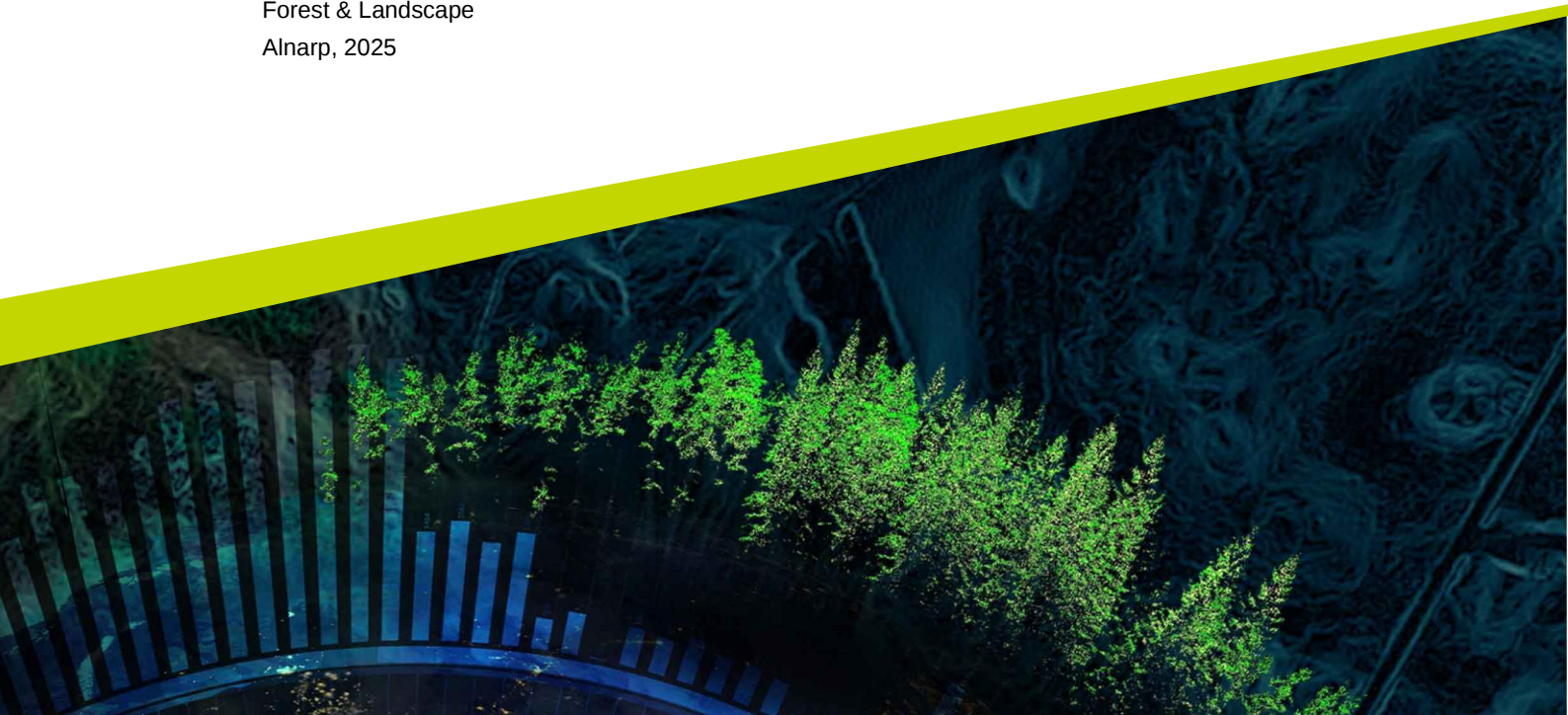


Reducing equivocality in Continuous Cover Forestry:

Communication practices among forest machine
operators and forest managers in Southern
Sweden

Olof Edström

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Swedish University of Agricultural Sciences, SLU
Southern Swedish Forest Research Centre
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Reducing equivocality in Continuous Cover Forestry:
Communication practices among forest machine operators and forest managers in Southern Sweden

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Abstract

Swedish forestry is under pressure to adapt to an increasing demand for Continuous Cover Forestry methods both from policy level decisions, as well as from private forest owners. A growing amount of evidence suggests the potential of CCF methods to increase biodiversity and provide higher social values in forests when compared to Rotation Forestry. However, implementation of CCF is partly to be understood as a communications issue. As new practices set new demands on forest professionals, mutual understanding regarding new goals and objectives can only come about through different processes of communication. To generate an example of and understand already existing practices during CCF work processes, this thesis examines the ongoing implementation of CCF in large scale forestry management in Southern Sweden through a single-case study. Data was collected through qualitative interviews with forest machine operators and forest managers and analysed through thematic analysis. Results show a that the same system used for Rotation Forestry practices is applied but used differently. That is, a system of communication where one-way and two-way communication coexist, but with greater reliance on direct contact through verbal and visual communication combined with well-established channels of written instructions during current CCF work processes. This is understood as a response to the equivocality associated with implementing new practices, such as CCF, and that reducing that equivocality requires both technical and organizational adaptation. However, this is also a sign of a method under development, where communication through iterative feedback processes shape both the work process and the forest structure outcome.

Keywords: CCF, communication, forest management, forest planning, forest machine operator, forest manager, qualitative methods, communication systems,

Table of contents

List of tables	5
List of figures.....	6
Abbreviations	7
1. Introduction	8
2. Theoretical background	10
2.1 Communication definitions	10
2.2 Communication in forestry operations	12
2.3 Information processing.....	14
2.4 Communication system.....	15
3. Research design	16
3.1 Analysis framework	17
4. Methods and materials	18
4.1 Data collection.....	18
4.1.1 Participants	18
4.1.2 The interview guide development.....	19
4.1.3 The interview procedure	19
4.1.4 The interview settings	21
4.2 The case	21
5. Results	24
5.1 Communication system in CCF work processes	24
5.2 Communication functions and preferences	26
5.3 The managers' perspectives.....	28
6. Discussion & conclusions	30
6.1 Limitations.....	32
6.2 Conclusion	33
References	34

List of tables

Table 1 List of participants, which interview or focus group they participated in and the duration of each interview. Some interviews were conducted as focus group interviews upon the request of the participants.	18
Table 2 Summary of the interview guide where the Section column refers to the general topics related to research question, the Interview Topics column outline specific areas of the questions asked. The Examples of Interview Questions column includes excerpts from the written guide and the transcripts.	20

List of figures

Figure 1 Illustration based on Lasswell's Linear model of communication. Source: Kabiru Haruna & Abd Ghafar 2018.	11
Figure 2 Convergence Theory of Communication: Convergence is the motion towards mutual understanding between two or more individuals. Convergence through communication is described as an iterative process where feedback processes incrementally lead to a mutual understanding. Source: Rogers & Kincaid 1981.	12
Figure 3 Model of Communication System in forestry practices. Agents (presented as green circles) and their one-way or two-way connections (uni- or bidirectional arrows) through channels (presented as pink hexagons) and the content transmitted between (presented as grey rectangles).	15
Figure 4 Distribution of areas managed by SSL throughout the county of Scania. (Personal Communication 2025)	22
Figure 5 Illustration of SSL's forest land management vision as balancing values related to biodiversity, economy in timber production, recreation and climate change adaptation. (Sandell Festin 2025)	23
Figure 6 Illustration of communication system in SSL forest operations. Agents, Channels content, content form and t, formats and the ways they are used in CCF work between SSL forest managers and their contracted forest company and forest machine operators. Arrows indicate one-way or two-way communication.	25

