Prescribed Burning in Norway--Effects on Soil and Regeneration

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BURNING IN NORWAY EARLIER AND AT PRESENT

THREE to four hundred years ago burning was used extensively in South-East Norway as a means to clear forest to prepare for sowing of grain in the ash. After a few years with grain (rye, barley or wheat) the area was left for forestry because the nutrients released by burning were utilized or leached from the soil. The forests that gradually occupied the abandoned areas, usually a mixture of conifers and broadleaved trees, were often dominated by birch. This procedure was used over greater parts of Scandinavia for a long time. Gradually it died out, and in the middle of the nineteenth century this type of burning ceased to exist in Norway.

To day, in Norway, we think of prescribed burning as a tool to ease the regenerating procedure on areas where timber is harvested. Burning in this respect was carried out to a small degree in the years before the last world war. In the 1950's the use of burning rose to its maximum when about 1500 hectars were burned annually. The total area of regeneration was between 40 and 50,000 hectars which means that 3 to 4 percent of the area for regeneration was burned. Rules and recommendations for prescribed burning were prepared by Strømsøe (1957).

At first, burning was carried out to prepare the ground for natural regeneration with seed trees left over the area, mostly of pine.

After the second world war, burning was to some extent also used in connection with artificial regeneration, sowing of Scots pine (*Pinus sylvestris*) and planting of Norway Spruce (*Picea abies*). However, prescribed burning in Norway is often difficult. Conditions for burning are not always good. Summers are often wet and weather is changeable. Also, better equipment is now available for preparing the soil by scarifying. Consequently, scarification is now often used for natural regeneration with seed trees, for sowing and even for planting. For these reasons and because the cost of burning has risen considerably owing to increasing labor costs, there has been no prescribed burning performed in Norway in the last 3–4 years.

PRESCRIBED BURNING EXPERIMENT

However, when The Department of Regeneration at the Norwegian Forest Research Institute came into operation in 1957 it was found that the effect of burning was an important research subject, and a project was started in 1958. The results from this research project form the main basis of my paper to be presented here to-day. Skoklefald (1973) has prepared a publication which is presently in printing.

The project was a rather small one with field experiments at four localities. Prescribed burning was carried out on a practical scale on areas clear cut 1 or 2 years before. Small plots for parallel studies on unburned sites were protected from burning. The aim of the study was to gather information about the effect of burning on different types of humus as regards the amounts of organic matter, nitrogen and mineral nutrients. In addition, the establishment and height growth of spruce and pine seedlings were to be followed.

Thickness and other properties of humus are very decisive for success of regeneration, especially for the germination of naturally fallen seed and for the establishment of the seedlings. Roots of seedlings need to penetrate quickly through the humus layer down to mineral soil which has a more stable moisture content. A rather thick

and less humified humus is common in coniferous forests of Norway. Plot locations ranged from 60° to 61°40¹ north. This is in southern Norway, where Oslo is situated at the 60th parallel. The mean summer temperature (June-September) varies from 10.5°C to 12.6°C centigrade (Table 1).

Figure 1 is a sketch of the layout of the experiment, showing the four replications at each locality.

TABLE 1. LOCATION AND TYPES OF RESEARCH AREAS

	N. Lat	Elevation m	Tm C°	Veg-Type
Lebiko	60° 09¹	355	12.6	Oxalis-Myrtillus
Setertjern	60° 35¹	520	11.3	Myrtillus
Fiskvik	60° 37¹	560	10.5	Calluna

Tm: Mean temperature June-Sept (1931–1960).

EFFECT OF BURNING ON ORGANIC MATTER

Humus samples for various types of analyses were taken by a 0.5 sq dm borer just after burning in Spring 1958 and every fall thereafter for 5 years. Finally samples were taken after 8 and 12 years. As an increased variation of humus thickness and content of nutrient was expected after burning, twice the number of samples were taken on the burned parts of the strips compared with the unburned ones.

Figure 2 shows the burning on *Calluna* type. Figure 3 shows the amount of organic matter in tons per hectare on unburned and burned areas, split on litter layer (A_{oo}) and humus layer (A_o). In comparison to the total weight of organic matter on unburned sites at the time of plot layout, the burning caused an immediate reduction equal to at least 11 tons per hectare. The weight of the litter layer decreased by 27 percent and that of the humus layer by about 18 percent.

