Assessing Rules and Ideas for Stem Selection in Cleaning

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The purpose of this study was to assess explicit and implicit rules and ideas concerning stem selection in cleaning to enable a decision support system for the practice to be developed. Qualitative semi-structured interviews were made with thirteen cleaners, who stated that a preferable stem should be of the desired species, straight, healthy, and have a preferable size and a suitable position in comparison to surrounding stems. Stem selection usually is intuitively made by experienced cleaners. They seem to consider similar attributes of trees, even though their implicit rules can only be partially clarified. This knowledge, in combination with the landowners' instructions, can probably be used in decision support systems for cleanings, which could be deployed in a machine, or be used for training inexperienced cleaners. The findings suggest that selections always should consider species, damage, and diameter. The range of obtaining information seems to be some five meters.

Key words: Forestry, cleaning, pre-commercial thinning, stem selection, decision support, interviews

Introduction

Background

Cleaning (cleaning/spacing or pre-commercial thinning) is a silvicultural tending operation. It is primarily done to improve the growing conditions of the remaining stems, cut stems usually have no commercial value, and are accordingly not removed for utilisation (Anon. 2000). However, a more operational definition of cleaning is the thinning of a stand, where the main part of the cut volume originates from stems of less than 10 cm in diameter at breast height (Pettersson and Bäcke 1998). Cleaning operations can be selective, geometrical, or a combination of both (Berg *et al.* 1973). In selective cleaning the main-stems are chosen individually. A main-stem is a tree that is selected to remain in a stand because it is considered to be of good quality, or at least better than surrounding stems, see also section 1.2. The reasons for making individual selections are usually the desire to create a stand of better quality and/or to influence species composition (e.g. Berg *et al*. 1973). Selective cleaning, hereby denoted cleaning, is predominant in Sweden and Finland, whereas geometrical cleaning is for example used in Canada (Ryans and St-Amour 1996) and for beech stands in southern Sweden and Denmark.

In Sweden, almost all cleaning is currently done motor-manually with brush-saws, and the cleaned area in 2001 amounted to 253 600 hectares (Anon. 2003). The annual cleaned area has decreased and the number of remaining stems in individual stands has increased over the last decade (Pettersson and Bäcke 1998, Anon. 2003). Therefore, it seems that the willingness to pay for cleaning is less than the actual cost. The cost of cleaning compared to logging and scarification has increased in the last twenty years (cf. Anon. 1995, Vestlund 2001a, Anon. 2003). The work is also laborious and this might be one reason why there are difficulties in finding cleaners (Vestlund 2001b). Therefore, new techniques seem to be needed to make future cleaning less expensive and to reduce the human workload. In Canada too, there are concerns that there will be a lack of cleaners and that costs of cleaning will rise (Anon. 2001).

Mechanisation may be a solution. However, mechanised cleaning has been found to induce mental stress because of the high workload, rapid decision-making involved, the constant precision required when manoeuvring the crane and tools, and the severely restricted visibility of the working environment (Gellerstedt 1997). To automate the cleaning, or to release an operator from some of the stress, a system for selecting stems would be beneficial, but this needs formalisation of present knowledge related to cleaning selections.

Cleaning instructions and actual performance

Cleaning instructions exist in written form, i.e. as cleaning manuals (cf. Brunberg 1990, Karlsson *et al.* 1997, Vestlund 2001a). They usually recommend leaving between 1 400 and 4 000 stems per hectare, depending on site quality and species, when cleaning stands with an average height of three metres. The recommended number of stems can vary for a given site quality and species with some 15-30 % in different instructions (e.g. Pettersson and Bäcke 1998, Anon. 1999, Normark and Bergqvist 2000). The instructions

are based on research regarding the effects of mean spacing of a stand on volume yield and quality parameters such as branch size (Persson 1976, Pettersson 1992, Nyström 2001). Generally, instructions also state that preferably straight, vigorous, and undamaged stems should be selected to remain (e.g. Karlsson *et al.* 1997). These instructions are quite general, and describe the desired result of cleaning, but do not state how cleaning operations, including selection, should be executed in detail.

Scientific knowledge about the actual outcome of different decisions made when selecting between individual trees during cleaning is limited. Pettersson (2001) argues that the volume growth per stem is increased by an even distribution. However, generally every other stem in young Scots-pine stands have some kind of damage, usually a spike branch or crook, and these damaged trees are more or less clustered in the stand (ibid.). Selecting stems for optimal stand development is therefore complex.

So, whether following the written instructions render desirable results at an individual level remains uncertain, but since cleanings are performed, there seems to be tacit knowledge, i.e. persons involved in cleaning seem to have an implicit understanding of how to acquire relevant information, make selections and proceed within the stand. In order to develop a decision support system, the selection rules must be derived and formally stated. A decision support system (expert system) aids the decision analysis process and explains the basis for the given recommendations (Giarratano and Riley 1998, Daume and Robertson 2000b). Such a system could also be a useful tool for training inexperienced cleaners.

For stem selection, two types of attributes need to be analysed, singletree attributes and relational attributes (Füldner *et al*. 1996, Daume and Robertson 2000a). For example: a tree is not just large according to its age (singletree attribute) but also to the mean dimension of the stand (relational attribute). In order to make optimal selections of main-stems the expected utility of the attributes for each course of action needs to be calculated (cf. Keeney and Raiffa 1993). However, it is not necessary to find the best solution. Instead, Daume and Robertson (2000b) argue that quickly finding a sufficiently good solution is the crucial feature of a practical decision support system. Kahn (1995) found that more than one criterion (attribute) must usually be considered in the decision-making process before cutting a stem during thinning.

