BRIEF REPORTS

Technical Development in Forest Regeneration in Finland

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The forest regeneration area in Finland was 166 000 hectares in 1998 of which the proportion of planting was 47 %, sowing 20 % and natural regenerating 33 %. Nowadays, mechanized ground preparation is carried out on nearly all regeneration areas. Of all ground preparation methods, disc ploughing is most common. Nowadays, such equipment is favoured which is able to flexibly execute various ground preparation methods in different parts of the regeneration area.

Of all seedlings produced in Finland, 87 % are container seedlings. The majority of seedlings are planted by hand with a pot tube. The proportion of mechanized planting is minimal for the time being. There are only a few planting machines in use. The development of mechanised planting must be carried out in close cooperation with seedling production.

Sowing is carried out in combination with mechanical ground preparation. Thus, sowing costs are lower compared with separately carried out hand sowing.

Environmental factors are matters also to be considered in different phases of forest regeneration.

Key words: sowing, mechanized sowing, planting, mechanized planting, regeneration technique, artificial forestation

Artificial forestation

The term artificial forestation is understood to mean the establishment of a new tree generation by planting and sowing (Saarenmaa 1997). Forest regeneration can also take place naturally. Mechanized preparation of the ground surface on the forest regeneration site is common practice. In this way artificial forest regeneration is made easy, competing ground vegetation and pine weevil (Hylobius abietis) damage is reduced, and conditions for growth and restocking are improved. Site preparation is generally carried out preceding both natural and artificial regeneration. The area regenerated in Finland in 1998 was 166 000 hectares; of this, 79 000 hectares (47 %) were planted, 33 000 hectares (20 %) were sown and about 54 000 hectares (33 %) regenerated naturally (Finnish Statistical Yearbook of Forestry 1999). The proportion of planting has diminished somewhat during the past ten years and that of sowing has increased. In the other Nordic countries the proportion of sowing is negligible, for example in Sweden less than one per cent of the total area regenerated.

Figure 1 shows the annual regeneration areas by site preparation methods. The proportion of prescribed burning has diminished since the 1960s; currently, it amounts to some 900 hectares per year. Mechanized site preparation has considerably increased since the 1960s.

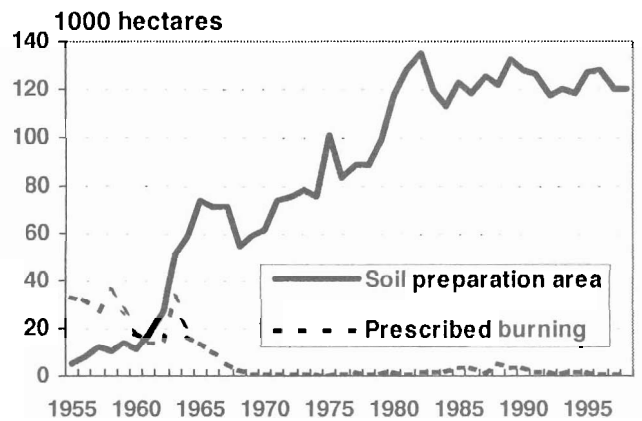

Figure 1. Extent of forest regeneration performed annually (Finnish Statistical Yearbook of Forestry 1999)

Figure 2 shows the area proportions of the various soil preparation methods from 1955 to 1996. Site preparation being a heavy work phase has been mechanized. It is carried out mechanically using various drawn devices, excavators, tilling devices mounted on hydraulic cranes and others. Four wheel drive agricul-

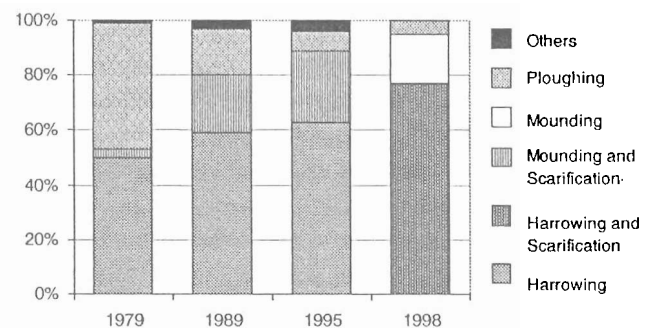

Figure 2. Proportions of different site preparation methods in 1979, 1989 and 1995 (Hämäläinen 1997) in 1998 (Finnish Statistical Yearbook of Forestry 1999)

tural tractors are suitable as prime movers for lighter devices. Heavier devices require a forwarder or a crawler tractor as their prime mover. Mechanized preparation of forest soils began at the end of the 1950s. The first to be used were patch scarifiers. These were followed by forestry ploughs, harrows and excavators. Nowadays, nearly all site preparation on regeneration sites is mechanized (Hämäläinen 1997).