Abbreviations

Abbreviation	Description
CCF	Continuous Cover Forestry
CI	Compartment Instruction
SSL	Stiftelsen Skånska Landskap (eng. Scanian Landscape Foundation)
SLU	Swedish University of Agricultural Sciences
RF	Rotation Forestry

1. Introduction

In Sweden, Continuous Cover Forestry, further referred to as CCF, is currently a niche practice but with an increasing interest in society in general and the forest sector. Of Sweden's total land area, 23,6 million hectares or 58% is made up of productive forest land (SLU 2025). Out of these, 778 thousand hectares or ~3,3% were estimated to be managed through some form of CCF management in 2023 (Skogsstyrelsen n.d.). CCF methods, as defined by the Swedish Forest Agency, are silvicultural methods that do not create clear-cuts, which are in turn defined as areas larger than 0,25 ha and where Swedish law requires regeneration based on forest height and density (Skogsstyrelsen 2021). CCF methods include selective logging, patch cuts and shelterwood systems. Through several studies, both in Sweden and internationally, there is increasing evidence that different CCF methods can deliver higher ecological and social values when compared to clear-cut forestry (Hertog et al. 2022). Nonetheless, there are several barriers to implementation of CCF which are rooted in the level of investment into clear-cut forestry within the Swedish forest industry and the culture and traditions this has produced during previous decades (Hertog et al. 2022). Previous processes changing the status quo in Swedish forestry, such as the implementation of environmental certification, has been studied and understood as a communications problem as it put new demands on each part of the supply chain, and thus inducing a change in culture in the sector (Keskitalo & Liljenfeldt 2014). Similarly, the demand for CCF methods in Swedish forestry is increasing, and the implementation of these should be, partly, understood as a communication problem as it too sets new demands on the forestry chain of production.

Communication is relevant for forestry as forestry deals with management goals and objectives, ranging from financial ones to those concerning biodiversity and sustainability of the environment. Mutual understanding of these goals and objectives come about through different kinds of communication. Swedish rotation, or clear-cut, forestry has a high-tech and well-developed system of communications and tools for transferring forest objectives between levels of operations, e.g. forest manager to forest machine operator. As the demands on forest output shifts from timber production to a wider range of ecosystem services, the required forest management changes accordingly. This increases demands on both forest planners and machine operators, as highlighted in a state-of-the-art review on CCF in boreal Nordic countries by Rautio et al. (2025). Among others, the review notes three important factors for the implementation and development of CCF methods relevant to this thesis: 1) Improving planning and working methods to reduce damage to remaining trees and the surrounding environment, 2) adapting working methods to the work environment. Here,

harvester operator skill and expertise are identified as key factors as both productivity and quality of work are essential factors in harvesting operations. And 3) that these developments require cooperation between stakeholders at all levels within forestry, including forestry machine operators, contractors and other forest professionals.

In CCF management, operation objectives formulated by the forest management planner may range from stand or landscape level down to instructions regarding individual trees. This requires more detailed instructions from the forest planner or manager, as well as a higher degree of detail in the given instruction and sets high requirements on machine operator skill (Rautio et al. 2025). Forest machine operators play a crucial role in shaping the forest structure. When dealing with detailed instructions for specific values or goals it is important to ensure communication clarity between forest managers and forest machine operators. Identifying differing communication preferences among forest practitioners at strategic and operational levels can therefore aid in developing the CCF work process.

This thesis focuses on the communication that occurs during the CCF work process between forest managers and forest machine operators. Through a single-case study design, it seeks to generate an example of how CCF is currently being applied in a large-scale forest management organization in Southern Sweden and what methods of communication between forest managers and forest machine operators are being employed to enable it. In a case study, in cooperation with the Scanian Landscape Foundation (in Swedish *Stiftelsen Skånska Landskap*, and further referred to as SSL), forest machine operators and forest managers are interviewed regarding how they communicate when working with CCF, as compared to clear cut forestry. As forest managers and forest machine operators work at a threshold where forest management theory is transformed into action through management operations, ultimately altering the physical environment, the forest, communication between these groups becomes an important factor for the forest structure outcome. The findings contribute to a deeper understanding of how communication practices enable or constrain adaptive forestry work. By examining communication as both a medium and a process of convergence, the study provides insight into the practical challenges and workarounds that emerge when organizational change meets field-level realities.

Within the organization of SSL, this study aims to answer the following research question:

- What communication practices have emerged between forest machine operators and forest managers during the implementation of CCF work processes?

2. Theoretical background

2.1 Communication definitions

Communication is context dependent and occurs within different social structures by which types of communication can be categorised. Using Rosengren's (2000) definitions, a basic level of social structure of communication is the group, defined as a group of less than 20 individuals, with a joint identity based on a common goal which can be either implicit or explicit. Furthermore, the group adheres to some more or less informal structure as well as some kind of informal or semi-formal leadership. Communication within or between groups and their surroundings describes the act of group communication. A subcategory to the group is the organization. An organization has, by Rosengren's definition, a formalized, more or less hierarchical structure, an explicit goal as well as a system of standardized procedures for decision-making and communication. In contrast to the group, where characteristics of individuals define the positions within the group, the position, or social rule, within the organization defines the desired characteristic(s) to be possessed by the individual who is to hold that position. Based on this definition, and distinction, group communication is categorised into two main forms; formally defined communication between individuals of different positions within the group and informally defined communication between individuals located at specific positions in the organization. The organizational level constitutes the scope of communication structure of this study, but to conduct study on different aspects of communication within an organization, the concept of communication itself needs to be defined.

According to Lasswell's linear model (1948), communication is defined as "*who – says what – in which channel – to whom – to what effect?*". By this framework, important aspects of communication are outlined (Figure 1). Here, the who is the communicating agent, or sender of what is said, or the message being sent. The message describes the content of the communication which, in turn, is passed on to the receiving agent, the whom, through a chosen medium or channel of communication. The last phase of communication in this model is effect, which suggests that the resulting outcome of communication is itself part of the communication and that the outcome is potentially shaped by the previous phases. Applying this model to a case study allows for an initial mapping of the building blocks of communication within the studied organization: the communicating agents, the channels and forms of communication they use, and the content being transmitted.

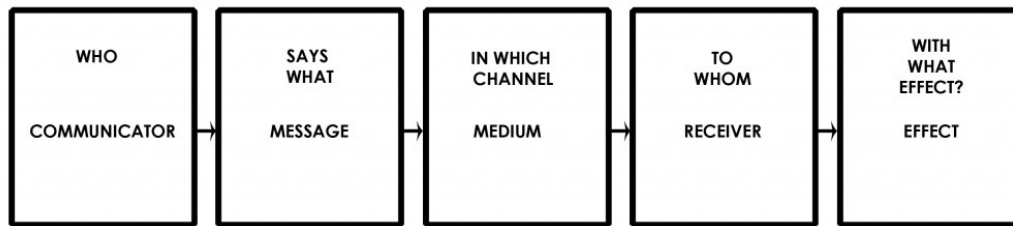


Figure 1 Illustration based on Lasswell's Linear model of communication. Source: Kabiru Haruna & Abd Ghafar 2018.

Lasswell's model is linear and provides an understanding of one-way communication. A two-way understanding of communication is provided by the Convergence Theory of Communication (Kincaid & Rogers 1981). This theory represents communication as an iterative process rather than an action, as it emphasizes the sharing or exchange of information between two or more participants in dialogue. Convergence is defined as:

“the tendency of two or more individuals to move toward one point, or for one individual to move toward another and to unite in a common interest or focus” (Rogers & Kincaid 1981 p.65)

The iterative dynamic of convergence theory stems from the incorporation of feedback processes, defined as diminishing series of corrections which allows the participants, or agents, to converge toward a state of greater mutual understanding, enabling cooperation, or to diverge toward a state of disagreement, potentially leading to conflict. This links mutual understanding (convergence) to cooperation, and disagreement (divergence) to conflict, which enables analysis of communication as a source of either successful cooperation or resulting conflict due to disagreement.

