Impact of Fire on Finnish Forests in the Past and Today

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Nearly every forest stand in Finland has been burnt down by a wildfire at least once during the past 400–500 years. Slash and burn cultivation (1700–1920) was practised on 50–75 percent of Finland's forests, while prescribed burning (1920–1990) has been applied to 2–3 percent of the country's forests. Because of land-use changes and efficient fire prevention and control systems, the occurrence of wildfires in Finland has decreased considerably during the past few decades. Owing to the biodiversity and ecologically favourable influence of fire, the current tendency is to revive the use of controlled fire in forestry in Finland. Prescribed burning is used in forest regeneration and endeavours are being made to revert old conservation forests to the starting point of succession through forest fires.

Keywords forest biodiversity, wildfires, slash and burn cultivation, prescribed burning
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1 Introduction

Biodiversity is presently the leading concept in forestry by developing forest silvicultural practices in boreal zones. This includes the dual objectives of protecting the rare and vulnerable forest ecosystems and practising the silviculture with more nature oriented principles. Silviculture is expected to follow methods that mimic natural events. Stand structures of production forests should manifest specific features of natural forests like the quantity of standing or fallen dead trees and the presence of broad-leaved species and charred wood.

In the case of Finland, for example, the way in which silvicultural measures are applied is steered by historical developments and human impact on forests (e.g. slash and burn cultivation and diameter based selection cuttings) and from the viewpoint of natural forests, by forest fires and other natural catastrophes. Wildfires have been a fundamental element of the natural development of Finnish forests, but the most important impact that fire has had on forests involved the partnership of man. This review summarizes the impact of fire on Finnish forests and evaluates the possibilities and needs for reviving fire management in silvicultural practices.

2 Wildfires

Hundreds of years ago, the forests of Finland were untouched wilderness areas. In addition to fires lit by lightning, fires were also lit by hunters. However, hunters would roam hundreds of kilometres beyond the outermost settlements. Occasionally they would start off forest fires deliberately, but mostly by accident. Negligence in putting out campfires was probably the main cause behind fires.

At times forest would be burnt purposely to attract moose into the smoke away from the insect pests. Hunters were then in a good position to slay them. Forests were also burnt with the purpose of providing better feeding grounds for moose (Kardell 1984).

The oldest statistics in Finland on the numbers of forest fires and on the areas swept over by them go back some 130 years (Saari 1923). While wildfires were very common on crown land in the 19th century, the areas affected were relatively small. Some 50 000–70 000 hectares were burnt down in the worst years 1868, 1888 and 1894. A hundred years ago, there were 150–200 forest fires each summer (Table 1, Fig 1).

The small area burnt in individual fires is explained by the weather conditions and the mosaic-like structure of Finnish woodlands, the alternation of dry heathland forests and wetland sites. One third of Finnish forests grow on peatland sites. Although hundreds of thousands of hectares of forest may have been burnt by fire during hot and dry summers, with suitable assistance from wind, Finland has not been afflicted by fire catastrophes to the extent of more continental boreal regions like Siberia or China.

Research results obtained in northern Sweden indicate that wildfires on dry sand and gravel soils ignited in natural conditions by lightning have reoccurred at an average interval of 50 years (Zackrisson 1977). On moist moraine soils this interval has been 120 years. South-facing

Table 1. Occurrence of wildfires on crown land in Finland during the period 1865–1920.

Period	Annually burnt Total, hectares	Number of fires in average/year	Average size hectares
1865–1870	13764	105	131
1871–1880	8507	134	63
1881–1890	8707	127	69
1891–1900	9335	121	77
1901–1910	3407	87	39
1911–1920	3560	127	28

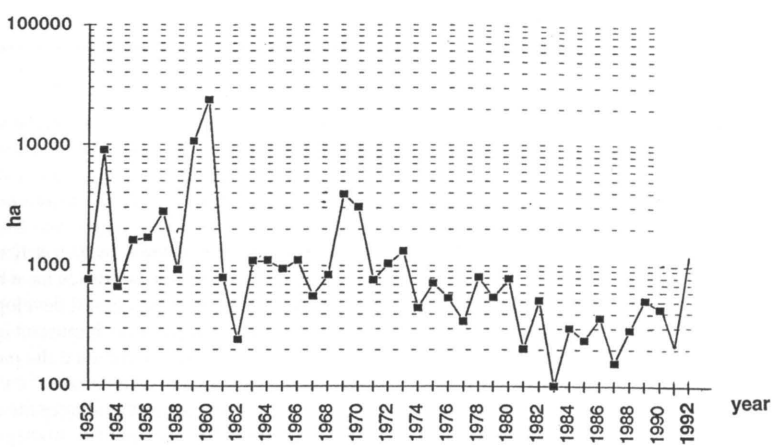

Fig. 1. The annual forest area burnt by wildfires in Finland during the period 1952–1992.

slopes have been more prone to wildfires than north-facing slopes; similarly, hill tops were sensitive to fire damage whereas valleys were not. Similar figures for fire intervals has been obtained troughout lake sediment analyses also in Southern Finland (Tolonen 1983). The interval between wildfires has shortened towards our time from 4000–3000 years b. Ch. With forest fire statistics and the average interval between fires as the basis, it can be estimated that Finnish forest land has been burnt down at least once during the past 400–500 years.

