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Beliefs among Formal Actors in the Swedish Forestry Related to Rutting Caused by Logging Operations

Attityder och åsikter med koppling till körskador inom olika yrkesgrupper i skogsbruket

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In the Arbetsrapporter series, Skogforsk presents results and conclusions from current projects. The reports contain background material, preliminary results, conclusions, and analyses from our research.

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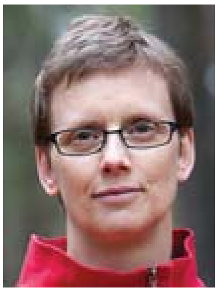

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Abstract

The challenge for the forestry is managing the forest in ways that maximize its economic output whilst having few or no negative effects on the ecological and recreational value of that forest. A logging operation involves several stages and different actors and attempts to reduce any physical soil disturbance due to logging. In this study, beliefs about rutting in forestry and possible remedies are investigated among formal actors who work in the Swedish forestry.
A questionnaire was distributed to participants on a nationwide course, focused on soil disturbance and water issues. The results show that different professional actors differ in their beliefs about the consequences of rutting, the current strategies to reduce rutting and about the observed need for development of strategies for forestry in the future. A key result is that those with less planning and decision power view the possibility to decrease rutting to be more difficult.

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Uppsala in December 2013

Annika Nordlund, Eva Ring, Lars Högbom and Isabelle Bergkvist

Content

Sammanfattning

Skogen har en viktig ekonomisk roll att spela i flertalet länder på den norra hemisfären. Detta till trots så fyller skogen flera behov i samhället i dag och dess värde kan variera från produktionsvärdet (exv. det ekonomiska värdet av timmer), ekologiska värdet (exv. skogens värde som koldioxidsänka, för biodiversitet och för vattenkvalitet), till dess rekreationsvärde för människor. I dag ses människor som tydliga konsumenter av de skogliga värdena, vilket har resulterat i att större vikt läggs på det ekologiska värdet och rekreationsvärdet. En av de stora utmaningarna för skogsbruket är således att förvalta skogen på ett sätt som maximerar det ekonomiska resultatet samtidigt som det har få eller inga negativa effekter på de ekologiska värdena eller på rekreationsvärdena. Att undvika att orsaka körskador är ett exempel på detta. Risken för att orsaka körskador är oftast störst i samband med slutavverkning. Hur utförandet blir på en enskild avverkningstrakt är ett resultat av en process som involverar flera olika aktörer och stadier, och som slutförs i en miljö där förhållandena varierar över både tid och rum. Att förstå vilka attityder och åsikter om körskador som aktörerna i denna process har, kan bidra till att man kan utveckla metoder eller arbetssätt som leder till färre körskador.

I denna studie undersöks attityder och åsikter om körskador till följd av skogsbruk, och möjliga motåtgärder, bland formella aktörer som arbetar i det svenska skogsbruket. En enkät delades ut till 1588 deltagare (svarsfrekvens >90 %, n=1 459) i en rikstäckande kurs som fokuserade på körskador och vattenfrågor i Sverige under 2010. Deltagarna var jämt spridda över landet med en medelålder på 42 år och i snitt 14 år i nuvarande tjänst. Deltagarna arbetade som entreprenörer (27.2%), skogsmaskinförare (45.2%), planerare (5.2%), produktionsledare (5.9%), virkesköpare (5.6%), inspektor på skogsägarföreningen (6.5%), eller i annan yrkesroll (4.4%). I syfte att möjliggöra gruppjämförelser delades deltagarna in i ålderskategorier (≤29 år; 30–49 år; ≥50 år). I snitt hade den yngsta ålderskategorin 4 år i nuvarande tjänst; för medelåldersgruppen var motsvarande snitt 11 år och för de äldre deltagarna 24 år.

Resultaten visar att olika yrkesgrupper skiljde sig åt i sina uppfattningar om konsekvenserna av körskador, synen på nuvarande strategier för att minska körskador och behovet av att utveckla framtida strategier. En ”körskada” definierades som ett hjulspår som är minst 2 dm djup och minst 5 m långt, och finns var som helst på drivningstrakten. Körskador ansågs påverka de många värden som skogen håller, men endast i liten utsträckning. Undantaget var dock åsikterna om de negativa effekterna körskador ansågs ha på vattendrag och sjöar. De yngsta deltagarna uppvisade generellt svagare åsikter om strategier och behov relaterade till körskador, förutom att dessa deltagare i större utsträckning än övriga deltagare ansåg att mängden körskador kan minskas om GROT uteslutande används för att förstärka markens bärighet. Även ålder i relation till roll i skogsbruket visade sig vara av betydelse, vilket föranledde att det kontrollerades för ålder i samtliga analyser i studien.

De olika yrkesgrupperna skiljde sig åt med avseende på åsikter om effekter av körskador, motåtgärder och utvecklingsbehov i relation till körskador. Ett exempel på detta är att inspektorer på skogsägarföreningar i mindre utsträckning än de i gruppen övriga som ansåg att körskador försämrar skogsmarkens naturgivna produktionsförmåga. Ytterligare ett exempel är det faktum att

maskinförare i större utsträckning än produktionsledare, virkesköpare och inspektorer på skogsägarförening ansåg att körskador minskar den biologiska mångfalden. Maskinförare ansåg i större utsträckning än alla andra yrkes-kategorier även att mängden körskador kan minskas om GROT uteslutande används för att förbättra bärigheten i marken. Ett viktigt resultat är att de deltagare som kan ses inneha mindre inflytande i planering och beslutsfattande upplevde det svårare att minska mängden körskador i skogsbruket.