Purpose

The purpose of this study was to assess explicit rules and implicit rules and ideas used in cleaning in order to facilitate the development of decision support systems for stem selection in cleaning. This was based on the assumption, that written instructions are too broad, and must be complemented with the cleaners' knowledge and experience in order to obtain a profound knowledgebase, as the links between the written instructions and the results of cleaning are currently vague.

Material and methods

This study was conducted according to the standard qualitative methodology (e.g. Patton 1990, Strauss and Corbin 1990, Creswell 1994, Denzin 1994, Fontana and Frey 1994, Miles and Huberman 1994, Yin 1994, Coffey and Atkinson 1996, Holme and Solvang 1997, Kvale 1997, Eisner 1998). Thirteen cleaners were interviewed in 2001 using semi-structured interviewing (Patton 1990). At first, some main headings were created, and a pilot-interview with a single cleaner was conducted. Then, a more detailed interview guide was constructed (Appendix 1), providing the basis for the questions asked during the interviews with the thirteen cleaners. Initially, three persons were interviewed (Vestlund 2001b). Subsequently, ten more interviews were conducted to extend and strengthen the findings from the first round. Not all questions were put to every person and the questions were not asked in any specific order (Patton 1990, Holme and Solvang 1997). This interview method has been adopted by various previous authors, such as Bliss and Martin (1989). The responses obtained in the pilot-interview were not used in the results.

The names of cleaning entrepreneurs and cleaners with varying experiences were obtained from forest companies and research colleagues. The interviewed cleaners (Tab. 1), all men, were either entrepreneurs themselves (5) or employed by an entrepreneur (8). Most of the commissions were obtained from industrial forest owners, but some also worked for non-industrial private forest owners, denoted NIPF owners. The cleaners worked in central Sweden, in the counties of Värmland, Västmanland, Uppland, Gästrikland, and Hälsingland. It was difficult for the cleaners to define how much time they had spent on cleaning,

Table 1. Information about the thirteen interviewed cleaners

Age-class	Number	Years worked professionally in forestry on various tasks		
		Mean	Minimum	Maximum
up to 30	3	2.85	0.05	6.5
31-50	3	7.00	2	10
51 and older	7	33.71	20	40

as it is not usually done when there is snow on the ground. However, it ranged from two weeks to at least 20 years, and the ten cleaners with more than two years cleaning practice were referred to as experienced cleaners. Three of the interviewees stated that they had formal forestry education.

The statements the interviewees made mostly concerned themselves, but in a few cases they referred to other cleaners, or cleaners as a group. The interviewees were informed about the purpose of the study in broad terms. To provide anonymity, names and places were removed from the material. All interviews were taped and then transcribed. Interesting information was clustered and checked for similarities or disagreements. The interviews were then interpreted and presented under a few headings as the findings were complementary and no real discrepancies appeared. The results were presented as a generalised image, a *gestalt* (Eisner 1998). From this *gestalt*, further abstractions were made. The abstracted results were compared with a selection of the literature regarding cleaning instructions (Brunberg 1990, Karlsson *et al.* 1997, Anon. 1999, Normark and Bergqvist 2000). The conclusions from these comparisons were used to form a set of basic rules for selective cleaning.

Miles and Huberman (1994) state that in order to avoid alienation and mystification a qualitative report should be written with active verbs, personal stance and straightforward expressions (cf. Denzin 1994). The results are therefore presented in active voice.

Results

Instructions given to the cleaners

Cleaning an industrially owned forest is often rather stereotypic. The instructions given state that 2 000 to 2 500 stems should remain per hectare, regardless of site quality. Some companies vary the number of stems per hectare more than others do. It was stated that a company required 2 200 to 2 300 stems per hectare over the whole area, while reasoning that the cleanings should not be too complicated. The minimum distance between two stems ranges from 50 cm to 100 cm, for different companies. Allowed percentages of deciduous stems in coniferous stands vary from about 5 to 20% for different companies and in different parts of Sweden. The persons in charge of the cleaning operations at the companies may also decide upon the number of deciduous stems to retain: some favour them and others do not. It was stated that to improve cleaning performance in the industrially owned forests, the landowners must provide more detailed directives regarding their quality preferences and how they want the stands to appear after a cleaning.

Most NIPF owners have a different attitude towards cleaning than the industrial forest owners. The former seldom have clear ideas of how cleaning should be conducted. Their interest is mainly to reduce the number of stems, although a few of them request "quality/a nice stand". The cleaners have more freedom on NIPF owned properties since they are free to create the results, and the NIPF owners are mostly pleased with their work. After cleaning, NIPF owned stands usually differ from industrially owned stands as they have more remaining stems per hectare and sometimes a higher percentage of deciduous stems.

Preferred characteristics of main-stems

A main-stem should have high quality, which is described as being of the preferred species, straight, and healthy with thin branches. Stems with straight branch-angles and a healthy leading-shoot are also preferred. Moreover, the main-stem should have an advantageous position and possibility for crown growth.

