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The Effect of Quality Management on Forest Regeneration Activities in Privately-Owned Forests in Southern Finland

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This study describes the effect of quality management on forest regeneration activities in privately-owned forests in southern Finland. The study material consists of two mail surveys conducted in 2006 and 2007. The questionnaires were sent to forestry professionals in Forest Owners' Associations (FOAs), who had either participated (participants) or not (non-participants) in the forest regeneration quality management interventions in years 2000–2006. Quality management interventions of the FOAs included field inventories, feedback meetings, and education sessions about quality techniques. The activities of participant and non-participant FOAs were compared in terms of the available resources, the actions taken, and the aspirations for improvement. In the FOAs, which had participated in quality management, the number of excavator contractors had increased by 16% more than in the non-participant FOAs. The contractors had acquired 23% more soil preparation equipment under the supervision of the participant forestry professionals. The soil preparation method used in conjunction with Norway spruce that had most increased in use was patch mounding. Seedlings that were 1.5 years and older were used by participant forestry professionals in the planting of Norway spruce 11% more than by non-participants. The planting workers had attended 14% more educational sessions, while the use of self-control measurements in soil preparation and planting density had been adopted 10% more frequently under the supervision of the forestry professionals participating in the quality management. A greater interest in obtaining feedback by using quality control inventories was also found among forestry professionals who participated in quality management.

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1 Introduction

The production of good-quality products and services has been considered one of the key elements in improving productivity and enhancing organisational survival (Ishikawa 1985, Deming 1986, 1994, Juran 1988, Hackman and Wageman 1995). Quality management facilitates adaptation to changes in operational environments and uncertain circumstances by emphasizing customer satisfaction, continuous improvement and learning, and also systems perspective (Deming 1986, 1994, Ishikawa 1985, Sitkin et al. 1994, Gitlow 2001). It has been considered a successful organisational innovation both in mass manufacturing and in high-volume services, where most of the production processes involve the identical repetition of standardized tasks (Garvin 1988, Silvestro 2001, Lillrank 2003). The main principles of quality management have included the standardization of work processes, analysis of uncontrolled variation, utilization of the systematically measured data, and learning from the results of continuous improvement (Ishikawa 1985, Deming 1986, Juran and Gryna 1993, Hackman and Wageman 1995). Other important principles have focused attention on customers and participative management practices, especially teamwork (Juran and Gryna 1993, Dean and Bowen 1994, Oakland 1994).

The implementation of quality management in areas where the assumptions of standardized mass manufacturing or high-volume services are not valid has been considered challenging for service providers (Silvestro 2001, Lillrank 2002). This kind of service is usually professional, with a low volume and high variety, where the rate of customisation or case sensitivity is high (Silvestro 2001, Lillrank 2002). These services have typically non-routine processes, unpredictable environments, controversial objectives, and may involve non-market transactions (Lillrank 2002, 2003). Silvestro (2001) considers that the identification of volume/variety differences in services forms the basis for developing different approaches to the implementation of quality management. Lillrank (2003) has proposed a continuum from standardised production processes through routine processes to non-routine processes in order to take into account the situational requirements.

Of the total forest land in Finland, 60% is under non-industrial private (=NIPF) ownership (Finnish Statistical... 2008). Furthermore, the NIPF owners' proportion of growing stock is approximately 64%. A Forest Owners' Association (=FOA) is a NIPF owner's body, the purpose of which is to promote profitability of forestry practiced by forest owners and the realisation of the goals they have set for forestry (Forest Management... 1998). There are many municipalities in Finland, where the FOA is the main silvicultural service provider. However, some new service providers have entered the market and the previously-mentioned nearly monopolistic transaction context has begun to change.

In the turn of the decennium, the quality management of forest regeneration service processes in the FOAs was in most cases at a fairly primitive level. Compared with the forest industry companies' own forests (e.g. UPM-Kymmene Corporation), there were few efforts of systematic, measurement-based, quality management (Kalland 2002, 2004). The definitions of quality, field measurements, and key indicators for different stages of the service process were developed in connection with conducted quality management inventories in 2000–2006 (Saksa et al. 2002, Saksa et al. 2005, Saksa and Kankaanhuhta 2007). The inventories confirmed that the control of variation in different product varieties was also one of the main elements in managing for the quality of forest regeneration services (Shewhart 1931, Juran 1951, Ishikawa 1985, Deming 1986, Taguchi 1986, Lillrank 2003, Kankaanhuhta et al. 2009a, 2009b). The results indicated that the selection of different tree species and methods for the prevailing environmental circumstances, and the way the methods were executed were the most common factors influencing the regeneration results (Miina and Saksa 2006, Miina and Saksa 2008, Kankaanhuhta et al. 2009b).

The forestry professionals are responsible for the FOAs operative services. In forest regeneration, they analyse the site conditions, provide information for the NIPF owners' decision making, and manage the ordered services. The forest regeneration service process has been split to four sub-processes in this study: 1) marketing of the regeneration methods and tree species; 2) soil preparation; 3) choice of regeneration mate-

rial; and 4) regeneration work. The service process is here classified as a routine process, where the quality of an end-product is determined by the selection of methods (or materials) in the subprocesses and by the execution of the methods (Lillrank 2003, Kankaanhuhta et al. 2009a).

The forest owner initiates the marketing subprocess, as he contacts a forestry professional. In Finland, the main regeneration methods are planting, direct seeding and natural regeneration (Finnish Statistical... 2008). The main tree species are Norway spruce (*Picea abies* (L.) Karst.), Scots pine (*Pinus sylvestris* L.) and silver birch (*Betula pendula* Roth.). The forestry professional proposes the regeneration methods and tree species (i.e. regeneration chain) to the forest owner according to site type and soil fertility information. This information is acquired either from the forest management plan and/or from a field visit. For example, the selection of direct seeding of Scots pine on too fertile, fine textured, or moist sites has yielded poor results (Kankaanhuhta et al. 2009b).

In the soil preparation sub-process, the final decision about the soil preparation method is made. For example, in the case of Norway spruce planting, the most important factor explaining the regeneration result was soil preparation (Kankaanhuhta et al. 2009b). In addition to the selection of the method, the number and quality of the produced planting spots is important (Harstela et al. 2006, Luoranen et al. 2007). In the choice of regeneration material sub-process, sufficient quantities and proper types of regeneration material are ordered, stored and delivered to the regeneration sites (Rikala 2002). In the regeneration work sub-process, the number of properly planted seedlings or the quantity of sown seed is important (Hyvän metsänhoidon... 2001, Luoranen and Kiljunen 2006). In addition, the timing of the activities and how the seedlings are taken care of influence the outcome. The end-result of the forest regeneration activities cannot be measured immediately. For example, in the quality control inventory method of privately-owned forests, the result of the forest regeneration service process was measured three years afterwards in planting, four years afterwards in direct seeding and five years afterwards in natural regeneration (Kalland 2002, 2004, Saksa and Kankaanhuhta 2007).