Det framgår av studien att införandet av rättsliga sanktioner inte sågs som en lösning på problemet med körskador, vilket kan vara ett tecken på en vilja inom skogsbranschen att själv ta ansvar för att lösa problemen. Att använda GROT uteslutande för att förbättra markens bärighet ansågs till en del kunna minska mängden körskador. Då GROT använts som markskydd kan denna GROT inte användas för energiproduktion. Det finns därför en möjlig intressekonflikt mellan att använda GROT som markskydd respektive biobränsle. Detta då GROT alltmer används i energiproduktionen. Frågan blir då i vilken utsträck-ning detta material bör användas som markskydd respektive biobränsle.

Denna studie bidrar med insikt om olika skogsaktörers åsikter om; konsekven-serna av körskador på dagens nivå, effektiviteten på nuvarande åtgärder för att minska mängden körskador och om behovet av utveckling som krävs för att minska framtida körskador. Denna kunskap kan bidra till en fortsatt utveckling av åtgärder och planeringsprocesser i skogsbruket. Dessutom belyser studien behovet av att arbeta med körskador på varje nivå inom skogsbruket, från maskinförarna med sitt ”hands-on” perspektiv till entreprenörer och andra yrkesgrupper i skogssektorn, från de unga till de äldre.

Introduction

Forest resources play an important economic role in countries in the northern hemisphere such as Sweden, Finland, Russia and Canada. Thus, the primary focus of forest management is one of maximizing financial value (Thunberg, 2006). However, the forest plays multiple roles in society and forms a part of the creation of historical, social and cultural identity and deliver of a multitude of ecosystem services. The degree to which the different values seen in the forests have been accentuated has changed with time and, today, forests have multiple uses and values, such as their production value (e.g. timber and pulpwood), their ecological value (e.g. forests are important as carbon sinks, for biodiversity and for water quality) and their recreational value (Berlin et al., 2006; Erickson et al., 2002; Fischer & Bliss, 2006; Fischer et al., 2010; Nordlund & Westin, 2011; Rydberg, 2001; Robinson et al., 2001). The increased emphasis on the ecological and recreational values of forests by the public may have an effect on the way the forests are managed (Kant & Lee, 2004; Li et al., 2010; Nordlund & Westin, 2011; Eriksson, 2012; Eriksson et al., 2012a; Eriksson et al., 2012b). The challenge for the forestry sector is to manage the forest in ways that maximize its economic output, whilst having as little negative effect on the ecological and recreational value as possible. If care is not taken to allow the multiple uses of the forest and to meet the demands on the forest by different interested actors (e.g. formal forestry actors, private forest owners and the public), the forestry sector may find itself in an arena of conflicting interests and diverging opinions on how forests should and should not be managed (Lindkvist et al., 2012). For instance, physical soil disturbance due to logging may have a negative effect on the ecological and recreational value. In this study, the aim is to investigate the beliefs of formal actors in the Swedish forestry about rutting in forestry and its possible remedies.

LOGGING IN SWEDEN

A logging operation can be described as a chain of events (Table 1). Every region or property is overviewed by a forest manager from a forestry company, or by the individual land owner. Suitable stands are identified and selected. The order in which the stands are to be harvested is influenced by many factors such as the demand for different assortments from the industry, the availability of suitable harvester systems, the spatial planning of the operations (logistics), the current load-bearing capacity of the soil, the road conditions and requests from individual forest owners. When the order of stands to be harvested has been decided, each operation is planned in detail. The planning can be carried out at the office and/or in the field, to inspect and mark out special features. The planning results in a stand-specific instruction, which is eventually delivered to the machine operators. The amount of information contained in these instructions differs widely.

The forestry operations are generally carried out by forest contractors. The felling manager directs and supervises a team of machine operators, but many decisions on how the operations are ultimately performed are taken by the machine operators themselves. Most of the machine operators are employed by forest contractors. In total, about 14 700 people were engaged as, or employed by, forest contractors in 2010, of which 96.4% were men and 3.6% were women (Swedish Forest Agency, 2011).

Table 1.
Principle description of the factors governing the different steps of a logging operation in Swedish forestry and the actors involved. “Study group” refers to the classification used in the present study.

	Selection	Field planning	Performance
	Cutting area is selected	Logging operation is planned	Logging is performed
Governing factors	Legislation Supply of cutting areas with required access classification[a)] Product demand by the market Requirement for profitability	Forest certification Cost efficiency Amount and quality of site information Attitudes	Type of harvester and forwarder Technical aids Instructions Amount and quality of site information Requirement for profitability Current conditions on site Skills Attitudes
Actors	Forestry employees Private forest owners Authorities	Forestry employees	Forest contractors Machine operators
Study group	Others Production leaders Timber byers Forest inspectors	Forest contractors Planners Forest inspectors	Forest contractors Machine operators

[a)] Classification of the accessibility of the cutting area based on *inter alia*, soil conditions , climate and access roads (cf. Berg, 1991).

SOIL DISTURBANCE AND ASSOCIATED BELIEFS

Currently, logging in Sweden is carried out all year round, in part because of a constant demand for wood by the industry. This means that forest land is subjected to traffic also during periods when the soil is more vulnerable to damage such as compaction and rutting. The seasons, as well as the preceding and current weather conditions, are all important for determining the load-bearing capacity of the soil (cf. Kozlowski, 1999). Moreover, Sweden has a north-to-south gradient in climate. In particular, the length of winter, measured as the period with snow cover, varies substantially from between 25 and 50 days in the far south to over 200 days in the north (www.smhi.se). Annual mean temperature ranges between +7°C in the southwest and –1°C in the extreme north. Normal annual precipitation varies between 600 to 1 200 mm. There is no clear north to south gradient when considering precipitation.