Ploughing was widely used in Northern Finland as recently as in the 1980s. Nowadays, it is of little significance. It has been replaced with mounding on sites requiring intensive preparation. Mounding and drainage-and-mounding are used in Northern Finland and also elsewhere in Finland on water-logged sites.

Disc trenching (Figure 2) is the most widely used site preparation method. Other light methods are scarifying and rotary-tilling. These are suitable for both natural and artificial regeneration on nearly all sites, excluding peatlands and upland sites with a thick raw humus layer. The effect of the terrain and logging waste on the result of ground preparation has been studied by Hämäläinen and Kaila (1987) and others.

Development of site preparation equipment has been successful in Finland. Devices of world renown in this field include TTS Forest's mechanically and hydraulically activated disc trenchers. The first mechanical disc trencher was made in 1961 and it was drawn by agricultural tractor. The hydraulically powered TTS Donaren was developed in the mid-1970s at the TTS Institute's Experimental Station mainly in compliance with Swedish requirements (Korhonen 1997).

The Sinkkilä scarifier is the best known scarifier. In recent years, development has been focused on devices which can be used to carry out light site preparation as well mounding (Sinkkilä scarifier, Toimi scarifier-mounder, TTS Delta IIB, and TTS Delta III). This development trend is most welcome. Although regeneration sites in Finland are small, the conditions are varied. In easy conditions, good results are achieved with existing multifunctional devices but mounding, for instance, in difficult conditions is not entirely satisfactory. Backhoes and excavators can be used to produce the desired mounds and even drainage ditches, and with accessories, patch scarifying is also possible. However, high costs are a restricting factor.

Present day site preparation equipment made in Sweden includes Donaren, Bräcke and the Eco rotary tiller. There is a wide array of site preparation equipment in different parts of the world: the alternatives range from very minor breaking of the soil surface to intensive ploughing or drainage-and-mounding.

The average sité preparation costs in Finland were FIM 741 per hectare for disc trenching, FIM 1008 per hectare for mounding and ploughing, and FIM 1448 per hectare for prescribed burning (Finnish Statistical Yearbook of Forestry 1999). Arnkil and Hämäläinen (1995) used the figure of FIM 590 per hectare as the disc-trenching cost and that of FIM 1200 per hectare as the cost of mounding when studying the cost of mechanized planting. Parpala (1995) obtained the figure of FIM 350 as the cost per hectare of mounding when using the agricultural tractor drawn Toimi mounder on sites with a thin raw humus layer.

Mechanized sowing

The practice in the United States since the early 1940s has been to use aeroplanes and helicopters in forest sowing (Sirén 1954). Sirén experimented with the use of an aeroplane for the same purpose in Finland in 1953 and 1954 in the surroundings of Helsinki and in Finnish Lapland. The areas selected for sowing in Lapland were sites burnt over seven to eight years previously and about 900 hectares in size. A runway measuring 25 m by 300 m was cleared manually in Kuttura within a week and 1300 kg of seed were sown. The restocking result was poor both in the airborne sowing and the control hand sowing on snow. This was mainly due to poor germination of the seed. As regards costs, airborne sowing was of the same order as hand sowing (Sirén 1954, Sirén 1957).

The prerequisite for mechanized sowing is that benefficient site preparation (Korhonen and Mänty 1991, Hyppönen 1998). There are plenty of suitable sowing machines for mechanized sowing, such as TTS/Palonen, TTS/Sigma (Figure 3), TTS/SeedGun (Figure 4), Marttin-

en Ky's Top-100, Tume MKL 2, and the Swedish made Bräcke. Mechanized sowing means that the seed is sown onto a prepared soil surface in a controlled manner. The amount of seed consumed in mechanized sowings is between 150 - 300 grams per hectare depending on the germination of the seed. In machine sowing the seed must not be damaged.

Figure 3. TTS-site preparation machine and TTS-Sigma seeder

Figure 4. Mounding and SeedGun seeder

After Hämäläinen (1997), sowing on lands owned by companies and the Finnish Forest and Park Service in 1996 was mainly carried out by machine during site preparation, and the average cost was FIM 831 per hectare (including the price of seed).