Quality management interventions of the FOAs included field inventories, feedback meetings and education sessions about quality techniques. They were conducted in 2000–2006. The effect of these interventions on the forest regeneration results could not be measured during the abovementioned time frame. As a result, the framework of extension program evaluation devised originally by Bennett (1975, 1976) was chosen for assessment of the effect of the interventions on the service processes. This framework provides information for the political decision makers and managers of the organisations: what will be decided about the continuation of the programs, what the future priorities are, and what the possible modifications will be.

Bennett's (1975, 1976) evaluation method consists of seven hierarchy levels. At the highest level, the effect of extension interventions on the measurable outcome of the actions is evaluated. In the present study the final target of evaluation would have been the changes in the measured regeneration results. At the second highest level, the changes in the recommended practices and structures of actions are evaluated, e.g., measurements of quality control, soil preparation methods and equipment, and planting densities. At the third level, the changes in the knowledge, attitudes, skills, and aspirations of the local actors are evaluated. In this case, the knowledge about key factors that eventually lead to good regeneration results is evaluated. At the fourth level, the reactions of the clients to the education interventions are evaluated. This level was not included in the present study. These four levels of the framework have also been identified earlier: end results, behaviour, learning, and reactions (Kirkpatrick 1976, Kirkpatrick and Kirkpatrick 2006). The three lowest levels of Bennett's framework measure the efficiency of interactions: the number of forestry professionals involved, the number and type of extension activities, and the extension personnel participating. These lowest levels have been excluded from this study, the scope of which was the evaluation of effectiveness.

The aim of this study was, then, to evaluate the effect of quality management interventions on the FOAs' forest regeneration service processes with respect to four principal goals. Firstly, what was the obtained feedback from the educational

sessions for the root causes of the results and what were the objectives, which were set? Secondly, what quality management tools had been adopted and what were the changes in available resources for the forest regeneration service processes? Thirdly, what forest regeneration practices were adopted in the FOAs? And fourthly, what were the attitudes and aspirations of the actors in implementing quality management techniques in forest regeneration?

2 Material and Methods

2.1 Acquisition of Data

The forest regeneration quality management inventories were carried out in the area of six forestry centres: Lounais-Suomi, Häme-Uusimaa, Etelä-Savo, Etelä-Pohjanmaa, Keski-Suomi, and Pohjois-Savo. The inventories were conducted in 2000–2006, and the FOAs participated in the quality work on a voluntary basis. There was no random or systematic sampling in selecting the FOAs (Kankaanhuhta et al. 2009b). The forestry professionals who had been working for these FOAs were named quality management participants or participant forestry professionals in this study. The rest of the FOAs in the area of these six forestry centres were regarded as "control" FOAs, with no forest regeneration quality management interventions. The forestry professionals in these "control" FOAs were named non-participant forestry professionals.

After completion of quality control inventories, feedback meetings were always arranged to which all of the forestry professionals employed by the participant FOAs were invited. In the feedback meetings, the root causes for the obtained inventory results were provided according to statistical analyses and current research knowledge. The participant forestry professionals were encouraged to explore the obtained data even deeper and set objectives for the improvement activities. Education dealing with quality management was arranged for the FOAs at forestry-centre level in Lounais-Suomi, Etelä-Savo, Etelä-Pohjanmaa, and Pohjois-Savo (Saksa and Kankaanhuhta 2007). Additional education concerning specific forest regeneration issues, e.g. soil preparation or direct seeding, was arranged, depending on the local circumstances of the forestry centres. Eleven of the quality work participant FOAs had second inventory, and at the majority of them extra educational activities dealing with the quality control of forest regeneration processes were provided. In general, in the current research project these FOAs were mainly treated as "quality work participant FOAs", but whenever an extra deviation occurred from the results obtained at the one-inventory FOAs, these FOAs were reclassified as two-inventory FOAs.

The "Forest regeneration quality management" research project concluded at the end of the year 2006, and the project report was sent to every FOA in southern Finland in June 2007 (Saksa and Kankaanhuhta 2007). Two mail surveys were sent to the forestry professionals at the participant and non-participant FOAs. The response time of the first survey was March–April 2006. This survey was named the "2006 survey" (Table 1). The second mail survey was scheduled for Autumn 2007, so the response time was September–October 2007 and the survey labelled the "2007 survey". The questions contained in the two surveys were practically the same, but the sample size in the 2006 survey was smaller, it was directed at forestry professionals (rather than chief executive officers = CEOs), and some of the FOAs had not yet participated in the field inventories conducted in Spring 2006. The 2006 survey has been used in this study as a pilot study and as a baseline for comparisons. In contrast, the 2007 survey was conducted in order to obtain an overall image of the addressed research aims. The prerequisite was that all of the participant FOAs would have had at least one growing season to initiate improvement efforts according to the feedback obtained from the inventories. This study covers mainly the results of the 2007 survey, but where there are major deviations in the results, the results of the 2006 survey are also presented.

The questionnaires were sent to all of the forestry professionals involved in the forest regeneration activities in the area of the six forestry centres. The chief executive officers of the FOAs were included in the sample of the 2007 survey. The control group consisted of all forestry professionals, both operative and CEOs, whose FOA had not taken part in quality work in the area of

the above-mentioned forestry centres. If only a part of an FOA, e.g., one municipality out of several, fell within the area of the six forest centres, the forestry professionals of this municipality were included in the sample.

2.2 Description of Data and Variables

The response rate for the 2006 survey was 64%, and the original sample size was 303 forestry professionals (Table 1). There were responses from 65 FOAs, and the average response rate for the main questions was 61%. The response rate for the 2007 survey was 54%, and the original sample size was 385 forestry professionals. There were responses from 64 FOAs, and the average response rate for the main questions was 52% (Appendixes 1–3). In terms of the number of questionnaires in the survey of 2007, the sample size was 27% greater than that of the survey of 2006.

The information obtained in the surveys was combined with information from the 9th Finnish National Forest inventory (=NFI9) at municipality level. In the 2006 survey, the respondents returning the questionnaire represented 69% of the forestry land of the six forestry centres. In the 2007 survey, the proportion of forestry land area was 71% (Table 1), and the number of responses showed an increase in most forestry centres.