The load-bearing capacity of soils is also determined by the soil type, for instance, soils with coarse texture typically have higher load-bearing capacity than soils with fine texture (cf. Berg, 1992; Kozlowski, 1999). In total, 75 % of the land area in Sweden is covered with till soils of varying texture (Fredén, 1994). The remaining land area is covered with sediments or peat. The soil types are fairly evenly distributed throughout the country (www.mark-info.se). The ground pressure of logging machines can be reduced by driving on tops and branches or portable bridges.

Rutting and soil compaction may hamper tree growth (Kozlowski, 1999) and rutting near surface water, causing increased sediment loads, may have a deleterious effect on downstream aquatic habitats. The chemical effects of rutting or soil compaction in discharge areas adjacent to surface water are largely unknown, despite these areas being important for surface water quality (Bishop et al., 2004). High methylation rates of mercury have been recorded in discharge areas and in peatlands (Bishop et al., 2009). Furthermore, rutting can affect the recreational and aesthetical value of the forest. Socially acceptable forestry tends to be regarded as providing beautiful scenery and serving wildlife needs, whilst also serving human needs (Ribe, 2006). Damage seen to ecosystems, such as rutting caused by logging, may have large effects and international implications, through its effect on individual beliefs (Gifford et al., 2009). Moreover, beliefs about ecological damage, in general, positively influence the acceptance of implementation of governmental environmental policies (Steg & Sievers, 2000). Studies about activism and controversy regarding forest management, for example, have stressed that differences in values and beliefs among different stakeholder groups is the root of the problem (Kennedy, 1985; McFarlane & Boxall, 2003; Vaske & Donnelly, 1999).

This study aims to investigate beliefs about the rutting associated with logging operations. More specifically, this study investigates whether rutting is perceived to be a problem within the forest sector, whether different professional categories view rutting to be more or less of a problem and if beliefs about current strategies and future requirements to decrease the level of rutting in forestry are viewed differently. An additional aim is to investigate if there are differences in the way rutting is perceived in different age groups with varying working experience in forestry.

Materials and Methods

A questionnaire was distributed to 1588 persons taking part in a nationwide course in Sweden during 2010; there were approximately 90 one-day courses given at a number of sites throughout Sweden. The questionnaire return rate was over 90 % (n = 1459). The courses taught how to perform forestry operations near surface water and on sensitive soils. Around twenty participants attended each course. The questionnaire was distributed to all participants at the beginning of each course, before the course had been given. Then participants, all of whom were active professionals within the Swedish forestry, filled in the questionnaire in about 20 minutes and thereafter returned it immediately to the leaders of the course.

PARTICIPANTS

The participants worked as Forest contractors (n=386, 27.2%), Machine operators (n=640, 45.2%), Planners (n=74, 5.2%), Production leaders (n=83, 5.9%), Timber buyers (n=80, 5.6%), Forest inspectors (n=92, 6.5%), and Other actors (n=62, 4.4%). The participants came from all over Sweden. The mean age of the sample was 42 years (Sd = 1.04) and the average number of years of work in their present position was 14 years. The gender distribution was extremely uneven with 97% male participants. However, this mirrors the gender distribution within Swedish forest industry contractors (Swedish Forest Agency, 2011).

The sample was divided into three age categories (≤29 years of age; 30–49 years of age; ≥50 years of age) in order to facilitate group comparisons. The average number of years of work in their present position in the group of young participants (≤29 years of age) was 4 years; for the group of middle-aged participants (30–49 years of age) 11 years on average, and for the older participants (≥50 years of age) 24 years on average.

QUESTIONNAIRE

The questionnaire consisted of five sections each assessing different beliefs related to rutting, with one section addressing the background information of the participants. In the questionnaire, rutting was defined as a wheel track, located anywhere within the cutting area, with a depth of 0.2 m and a length of at least 5 m. In one section, beliefs about different strategies to reduce the current level of rutting were assessed with eleven rutting-reducing strategy items. Beliefs about the individual forest owners' financial responsibility for rutting and whether the participants felt that the individual forests owners should be asked, before work begins, whether they would be willing to pay extra for a reduced level of rutting (compared to the normal level) was assessed with two statements. Beliefs about the negative effects that rutting has on forest resources was assessed with five items, followed by a statement related to whether reduced levels of rutting was believed to be an important part of routine environmental measures in the forestry sector. Finally, there was one question assessing the perceived level of difficulty of reducing rutting. The perceived importance of different strategies in order to decrease future rutting in forestry was assessed with seven statements. The participants rated each of the statements on a 7-point scale (1 = strongly disagree to 7 = fully agree). Beliefs about the potential increased costs associated with using strategies to reduce rutting and how this extra cost might be financially compensated was assessed with four statements for which the participants were asked to choose which they most preferred. The final section of the questionnaire contained questions relating to background information such as age, work experience etc.

STATISTICAL ANALYSES

A series of One-way Analyses of Variance (ANOVA) were conducted on the different beliefs about rutting using age group category or professional category as grouping variable. The age group categories were 29 years of age or younger, 30–49 years of age and 50 years of age or older. In the ANOVAs using professional category as grouping variable, age was included as covariate. Pairwise comparisons for professional category, post hoc with Bonferonni correction for multiple comparisons, were conducted for all analyses showing significant effects of group (professional category). Subscripts in Tables 3–5, represent significantly differences at $p < 0.05$ in pairwise Bonferonni-corrected post-hoc *t*-tests, after controlling for age between the different professional categories.