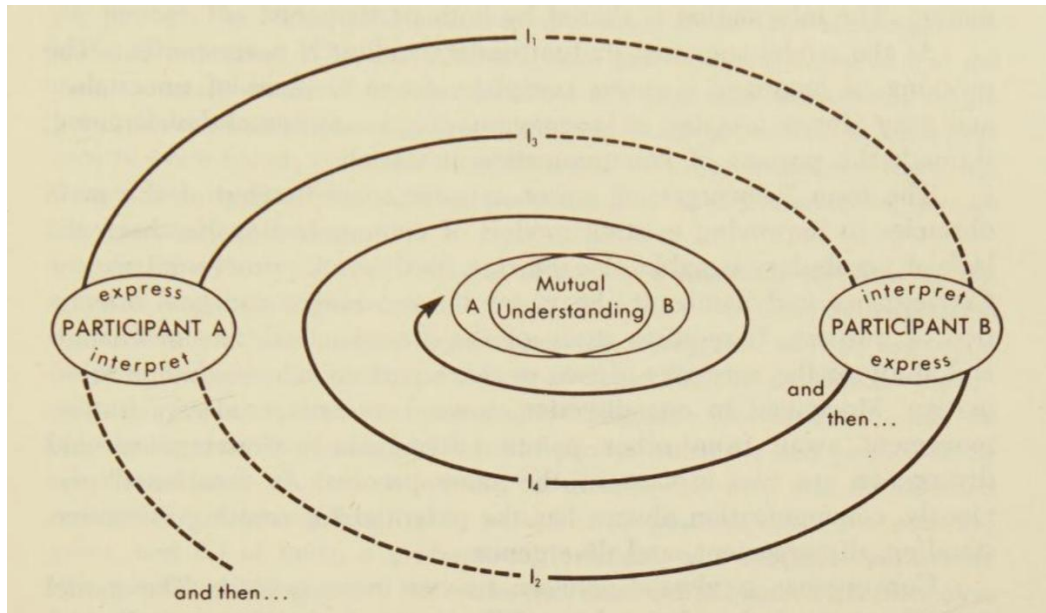


Figure 2 Convergence Theory of Communication: Convergence is the motion towards mutual understanding between two or more individuals. Convergence through communication is described as an iterative process where feedback processes incrementally lead to a mutual understanding. Source: Rogers & Kincaid 1981.

For this study, the building blocks of communication are categorised to allow for a mapping of the different aspects of the occurring communication within the organization of SSL. Based on Lasswell's linear model the categories of agent, content, channel are used. Added to these are form, frequency, and purpose of communication. Content can be instructions, goals, complaints, suggestions, feedback or questions. Examples of channels include emails, phone calls or text messages, maps, apps, face-to-face meetings or other vehicle through which communication is conducted. Form is related to channels but highlights if the communication is for example written, verbal or visual, digital or physical. Further categorization by one- or two-way communication as well as formal or informal organizational communication based on the frameworks presented above will also be incorporated to produce an understanding of the prevalent patterns and pathways of communication within SSL.

2.2 Communication in forestry operations

In the context of this study communication is the link between forest managers and forest machine operators. Since the 1980s in Sweden, these groups have gradually separated into contractors and customers, where the machine operator is either part of or sole member of a company, while forest management and planning has remained in the forest owner or timber buyer organizations (Johansson et al. 2021). Previous research on communication in forestry operations have focused on the role of digitalization and Information and Communication Technologies, or ICTs (Gavilanes Montoya et al. 2023;

Jäntti & Aho 2024) and machine operators' experiences of wellbeing (Best & Visser 2024) for productivity. However, to my knowledge, few papers have looked at communication in collaborative efforts during work processes. Forestry is largely related to management goals and objectives, carried out through the combination of forest operations and time. A central tool in communication between forest planner and operator is the compartment instruction (known as *traktdirektiv* in Swedish). This instruction functions as a bridge between the forest operation planner and the machine operator. The content of the instruction should include information regarding both the compartment, and/or stand, as well as the exact measures that should be implemented in the forest management operation at hand. The compartment instruction is an example of a well-established communication practice that is relied upon in rotation forestry. In Fennoscandian rotation forestry, aside from what is written in the compartment instruction, it is in practice the responsibility of the machine operator to choose which trees to fell and which ones to save (Rautio et al. 2025). When, new requirements are set on the output of forest operations, the content of the compartment instructions change. For example, the implementation of forest certifications in Sweden added several environmental considerations and required outputs to the forest operation process such as deadwood and nest tree conservation (Keskitalo & Liljenfeldt 2014). These had to be mutually understood by both the forest operation planner and the forest machine operator to be effectively produced. Keskitalo & Liljenfeldt, in their 2008 study of implementation of forest certification (FSC, PEFC) in Sweden identified the process as highly related to

“implementing a culture that places great demands on communication between different part of the felling and forest management chain, from the top management to the contractor in the field.” (Keskitalo & Liljenfeldt 2014)

Similarly, Hertog et al. (2022) identifies CCF as a niche practice with the potential of changing the status quo of rotation forestry (RF) in Sweden, and that the slow uptake of CCF is partly due lack of knowledge among forest professionals, but that the underlying explanation for that is related to culture within the forestry sector. In CCF management, operation objectives formulated by the forest management planner may range from stand or landscape level down to instructions regarding individual trees. This requires more detailed instructions from the forest planner or manager, as well as a higher degree of detail in the given instruction and sets high requirements on machine operator skill (Rautio et al. 2025).

2.3 Information processing

Information processing is the acquisition, recording, organization, retrieval, display, and dissemination of information (Slamecka 1998). Information processing and communication are intertwined processes. Communication is a form of information processing through which information is gathered and disseminated (Burton et al. n.d.). In their paper on the relation between organizational structure and information processing, Daft and Lengel (1986) suggest uncertainty and equivocality as the two main forces influencing information processing. Using their definition, uncertainty is understood as the lack of information and can be reduced through the acquisition of new or more data. This requires that the organization works in an environment or with an issue where questions can be asked and answers obtained. Equivocality on the other hand is synonymous with ambiguity. It is “the existence of multiple and conflicting interpretations about an organizational situation” (Daft & Lengel 1986 p. 556). High equivocality means confusion and lack of understanding. And that asking a yes or no question is not feasible as participants are either uncertain about what questions to ask, or a situation is ill-defined, and if questions are asked, they will not result in a clear answer.

The necessity to reduce uncertainty leads to the acquisition of objective information to answer specific questions. Equivocality is reduced by exchange of existing views among the involved actors to define problems and shared interpretations that can direct future activities. Daft and Lengel (1984) report that face-to-face media has been found preferred for messages containing equivocality, while written media has been preferred for unequivocal messages. In high-equivocality situations, organizations prescribe fewer rules for interpretation and allow for rapid cycles of back-and-forth communication through direct contact, this could mean face-to-face meetings or communication over the phone.

This view provides an understanding of the roles and functions of communication in organizations. Communication is a form of information processing but also enables other forms of information processing. The need to reduce uncertainty and equivocality leads to different structural mechanisms within organization as uncertainty is reduced through acquiring the needed data while equivocality is reduced through generating mutual understanding.