In the 2007 survey the proportion of chief executive officers amongst the participant forestry professionals was 15% and 20% of the non-participant professionals, respectively. The average length of service was 19 years (SD 9.5 years) for all participant forestry professionals, and 20 years (SD 9.7 years) for non-participant forestry professionals. The average annual regeneration land areas covered by operative forestry professionals did not significantly differ between the participant and non-participant FOAs in the 2007 survey. The average annual planting area of an operative forestry professional during the previous five years had been 71 ha (SD 48.3 ha) in the participating FOAs and 77 ha (SD 47.5 ha) amongst the non-participant FOAs. The average annual direct seeding area was 17 ha (SD 23.6 ha), and the natural regeneration area 10 ha (SD 12.1 ha) amongst the participant FOAs. For the non-participant FOAs the annual direct seeding area was 23 ha (SD 32.5 ha) and the annual natural regeneration area 12 ha (SD 10.6 ha), respectively.

The chief executive officers of the FOAs may have specialized purely in management activities,

Table 1. The distribution of responses at forestry centre level. The proportions of forestry land in relation to the total area of the surveys applying the classification: participant, non-participant and no response (The 9th National Forest Inventory, municipality level data).

Survey year	Forestry centre[a)]	Quality work participation			Coverage of forestry land (NFI9)		
		Non-participant, %	Participant, %	Responses, total	Non-participant, %	Participant, %	No response, %
2006	L-S	14	27	44	2	8	4
	H-U	42	8	37	7	3	3
	E-S	10	20	33	4	9	3
	E-P	16	19	35	4	10	7
	K-S	10	6	14	5	3	10
	P-S	8	20	31	4	10	4
	Total	100	100	194	26	43	31
2007	L-S	5	20	30	1	7	6
	H-U	31	9	36	6	3	4
	E-S	16	20	38	3	9	3
	E-P	29	19	47	6	10	6
	K-S	6	12	20	2	8	8
	P-S	13	20	35	4	12	2
	Total	100	100	206	22	49	29

[a)] Abbreviations for forestry centres: L-S = Lounais-Suomi, H-U = Häme-Uusimaa, E-S = Etelä-Savo, K-S = Keski-Suomi, E-P = Etelä-Pohjanmaa, P-S = Pohjois-Savo.

or they may also have operative responsibility of, e.g., the silvicultural services. Altogether, 83% of the participant respondents of the 2007 survey had inventoried regeneration areas under their supervision. The chief executive officers accounted for 8% of the inventoried areas, and "normal" participant forestry professionals accounted for 75% of the inventoried areas. The feedback meetings after the inventories were participated in by 74% of the respondents.

The representatives of the non-participant FOAs were asked whether they had participated in any seminars or educational sessions concerned with forest regeneration quality management. In the 2007 survey, seminar participation accounted for 74% of such responses. In addition to educational sessions, professional magazines and newspapers were the most common sources of information cited in response to the open question. Other sources of information included publications such as books, the Internet, colleagues, and internal development events in the regional forest owners' unions.

The questionnaires of the 2006 and 2007 surveys included questions about the defined resources; key performance indicators; and attitudes, aspirations and improvement activities of the forest regeneration service process (Appendixes 1–3). This information was mainly measured by nominal-scale variables. The target densities of planted seedlings and target quantities of seed to be sown were measured as discrete, absolute scale variables. The completion time of direct seeding was an interval-scale variable.

2.3 Analysis Methods

Conventional statistical methods were applied in most of the analysis. These were sample means, cross-tabulations, χ^2 tests, and linear regression. In the case of Scots pine direct seeding, the quantities of seed per hectare were analysed by applying ANOVA and linear mixed models, since there was a potential correlation between the forestry professionals working within the same forestry centre. There would also have been a correlation between the forestry professionals within the same FOA, but there were too few forestry professionals per FOA for this correlation structure to be applied (forestry centre, FOA, forestry professional). SPSS 15.0.1 for Windows was used for the computations. The model fit was tested initially using maximum likelihood (ML), and the final parameters were estimated using restricted maximum likelihood (REML). The fixed effects were tested using F-test statistics.

3 Results

3.1 Obtained Feedback and Objectives Set

The participant forestry professionals were asked to rank the reasons for the inventory results according to the feedback which they had obtained (Table 2). In the 2007 survey, there were three main reasons given in connection with the type of soil preparation for planting of Norway

Table 2. Forestry professionals' rankings (1–9) of the reasons for their poor inventory results (the 2007 survey). The proportions of ranking between 1 and 3 were added together. (n = 126).

Reasons for the inventory results obtained	Proportions (ranks 1–3), %	Mode of rank	Responses (n)
Too light or wrong type of soil preparation method for Norway spruce	67	1	106
Direct seeding of Scots pine on too fertile site type	52	1	98
Too low planting densities (seedlings per ha)	41	2	93
Planting of Scots pine on too fertile site type	35	3	89
Too small seedling type of Norway spruce	22	4	85
Too slow execution of regeneration chain after cutting	18	5	79
Too small amount of seed in Scots pine direct seeding (g per ha)	13	7	71
Too late execution of direct seeding in the middle of summer	12	8	75
Other reason	6	3	13

Table 3. The proportions of objectives set after the feedback meetings (the 2007 survey). The proportions of the three most important objectives were added together.

Objective	Proportion, %
Change/selection of soil preparation method (usually further mounding methods)	29
Selection of regeneration chain according to site conditions	21
Planting density/quality of planting work	15
Selection of seedling material (increase in larger seedlings)	10
Density of planting spots and quality of soil preparation	7
Other objective (pre-commercial thinnings, general quality etc.)	5
Control measurements/quality work/guarantees	4
Change in sowing method	3
Intention to produce faster regeneration chains from harvest to regeneration work	2
Marketing of proper regeneration chain, extension education and training	1
Proper care and delivery of seedlings	1
Greater quantity of sown seed	1
Earlier timing of sowing work	1
Total	100

spruce, the artificial regeneration of Scots pine on excessively fertile sites, and planting densities that were too low.

The forestry professionals who had determined the objectives of their improvements after the feedback meeting accounted for 76% of the responses. The three most important improvement objectives were investigated in an open question posed to the forestry professionals. The proportions of mentioned objectives were added together (Table 3). Changes in soil preparation methods accounted for 29% of the total; the selection of a proper regeneration chain for the site conditions accounted for 21%; planting density and the quality of the regeneration work accounted for 15%; and the selection of proper seedling material accounted for 10% of the objectives.

