

Uneven-aged forest management in boreal Sweden: local forestry stakeholders' perceptions of different sustainability dimensions

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Summary

To implement policies on sustainable forest management (SFM), there is a need to satisfy economical, ecological and socio-cultural sustainability objectives. Due to a long history of sustained yield wood production to satisfy the needs of the forest industry, clearfelling management systems are used in ~96 per cent of managed forests in Sweden. To satisfy the intentions of contemporary forest and land use policies, uneven-aged forest management systems as a complement are currently debated. We interviewed local forestry stakeholders in the Swedish boreal forest region's north and south about their views on and attitudes towards different forest management systems' contribution to SFM. Most stakeholders were generally negative to the use of uneven-aged system for sustained yield wood production but saw advantages for ecological and socio-cultural dimensions of SFM. To encourage the use of even-aged cohort and uneven-aged systems to satisfy all dimensions of SFM, there is a need for improved communication, education and public awareness. This could ultimately lead to a more constructive and less heated debate. In addition, there is a need of more empirically based knowledge about uneven-aged and cohort forest management systems' pros and cons when it comes to satisfying economical, ecological and socio-cultural objectives.

Introduction

In Sweden, there is a long-lasting and still ongoing debate about the relative benefits of and problems with uneven-aged selection felling systems (Wallmo, 1897; Welander, 1938; Arpi, 1959; Hagner, 2005a). When forestry to satisfy forest industrial needs of wood began in the boreal ecoregion's north in the latter half of the nineteenth century, selective methods focussing on extraction of large and valuable trees dominated (Arpi, 1959). In the southern boreal forest, the history of forestry is more than a century longer, and selective cuttings, selection and clearfelling systems were used to satisfy the contemporary iron industry's need for a sustained yield of wood (Obbarius, 1845). As a response to the previous exploitation of the Swedish boreal forests' wood resources, and after a long debate during the

beginning of the twentieth century, clearfelling systems were shown to be efficient for the industry's needs (e.g. Utterström, 1979; Hagner, 2005b).

To meet the requirements from the 1948 forest policy that aimed towards a sustained yield and economic profitability (Arpi, 1959; Ekelund and Dahlin, 1998; Enander, 2007), Swedish forestry thus started to focus on clearfelling systems from the 1950s (e.g. Utterström, 1979; Hagner, 2005b). As a consequence, large areas with boreal forests previously exploited using selective cuttings (i.e. dimension fellings or high grading) were restored to re-gain and improve their productivity (Hagner, 2005b). Already by the 1960s, even-aged management had become the dominant silvicultural system in Sweden. Thus, the forest policy objectives of a sustained yield of timber formulated in the early twentieth (Enander, 2001) and mid-twentieth century were achieved from 1970 and onwards (Enander, 2003).

Today, 96 per cent of timber harvesting in Sweden is done using clearfelling systems (Anonymous, 2002a).

Clearfelling systems are easy to plan and use, and if combined with planting or seed-tree regeneration, they work well for wood production on all site types in Sweden. This has, however, resulted in a clear mismatch between how different forest types are managed on the one hand and their natural forest disturbance regime on the other (Angelstam, 1998, 2003; Angelstam and Kuuluvainen, 2004; Axelsson *et al.*, 2007; Puettmann *et al.*, 2008). To alleviate this problem, the use of uneven-aged selection forest management systems encouraging continuous tree cover (CTC) has been advocated in Sweden (Anonymous, 2001; Gustafsson *et al.*, 2001). Axelsson *et al.* (2007) estimated that in two large study areas (~5 million ha each) in south-central and northern Sweden at least 10 per cent of the sites in the present forest landscape would have hosted CTC forest types under natural conditions. The same study showed that clearfelling systems were used on all site types including CTC site types. Reviewing the occurrence of different natural forest disturbances, Shorohova *et al.* (2009) concluded that stand-replacing was not the most common disturbance in Fennoscandia under natural conditions. This suggests that the natural level of CTC was much higher.

Both nationally and internationally, the general forest policy trend is towards a broader set of management objectives (e.g. Ministerial Conference on the Protection of Forests in Europe, 1998, 2003; Anonymous, 2002a, b; Innes and Hoen, 2005; Mason *et al.*, 2005; Keeton, 2007). This is a new situation for industry-oriented forest managers that historically could focus on sustained yield of timber and pulpwood only (Siiskonen, 2007).

Many European countries and regions were faced with the need to develop multifunctional forestry earlier than Sweden. To mitigate problems with sustainability issues such as natural hazards, countries in the European Alps developed continuous cover methods several hundred years ago (Dengler, 1944, 1990). To become more nature based, and hence to emulate natural forest structures, Switzerland banned clearfelling in 1902 and Slovenia in 1948/49 (Diaci, 2006). Similarly, recent forest policy statements envisage a much greater use of selection system forest methods in Europe (Anonymous, 2002a, b; Mason *et al.*, 2005). However, in Sweden, the results of Axelsson *et al.* (2007) suggest that the current low diversity in silvicultural systems does not match the current forest policy ambitions in Sweden.

The Swedish forest law (1979) and subsequent policies have evolved from a main aim of securing timber production on private and public land to allow for and promote a larger diversity of forest management systems that satisfies economic, ecological and socio-cultural dimensions (Statens Offentliga Utredningar, 1993; Anonymous, 2008a). As a response to this development and recent evaluations of the Swedish forest policy, the Swedish forest agency initiated a project named 'Continuous cover forestry and continuous forests' with the aim to increase the knowledge about uneven-aged forest management (Anonymous, 2004; Cedergren, 2008).