In the years following burning, loss of weight continued particularly in the litter layer, which in the course of 8 years was reduced by about 65 percent. Also, clear cutting without burning caused a

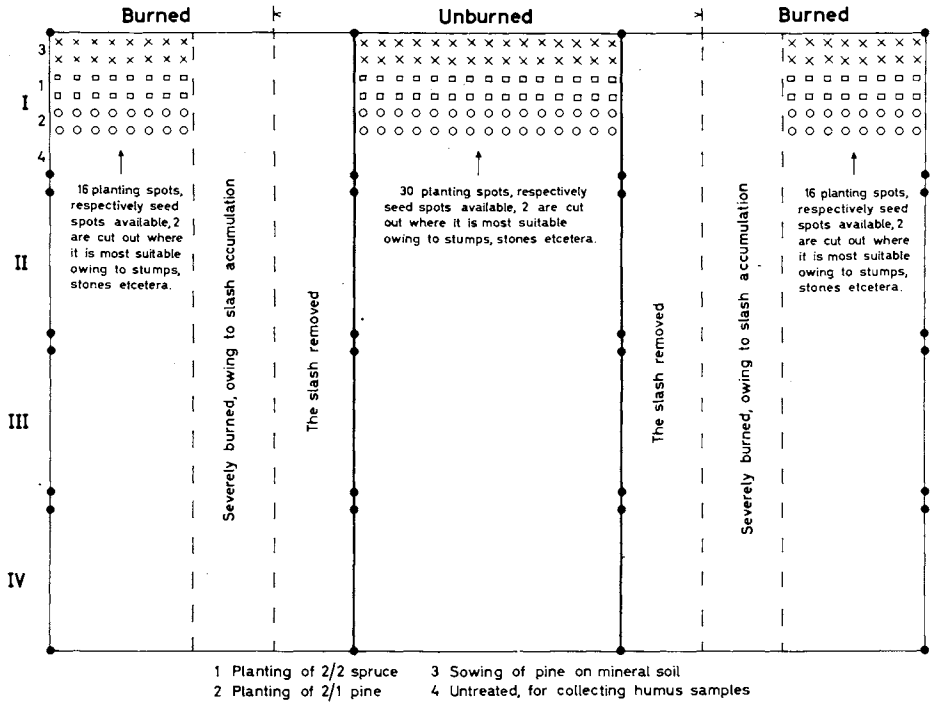

FIG. 1. Sketch of layout.

considerable loss of organic matter in the litter layer. In this case, in the course of 8 years, a loss of weight equal to more than 50 percent could be registered.

The previous comparisons are based on averages of all four localities.

EFFECT OF BURNING ON NUTRIENT ELEMENTS

The amount of nitrogen in kilos per hectare is shown on the other half of Figure 3. The total loss of nitrogen from the litter and humus layer in the year of burning was estimated at between 160 and 170 kilos per hectare. Besides, it was ascertained that changes in the

FIG. 2. Burning on *Calluna* type.

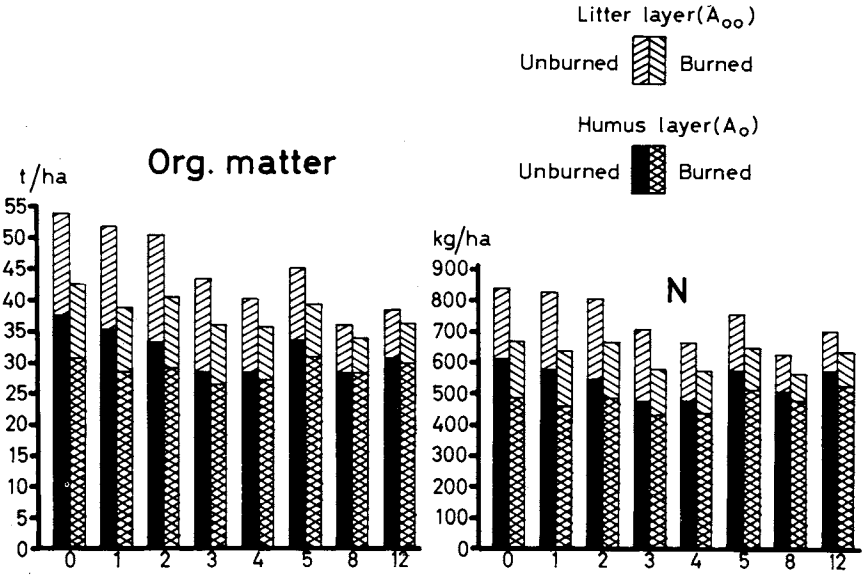

FIG. 3. Weight of organic matter and of total nitrogen in litter layer and humus layer.

amount of nitrogen were closely related to changes in the content organic matter, so that the weight of nitrogen continued decreasing as more organic matter was decomposed. Accordingly, clear cutting without a subsequent burning also lead to a considerable reduction in the total supply of nitrogen.

