

# Establishment of *Cladonia stellaris* after artificial dispersal in an unfenced forest in northern Sweden

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*Abstract.* In 2002, fragments and whole thalli of reindeer lichen, mainly *Cladonia stellaris*, were spread in a typical Scots pine forest in northern boreal Sweden to study the survival and development after artificial lichen dispersal. The forest was not fenced, allowing reindeer access to graze. Lichens were dispersed in intact vegetation in 1 m<sup>2</sup> plots by one of two methods: either as an intact lichen mat (patch) of 0.25 m<sup>2</sup> in the centre of the plot or as fragments scattered (scatter) across the whole plot. The lichen was then monitored by photo inventory. In 2006, three years after the first inventory, all patch plots had been partially grazed by reindeer and the lichen cover measured in both patch and scatter plots had decreased severely. In 2008, the lichen cover in the patch and scatter plots had increased by up to 54% and 88%, respectively, of the cover measured during the first inventory in 2003. A significant increase in the number of fragments in the plots was also observed between 2006 and 2008, suggesting that in addition to growing like naturally established thalli, the lichen had spread and slowly colonized the plots. Dispersing lichen by the “patch” method appears to be less cost-efficient than the “scatter” method, if the area is grazed by reindeer. These results support the hypothesis that dispersal of reindeer lichen could be an effective means of restoring lichen stands, which are important for reindeer husbandry, even if the area is open to reindeer grazing.

**Key words:** Forestry, lichen pasture, photo inventory, reindeer grazing, reindeer lichen.

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## Introduction

In northern Sweden, the herding of semi-domesticated reindeer (*Rangifer tarandus tarandus*) is based on migrations between seasonal pastures that cover about 40% of the total land area (Statistics Sweden, 1999). Winter pastures are traditionally located in forests, where the snow conditions are more favourable than in the mountains or marshes. During winter reindeer graze on both epigeic (*Cladonia* spp.) and

epiphytic (*Alectoria* and *Bryoria* spp.) lichens, which together comprise up to 80% of their winter diet (Gaare, 1968; Bergerud & Nolan, 1970; Danell *et al.*, 1994; Kojola *et al.*, 1995; Kumpula, 2001). During the 20<sup>th</sup> century, commercial forestry has had major effects on the forests and landscape structure in northern Sweden resulting in a loss of reindeer winter grazing grounds (Berg *et al.*, 2008).

At the stand level, the mechanical soil preparation prior to artificial forest regeneration has aroused controversy between reindeer herders and forestry companies in recent decades. Forest scarification reduces the area available for reindeer grazing by decreasing the cover of ground lichen and exposing mineral soil (Roturier & Bergsten, 2006). However, this operation is important for rapid forest regeneration, which is also in the interest of Sami reindeer herders, because of the positive influence a tree cover has on snow conditions and grazing conditions.

When conventional scarification methods such as harrowing are used, they can affect up to 45-55% of the vegetation cover and have very long-term consequences for the recovery of ground vegetation (Eriksson & Raunistola, 1990). This is especially true for ground reindeer lichens because they need a suitable substratum on which to establish (Roturier

*et al.*, 2007) and their growth rate is generally low (Kärenlampi, 1971; Helle *et al.*, 1983; den Herder *et al.*, 2003).

A general characteristic of the fruticose ground reindeer lichens is that they mainly propagate through the dispersal of fragmented thalli (Kiss, 1985; Honegger, 1996; Webb, 1998). The brittleness of dry thalli facilitates dispersal, which is mediated by wind and animals (Heinken, 1999). By imitating the natural dispersal of lichen fragments it was hypothesized that it may be possible to artificially disperse reindeer lichen and promote faster re-establishment of lichen, *e.g.* on disturbed soils (cf. Roturier, 2007). To further assess the potential utility of such an approach, two alternative methods of artificially spreading lichen were tested in a field experiment in a forest stand in boreal Sweden, to evaluate the effects of the spreading method on reindeer lichen survival and development in intact ground vegetation.

