



Vegetation structure and composition following fire and clear-cutting in Klenemåla, Småland

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Vegetation structure and composition following fire and clear-cutting in Klenemåla, Småland

Vegetationsstruktur och artsammansättning efter brand och kalavverkning i Klenemåla, Småland

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Keywords: Disturbance ecology, vegetation structure, species composition, forest management, Scots pine (*Pinus sylvestris*), boreal forest, prescribed burning, clearcutting

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Abstract

Forest disturbances are significant in shaping vegetation structure, composition and ecosystem development in boreal forests. In modern Swedish forestry, clearcutting is the dominant type of disturbance while prescribed burning is sometimes used to restore ecological processes historically associated with wildfire. This study compared early vegetation structure and composition following prescribed burning and clearcutting in boreal Scots pine (*Pinus sylvestris*) forests in Klenemåla, Småland, Sweden, with an additional control stand representing long-term stand development without recent disturbance. Vegetation sampling was conducted using 40 ground vegetation plots per site, combined with structural measurements in randomly selected larger plots. Species composition, vegetation cover and stand structure were compared among the three disturbance types.

The results showed clear differences in vegetation development depending on treatment type. Both burned and clearcut sites exhibited a higher total species richness, with nine species each, compared to the four species found in the control, when combining all 40 sampling plots within each treatment. However, at the single-plot scale, the single-factor ANOVA and post-hoc Tukey's test showed that the only statistically significant difference in mean species richness per plot was between the burned and clearcut treatments, where the clearcut had a higher average number of species per plot. Furthermore, the two disturbance types differed in vegetation composition and structural variation. Grasses and raspberry (*Rubus idaeus*) characterised the clearcut site. The absolute mean total vegetation cover was high and roughly equal to the other treatments, but the variation between plots was low. The burned site, in contrast, showed greater heterogeneity in vegetation cover between plots and stand structure, with a mixture of early successional species and forest understory species such as bilberry (*Vaccinium myrtillus*) and cowberry (*Vaccinium vitis-idaea*).

These findings indicate that disturbance type influences not only the total species richness, but also species composition and structural diversity. Prescribed burning may therefore contribute to greater ecological variation than clearcutting, with implications for long-term biodiversity and forest management. The study highlights the importance of considering different disturbance regimes and types when evaluating vegetation development and biodiversity in managed boreal forests.

Keywords: Disturbance ecology, vegetation structure, species composition, forest management, Scots pine (*Pinus sylvestris*), boreal forest, prescribed burning, clearcutting

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1. Introduction

Forests in Sweden have long been shaped by both natural disturbances and human management (Zackrisson, 1977; Niklasson & Granström, 2000). Among natural disturbances, fire has historically played an important ecological role by creating variation in the landscape and supporting biodiversity through changes in vegetation structure, nutrient availability and habitat conditions (Kuuluvainen & Aakala, 2011). In modern forestry, however, natural fires are largely suppressed through active fire prevention, while clearcutting has become the dominant form of disturbance in managed forests (Granström, 2001). To reintroduce some of the ecological effects of fire, prescribed burning is sometimes used, although on a very limited scale, as a management tool (Bergeron et al., 2002; de Chantal et al., 2005; Heikkala, 2016).

Although fire and clearcutting both act as major disturbances, their effects on forest ecosystems differ. Fire influences soil properties, nutrient availability and light conditions through the consumption of organic material and the partial mortality of trees (Santin & Doerr, 2016). In contrast, clearcutting primarily removes the tree layer, while the soil impacts are often less severe than in areas subjected to high-intensity fire, although this varies with disturbance severity (Chen & Shrestha, 2012). These differences influence how vegetation develops after disturbance, as species establishment is shaped by environmental conditions and biological legacies (Franklin et al., 2000).

Fire and clearcutting also differ in the spatial patterns they create. Fire often creates uneven patterns of tree survival, soil exposure and burn severity, resulting in spatially heterogeneous conditions within the stand (Turner et al., 1997; Certini, 2005). In contrast, clearcutting typically creates open conditions, with high light availability but less variation in soil disturbance, which can favour rapid colonisation by a smaller number of competitive species (Swanson et al., 2011). As a result, the type of disturbance may influence total species richness, as well as small-scale variation and patterns of species dominance.