2.4 Communication system

To make sense of the communication processes in forestry practices, a simple adapted communication model is proposed (Figure 3). In this model, the above-mentioned building blocks of communication and their connections are illustrated. The sum of these connections between different agents through different channels can be understood as the flows of communication within the organization. In this model agents (green circles), their one-way or two-way communications (uni- or bidirectional arrows) through channels (pink hexagons) and the content transmitted between them (grey rectangles) are mapped as a network of connected nodes. The model does not assign weight or importance to channels, agents or contents. It simply maps what connections exist within the network and in what scenarios they are active.

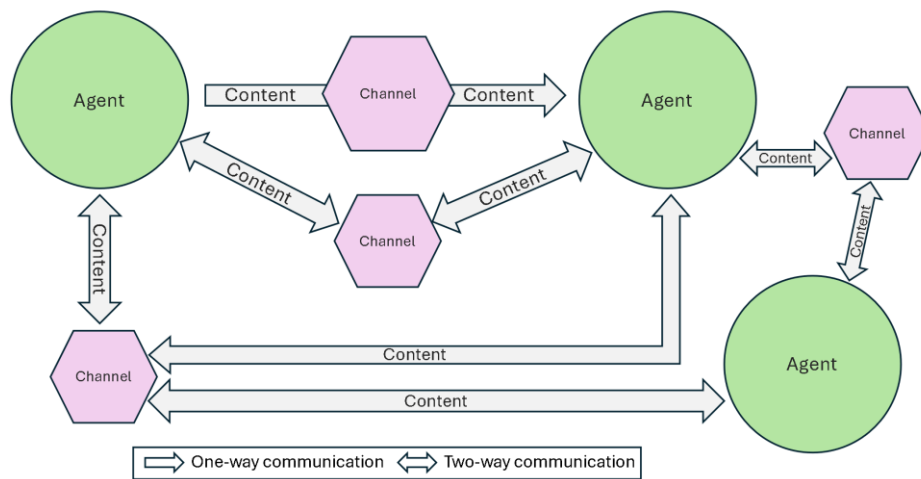


Figure 3 Model of Communication System in forestry practices. Agents (presented as green circles) and their one-way or two-way connections (uni- or bidirectional arrows) through channels (presented as pink hexagons) and the content transmitted between (presented as grey rectangles).

3. Research design

This study employs a qualitative approach through an exploratory single-case study research strategy (Yin 2018). The case study research strategy is suitable when examining contemporary phenomenon, in this case the communication and work practices associated with CCF work, within real-life contexts, work teams of forest professionals within a forest organization in Southern Sweden. In case studies, contextual conditions are seen as important factors for understanding the phenomenon itself and case studies enable examination when boundaries between phenomenon and context are not clear (Yin 2006).

As mentioned, CCF in Sweden is a niche practice, and the limited uptake is partly assigned to lack of knowledge, data and research (Hertog et al. 2022). As such this study uses an exploratory approach, with the aim of generating insight into processes, practices or issues within a little-studied field. It is a single-case study as it is potentially revelatory; examining CCF related work practices within a forest organization is not a common opportunity as the practice itself is not common. The unit of analysis is the groups working with CCF, managers and operators, the communication or interaction between them, the process of CCF work, and the context in which these units exist which I term the manager-operator threshold. The descriptive information, regarding how things are done, obtained through this research strategy should be of value for further research, especially as exploratory single-case studies may not be considered complete studies in and of themselves, but rather initial investigations (Yin 2006).

Regarding the generalizability of single-case studies, there are several ways of thinking. Flyvbjerg (2006) writes of the single-case study, as ideal for generalizing through falsification of propositions, and that the “force of example”, e.g. one produced through a descriptive study of a phenomenon, is an underestimated source of scientific development. In a similar vein, Stake (1995) puts forth the view that the main point of case studies is not generalization, but particularization. This means examining a particular case thoroughly, emphasizing uniqueness, which requires knowledge of what makes the case different from others. Both Yin (2006) and Stake (1995) emphasize the importance of triangulation of sources as the foremost method of generalizing from a case study, and that in case study research, analytical generalization is relied upon to generalize based on a particular set of results to some broader theory. In this case the theories of communication, socio-technical systems theory and media richness theory.

This study considers SSLs implementation of CCF as an example of a unique phenomenon, from which the aim is to learn, or reveal, how communication is conducted within this context, why that is, and if it is relevant to other organisations. The main data source here will be the qualitative interviews and the policy documents of SSL.

3.1 Analysis framework

Data was analysed using thematic coding in order to identify patterns across interviews (Braun & Clarke 2006). All interviews combined make up the data corpus, the data set consists of the collection of interview parts regarding the research topics, a data item is a specific interview section and data extracts are the quotes used to exemplify results. Coding was deductive as it was based on pre-defined research questions regarding communication. Data items were coded with focus on communication with the aim to identify patterns regarding communication across the whole dataset.

The data corpus was thus scanned for questions and replies regarding aspects of communication between forest managers at SSL and forest machine operators contracted by SSL. These aspects include channel, format, frequency, sender/recipient and purpose of communication. The category channel includes, email, phone call or text message, maps, apps, on-site meetings or other vehicle through which communication is conducted. Form is related to channels but highlights if the communication is written, verbal, visual, digital, physical. Content can be compartment instructions, instructions, goals, complaints, suggestions, feedback or questions. Sender/recipient is either forest manager, forest machine operator or intermediary. Prompts include unexpected issues, suggested change, need for clarification. Also considered during this process were routines of communication, combinations of communication forms, as well as examples of instructions which were seen as clear/unclear or useful/less useful, roles in communication and preferences regarding communication. These categories are based on the definitions of coding presented above in combination with initial familiarization with the material and functions as a base for the initial coding. Based on this a network analysis was carried out to map the flows of communication within the organization of SSL.

4. Methods and materials

4.1 Data collection

The scope of this study is delimited to the context of the organization of SSL and its immediate surroundings. Within this context the study is focused on the implementation of CCF and associated communication processes. To gain insight, the aim was to gather information from individuals with personal experience regarding the topic and to collate and analyse this information. To do this semi-structured, qualitative individual interviews and focus group interviews were conducted. As the goal is to gain insight on particular experiences regarding a contemporary phenomenon, a study was designed to map the organizational mechanisms surrounding CCF work and to explore the emerging communication practices among the managers of SSL and the machine operators carrying out CCF in SSL forestlands.

4.1.1 Participants

With the assistance of SSL, all machine operators who had experience in both conventional clearcut forestry and CCF work commissioned by SSL as well as all (three) forest managers employed at the time of the study were contacted and scheduled for interviews. Table 1 describes the study participants, the interview they participated in and its duration.

Table 1 List of participants, which interview or focus group they participated in and the duration of each interview. Some interviews were conducted as focus group interviews upon the request of the participants.

Interview ID	Participants (shorthand)	Duration (hours:minutes)
Operator 3	Operator 3 (O3)	0:57
Operator 4	Operator 4 (O4)	0:34
Operator 5	Operator 5 (O5)	0:40
Focus Group ID		
Operator 1+2	Operator 1 (O1) Operator 2 (O2)	0:56
Manager 1+2+3	Manager 1 (M1) Manager 2 (M2) Manager 3 (M3)	1:03

4.1.2 The interview guide development

An interview guide (Table 2) was developed based on the research question. The guide was divided into topic categories and arranged for a suggested logical flow of the interview while still allowing for flexibility and follow-up questions. The topic categories were as follows: Introduction, CCF, communication with manager, instructions, uncertainty and misunderstandings, learning and feedback. Within each section, questions were developed, refined and expanded on to mitigate redundancy, adjust formulations for conversation, and to manage the number of questions within the planned interview timeframe of 60 minutes. Experiences from RF was used as a comparative baseline for questions regarding CCF practices. Questions were designed to allow for simple follow-ups and to be expandable.