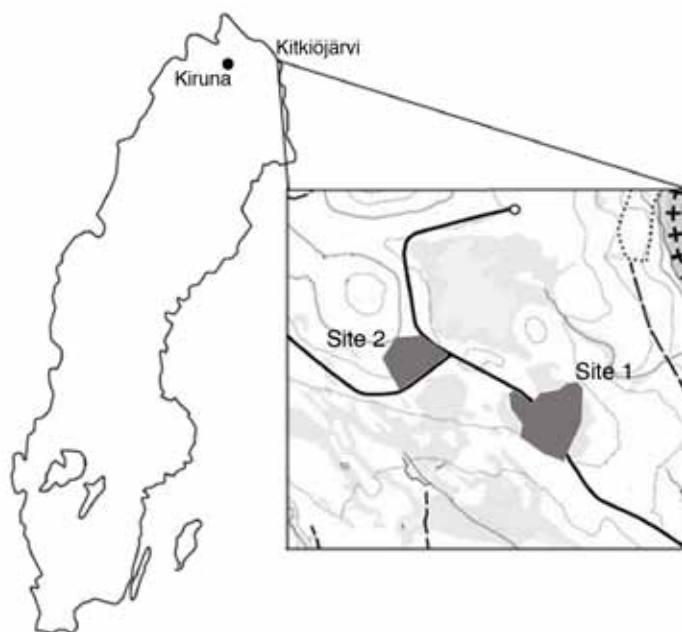


Fig. 1. Location of the experimental sites in the area of Kitkiöjärvi (67°49'N, 23°09'E), in northern Sweden.

## Material and methods

### *Design and experimental area*

The experiment was established in a pine forest in the area of Kitkiöjärvi (67°49'N, 23°09'E), in northern boreal Sweden (Fig. 1). The two sites were located on a mesic soil, typical of the northern boreal region (Esseen *et al.*, 1997) with cowberry (*Vaccinium vitis-idaea*) type ground vegetation. The bottom layer was dominated by mosses (*Pleurozium schreberi* and *Polytrichum commune*) with some elements of *Cladonia rangiferina*, and the field layer was dominated by cowberry and bilberry (*V. myrtillus*). The field layer also contained some elements of crowberry (*Empetrum nigrum*) and heather (*Calluna vulgaris*), which were present to a greater degree in site 2. The annual temperature sum was about 770 °C and the annual precipitation was between 400 and 600 mm (1961-1990, www.smhi.se).

The experimental site was not fenced and thus was open to reindeer grazing. The area is located within the winter grazing area of the reindeer herding community of Muonio, but since it is adjacent to an autumn grazing area, it can also be grazed during the bare soil season.

In September 2002, reindeer lichen was manually dispersed in plots (1 m x 1 m) distributed between two locations (1000 m apart). The 1 m<sup>2</sup>-plots were randomly established within an area of 2400 m<sup>2</sup> within each site. The lichen dispersed was mainly *Cl. stellaris* (80%) and *Cl. rangiferina* (20%) – nomenclature following Santesson *et al.* (2004). First a frame (0.5 m x 0.5 m) was filled with 3 litres of reindeer lichen (approximately 200 g dry matter). Then lichen was spread in the plots by one of two methods: either by transferring the lichen to the centre of each plot in a 0.25 m<sup>2</sup>-square (referred to as *patch dispersal*), or by spreading it across the whole plot after manual fragmentation, giving fragments of lichen ranging between 0.5-5 cm (referred to as *scatter dispersal*). Control plots were established at each site, *i.e.*

without any artificial dispersal of lichen. There were 48 experimental plots of 1 m<sup>2</sup> in total: at site 1 there were 9 replicates for patch, 10 replicates for scatter and 3 replicates for the control; while for site 2 there were 10 replicates for patch and scatter and 6 replicates for the control. Thus the experiment was considered as an unbalanced randomised block design, with two blocks (sites), and three levels for the factor 'dispersal method'. The reason for the unbalanced design is that in 2005 the first location was clear-cut by the forest owner and a substantial number of the experimental plots were impossible to locate anymore or had to be abandoned. In order to follow the changes of each plot through time, the plots destroyed during clear-cutting were ignored.

### *Image Inventory*

The establishment of the dispersed reindeer lichen in the vegetation was followed using a photographic inventory; an approach that, according to Dietz & Steinlein (1996), yields satisfactory results for unsaturated vegetation and is useful for detecting changes over time. The approach has also been tested in boreal forest vegetation by Vanha-Majamaa *et al.* (2000). For this purpose, photographs were taken of all the plots, from vertically overhead, using a tripod-mounted Nikon Coolpix 4500 digital camera at 2272x1704 resolution, with high quality definition. Photographs were taken on overcast days, to avoid shadows, and when the lichen was wet. Three series of photographs were taken, each at the end of June in 2003, 2006 and 2008. The first inventory was thus carried out one winter after establishment of the experiment.