Results

Significant differences in beliefs between the three age groups were detected (Table 2). In general it was shown that the youngest age group of forest actors expressed weaker beliefs about strategies and need related to rutting, except that the youngest age group more strongly believed that the strategy to exclusively using the tops and branches to improve the load-bearing capacity of the soil is a viable strategy. The results indicate that age, and thus work experience, may co-vary with profession and age was therefore included as co-variate in the ANOVA of beliefs among different professional categories.

In Table 3 the mean values of beliefs about problems related to rutting in forestry in the overall sample and in the seven professional categories of course participants is shown. The results showed that the respondents believed that rutting affects the multiple values of the forest to some degree, even if they believed that those effects were generally quite moderate. The exception is the stronger negative effect that rutting was believed to have on streams and lakes. In addition, the perceived level of difficulty in decreasing the level of rutting was found to be only moderately difficult. Reducing rutting was, however, already believed to be an important part of routine environmental measures in forestry.

Table 2.
Means and standard deviations, in brackets, for beliefs about rutting in three age groups.

	≤ 29 years of age	30–49 years of age	≥ 50 years of age
Attitudes towards the current level of rutting:			
Affects the recreational value of forest negatively[a]	4.09 (1.43)$_{1,2}$	3.98 (1.60)$_{1}$	4.25 (1.58)$_{2}$
Affects the cultural value of the forest negatively[b]	4.18 (1.49)$_{1,2}$	4.08 (1.51)$_{1}$	4.33 (1.58)$_{2}$
The level of rutting can be decreased:			
By increasing the amount of information in the stand-specific instructions[c]	5.42 (0.10)$_{1}$	5.64 (0.06)$_{1}$	5.89 (0.07)$_{2}$
By making the available information in the stand-specific instructions more comprehensible[d]	4.61 (0.12)$_{1}$	4.69 (0.07)$_{1}$	5.19 (0.08)$_{2}$
By spending more time on planning in the field[e]	5.93 (1.32)$_{1}$	6.14 (1.14)$_{2}$	6.20 (1.11)$_{2}$
By increasing the level of competence among those who plan in the field[f]	5.63 (1.43)$_{1}$	5.85 (1.30)$_{2}$	5.97 (1.26)$_{2}$
By insuring that the logging manager and the forest contractor discuss any technical issues concerning the logging beforehand for each site[g]	5.19 (1.51)$_{1}$	5.40 (1.53)$_{1}$	5.76 (1.34)$_{2}$
By increased level of follow-up and feedback after logging[h]	4.80 (1.51)$_{1}$	5.13 (1.40)$_{2}$	5.42 (1.36)$_{3}$
By exclusively using the tops and branches to improve the load-bearing capacity of the soil[i]	5.31 (1.66)$_{1}$	4.98 (1.86)$_{2}$	5.19 (1.86)$_{2}$
By regulating how difficult sites and rutting should be handled in the contract drawn up between the forest contractor and the client[j]	4.83 (1.53)$_{1}$	4.88 (1.74)$_{1}$	5.17 (1.65)$_{2}$
By introducing explicit legal sanctions[k]	2.90 (1.72)$_{1}$	3.11 (1.84)$_{1}$	3.39 (1.88)$_{2}$
Need for development for a future reduction in rutting:			
Develop new technical aids in order to protect land and water during off-road transports[l]	5.11 (1.42)$_{1}$	5.41 (1.39)$_{2}$	5.62 (1.33)$_{3}$
Clearly defined what serious rutting is[m]	5.00 (1.51)$_{1}$	5.27 (1.42)$_{2}$	5.49 (1.37)$_{3}$
Develop improved contract and buying procedures[n]	4.81 (1.38)$_{1}$	4.93 (1.52)$_{1}$	5.22 (1.48)$_{2}$
Explain the allocation of responsibility, costs and sanctions related to rutting[o]	5.00 (1.39)$_{1}$	5.28 (1.43)$_{2}$	5.46 (1.41)$_{2}$
Develop guidance about which services to use in different situations and how these services are best used[p]	5.17 (1.31)$_{1}$	5.39 (1.33)$_{2}$	5.62 (1.24)$_{3}$

Note: One-way Anova, [a] $F(2, 1388)=4.01$, $p=0.018$; [b] $F(2, 1392)=3.49$, $p=0.031$; [c] $F(2, 1370)=7.90$, $p<0.001$; [d] $F=(2,1364)=14.02$, $p<0.001$; [e] $F=(2,1372)=4.86$, $p=0.008$; [f] $F=(2,1375)=6.10$, $p=0.002$; [g] $F=(2,1386)=14.32$, $p<0.001$; [h] $F=(2,1382)=17.07$, $p<0.001$; $F=(2,1380)=3.72$, $p=0.025$; [j] $F=(2,1368)=5.09$, $p=0.006$; [k] $F=(2,1374)=6.68$, $p=0.001$; [l] $F=(2,1390)=12.36$, $p<0.001$; [m] $F=(2,1377)=10.42$, $p<0.001$; [n] $F=(2,1374)=8.35$, $p<0.001$; [o] $F=(2,1385)=9.58$, $p<0.001$; [p] $F=(2,1393)=11.05$, $p<0.001$.
Means for the different age categories with different subscripts are significantly different at $p < 0.05$ in pairwise Bonferonni-corrected post-hoc *t*-tests.

Table 3.
Means and standard deviations for beliefs about problems related to rutting in forestry in the overall sample and for seven sub groups of professional categories (forest contractors, machine operators, planners, production leaders, timber buyers, inspectors, and others).