For main-stems, the cleaners try to select stems with diameter and height equivalent to the surrounding main-stems. Although, if two stems are considered equal with respect to the quality and potential for crown growth, the stem with the largest diameter is usually selected. A thin stem might be preferred in a young stand, but in a relatively older stand, thin stems must be cut as their ability to compete is weak. A pine of good quality can be recognised, when it is at least three metres tall, by looking at the height of self-pruning in comparison to surrounding stems. Deciduous stems should be lower than pine stems so that their crowns are separated, otherwise the deciduous stems will damage the pines by whipping. However, spruces can tolerate larger discrepancies in the canopy (compared to pine).

Practical selection

Skilful, experienced cleaners state that their selections are made automatically, whereas less experienced cleaners sometimes need to think for a brief moment. No two cleaners perform cleaning in the same way; there are variations in remaining stems per hectare and the percentage of deciduous stems, but the overall result is usually accepted. The cleaners do not have any problem separating species, but they cannot easily explain how they do it, though attributes they mention are colour of the needles and bark, and also the branch-structure of the trees.

The cleaners only have a short time to make their selections, so they are constantly looking around, forming opinions about the stems as they walk through the stand. At first, obvious candidates for

cutting are removed. These stems are conspicuous within the stand, being either large stems with thick branches (wolf-stems), or small suppressed stems. Thereafter, there are fewer stems to choose between and the selection becomes easier; choosing which stem to leave often "comes naturally".

It is more important to leave stems of good quality than to achieve a desired spacing. In spots with few stems, all stems are left, because it is better to have stems of poor quality than none at all. If the stand contains few stems of good quality, i.e. with the above mentioned characteristics, inferior or unwanted stems, like wolf-stems, stems of undesired species, or damaged stems, must be accepted as main-stems since no better alternatives exist. Selections are made on the basis of expected future profitability and investments already made, i.e. larger trees and planted trees are favoured. However, an inferior stem competing with a stem of better quality is always cut. Small stems can be left untreated, and most cleaners state that the height of these stems should be no more than 0.5 metres, whereas others argue that stems up to one third of the mean height of the stand can be tolerated. However, it was also stated that all stems close to a main-stem should be cut, to facilitate the subsequent thinning.

The visibility in a stand is generally about five metres, sometimes up to ten metres. Cleaners "look through" the stand in search of main-stems. Visibility in a pine stand is much better than in a deciduous stand, especially in summer. About three, but occasionally up to ten, main-stems are always selected in advance, so that the cleaning can go on continuously. If the space between main-stems is wide (two metres or more), it is not possible to distinguish more than three stems at a time. These selected stems can be changed, though, as the cleaner approaches them and new information evolves. Within the nearest one to two metres, the cleaning is already made in the cleaner's mind, but there is no major planning ahead beyond this.

Difficulties

Cleaning should be done according to the given instructions. But occasionally they cannot be followed, if it is discovered that the results then would become inferior. The most common reason for this is that the desired species cannot be selected, due to absence or damage.

Cleaners consider an even stand with many stems of the wanted species, i.e. many good options, easy to clean. In this respect early cleanings, especially natural regenerations, are better than delayed cleanings. In stands where cleaning is delayed, competition results in damaged stems so most selections are forced. These stands are also unstable, as the crowns have become elevated, and must be thinned out gradually to prevent further damage due to factors such as snow and wind. Cleaning is also more difficult if the stand is too dense, i.e. has many stems per hectare or many stems in seed spots.

The most common types of stem damage in cleaning stands are caused by whipping or moose. Certain young forest areas of Sweden are so heavily damaged by moose that the planted pines cannot be selected as main-stems. Basal crooks originating from plantation cause further problems. By looking at the stem and the shoots, or by checking the colour of the trees, damage can be discovered. Discoloured needles or leaves, needle loss or too many needles indicate damage. Root swelling and/or hanging branches on the lower branch whorls can reveal root-rot in spruce. It was also mentioned that a damaged stem can be distinguished by the bark's roughness. However, not all damage is revealed. There is no time to check the reverse side of the stems, and sometimes moose damage is difficult to detect. Inexperienced cleaners often have a greater tendency than experienced cleaners to leave too many stems per hectare, as they do not have the same awareness of the results. It was stated that it can be difficult to leave stems at a wider spacing than two metres, especially for birches. Sometimes mistakes are made and the wrong stems are cut, this may be due to concealed damage or through negligence, for example, the saw blade may slip and damage a main-stem. Experienced cleaners think that less experienced cleaners sometimes detect damage too late; a beginner may not know exactly where to look. Cleaners without experience need more control and supervision, but within a season most people can probably reach 90% of a professional cleaner's technical ability as well as perceptual capacity. However, to be an experienced cleaner takes some years, and no one is ever flawless.

There can be visibility problems in deciduous stands, however this can be dealt with by postponing the cleaning until the leaves have fallen. Weather conditions can also cause problems, for instance both sunshine and rain reduce visibility.