The photographs were automatically processed using WinCAM™ (Regent Instr., 2007), which enables images to be analysed according to colour and to group colours in order to distinguish objects from the background. A *debris filtering* function was set up to exclude

objects smaller than 30 pixels (corresponding to about 10 mm<sup>2</sup>) from the analysis. A double manual check was always carried out to avoid excluding objects that were actual lichen fragments and/or to exclude objects that had been automatically classified as *reindeer lichen fragment* by mistake, e.g. epiphytic lichen of the genus *Hypogymnia* that might have dropped into the plot as a result of the wind.

### Statistics

To determine the effects of the different fac-

tors on the establishment and development of the lichen, an analysis of variance (ANOVA) was performed using the general linear model procedure in Minitab 15.1 (Minitab Inc., 2006). Site and dispersal method were considered as fixed factors. The response variables were the area in the plots covered by lichen, the area of individual lichen fragments and the number of lichen fragments in the plots, and the area covered by dwarf shrubs. Since the variance was non-constant and the ranges of the response variables were large, logarithmic transforma-

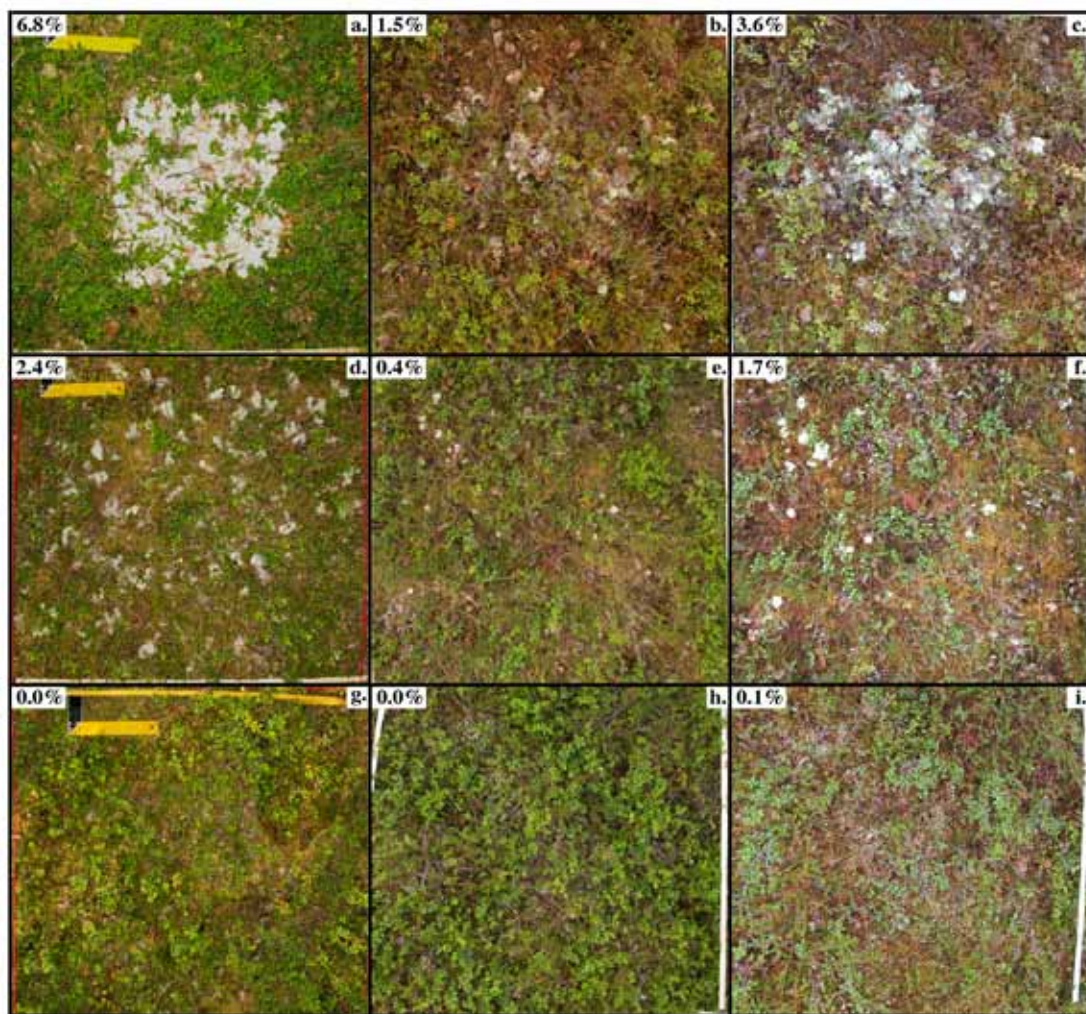


Fig. 2. Typical changes over time in lichen cover in a patch plot (a, b, c), a scatter plot (d, e, f) and a control plot (g, h, i), as shown by images taken in 2003 (left column), 2006 (centre column) and 2008 (right column). The percentage indicates the measured lichen cover in the images.

tion was applied to the response variables as suggested in Sabin & Stafford (1990). Differences were considered significant if  $P \leq 0.05$ . When significant effects were found, Tukey *post-hoc* test was applied to compare the effects of dispersal method on the response variable. Paired *t*-tests were used to evaluate the significance of differences between the years. Pearson correlation coefficients were also calculated to assess the strength of possible correlations between factors, deeming correlations to be significant if  $P \leq 0.05$ .