	Overall Mean (Sd)	**Sub group , Mean (Sd)**						
		Forest contractor	**Machine operator**	**Planner**	**Production leader**	**Timber buyer**	**Forests inspector**	**Other**
Decreased rutting in the forest is an important part of routine environmental measures taken in the forestry[a]	5.75 (1.30)	5.89 (1.22)$_{1,2}$	5.58 (1.38)$_{1}$	5.97 (1.21)$_{1,2}$	5.80 (1.24)$_{1,2}$	6.06 0.93)$_{1,2}$	5.66 (1.30)$_{1,2}$	6.27 (1.03)$_{2}$
To decrease the level of rutting in the forestry is very difficult[b]	4.23 (1.71)	4.04 (1.78)$_{1}$	4.46 (1.74)$_{2}$	4.03 (1.73)$_{1,2}$	4.21 (1.46)$_{1,2}$	3.74 (1.40)$_{1}$	4.22 (1.60)$_{1,2}$	3.76 (1.46)$_{1}$
Attitudes towards the current level of rutting:								
– Affects the recreational value of forest negatively[c]	4.08 (1.59)	4.13 (1.56)$_{1,2}$	4.11 (1.58)$_{1,2}$	4.21 (1.58)$_{1,2}$	3.58 (1.59)$_{1}$	3.91 1.65)$_{1,2}$	3.80 (1.56)$_{1,2}$	4.45 (1.80)$_{2}$
– Affects the cultural value of the forest negatively[d]	4.18 (1.53)	4.16 (1.54)$_{1,2}$	4.22 (1.53)$_{1,2}$	4.40 (1.41)$_{1,2}$	3.86 (1.59)$_{1}$	3.80 (1.63)$_{1}$	4.00 (1.44)$_{1,2}$	4.79 (1.51)$_{2}$
– Affects the long-term site productivity negatively[e]	3.92 (1.56)	4.04 (1.59)$_{1,2}$	3.89 (1.56)$_{1,2}$	3.90 (1.61)$_{1,2}$	3.72 (1.57)$_{1,2}$	3.78 1.42)$_{1,2}$	3.58 (1.33)$_{1}$	4.40 (1.65)$_{2}$
– Affects streams and lakes negatively[f]	4.99 (1.51)	5.00 (1.55)$_{1}$	4.96 (1.54)$_{1}$	5.07 (1.44)$_{1,2}$	5.02 (1.39)$_{1,2}$	4.73 (1.53)$_{1}$	4.81 (1.37)$_{1}$	5.68 (1.25)$_{2}$
– Decreases the level of biodiversity in the forest[g]	3.68 (1.55)	3.68 (1.25)$_{1,2}$	3.87 (1.51)$_{2}$	3.82 (1.52)$_{1,2}$	3.11 (1.53)$_{1}$	3.10 (1.47)$_{1}$	3.18 (1.39)$_{1}$	3.68 (1.55)$_{1,2}$

Note. Main effect of group (professional categories); [a]$F(6, 1373)=4.46$, $p<0.001$, [b]$F(6, 1373)=5.14$, $p<0.001$, [c]$F(6, 1369)=2.77$, $p=.011$, [d]$F(6, 1372)=3.46$, $p=0.002$, [e]$F(6, 1374)=2.13$, $p=0.047$, [f]$F(6, 1375)=2.64$, $p=0.015$, [g]$F(6, 1373)=7.82$, $p<0.001$. Means for the different professional categories with different subscripts are significantly different at $p < 0.05$ in pairwise Bonferonni-corrected post-hoc *t*-tests, after controlling of age.

Some differences between the groups were detected for the expressed beliefs about whether decreased rutting is an important part of routine environmental measures taken in the forestry. The results show that the other category believed that such environmental measures were routine to a significantly higher degree compared to machine operators. The results of the ANOVA (controlling for age) concerning beliefs about the level of difficulty in reducing rutting showed a main effect of professional category. The pairwise comparisons showed that machine operators perceived it to be significantly more difficult to reduce rutting compared to the forest contractors, timber buyers, and the other category.

The results of ANOVAs, controlling for age, further showed that the categories of profession differed with respect to what degree rutting was perceived to affect the recreational value of the forest negatively with main effects of age and professional category. Here, the other category perceived the negative effect on the recreational values to be greater compared to production leaders. Significant differences was also found for the perceived negative effect of rutting on the cultural value of the forest, in that the other category believed this to be true to a significantly larger degree compared to production leaders and timber buyers. A main effect was also seen for professional category with regards to the perceived negative effect of rutting on long-term site productivity. Pairwise comparisons show that the other category believed this to be true to a significantly larger degree compared to the forest inspectors. Pairwise differences were found for the perceived negative effect of rutting on streams and lakes. Here, the other category believed this to be true to a significantly larger degree compared to forest contractors, machine operators, forest inspectors and timber buyers. Lastly, there were differences related to the believed decrease in the level of biodiversity in the forest as a result of rutting. Pairwise comparisons showed that machine operators believed this to be true to a significantly larger degree compared to production leaders, timber buyers, and forest inspectors.

Furthermore, ANOVAs (with age entered as covariate) indicated differences between professional categories with respect to their beliefs about how the increased cost of logging relating to a reduction in rutting should be dealt with. Results for the belief that forest owners should pay more when the site has reduced rutting than would normally be expected showed significant main effects of and professional category ($F(6, 1348)=6.01$, $p<0.001$). The pairwise comparisons showed that planners and forest inspectors believed this to a significantly lesser degree compared to forest contractors and machine operators. Differences were also present with regards to the beliefs that forest owners always are consulted, before the logging starts, on whether or not he/she is prepared to pay more to reduce rutting below that that would normally be expected, showing significant main effects of professional category ($F(6, 1363)=10.65$, $p<0.001$). Here, pairwise comparisons showed that forest contractors and machine operators believed this to a significantly higher degree compared to production leaders, timber buyers, and forest inspectors.