3.2 Changes in Available Resources and Self-Control Practices

The changes in the resources of the forest regeneration service processes were examined by means of a set of questions covering the number of soil preparation sub-contractors; their soil preparation equipment; the participation of soil preparation machine operators and planting workers in educational sessions; and the adoption of self-control measurements (Appendix 1). In the following, the main results of the 2007 survey are presented in text and compared with the results of the 2006 survey in tabular format. The notable differences are also mentioned in the text.

In the participant FOAs, the number of soil preparation contractors using excavators had increased by 16% more than in the control FOAs (Table 4). The difference was statistically significant. The excavator contractors had acquired 23% more soil preparation equipment under the supervision of the participant forestry professionals compared with the non-participant ones. The difference was also statistically significant. The forestry professionals were asked in an open question about the kind of soil preparation equipment that the excavator contractors had bought. Patch mounding (upturned humus forming a flat mound with a double humus layer) equipment accounted for 64%, unspecified buckets accounted for 16%, and excavators themselves accounted for 16% of the responses of participant forestry professionals. The rest of the equipment included, for example, buckets for inverting (making a mound on a mineral soil mounding pit with a single humus layer). Among the non-participant forestry professionals, patch mounding equipment accounted for 43% of the responses, unspecified buckets for 26%, and excavators themselves for 24%.

If respondents replied that the number of soil preparation contractors had increased, the soil preparation methods, which were used with planting of Norway spruce, increased the most among

Table 4. Changes in available resources for the forest regeneration service process.

Information intended to be measured	Survey year	Participation	Proportion, %			No. of responses	χ^2-value
			Yes	I cannot say	No		
Increase in the number of soil preparation contractors using an excavator	2006	Part.	45	(-)	55	125	0.20
	2006	Non-p.	48	(-)	52	60	
	2007	Part.	59	(-)	41	122	4.91*
	2007	Non-p.	43	(-)	57	79	
Acquisition of new soil preparation equipment	2006	Part.	48	(-)	52	123	10.05**
	2006	Non-p.	73	(-)	27	59	
	2007	Part.	80	(-)	20	118	11.74***
	2007	Non-p.	57	(-)	43	79	
Soil preparation machine operators have participated in education sessions	2006	Part.	89	3	8	126	4.10
	2006	Non-p.	80	10	10	60	
	2007	Part.	92	6	2	121	6.96*
	2007	Non-p.	85	4	11	79	
Planting workers have participated in education sessions	2006	Part.	58	3	39	126	0.001
	2006	Non-p.	58	4	38	60	
	2007	Part.	80	6	14	123	8.23*
	2007	Non-p.	66	4	30	79	
Self-control measurements of soil preparation and planting density	2006	Part.	37	3	60	126	1.42
	2006	Non-p.	28	5	67	60	
	2007	Part.	54	7	39	123	9.35**
	2007	Non-p.	44	0	56	78	
Self-control measurements of germination of Scots pine seed at the end of the sowing summer	2006	Part.	18	(-)	82	125	1.25
	2006	Non-p.	12	(-)	88	59	
	2007	Part.	16	(-)	84	121	1.20
	2007	Non-p.	10	(-)	90	78	

Participation = Participation in forest regeneration quality management.
Part. = Participant, Non-p. = Non-participant
(-) = This alternative was not available for the respondents.
* significant at 0.05, ** significant at 0.01 and *** significant at 0.001 level.

the participant forestry professionals were patch mounding (73%) and mounding with ditching (17%) (Fig. 1). Respectively, in the case of non-participant forestry professionals, patch mounding accounted for 56% of the responses and mounding with ditching for 23%.

The participation of machine operators and planting workers in the educational sessions was also observed. In areas under the supervision of participant forestry professionals, the machine operators took part in soil preparation educational sessions 7% more compared with the areas under the supervision of non-participant forestry professionals. Planting workers attended the planting and seedling handling educational sessions 14% more under the supervision of the participant forestry professionals. The difference in the proportions of planting workers was statistically significant.

The self-control measurements of soil preparation and planting density were adopted 10% more frequently under the supervision of the forestry professionals participating in the quality management. This type of self-control measurement of the germination of Scots pine seeds after direct seeding was shown to be 6% more common among the participant forestry professionals.

The participation of the planting workers in educational sessions was compared with the adoption of self-control measurements of planting density. In the case of quality-work participant forestry professionals, the responses confirmed 17% more frequently that there had been educational sessions concerned with planting work and that self-control measurements of planting density had been adopted (Table 5). For the participant forestry professionals, the differences

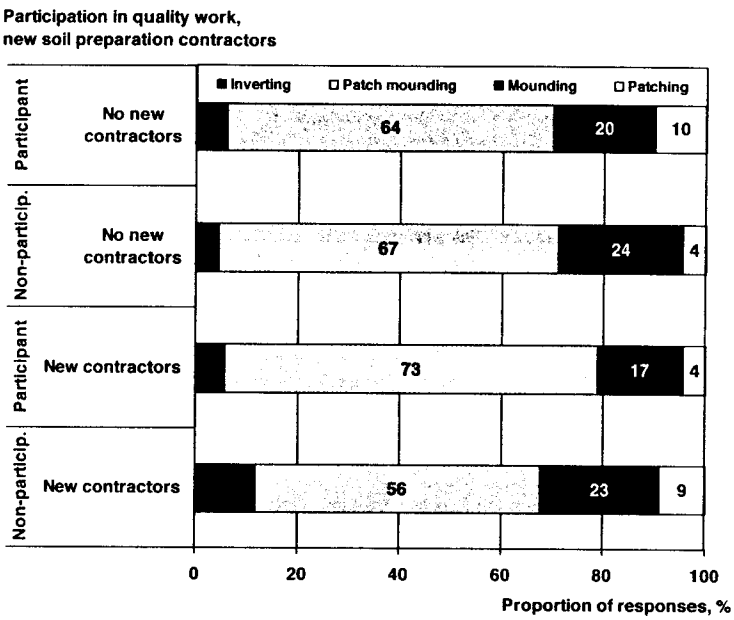

Fig. 1. Increase in the number of contractors (=new contractors) and the most generally increased soil preparation method of Norway spruce in the 2007 survey. The mounding class means mounding with ditching.

Table 5. The adoption of self-control measurements of planting density in areas where the planting workers employed by respondents (quality work participant and non-participant) have received planting work education (2007 survey).

Participation in quality work	Participation in planting education	Self-control measurements of soil prep. and planting density		No. of responses	χ^2-value
		Yes, %	No, %		
Non-participant	Education	33	33	52	2.61
	No education	11	23	26	
Participant	Education	50	31	99	10.44***
	No education	5	14	24	

* significant at 0.05. ** significant at 0.01 and *** significant at 0.001 level.

between groups of planting work educated and non-educated were statistically significant with an χ^2 p-value of 0.001.