## Results

### *Establishment of dispersed reindeer lichen*

In 2003, after the first winter following establishment of the experiment, the dispersed lichen had almost completely disappeared from some experimental plots. This was particularly more visible on patch plots than on scatter plots because of the dispersal method (Fig. 2). The dispersed lichen had disappeared from 15% of the patch plots ( $n=40$ , *i.e.* before the clear-cut). Three winters later, in 2006, the dispersed lichen had almost completely disappeared from 100% of the patch plots ( $n=19$ , *i.e.* after the clear-cut). On average there was a reduction by 77% of the lichen cover in comparison to the lichen cover measured in 2003 (Fig. 3).

The scatter plots were not so severely affected and they had a significantly higher percentage of remaining lichen cover than the patch plots. In 2006, the lichen cover had decreased by 62% since 2003 (Fig. 3).

In 2008, five years after the first inventory, the measured coverage was about 46% and 12% lower than the values measured in 2003, for patch and scatter plots, respectively (Fig. 3). The difference between the two dispersal methods was still significant. Between 2006 and 2008, on average

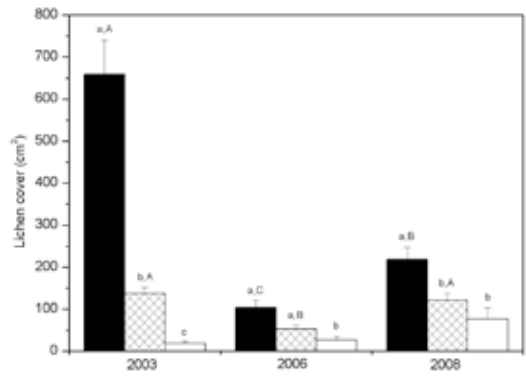


Fig. 3. Mean lichen cover area ( $\text{cm}^2$ ) in patch (black;  $n=19$ ), scatter (cross-hatched;  $n=20$ ) and control (white;  $n=9$ ) plots over time. Different lower case letters indicate significant between-treatment differences (Tukey's test:  $P < 0.05$ ); different capital letters indicate significant between-year differences (Paired *t*-test:  $P < 0.05$ ). Error bars=Standard error of mean (SEM).

the lichen cover increased by about  $90.4 \text{ cm}^2$  in the experimental plots, and there were no significant differences between the dispersal methods in this respect (Table 1). This corresponded to an average increase in relative lichen cover of  $1.79 \text{ cm}^2 \text{ cm}^{-2}$  in the patch and scatter plots. The lichen cover in the control plots also increased at similar relative rates to those recorded in the patch and scatter plots during the same period (Table 1).

Table 1. Increases in lichen cover (mean  $\pm$  SEM) between 2006 and 2008 in patch dispersal, scatter dispersal and control plots.