Post-disturbance vegetation development is further shaped by the biological legacies that remain after disturbance. These legacies include surviving vegetation, seed banks and soil structure, all of which influence vegetation recovery (Franklin et al., 2000). In burned forests, some species may survive via resprouting or seed banks, while others establish in post-fire environments (Keeley et al., 2011). Species such as dwarf shrubs, mosses and disturbance-adapted pioneer species may therefore respond differently depending on the severity of the disturbance. In clearcuts, the removal of the tree layer strongly alters competition and light conditions, often favouring grasses and fast-growing light-demanding species (Hedwall et al., 2013). This suggests that disturbance

type influences both the pace of recovery and the composition of regenerating vegetation.

Broader ecological theories of disturbance and biodiversity provide a framework for these patterns. The Intermediate Disturbance Hypothesis suggests that biodiversity may be highest at intermediate levels of disturbance, where strong species dominance is reduced while habitat diversity remains relatively high (Connell, 1978). In boreal forests, disturbance has long shaped vegetation structure and species diversity (Kuuluvainen, 2009). Both the absence of disturbance and simplified disturbance regimes may reduce ecological variation over time (Connell, 1978).

Disturbance effects may also extend beyond vegetation itself. Changes in ground vegetation and stand structure can influence habitat quality, forage availability and ecological conditions for other organism groups, including insects, birds and large herbivores (Siitonen, 2001; Fuller et al., 2007). This makes vegetation responses an important first step in understanding wider ecosystem effects. This is especially relevant in boreal production forests, where timber production must be balanced with biodiversity and other ecological values (Lindenmayer & Franklin, 2002; Bergeron et al., 2002; Heikkala, 2016).

The overall aim of this study is to compare vegetation structure and composition following two different types of disturbance: prescribed fire and clearcutting, using an undisturbed control stand as a baseline. The study focuses on ground vegetation and seeks to identify differences in species composition, vegetation cover and patterns of dominance among the three treatment types.

The following research questions will be addressed:

- How does species composition differ between burned and clearcut areas compared to the control stand, which shows long-term stand development without recent major disturbance?
- How does vegetation cover and its variation among individual sampling plots vary among the three treatments?
- Are there species specifically associated with either burned or clearcut areas?

Based on existing ecological knowledge of disturbance effects, the following hypotheses are proposed:

- The average number of species per plot and mean vegetation cover will differ among the three treatment types
- The burned site will show greater within-stand variation in both species composition and vegetation cover compared to the clearcut and control sites
- Clearcut areas will be dominated by a smaller number of fast-growing, light-demanding species

By comparing vegetation responses to prescribed fire and clearcutting, this study aims to improve understanding of how forest management practices influence biodiversity, vegetation heterogeneity and ecological functions in boreal forest landscapes. Such knowledge is relevant for sustainable forest management strategies that seek to balance production goals with biodiversity.

2. Materials and methods

2.1 Study area

The study was conducted during April 2026, in Klenemåla, Småland, Sweden, where two forest stands were subjected to different disturbances: prescribed burning in 2020 and clearcutting in 2021. A control stand with similar initial conditions was also included for comparison. The burned stand is 3.03 hectares, the clearcut 2.90 hectares and the control 2.97 hectares, meaning that the total area investigated across all three study sites is 8.9 hectares. The location of the sites is shown below (Fig. 1a,b).

Prior to disturbance, all sites shared similar characteristics, including soil type, vegetation composition and stand structure. The forests were dominated by Scots pine (*Pinus sylvestris*) and were growing on podzol soils, typical of pine forests in southern Sweden. The field layer consisted mainly of bilberry (*Vaccinium myrtillus*) and mosses, with relatively low structural variation in the tree layer (pers. comm. Therese Lindström., Johan Ericsson, Södra Skogsägarna). Following disturbance, the sites developed under different conditions depending on the type of treatment, forming the basis for comparison in this study.



Figure 1. Study area and site layout in Klenemåla, Småland, Sweden. (a) Location of the study area in southern Sweden (Google maps, 2026). (b) Spatial arrangement of the burned, clearcut and control sites. (c, d) Detailed map of the burned (1), control (2) and clearcut (3) site, showing stand boundaries. Maps produced by Johan Ericsson.

2.1.1 The burned site

The burned study area corresponds to part of a larger area subjected to prescribed burning in August 2020 (Fig. 1b,c). The fire was implemented as a controlled prescribed burn, resulting in varying fire intensity across the area. Large parts of the forest floor were affected, with consumption of mosses, litter and parts of the humus layer, and in many places exposure of mineral soil. The disturbance also caused partial tree mortality. Since the burning, the site has developed under conditions of increased light availability and altered soil properties (Fig. 2a,b). The variation in fire intensity has contributed to a heterogeneous stand structure, with a mix of more open and denser patches. Deadwood is present in the form of both standing and fallen trees, and regeneration has established in the areas where mineral soil was exposed.