3.3 Changes in Applied Regeneration Practices

The forest regeneration service process was defined as starting with a marketing sub-process, where the soil and site types are checked and an appropriate regeneration chain recommended to the forest owner (Appendix 2). There was no significant difference in the numbers of visits made between participant and non-participant forestry professionals to check the site and soil information (Table 6).

The marketing rationale for an appropriate regeneration chain for forest owners was inquired. The intention of the question was to explore changes in the methods and information content that were used in advising forest-owners about the regeneration processes. New ways to tell about

Table 6. Changes in applied practices in the forest regeneration service process (part 1).

Information intended to be measured Alternative	Survey year, QM participation			
	2006		2007	
	Participant	Non-participant	Participant	Non-participant
Increased number of visits to check site and soil characteristics				
Yes (%)	42	36	53	59
I cannot say (%)	11	2	5	6
No (%)	47	62	42	35
No. of responses	123	61	124	80
χ^2-value		6.46*		1.04
New argumentation in the marketing phase of the regeneration chains				
Yes (%)	58	48	65	51
No or I cannot say (%)	42	52	35	49
No. of responses	125	60	121	79
χ^2-value		1.4		4.26*
The most common soil preparation method for Norway spruce				
Mounding (%)	50	40	63	73
Patching (%)	32	23	27	19
Disc trenching (%)	18	37	10	8
No. of responses	121	57	124	79
χ^2-value		7.47*		2.45
The most greatly increased soil preparation method for Norway spruce				
Patch mounding (%)	55	34	70	61
Mounding with ditching (%)	31	34	18	24
Patching (%)	11	22	6	7
Inverting (%)	2	10	6	8
Disc trenching (%)	1	0	0	0
No. of responses	118	59	124	80
χ^2-value		12.07*		1.79
The most commonly used type of seedlings for Norway spruce				
1.5 year and older	87	92	91	80
One-year-old	13	8	9	20
No. of responses	61	119	116	76
χ^2-value		1.08		5.01*

QM. participation = Participation in forest regeneration quality management.
* significant at 0.05, ** significant at 0.01 and *** significant at 0.001 level.

the regeneration chains were noted 14% more frequently amongst the participant forestry professionals compared with the non-participants. The difference between the participant and non-participant respondents was statistically significant.

An open question was put to the forestry professionals concerning the kind of new argumentation they had found in support of marketing. 43% (n = 52) of the participant forestry professionals claimed that they had come across new argumentation, while 49% (n = 39) of the non-participant forestry professionals claimed the same. Feedback from the inventories combined with personal experience was named by 29% (n = 35) of the participant forestry professionals. Because the non-participant forestry professionals had no chance to access the feedback from the inventories, information gathered from quality management research and personal experiences were used as the classification criteria. This argumentation was used by 13% (n = 10) of the non-participant forestry professional respondents.

In the soil preparation sub-process, the most common soil preparation methods used in Norway spruce planting were mounding and patching. In the 2006 survey, a total of 82% of the participant forestry professionals used these methods, while

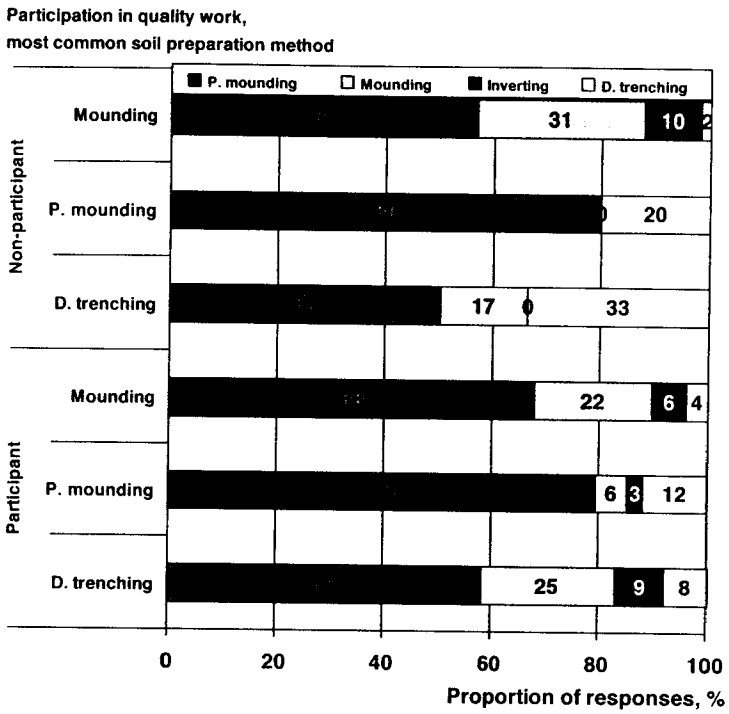

Fig. 2. Increased use of soil preparation methods compared with the most common soil preparation methods for Norway spruce in the 2007 survey. For example, if mounding has been the prevailing method during the past five years, how patch mounding (=p. mounding), mounding with ditching (=mounding), inverting and disc trenching (=d. trenching) have been increased among the respondents.

the figure for the non-participant forestry professionals was 63% (Table 6). In the 2007 survey, the proportion of mounding and patching was ca. 90% for both groups of forestry professionals, and the proportion of disc trenching had decreased to ca. 10%. There was an increase in the proportions of mounding in the 2007 survey compared with the 2006 survey. Mounding was 10% more common among the non-participant forestry professionals. It should be noted, however, that the sample was not identical, e.g. from Lounais-Suomi there were fewer responses.

The soil preparation method that had most increased with Norway spruce planting was patch mounding (Table 6). In the 2007 survey, patch mounding accounted for 70% of responses given by participant forestry professionals, while it accounted for 61% of the responses given by non-participant professionals. The second greatest increase was in the proportions of mounding with ditching, which had increased more among the non-participant forestry professionals.

The most common soil preparation method used and the one that had most increased in use in connection with Norway spruce were cross-tabulated so that it could be discovered whether any increase in the use of a particular method was different in areas where there were different soil preparation practices. Where mounding was the most common method used, patch mounding had increased according to 68% of the responses received from participant forestry professionals (Fig. 2). According to the non-participant forestry professionals patch mounding had also increased according to 57% of the responses. Increased mounding with ditching accounted for 22% of the responses received from the participant forestry professionals and for 31% of responses given by non-participant forestry professionals, respectively.

