SILVICULTURE AND MANAGEMENT OF SCOTS PINE IN SWEDEN

G. EGNELL

Dept. of Silviculture. S-901 83 Umeå, Sweden
Gustaf.egnell@ssko.slu.se

SUMMARY

This paper gives some information about silvicultural trends in Sweden with the main focus on management of Scots pine stands and measures proposed to enhance biodiversity. During the last decades there has been a shift away from volume production orientated forestry towards forestry focusing on both production and environment with a special emphasis on biodiversity. Our current Forestry Act has two equal goals, (i) forest production and (ii) environment with sustained biodiversity. The major Swedish forest companies and other forest owners are signing agreements in order to meet certification requirements and show that their forest management considers the sustainability of the whole forest ecosystem and the environment of surrounding ecosystems. Even though Scots pine will still mainly be managed on a clear-cutting system, these developments will change Swedish Scots pine forests from even aged, uniform monocultures towards more mixed species and multi-storied stands. Prescribed burning will be practised on Scots pine sites as a site preparation measure that also enhances biodiversity. In this way silviculture will mimic the major natural disturbance agent in boreal Sweden – forest fire. Measures to enhance biodiversity are based on the best available knowledge, but the effect of these measures on biodiversity and forest production is largely unknown. Another uncertainty is how these new stands should be managed in an efficient way.

KEY WORDS: *Pinus sylvestris*
Sustainable forestry
Boreal forest

INTRODUCTION

Scots pine (*Pinus sylvestris* L.) is, together with Norway spruce (*Picea abies* (L.) Karst.), the most common tree in Sweden, distributed over almost all the country. Scots pine represents 39 % (1,078 million m^3) of total standing volume (Fig. 1) and 37 % (8.6 million hectares) of the total forest area (Fig. 2) with an annual growth of 33 million m^3.

Scots pine is the dominant tree species on Gotland – the largest island in the Baltic with shallow calcareous soils. It is also the dominant species in the western part of central Sweden – where it goes all the way up to the timber line – and in the eastern part of the northernmost two provinces Västerbotten and Norrbotten (Fig. 3).

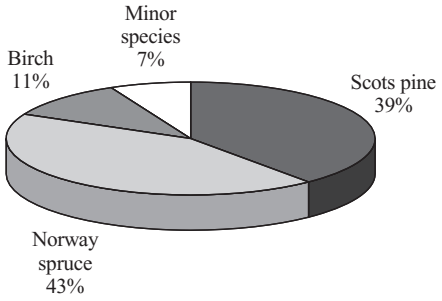

Fig. 1.–Standing volume (%) by tree species in Swedish forests. Total standing volume is 2,808 million m^3. Source: Swedish National Forest Inventory (Anon. 1999)

Volumen en pie (%) por especie arbórea en Suecia. El volumen total es 2.808 millones de m^3. Fuente: Inventario Forestal Nacional Sueco (Anon. 1999)

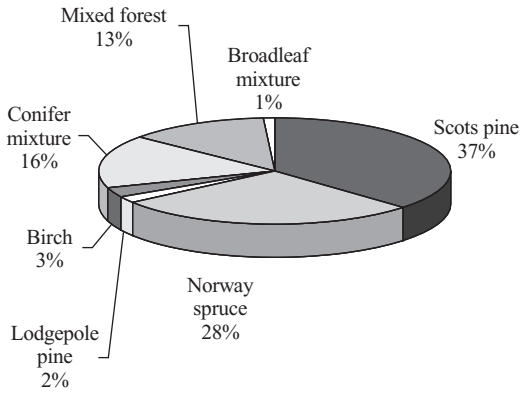

Fig. 2.–Forest area (%) by tree species in Sweden. Total forest area is 22.6 million hectares. Source: Swedish National Forest Inventory (Anon. 1999)

Superficie forestal (%) por especie arbórea en Suecia. La superficie forestal total es de 22,6 millones de ha. Fuente: Inventario Forestal Nacional Sueco (Anon. 1999)

Note:
Scots pine forests (> 70 % pine); Norway spruce forests (> 70 % spruce); lodgepole pine forests (> 70 % lodgepole pine); birch forest (> 70 % silver/downy birch); conifer mixture (> 70 % conifers); mixed forest (< 60 % conifers); broadleaf mixture (> 70 % broadleaves).