Dispersal method	Lichen cover increase	
	Absolute value ( $\text{cm}^2$ )	Relative value ( $\text{cm}^2 \text{ cm}^{-2}$ )
Patch ( $n=19$ )	$114.5 \pm 22.1$	$1.88 \pm 0.39$
Scatter ( $n=20$ )	$67.5 \pm 11.1$	$1.7 \pm 0.33$
Mean ( $n=39$ )	$90.4 \pm 12.6$	$1.79 \pm 0.25$
Control ( $n=9$ )	$52.6 \pm 18.3$	$1.67 \pm 0.39$

### Changes in reindeer lichen cover over time

In 2003, one winter after the dispersal of reindeer lichen, the patch plots had significantly greater cover of lichen (653 cm<sup>2</sup>) than the scatter plots (138 cm<sup>2</sup>) (Fig. 3), although initially the same quantity of lichen was dispersed in each plot in autumn 2002. The lichen cover in the control plots was significantly lower (21 cm<sup>2</sup>) than in both kinds of treatment plots. Between 2003 and 2006 the lichen cover decreased significantly in the patch plots and, by a lesser degree, in the scatter plots (to 104 and 53 cm<sup>2</sup>, respectively). The difference between the two dispersal methods in this respect was not significant (Fig. 3), but the lichen covers in the control plots was still slightly, but significantly, lower than in plots in which lichen had been dispersed. Finally, between 2006 and 2008 the lichen cover increased significantly ( $P \leq 0.001$ , except for control plots) almost two-fold for all the treatments, with no significant differences in growth rate of the lichen cover between the different treatments (Table 1). The lichen cover rose by up to 219 cm<sup>2</sup> in the patch plots and was significantly different from the lichen cover in the scatter and control plots (121 cm<sup>2</sup> and 79 cm<sup>2</sup>, respectively) (Fig. 3).

The clear-cutting in site 1 did not have any significant effect on the total reindeer lichen cover in the experimental plots within the time interval of the study. However, it did significantly affect the cover of *Cl. stellaris* in 2008 in relation to the total reindeer lichen cover (Table 2). In 2008, fragments that for certain could be identified as *Cl. stellaris* accounted for 75% of the lichen cover in the patch and scatter plots on average at site 1 (clear-cut), but only 43% at site 2, and the difference between the two sites in this respect was significant for the scatter plots.

The clear-cutting in site 1 also had a significant effect on the field-layer vegetation cover (Fig. 4). At site 1 the vegetation cover decreased

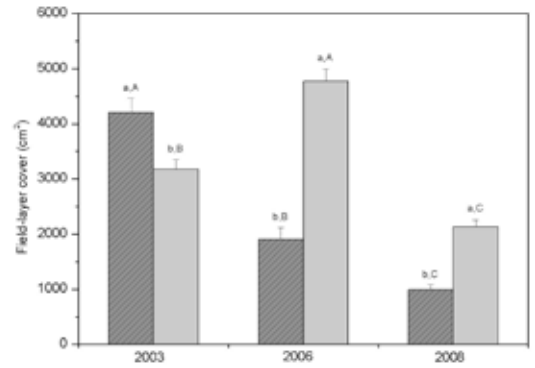


Fig. 4. Changes in mean field-layer cover area (cm<sup>2</sup>) in the experimental plots in site 1 – clear-cut (striped;  $n=22$ ) and site 2 (grey;  $n=26$ ) over time. Different lower case letters indicate significant between-treatment differences (Tukey's test:  $P < 0.05$ ); different capital letters indicate significant between-year differences (Paired  $t$ -test:  $P < 0.05$ ). Error bars=SEM.

significantly, by about 50% between 2003 and 2006, then further declined between 2006 and 2008 to ca. 10% of the total plot area. At site 2 the vegetation cover increased significantly by 50% between 2003 and 2006, then decreased between 2006 and 2008 to 21% of the total plots area.

The image analysis software enabled us to count the number of “objects” identified as *reindeer lichen* (thalli or fragments of thalli) using the colour analysis. The number of reindeer lichen fragments in the treatment plots followed a similar course to the reindeer lichen cover; a severe decrease in the number of fragments between 2003 and 2006 was followed by an increase between 2006 and 2008 (Table 3). In contrast, numbers in the control plots increased slightly (and non-significantly) both from 2003 to 2006 and from 2006 to 2008. The number of lichen fragments per plot in 2008 was positively correlated with the number of lichen fragments per plot in 2006 ( $R^2 = 60.2$ ,  $df = 47$ ,  $F = 69.7$ ,  $P < 0.000$ ).