In the choice of regeneration material sub-process, the seedling types of Norway spruce that were

Table 7. Changes in applied practices in the forest regeneration service process (part 2).

Information intended to be measured / Alternative	Survey year, QM participation			
	2006		2007	
	Participant	Non-participant	Participant	Non-participant
The most greatly increased type of seedlings for Norway spruce				
1.5 year old	42	49	40	47
Two-year-old	26	18	31	20
Equal amounts	19	23	22	23
One-year-old	13	10	7	10
No. of responses	123	61	121	79
χ^2-value		2.26		3.22
The completion date for Scots pine direct seeding				
Before 15.5.	4	8	2	4
16.5. – 31.5.	19	35	16	13
1.6. – 15.6.	59	49	56	52
After 16.6.	18	8	26	31
No. of responses	114	51	100	69
χ^2-value		8.29*		1.40

QM participation = Participation in forest regeneration quality management.
* significant at 0.05. ** significant at 0.01 and *** significant at 0.001 level.

most commonly planted were 1.5 years and older. They were used by participant forestry professionals 11% more than by non-participants. The other seedling types used were one year old, and the responses were concentrated on the forestry centres of Etelä-Pohjanmaa and Lounais-Suomi. The difference in the types of seedlings used was statistically significant. The seedling type with the greatest increase in use was 1.5 year-old seedlings. It was found that the greatest difference between the groups of forestry professionals was in the use of two-year-old seedlings (Table 7). The increase in the use of this seedling type was 11% greater among the participant forestry professionals compared with the non-participant ones. The use of one-year-old seedlings had increased least.

The target densities of seedlings are used in the choice of regeneration material sub-process, when adequate numbers of seedlings are ordered by the forestry professionals. In addition, the target densities are used in the regeneration work sub-process, when the self-control measurements of planting density are used by the planting workers. In the case of Norway spruce planting, the average target densities used by participant and non-participant forestry professionals were practically the same (Table 8). In the case of Scots pine planting, there was a small but statistically significant difference in favour of the participant forestry professionals. In the case of silver birch planting there was no significant difference between the forestry professional groups.

The quantities of seed used in Scots pine direct seeding were analysed. The estimated mean for the quantities of seed used by the participant forestry professionals was 313 g per ha, and 295 g per ha for the non-participant forestry professionals (Table 8). The quantities of seed used were also analysed using and linear mixed models employing the forestry centre as a random effect. The variance partition coefficient for the forestry centre random effect accounted for 16% of the total variation (estimate of total variance: 3928). The random effect was not statistically significant (p-value: 0.17), and therefore the linear mixed model was not used.

Where participant forestry professionals were divided into two groups according to the number of participating inventories, the groups studied were named: non-participants, one-inventory forestry professionals, and two-inventory forestry professionals (Table 9). The estimated means for the quantities of seed used were 295 g per ha for the non-participants; 306 g per ha for the one-inventory forestry professionals, and 323 g per ha for the two-inventory forestry professionals. The differences in the quantities of seed proved to be

Table 8. Applied target densities and quantities in the forest regeneration service process.

Information intended to be measured	Survey year	Participation	No. of responses	Mean	SD	Df	T-test value
The target density applied in the planting of Norway spruce (seedlings/ha)	2006	Part.	126	1861	123	185	2.29*
	2006	Non-p.	61	1816	129		
	2007	Part.	123	1858	100	201	0.16
	2007	Non-p.	80	1856	126		
The target density applied in the planting of Scots pine (seedlings/ha)	2006	Part.	122	1982	91	177	0.85
	2006	Non-p.	57	1970	87		
	2007	Part.	120	2009	97	196	2.19*
	2007	Non-p.	78	1978	98		
The target density used in the planting of silver birch (seedlings/ha)	2006	Part.	120	1589	56	176	0.13
	2006	Non-p.	58	1588	68		
	2007	Part.	114	1600	38	191	1.20
	2007	Non-p.	79	1594	33		
The quantities of seed used for Scots pine direct seeding (g/ha)	2006	Part.	125	313	62	179	1.59
	2006	Non-p.	56	296	74		
	2007	Part.	121	313	55	197	1.98*
	2007	Non-p.	78	295	73		

Participation = Participation in forest regeneration quality management.
Part. = Participant, Non-p. = Non-participant
* significant at 0.05, ** significant at 0.01 and *** significant at 0.001 level.

Table 9. The quantities of seed used for Scots pine direct seeding according to the experience of quality work.

Survey year	Quality work experience	No. of responses	Mean (g/ha)	SD	F-test value	Significance (p-value)
2006	Non-participant	56	296	74	5.30	0.006
	One inventory	67	297	63		
	Two inventories	58	330	57		
2007	Non-participant	78	295	73	3.04	0.05
	One inventory	71	306	56		
	Two inventories	50	323	52		

Quality work experience = Experience of quality work.

statistically significant using this classification of the forestry professionals. According to the Bonferroni and Tukey tests, the groups of non-participants and two-inventory forestry professionals differed from each other. The forestry centre was not statistically significant either as a covariate or as a random effect in the linear mixed model (p-value: 0.16). The variance partition coefficient accounted for 19% of the total variation (estimate of total variance: 3952). The highest quantities of seed were used in Etelä-Pohjanmaa (343 g ha^{-1}) and Lounais-Suomi (325 g ha^{-1}). The lowest quantities of seed were used in Häme-Uusimaa (270 g ha^{-1}) and Keski-Suomi (284 g ha^{-1}). It was concluded that the quantities of seed used were higher among the forestry professionals with a longer experience of quality management.

The finishing time point concerning the mechanised sowing of Scots pine was investigated in relation to the forestry professionals. According to 26% of the participant forestry professionals, mechanised sowing was completed after the 15th of June during the previous five years. In the case of the non-participant forestry professionals, mechanised sowing after 15th of June accounted for 31% of their responses.

3.4 Attitudes to and Aspirations in Implementing Quality Techniques

Measurements of existing knowledge about the various aspects of forest regeneration activities suggested no real differences between the participant and non-participant forestry professionals. Both groups possessed adequate knowledge about the economic significance of good regeneration results, e.g. in the case of Norway spruce or Scots pine. In addition, knowledge about target densities at a stand age of between three and five years was adequate. Another question concerned the interests, attitudes and aspirations required for the application of quality management techniques in the future. Interest in quality control inventories three to five years after regeneration activities was investigated (Appendix 3). 55% of participant forestry professionals and 49% of the non-participants supported the inventories in the area under their supervision (Table 10).