To support implementation of sustainable forest management policies by a diversification of forest management

systems, it is important to improve the understanding of how different stakeholders in the forest sector could contribute (Anonymous, 2005; Veltheim, 2006). Given the long history of debate concerning forest management systems, and the focus on advice as the main policy implementation instrument in Sweden, understanding the views of local foresters is crucial. The aim of this study is to understand local stakeholders' use of different forest management systems and their perceptions on how uneven-aged selection felling systems could contribute to sustainable forest management's economic, ecological and socio-cultural dimensions. Using semi-structured interviews, we explored local forestry stakeholders' knowledge about willingness and ability to use uneven-aged forest management systems in two study areas that represent the southern and northern part of Sweden's boreal forest region.

Methods

Study areas and stakeholders

In Sweden, boreal forest land is owned by non-industrial private forest owners (38 per cent), the government and the state forest company Sveaskog (38 per cent), large forest companies (19 per cent), forest commons (2.4 per cent) and the rest shared among small companies, municipalities and the church. There are, however, large regional differences in forest land ownership pattern, forest ecosystems, forestry and history of forest use (Eliasson, 2002; Angelstam, 2003; Kardell, 2004; Holmberg, 2005). This means that different forest history phases have occurred during different time periods in different regions (Angelstam *et al.*, 1997). To exemplify regional differences with respect to land use and forest management history and emphasizing the situation in boreal forest, we selected two important transition zones as study areas (Figure 1).

The southern study area named Bergslagen was located in south-central Sweden. This area forms the natural southern border of the boreal forest (Figure 1) and includes both higher altitude areas with a long forest land use history and lower altitude areas that were cleared for agricultural purposes thousands of years ago (Welinder *et al.*, 2004). In this part of Sweden, intensive forestry started in the eighteenth century, driven by the mining and metallurgic industry (Wieslander, 1936; Bladh, 2002). Initially, the forest was exploited by selective harvest of timber where initially large dimension trees only was the target and no forest management was applied (Enander, 2005). In the seventeenth and eighteenth centuries, the Bergslagen area was one of the world's largest iron producers (Eriksson, 1955). The iron industry demanded large amounts of charcoal. This resulted in short rotations of 40–60 years (Almquist *et al.*, 1980; Ek, 1995; Angelstam *et al.*, 2010). At the end of the iron industrial époque in the late nineteenth century the increasingly used clearfelling systems with regeneration by planting was debated (Wallmo, 1897). Land ownership in Bergslagen is fragmented with ~70 per cent owned by owners with properties less than

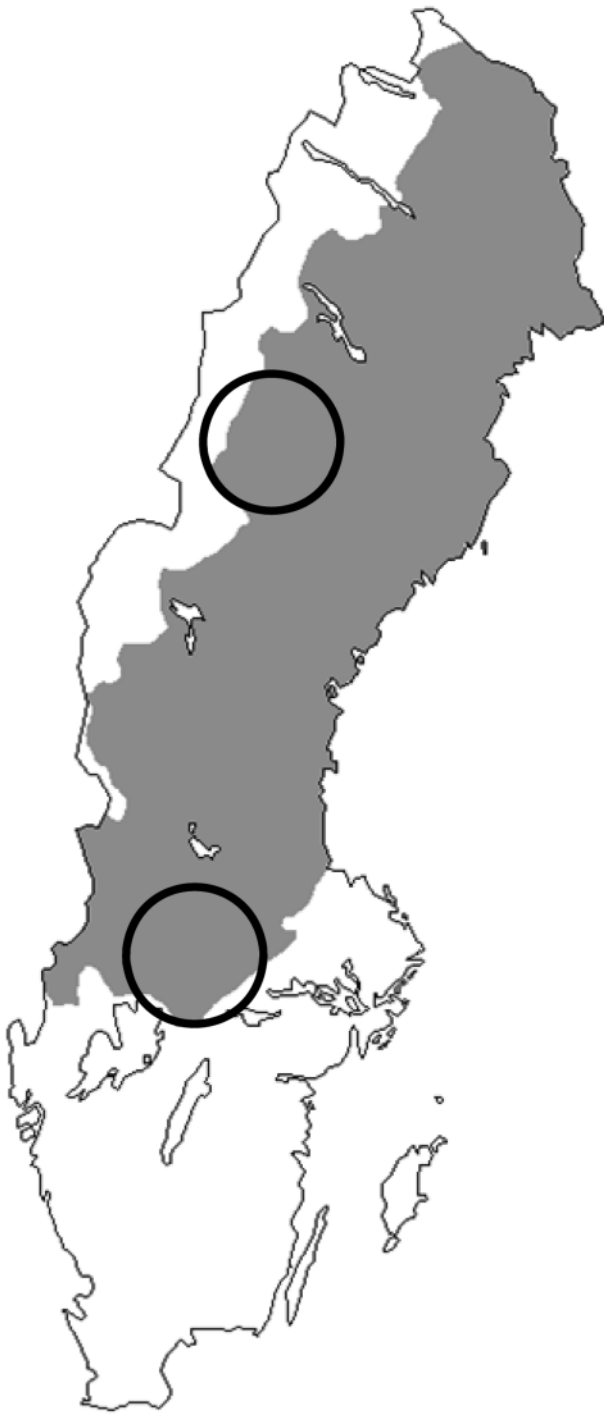


Figure 1. Map of Sweden with two study areas marked by circles and Sweden's boreal forest region coloured grey (Anonymous, 1999). The southern study area is located at the southern border of the boreal forest region called Limes Norrlandicus (Selander, 1955; Fransson, 1965), while the northern study area is located at the border where the boreal forest changes to the alpine forest/alpine region. This coincides with the cultivation limit, i.e. the border above the establishment of farms was not feasible and not allowed due to considerations to reindeer herding Sámi's (Lundmark, 2005).