4.1.3 The interview procedure

The research coordinator at SSL, M1, set up the interviews and was in contact with interviewees before they took place. Prior to carrying out the interview a privacy policy statement and participation consent form, together with a short summary of the topics of the interview was distributed to each participant. This was done to make sure the participants were aware of the expectations ahead of time and to create a suitable environment for carrying out the interviews. With the aim of attaining more natural responses and to avoid premeditated answers, the complete interview guide with all the questions was not distributed.

All interviews took place in the working environments of each participant. Machine operators were interviewed at their current working site, often just next to their equipment. This provided an environment where interviewees could reference their physical work environment during interviews. Forest managers were interviewed as a group in their shared office. This was done upon request of the interviewees.

The reason for interviewing both managers and machine operators were to be able to study the communication between the strategic and operative levels of forest management. The intention to gain a comprehensive understanding of both sides' ideas of what constitutes common problems and hurdles, as well as solutions or important forms of communication would hopefully enable an identification of consistencies and/or discrepancies between forest managers and machine operators regarding the chosen topics.

For each interview, the author and the research coordinator drove out to each operator's current working site. This worked as an opportunity for the author to introduce the purpose of the project further.

Table 2 Summary of the interview guide where the Section column refers to the general topics related to research question, the Interview Topics column outline specific areas of the questions asked. The Examples of Interview Questions column includes excerpts from the written guide and the transcripts.

Section	Interview Topics	Examples of Interview Questions
Intro CCF/RF	Background CCF Experience CCF/RF differences	Describe your education background or work life experience in forestry What comes to mind when I say CCF? What previous experience do you have working with CCF? Is it different working with CCF compared to RF, if so, in what way? Are there practical challenges when working with CCF, if so, what are they?
Communication Instructions Feedback	Comm. w/ manager Comm. preferences Instructions, feedback and learning	Does the communication between you and the manager differ when working with CCF? - In what way? What type of communication is most common and how often does it occur? - What do you usually talk about? How do you usually receive instruction, through what channel? - What level of detail? Is there a way you prefer receiving instructions, if so, why? Are there opportunities for feedback between yourself and the manager? - What does the feedback usually concern?
Communication Uncertainty Misunderstanding	Comm. w/ manager Dealing with uncertainty and misunderstandings	Have you experienced a situation when you were uncertain on how to proceed while working with CCF? - What did you do then? - Did that resolve the uncertainty? Have you experienced any misunderstandings between yourself and management? - What happened and how did you proceed?

4.1.4 The interview settings

As mentioned above, all interviews were conducted on the current worksite of each participant, and all interviews were conducted during working hours. The sites of the harvester machine operators were spread across northern Scania and were accessed by car.

The first interview (Operator 1+2) was conducted at a young spruce forest stand about to be thinned, on a site not under SSL management. The interview lasted for one hour. With two participants, answers to some questions were in some cases more thoroughly developed by one of the two and sometimes resulted in dialogues between the two participants.

The second interview (Operator 3) was carried out in the morning at a site that did not belong to SSL. The interview lasted for one hour. The forest of operations was young spruce stand where thinning was being conducted.

The third interview (Operator 4) was conducted in the morning in a mature beech forest on a ridge, on a site not owned but managed by SSL. Accompanying the harvester operator was a chainsaw operator, who did not participate in the interview. The current operation was diameter class felling of large volume beech trees. The interview lasted 34 minutes.

The fourth interview (Operator 5) took place in a young spruce forest where a first thinning was carried out which was not under SSL management. The interview time was 40 minutes.

The fifth interview (Manager 1+2+3) was conducted at SSLs office. This interview was conducted as a focus group interview with all three forest managers present. Initially, each participant got to take turns answering each question, at some certain points answers developed into dialogues among the participants, after which the following question or topic in the interview guide was brought up by the interviewer. The duration of the interview was 1 hour and 3 minutes.

4.2 The case

The county of Scania is located in the southernmost part of Sweden, and consists of roughly 38% forested land, mostly concentrated in the northeastern half of the county, and 42% agricultural land in the southwestern part (Skånsk Skogsstrategi & Erik Bergqvist 2018). SSL is an important forest actor in Scania, as it manages ~9000 hectares of productive forest land distributed across the county (SSL 2023).

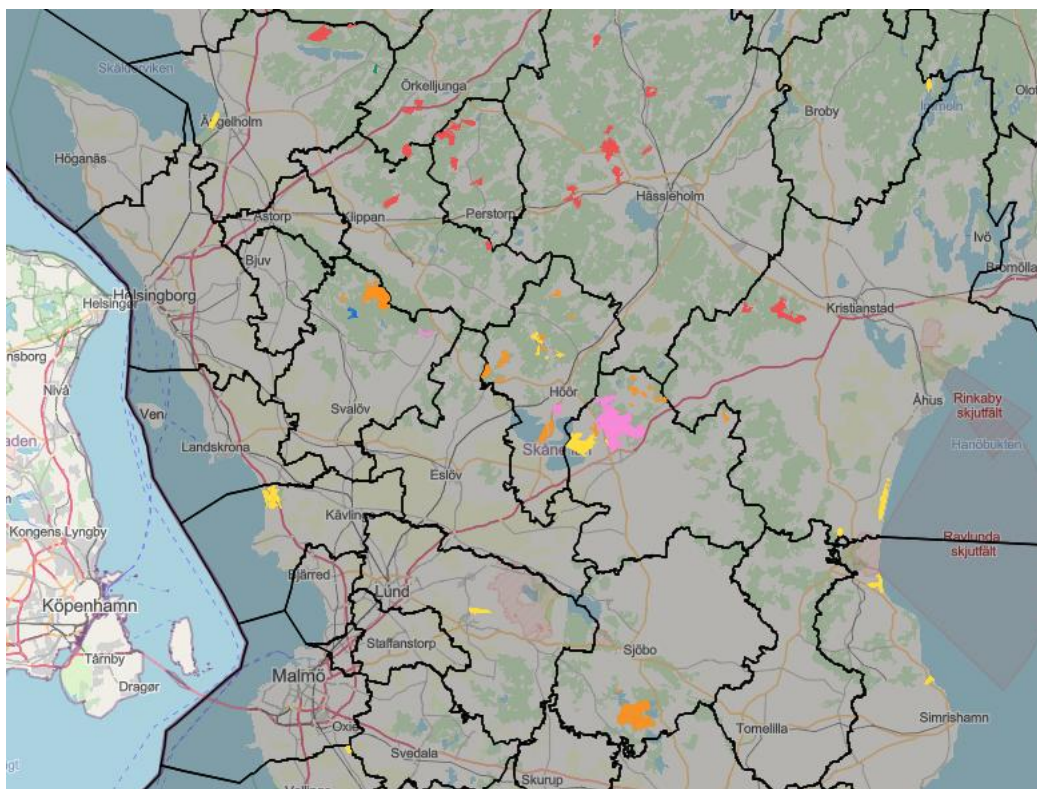


Figure 4 Distribution of areas managed by SSL throughout the county of Scania. (Personal Communication 2025)

The foundation was established in 2004 by the Regional Council of Scania, which partly funds the foundation and for which the foundation manages parts of the forest land under county jurisdiction. According to its mission statement (SSL 2023), the aim of the foundation is:

“To protect, preserve, restore and develop natural and cultural environments, as well as promote outdoor recreational activities”

In their current forest strategy, to support these goals through forest management, SSL emphasizes multifunctional and adaptive forestry management methods as pathways to balancing the values in the landscapes they manage. These values include climate change adaptation, supporting biodiversity, timber production and recreation (SSL & Bernö 2022).