As well as the number of lichen fragments,

Table 2. Fraction of *Cladonia stellaris* cover in relation to the total reindeer lichen cover in the experimental plots in 2008 (mean  $\pm$  SEM). Different lower case letters within columns indicate significant between-treatment differences (Tukey's test:  $P < 0.05$ ); different capital letters within lines indicate significant between-site differences (Paired  $t$ -test:  $P < 0.05$ ).

Dispersal method	Site 1 – clear-cut	Site 2 – undisturbed
Patch	0.65 <sup>a</sup> $\pm$ 0.07	0.48 <sup>a</sup> $\pm$ 0.06
Scatter	0.84 <sup>aA</sup> $\pm$ 0.09	0.38 <sup>aB</sup> $\pm$ 0.05
Control	0.00 <sup>b</sup> $\pm$ 0.00	0.00 <sup>b</sup> $\pm$ 0.00

the average area of the lichen fragments increased slightly between 2006 and 2008. The analysis of the fragments' size distribution within the plots showed a significant increase in numbers of large lichen fragments ( $> 2 \text{ cm}^2$ ) between 2006 and 2008, while the percentage of smallest fragments ( $< 0.5 \text{ cm}^2$ ) remained unchanged (Table 3).

## Discussion

### *Interpretation of the results*

There were significant between-dispersal methods differences in mean lichen cover in the summer of 2003, one winter after dispersal (Fig. 3), although each treated plot received the same amount of lichen. When dispersed as patches of  $0.25 \text{ m}^2$ , *i.e.* by implanting intact lichen thalli into the ground vegetation, the lichen appeared to be able to compete more strongly with the dwarf shrub and moss veg-

etation than when it was dispersed by scattering. When dispersed as fragments a few centimetres long the lichen could fall in some position that was unsuitable for growth. Six months of wind, precipitation and snowmelt would probably be sufficient to generate significant between-treatment differences in this respect.

The severe reduction in reindeer lichen cover between 2003 and

2006 in the patch plots can only be attributed to physical removal (Fig. 2). The experimental area was not fenced so reindeer were almost certainly responsible, since they have been grazing in the area every winter (T. Sevä, pers. comm., 15 March 2009). Furthermore in 2003, 14 out of 40 patch plots showed clear signs of foraging, *e.g.* the tops of the dispersed lichen had been removed while the base remained, which is a typical sign of grazing by reindeer under a snow cover. The less severe reduction in lichen cover in the scatter plots between 2003 and 2006 could also have been due to reindeer grazing.

After 2006, the average lichen cover increased by  $1.77 \text{ cm}^2 \text{ cm}^{-2}$  with no significant differences between the scatter, patch and control plots (Table 1). This suggests that the dispersed lichen that remained after the disturbance by reindeer established and grew in the

Table 3. Mean number of lichen fragments, average size of the lichen fragments ( $\text{cm}^2$ ), and the percentage of small ( $< 0.5 \text{ cm}^2$ ) and large lichen fragments ( $> 2 \text{ cm}^2$ ) in the patch, scatter and control plots in 2003, 2006 and 2008. Different lower case letters within columns indicate significant between-treatment differences (Tukey's test:  $P < 0.05$ ); different capital letters within lines indicate significant between-year differences (Paired  $t$ -test:  $P < 0.05$ ).

Dispersal method	2003		2006			2008			
	No. <sup>1</sup>	No.	Avg.	Sm. Fr.	L. Fr.	No.	Avg.	Sm. Fr.	L. Fr.
Patch ( $n=19$ )	397 <sup>a,A</sup>	196 <sup>a,B</sup>	0.59	68.3	5.6 <sup>a,B</sup>	325 <sup>a,A</sup>	0.66	63.9	7.5 <sup>a,A</sup>
Scatter ( $n=20$ )	248 <sup>b,A</sup>	85 <sup>b,C</sup>	0.64 <sup>a</sup>	59.4	5.6 <sup>a,B</sup>	156 <sup>b,B</sup>	0.74	62.0	9.8 <sup>a,A</sup>
Control ( $n=9$ )	67 <sup>c</sup>	84 <sup>b</sup>	0.37 <sup>b,B</sup>	79.2	0.6 <sup>b,B</sup>	127 <sup>b</sup>	0.57 <sup>A</sup>	60.5	5.5 <sup>b,A</sup>