Figure 2. Stand structure and canopy characteristics across three forest treatments. (a, b) Burned site following prescribed fire in 2020, showing stand structure and variation in canopy density. (c) Clearcut site with young regeneration and early stand development following harvesting and planting. (d, e) Control site showing a recently undisturbed pine stand structure and uniform canopy density.

2.1.2 The clearcut site

The clearcut site (Fig. 1b,d) was harvested in 2021, shortly after the burning took place in the nearby stand. Prior to planting, the site was mechanically scarified using disc trenching. This contributed to substantial soil disturbance and influenced subsequent vegetation establishment. In 2022 the area was planted with pine, with approximately 85% of the current pine regeneration being planted and the remaining portion naturally regenerated. Subsequent management included wildlife protection treatments (repellent) from planting until 2024, as well as an early broadleaf cleaning in 2024 (pers. comm. Johan Ericsson, Södra Skogsägarna). The site is currently dominated by young regeneration and represents an early stage of forest development after clearcutting (Fig. 2c). The structure is relatively dense at ground level, with no larger trees remaining, clearly distinguishing it from both the burned and control site.

2.1.3 The control site

The control site (Fig. 1b,c) consists of an approximately 106-year-old pine-dominated stand and has not been subjected to any recent natural or unnatural disturbances comparable to fire or clearcutting. It is therefore used as a reference representing long-term managed stand development under similar site conditions, rather than an undisturbed natural forest.

The stand grows on podzol soil and is characterised by a relatively open structure with Scots pine as the dominant species. The field layer consists mainly of bilberry and mosses. The stand shows a more uniform structure, reflecting long-term development without major disturbance (Fig. 2d,e). The trees are of relatively similar size and age.

2.2 Sampling design and measurements

Vegetation was sampled using 40 square plots (0.25 m²) at each site (burned, clearcut and control). The plots were placed approximately 20 meters apart in order to cover the approximate 3-hectare study areas at each site. Plot locations were determined using the mobile application Avenza Maps, where a gridded map was created to guide their placement in the field. To ensure that sampling accurately reflected ground vegetation, any plot that intersected deadwood was shifted one meter to the right. All plant species present in each plot were recorded, followed by a visual estimation of the vegetation cover per species.

In 10 of the 40 plots at each site, additional measurements of tree structure were carried out. These plots were selected at random using a random number generator. Using the same centre point at the smaller plots, a circular area with a

radius of 10 meters was established. Within these areas, the number of stems, tree species and diameter at breast height (DBH) were recorded. These measurements were used to estimate stand structure and light conditions at each site.

Fieldwork was carried out over four days in early April, during early spring conditions. At this time of year, deciduous vegetation had not yet leafed out, which improved the visibility of ground vegetation. A square frame was used to define the boundaries of the smaller plots, while a 10-meter string (measured using a measuring tape) was used to establish the larger circular plots. A plastic stick was used to mark the centre point of both the small and large plots, helping when measuring the larger circular plots. Observations were recorded using a printed protocol and plant species were identified using a comprehensive field guide (Mossberg and Stenberg, 2021). A camera was then used for documentation of all plots so the data collected could be reviewed.

The collected data was used to calculate descriptive statistics for each site. For vegetation data, total cover per species, species frequency, mean total vegetation cover and standard deviation were calculated to describe the vegetation and its variation between plots. For tree data, basal area, basal area per hectare and mean diameter at breast height were calculated to describe stand structure. These measures were used to compare the burned, clearcut and control sites.

2.3 Statistical analysis

To test if the average number of species per plot differed significantly between the three treatment types, a single-factor Analysis of Variance (ANOVA) was used. The test was performed with a significance level of $\alpha = 0.05$ to evaluate the global differences alongside the corresponding F-statistic and degree of freedom (*df*). After running the ANOVA a post-hoc Tukey HSD test was used to compare the treatment groups in pairs to find out which groups had different means. For these pairwise comparisons, the mean differences, standard errors, *q*-statistics, 95% confidence intervals, *p*-values and Cohen's *d* effect sizes were calculated to evaluate the strength of the differences between the treatments. All statistical calculations and tests were performed using Microsoft Excel and the Real Statistics Resource Pack Excel add-in.