1000 ha in size. The remaining forests are owned by private forest companies, the state forest company, the state, commons and the church.

The northern study area was located in western Västerbotten and south-west Norrbotten counties in the northern part of Sweden (Figure 1). In this area the history of industrial forestry is relatively short. In the north of Sweden the main driver that affected forests and forestry was the timber frontier that arrived in the late nineteenth century (Arpi, 1959). The timber frontier was associated with the demand for wood from international markets (Östlund and Zackrisson, 2000; Angelstam *et al.*, 2004). However, large parts of the forests close to the mountains, and at higher altitudes, have still not been used for intensive sustained yield wood production (Forsell and Axelsson, 1990; Axelsson *et al.*, 2007). As in the south boreal Bergslagen area, the first industrial use of the forest resource was unsustainable exploitation by selective cuttings with no or very limited forest management both on government and privately owned land. This exploitation of the forests was supported by government regulations for forestry on state-owned land and regional laws on dimension cutting in the coastal parts of Västerbotten and Norrbotten counties as well as by a special law (Swedish: utsyningslagen) regarding private land further away from the coast (Enander, 2005). In this study area, ~25 per cent of the properties were less than 1000 ha in size. The state, forest commons and several large forest companies are the other main owner categories. The population is sparse with only few smaller urban centres.

Data collection and analysis

In both study areas, we identified local level forestry stakeholders for the interviews. The idea was to only include stakeholders that were involved directly with forestry activities. This resulted in a group made up of forest owners, planners, wood buyers, forest planning consultants and representatives of forest owner associations, forest commons, the Swedish church, the Swedish property board, municipalities and the Swedish forest agency.

Data were collected through qualitative interviews with open-ended questions (Kvale, 1996, 2007; Kvale and Brinkman, 2008). The interviews were organized in three blocks (1) understanding of, (2) willingness to use and (3) ability to use selection felling systems (Sabatier, 1986; Lundqvist, 1987: 43). The interviewees were given full freedom to express their thoughts and to reason about the questions. The interviews were carried out in the interviewee's office or home. The interviews took 30 to 90 min. We interviewed 28 local forestry stakeholders in the two study areas. The informants were chosen to represent all groups directly involved with forest planning, such as (1) forest industries, (2) forest consultants, (3) government agencies and (4) non-industrial private forest owners. For groups 1, 2 and 3, we interviewed most or all organizations active in the study areas, while for group 4, our ambition was to include forest owners with different profiles. The interviewee groups were selected as to have stakeholders with similar

profiles and the same number of interviewees in the two study areas. In this study, we stress the qualitative aspect to different stakeholders' perceived pros and cons towards selection felling systems ability to contribute to satisfying different sustainable forest management (SFM) criteria. Our aim was thus to collect different views but not to quantify these views.

All interviews were transcribed and the texts were concentrated and divided into groups according to the three blocks mentioned above. Concentration of the sentences means that opinions stressed by the interviewees were shortened, translated and rewritten as clear as possible (Ryen, 2004). We present the full spectrum of opinions with examples from the interviews. The analysis was an iterative process where we continuously back-checked with the recorded interviews and first transcriptions to safeguard accuracy. For each of the three blocks mentioned above, a number of specific issues or questions were selected to make it easier to compare the opinions of different interviewees. For all interviewees, their opinions on each issue were classified as (1) agree completely, (2) agree partly and (3) do not agree.

Terminology and definitions

CTC forests formed important green infrastructures needed for the maintenance of species, habitats and processes in the naturally dynamic and pre-industrial cultural landscapes (Angelstam, 2006; Shorohova *et al.*, 2009). We use an ecological definition based on the disturbance regime paradigm. It defines CTC forests as those growing on site types with multi-cohort and gap phase dynamics (Falinski, 1986; Rülcker *et al.*, 1994; Fries *et al.*, 1997; Angelstam and Kuuluvainen, 2004; Shorohova *et al.*, 2009). In a naturally dynamic landscape, the multi-cohort and gap phase dynamics groups were found mainly on wet and dry sites. In addition, a culturally caused CTC forest type was found in many agricultural areas, i.e. the wooded grasslands, which is the main cultural woodland type in Sweden (Ihse, 1995), a minimum 0.5 ha, more than 10 per cent crown cover and minimum of 5 m high in line with internationally agreed definitions of forest and other woodland (Anonymous, 2008b). All natural or culturally caused CTC forests historical varied a lot in age distribution, density and tree species, in time and space. CTC forests and wooded grasslands can thus potentially maintain structures and habitats that are rare in the present landscape where sustained yield wood production is the main objective.