The annual number of fires, several hundred (400–500), has remained constant during the last decades because of efficient fire prevention. Today, the average area afflicted is a mere 0.5 hectares (Fig. 1) whereas a hundred years ago it was between 60–80 hectares. The total area burnt during the past 40 years amounts to approx. 80 000 hectares (Metsätilastollinen Vuosikirja 1993–94).

Spruce *(Picea abies)* is usually killed by fires. While old, thick-barked pine *(Pinus silvestris)* will usually survive, the butt will often become scarred in places where the cambium under the bark is killed by the fire. Silver birch *(Betula pendula)* is another species that has developed a degree of fire resistibility. Pioneer tree species (birch, aspen, alder and pine) are the first to reclaim burnt, treeless sites. The young forest is dominated by broadleaves of both coppice and seed origin. Gradually, the short-lived light-demanding pioneer species begin to give up and pine begins to take over. Later on, the sites begin to have an increasing proportion of spruce and in the climax stage stands will be composed almost entirely of spruce. The species composition in the climax stand depends on site quality. On dry sites, pine will be the dominant species, but as the site becomes more moist, spruce takes over (Kalela 1945, 1948, Kuusela 1990, Schmidt-Vogt 1991).

The fire has a vital importance in maintaining the nutrient cycle, biological productivity, and biodiversity. In a climax stage forest the nutrients are bound up in the growing stock and in the underlying raw-humus layer. Only a few percent of the total nutrients are actually involved in the cycle between the trees and the soil. The raw-humus layer of an old stand of spruce, for example, will contain 1500 kg/ha of nitrogen in an unavailable form. At the same time, a mere 20 kg/ha of nitrogen is actually cycling between the trees and the soil (Kellomäki 1987).

3 Slash and Burn Cultivation

Although wildfires belong to the natural succession of boreal forests, the most important impact that fire had on forests in the 18th and 19th centuries in Finland involved the partnership of man. The rural populations of those times relied on the practice of slash and burn cultivation for their livelihood.

The two principal forms of slash and burn cultivation were practised (Vilkuna and Mäkinen 1988):

1) The first phase was to burn down the more fertile forests dominated by broadleaves nearby the villages. This technique was called "lehtipuukaski". The swidden areas close to settlements were subjected to turnip, barley and rye shifting cultivation. The fallowing period between the crops in turnip, barley and rye cultivation was 8–30 years depending on the development of the secondary forest.

   A fresh opening would be made in a grey alder wood or a mixed wood that had established by natural regeneration in the area. Fast-growing tree species did not take long to build up a sufficient amount of combustible woody material. Plots would be cropped for 1–2 years and then they would be left fallow and allowed to revert to forest.

2) In the 16th century, slash and burn cultivation began to be practised in middle and eastern Finland with a technique to cut down and burn mature stand of spruce sometimes very far from the settlements. This technique was called "huuhtakaski". The new technique led to the spreading out of human settlement throughout the country.

   The basic idea for this technique was the killing of standing trees by ring-barking. (pykälikkömenetelmä). The ring-barking of old, mature trees – perhaps as many as 300 trees per hectare, was a preparatory stage. The drying-up of the trees and