The level of rutting in forestry can be managed in different ways. In table 4 mean values for beliefs about rutting reduction strategies for the overall sample and the sub groups of professional categories are presented.

Table 4.
Means and standard deviations for beliefs about different strategies for reducing the level of rutting in the forestry in the overall sample and for seven sub groups of professional categories (forest contractors, machine operators, planners, production leaders, timber buyers, inspector, and others).

	Overall Mean (Sd)	**Sub group, Mean (Sd)**						
The level of rutting can be reduced:		Forest contractor	Machine operator	Planner	Production leader	Timber buyer	Forest inspector	Other
By spending more time on planning in the field	6.11 (1.19)	6.27 (1.08)$_{1}$	6.11 (1.24)$_{1}$	5.90 (1.24)$_{1}$	5.99 (1.16)$_{1}$	6.09 (1.01)$_{1}$	5.99 (1.22)$_{1}$	5.95 (1.19)$_{1}$
By increasing the level of competence among those who plan in the field[a].	5.84 (1.34)	6.01 (1.30)$_{1}$	5.84 (1.37)$_{1}$	5.55 (1.39)$_{1.2}$	5.94 (1.04)$_{1}$	5.82 (1.08)$_{1.2}$	5.32 (1.44)$_{2}$	5.95 (1.21)$_{1}$
By increasing the availability of portable bridges, ground protection, tracks for forest machines to improve their load-bearing capacity of the soil etc[b]	5.79 (1.32)	5.71 (1.42)$_{1}$	5.79 (1.35)$_{1}$	5.71 (1.31)$_{1}$	5.81 (1.11)$_{1}$	5.81 (1.18)$_{1}$	5.95 (1.12)$_{1}$	6.19 (0.92)$_{1}$
By increasing the amount of information in the stand-specific instructions.	5.67 (1.44)	5.70 (1.50)$_{1}$	5.65 (1.46)$_{1}$	5.53 (1.43)$_{1}$	5.77 (1.24)$_{1}$	5.81 (1.19)$_{1}$	5.36 (1.52)$_{1}$	5.89 (1.29)$_{1}$
By insuring that the logging manager and the forest contractor discuss any technical issues concerning the logging beforehand for each site.	5.47 (1.49)	5.64 (1.46)$_{1}$	5.44 (1.48)$_{1}$	5.71 (1.35)$_{1}$	5.33 (1.54)$_{1}$	5.44 (1.44)$_{1}$	5.20 (1.51)$_{1}$	5.32 (1.61)$_{1}$
By increased level of follow-up and feedback after logging[c].	5.15 (1.43)	5.01 (1.47)$_{1}$	4.92 (1.43)$_{1}$	5.74 (1.33)$_{2}$	5.81 (1.06)$_{2}$	5.65 (1.27)$_{2}$	5.41 (1.28)$_{1.2}$	5.84 (1.32)$_{2}$
By exclusively using the tops and branches to improve the load-bearing capacity of the soil.	5.12 (1.83)	5.15 (1.77)$_{2}$	5.54 (1.98)$_{3}$	4.59 (1.70)$_{1.2}$	4.12 (1.88)$_{1}$	4.66 (2.10)$_{1.2}$	4.46 (1.82)$_{1}$	4.18 (1.96)$_{1}$
By regulating how difficult sites and rutting should be handled in the contract drawn up between the forest contractor and the client[d].	4.97 (1.67)	5.00 (1.85)$_{1.3}$	5.08 (1.64)$_{2.3}$	4.73 (1.49)$_{1.2}$	4.68 (1.48)$_{1.2}$	5.13 (1.51)$_{1.2}$	4.43 (1.47)$_{1}$	5.05 (1.46)$_{1.2}$
By making the available information in the stand-specific instructions more comprehensible	4.83 (1.69)	4.69 (1.75)$_{1}$	4.82 (1.75)$_{1}$	5.12 (1.63)$_{1}$	4.94 (1.54)$_{1}$	4.99 (1.51)$_{1}$	4.63 (1.76)$_{1}$	5.44 (1.50)$_{1}$
By exclusively presenting the stand-specific instructions in digital format[e].	3.73 (1.79)	3.44 (1.82)$_{1}$	3.64 (1.79)$_{1.2}$	4.25 (1.55)$_{2.3}$	4.61 (1.97)$_{3}$	4.32 (1.53)$_{2.3}$	3.78 (1.70)$_{1.2.3}$	3.85 (1.46)$_{1.2.3}$
By introducing explicit legal sanctions[f].	3.15 (1.83)	2.90 (1.85)$_{1}$	3.04 (1.81)$_{1.2}$	3.52 1.88)$_{1.2.3}$	3.67 (1.71)$_{2.3}$	3.62 (1.76)$_{2.3}$	3.25 (1.73)$_{1.2.3}$	3.92 (1.86)$_{3}$

Note. Main effect of group (professional categories); [a]$F(6, 1357)=3.77$, $p=0.001$, [b]$F(6, 1362)=17.77$, $p<0.001$, [c]$F(6, 1363)=11.77$, $p<0.001$, [d]$F(6, 1351)=3.17$, $p=0.004$, [e]$F(6, 1350)=7.81$, $p<0.001$, [f]$F(6, 1355)=6.25$, $p<0.001$.
Means for the different professional categories with different subscripts are significantly different at $p < 0.05$ in pairwise Bonferoni-corrected post-hoc *t*-tests, after controlling of age.

The results show that strategies aimed at reducing rutting by presenting the stand-specific instructions in digital format and introducing explicit legal sanctions were the strategies that were perceived to be least effective. The most effective strategies for reducing rutting were perceived to be those that involved spending more time on planning in the field, increasing the level of competence among those who plan in the field, increasing the availability of portable bridges, ground protection and tracks for forest machines to reduce their ground pressure etc. and increasing the amount of information in the stand-specific instructions.