Without giving figures or going into details it can be briefly mentioned that calcium also increased after burning, especially in the litter layer. However, the increase was relatively small, compared with investigations in Sweden and Finland. This probably resulted from the rather low amount of debris burned in this project.

Analyses were done on potassium (K), phosphorus (P), magnesium (Mg) and manganese (Mn). A heavy reduction in potassium was registered both on burned and unburned sites after 3 years. From then on, the content of potassium changed only to a small degree.

The results indicate that the processes of mineralization induced by clear cutting or by burning may in a short time lead to a considerable loss of potassium from the humus layer. However, according to Viro (1969) the greater part of this loss is fixed in the mineral soil underneath.

CHANGE IN pH VALUE

The burning caused a rather pronounced increase in the pH value, especially in the litter layer. The first fall, pH on burned sites reached the value of 6.0 as compared to 4.7 on unburned sites. (Fig. 4). An increase in the pH value also occurred in the humus layer, but the effect was less pronounced. After 8 years only little of the effect on pH value was left.

GERMINATION AND ESTABLISHMENT BY SOWING

Sowing of pine in scarified plots gave far better results on burned areas than unburned. After 2 years, 89 percent of the plots had seedlings on burned sites against 49 percent on unburned. After 8 years the percentages were 79 and 46. On burned sites there were considerably more seedlings per scarified plot than on the unburned ones.

According to Huss and Sinko (1969) this positive effect of burn-

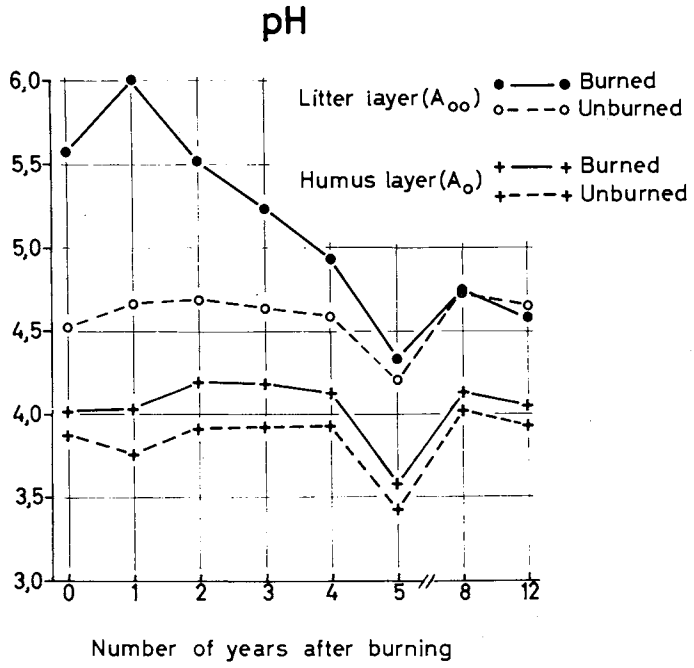

FIG. 4. Acidity in litter layer and humus layer.

ing on germination and establishment of pine seedlings seems mainly to be limited to the year of burning. However, the reason for these results is not fully clear. Among other factors it may depend on a reduced population of seedeating mammals or insects.

SURVIVAL AFTER PLANTING

Planting of 4-year old Norway spruce (*Picea abies*) and 2-year old pine seedlings (*Pinus sylvestris*) may be considered as the main item of the experiment. Percentage of survival, at two localities were greatly disturbed by a beetle (*Hylobius abietis*) and by a fungus (*Phacidium infestans*). At one locality only a few seedlings were left and this locality is omitted in the following averages.

For the three remaining localities the average percentage of survival after 12 years for pine was 58 on burned and 42 on unburned areas. For spruce it was 83 and 78. There may be two reasons for the higher rate of establishment on burned areas. Firstly, competition from vegetation for water and nutrients was very limited on burned areas for some years, and secondly, amount of nutrients available was greater after burning.

Because of the rather limited number of seedlings planted (896 of each of the two species) and the interference by the beetle and fungus, not too decisive conclusions should be drawn with regard to establishments and survival of seedlings. The tendency, however, for slightly better survival on burned areas is also found in other experiments if untouched by insects and fungi (Tiren 1958). On the other hand, there is often a tendency that insects and fungi, when they occur, do destroy more seedlings on burned than on unburned sites.