Foundations of cleaning knowledge/experience

Today, many entrepreneurs and cleaners do not have much contact with the assigner during the work and feedback is sparse. Previously, cleaners working for forest companies had training-days, in which a cleaner cleaned a designated area and an expert gave him feedback as he worked. If anything was done wrongly, it was easier to correct than it is today. Presently, cleaners usually make one or perhaps two sam-

ple plots per day to check if the number of remaining stems is correct. The number of remaining stems per hectare is also checked by the forest owner, but only after the work is completed. Such follow-ups might also include information on the variety of species, the height of the main-stems, and the number of damaged stems. Experienced cleaners do not perceive this shortage of information from the owner as a problem. They have worked with the companies for many years and feel that the assigners trust their work. Occasionally the person in charge of the cleaning finds inaccuracies in the cleaning and issues a rebuke, but such situations are usually resolved through discussion with the supervisor and the cleaners. The result of the company's' follow-up is that if the cleaning is acceptable, the cleaner is offered commissions for the following year. NIPF owners seldom make any formal checks. However, those who want "quality" are interested in the way the cleaning is conducted and are usually pleased with the results, as far as the cleaners know. Cleaners think that they could make better selections if they have more time to perform their work. Today the pressure is high since the payment per hectare is about the same as it was ten years ago.

Comparison of implicit and explicit rules

The implicit "rules" that the cleaners use to complete their work differed somewhat from the explicit rules, which were extracted from published literature/ cleaning manuals (Tab. 2). There are apparent differences in the number of requested stems per hectare and the height allowed for untreated stems. There are also dissimilarities for example regarding the unwanted characteristics. Note that the interviewed cleaners all work in central Sweden, but the literature concern the whole of Sweden.

Discussion

The research method

Qualitative methods can be used to gain an understanding of individual behaviour and motivations that are unknown *a priori*, for example how cleaning is performed (cf. Bliss and Martin 1989, Strauss and Corbin 1990). Since no previous research, to my knowledge, exists about cleaners' selections during cleaning, data were gathered from persons involved in cleaning.

Table 2. Abstracted implicit and explicit rules for cleaning in industrial owned forests

Category	Cleaners Implicit "rules"	Manuals Explicit rules
Stems per hectare	2 000 - 2 500	1 400 - 4 000
Minimum distance between stems	50 - 100 cm	60 cm - 100 cm [1,3,4]
Preferred "position"	possibility for crown growth	distance between stems should not be greater than twice the recommended spacing [1]
Preferred stem characteristics	of the preferred species, healthy leading-shoot, straight, undamaged, small branches, straight branch-angles, "equivalent" to surrounding stems	of the preferred species [4] vigorous, undamaged, small branches, straight branch-angles [2]
Unwanted characteristics	stem- or shoot damage, basal crooks, discoloured needles or leaves, needle loss or extreme amounts of needles, root swelling, hanging branches at the lower branch whorls	small stems, damaged, wrong species [1] stem crooks, top failure, spike knot, very thick branches, stem damage [2] wolf-stems, damage [4]
Allowed percentages of deciduous stems in coniferous stands	5 - 20%	at least 10% [2] 5 - 20% [3,4]
Height Coniferous/Deciduous	Pine crowns must be separated from deciduous crowns	even canopy (especially pine stands) [4]
Allowed height for untreated stems	0.5 m - 1/3 of the mean height of the stand	lower than 30 cm [1] less than 1/2 of the mean height of the stand [2,3]

The manual with most information is used as a reference for the table ([1] Brunberg 1990, [2] Karlsson *et al.* 1997, [3] Normark and Bergqvist 2000, [4] Anon. 1999).

For qualitative studies, data can be obtained in six forms: documents, archival records, interviews, direct observations, participant observations, and physical artifacts (Yin 1994). For this case study, documents (Berg *et al*. 1973, Persson 1976, Brunberg 1990, Pettersson 1992, Anon. 1995, Karlsson *et al.* 1997, Pettersson and Bäcke 1998, Anon. 1999, Normark and Bergqvist 2000, Nyström 2001, Pettersson, 2001, Vestlund 2001a, Anon. 2003) were used to acquire a theoretical framework on cleaning. As regards observations, they are problematic in studying cleaning, since there are few safe positions from which valuable observations can be made. Studying artifacts requires in-depth knowledge of the stands before and after cleaning, and it does not elucidate the cleaners' reasons for making certain choices. Therefore, interviews were chosen as the main method. Different forms of interview (e.g. structured, unstructured or semi-structured; Patton 1990) are suited to different situations (cf. Fontana and Frey 1994). Semi-structured interviews use a guide, that can be modified over time, to focus attention on areas of particular importance or to adapt to changing circumstances or new understandings (Bliss and Martin 1989, Patton 1990). In order to catch the viewpoints of the interviewees, they should be free, as far as possible, to modify the course of the interview, so the guide should not be followed servile (Holme and Solvang 1997). Coffey and Atkinson (1996) state that data should never be collected without substantial simultaneous data analysis. Therefore, not all questions were asked to all cleaners, as some questions yielded few or no answers. Usually interview studies consist of 15 +/- 10 interviews (Kvale 1997), but there are no strict criteria concerning sample sizes (Patton 1990). More interviews do not automatically lead to better knowledge or good science, but interviews are likely to be much more revealing if the interviewer has a good background knowledge of the subject (Kvale 1997). As the author has considerable theoretical knowledge and practical experience of cleaning, this prerequisite was considered to have been fulfilled in this study. There is no statistical test of significance to determine if qualitative results are valid (Eisner 1998). To overcome this limitation, cleaners with varying degrees of experience of forest work were interviewed, since Patton (1990) states that any common patterns that emerge from great variation are of particular interest and value in capturing the core experiences and central, shared aspects. Accordingly, it was assumed that the inexperienced cleaners' expressed ideas on cleaning should concern more basic and probably more fundamental issues than those of experienced cleaners. For the latter category the knowledge how to perform cleaning is becoming tacit and harder to express. The retrieved information was believed to be sufficient to meet the aims of the study.As advised by Strauss and Corbin (1990), the very first interviews were entirely transcribed and analysed before proceeding to the next interviews (Vestlund 2001b). Qualitative studies concern the process of understanding, by building complex, holistic pictures, formed with words and reporting detailed views of informants (Creswell 1994). Thus, the results were presented as a *gestalt*, that matches a pattern or overall quality beyond the individual attributes (Eisner 1998). Consistent with the qualitative approach, the findings can be subjected to alternative interpretations.