It is important to understand the differences between selection systems and selective cutting (Matthews, 1989; Puettmann *et al.*, 2008). A selection felling system (Continuous Cover Forestry (CCF) or uneven-aged forest management) means felling of scattered single trees and/or small groups of trees selected over a larger area. The remaining trees should represent all age classes. If natural regeneration fails, it will be complemented by planting. A suitable mixture of shade-tolerant species should be maintained. Young saplings should be freed from suppression,

and defective stems should be removed if they hamper the development of better ones. This recommendation may be adjusted if the aim of management is other than timber and pulpwood production. The use of selection felling systems will maintain a CTC. How much that could be harvested depends on the condition of the forest and the site type. Research indicates that there is a need to maintain quite high standing volumes to maintain a high annual growth (Lähde, 1994). CCF includes different kinds of selection felling systems. By contrast, selective cutting means high grading or high-dimension felling. Thus, valuable high-dimension trees are felled and no management is carried out to improve the remaining trees or the stand (Anonymous, 1999b). This is not a silvicultural method (Matthews, 1989) but is practised in many areas around the world. Selective cuttings were historically often termed 'selection felling', and this contributed to giving CCF a poor reputation (Schutz, 1994; O'Hara, 2002; Enander, 2005; Siiskonen, 2007; Lundqvist *et al.*, 2007).

Results

A misunderstood forest management system

The local forestry stakeholders and users that were interviewed expressed many different opinions on forest management and what kind of forestry method that would be useful in a particular site type and region. For example, one respondent said: 'You need to be careful about the knowledge of experienced people. No forest agency in the south knows the mountain forest better than the local people. They need to listen to them they are the experts on continuous cover forestry. They know the ground and have experience on how to regenerate the forest'. Several respondents associated CCF using uneven-aged selection felling systems to selective cuttings and high grading that was common in the area before the 1950s. An example was the following statement: 'I do not know too much about continuous cover forestry, but I know how many "5:3" forests that were restored in the 1970s, a result from high-grading in low productive and sparse areas. This is the risk you get if you use that kind of harvesting' (5:3 was the number of the law paragraph that handled restoration of pre-1950s degraded forests in Sweden. It is often used to name the poor condition of forest stands that remained after the selective felling phase.). One respondent expressed his opinion about the Liberich selection system approach (In Sweden, a local selection felling system called Liberich has been developed (Hagner, 1998, 2005a). It is, however, strongly contested (e.g. Lundqvist, 2007; Hagner, 2007).): 'I am taking a course where we have discussed Mats Hagner's Liberich method, and I do not believe in anything of this. This is how to create rest forests and 5:3 forests' (Swedish: rest- och trasskogar, English: forests that have lost their productivity due to repeated high grading and a lack of forest management). They were present on my father's land. I removed them the first years and planted a new forest. They had been harvested with selective cuttings, they were

allowed to grow as they liked. The best method is clear-cutting, take away what is harvested and then you should scarify and plant'. By contrast, another respondent said: 'I think you should use Liberich. Clear-felling is on its way out both because of environmental concerns and cultural remains. It is said that Liberich works only if your forest is layered, but it becomes layered if you optimize the present value. You can harvest large dimension timber early, and you create quality for the future.' In the northern study area, some respondents associated CCF to a selection felling system that had been developed locally for harsh conditions at high altitude sites where regeneration after clearfelling was known to be difficult. Instead continuous thinning with a high removal rate is used to secure regeneration. Several respondents did not separate thinning from selection felling systems, and only few understood that selection felling systems is not equivalent to selective cuttings (high grading) where harvesting of large dimension trees only are the aim.

The scepticisms among interviewees towards the use of uneven-aged management systems was summarized by one interviewee as 'Earlier when you used selection felling systems you often used it on the wrong site types. We don't have the right forest type today. Then you get a wounded forest as we call it here, and you don't like that, it's not good. You have to be careful'. Another pointed out that the harvesting method used earlier was not really a selection felling system, 'Selection felling systems were very common, it is often called selection felling but it was really high-grading or dimension felling of larger trees. This was also a type of "continuous cover forestry", often considered as the 'green lie'.

To conclude, uneven-aged forest management was associated by interviewees to anything from forest exploitation by selective cuttings and thinning to selection harvesting in areas with other than pure timber production aims but not a method for intensive timber production. There was also confusion about the terminology when forestry systems was discussed and described. Some respondents who remembered how things were done before the clearfelling era had a hard time to place selection felling systems in a modern context 'Selection felling is a thing of the past with the technology you had, you never thought of large clear-cuts'. One respondent pointed out how the Swedish forestry education and its concentration towards wood production using even-aged forest management systems meant that he did not get any education on alternative forest management systems and very little about conservation and biodiversity during his studies to become a forester.

Willingness to use uneven-aged forest management

A majority of the respondents were of the opinion that there is a need for a more diverse set of forest management methods than what is used in boreal Sweden today. Some interviewees thought that clearfelling systems were enough to satisfy contemporary forest policy contents. A clear majority also expressed the opinion that different forestry stakeholders affect each others' use of forest resources, but

they did not see it as a problem. Many also expressed the opinion that the environmental considerations in the Swedish forest policy that are used today were good enough to satisfy the intentions of the policy. They had experienced a clear improvement in how ecological issues are dealt with. Several respondents expressed the view that alternative management regimes are needed to meet the needs from other forestry stakeholders and especially as an alternative where social use of the forest is high. Most respondents thought fully or partly that it is possible to even out the differences between naturally dynamic and managed forests, even if many also added that it would result in a loss of income for forestry.