HEIGHT GROWTH OF SEEDLINGS

Figures 5, 6 and 7 show mean height development for the three localities, Lebiko, Setertjern and Fiskvik. As indicated in Table 1 the three localities are on *Oxalis Myrtillus* type, *Myrtillus* type and *Calluna* type.

On the two best types, at Lebiko and Setertjern, the height increment was greater during the first 4 years on burned areas, the difference in height at the 4th year varying between 7 and 13 cm. This is the case for planted seedlings both of pine and spruce and for the seedlings after sowing pine. After the first 4 years, however, the height increment on unburned areas was slightly higher than on burned areas, and 7 to 9 years after burning, the seedlings on unburned areas took over as leading in height. This was the case on the two first localities where the heights on unburned areas on average were 27 and 11 cm greater on unburned areas after 12 years. These differences are expected to increase in the years to come as the length of the leaders at 12 years were greater on unburned areas. Similar trends in height development have been noticed earlier by Holmgren (1958) and Uggla (1967).

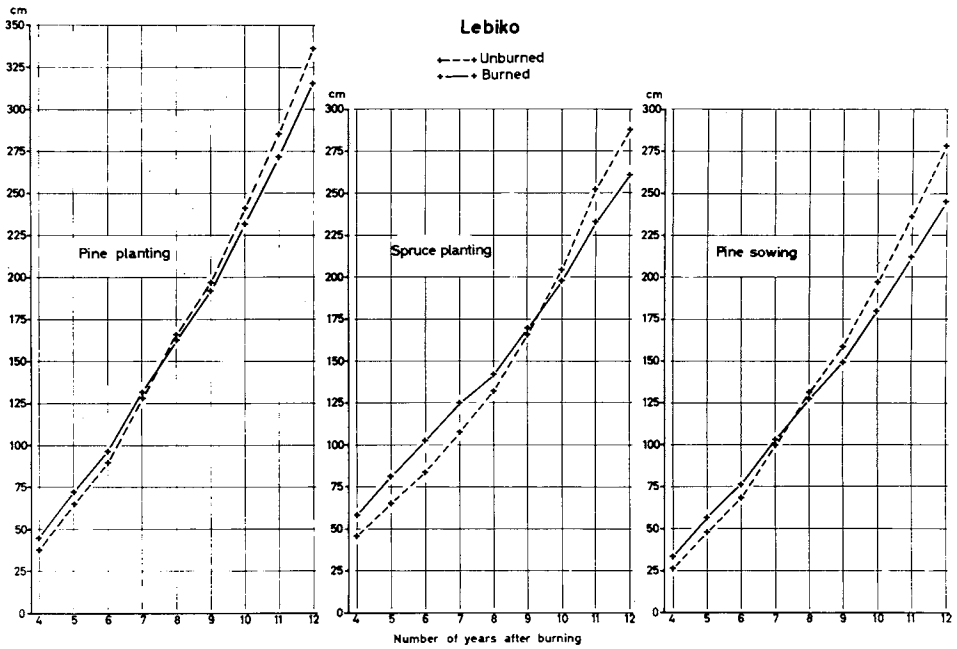

FIG. 5. Mean height, *Oxalis-Myrtillus* type.

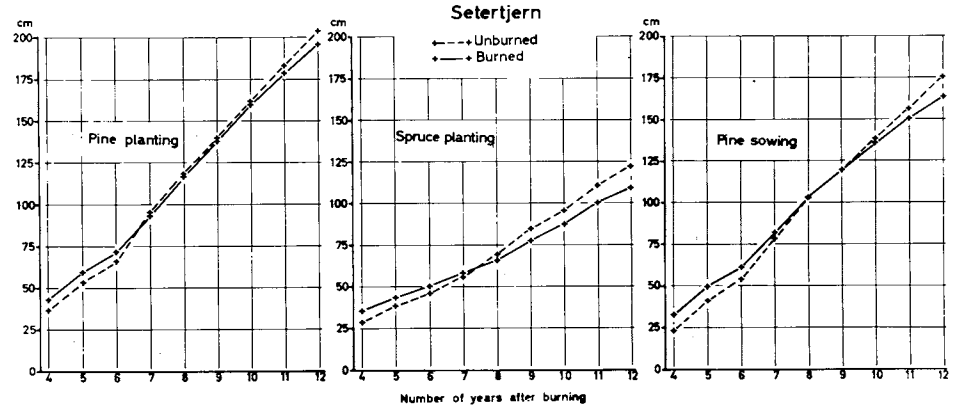

FIG. 6. Mean height, *Myrtillus* type.