The results of mechanized sowing on sites suitable for sowing have been at the least satisfactory for both pine and mixed sowing of pine and spruce. Mechanized sowing has also been employed when ensuring and speeding up natural regeneration (Kinnunen 1992). Sowing carried out in conjunction with site preparation results in labour cost savings when compared to manual sowing as a separate work phase. The germination conditions are considered to be better when sowing is carried out in conjunction with site preparation when the soil is porous and the harmful effects of competing ground vegetation are not involved. Although the ground surface is rough immediately after preparation, devices for making small holes have been developed and tried in Sweden and also in Finland (Kinnunen 1992, Winsa and Bergsten 1994, Winsa 1995). Seed germination has been better in these small depressions than in patches where seeds have been sown onto soil treated in the conventional manner (scarified, disc-trenched). Covering the seed has also been observed to improve restocking (Yli-Vakkuri & Räsänen 1971, Kinnunen 1982, 1992).

Mechanized planting

Planting machines are used to speeding up the planting work and make it lighter. Combination ploughing and planting machines were experimented with already at the close of the 1800s in the United States with horses as the draught animals (Appelroth 1969). These planting machines functioned with the ploughing principle and thus were suited mainly for planting on field-like ground. Such ploughing planting machines are still in use and they are particularly common in the planting of short rotation tree species (Harstela and Tervo 1983). When felling, the heaviest work stage in forestry, had been mechanized, interest toward mechanized planting grew at first in Sweden and later also in Finland. The Serla planting machine was developed in Finland in the 1970s (Kaila 1984). However, planting machines suited best for afforestation of fields and extremely good reforestation sites had been developed considerably earlier (Appelroth 1969, Appelroth and Harstela 1970).

G. A. Serlachius Oy's Serla planting machine carried out both site preparation and planting simultaneously. The feeding of containerised seedlings to be planted was automated. The technical success of planting averaged 90 %. A follow-up study of the machine showed that the average machine output was 655 seedlings per effective hour. At the end of the follow-up period, with modifications made to the machine, the

output was about 900 seedlings (Kaila 1984). Although this planting machine was technically quite functional, it could not be made economically profitable. Attempts were made to market the machine in Sweden for instance, where there was more interest in mechanized planting than in Finland. However, the Swedes chose the Swedish made Silva-Nova planting machine and went on to developing it.

Present day planting machines can be divided into three categories: (i) small and partly mechanized such as Hevotrack and Silviplant, (ii) those that move forward intermittently (i.e. the machine moves forward, stops and plants the area within its reach such as the Bräcke-Planter, Eco-Planter and Ilves), and (iii) continuous action automated planting machines such as the Silva-Nova. (Hallonborg et al. 1997). The examples given are by Nordic manufacturers. The choice of planting position when using partly mechanized and intermittently moving planting machines is made by the operative. With continuous action machines, the operative determines the spacing of the plants while the machine "senses" suitable planting positions.

The 1960s saw the introduction of the motorised mole by means of which a patch and a hole were bored into the soil to receive the seedling. A similar principle is involved in the construction of the planting machines called Hevotrack and Silviplant. Their output per hour is between 200 - 220 seedlings with two planters (Hallonborg et al. 1997).

Figure 6 shows a Bräcke-Planter mounted on an excavator. The planter includes a site-preparation plate, a planting tube with its compacting device and a seedling cassette. There is room for 60 - 70 containerised seedlings in the seedling holder and it is filled manually. In accordance with the results of a study by Arnkil and Hämäläinen (1995), the average output of the machine varied between 133 and 168 seedlings per hour. This rate included about 20 % interruptions. With the aid of the results of Swedish studies, the output of the machine is at best about 250 seedlings (von Hofsten 1993). In accordance with the studies conducted by Rummukainen (1995) and by Kautto (1997), at the Finnish Forest Research Institute, the hourly output of the machine was about 140 seedlings with one third of the time being taken up by site preparation. After Kautto (1997), the output of the machine should increase 50 % for the machine to be competitive with manual planting. The Swedish Eco-Planter 2000 has achieved a maximum hourly output of over 500 seedlings in good planting conditions. The machine comprises two planting units and the functions also include a site-preparation device called Eco-Fräser (Hallonborg et al. 1997).

The Ilves planting machine (Figure 5) is lighter than the Bräcke-Planter (Figure 6), but it does not include site preparation. The machine can be installed in place of the grapple on the hydraulic arm of an agricultural tractor or forwarder. The machine includes a seedling cassette, which is filled manually, placed above a hydraulically driven pot tube. The cassette has room for 102 - 150 seedlings depending on the size of the cassette. The productivity per effective hour was between 140 and 230 seedlings (Rummukainen and Tervo 1994, Kautto 1997). After Rummukainen, a rise in the productivity of planting work to 250 seedlings per hour when using the agricultural tractor based machine makes it competitive with manual planting. After Kautto (1997), an additional output of 30 % is required for the agricultural tractor based planting machine and 50 % for the forwarder based unit for them to be competitive with manual planting. The difference is due to the higher capital expenditures of a forwarder compared to an agricultural tractor.