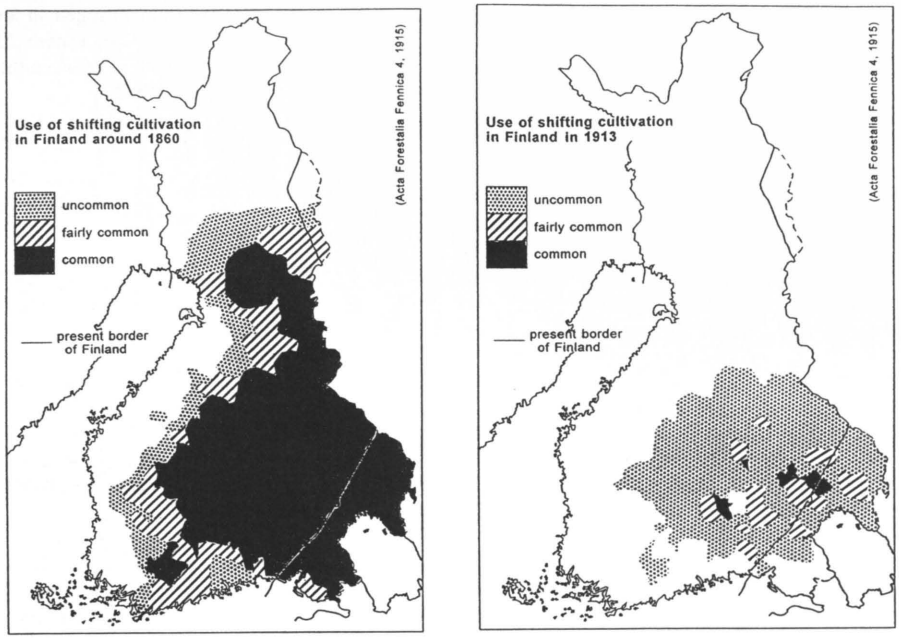

Fig. 2. The relative application of slash and burn cultivation in different localities of Finland during the years 1860 (3a) and 1913 (3b).

their roots made the raw-humus layer more porous, which in turn improved the burning. A drying period of 10–15 years was followed by the burning. Not all of the ring-barked trees were necessarily cut down. Rye was sown in the ash.

During the intervals between consecutive swidden operations, the plots of land would often serve as forest pastures. Grazing of farm animals hindered the forestation as mere grass was not adequate to satisfy the nutritional requirements of the farm stock. The cows and horses would eat tree seedlings and lower branches and consequently swidden areas would develop into patchy forests (Heikinheimo 1915). These areas would also be accessed for winter fodder for the cattle and horses and conifer branches as bedding. Collecting of conifer branches tended to reduce the survival of spruce. Fields and meadows had to be fenced and this consumed a lot of sapling and thus influenced the species composition of swidden areas (Helander 1949, Linkola 1987).

Heikinheimo's studies (1915) revealed that slash and burn cultivation in Finland was practised over more than 4 million hectares per year (Fig. 2). By the beginning of this century, some 50–75 percent of Finland's forest area had been exploited in this manner. In the eastern part of Finland shifting cultivation was practised longer and more intensively than anywhere else in the country.

Slash and burn cultivation gave rise to conflicting opinions. It was necessity for the livelihood of the rural population. Nevertheless, the government authorities were worried because of it. On the other hand, already in the 19th century it was feared that loss of forest cover because of shifting cultivation would lead to a cooling of the climate and to Finland becoming unsuitable for human settlement (Leikola 1988). Another, more urgent cause for concern involved the rising economic significance of the forests. Sawtimber and timber for mining were becoming

increasingly important. Concern over the loss of the country's forest resources culminated in the inviting of a German forestry expert, E. von Berg, in 1858 to come and report on the state of Finland's forests. The report gave a very gloomy view of the forests in areas of intensive shifting cultivation. Moreover, tar distillation, a practice that destroyed the best trees, had created large areas of dismal landscape, especially in western Finland. The forests in the vicinity of villages were all-aged woods of pine, hardwoods and mixed species. Slash and burn cultivation had already made it difficult to find firewood or timber for building and construction near villages (von Berg 1859).

Legislation was passed in an endeavour to safeguard timber for industrial needs. A bill passed in 1734 made it compulsory for farmers to have a licence before they could burn over forest. But it was not until the end of the century that this regulation began to have a real effect in heartland of shifting cultivation. The Private Forest Act of 1929 still permitted the practice of slash and burn, but only in places where it could be defended as being a sensible practice.

In addition to influencing the availability of timber, slash and burn cultivation had a major influence on the landscape, the cycling of soil nutrients and regional biodiversity (Linkola 1987). It also influenced the nutritional status of inland waters and the species composition of the forests.

The results of the first national forest inventory, conducted in 1921–1923, showed that 50–60 percent of the forest land in south-eastern Finland was covered by woodlands less than 40 years of age (Ilvessalo 1927). Broad-leaved species accounted for nearly half of the forest area with the share of spruce being only 12–15 per cent. The most recent inventory conducted in the same part of the country, and completed in 1988, revealed that spruce and pine amount to 40 percent each with broadleaves making up the remaining 20 per cent (Metsätilastollinen vuosikirja 1993–94).