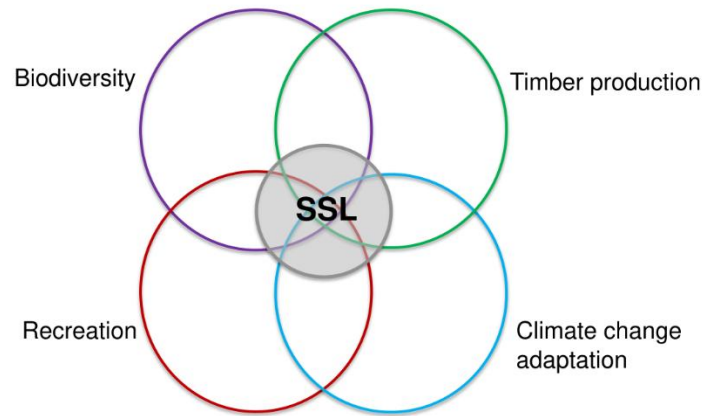


Figure 5 Illustration of SSL's forest land management vision as balancing values related to biodiversity, economy in timber production, recreation and climate change adaptation. (Sandell Festin 2025)

Part of the strategy to achieve this is to increase the amount of forest managed through CCF methods by ~100 hectares per year. A process which has been ongoing since 2010. This makes SSL a highly relevant organization for the purposes of this study.

This is a niche context, and results may not be possible to generalize to forestry industry or owners' associations, but hopefully to more public forest organizations like the Swedish church or municipal forest management units. Furthermore, in most parts of Sweden the ecological setting is different from that of SSL and Scania. While Swedish forests are dominated by evergreen species, pine and spruce, Scanian forests contain most native broadleaf species as well. The variation in forest types that SSL manages contribute to the possible expansion of CCF areas. This is because some, like beech forests, are well suited and traditionally managed through CCF under current definitions. This is also in line with the goal of the organization of expanding the broadleaf coverage. Although forest conditions differ across the country and dictates viable management methods, perhaps the communication practices can be transferrable?

5. Results

5.1 Communication system in CCF work processes

Based on extracts from the data set, in which different forms of communication and transferring of instructions was mentioned, channels between forest manager and forest machine operators were mapped (see figure 5). When applying this model of mapping, several channels of communication between forest manager and harvester machine operator can be identified.

Written compartment instructions and the associated maps are transferred from forest manager to the contracted forest company, which in turn forwards it to the app where it is available to all machine operators involved, either via a machine's onboard computer or via phone.

[“it's an app we use where they enter the jobs. SSL uploads the compartment instructions directly into it, writes notes, and draws and so on” -O2]

[“I have it both in the machine, on my phone, and I can access it at home too “-O3]

This is seemingly a one-way communication channel. However, between the app, the onboard machine computers of the forwarder and harvester, two-way communication occurs through continuous exchanges and updates on for example, harvested volume, GPS coordinates of conservation trees or strip roads.

[“Then it carries over to the forwarder if I have the same system in the forwarder. Then I can add to it during the logging. And draw and write things, and then the forwarder operator can see what I have done and not done, and what he should keep in mind.” O3].

Two-way communication between forest manager and harvester machine operator also occurs, verbally, via phone and verbally and visually via on-site meetings. While written instructions are mostly used in one-way communication. Two-way communication mostly occurs through verbal communication either over phone or on-site. When facing uncertainty or when unforeseen issues arise, harvester machine operators routinely contact forest managers via phone calls to ask for clarification of instructions, ask for permission to proceed with a solution to an unforeseen problem or to inform of previously unknown features in the landscape.

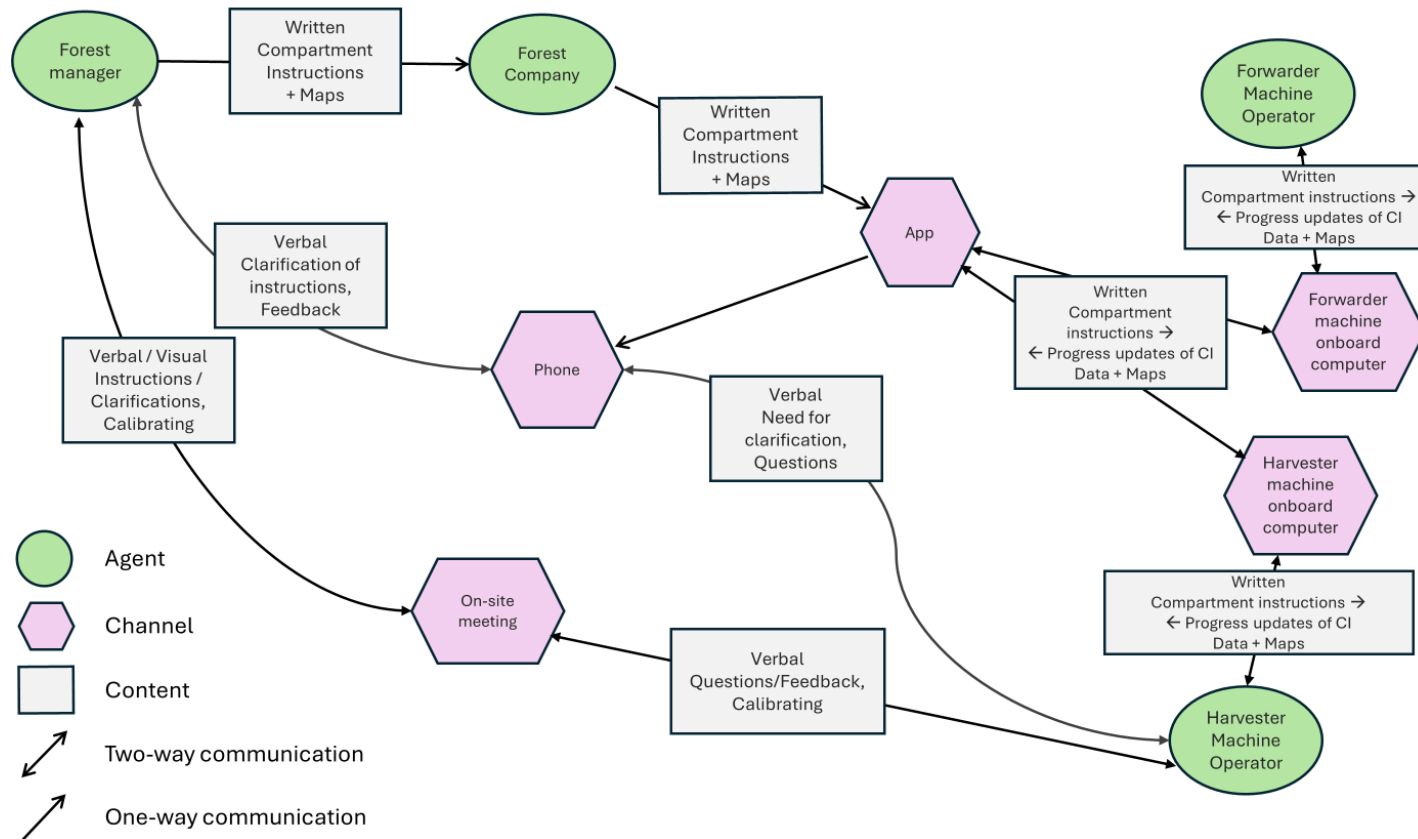


Figure 6 Illustration of communication system in SSL forest operations. Agents, channels, content, content form and formats and the ways they are used in CCF work between SSL forest managers and their contracted forest company and forest machine operators. Arrows indicate one-way or two-way communication.