3. Results

3.1 Site overview

The three study sites differed in both vegetation structure and ground cover (Fig. 3). Vegetation in the burned site was relatively dense and heterogeneous with only a few plots containing bare soil. The clearcut site, in comparison, was characterised by vegetation dominated by fast-growing species such as grasses and raspberry (*Rubus idaeus*). The control site displayed a more uniform vegetation structure with a limited number of species, primarily bilberry and cowberry (*Vaccinium vitis-idaea*), which were consistently present across the plots. These structural differences provide important context for interpreting patterns in vegetation composition and cover.

Stand structure also varied among the sites. The burned site showed significant variation, with basal areas ranging from 9 to 41 m²/ha, indicating a heterogeneous distribution of trees. Some plots were relatively open while others were denser. Mean DBH ranged from 23 to 40 cm, showing a variety of both smaller and larger trees in the stand. The clearcut site was dominated by young regeneration, with no trees exceeding 10 cm in DBH. The control site however, exhibited a more uniform stand structure, with basal area ranging from 25 to 50 m²/ha. Mean DBH showed limited variation, ranging from 29 to 34 cm. This structure indicates a relatively even-aged stand with similar tree sizes.



Figure 3. Representative vegetation structure of a) burned site, b) clearcut site, c) control site.

3.2 Species composition

Species composition differed among the burned, clearcut and control sites (Table 1). Several species occurred across all sites, including bilberry, cowberry, common heather (*Calluna vulgaris*) and mosses.

The burned site showed a relatively high occurrence of mosses (78%) and bilberry (68%), while cowberry was less frequent (60%), although still common. In the clearcut site, fast growing, light demanding species were more prominent. Raspberry and rowan (*Sorbus aucuparia*) were the only species exclusive to the clearcut area, alongside a high frequency of grasses (65%). The control site was dominated by typical understory species of boreal pine forests, particularly bilberry (98%) and cowberry (90%), with moss present in all plots (100%).

Species richness differed between the sites. When counting the total number of species found across all 40 sampling plots combined, the burned and clearcut site both showed the highest number of species (nine species each), whereas the control site had substantially lower richness, with only four species recorded in total (Table 1). It is important to clarify that these numbers represent the total species richness summed up across all 40 sampling plots for each treatment, not the number of species found inside a single individual plot.

A single-factor ANOVA was calculated to determine if the number of species per plot differed significantly. This analysis revealed a statistically significant difference between treatments ($df = 2, F = 4.91, p = 0.0089$). The post-hoc Tukey HSD test showed that the only statistically significant difference at the 95% confidence level was between the burned and clearcut sites ($p = 0.00773$). On average, the clearcut plots had a significantly higher number of species per plot (mean = 3.3) than the burned plots (mean = 2.7) (Fig. 4). There was no significant difference between the burned site and the control site ($p = 0.6221$), and the difference between the clearcut site and the control site was also not significant ($p = 0.08877$), though it showed a slight trend.

Table 1. Frequency (%) of plant species occurrence, expressed as the proportion of plots in which each species was recorded, and species richness in burned, clearcut and control sites.

Species	Burned (%)	Clearcut (%)	Control (%)
Bilberry (<i>Vaccinium myrtillus</i>)	67.5	42.5	97.5
Cowberry (<i>Vaccinium vitis-idaea</i>)	60	57.5	90
Raspberry (<i>Rubus idaeus</i>)	0	47.5	0
Wild strawberry (<i>Fragaria vesca</i>)	2.5	0	0
Common heather (<i>Calluna vulgaris</i>)	10	7.5	2.5
Bracken (<i>Pteridium aquilinum</i>)	7.5	10	0
Grasses	15	65	0
Mosses	77.5	85	100
Pine (<i>Pinus sylvestris</i>)	27.5	10	0
Birch (<i>Betula pendula</i>)	5	0	0
Rowan (<i>Sorbus aucuparia</i>)	0	2.5	0
Total species richness	9	9	4