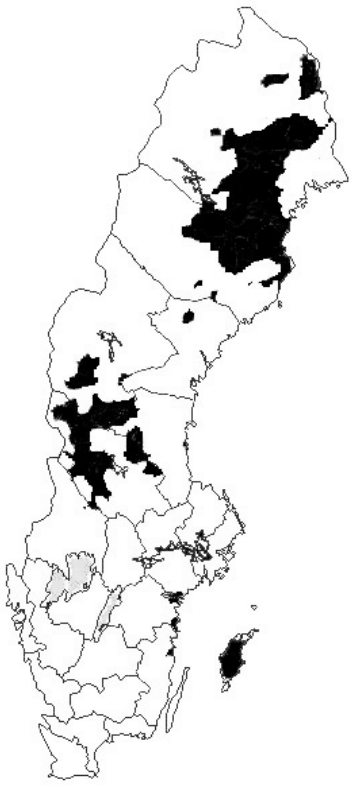

Fig. 3.–Map showing black areas where Scots pine is the dominant (> 50 % of standing volume) tree species in Sweden. Source: Swedish National Forest Inventory (Anon., 1999)
Mapa de las zonas, en negro, en donde el Pino silvestre es la especie dominante (> 50 % del volumen en pie) en Suecia. Fuente: Inventario Forestal Nacional Sueco (Anon, 1999)

MANAGEMENT GOALS

From 1950 to 1980 the overall management goal in Swedish forestry was to increase volume production to provide an expanding timber processing sector with raw material. This was particularly true for the forest companies with investments in both forests and industries. This goal was successfully met by Swedish foresters and standing volume was increased, albeit at the expense of lower biodiversity in our forests. However, since 1980 until the present day, there has been a gradual change in emphasis in forest management goals in Sweden so that the new Forestry Act has two goals, (1) forest production and (2) environment with maintenance of biodiversity as an important part. All major Swedish forest companies have signed the Swedish FSC agreement (Forest Stewardship Council) in order to certify that their timber is produced by forestry management that considers the whole forest ecosystem and the environment of surrounding ecosystems.

Approximately 70 % of the income for a forest owner come from sawtimber and 30 % from pulpwood. High quality Scots pine timber is more valuable than spruce timber (Table 1).

TABLE 1

AVERAGE SAWTIMBER AND PULPWOOD PRICES (EUR PER M^{-3}) IN SWEDEN 1999

Precios medios de la madera de sierra y pasta en Suecia en 1999 (Euros/m^3)

	Scots pine	Norway spruce
Saw timber		
Class 1	87	65
Class 2	65	56
Class 3	68	54
Class 4	57	42
Pulpwood	24	27

Therefore, the production of high-quality Scots pine timber has been and is a major goal for many of the private forest owners, who own 50 % of the forests in Sweden. A new problem that has emerged during the last decades is the increasing pressure from moose (*Alces alces*). The moose and other large herbivores have been favoured by the clear-cutting system and the low abundance of large carnivores. Particularly during winter Scots pine is heavily browsed by moose. As long as only the side branches are browsed it is not a serious problem but it is very common that the leading shoot is also damaged. This causes serious technical damages to the first log. During winter, when the young pine tree is frozen, it cracks easily as it is browsed and the risk of loosing the leader remains until the tree is more than 6 metres tall. In certain areas with a heavy browsing pressure, forest owners have used other tree species than Scots pine, mainly Norway spruce, even if the site is suitable for pine. The use of different management systems to avoid moose damage on Scots pine during winter has been discussed (Edenius, 1992).

SCOTS PINE FOREST TYPES

The majority of Scots pine forests in Sweden are natural. However, to some extent local genotypes have been replaced with genetically improved material used in artificial regeneration following clear-cutting. Scots pine in Sweden is confined to poor soils i.e. shallow soils, coarse-textured soils, and wet soils (peat). Nevertheless, Scots pine could grow on any soil but is not competitive enough on better soils where, without any disturbance, it is outcompeted by other tree species – particularly Norway spruce, but also birch and other deciduous trees.

In Sweden we use field vegetation to describe our forest types according to a system developed by Lundmark (1974).

