Impact of soil scarification on reindeer pastures.

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Summary: During recent years, soil scarification has become a standard procedure for improving seed beds after logging. Around 57 000 ha were treated, primarily through harrowing and ploughing, in the counties of Västerbotten and Norbotten during 1985.

The positive effects of scarification, from a forestry point of view, are improved access to plant nutrients, raised soil temperatures and reduces surface moisture.

The aim of the present study was to describe long-term changes in the ground vegetation following scarification.

Harrowing affects 45-55% of the plant cover while ploughing affects 65-90%.

10 years after ploughing and harrowing about 20% of the surface is still without vegetation.

Real long-term effects remain in dispute. It has been claimed that ploughing, at least, may lead to irreversible changes.

Key words: Forestry methods, harrowing, ploughing

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Introduction

All types of soil scarification after final felling of forest stands aim to support germination of tree seeds and establishment of tree plants and their further development.

The silvicultural effects of different kinds of site preparation are well documented (Mälkönen, 1987; Pohtila, 1977; Söderström, 1975, 1976, 1988; Örlander, 1986). Scarification influences soil temperature, soil moisture, competition from surrounding vegetation, nutrient circulation and hydrology and ultimately, also plant growth (Bäcke *et al.* 1986). However, there are few experiments or published studies which describe effects of scarification on the ground vegetation (i.e. the field-and bottom layers).

The aim of this investigation was to study the long-term effects of harrowing and ploughing, especially on plant species that are grazed by reindeer.

Reindeer are herded over almost all of the two northernmost counties in Sweden, Norrbotten and Västerbotten, and in a considerable

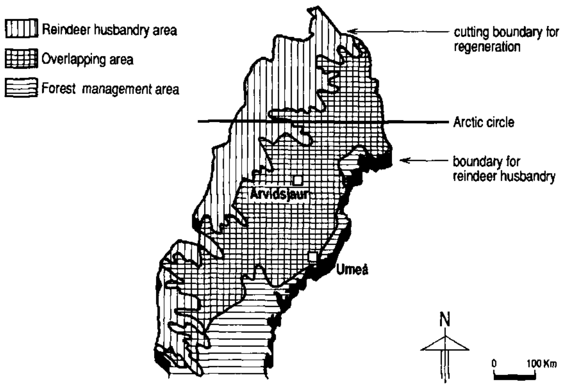

Fig. 1. Areas of interest to forestry and to reindeer husbandry in northern Sweden (Mattson, L. 1981).

part of the county of Jämtland (Fig. 1). Most of the winter range lies below and east of the cutting boundary for regeneration (Fig.1). In this part of Sweden, logging is the major industry.

According to the Forestry Act, all logged areas have to be reforested either artificially by planting or sowing, or naturally from seed trees. (Only Scots pine, *Pinus sylvestris*, is left as a seed tree, because of the risk of wind-throws which would occur if spruce trees, *Picea abies*, were left solitary. The current trend is to treat the ground after logging in most sites (Skogsvårdstyrelsen, 1987). Harrowing is by far the most common practise but mounding is increasingly used (Fig. 2).

During the last eight years the total annual scarification area in the northernmost county, Norrbotten, has totaled 27 000 ha. Of this area 20% is ploughed (Fig. 3). There is, however, a great variation between counties, different districts and ownership categories within counties (Fig. 2).

Study area

The study area is located between latitude N 63°and 68°in N Sweden. It belongs to the northern boreal vegetation zone according to Ahti *et al.*, (1968). The study objects are situated between 300 and 580 m a.s.l. The growing season lasts 130-150 days. The temperature sum for the whole region is less than 800°C with an threshold value of +5°C (Odin *et al.*, 1983). The annual precipitation is 450-550 mm, of which 35-45% falls as snow (Atlas över Sverige, 1971).

Methods

Based on information from the National Forest Enterprises of Sweden, a number of regeneration stands were defined. The aim was to find as comparable areas as possible from biotic and abiotic viewpoints.

The scarification methods which so far have been studied are ploughing and harrowing. Because of the differences in construction, in the degree of disturbance capacity, ect., between the earlier and the existing scarifiers, we have concentrated on regeneration areas, which were cultivated with the most frequently used machines and models still utilized.