Results

Generally, landowners' instructions to the cleaners are mainly concerning the desired results. How these results are to be reached is left to the cleaners to a large degree. Some cleaning manuals give more explicit descriptions of how the work could be executed (e.g. Brunberg 1990). However, the interviewees never mentioned them as a source of knowledge about cleaning performance.

The assigners seem both to trust their cleaners to perform the cleaning appropriately and to be pleased with the results. This is interesting, since more than half of the cleaned stands in a Swedish inventory had more than 4 000 stems (larger than two cm in diameter at stump-height) per hectare after cleaning (Pettersson and Bäcke 1998), although the number requested according to the cleaners is seldom more than 2 500 in industrial forests. If the true target is around 4 000 stems per hectare, stipulating 2 500 stems is appropriate, since it yields the desired results, but to apply this instruction into a decision support system would fail, because the system would give recommendations that strictly followed the instructions. However, it is likely that the instruction for 2 500 stems is closer to the companies' true targets, and the more dense cleaning results are a product of poor communication and/or laborious, stressful working conditions. A related aspect is that there is a discrepancy between the stated requests and the forest companies' published cleaning manuals. Another apparent difference between the cleaners' statements and written instructions concerns the height allowed for untreated stems (Table 2). There might also be other differences which were not detected here. However, current instructions might change in the future, as they have done in the past (e.g. Söderström 1980), but they must be considered, and used as a basis for stem selections.

Follow-ups by industrial forest owners are usually restricted to counting stems per hectare, and per-

haps the amount of deciduous stems, but the cleaners state that there is no follow-up regarding the types of stems that are left on an individual level. The follow-ups do not reflect the selections the cleaners have made. The cost would certainly rise with such a follow-up, but it could be valuable since the cleaners would like more immediate directives regarding the companies' actual requests. A NIPF owner may undertake some kind of a follow-up, but he/she seldom communicates such knowledge.

Humans dealing with complex situations use only a few data for making decisions. We have access to our own knowledge and experience, but the amount we can retrieve in a meaningful way seems to be limited. Thus, the knowledge of a human expert is often heuristic in nature, based on useful "rules of thumb" rather than absolute certainties (Cawsey 1997). Accordingly, the cleaners in this study use complex attributes in a complex manner, but are not aware of how they do it and are unable to express their rules. A skilled cleaner "knows" by experience what he is supposed to do and achieve, and does not find the selection difficult.

However, there is little reason for pursuing the aim of revealing these "rules of thumb", since the cleaners get limited feedback. This makes the quality of these rules questionable, since feedback is essential for persons to learn how their rules work (cf. Magnusson 1978). Without feedback the rules also become individual, every cleaner makes his own rules. Some cleaners have been working with cleaning for many years and have probably acquired their rules in the past, when they had feedback. However, the requested performance parameters might have changed over the years. Lack of feedback is clearly a problem of the new generation of cleaners and might be a reason for the inability to reach the requested density.

The cleaners expressed clear preferences concerning the characteristics of main-stems, which is most interesting. This implies that they use similar inputs for their "rules of thumb", even if their rules are individual. These preferences were to a large extent the same for all of the cleaners (Table 2). However, inexperienced cleaners mention the attribute diameter to a greater extent than experienced cleaners. With increasing experience more sophisticated attributes, such as height of self-pruning or straightness of the branch-angles are mentioned. It seems that experienced cleaners no longer need to explicitly examine the diameter of trees; they probably "feel it", i.e. perceive it at a sub-conscious level. These attributes should be considered when developing a decision support system for cleaning.

Thus, as initially assumed, the correlation between the instructions and the results seems to be poor. The cleaner, the given instructions, and the stands' characteristics determine the outcome and if sufficiently good decisions can be made in practice. These findings are consistent with reports by Daume et al (1997), who found that thinnings are connected to the thinning personnel, and Kahn (1995), who found that tree selection for cutting during thinning was based partly on subjective criteria and partly on indistinct instructions. However, satisfactory results can be reached through a variety of cleaning performances. It is important, for silvicultural practices in general, to know the probability that a given instruction will generate a specific result. However, this calls for research beyond the scope of this paper.