On the poorest type – **lichen type** – Scots pine remains the dominant species even without the influence of the natural disturbance agent, which is fire. Naturally these sites were often disturbed by fire (Zackrisson, 1977). This type covers large areas in northern Sweden – predominantly on alluvial sandy sediments along the major rivers – on shallow soils and on soils with poor mineralogy such as our porphyric soils in the western part of central Sweden. The high fire frequency on these sites resulted in less intensive fires and a large number of Scots pine trees probably survived. This resulted in stands with a wide diameter and age distribution.

On slightly better sites – ***Vaccinium vitis-idaea*** type – Scots pine may dominate for a long time after a major disturbance but Norway spruce comes in from below. Eventually, without any disturbance, the pine may be succeeded by spruce. Other tree species that may occur in mixture with pine are aspen (*Populus tremula*) and silver birch (*Betula pendula*).

The ***Vaccinium myrtillus*** type could be dominated by Scots pine after a major disturbance but usually pine occurs in mixture with spruce and/or birch, predominantly silver birch but also downy birch, (*B. pubescens*) and aspen. Without any disturbance spruce tends to become the dominant component of the stand.

Scots pine may also dominate on wet sites like ***Vaccinium uliginosum – Ledum palustre type,*** often in mixture with spruce and birch (predominantly downy birch).

NATURAL SUCCESSION

Early natural successional stages of Scots pine often include a number of large pines that survived a forest fire and a fairly large quantity of dead (burnt) wood besides the young trees. These stands can develop into a two- or multi-storied forest. The fire may have favoured other pioneer species like birch, aspen and goat willow (*Salix caprea*) on sites more fertile than the lichen type. They could have outgrown the pine in some areas or occurred in mixture with pine. Intense forest fires may occasionally have killed all or most of the trees resulting in a single storied forest. At a later stage on the more fertile sites, secondary species such as Norway spruce colonise the understorey resulting in a multi-storied stand with scattered old large pine trees. Eventually those old pines die resulting in an almost pure Norway spruce stand unless there is a new forest fire to force the system back to the beginning again.

Fossil pollen data in southern Sweden indicate that a «rich mixed *Pinus* forest» with *Betula, Tilia, Quercus* and *Alnus* species in mixture with pine (Björse and Bradshaw, 1998) existed 1000-2000 years ago, mainly in the dry eastern part of southern Sweden. This is a region that also has a high lightening frequency. Whether these forests vanished due to human activity or due to climate change is difficult to tell.

SILVICULTURAL PRACTICE

Silvicultural practice in Sweden from 1950-1980 focused on volume production. Silviculture was based on clear-cutting on large areas followed by artificial regeneration – predominantly with mechanical site preparation and planting. However, on poor pine sites (lichen type – *Vaccinium vitis-idea* type) the use of natural regeneration was often favoured. During most of this period only Scots pine and Norway spruce were considered as valuable trees in the boreal forest and competing deciduous trees were sprayed with herbicides or cut down in pre-commercial and subsequent thinnings. Pine was the preferred species in northern Sweden and pine was planted outside its natural range on more fertile sites at the expense of spruce. In southern Sweden it was the opposite, and spruce was planted on pine sites. During thinning, single storied monocultures were developed by cutting from below and from above. Those unnatural stands are now a part of our forest landscape.

Beginning in the 1980's, silviculture has become more site-adapted with pine planted on poor soils, spruce on better soils and mixtures on intermediate sites. A market has been developed for deciduous trees both as saw timber and in the pulp and paper industry. However, in some areas, browsing pressure is a problem for successful establishment of deciduous trees and Scots pine. Scots pine is mainly managed under a clear-cutting system with two means of regeneration – either natural regeneration using seed-trees or planting. The use of natural regeneration has increased in Sweden at the expense of planting so that today natural regeneration is practised on 40 % of the annual regeneration area, predominantly on Scots pine sites (Fig. 4).