Figure 5. The Ilves planting machine

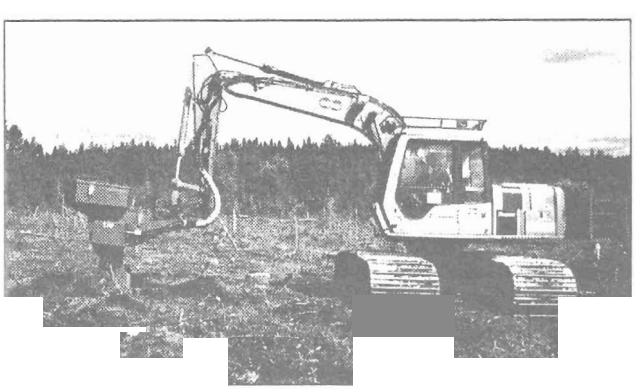

Figure 6. The Bräcke planting machine

Mechanized site preparation and manual planting continue to be the most profitable alternatives. In accordance with the research by Häggblom and Kaila (1982) the planting work relative time use in mattock planting (bare root, transplanted pine seedling) is 100 and in tube planting with small container seedlings is 50.

However, considering that the output of the Swedish Silva-Nova planting machine is about 1500 seedlings per hour, it is considered to be competitive with manually performed pot tube planting. In accordance with the results of studies conducted in Sweden, the hourly outputs have been as high as between 1500 and 2000 seedlings per hour (Hallonborg et al. 1997). Conifer seedlings have been machine planted almost through the whole growing season.

In accordance with the results of a study by Hämäläinen (1997), the costs of planting (including wages and social security costs and costs of seedlings excluding VAT) on average were FIM 2123 per hectare for pine and FIM 2402 for spruce on company land and land administered by the Finnish Forest and Park Service in 1996. That year the proportion of mechanized planting on these lands was only 3%. In accordance with the Finnish Statistical Yearbook of Forestry (1999), the average planting costs in Finland were FIM 3309 per hectare. These unit costs include wages (excluding salaries of planning and supervisory staff), social security payments, pension contributions and insurance premiums, holiday compensations, earnings levelling system payments and seedlings as well as other costs characteristic of the work in question.

Development of mechanization of planting and plant production need to be performed in close co-operation. Mechanization of planting work benefits if it is kept in some form under consideration and preconditions are created for different future alternatives. The feed automation of plants may improve the output of a planting machine by approximately 15 percent units. Finnish forests will be regenerated by planting also in the future. In Finnish forests there are regeneration sites which are behind schedule and whose regeneration should be carried out primarily by planting.

The 1990s were a decade in which environmental interests had been taken into consideration more than ever before (Korhonen 1997). Environmental issues are to be considered also at different stages of forest regeneration. Nowadays, the trend is towards devices enabling flexible execution of varying site preparation to meet the needs of individual parts of the regeneration area.

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ТЕХНИЧЕСКОЕ УСОВЕРШЕНСТВОВАНИЕ ЛЕСОВОССТАНОВЛЕНИЯ В ФИНЛЯНДИИ

Л. Терво

Резюме

Лесовосстановление в Финляндии в 1998 году было проведено на территории общей площадью 166000 га, из них 47% облесено посадкой, 20% – посевом, и 33% естественным путём. В настоящее время механическая подготовка почвы проводился почти на всех площадях, отведенных для лесовосстановления. Наиболее распространённый метод подготовки почвы является подготовка её орудиями дискового типа. В настоящее время предпочтение отдаётся орудиям подготовки почвы, которые позволяют гибко применят различные методы подготовки почвы в зависимости от условий местопроизрастания.

87% всего посадочного материала, выращиваемого в Финляндии, является саженцы с закрытой корневой системой. Большинство саженцев высаживаются вручную с помощью посадочной порубы. Механизированная посадка леса в настоящее время производится в минимальных объёмах, для которой используется только несколько лесопосадочных машин. Развитие методов механизированной лесопосадки должно проводится в тесном сотрудничестве с методами производства посадочного материалам

Посев леса производится одновременно с подготовкой почвы. Это позволяет уменьшить затраты на создание лесных культур, по сравнению с ручным посевом после подготовки почвы.

Факторы окружающей среды являются также важными, и должны учитываться в различных фазах лесовосстановления.

Ключевые слова: посев, механизированный посев, посадка, механизированная посадка, техника лесовостановления, искуственное лесовосстановление.