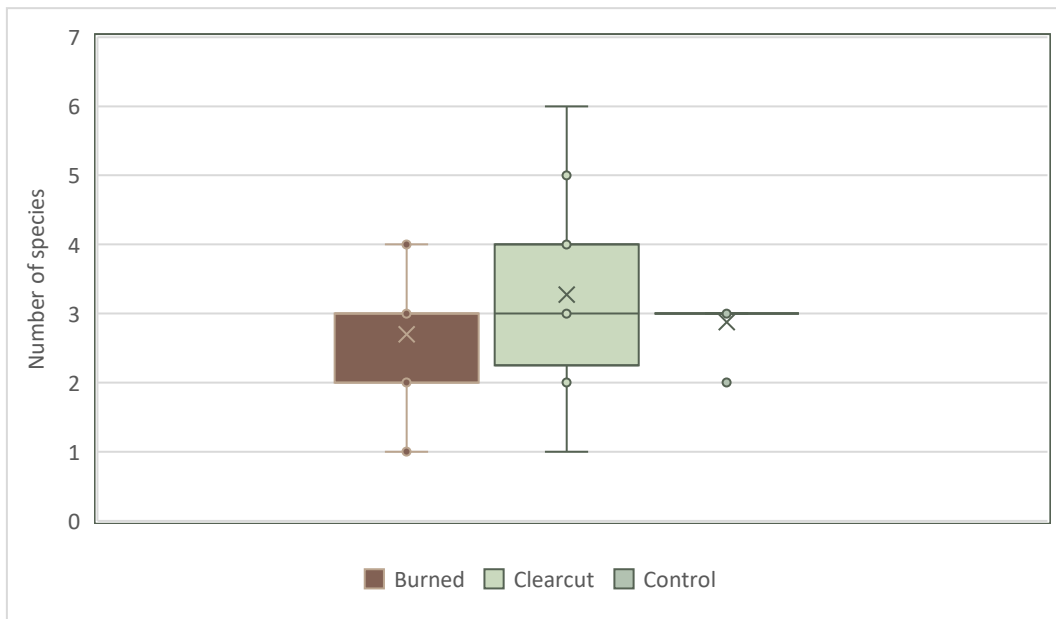


Figure 4. Plot-level (0.25 m^2 plots, $n=40$ per treatment) species richness across the three management treatments. The boxplot shows that species richness differs significantly among treatments ($F(2, 117) = 4.91, p = 0.0089$), driven by a significantly higher mean number of species in clearcut plots compared to burned plots ($p = 0.00773$). The boxes show the interquartile range (25th to 75th percentile) with a horizontal line marking the median, and the “X” marking the mean. The whiskers extend to the minimum and maximum values within $1.5 \times \text{IQR}$, while the individual dots represent the outliers.

3.3 Vegetation cover

Mean vegetation cover varied among treatment types (Table 2). In the burned site, vegetation was dominated by mosses (27%) and bilberry (32%), followed by cowberry (19%), which together accounted for most of the total vegetation cover. Birch (*Betula pendula*) and wild strawberry (*Fragaria vesca*) were exclusive to the burned site, albeit occurring at low frequencies. The clearcut site showed a more mixed composition. Grasses (35%) and mosses (23%) had the highest cover, while raspberry, although present exclusively in this site, contributed to a smaller proportion (7%). In the control, mosses dominated the vegetation cover (59%), while both bilberry (21%) and cowberry (18%) also contributed substantially.

The mean total vegetation cover was roughly equal and very high across all three sites, with the clearcut showing 100%, followed by the control site at 98.35%, while the burned site had 94.43%. The three habitat types differed in heterogeneity among plots in terms of total vegetation cover (Fig. 5). Variation in total vegetation cover among plots was highest at the burned site, indicating more heterogeneous recovery patterns. Meanwhile, the clearcut site showed relatively low variability, and the control site showed moderate variation.

Table 2. Mean vegetation cover (%) of the six most dominant plant species in burned, clearcut and control sites.

Species	Burned (%)	Clearcut (%)	Control (%)
Bilberry (<i>Vaccinium myrtillus</i>)	32	8.8	20.6
Cowberry (<i>Vaccinium vitis-idaea</i>)	18.6	16.3	18.4
Raspberry (<i>Rubus idaeus</i>)	0	6.5	0
Common heather (<i>Calluna vulgaris</i>)	2.8	2.3	0.1
Mosses	27.2	22.8	59.3
Grass	3	35.1	0