Conclusions

A decision support system must give advice that meets the landowners' requests, and it has to be adjustable to the various instructions that could be given. The selection of main-stems is important, but must be quick to be cost-effective. Optimal selection of main-stems requires information that is very difficult to obtain as cheaply and quickly as it is needed. Therefore, cleaning is and must be done with a satisfying rather than an optimal approach. The human way to solve complex problems cannot be described objectively since the persons involved are not fully aware of how they make their choices. However, the amount of information and knowledge that is needed to produce acceptable results might not be immense. The cleaners' recurrent statements abstracted and presented in section 3.6. may be sufficient for this, in combination with written instructions. A selection based on the preferred species composition, spacing, diameter and height, in combination with selecting stems without observed damage might suffice in many stands (Figure 1). Practical selection of main-stems in cleaning must rely on data concerning a small-scale, since information beyond a certain distance is unobtainable: cleaners usually manage to obtain and work with information within a radius of some five metres. The information acquisition range for a decision support system would probably be similar.

There is a need to develop better cleaning instructions, not only to enable decision support systems to be developed, but also to improve cleaning in general. By gathering the implicit "rules" and improving follow-up procedures, the relationship between the instructions and the results could be established, and this would improve the quality of the work. With a decision support system the cleaners would get more immediate directives about how to proceed, which they request. This kind of support could improve the com-

Basis for selecting a main-stem:

1. Select trees fulfilling all quality criteria*
2. Select acceptable trees (trees fulfilling some of the quality criteria*) if no better alternatives are available
3. Select any tree if no other tree exists

Restrictions:

- Number of stems per hectare
- Minimum distance between trees

*** Quality criteria:**

1. Preferred species
2. Preferred diameter
3. Degree of damage

- Straightness
- Preferred height
- Thinness of branches
- Straightness of branch-angles
- Healthiness of leading shoot

Figure 1. Possible parameters of a decision support system for operator training, for mechanisation, or automation of selective cleaning. The first three quality criteria are listed in order of importance, the other five are not ordered in this way.

munication between the assigners and the cleaners, and it would give inexperienced cleaners the ability to make better (i.e. closer to requested) selections and perhaps learn faster. Such a system could also be useful when the cleaner find the selections difficult to make, as well as for mechanisation or automation.

References

Anon. 1995. Statistical Yearbook of Forestry. Sveriges officiella statistik, National Board of Forestry, Jönköping, Sweden. p. 245. (In Swedish with English summary). ISBN 91-88462-25-0.

Anon. 1999. Röjning [Cleaning]. StoraEnso Skog, Falun, Sweden. p. 9 (In Swedish).

Anon. 2000. Skogsencyklopedin [The Forest Encyclopaedia]. Sveriges Skogsvårdsförbund, Stockholm, Sweden. p.389-390. (In Swedish). ISBN: 91-7646-041-X.

Anon. 2001. Annual Report. Forest Engineering Research Institute of Canada. Pointe-Claire, Quebec, Canada. p. 8. (www.feric.ca).

Anon. 2003. Statistical Yearbook of Forestry. Sveriges officiella statistik, National Board of Forestry, Jönköping, Sweden. p. 118, 127, 237. (In Swedish with English summary). ISBN 91-88462-54-4.

Berg, H., Bäckström, P.O., Gustavsson, R. and **Hägglund, B.** 1973. Några system för ungskogsröjning - en analys [Analysis of some systems for cleaning of Young Forest Stands]. Redogörelse Nr 5, Forskningsstiftelsen Skogsarbeten, Stockholm, Sweden. p. 12. (In Swedish). ISSN: 0346-6671.

Bliss, J. and **Martin, J.** 1989. Identifying NIPF Management Motivations with Qualitative Methods. Forest Science 35(2): 601-622.

Brunberg, B. 1990. Handledning i Röjning [Manual for Cleaning]. Forskningsstiftelsen Skogsarbeten, Kista, Sweden. p. 6, 39-40. (In Swedish). ISBN 91-7614-073-3.

Cawsey, A. 1997. Essence of Artificial Intelligence. Prentice-Hall, UK. p.40-46. ISBN 0-1357-1779-5.

Coffey, A. and **Atkinson, P.** 1996. Making Sense of Qualitative Data: Complementary Research Strategies. Sage, Thousand Oaks, California. p. 2. ISBN 0-8039-7052-8.

Creswell, J. 1994. Research design: qualitative and quantitative approaches. Sage Publications, Thousand Oaks, California. p. 2, 12, 162. ISBN 0-8039-5254-6.

Daume, S., Füldner, K. and **Gadow, K.v.** 1997. Zur Modellierung personspezifischer Durchforstungen in ungleichaltrigen Mischbeständen (Modelling person specific thinnings in unevenaged mixed stands). Allg. Forst- u. Jtg., 169. Jg., 2: 21-26. (In German with English summary).

Daume, S. and **Robertson, D.** 2000a. A Heuristic Approach to Modelling Thinning. Silva Fennica 34(3): 237-249.

Daume, S. and **Robertson, D.** 2000b. An architecture for the deployment of mobile decision support systems. Expert Systems with Application 19(4): 305-318.

Denzin, N. 1994. The practices and politics of interpretation. In: Denzin, N. and Lincoln, Y. (ed.). Handbook of qualitative research, Sage Publications, Thousand Oaks, California. p. 902 (897-922) ISBN 0-8039-4679-1.

Eisner, E. 1998. The enlightened eye: Qualitative inquiry and the enhancement of educational practice. Merrill, Prentice-Hall Inc, Upper Saddle River, New Jersey. p. 39, 201. ISBN 0-13-531419-4.