<sup>1</sup> Since the fragments were difficult to dissociate from each other, the numbers for the patch plots should be considered as rough estimates in 2003.



same way as naturally established lichen thalli. The increase in the fragment's average area and particularly the increase in the percentage of fragments larger than 2 cm<sup>2</sup> between 2006 and 2008 also support this conclusion (Table 3). During the same period of time the number of fragments in all the plots also increased, especially in the patch and scatter plots, while the percentage of the smallest fragments per plot remained the same (Table 3). Thus a significant number of small fragments appeared in the plots. These results suggest that in addition to growing as naturally established thalli, the lichen could begin to spread and slowly colonize the plots. This is also strengthened by the fact that the increase in number of lichen fragments per plot also seemed to depend on their initial occurrence. The number of lichen fragments in 2008 was positively correlated with the number of lichen fragments two years earlier.

A possible bias regarding the increased number of fragments could be the decrease in field-layer cover (Fig. 4) that might make lichen fragments more detectable when using an analysis based on photographs taken from above. Another reason for an increase in fragment numbers could be trampling by reindeer, even during summer, as scattered reindeer were observed during fieldwork.

The increased number of lichen fragments in the control plots (Table 3) makes it difficult to ascertain whether the lichen cover increase of patch and scatter plots by small fragments was a consequence of the artificial dispersal or not. Colonies composed of *Cl. rangiferina* and *Cl. arbuscula* were observed particularly in plots with abundant cover of the moss *P. schreberi*, which has also been observed to be a suitable substratum for ground lichen growth by Coxson & Wilson (2004) and Roturier *et al.* (2007). The observed development of reindeer lichen in the control plots thus indicates that natural dispersal also occurred. Nevertheless, a major

difference between the patch and scatter plots and the controls was that no *Cl. stellaris* was found in the latter (Table 2). *Cl. stellaris* is often considered as a late succession species (Ahti & Oksanen, 1990) and no "naturally grown" colonies of *Cl. stellaris* were observed in the surrounding forest. The dispersed *Cl. stellaris* clearly established among the dwarf shrubs and mosses in the patch and scatter plots, possibly because ground vegetation can promote lichen growth by prolonging their hydration periods (Kershaw & Field, 1975; Jonsson *et al.*, 2008). Since the growing conditions seemed to become more generally favourable for lichen growth with time in this experiment, it is likely that numerous fragments of *Cl. stellaris* also began to spread and grow in the patch and scatter plots.

Clear-cutting is known to decrease the cover of bilberry *V. myrtillus* (see *e.g.* Kardell, 1980; Bergstedt & Milberg, 2001), and promote the growth of *Cl. stellaris* and other epigeic reindeer lichens (Bråkenhielm & Persson, 1980; Webb, 1998). Site 1 was clear-cut in 2005, which decreased the field-layer vegetation cover (Fig. 4) and promoted the growth of dispersed *Cl. stellaris* (Table 2).

In contrast, apart from some selective cutting in 1901, site 2 had not been cut, thinned or fertilized in its history, but the field-layer cover also significantly decreased at this site between 2006 and 2008 (Fig. 4). This result was mainly due to a decrease in *V. myrtillus* cover, which was less abundant at the inventory in late June 2008 than at the times of the earlier inventories. The local occurrence of a pathogen could have been responsible for this defoliation (*cf.* Forsum, 2008) although this was not confirmed. Although the causes of the changes in the field-layer vegetation differed at the two sites, reduced cover probably promoted lichen growth in both cases as shown by the increase in the lichen cover in the control plots in both sites. Without such a decrease in the field-layer



cover at site 2, the difference in lichen cover between the clear-cut and not clear-cut site would have been much larger.