Differences were found between professional categories, after controlling for effects of age, (see Table 4) with regards to strategies aimed at: using the tops and branches exclusively to improve the load-bearing capacity of the soil, increasing the level of follow-up and feedback after logging, increasing the level of competence among those who plan in the field, regulating how difficult sites and rutting should be handled in the contract drawn up between the forest contractor and the client, introducing explicit legal sanctions, and exclusively presenting the stand-specific instructions in digital format.

With regards to using the tops and branches exclusively to improve the load-bearing capacity of the soil, this was perceived to be more important for machine operators compared to all other professional categories. In addition, forest contractors believed this to be more important compared to production leaders, forest inspectors, and the other category. Increasing the level of follow-up and feedback after logging was perceived to be less important to forest contractors and machine operators compared to planners, production leaders, timber buyers, and the other category. Increasing the level of competence among those who plan in the field was perceived to be less important to forest inspectors compared to forest contractors, machine operators, production leaders and the other category. Regulating how difficult sites and rutting should be handled in the contract drawn up between the forest contractor and the client was perceived to be more important to machine operators as compared to forest inspectors. Introducing explicit legal sanctions was perceived to be less important to forest contractors and machine operators, as compared to the other category. In addition forest contractors held this strategy as less important than production leaders and timber buyers. The strategy of exclusively presenting the stand-specific instructions in digital format was perceived to be less important to forest contractors and machine operators as compared to production leaders. Forest contractors also believed in this strategy to a lesser degree compared to planners and timber buyers.

Table 5 shows the mean values for the importance of different strategies in order to reduce future rutting in the forestry in the overall sample and the sub groups of professional categories. The results show that the respondents found all of the presented strategies for improvement or development to be quite important, with no one strategy standing out as either very important or not important at all. About half of the respondents felt that financial compensation should be paid by the buyer organization to the forest contractor (47%),

Table 5.
Means and standard deviations of beliefs about the importance of different strategies in order to reduce future rutting in the forestry for the overall sample and for seven sub groups of professional categories (forest contractors, machine operators, planners, production leaders, timber buyers, inspectors, and others).

	Overall Mean (Sd)	**Sub group, Mean (Sd)**						
What do we need to develop in order to reduce future rutting?		Forest contractor	Machine operator	Planner	Production leader	Timber buyer	Forest inspector	Other
Improved function of portable bridges. ground protection etc.	5.45 (1.44)	5.39 (1.50)$_1$	5.41 (1.48)$_1$	5.34 (1.63)$_1$	5.53 (1.36)$_1$	5.64 (1.26)$_1$	5.76 (1.19)$_1$	5.81 (1.14)$_1$
Develop new technical services in order to protect land and water during off-road traffic[a].	5.41 (1.39)	5.37 (1.40)$_1$	5.30 (1.43)$_1$	5.56 (1.36)$_1$	5.65 (1.26)$_1$	5.53 (1.25)$_1$	5.64 (1.40)$_1$	5.89 (1.17)$_1$
Develop guidance about which services to use in different situations, and how these services are best used[b].	5.41 (1.31)	5.35 (1.34)$_1$	5.35 (1.33)$_1$	5.64 (1.08)$_{1.2}$	5.72 (1.22)$_{1.2}$	5.60 (1.13)$_{1.2}$	5.24 (1.45)$_1$	5.98 (1.03)$_2$
Explain the allocation of responsibility, costs and sanctions related to rutting.	5.29 (1.43)	5.42 (1.51)$_1$	5.17 (1.41)$_1$	5.38 (1.22)$_1$	5.35 (1.45)$_1$	5.22 (1.39)$_1$	5.12 (1.47)$_1$	5.74 (1.21)$_1$
Clearly define what serious rutting is[c].	5.29 (1.44)	5.36 (1.44)$_{1.2}$	5.28 (1.42)$_2$	5.37 (1.22)$_{1.2}$	5.40 (1.55)$_{1.2}$	5.16 (1.57)$_{1.2}$	4.85 (1.58)$_1$	5.50 (1.28)$_{1.2}$
Develop improved contract and buying procedures[d].	5.00 (1.48)	5.28 (1.49)$_2$	5.21 (1.35)$_2$	4.47 (1.41)$_1$	4.43 (1.55)$_1$	4.39 (1.44)$_1$	4.10 (1.54)$_1$	4.73 (1.59)$_{1.2}$
Develop the digital planning tools further[e].	4.57 (1.59)	4.46 (1.69)$_{1.2}$	4.68 (1.56)$_2$	4.56 (1.57)$_{1.2}$	4.60 (1.73)$_{1.2}$	4.55 (1.27)$_{1.2}$	4.16 (1.50)$_1$	476 (1.56)$_{1.2}$

Note. Main effect of group (professional categories); [a]$F(6, 1370)=2.21$, $p=0.040$, [b]$F(6, 1374)=3.86$, $p=0.001$, [c]$F(6, 1358)=2.26$, $p=0.010$, [d]$F(6, 1356)=19.36$, $p<0.001$, [e]$F(6, 1363)=2.67$, $p=0.012$. Means for the different professional categories with different subscripts are significantly different at $p<0.05$ in pairwise Bonferonni-corrected post-hoc *t*-tests, after controlling of age.

24% believed that it should be dealt with through fixed general increases in price for the specific sites, 18% felt that it should be paid by the individual forest owner to the forest contractor and 11% believed that it should be dealt with through a general increase in price regulated in the yearly agreement between the forest contractor and the client.