The soil moisture and the thickness of the humus layer primarily determine the method to be used. We decided to choose areas with me-

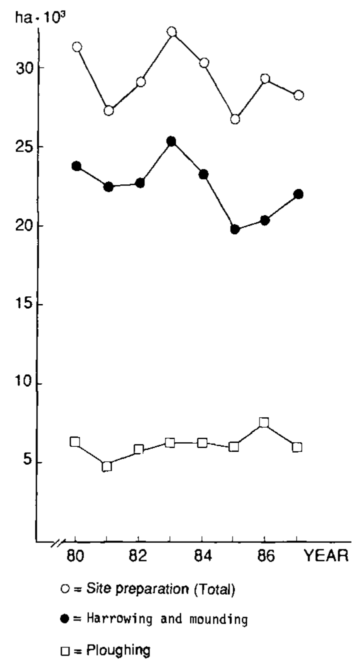

Fig 3. Site preparation during the period 1980-87 in the county of Norrbotten (Source: The National Board of Forestry.)

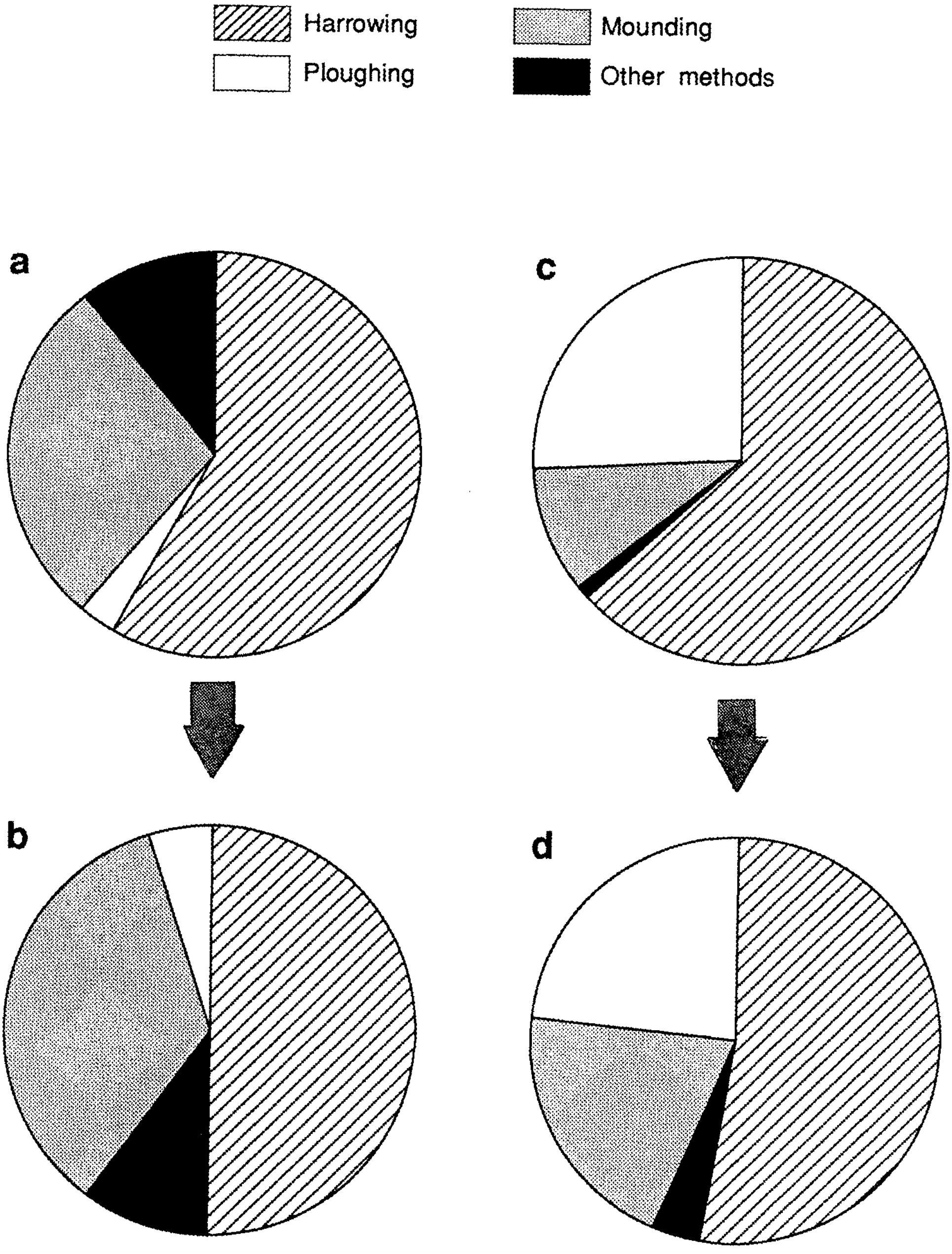

Fig. 2. The percentage distribution of different site preparation methods in 1987 and prognoses for 1991/92 in the two northernmost counties of Västerbotten and Norrbotten. Values apply only to state-owned forests. (Source: The National Forest Enterprise of Sweden).
a= Västerbotten 1987 b= Västerbotten 1992
c= Norrbotten 1987 d= Norrbotten 1991