Most of the respondents were dissatisfied with the Swedish forest policy in general, and only a few expressed that they were positive to the Swedish forest policy. This applied to both production- and conservation-oriented respondents. Most respondents wanted clearer directives and a stronger enforcement of the forest policy. With the present policy, many were not sure if any of the production or environmental goals could be reached. Several of the respondents thought it was hard to understand what an equal importance of production and environmental goals, as described in the policy, means in practice. Several reacted in a negative way when the term CCF was mentioned. They suspected that the term was used with the aim to increase biodiversity conservation measures, and they claimed having previous experience of other approaches that had limited the freedom of forest owners. However, on specific sites and on land important for social use purposes, most could see the usefulness of CCF. A common feature of the respondents that had experienced unsatisfactorily environmental and social considerations was that they liked to blame someone else. While private forest owners often pointed out the forest industry, forest industry employees pointed out private forest owners. Quotes by forest industry employees: 'The forest companies takes 10 times more considerations than private land owners' and 'The forest industries manage themselves, I believe in it, therefore the forest agency should work harder with private land owners. But we are not without stains. Some are too soft when they control us'. The opposite opinion was expressed by private forest owners as: 'The forest industries do not look as careful as I do, I believe. They can fell everything around a village while I have to consider the environment and keep some'. and 'In my forestry there are no larger clear cuts than you can see from one side to the other. You can almost through a stone over them. Clear cuts like the industry did before, over full mountains, they are not present anymore'.

Respondents often felt that they had no responsibility to implement the goals of the Swedish forest policy. A majority thought that it is the responsibility of the politicians to realize the forest policy through clear laws and by reimbursements for economic losses. A large part of the respondents wanted the local forest agencies to charge forest owners that do not manage their forests in an ecologically, economically and socially sustainable way. Many had a strong confidence in the local forest agency officers

when it came to providing appropriate advice. This was expressed by one respondent: 'Even if there is not a law for everything the forest agency should be able to force forest owners to do things. They are competent, that's enough. It can be controversial but if you like to keep the freedom you cannot regulate details'. Some respondents expressed contempt towards knowledgeable instances without experience, for example one respondent: 'It was in the 60s we started with clear cuts here, and now it is only cleared areas. The people who know, the educated, say we are supposed to do like this'.

Almost all respondents said that a landscape approach to forestry operations and forest structures of some kind is important. By this, they referred to a larger geographical area than their own property and the need for cooperation among forest owners. However, many expressed worries that there was no operational solution in place that could facilitate a landscape approach. They also saw many difficulties in the development of an operational solution. Respondents in the north were more hesitant to landscape approaches than respondents in the south. What seemed to be lacking was a function to facilitate different stakeholder's activities in a larger area. It was often mentioned that neighbours sometimes do cooperate when they harvest and sell forest to increase the profit. Forest companies often had a working coordination internally for their own work. However, they saw large problems if a landscape approach to planning and coordination with neighbouring landowners should become a reality.

A clear difference between the southern and northern respondents was that fewer in the north had other than economic goals with their forestry. In the south, a majority expressed the importance of other goals than economy. In the north, fewer expressed this instead a majority claimed that economy was their only goal and that they depended on income from the forest. In the south, none of the private forest owners claimed that they needed income from their forest.

A few respondents witnessed about the difficulties for CCF to be accepted as a complementary forest management principle in Sweden. One reason for this is probably the clear-cut only direction of Swedish forestry educations, here expressed by a forester: 'Partly this is a question about attitudes. We are educated in the same school everyone, moulded in the same cast. You can imagine what happens if you put a bunch of 20-year olds in the same school. It is the conventional forest management principles that most of us, despite our specializations have learned.'

Another respondent working for the forest owner association had experienced the unwillingness to discuss alternatives to the dominant clearfelling approach: 'When I go to meetings and we will discuss thinning, then they say: you can leave since you do not do this anyway! They almost bully me for this. At the same time I can show 1000s of harvested cubic metres with happy private forest owners instead. I do not care since I do not have too long time to retirement. During my last years I can support this, it is harder for the younger guys and girls that are coming with a message like mine.' According to the same respondent,

there is a large potential, mainly among non-industrial private forest owners, in using CCF methods. The forest can be maintained and the forest owner can still earn some money by smaller harvesting at several occasions. This respondent mentioned the importance of not forcing a forest owner to use a new method but letting the forest owner chose on his own.

Ability to use uneven-aged forest management towards SFM

Respondents claimed that technology and knowledge needed for practising CCF is available today. However, they often saw difficulties with CCF because this was seen as a practise of the past. Most respondents claimed it is fully or partly impossible to use CCF for economical reasons. The influence from the Swedish forest policy was commented: 'The forest policy is rigid. In forestry it has always been like that . . . but the new forest policy is better, you are not as much steered today. Earlier you could be forced to do fellings. Today you are free to test different methods, so it is better'. Another opinion was that employees in forest companies had too many obligations to satisfy all demands from the management. This was elaborated by a respondent who worked in the north in an area with an ongoing conflict between Sámi's reindeer husbandry and forestry: 'It has been said that we can run over the Sámi if needed, but we have not done it. Even if the Sámi say no, they cannot stop us. But I do not think it is good since we are certified and supposed to take considerations. But if you are under pressure from all sides you never know what happens. Selling of forest, development of nature reserves, problems in the dialogue with the Sámi . . . the business will be under pressure. Previously it was so easy to operate forestry. Now we need to save more forest and still deliver the same volumes.'