The forestry professionals were assessed to discover whether, in the case of the inventories being financially supported by the Ministry of Agriculture and Forestry they would be interested in inventories being made in the areas under their supervision. The response was clear: 84% of the participant forestry professionals supported inventories in the case of financial support, while 67% of non-participant forestry professionals did so (Table 10). The difference was statistically significant.

The attitudes of the forestry professionals to the high cost of quality control inventories compared with the direct costs of regeneration activities were investigated, and 44% of the participant and 32% of non-participant forestry professionals did not consider the inventories too expensive (Table 10). Respondents who considered the inventories too expensive were given an opportunity to name the price that they would be willing to pay for such inventories. The average price suggested by the participants was 27 € per ha (SD 24 € ha^{-1}), while the average price for the non-participants was 31 € per ha (SD 36 € ha^{-1}).

The aspirations of forestry professionals to obtain more information about forest regeneration quality management were investigated. They were asked whether they were interested in participating in educational sessions concerning forest

Table 10. The changes in attitudes and aspirations of the actors vis-à-vis implement quality management techniques.

Information intended to be measured	Survey year	Participation	Proportion, %			No. of responses	χ^2-value
			Yes	ICS	No		
The level of interest in quality control inventories at own cost	2006	Part.	59	26	15	123	15.44***
	2006	Non-p.	46	13	41	61	
	2007	Part.	55	30	15	121	1.82
	2007	Non-p.	49	29	22	76	
The level of interest in quality control inventories if they are partly financially supported by the Ministry of Agric. and Forestry	2006	Part.	86	12	2	125	2.43
	2006	Non-p.	85	8	7	61	
	2007	Part.	84	13	3	122	9.15**
	2007	Non-p.	67	23	10	78	
The attitude to the costs of quality control inventories compared with the total costs of regeneration activities	2006	Part.	16	41	43	122	4.05
	2006	Non-p.	28	38	34	61	
	2007	Part.	13	43	44	117	3.19
	2007	Non-p.	18	50	32	78	
The aspirations of the forestry professionals to obtain more information about forest regeneration quality management	2006	Part.	77	16	7	125	1.54
	2006	Non-p.	69	20	11	61	
	2007	Part.	72	20	8	119	3.9
	2007	Non-p.	71	13	16	80	

Participation = Participation in forest regeneration quality management.
Part. = Participant, Non-p. = Non-participant
ICS = I cannot say
* significant at 0.05, ** significant at 0.01 and *** significant at 0.001 level.

regeneration quality work in the future. The proportion of individuals interested was at the same level for both groups of forestry professionals, accounting for 71%–72% of the respondents.

4 Discussion

The purpose of this study was to evaluate the effect of quality management interventions on the activities involved in the forest regeneration services of the FOAs. The objectives set by the forestry professionals after the feedback meetings of the quality control inventories were achieved to some extent. The main principles of quality management were considered to function well. However, there were indications that there would be further needs to encourage and enable the service providers to set explicit objectives, to obtain more often feedback, and to solve problems systematically.

The FOAs participated in the quality work voluntarily in order to improve their forest regeneration services. The quality work participant FOAs represented neither a random nor systematic sample of the FOAs in the area of the six forestry centres in southern Finland. In addition, the number of FOAs that participated in the quality work varied from one forestry centre to the next. As a result, the data was not balanced: there were different proportions of non-participant FOAs from the various forestry centres. However, the coverage of the municipalities in the area of the six forestry centres was considered to represent the conditions in southern Finland reasonably well. The 2007 survey constituted the main material in the analysis since the effect of the various quality management interventions had not yet been completed at the time of the 2006 survey. The material obtained was considered adequate, and the only shortcoming was the response rate from Lounais-Suomi, which may have been reflected in the results as a result of the lower coverage of responses.

The participant forestry professionals were given an opportunity to rank the main reasons for the inventory results, which were covered, e.g., in the feedback sessions and the project report (Saksa and Kankaanhuhta 2007). In addition, they were permitted to list the main objectives that they had set in light of the feedback sessions. Comparing the reasons for the inventory results obtained and the set objectives with the main questions (Appendixes 1–3), the content validity of the main research questions could be rated good. Considering the reliability of the questions, however, there were a number of shortcomings. It was possible that the responses of the non-participant forestry professionals were more "optimistic" with regard to the prevailing forest regeneration practices, since no inventory or other background information were made available by these FOAs. In addition, there was an indication that some deviations existed in the proportions of answers between the 2006 and 2007 mail surveys. The target groups were not, however, identical: some interventions were still made after the 2006 survey, and a number of differences could even be expected as a result of the elapsed time (two growing seasons).

The FOAs that did not participate in the quality work could only be considered to be a nominal "control" group when the effects of quality management interventions were measured. Firstly, quality management is only one approach among many for implementing interventions, and the non-participant FOAs may have had other intervention projects running in order to improve their operative actions. For example, in some FOAs there may have been projects aimed at developing cost-efficient silvicultural services (Harstela et al. 2006). Secondly, the educational sessions arranged by the regional Forest Owners' Unions or forestry centres may have stimulated improvement interventions in some of the non-participant FOAs. Thirdly, the project report produced by Saksa and Kankaanhuhta (2007) may have affected the knowledge and attitudes of the non-participant forestry professionals, since it was sent to the FOAs more than two months before the 2007 survey.

In the marketing phase of the forest regeneration service process, the number of the control visits to the intended regeneration sites by the forestry professionals, was considered hard to assess, although some general objectives had been set for this (Table 3). An increase in field visits was reported by both of the respondent groups, but the reliability and extent of this increase

was difficult to evaluate. The forestry professionals who had participated in quality work had found innovative ways of telling about successful regeneration methods more frequently to forest owners than had their non-participant counterparts. However, this difference was not considered to be very large in practice. Measurement-based personal experience dominated in the responses of the participant forestry professionals. Obviously, the non-participant forestry professionals were unable to obtain as much support from the empirical measurements unless they had adopted some sort of quality control inventory method of their own.

In the soil preparation sub-process, there were significant changes in the resources of this sub-process as compared with the participant and non-participant forestry professionals. The increase in the number of excavator contractors was greater among the FOAs, which had participated in quality work. In addition, the contractors under the supervision of the participant forestry professionals had acquired more new soil preparation equipment than those under the supervision of the non-participant forestry professionals. Compared with the reasons found for the regeneration results and the objectives set after the field inventories (Tables 2 and 3), the results obtained by mail survey were logical. In addition, the types of soil preparation equipment acquired were logical compared with those questions where the majority of the most increased soil preparation methods were surveyed.