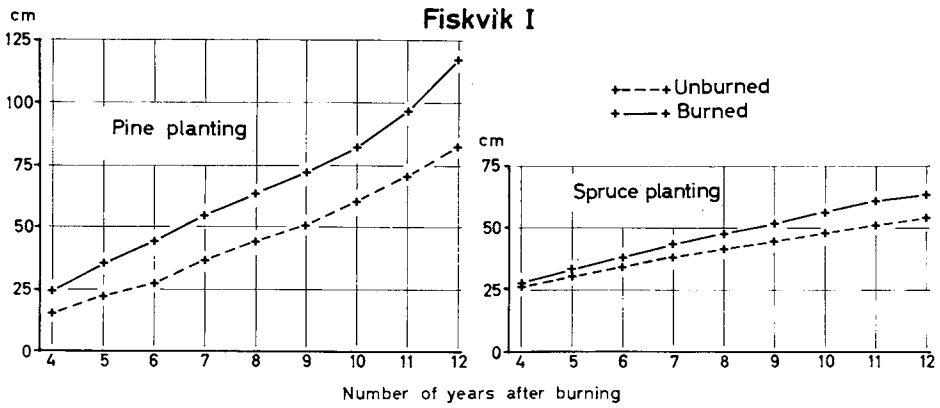

FIG. 7. Mean height, *Calluna* type.

On the *Calluna* site however, at Fiskvik, (Fig. 7) the situation is different. In all the years after burning the height increment has been greater on burned areas. This is especially the case for pine which is the suitable species on this vegetation type, but even spruce had so far the best growth on burned sites. The difference for pine after 12 years was 33 cm. (height 82 and 117 cm). The length of the leaders at 12 years was about 9 cm greater (21 against 12 cm) on burned areas and the difference in height is expected to increase in the years to come.

A test of the regression coefficients for the height curves between 4 and 12 years show a highly significant difference ($p = 0.001$) between burned and unburned areas on all localities except pine planting at Setertjern where the level of significance is lower ($p = 0.05$).

ANALYSES OF NEEDLES

Analyses of mineral elements in ½-year-old needles were made after 2, 3, 5 and 12 years. For spruce, the content of nitrogen was highest on burned areas after 2 years. After 5 years the picture had

changed and the nitrogen content was highest on unburned areas, a situation that still was the same at 12 years. For pine the differences were rather small except for Calluna site where the nitrogen content was highest on the burned areas throughout the whole period. The variation in nitrogen content in needles corresponds nicely with the growth of the seedlings.

CONCLUSIONS

Although this experiment is rather small in size, analyses and measurements of different kinds were quite intensive. Consequently the conclusions to be drawn may be rather precise for the spots and types investigated. On the other hand results should not be generalized to other types or areas without strong precautions.

The results show that on the *Oxalis-Myrtillus* type and *Myrtillus* type the growth on unburned areas after 12 years has been better than on burned areas. It is likely that the difference in favor of no burning will increase in the following years. This may be partly due to direct loss of nutrients at the burning and leaching in following years when ground vegetation is sparse. Also it may be partly due to a speeding up of humus decomposition. This releases nutrients too quickly in the first few years after burning which leads to a scarcity of available nutrients later on.

Burning on *Oxalis-Myrtillus* and *Myrtillus* types is not beneficial unless the burning will result in a considerable increase in survival of seedlings. In this experiment there has been a clear tendency for an increased survival after burning. However, it is doubtful whether the increase has been great enough to justify burning on the types mentioned. In this connection it ought to be mentioned that there are great variations within the vegetation types. For example, the *Myrtillus* type in this experiment had a rather mild humus. There occur variants of the *Myrtillus* type with some resemblance to the *Calluna* type in which burning has been shown to be beneficial. On the *Calluna* type there is a clear positive effect of prescribed burning especially on growth, and in this experiment also on survival. The needle analyses show higher nitrogen content on the burned areas so far, indicating that the burning has been beneficial on this type

which has a thicker raw humus layer (in Norway usually 5 to 10 cm). The proportion of areas to be burned in Norway on this vegetation type in relation to scarifying or other methods of regeneration will depend on the cost of the different methods. At present the cost situation is unfavorable for burning.

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