If this channel of communication is not sufficient to resolve what prompted the initial communication, it can be further used to plan an on-site meeting. The on-site meeting as a channel of communication is mainly used in two scenarios. Either to resolve uncertainty during an ongoing work phase, e.g. if a machine operator is unsure what intensity of thinning to apply, the forest manager can create a reference area by marking the tree they want to have felled or saved.

Or for the forest manager and harvester machine operator to plan an upcoming job together. Although not common, in some instances a forest manager rides along with the forest machine operator in the harvester. This is done to understand what the operator sees during work, for the forest manager to better understand their perspective in operations. The on-site meeting is also the channel through which feedback between both communicating agents mainly occurs. And in general, communication between forest managers and machine operators occurs in both written and verbal form

[“Well, it's both verbal and written — most often, it's a combination of both.”-O3]

5.2 Communication functions and preferences

Among the interviewed harvester machine operators there was a general view that different forms of communication had different functions and that the combination of communication forms are useful when conducting CCF work. That is the combination of written, such as compartment instructions, verbal communication, like discussions during a phone call or an on-site meeting, and visual instructions like ribbons or spray paint to mark individual trees, or groups of trees.

These have separate but connected functions. Written instructions, like compartment instructions, are important as a documented reference of what has been planned. They are sufficient when instructions are general across an area. For example, diameter stems or other familiar practices of harvesting certain sizes or species of trees.

["You could make a note of it and put it on paper — that all stems thicker than 40 cm of a certain tree species should preferably be removed, and all stems thinner than 20 cm should be kept. Then, the middle layer could be thinned in a regular way, but with the whole thing a bit more documented...it's pretty good for me when I'm in the machine, because having it in writing removes a certain element of uncertainty " -O3]

["It has to be on paper and things like that, but the most important part probably comes from meeting face to face.” - O5].

Verbal instructions, like phone calls or discussion during on-site meetings, are considered important for garnering mutual understanding of the goal expressed by the manager. Or when planning operations at a new work area together.

[“You walk around and look at the area based on what you think, and then you bounce ideas back and forth, kind of like that. It’s much more important with continuous-cover forestry that you go through it together.” - O5]

[“And I usually like to ask, ‘What’s your thinking? How do you want it to look afterward?’ Whether I can actually make it happen is another matter, but I need to understand their thinking in order to get close to it.”-O3]

They are also important when instructions are deviating from previously established routines or decisions.

[“If there is something specific that doesn’t follow, if we say the usual norm, then we look together in real life and see what it is and what the idea is” - O3]

What prompts a phone-call or request to meet on-site is usually new issues, uncertainty or unclear instructions regarding specific trees.

[“Yeah, if there's something unclear, you just make a call” -O1]

Or when unforeseen issues are identified by the forest machine operators, for example when a stand description doesn’t match the stand in real life. They can function as an on-the-go problem solving solution. Visual instructions, like marking individual trees to be either felled or not felled, fill a similar function to on-site meetings but do not require both parties to be present at the same time. These are considered as detailed and clear instructions by harvester machine operators but require a high degree of certainty and on-site presence from forest manager.

[“The easiest way is to take a spray bottle out and mark several trees — ‘this one, this one, and this one I’d like you to remove or keep.’”-O3]

Visual instructions are considered more useful than written ones in cases where instructions are detailed or they concern specific features in the landscape, e.g. specific tree species or individual trees.

[“like if there's a birch there, you don't need to write a whole page about it. If it's important, just mark it with a ribbon and write that it should be preserved” – O2]

5.3 The managers' perspectives

For the forest managers, working with CCF is different from RF management as it requires both parties to learn new principles and for the managers to transfer their way of thinking to machine operators.

[“Yeah, they need more detailed information, and as we've mentioned, they need to learn the principles and way of thinking. And that requires us to be out there quite a lot, and first, we need to know what we want ourselves. After that, we can try to communicate it to them, it takes more time, but still.”-M2]

Managers confirmed that visual instructions were the common and preferable method in scenarios when work at new CCF compartment is in an initial phase. Visually marking a group of trees allows both forest manager and machine operator to calibrate their respective understanding of the objective at hand.

[“Yeah, I kind of think like this too — I mark an area as an example, like ‘this is how I’m thinking,’ and if they want me to mark more, I can do that, but I prefer that they try it first without it.”-M1]

But they also specify that visual instructions are intended to work as a guide in further scenarios rather than the actual instructions as. It should work as a training tool more than a rulebook, both for machine operators and the managers themselves, as doing it for each stand or tree would be too time consuming.

[“Because it ends up being an incredible amount of work, and then you don’t build the knowledge to make assessments on your own. It should act as a support.”-M2]

[“You have to do it, because it’s hard to explain if you don’t get it yourself — you know what I mean, you have to see it.”-M2]

Regarding written instructions, forest managers acknowledge that their compartment instructions can be longer than other actors which the machine operator work for. But a higher level of detail and specificity in CCF compartment instructions as compared to RF is also considered as one way of communicating their goal or vision, or way of thinking.

[“We've been told that we write very detailed stand directives compared to many others. Sometimes, for example, machine operators might get something from a timber buyer that just says ‘birch thinning’ or ‘spruce thinning’ and that’s it. Whereas we come with several sentences, like ‘we want spacing of one meter, we want to remove this and that,’ and so on. And I’ve noticed that the machine operators find it more enjoyable too. Of course, you have to trust them, but I also see it as my responsibility, I have a vision and a goal for the stand, and it’s my job to make sure they understand what I want.”-M1]

Vice versa, when it comes to understanding the way of thinking of machine operators, one method used is to, during an on-site meeting, ride along as the harvester machine operator works to better understand their perspective and how the forest looks from their seat in the operator's cabin. This can also be utilized when there are trees a manager is really concerned about, then functioning as a co-pilot of sorts.

[“Yeah, what we can do with these practical things is to have them tell us what problems and obstacles they face in their work because of this — like, for example, we want to keep as much of the understory as possible, but they still have a job to do. So they need to give us feedback on what the issues are. That's why it's been pretty useful, like we've done sometimes, to ride along in the machine for a bit and see — ‘what does it look like from their perspective?’ That's quite important.”-M3]

These procedures further functions as opportunities for feedback regarding work in both directions. Machine operators are able to inform managers of the requirements the forest machine sets during the work processes, while the manager is able to show what he or she means by certain phrases in the written compartment instruction. Another venue of feedback is the follow-up report, describing the structure of a stand after an operation, in terms of volume and basal area for example. This is considered an area of important potential improvement as it is an important part of planning ahead.

[“if we want to maintain the quality of our plans, we need to have the right information going in — like, what does the stand look like after thinning? If we don't know anything, then we have to guess, and that's much worse than getting some feedback from the machine operator. And ideally, the best would be to go out with an app and take measurements in the stand. But we don't actually have time for that — there's no chance to do it either.”-M3]

Overall, having the opportunity to maintain collaboration over several years is considered an important factor in conducting successful CCF work. This relates both the time it takes to learn the process involved but also the relationship of communication that comes with it, this seemingly holds true for both groups.

[“I mean, we're lucky in that we basically have four or five harvest operators who work for us, and that makes it pretty easy for them to build up a knowledge base. When they come to the SSL and we say it should be continuous cover forestry, they can think back to how we've done it before — and then they go with that. And I think you can really notice a difference now compared to, say, three years ago. The time we've invested has paid off.” - M1]

[“we've come a good way with the approach we've started to implement, and they've taken it on board. And yeah, it goes both ways — if no one knows how we want things done, then nothing will change. So no, they've definitely been receptive. Both sides want a good result in the end.” - O2]

6. Discussion and conclusions

As a result of implementing CCF management methods, several communication practices have emerged within SSL. Most notably, an increased reliance on rich media such as face-to-face meetings, which include both verbal and visual instructions. From an information processing perspective, this can be understood as a response to the equivocality that comes with working under new methods, where available data does not allow for straightforward yes/no answers. Several studies (Hertog et al. 2022, Skogsstyrelsen 2023) have pointed out that data and research on CCF management are lacking.