Photo 1 a,b. The main site preparation methods to be used are harrowing and ploughing. A) deep cultivator (=plough), B) scarifier of harrow type. (Photo: O.E.)

Photo 2. Harrowed pine stand with seed trees. Harrowing is the most common site preparation method in Northern Sweden. (Photo: O.E.)

Photo 3. With modern scarifiers the degree of disturbance and the depth of furrow is adjustable. (Photo: O.E.)

sic soil moisture types dominated by sand to fine sand moraine, because these types dominate within the reindeer area.

As we could not study a limited number of sites over a long period of time we instead had to select our investigation areas in an age series, based on year of treatment. A number of control sites, *i.e.* mature forest stands comparable to the logged ones before logging and situated quite close to them, were also chosen and inventoried; accordingly we are using a static method (Austin, 1977).

In each investigation area the relative frequencies of the different subsections - tilt, shoulder, ditch bottom and intact ground - were recorded. The standing crop of the ground vegetation on each subsection was calculated.

A number of parallel transects, at a 45° angle to the dominating plough course, were distributed across the sites. A number of sample plots were systematically placed along these transects and in each plot the following measurements were made:

1. In the 1 m^2 plots the cover of each plant species or plant group, both in the whole plot and in the respective subsection within the plot, were estimated and the proportion of each subsection was estimated.
2. On every subsection a vegetation sample (500 cm^2) was taken in order to quantify the standing crop. The samples were brought to the laboraory, where they were dried, sorted and weighed.
3. From the centre of each plot a 10 m measuring tape was laid out at right-angles to the predominant plough course and along that tape the length each subsection occupied was measured.
4. The height differences between the intact ground level and the manipulated subsections, top of tilt and shoulder, and bottom of ditch, were measured.

Preliminary results and discussion

The material presented below is preliminary and, in many ways, also incomplete. Some data from an earlier pilot study are also included (Eriksson, 1985).

Physical features

The proportion of intact ground on recently ploughed areas varied between 13-22% and on harrowed areas between 48-56%. The values obtained on the ploughed areas agree well with those reported by Kellomäki (1971) and Ferm & Pohtila (1981) from ploughed areas from different parts of Finland. Eriksson (1985) also obtained similar values in his investigation carried out near Jokkmokk in North Sweden.

The heights of the tilts varied form 17 to 27 cm on ploughed areas and from 14 to 15 cm on the harrowed areas in relation to the intact ground. There was, however, no clear reduction in height with time, probably because so few stands have been investigated.

Development of the vegetation

The proportion of litter, mineral soil and humus decreased from 48% to 17% during a period of eleven years on harrowed sites (Fig. 4 a,b) and from 75% to 10% during twenty years on ploughed sites.

The ground vegetation developed rapidly during the first years, but later the changes were somewhat slower. Ferm & Pohtila (1981) found a similar trend in their study. Many factors may affect this process: soil moisture, type of soil, temperature sum, tree layer, etc.

The control stands (mature stands) represent the hypothetical situation before site preparation. According to Sjörs (1980), succession may be irreversible. It is, thus, not certain that the prepared stands return to the same composition in the long run. In fact, the desirable long-term effect of scarification is to increase the forest production. If that is true, this long-term effect should then also be seen on the ground vegetation. Twenty years is, however, too short a period of time to determine whether succession will lead to another composition in the mature second growth stand.