Fontana, A. and **Frey, J.** 1994. Interviewing, the art of science. In: Denzin, N. and Lincoln, Y. (ed.). Handbook of qualitative research, Sage Publications, Thousand Oaks, California. p. 361-376. ISBN 0-8039-4679-1.

Füldner, K., Sattler, S., Zucchini, W. and **Gadow, K.v.** 1996. Modellierung personenabhängiger Auswahlwarscheinlichkeiten bei der Durchforstung (Modelling person-specific tree selection probabilities in a thinning). Allg. Forst- u. Jtg., 167. Jg., 8: 159-162 (In German with English summary).

Gellerstedt, S. 1997. Mechanised cleaning of young forest – The strain on the operator. Int. J. of Ind. Erg. 20(2): 137-143. ISSN 0169-8141.

Giarratano, J. and **Riley, G.** 1998. Expert Systems, Principles and Programming (3rd ed.). PWS Publishing Company, Boston, Massachusetts. p. 1-14, 165-166. ISBN 0-534-95053-1.

Holme, I.M. and **Solvang, B.K.** 1997. Forskningsmetodik: Om kvalitativa och kvantitativa metoder [Research methodology. About qualitative and quantitative methods]. Studentlitteratur, Lund, Sweden. p. 101. (In Swedish). ISBN 91-44-00211-4.

Kahn, M. 1995. Die Fuzzy Logik basierte Modellierung von Durchforstungseingriffen (Modelling thinning regimes with a fuzzy logic controller). Allg. Forst- u. Jtg., 166. Jg., 9-10: 169-176. (In German with English summary).

Karlsson, H., Lundmark, J., Sundkvist, H., Wahlgren, B., Jacobsson, J. and **Johansson, O.** 1997. Röjningshandbok, virkeskvalité - ståndortsanpassning - naturvård [Cleaning manual, wood quality - site adaptation - nature conservation]. AssiDomän Skog & Trä, Stockholm, Sweden. p. 11, 39-55. (In Swedish).

Keeney, R. and **Raiffa, H.** 1993. Decision Analysis: Introductory Lectures on Choices under Uncertainty, Random House. p. 31-69, 128-130. ISBN 0-521-4418504.

Kvale, S. 1997. Den kvalitativa forskningsintervjun. Studentlitteratur, Lund, Sweden. p. 98-99. (In Swedish). ISBN 91-44-00185-1. (Published in English by Sage Publications, Thousand Oaks, California. 1996: InterViews - An Introduction to Qualitative Research Interviewing. ISBN 0-8039-5819-6).

Magnusson, D. 1978. On the human limitations. Report from the Department of Psychology, the University of Stockholm, Supplement no 43, Stockholm, Sweden. 15p. ISSN 0345-021X.

Miles, M. and **Huberman, M.** 1994. Qualitative data analysis: an expanded sourcebook (2nd ed.). Sage Publications, Thousand Oaks, California. p. 301 ISBN 0-8039-4653-8.

Normark, E. and **Bergqvist, G.** 2000. Röjningshandledning [Cleaning manual]. Holmen Skog, Örnsköldsvik, Sweden. p. 4-7. (In Swedish).

Nyström, K. 2001. Growth models for young stands: development and evaluation of growth models for commercial forests in Sweden. Acta Universitatis agriculturae Sueciae. Silvestria, 180. Swedish Univ. Ag. Sci., Umeå, Sweden. 31 p. ISBN 91-576-6064-6.

Patton, M. Q. 1990. Qualitative Evaluation and Research Methods (2nd ed.). Sage Publications Newbury Park, California. p. 172, 184, 196, 280-281, 283-284, 360-362. ISBN 0-8039-3779-2.

Persson, A. 1976. Förbandets inverkan på tallens sågtimmerkvalitet (The influence of spacing on the quality of sawn timber from Scots pine). Research Notes No. 42, Department of Forest Yield research, Royal College of Forestry, Stockholm, Sweden. p. 26-27,60. (In Swedish with English summary). ISSN 0585-3303.

Pettersson, B. and **Bäcke, J.** 1998. Röjningsundersökning 1997, Produktion - Miljö [Cleaning inventory 1997, Yield - Environment]. Meddelanden Nr 7, Swedish National Board of Forestry, Jönköping, Sweden. 18 p. (In Swedish). ISSN 1100-0295.

Pettersson, N. 1992. The effect on stand development of different spacing after planting and precommercial thinning in Norway spruce (*Picea abies (L.) Karst.*) and Scots pine (*Pinus sylvestris L.*) stands. Report No. 34, Department of Forest Yield Research, Swedish Univ. Ag. Sci., Garpenberg, Sweden. (Partly in Swedish). 17 p. ISSN 0348-7636.

Pettersson, F. 2001. Effekter av olika röjningsåtgärder på beståndsutvecklingen i tallskog (Impact of different cleaning regimes on the development of Scots-pine stands). Redogörelse nr 4, Skogforsk, Uppsala, Sweden. p. 16, 20. (In Swedish). ISSN 1103-4580.

Ryans, M. and **St-Amour, M.** 1996. Mechanized systems for early stand tending in central and eastern Canada. Report No 2, SkogForsk, Uppsala. p. 189-198. ISSN: 1103-6648.

Strauss, A. and **Corbin, J.** 1990. Basics of qualitative research: Grounded theory procedures and techniques. Sage Publications, Newbury Park, California. p. 19, 30, 42-43. ISBN 0-8039-3250-2.