Ecological dimensions

Only few respondents questioned that uneven-aged forest management would support ecological values in the forest: 'No landscape is only clear-cuts. The bird is moving and the moose has legs, and they are affected in a positive way by clear-felling forestry.' The other critical respondent, said: 'It will become very closed and dark stands in a selection felling forest because of the multiple layers, maybe three generations in the same stand. The question is what kind of organisms would enjoy it there. To create small gaps would maybe work better biologically.' In contrast, most respondents thought uneven-aged forest management would promote biodiversity conservation. Issues like a long continuous habitat, deadwood and large and old trees were mentioned as positive for biodiversity.

Economic dimensions

In stark contrast to the opinions about CCF and biodiversity, very few respondents thought that CCF would favour economy, and only some thought that it could partly benefit the economy. The most common view was that CCF would not benefit the economy. Most respondents still considered

CCF something for forest owners with other motives than timber production and economic profit, or in areas where traditional clearfelling is impossible, such as close to urban areas and on sites with ecological values that could not be maintained if clearfelling systems would be used. One respondent claimed that CCF could potentially give an improved economy by providing higher quality timber: 'Often we are too quick in cutting down the trees. One should be careful when choosing the right stand to cut and be even more careful when marking for the cross cut. You know the tree species but not the quality. It has been coming for a long time, but never happened. You trust the machines too much. You only want to fill the volumes.' However, according to another respondent, there is no market for higher quality wood that could potentially be produced by using continuous cover forest management systems: 'It is not sure that you get some extra money for good qualities. We have only bulk-saw-mills up here. Today there is no industry that is good in taking care of quality wood. You need to get well paid to use alternatives to clear-felling. It is not sure you will.' And the opposite opinion was also expressed: 'Quality is what always gave income. The growing middle class will request wood products with good quality. They do not like imitations and surrogates, it is fashion to build with real wood today. We export more and more of such products to China and Japan, and they can pay twice the price! Pulp wood is already poorly paid, and how could we compete with Brazil who produces as much in 20 years as we do in 100?' Some respondent questioned the importance of the forest industry to the Swedish economy: 'The forest industry contributes only 3-4% of our added value income, that is the relevant measure for an industry. Do we really need forestry? It would not affect so much if it was closed, but then we are looking at the added value. You do not earn from exporting a product that is not value added. It's a myth that the forest industry is important to the Swedish economy.' However, several other interviewees stressed the importance of the forest industry to the Swedish economy.

Social dimensions

Almost all respondents agreed, fully or partly, that social values would be favoured by CCF in some areas. Many respondents were more positive to CCF as a tool to manage social values than as a tool to manage ecological values. These respondents related this to themselves and their own experiences with considerations for people when planning to harvest your forest, i.e. one do not clearfell up to your neighbour's house or in areas that are much used by people. In comparison, it was harder for the informants to see and understand the requirements for biodiversity conservation in terms of forest ecosystems' composition, structure and function. The importance of hunting was mentioned by several respondents: 'Many people are buying forest only because of the possibility to hunt'. One respondent that planned to buy forest did not have the economic option to manage the forest to promote hunting values: 'If I had no instalments on my loans to think about I would have used some kind of continuous cover forestry. Then the

hunting value would be bigger compared to if I harvest everything.' The same respondent continued: 'When I have bought the forest it will be a slaughter immediately. Then I have to plant and clean, but if I will not become a very old man I will never experience grown up forest again. This is the only way to get rid of as much as possible of the interest cost'. The potential of hunting as a way to earn money from the forest was expressed by another respondent: 'Hunting is quite important. It is possible to earn money there. But you need to be a good entrepreneur, or have someone that coordinates the business. In the city, at the big Hotel, they cooperate with small local entrepreneurs. Hunting, pike fishing, snowmobile . . . then you can operate it with a good size of the business'. The connection between multiple values in the forest and the number of jobs was brought up by many respondents. A majority believed that job opportunities in the forest industry are threatened by CCF. A few saw an unused potential for new jobs in new areas like hunting, sports fishing and nature tourism.

Discussion

Emerging acceptance of increased forest management diversity

Forestry stakeholders interviewed in this study were negative to uneven-aged selection felling systems as an alternative to even-aged clearfelling system for sustained yield wood production. However, they were positive to uneven-aged management systems as a complement to clearfelling systems not only to satisfy mainly social sustainability objectives but also to some extent ecological ones. This is in agreement with Lindhagen (1996a, b) who showed that people generally preferred forests that were not managed with clearfelling systems. A majority of the interviewees expressed concerns over the economic feasibility of using selection felling systems.

There are clearly different opinions and results about the profitability of CCF. Research by Tahvonen *et al.* (2010) showed that CCF can be profitable to private forest owners even if less volume is produced. In Sweden, there is a heated debate regarding the use of either clearfelling or uneven-aged forest management methods as tools to implement sustainable forest management policy. The originator of the Liberich system, a specific kind of CCF, claims that with this system, the Swedish forest industry would earn at least twice as much (Hagner, 2007). On the other side, analysing the scenario of changing from clearfelling systems only to only uneven-aged methods on all site types in Sweden, Karlsson and Lönnstedt (2006a, b) estimated the economic loss for the Swedish forest industry to 16 billion SEK annually. We strongly oppose to this pseudo-scientific rhetoric and argue instead that implementation of the current forest policy and the vision of sustainable forest management require a suite of forest management systems that match the diversity of natural forest disturbance regimes in different ecoregions and site types (Angelstam, 2003;

Kuuluvainen, 2009). This allows for a diversity of goods, ecosystem services and landscape values (e.g. Merlo and Croitoru, 2005). Hence, both clearfelling systems and CCF systems are important tools that contribute to the sustainable forest management process in different ways.