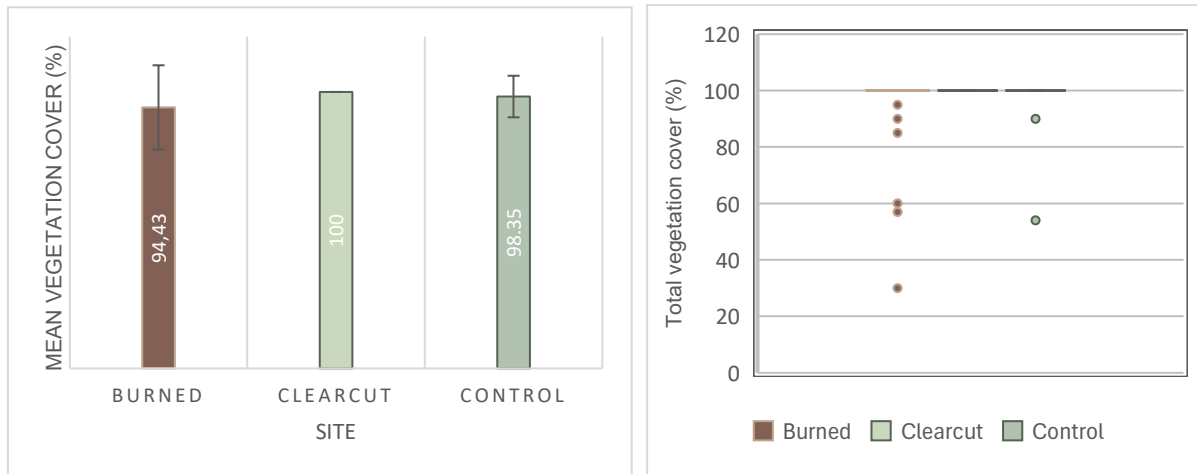


Figure 5. (a) Mean total vegetation cover (%) in burned, clearcut and control sites (error bars represent ± 1 standard deviation). (b) Variation in total vegetation cover (%) among plots in the three sites.

3.4 Species dominance patterns

The relative contribution of dominant species was different when comparing the sites (Fig. 6). In the burned site, vegetation cover was largely dominated by mosses and bilberry. In the clearcut, vegetation composition was more diverse, with grasses and early successional species such as raspberry contributing to the total cover. The control site was dominated by mosses, with bilberry and cowberry also contributing significantly, resulting in a stable, less varied vegetation composition.

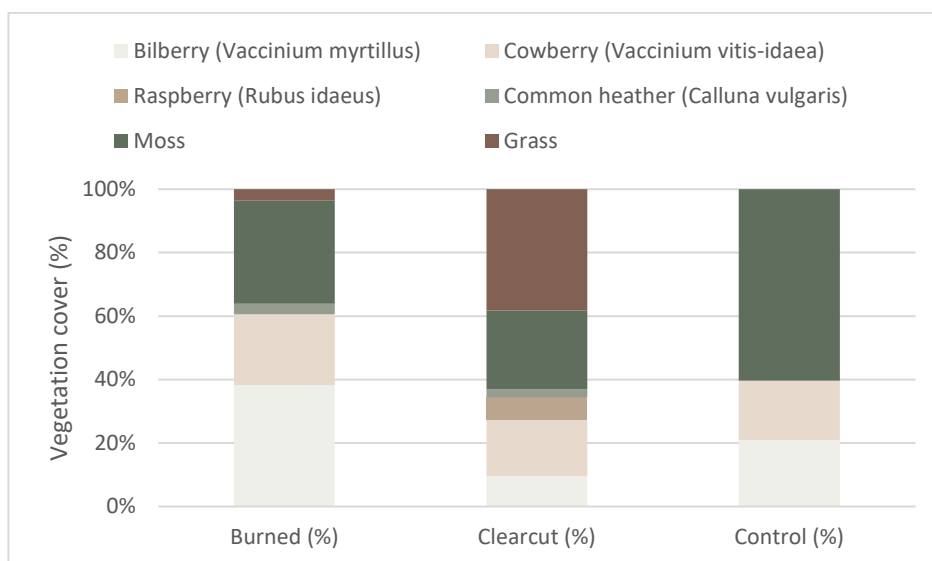


Figure 6. Mean total vegetation cover (%) in burned, clearcut and control sites.

4. Discussion

The results show that disturbance type influences early vegetation structure and composition in boreal pine forests, both in terms of species composition, vegetation cover and structural variation. These patterns can be understood within the framework of disturbance ecology, where different types and intensities of disturbance create contrasting environmental conditions that shape post-disturbance succession (Pickett & White, 1985; Turner, 2010). In this study, the burned, clearcut and control sites represent different positions along a disturbance gradient, which provides a useful basis for interpreting the results.