Excavator-based soil preparation methods were most common in the regeneration of Norway spruce. Mounding accounted for a greater proportion of the responses given by the non-participant forestry professionals than by the participant ones. Patching, however, was more common amongst the participant forestry professionals, whereas disc-trenching gained only a minority response from both groups of forestry professionals. In the case where results were compared with the 2006 survey, mounding had increased and disc-trenching had decreased considerably amongst the non-participant forestry professionals. The increasing proportion of mounding can also be observed from the silvicultural statistics of Finland in 2002–2007 (Finnish Statistical... 2008). There may have been several reasons for the contradictory results between the surveys and for the great increase in the use of mounding on the part of the non-participant forestry professionals. Firstly, the two surveys were not answered by exactly the same groups of forestry professionals. Secondly, the report containing the results of the forest regeneration quality management project was sent to all of the FOAs, including some of the 2006 survey results. This may have influenced the respondents to the 2007 survey, which indicated the recommended soil preparation methods as the "correct answers" to questions contained in the survey. Thirdly, the non-participant FOAs may have adopted more mounding independently.

The greater use of mounding by the non-participant FOAs was tested. The data on the FOAs collected by the Statistical Information Service of the Finnish Forest Research Institute was used. The proportions of soil preparation methods reported in the forestry statistics dating from 2006 were compared with the survey. Since the forestry statistics data was not collected on a basis of tree species, the criterion for the proportion of Norway spruce planting per FOA was set at two-thirds of the planted regeneration areas. According to the responses received from the 2007 survey, the proportion of mounding and patching was 79% for the participant FOAs and 70% for the non-participant FOAs. This comparison suggests that the answers to this question cannot be considered very reliable. However, it has to be emphasized that this comparison was made only on the basis of the statistical information of a single year.

A question concerning the soil preparation method that had increased most, for its part, yielded consistent results. Compared with the reasons for the inventory results and the objectives set after the various feedback sessions, this question yielded a logical distribution of soil preparation types amongst the participant forestry professionals: patch mounding dominated compared with a reduced proportion of mounding with ditching. Patch mounding was a dominant topic when the recommended excavator-based soil preparation methods were discussed at the feedback sessions following the inventories. Patch mounding also dominated among the non-participant respondents, although they tended also to use a greater proportion of mounding with ditching than did the participant forestry professionals.

In the case of the participant FOAs, the soil preparation machine operators had participated more frequently in educational sessions than had the non-participant FOAs. The greater proportions of participants in soil preparation education for both respondent groups were logical compared with the proportions taking part in planting work education. In many forestry centres there had been education sessions where the proper soil preparation methods has been taught to everyone interested in that area.

In the choice of the regeneration material sub-process, the forestry professionals who had participated in the quality work used significantly more 1.5-year and older Norway spruce seedlings than did the non-participants. The use of 1.5 year-old seedlings had increased most, but the greatest difference between the forestry professional groups was in their use of two-year-old seedlings. The use of one-year-old seedlings found its greatest concentration in Etelä-Pohjanmaa and Lounais-Suomi, which was considered logical in light of the tradition of lighter regeneration methods. The proportions of seedling types used may vary to some extent from year to year according to the seedling types available from the stocks supplied by the seedling producers. On the other hand, the availability of seedling types should be at the same level in the same geographical areas for both participant and non-participant FOAs. Obtaining more competent, in this case older, seedlings could also be considered more related to the FOAs committing themselves to ordering the seedlings used in larger quantities early enough, which in turn will lead to improvements in their availability.

In the regeneration work sub-process, the differences in the planting densities used by the participant and non-participant forestry professionals were small. However, there were fewer low planting densities amongst the quality work participant professionals. The planting densities were considered to be at a good level as they were compared with the silvicultural recommendations (Hyvän metsänhoidon... 2001, 2006). The target densities applied in the quality control inventories at the stand-age of three years were generally considered reasonable and even higher densities were generally considered appropriate.

In the case of the participant FOAs, planting workers had taken part in significantly more educational sessions than had the non-participant FOAs. The proportions of participation in planting education were smaller than for soil preparation education. There were more self-control measurements of soil preparation and planting density in the areas supervised by the quality work participant forestry professionals. The education concerning planting work seemed to enhance the adoption of self-control measurements in the areas under the supervision of participant forestry professionals, but the same effect could not be observed amongst the non-participant forestry professionals. This finding suggests that successful adoption of a certain quality management tool may require multiple interventions on the part of different agents of change.

The quantities of seed used in Scots pine direct seeding were greater for the forestry professionals who had a longer history of quality work. However, the quantities of seed used may vary annually, depending on the quality and current germination capabilities of the seed material, and this study was only a snapshot of the applied practices. The quantities of seed were considered to be at a good level as they were compared with the silvicultural recommendations (Hyvän metsänhoidon... 2001, 2006). There was also kurtosis in the seed quantity distributions, which may indicate that the respondents have used memorized guidelines instead of real operational statistics as they have answered to this question. The results obtained from the 2006 survey supported the results of the 2007 survey. Generally speaking, the participant FOAs finished the mechanised sowing work earlier than did the non-participant ones. In light of the information content of the feedback sessions produced by the participant FOAs, the result was logical but statistically insignificant. In many studies (e.g. Saksa and Kankaanhuhta 2007, Kankaanhuhta et al. 2009b) the site and soil type has been shown to be the most important factor influencing the success of Scots pine direct seeding. The identification and selection of proper sites for this regeneration method could not be verified by this study.

The forestry professionals' interest in obtaining systematic feedback on their actions was investigated by means of two linked questions: what would be their interest in quality manage-

ment inventories either at the cost of the FOA or subsidised by the Ministry of Agriculture and Forestry? The results were as expected: the interest in inventories was considerably lower, since their own resources were at stake. In general, it seemed that interest in obtaining feedback by means of quality control inventories was higher amongst the forestry professionals who had already been able to try out this strategy. The average cost of the inventories varied from 25 € to 32 € per ha in the years 2002–2006 (Saksa and Kankaanhuhta 2007). Some forestry professionals, however, considered the inventory costs too high, although the permitted average costs fell within the previously mentioned range.

The widespread understanding of forestry professionals of the economic significance of a good regeneration result and their understanding of the most appropriate regeneration methods were demonstrably at a good level of competence. However, as many of the results indicated, difficulties still seemed to exist in implementing this general level of knowledge in terms of consistent practices. This observation emphasizes the FOAs' need for continuous improvement and for a commitment to learning. Although, this is the FOAs' own strategic issue, it is also a serious question for the forest policy decision-makers. The operative measurement-based quality management systems of the young stands can provide a concrete supplement for the current forest management planning systems.

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