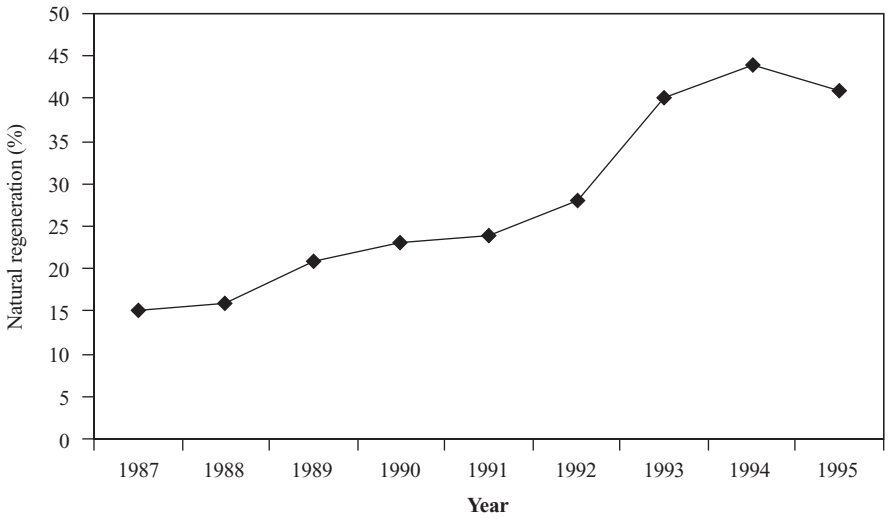

Fig. 4.–Natural regeneration in percent of total regeneration area in Sweden 1987-1995. Source: Swedish National Forest Inventory (Anon. 1999)

Regeneración natural, en porcentaje respecto de la superficie total de regeneración, en Suecia durante 1987-1995.
Fuente: Inventario Forestal Nacional Sueco (Anon. 1999)

Achieving successful natural regeneration with seed-trees often requires some mechanical site preparation, particularly on more fertile sites. Scarifying is the most common practice even though it is not an optimal site preparation for seed germination (cf. Bergsten, 1988; Winsa, 1995). The recommended number of seed-trees is from 75 to 150 per hectare, with the highest number in southern Sweden indicating that the seed-trees also have a function as shelter. It is also evident that advance growth is an important part of the regeneration under seed-trees (Sundkvist, 1993).

Planting operations usually starts with mechanical site preparation during the first or second growing season after felling with scarifying and mounding as the most common techniques. Thereafter, 2000 to 2500 containerised seedlings per hectare are planted manually. Once establishment has been achieved, the main stand tending measures during a rotation period of 80-130 yrs are pre-commercial thinning and one to three thinnings. About 30 % of the basal area is removed in thinnings and the trend is towards thinning from above i.e. primarily cutting the dominant trees. Fertilisation with N, P and K has been an important part of Scots pine silviculture but is now restricted due to the requirements of certification.

SILVICULTURE AND WOOD FUEL

A possible future change in forest management involves a «new» assortment – wood fuel. Together with other countries Sweden has signed the Kyoto protocol with the intention of decreasing the CO_2-emissions. Biofuels are already important in Sweden providing 20 % of our energy supply (90 TWh) (Anon., 1998). A major part of this bioenergy originates from residues from our forest industries e.g. black liquor, bark and sawdust and this source of residues is now fully utilised. Thus, the only way to increase the use of wood fuels in Sweden is to include logging residues – which has already started with the highest intensity in southern Sweden – and to change our silvicultural systems to increase biomass production.

By increasing the stocking density during early stand establishment biomass production is increased. For Scots pine this may result in dense stands (pure or mixed), either naturally regenerated or directly seeded, where biomass production is maximised at the same time as certain criteria for timber quality is favoured. Thus, there is a possibility that we may see more dense young Scots pine stands in the future. This potential development is not possible unless flexible harvesting techniques are developed that can handle small stems in an efficient and economically sound way.

SILVICULTURE AFTER CERTIFICATION

The current Forestry Act emphasises both production and environmental goals, with sustainable use of our forests as a guiding principle. Swedish forestry is also concerned to have a good reputation on the international market and the major forest companies have signed an agreement with FSC (Forest Stewardship Council) in order to certify that pro-

duction of their raw material meets the required international standards. The FSC-agreement now covers 9 million hectares of forests in Sweden. Private forest owners, who own 50 % of our forests, are following a similar path with agreements adapted to the needs of small forest owners. These new agreements are now shaping the future of forestry in Sweden. Among others aspects the FSC agreement includes the following environment and biodiversity standards:

- At least 5 % of the productive forest area is exempted from management other than the measures required to preserve and support the natural biological diversity of the habitat.
- Soil scarification is to be limited to sites where this measure is required to achieve good regeneration.
- Owners of larger landholdings are to take all reasonable measures to burn an area corresponding to at least 5 % of the regeneration area of dry and mesic areas during a 5-year period. «Larger landholdings» are not defined in the standards but they are written for large forest companies with landholdings of hundreds of thousand hectares.
- Natural regeneration, for example under shelterwood and seed tree systems, is used where this method will result in good regeneration of species of tree adapted to the site and to management goals.
- Trees with high biodiversity value should be protected in all measures, and not felled. Cleaning and thinning are carried out in a way that protects, to a reasonable extent, potentially high biodiversity value trees.
- When felling for regeneration, enough wind-resistant trees of various species with good chances of developing into large, old trees during the next rotation period should be left, with the aim of incorporating at least 10 such trees per hectare into the next forest generation.
- Dead wood, except for small felling residues, is to be protected from forest management unless there is a documented risk of the mass reproduction of insect pests.
- Standing dead wood, such as high stumps of common deciduous and coniferous trees should be created during thinning and regeneration fellings.
- The origin of seedlings and seeds is to be documented. Provenances adapted to the site are to be used within the framework of the National Board of Forestry regulations and general guidelines.
- If their natural presence allows, broadleaved trees are to be protected when cleaning and thinning so that they make up at least 5-20 % of the stand, including the immediately surrounding area (depending on region, soil conditions, site quality and the total proportion of broadleaved trees on the forest holding).

The impact of these new forestry standards is just beginning to be felt. They will be of most benefit to biodiversity, probably at the expense of lower volume production – but, if these measures improve timber quality and create more diverse and interesting forests, the combined benefit from this new forestry may be equal or higher than that from its predecessor. From a biodiversity point of view – based on the habitat requirements of the forest species on the Swedish red data list – the most important changes are the increase in the number of mature trees, in amounts of dead wood (burnt wood), in deciduous trees, and in mixed species stands. By using natural regeneration in combination with prescribed burning, silvicultural practice is getting closer to emulating the disturbance pat-

terns in natural forests. This will be particularly true if some trees are left before prescribed burning to provide burnt and dead wood and if some of the surviving seed trees are retained as well.

Many of these new measures to enhance biodiversity will lead to the development of new stand types, for instance mixed species stands with some scattered large and old trees. There is limited knowledge on how these stands are to be managed and how beneficial they may be for biodiversity. Thus, there is a challenge for foresters and forest researchers to develop appropriate guidelines.

CONCLUSIONS

Management of Scots pine forests in Sweden, as well as of other forest types, has been rather uniform for a long time with volume production as the major goal. Major changes in silvicultural practices, based on best available knowledge, are being implemented at the present time in order to favour the environment and biodiversity in particular. Whether these changes will have a positive effect on biodiversity and what their effects will be on the forest economy remains to be seen. Such evaluations will be a major research field in Sweden.

RESUMEN

Silvicultura y gestión de Pino silvestre en Suecia

Este trabajo presenta información sobre las tendencias selvícolas en Suecia, siendo el enfoque principal la gestión de las masas de Pino silvestre y las medidas propuestas para incrementar la biodiversidad. Durante las últimas décadas ha habido un cambio desde la selvicultura orientada a la producción de volumen hacia una selvicultura basada en la producción y el ambiente, con un énfasis especial en la biodiversidad. La actual Ley forestal sueca tiene dos objetivos iguales: (i) producción forestal y (ii) ambiental manteniendo la biodiversidad. Las principales compañías forestales suecas y otros propietarios forestales están firmando acuerdos para alcanzar los requisitos de certificación y mostrar que su gestión de los montes considera la sostenibilidad del ecosistema forestal en su conjunto y el ambiente que rodea a los ecosistemas. Aunque el Pino silvestre todavía se trata por cortas a hecho, estos desarrollos cambiarán los bosques suecos de Pino silvestre de unas masas de monocultivo regulares, y uniformes hacia rodales con más mezclas de especies y de varios estratos. Las quemas prescritas se practicarán en las masas de Pino silvestre como una medida de preparación del terreno, que también aumenta la biodiversidad. De esta forma la selvicultura imita al principal agente perturbador en suecia boreal, el incendio forestal. Las medidas para aumentar la biodiversidad se basan en el mejor conocimiento disponible, pero el efecto de estas medidas sobre la biodiversidad y la producción forestal se desconocen. Otra incertidumbre es como estos nuevos rodales pueden gestionarse de una manera eficiente.

PALABRAS CLAVE: *Pinus sylvestris*
Selvicultura sostenible
Bosque boreal

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