Regarding the proposed hypotheses, the first was only partially supported. While the average plot-level richness differed between the clearcut and burned treatments, the mean total vegetation cover remained high and relatively uniform across all three sites. The second hypothesis was fully confirmed. The burned plots exhibited the highest within-stand variation in vegetation cover and species composition. The third hypothesis was also confirmed because the clearcut plots were uniformly dominated by a high cover of grasses and raspberry.

The results do not fully fit with a simple interpretation of the Intermediate Disturbance Hypothesis, which predicts that biodiversity reaches a peak at intermediate levels of disturbance and drops at high levels (Connell, 1978). Both the burned and clearcut sites showed higher total species richness than the control, but their total species counts did not differ from each other. The similarity in their total species richness suggests that disturbance promotes the establishment of a wider range of species compared to more stable conditions. This similarity indicates that there may not be a major difference in disturbance intensity between burned and clearcut sites, as both represent severe disturbances that occurred just once. Instead, the stands differ in the type of disturbance. This indicates that early successional stages may support relatively high species richness due to delayed competitive exclusion, while differences between disturbance types are more strongly reflected in species composition, dominance and spatial variation (Huston, 2014).

The clearcut site was characterised by high vegetation cover with grasses and raspberry (*Rubus idaeus*) as prominent species, which is typical for early successional vegetation in open environments with high light availability. The absence of a tree layer creates favourable conditions for fast-growing, light-demanding species (Hedwall et al., 2013). In addition to increased light availability, clearcutting can also increase nitrogen availability in the soil since tree uptake of nutrients ceases after harvest. This leads to greater nitrogen mobilisation and nutrient availability for competitive grasses and shrubs (Länsstyrelsen Västra Götaland, 2008). This leads to rapid colonisation and high total vegetation cover, but also to relatively uniform conditions, which is reflected

in the low variation in vegetation cover between plots. Similar patterns have been observed in other studies, where clearcutting leads to early-successional regeneration dominated by a limited number of fast-growing, competitive species (Swanson et al., 2011; Roberts & Zhu, 2002).

In contrast, the burned site showed a more heterogeneous vegetation pattern, both in terms of species composition and vegetation cover. The variation in basal area and tree size within the burned site indicates uneven survival of trees following fire, which likely contributed to differences in light conditions at the ground level. In addition, fire affects the soil by consuming organic material and exposing mineral soil, thereby altering soil properties and contributing to spatial variability in post-fire conditions (Certini, 2005). Because different areas experience differing levels of tree mortality and soil impact, the variation in fire intensity within the stand further increases this heterogeneity (Turner et al., 1997; Johnstone et al., 2016). These factors together are likely to promote a more diverse set of environmental conditions, which can support a mixture of early successional species and forest understory species.

The presence of bilberry and cowberry in the burned site suggests that not all vegetation was removed by the fire. Many boreal species are able to survive fire through resprouting from belowground structures or regenerate from seed banks, allowing them to persist after disturbance (Keeley et al., 2011; Keeley & Pausas, 2022). This aligns with the concept of biological legacies, where surviving organisms and structures influence post-disturbance recovery (Franklin et al., 2000; Granström, 2001). In comparison, clearcutting removes the tree layer but does not generally create the same heterogeneous soil disturbance patterns as fire alone; however, in this case, post-harvest soil scarification through disc trenching also significantly altered soil conditions and likely affected vegetation establishment. Even though disc trenching creates a bumpy soil surface, grasses and raspberry still established with high consistency across the stand. This widespread, even growth explains why the clearcut exhibits such a low variation in vegetation cover between the sampling plots, even though the physical soil surface contains structural variation. This mechanical site preparation may have reduced some of the contrast between burned and clearcut conditions by creating an additional soil disturbance.

The exclusive occurrence of birch and wild strawberry in the burned site further supports the idea that fire creates unique ecological niches that are not present in the clearcut or control sites. Birch is a well-known pioneer species that can rapidly colonise post-fire environments through seed dispersal and establishment on exposed mineral soil (Johnstone et al., 2016; Kuuluvainen & Aakala, 2011), while wild strawberry is commonly associated with open, disturbed habitats where competition is reduced (Roiloa & Retuerto, 2007). Their presence suggests that fire-generated heterogeneity may create a broader range of

regeneration opportunities than clearcutting alone. However, since the total inventoried area was only 10 m² per stand (40 plots of 0.25 m² each), these rare pioneer species might actually be present in the inventoried parts of the other treatments and were simply missed during sampling.