Differences were found between professional categories, after controlling for effects of age (see Table 5), were seen with regards to importance of future strategies aimed at: developing guidance about which services to use in different situations and how these services are best used, further developing digital planning tools, clearly define what serious rutting is, and developing improved contracts and buying procedures.

The professional category others believed the strategy to develop guidance about which technical aids to use in different situations and how these are best used, to be significantly more important compared to forest contractors, machine operators, and forest inspectors. To further develop digital planning tools was seen as more important among machine operators compared to forest inspectors, which was true also for the perceived degree of importance of clearly defining what serious rutting is. Improved contracts and buying procedures was perceived to be more important among the forest contractors and machine operators, as compared to planners, production leaders, timber buyers, and forest inspectors. No pairwise comparisons were significant with regards to the viewed importance of developing new technical services in order to protect land and water during off-road traffic.

Discussion and Implications

One relevant issue when dealing with the reduction of rutting in forestry is not only what the present strategy is, but also the need to develop existing or new strategies for forestry in the future. This could involve improving existing methods of managing rutting, or developing whole new strategies. One interesting result is that machine operators expressed more concern about the difficulty of reducing rutting. When compared to the other professional groups in the study, they also strongly believed that countermeasures to rutting as a part of everyday routine were thought to be carried out to a lesser degree. Machine operators also more strongly perceived that rutting negatively affects the biodiversity of the forest. Since machine operators are working on site, their opinion about the degree of difficulty, the environmental measures taken and the effects on biodiversity is important and indicates a need for improvement. It is evident that the most serious consequence perceived relates to the negative effects on streams and lakes, indicating that the issue of rutting is, in some sense, a question of water quality, reflecting the current debate on the environmental effects of rutting in Sweden.

The results regarding potential age differences indicated that the young professionals in the forest sector may have a different view of the requirements associated with dealing with the consequences of rutting and reducing rutting. Young forest professionals expressed weaker beliefs about strategies and need related to rutting, except that they more strongly believed that exclusively using the tops and branches to improve the load-bearing capacity of the soil is a viable strategy. Since the results mostly convey that the younger generation of forest professionals does not strongly agree with certain consequences and strategies, this can be an indication that the forest industry needs to consider a potential generational shift in beliefs about the effects of rutting and the best ways to deal with it. It may however also be that beliefs change with years and experience.

In general, the results indicate that there is an overall positive view on the wide range of strategies currently used for the reduction of rutting. In addition, we see that the results convey the perception that there is a need for improvements and new developments within a broad range of strategies; however, no single strategy was seen as the ultimate solution. It is evident from the results that the introduction of legal sanctions is not seen as a solution to the problem of rutting and might be a sign of a desire within the forest sector to take responsibility to solve the problem within the sector. Using tops and branches to improve load-bearing capacity at the site is a measure that has some support; however, one should note a possible conflict of interest here. Tops and branches are increasingly being harvested for energy production, which is not possible if it has been used for ground protection; thus the question is to which degree this material should be left for reinforcement or used as biofuel. The view on information in a digital format was surprisingly negative and one may wonder if it is due to foreseen technical problems in the field or a more general negative stand on the digitization of information. A conclusion is that this question should be revisited for further investigation.

Differences in professional objective in the forestry among the different professional actors were present, after controlling for any effects of age. Forest contractors and machine operators stood out in their view that exclusively presenting the stand-specific instructions in digital format was less important. A strategy the production leaders viewed as more important in contrast. Forest contractors and machine operators stood out together in their view that follow-up and feedback was less important and that exclusively using the tops and branches to improve the load-bearing capacity of the soil was more important to machine operators. Follow-up and feedback was viewed as more important among production leaders, timber buyers and the other category. It is important to understand the different roles played in forestry by the different actors and ensure that measures taken speak to all categories in order for any measures taken to be perceived as legitimate.

When the participants took a future perspective on the reduction of rutting, the results show that there is a perceived need for development of a wide range of measures to reduce rutting. Some differences were present between the different professional categories, but overall the similarities dominated. Again, these professional actors did find the further development of digital planning tools to be least important, while improved on-site functions were viewed as very important.

This study was conducted in the setting of a series of seminars concerning rutting and rutting for professional actors in the forest sector and, even though the questionnaire was distributed at the very beginning of the seminar, selection bias may have been present in the sample. The seminar participants may already have been more interested, concerned, or professionally obliged to learn more about rutting issues, which may have influenced the results. In addition, since the participants in the study were those who had enrolled for the seminar, the professional categories of actors were not under the researchers' control. The groups (forest contractors, machine operators and other professional actors) were based on the available distribution. The group "other professional actors" was heterogeneous, which may have hidden certain professional groups and their beliefs, within the group categorized as other professionals. This line of research and these research questions thus need to be further investigated.

The limitations aside, this study contributes insight into the beliefs among professional forest actors about the consequences of rutting, effectiveness of current measures to reduce rutting and the developments required to reduce future rutting. This knowledge may aid in the further development of measures and planning processes in relation to forestry. In addition, the observed interaction between age and professional position highlights the need to work on rutting issues at every level of forestry, from the hands-on actors operating machines on site to the contractors and other forest officials or actors. There may be a generational shift in beliefs that requires changes in how rutting issues are managed.

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arbetar för ett lönsamt, uthålligt mångbruk av skogen. Bakom Skogforsk står skogsföretagen, skogsägareföreningarna, stiften, gods, skogsmaskinföretagare, allmänningar m.fl. som betalar årliga intressentbidrag. Hela skogsbruket bidrar dessutom till finansieringen genom en avgift på virke som avverkas i Sverige. Verksamheten finansieras vidare av staten enligt särskilt avtal och av fonder som ger projektbundet stöd.

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