#### *Possible applications for restoration of reindeer lichen*

Despite the lack of fencing at the experimental sites and the partial grazing by reindeer of lichen dispersed in the plots, the dispersed lichen grew (and even probably started to spread within the plots) and overall the artificial dispersal led to increased cover of reindeer lichen in the plots. However, the results presented in this paper, six years after the establishment, should be followed in the future to confirm these trends. Restoration of reindeer lichen pastures is an important matter that has been discussed for many years (Barashkova, 1964; Gaare & Wilmann, 1998; Polezhaev & Berkutenko, 2003; and even Kallio's study reported in Crittenden, 2000), but no practical measures are applied today in Swedish forests. It is necessary to encourage further research in this direction considering the need to ensure a multiple-use of the boreal forest and the threats of climate change to reindeer herding (e.g. Heggberget *et al.*, 2002; Moen, 2008). Other questions remain to address before applying these treatments in practice, e.g. after clear-cutting and soil preparations. First of all it should be noted that dispersed reindeer lichens do not establish easily on mineral soil (Roturier *et al.*, 2007). A further factor that should be taken into account is that the high tree stem density at early stages and subsequent canopy closure could promote other species, such as bryophyte species, at the expense of reindeer lichens (Bråkenhielm & Persson, 1980; Coxson & Marsh, 2001; Sulyma & Coxson, 2001).

However, even though it seems unreasonable to disperse lichen using the "patch" method, because of the large percentage lost through reindeer grazing, dispersing lichen by the "scatter" method seems to be useful, since

the lichen cover in the plots in 2008, *i.e.* six years after the dispersal, was only 12% lower than the lichen cover measured in 2003 (Fig. 3). Mesic sites supporting vegetation of dwarf shrubs with spots of ground lichens are generally not considered to be the most valuable grazing lands, but Sami herders do make use of them since they have different properties from the generally favoured lichen-rich pine-heath, and notably offer more grazing opportunities in some snow conditions. Development of measures that may enable foresters to increase reindeer lichen cover locally in such forest type could provide a means of compensating reindeer herders for the reduced grazing opportunities forest regeneration after clear-cutting.

In northern Sweden, all the large forest companies are now certified by the Forest Stewardship Council, which obliges them to "give consideration to the Sami people's reindeer husbandry" ([www.fsc-sweden.org](http://www.fsc-sweden.org)). Together with appropriate forest management practices, *i.e.* gentle soil scarification and suitable pre-commercial thinning, dispersal of reindeer lichen could be considered as a potential joint compensation measure between forest owners and Sami reindeer herders to minimize effects on reindeer grazing. Commercial harvest of reindeer lichen is practiced since the beginning of the 20<sup>th</sup> century (Llano, 1948; Kauppi, 1979) and has been a current practice by Sami people even before that (Lyng, 1921, p. 11). For example between 1970 and 1975, 3000 tons of reindeer lichen were exported from Fennoscandia in average annually for decoration purposes (Kauppi, 1979; 1993). About 240 litres of reindeer lichen was necessary to establish this experiment, and in 2008, the price for a sack of 60 litres of lichen was about 60 SEK (Swedish crowns). Thus, sufficient supplies should be readily available at possibly affordable price.

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## Etablering av *Cladonia stellaris* efter artificiell spridning i ej inhägnad skog i norra Sverige

*Abstract in Swedish / Sammanfattning:* Renlav (främst *Cladonia stellaris*) spreds manuellt 2002 i en talldominerad skog i norra Sverige för att studera lavens etablering efter artificiell spridning. Försöksområdet var inte hägnat utan öppet för renbete. Laven spreds i intakt markvegetation på 1 m<sup>2</sup>-tytor, antingen i form av intakta lavbålar (0,25 m<sup>2</sup>) i ytans centrum eller som fragment över hela provytan. Lavens etablering följdes med hjälp av fotoinventering. År 2006, tre år efter första inventeringen, hade alla provtytor betats av ren och lavens täckningsgrad hade reducerats betydligt. Vid inventeringen 2008 hade lavens täckningsgrad ökat med upp till 54% (intakt lav) resp. 88% (lavfragment), i jämförelse med täckningsgraden den första inventeringen. Mellan 2006 och 2008 ökade antalet fragment per provyta signifikant vilket indikerar en fortsatt naturlig etablering med spridning via fragment. Att sprida lav i form av intakta lavbålar förefaller mindre kostnadseffektivt än spridning av lav i fragmentform om spridningsområdet är öppet för renbete. Resultaten utgör ett stöd för hypotesen att artificiell spridning av renlav kan vara ett effektivt sätt att restaurera viktiga renbetesområden, även om området inte är skyddat för renbete.