Söderström, V. 1980. Ekonomisk skogsproduktion. D. 3, Beståndsvård [Economical forest production. D3 Stand tending]. LT, Stockholm, Sweden. 216 p. (In Swedish). ISBN 91-36-01486-9.

Vestlund, K. 2001a. Autonom röjning, förutsättningar (Autonomous Cleaning of Young Forest Stands, Conditions). Report No. 12, Department of Forest Management, Swedish Univ. Ag. Sci., Uppsala, Sweden. 39 p. (In Swedish with English summary) ISSN 1403-9516.

Vestlund, K. 2001b. Redovisning av intervjuer med tre personer som utför ungskogsröjning (Report of Interviews with three Persons performing Cleaning and Spacing in Young Forest Stands). Report No. 14, Department of Forest Management, Swedish Univ. Ag. Sci., Uppsala, Sweden. 15 p. (In Swedish with English summary) ISSN 1403-9516.

Yin, R. 1994. Case study research: Design and methods (2nd ed.). Sage Publishing Thousand Oaks, California. p. 80. ISBN 0-8039-5662-2.

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Appendix 1, The interview guide

CLEANING IN GENERAL

• To describe cleaning to a person who does not know what it is, what would you say? What tasks are included… (Sawing, finding stems, transportation, maintenance etc)

• How large areas do you clean per day?

• How is the work organised? Who does what?

• What problems can arise? How are they solved?

• When are other people contacted? Fellow workers, supervisors, others?

• What characterises an easy/difficult cleaning?

• What makes cleaning important for you?

• What do you like least/not like about the work?

DESCRIBE THE TREES

• How would you describe a pine / a spruce / a deciduous stem?

• How do you/Do you see if a stem is healthy? What is the most common type of damage? Measures taken?

CLEANING - STEM SELECTION

• What is quality? What "attributes" do you look for?

• How do you see if a stem is of good quality? How and where do you look? When do you look? Precision...

• Is it easy/difficult to make selections? Is it easier in "delayed" cleanings / in plantations? *"It is stressful to make selections in thinning."*

• Do selection problems occur? How are they solved?

• Which is most important, stem selection or spacing?

• How many main-stems do you see at a time? When you have cleaned around a main-stem, how many other main-stems have you already selected?

• Do you look upwards? How much do you look sideways? Do you check the spacing?

INSTRUCTION / FOLLOW-UP

• What instructions do you get (mix of species, stems per ha)? Have the instructions changed? In what way? When has this happened? Are instructions given for individual stems?

• What "actual" demands do the assigners make for the performance? Do they differ amongst different assigners?

• Do the forest owners' demands affect how you clean? Does the forest owner know how he/she wants the work done? Does the forest owner know what the stand should look like after cleaning? Does this match? Do the forest owners really want what they say they want?

• Must the instructions sometimes be ignored? Why? Who decides?

• How is your performance judged? Negative/ positive criticism? Silence?

• Is the follow-up made by you / the boss/ the assigner? Is the follow-up good? Do follow-ups and feedback (regarding stem and species selection, stems per hectare, canopy, gaps etc) differ between companies?

• Have the results of the cleanings deteriorated?

KNOWLEDGE...

• Can the quality of the cleanings be improved? How? What would be required for you and the assigners? (More precise instructions, better follow-up, increased wages, more time?). What would one gain - better stem selections?

• What knowledge is needed to clean? School, experience? How long does it take to become a good cleaner?

ADVANCE

• How much do you know in advance? Own knowledge/experience... maps, oral advice, other kinds of information?

• How far can you see? What expectations do you have?

• What can you see behind the shrubs/brushwood?

• Is there no main-stem sometimes where you thought there should be one?

AUTONOMY

• When is the cleaning finished? How does the stand then look?

ОЦЕНКА КРИТЕРИЕВ И КОНЦЕПЦИЙ ОТБОРА СТВОЛОВ ПРИ ПРОЧИСТКЕ

К. Вестлунд

Резюме

Целью данного исследования являлась оценка явных и неявных критериев и концепций отбора стволов при рубках ухода, которые позволили бы усовершенствовать систему рекомендаций для принятия решений на практике. Полу-структурированные интервью были проведены с тринадцатью вальщиками, которые утверждали, что плюсовой ствол выбирается на основании глазомерной таксации: соответствие желаемому виду, должен быть прямым, здоровым и иметь предпочтительный размер и подходящее месторасположение в сравнении с окружающими стволами. Обычно, опытные вальщики проводят отбор стволов интуитивно; при этом они, вероятно, принимают во внимание сходные характеристики отбираемых деревьев, даже если при этом возможно только частичное выявление неявных закономерностей отбора. Данная информация, в сочетании с инструкциями владельца земельной собственности, может быть применена как в системах поддержки принятия решений при проведении прочистки, которые могут быть использованы в машинах, так и для подготовки вальщиков. Результаты данного исследования указывают на то, что при отборе стволов всегда должны учитываться вид, повреждения и диаметр ствола. Область получения этой визуальной информации составляет около пяти метров.

Ключевые слова: лесное хозяйство, прочистка, выборочная прочистка, до-коммерческое прореживание, рубка промежуточного пользования, отбор стволов, система поддержки принятия решений, интервью