4 Prescribed Burning

With the ending of the era of slash and burn cultivation in the early part of this century, methods derived from this practice began to find use in the regeneration of under-productive forests. Burning of logging waste and raw humus layer was recommended as a means of promoting the natural regeneration. Broadcast-seeding-on-snow in spring, with prescribed burning preceding it, found widespread use in the 1920s. Prescribed burning in those times amounted to approx. 8000 hectares per year (Fig. 3). With time, however, this method's popularity declined; in the 1930s, the annual area burnt over in this manner was only a few hundred hectares a year (Kulotus-

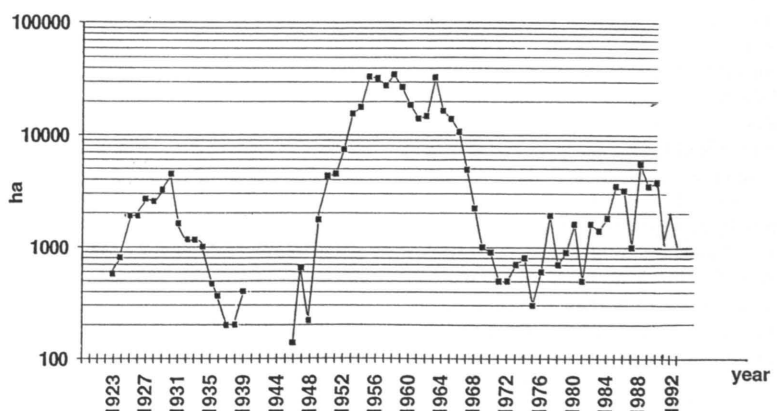

Fig. 3. Annual areas treated with prescribed burning in Finland during the period 1920–1992.

toimikunnan mietintö 1980).

Prescribed burning enjoyed a comeback after World War II and the peak of over 30 000 hectares was reached in the mid-1950s. This method was used especially for the regeneration of northern Finland's spruce stands characterised by thick raw humus layer. However, this prescribed burning's second coming came to an end in the latter half of the 1960s when it was replaced by mechanized site preparation. The annual area of prescribed burning stayed at 500–1000 hectares a year up to the recent past.

The reasons for the decline in prescribed burning are technical. The burning depends on weather conditions and this leads to difficulties in organising the operation. The risk of fire getting out of control, the risk of nutrients being leached from the soil, and the increased risk for fungal or insect epidemics in the dense young pine stands are the most common forest regeneration problems associated with prescribed burning.

Prescribed burning has many advantageous influences on the physical, chemical and biological properties of the soil. These effects depend on site fertility and the intensity of the fire (Mälkönen 1993). Prescribed burning is recommended on moist and dryish mineral soils with sufficient stores of soil water. On more fertile sites, prescribed burning can reduce the availability of phosphorus. The nitrogen released from burning organic matter is lost entirely into the atmosphere and consequently the stores of nitrogen in the forest are reduced. This loss of nitrogen is not, however, fatal for the development of new forest growth, because only a small proportion of the nitrogen stored in forest soils is in a mineralised form. Prescribed may rise by 1–2 units of the pH of the humus layer and stay there for several decades. The rise in pH in the uppermost mineral soil layer has been modest.

Artificially regenerated forests by planting or seeding in Finland currently amount to slightly more than 5 million hectares. Since the total productive forest area is approx. 20 million hectares, artificially regenerated forests represent 25 percent of the whole (Parviainen 1994). Following soil scarification, regeneration sites produce an abundance of naturally arisen conifer and hardwood seedlings, and these develop into mixed woods (Parviainen 1988). Over a period of 80–90 years, prescribed burning has been applied on a total of 0.5 million hectares. This corresponds to 12 percent of Finland's artificially regenerated forests and 2–3 percent of the total forest area.

5 Conclusions

Nearly every forest stand in Finland has been burnt down by wildfires at least once during the past 400–500 years. Slash and burn cultivation (1700–1920) was practised in 50–75 percent of Finland's forests while prescribed burning (1920–1990) has been applied to 2–3 percent of the country's forests.

Since wildfires, a fundamental element of the natural development of boreal forests, have been subdued, forest structure and biological diversity in production forest will change unless fire or its substitutes are implemented as silvicultural measures. The only way to ensure the existence of organisms reliant on charred wood is to increase the use of prescribed burning in forest regeneration (Annila 1993). The long-term maintaining of forest biodiversity, productivity and the nutrient cycle inevitably mean that the natural cycle should be simulated by creating an open stage with a proportion of decaying woody material. This can be simulated through small-scale regeneration cutting areas, untouched small keybiotopes, by favouring broadleaves, and by speeding up the soil's nutrient cycle through light site preparation techniques or prescribed burning (Parviainen and Seppänen 1994).

One element of the variation in the biodiversity of Finnish forests lies in the country's remaining natural forests (approx. 10 percent of the area of forest land). Untouched forests are needed to be set aside as national parks and nature reserves representing different site types and regions. In order that forest environment might be enriched with the various successional stages, conservation areas should be extended to include pristine forests of all ages. In fact, there is a need to burn areas of standing forest here and there, and thus create natural forests in their early stages of development.

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