Interviewees were generally unable to differ between selective cuttings and selection systems. Hence, many worried about alternatives to clearfelling as they perceived this as going back to unsustainable selective cuttings that were used before the sustained yield era and that was blamed for the degradation of the Swedish forest resource until the end of the nineteenth century (Hagner, 2005b; Enander, 2007). A clear majority of the respondents were of the opinion that knowledge and technology for CCF is available. Our interpretation of this opinion is that technology is available for selection harvesting systems but that knowledge about selection systems for intensive industrial production is limited. Thus, the prerequisites for using alternatives to even-aged management systems are not good in Sweden due to the forest sectors' mainstreaming towards clearfelling systems only (Siiskonen, 2007). It is therefore difficult to find both competent forest management advisors and affordable solutions to harvesting for forest owners that prefer selection felling systems. Indeed, wood buyers and forest management consultants interviewed in this study had noticed an increased demand of advice about alternative management systems from small forest owners but admitted that they are not good at meeting this demand. This is not surprising given the forest industry-oriented traditions in Swedish forestry education (Angelstam *et al.*, 2010).

The following example illustrates this. Presently, a local private forest owner in the north of Sweden is challenging the forest law trying to get permission to use a selection felling approach that is in the legal grey zone. The Swedish Forest Agency holds the opinion that it leaves too low standing volumes and thus negatively affects the productivity of the forest (e.g. Johansson, 2009; Kjellin, 2011). In addition, they do not accept the practice of planting in a CTC forest to secure regeneration as an evidence-based method. It has resulted in several court cases and the latest was recently closed due to changes in the Swedish forest law in September 2010. This might mean that the whole legal process will restart all over again. Recently, there has been presented arguments both for and against alternatives to even-aged management systems (Karlsson and Lönnstedt, 2006a, b). By contrast, in Finland, after a long history of even-aged forestry recommendations (Siiskonen, 2007), the present forest law is more open to uneven-aged management and a new policy revision with the aim to increase the diversity of forest management systems has been initiated (Anonymous, 1996; Anonymous, 2011).

Summarizing, the views on CCF among the interviewees ranged from (1) worries about going back to something that did result in unsustainable use of the forest resource in the past, (2) the potential of CCF as a complement to clearfelling systems to satisfy especially considerations to social sustainability and to (3) a concern regarding how to meet the increased demand from forest owners that prefer

to use alternatives to clearfelling systems on their land. Many respondents thought that the ecological considerations implemented by the forest law, and forest certification, were sufficient tools to meet the requirements in the Swedish forest policy. In contrast to this, the evaluation of the Swedish forest policy in 2002 shows that this was not the case (Anonymous, 2002a).

Different forest history phases – different management systems

In the study area in south-central Sweden, boreal forestry developed as a support to the dominating mining and iron industries. As a result, clearfelling became the dominant forest management system used and taught from the early nineteenth century (Bladh, 2002; Brynte, 2002). Later, the same forest management system became an effective method to satisfy the needs of the forest industry. Today rural south-central Sweden no longer depends on the formerly very important mining and forest industries since they have been closed, moved or just do not employ many people today (Isacson *et al.*, 2009; Svensson, 2009; Angelstam *et al.*, 2010; Angelstam *et al.*, 2011). Instead, this part of Sweden is developing new ways for rural development based on forest goods, ecosystem services, as well as forest and woodlands landscape ecological and cultural values as resources for tourism and recreation (e.g. Vail and Hultkrantz, 2000). The traditional Swedish clearfelling management system is thus currently contested by actors who advocate uneven-aged systems for both ecological and socio-cultural reasons expressed in current forest policy (Siiskonen, 2007; Axelsson *et al.*, 2007; Tahvonen, 2009).

This transition from exploitation to sustained yield and towards multiple use of the forest landscape is evident from a comparison of other European regions that are in different forest history phases (Angelstam *et al.*, 2011). (1) NW Russia where both areas harvested by extensive methods and more or less intact natural forests with no forest management can be found (Angelstam *et al.*, 1997; Jasinski and Angelstam, 2002; Torlopova and Il'chukov, 2004; Van der Sluis *et al.*, 2003; Nordberg *et al.*, in review). (2) North Sweden where the logging frontier today is reaching the protected areas in the mountain range. Here, the tourism industry is developing and thus put demands on the forest industry for them to co-exist peacefully (Wik, 1962; Elbakidze *et al.*, 2010). (3) The Harz Mountains in Germany where the ideas about sustained yield forest management were developed during the eighteenth century. Today, forest management in this area has turned towards uneven-aged management emphasizing ecological and social values (Lehman, 2001; Jansen *et al.*, 2002; Hauhs and Lange, 2001). (4) Scotland, where forest restoration for multiple use is needed after a long history of intensive forest use and deforestation (Steven and Carlisle, 1959; Grant, 1994; Summers *et al.*, 1999; Moss, 2001; Davison and Galbraith, 2006).

Forests and woodlands thus provide goods, ecosystem services and values, the profiles of which vary in time and

space (Kennedy *et al.*, 2001; Merlo and Croitoru, 2005; Wulder *et al.*, 2007). This is consistent with internationally agreed definitions on what a forest is (Anonymous, 2008b), which includes not only forests with high trees but implicitly also cultural woodlands. Traditional land uses such as forestry, nature conservation, agroforestry, agro-silvo-pastoralism and rural development are thus interdependent, and there is a need for land managers to cooperate. The same applies to cultural aspects of wooded grasslands (Saltzman *et al.*, 2011), which are an important element of rural development and biodiversity in many parts of Europe (Angelstam, 2006).