The occurrence of common heather (*Calluna vulgaris*) across all sites, but with higher cover in disturbed areas, is particularly interesting. Heather is known to be strongly associated with disturbance, especially fire, which can stimulate germination and reduce competition from other species (Vandvik et al., 2005). Long-term studies have shown that heather declines in the absence of disturbance, while periodic disturbance maintains its presence in the landscape (Vandvik et al., 2005). The results of this study therefore support the idea that both disturbances can promote heather cover, as fire can trigger the activation of the usually abundant underlying soil seed bank (Vandvik et al., 2005), while clearcutting reduces overstory shading to let existing individuals expand.

The control site showed a homogenous vegetation structure dominated by mosses and dwarf shrubs, with low species richness and relatively uniform conditions. The stand has not been subjected to any recent disturbance, which is consistent with the field information from forest management. However, it is important to note that this does not represent an undisturbed natural forest. The stand is even-aged and has established through natural regeneration. It has undergone one thinning operation in early 2000 (pers. comm. Johan Ericsson, Södra Skogsägarna). Although not previously clearcut, it has still developed under forest management, which may contribute to the relatively low structural diversity and stable vegetation patterns commonly associated with managed stands (Kuuluvainen, 2009). This means that the comparison in this study is between sites with different disturbance histories and management regimes, rather than between undisturbed and completely natural conditions.

The differences in vegetation between the sites are also likely to have implications for other organism groups. Vegetation structure and composition influence habitat availability and food resources, which in turn affect insects, birds and large herbivores (Siitonen, 2001; Fuller et al., 2007). For example, the high abundance of grasses and shrubs in the clearcut site may provide important forage for herbivores such as moose and deer, while the more heterogeneous structure of the burned site may support a wider range of insects and bird species due to increased habitat diversity (Swanson et al., 2011; Fedrowitz et al., 2014). This highlights the importance of considering multiple trophic levels when evaluating the ecological effects of disturbance types.

From a management perspective, the results suggest that prescribed burning and clearcutting create different ecological conditions that may complement each other at the landscape scale. Clearcutting promotes rapid vegetation growth and high cover, while burning increases structural variation and allows some forest

species to persist. This supports the idea that variation in disturbance regimes can enhance landscape-level diversity compared to uniform management practices (Mori et al., 2013).

In this study, several limitations should be considered. The study was based on one site per disturbance type, which limits the generality of the results. In addition, the sampling was conducted during early spring, and seasonal variation in vegetation was not captured. The sites are also in early successional stages, and vegetation patterns are likely to change over time as succession progresses (Johnstone et al., 2016). Finally, visual estimation of vegetation cover may introduce some uncertainty, although it is a commonly used method in vegetation studies (Kent, 2011). Because the visual estimation was done by one person, any personal bias or subjective errors were consistent across every plot, making the relative differences between the treatments reliable.

5. Conclusions

In summary, the results show that early vegetation structure and composition in boreal pine forests are heavily shaped by disturbance type. Both prescribed burning and clearcutting increased species richness compared to the control site, but they differed substantially in how vegetation developed following disturbance. Prescribed burning created more heterogeneous conditions and supported a mixture of species, while clearcutting led to more uniform vegetation dominated by fast-growing, light-demanding species. These findings suggest that disturbance type influences species richness, alongside species composition, structural variation and potential ecological functions.

Based on these findings, several management recommendations can be made for forestry practices. Prescribed burning can be used to create a mix of micro-habitats because of the varying fire intensity, letting unique pioneer species establish. To reduce the uniformity seen after clearcutting and disc trenching, forest managers can leave retention patches to break up the grasses and raspberry. While these fast-growing pioneer species provide valuable open forage, preventing them from forming a complete monopoly protects keystone food webs and preserves sensitive soil-cooling mosses (Fedrowitz et al., 2014). These retention patches preserve nearby groups of surviving plants, which accelerates the recovery of typical understory species. This allows them to expand right away instead of waiting decades for automatic recolonization after canopy closure. Finally, forest planning can focus on creating a mosaic landscape by combining prescribed burning, retention clearcuts and older undisturbed stands. This strategy keeps regional plant diversity high while balancing open and sheltered habitats, in turn supporting different organisms. The results of this study therefore support the idea that incorporating a diversity of disturbance regimes, including prescribed fire, can contribute to more ecologically varied boreal forests.

6. AI usage

AI tools were used to help improve language and grammar, as well as provide suggestions for general improvements of the text. The author is responsible for all content, analysis and conclusions in this thesis.

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