Although existing communication systems are well-developed for supporting information processing in rotation forestry, these do not appear to translate seamlessly into CCF processes. This suggests a mismatch between the current technological tools and the practical needs of CCF within SSL, which has in turn led to a rise in informal communication practices. This raises new questions: Are the communication technologies developed for rotation forestry inherently incompatible with CCF? Or is it that CCF methods are not yet fully understood or developed enough to be incorporated into existing systems that rely on less rich forms of communication such as written compartment instructions?

According to Daft and Lengel (1986), reducing equivocality and uncertainty requires both technological and organizational adaptation. At the manager-operator threshold within SSL, such organizational adaptation can already be seen, as illustrated by the emerging communication practices in response to CCF implementation. These adaptations have supported collaborative learning, the mutual understanding of new challenges, and the ongoing development of SSL's internal CCF workflow. This exemplifies the broader cultural transformation within forestry needed for CCF to expand further, as noted by Hertog et al. (2022). However, the lack of data, knowledge, and skills available to forest managers and machine operators may hinder the integration of CCF methods and existing information and communication technologies. If these are not currently aligned with CCF needs at SSL, it's plausible they are also misaligned in other forestry organizations. SSL has been gradually expanding its use of CCF methods on its own lands since 2010, making it one of few large-scale forest owners in Sweden to engage with CCF at this level. However, it's important to note that SSL is a foundation, partly funded by the County of Scania, and not an industrial forestry company. This gives them a different financial structure and potentially more freedom to experiment with management approaches that do not necessarily prioritize maximized financial return.

For other forest actors interested in implementing CCF, doing so will require more than just technological upgrades or improved data collection—it will also depend on organizational structures. Designing communication systems that suit the nature of CCF work practices will be essential to overcoming both uncertainty and equivocality. As demonstrated in the SSL case, communication practices tend to shift under CCF due to its higher level of equivocality, whereas rotation forestry generally presents lower equivocality and can be managed using less rich communication tools. In line with Daft and Lengel's (1986) media richness theory, the channels used must be suited to the complexity of the task at hand. While uncertainty can be addressed by gathering more data (which is lacking in the context of CCF in Sweden), equivocality, where multiple or conflicting interpretations exist among work groups, requires richer forms of communication.

At the operational level, the work required to carry out CCF objectives does not always diverge dramatically from practices rooted in clear-cut forestry. However, in this study, the need for on-the-ground, face-to-face communication was notably higher. This heightened need for direct interaction suggests a work process still in development. I argue that this is not a permanent characteristic of SSL's communication and operations, but rather part of a convergence process in which a new workflow is taking shape. Managers and operators are still in a learning phase, they acknowledge they are experimenting, often uncertain of outcomes, yet they proceed collaboratively. This aligns with what Rautio et al. (2025) identified as one of the keys for CCF expansion.

While broader systemic factors continue to explain many of the barriers to wider CCF adoption in Sweden, understanding how these methods are applied and negotiated at the operative level helps to loosen one strand of a very complex knot. Overcoming barriers at the point of execution, by integrating the knowledge and expertise of those doing the work, may make CCF more appealing and accessible to a wider range of actors. In other words, having tangible examples where initial communication hurdles have been addressed could inspire confidence among actors who are interested but not yet convinced. The potential benefits of CCF can only be properly evaluated if the methods are put into practice to some extent, even as experimental trials.

The results suggest that developing mutual understanding of operational goals is a crucial factor for successful CCF implementation. This early-phase convergence is likely a necessary part of any transition to methods that diverge from established routines or norms.

As emphasized by Rautio et al. (2025), the skills and expertise of forest machine operators are central to CCF success. With regeneration and retained trees, as well as natural and cultural values to consider, damage mitigation becomes even more important. Forest managers and operators work at the threshold where theory becomes practice, where decisions directly shape the physical forest. Communication at this threshold plays a vital role in determining forest structure outcomes and the ecosystem services those forests can offer. For instance, choices about which species or tree sizes to retain or remove affect the forest's capacity to deliver a range of ecosystem services, which are critical for sustainable development. Sweden's long-standing use of even-aged rotation forestry has left its forests with relatively low structural diversity (Ericsson et al. 2005). But with increasing interest and pressure for multifunctional forestry that can deliver on multiple ecosystem service fronts, CCF is gaining relevance. To enable its expansion, organizational adaptivity and increased efforts to produce the data are necessary.

Suggestions for further research:

- How do communication practices between forest managers and operators influence forest structure outcomes under CCF?

6.1 Limitations

The choice of research strategy, exploratory single-case study, is due to the time restrictions of a bachelor thesis of 10 weeks. Although a complete case study would be possible with more experience, for a newcomer to the methodology of case study research, this timeframe has necessitated some delimitations which limits both the scope and potential generalizability of the study.

Regarding limitations of the case. The geographical context of Southern Sweden is not representative of most of the forest land in other parts of Sweden. Growth conditions are often better and species diversity higher than in for example Northern Sweden. However, as this thesis focuses on the communication practices rather than biological or ecological aspects of CCF, the findings may still be of value in other contexts. The organizational structure of SSL, being a foundation partly funded by a public organization, may render it difficult to generalize the findings to actors in the forestry industry as these may have different demands for financial returns on investments. Also, as SSL provides operators with work and business opportunities, there is a potential influence on the given answers during interviews. Furthermore, in the first interview (O1 & O2) was carried out as a focus group interview upon the request of one of the participants. Both participants worked for the same company where O2 was one of two owners and

O1 was employed as machine operator. This may have had an influence on the answers given by O1 and having separate interviews would have been preferable. However, this enabled the interviewees to follow up and expand on each other's answers and asking each other follow up questions. Although research coordinator (M1) was not participating or listening to the interviews, instead tending to office duties out of hearing range, the fact that they were involved in the idea of the study and that they organized the participation of the machine operators, may have affected the answers of the interviewees. The questions were not focused on a critique of the managers, but it is still an important factor to mention. However, given the very few cases where CCF is currently taking place it would be difficult to find operators and managers that are not directly connected between each other. There is also a positive aspect of this link between the two types of participants, as they are reflecting on the same experiences but from different points of view.

6.2 Conclusion

This study has examined the communication practices that have emerged between forest managers and machine operators during the implementation of Continuous Cover Forestry (CCF) within SSL. The findings show that the shift toward CCF has brought about a notable increase in the use of rich media, particularly face-to-face meetings that facilitate verbal and visual communication. These practices have emerged in response to the higher equivocality of CCF work, where outcomes are less predictable and existing data insufficient. Communication at the manager-operator threshold has also become more collaborative and adaptive. Rather than following fixed routines, managers and operators engage in ongoing dialogue to develop mutual understandings and respond flexibly to challenges in the field. This shift reflects an organizational adaptation that supports learning and iterative development of new workflows.

Importantly, communication is not merely a support function in the transition to CCF. It is a central mechanism through which the new workflow is being developed. The convergence of practice seen within SSL suggests that rich and informal communication will remain essential, at least in the early phases of CCF implementation. These findings highlight that successful adoption of CCF depends not only on technological or silvicultural innovation, but on the social processes of organizational adaptation and convergence on mutual understanding.

Overall, the study underscores that developing a mutual understanding of operational goals and fostering continuous dialogue are key enablers of CCF adoption.

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