In terms of forest policy development and forest use in Sweden's boreal region, the recent history of industrial forestry can be divided into three broad phases, taking place during different time periods in different parts of the country (Östlund and Zackrisson, 2000): (1) selective cuttings until the early twentieth century in the north and until early nineteenth century in the south, (2) a sustained yield production phase with large scale restoration of degraded forests and with focus on value-added production in the export-oriented forest industry was implemented from 1948 until the 1970s in the north and about 100 years earlier in the south linked to mining and metallurgic industry and (3) the emerging multiple use phase that started by introducing ecological considerations in the late 1970s. Finally, the present forest policy aims at the development of long-term economically, ecologically and socially sustainable forests (Anonymous, 2007). This multiple use policy phase is common to many countries and implies need for application of an increased diversity of forest management systems. This includes also an increased demand for CCF to be able to deliver the goods, services and values that the society asks for (Merlo and Croitoru, 2005; Nilsson *et al.*, 2011). That different forest historical phases can be found at the same time but in different places, offers a unique opportunity for mutual learning among forest landscapes as integrated social-ecological systems in different places. Learning in networks of landscape laboratories is an important tool to assist the sustainable forest management process (Angelstam *et al.*, 1997; Axelsson, 2009).

Sustainable forest management requires multiple forest management systems

Two recent evaluations of the implementation of Swedish forest policy discuss the need to diversify the forest management systems to meet the current policy objectives for forests and their use (Anonymous, 2002a; Mikaelsson *et al.*, 2006). The first of the evaluations led to the 'Continuous forests and continuous cover forestry project' implemented by the Swedish forest agency (Cedergren, 2008). The main results were as follow. A definition of continuous forest; an estimate of the amount potential continuous forest (1.8 million ha); an estimate of the amount likely continuous forest (0.4 million ha); discussions on how to identify and locate existing continuous forests; a definition of clearfelling free forestry; a discussion on when CCF is legal; a discussion on how CCF could be beneficial

to biodiversity conservation; the conclusion that CCF usually means a net loss compared with clearfelling systems; an estimate that CCF could be used on 5–10 per cent of the forest land; the development of principles on how to compensate forest owners that are prescribed CCF and a discussion on the need for continued work.

While social values may be satisfied by CCF methods, we emphasize that CCF does not necessarily mean improved ecological considerations or efficient biodiversity conservation. Intensive CCF aimed at sustained yield wood production is as imperfect in satisfying ecological sustainability objectives as clearfelling management systems (e.g. Angelstam, 2003). The reason is that the amounts of deadwood, old trees and other natural forest structures in relation to what species require are generally not secured. For CCF methods to contribute to conservation, special efforts with the aim to increase deadwood of different decay stages (Stokland, 2001), to maintain old and large trees (Kuuluvainen, 2002; Nilsson *et al.*, 2002), to use more natural tree species compositions (Kuuluvainen, 2002; Åberg *et al.*, 2003) and to apply CCF methods at site types where it mimics natural disturbance regimes (Axelsson *et al.*, 2007). To contribute to ecological sustainability, there is in addition a need for forest biodiversity management systems (Swe. 'naturvårdande skötsel') that emulates natural and cultural disturbance regimes and where protection, management and restoration of natural forests' composition, structure and function are the key aims (Anonymous, 2010c, d).

Sweden has had a polarized debate on the use of uneven-aged CCF or even-aged clearfelling management systems for more than a century (Wallmo, 1897; Siiskonen, 2007). This debate has been entertained by stakeholders representing different phases in the history of forest use. Today, the forest industry, biodiversity conservationists and groups using socio-cultural arguments are the main parties. At present, the policy pendulum that in 1993 swung from sustained yield wood production only to in addition more environmentally oriented forestry has moved back somewhat to more production-oriented forestry again for both forest industry and to supply bioenergy (Anonymous, 2007). Thus, the definition of SFM policies continues to evolve. Nevertheless, to meet the requirements of the Swedish forest policy, there is a need to adapt forest management systems that match natural disturbance regimes of different forest site types and regions on the one hand (Fries *et al.*, 1997; Angelstam, 1998; Axelsson *et al.*, 2007) and to emphasize the development of products from a range of goods, services and values (Merlo and Croitoru, 2005) including social forestry (Sastamoinen, 2005; Björk *et al.*, 2008, Nilsson *et al.*, 2011) on the other. Current international, European and Swedish policies focus on sustained yield, biodiversity conservation, rural development and urban forestry. This has made the Swedish government initiate investigations about green infrastructure development for ecosystem services and human well-being and new approaches to forest management (Anonymous 2010a, b). This diversity of objectives does require a diversity of forest management systems.

Conclusions

The Swedish forestry sector has been very successful at implementing the sustained yield paradigm throughout Sweden since about 1950. However, the current forest policy aiming at SFM still remains to be implemented on the ground. To implement this, a new set of tools are needed in the forest landscape manager's toolbox. These range from hardware methods to adapt forest operations to satisfy ecological, economic and socio-cultural dimension and soft-wares as to encourage stakeholder participation at stand to estate and landscape and even regional levels. CCF is one of the several forest management systems needed to deliver the goods, services and values that societies desire from forest landscapes.

Funding

Funding for this study was provided by the Swedish research council FORMAS and Marcus och Amalia Wallenbergs Minnesfond.

Conflict of interest statement

None declared.

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Received 22 January 2011