It seems to take more than twenty years in

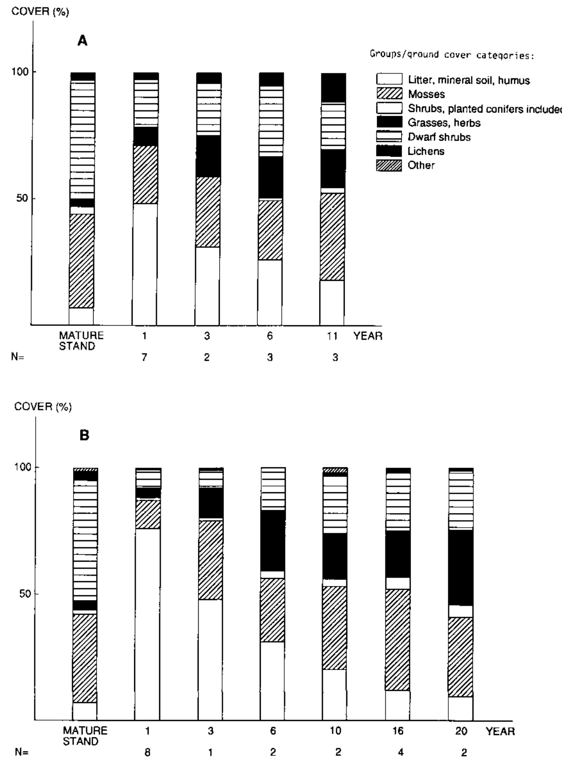

Fig. 4. Harrowed sites of different age. Cover (%) of 7 different groups/ground cover categories on sites of different ages after soil scarification. A=harrowed sites, B=ploughed sites N=number of investigated stands.

ploughed areas (Fig. 4 b) before the soil is covered by ground vegetation. The time period is probably a little shorter on harrowed areas (Fig. 4a). The total percentage cover of dwarf-shrubs was lower than the mature stand 11 years after ploughing and 16 years after harrowing. The opposite effects were observed for the sum of grasses and herbs (Fig. 4 a,b). The dominant dwarf-shrubs in the study stands were *Vaccinium myrtillus*, *Vaccinium vitis- idaea*, *Vaccinium uliginosum* and *Empetrum hermaphroditum*. *Deschampsia flexuosa* was the most common graminoid. Herbs such as *Chamaenerion angustifolium*, *Linnea borealis*, *Solidago virgaurea* were quite rare. *Pinus* and *Picea* plants, *Salix spp. and Betula pubescens* were the most frequent shrubs. Lichens in the study stands were of rare occurrence.

The abundance of *Empetrum hermaphroditum* and *Vaccinium myrtillus* decreased after ploughing (Fig. 5). Eleven years after the scarification their coverage was reduced by 10-15% compared to the control sites (Fig. 5). Mosses common in mesic forest types, like *Pleurozium schreberi* and *Hylocomium splendens,* had also decreased. *Deschampsia flexuosa,* which had a coverage of only a few per cent in mature stands, increased to a coverage of about 15-30% in areas which were scarified eleven years earlier. *Vaccinium vitis-idaea* had an irregular development.

Pioneer mosses and mosses which are common in dry sites like *Polytrichium piliferum* and *Ceratodon purpureus,* had a coverage about 30-35% higher than the mature forest eleven years after site preparation.

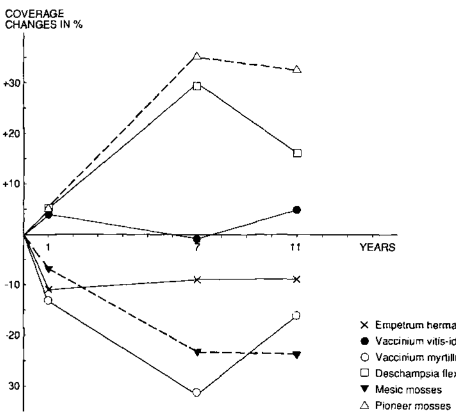

Fig. 5. Relative changes of different species/groups during 11 years (n=3x(20+20)) on ploughed sites compared to mature, control stands.

The differences in cover are significantly different from the cover values in the mature stands for all species and species groups already seven years or, as for *Vaccinium vitis-idea,* after ten years. Ingelög (1974) decribes the same kind of vegetation changes after clear-cutting without site preparation.

The vegetation on different subsections

The succession of the vegetation on the different subsections differs from the vegetation development in the whole area. After eleven years *Deschampsia flexuosa, Vaccinium myrtillus, Empetrum hermaphroditum* and the mesic forest mosses are more abundant on the intact ground than on the other subsections. On the ditch bottoms the pioneer mosses dominate. *Vaccinium vitis-idaea* is more abundant on tilts than on the other subsections. These trends agree very well with those deseribed by Ferm & Pohtila (1981).

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