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Research Paper

Can powerline clearings be managed to promote insect-pollinated plants and species associated with semi-natural grasslands?

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ABSTRACT

Powerline clearings are common in urban and semi-urban landscapes worldwide. The clearings could potentially promote flowering species associated with open-canopy habitats, and provide alternative habitat for species dependent on semi-natural grasslands, but the empirical evidence for this hypothesis is weak. We carried out a large-scale field study of understorey plant communities at 51 sites in powerline clearings and adjacent boreal forest. At each site, we placed four 4 m × 5 m plots with five 1-m^2 subplots in the clearing centre and a parallel set of plots 100 m into the adjacent forest. Habitat characteristics were sampled at plot and site level and from digital maps. The clearings had a higher richness of species associated with semi-natural grasslands, and a higher richness of shade-tolerant and shade-intolerant forb species. Total plant richness and diversity were higher in the clearings than in the forests. The magnitude of difference in species composition between clearings and forest, and plant community properties in the clearings, depended on the environmental context (age of the clearing, productivity, shading by tree regrowth, landscape fragmentation, climate). Our results indicate that over time, powerline clearings develop into novel habitats. Low-productive sites were dominated by Ericaceaous dwarfs shrubs. Richness of forbs and semi-natural grassland species in the clearings increased with productivity. Richness of shade-intolerant forbs and semi-natural grassland species increased with fragmentation of the surrounding landscape. We conclude that frequent clearing of productive sites can enhance plant biodiversity – including richness of insect-pollinated species – and mitigate the loss of species associated with semi-natural grasslands.

1. Introduction

Transformation of lands for human use has been identified as a principal driver of biodiversity loss across the planet, along with habitat fragmentation and modifications of natural disturbance regimes (Ellis et al., 2013; McGill, Dornelas, Gotelli, & Magurran, 2015). Yet, altered land use also brings new possibilities and not all changes need to have negative impacts on biodiversity (Hobbs, Higgs, & Harris, 2009). When the retention of the historical ecosystems is no longer feasible, it is important to evaluate the effects of land use and the conservation value of alternative habitats. Used land may provide new habitats for native species, but more studies are needed to understand how such areas can sustain biodiversity and ecosystem functioning and services (Hobbs et al., 2009).

In the ongoing urbanization process the construction of extensive networks of linear infrastructure like roads, railways and transmission line corridors cause land use transformation far beyond the city borders and even outside urban region boundaries (Forman, 2014). Clearing of transmission corridors transforms forests into semi-open or open-canopy habitats and leads to fragmentation of forested landscapes worldwide (Eldegard, Totland, & Moe, 2015). Most available literature on the environmental impacts of powerline clearings have evaluated impacts on animal populations and communities, especially birds (*e.g.*, Askins, Folsom-O'Keefe, & Hardy, 2012), mammals (*e.g.*, Bartzke, May, Bevanger, Stokke, & Roskaft, 2014) and insects (*e.g.*, Wojcik & Buchmann, 2012). Negative impacts include electrocution, edge and barrier effects and possibly negative health effects from electromagnetic fields (Forman, 2014). However, during the last decade several studies have highlighted the potential value of powerline clearings as foraging or nesting habitats for several taxonomic groups of animals like bees (Russell, Ikerd, & Droege, 2005), butterflies (Berg, Ahrné, Öckinger, Svensson, & Söderström, 2011; Forrester, Leopold, & Hafner, 2005), terrestrial gastropods (Nekola, 2012) and early successional birds and mammals (Askins et al., 2012; Clarke & White, 2008). Yet, the vegetation under the powerlines, which provides essential shelter, nesting and food resources for these animals,

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has received relatively little attention (Wagner, Metzler, Leicht-Young, & Motzkin, 2014) and studies are typically on relatively small spatial scale (Lampinen, Ruokolainen, & Huhta, 2015). Moreover, the majority of studies have been carried out in Australian and North American ecosystems, whose degree of human interference are relatively recent compared to cultural landscapes of many European countries, which have been shaped by humans over several centuries and typically have more intensively managed adjacent forest (Bengtsson, Nilsson, Franc, & Menozzi, 2000).

In forested landscapes, the vegetation under powerlines is continually reset to earlier successional stages, but there is a substantial variation in the management practices within and among countries. Practices range from herbicide application or frequent mechanical mowing of all vegetation to less intensive disturbances such as manual clearing of the woody vegetation every 5–12 years, depending on productivity (*e.g.*, Russell et al., 2005). Powerline clearings may provide habitats dominated by native early successional graminoids, forbs, dwarf shrubs and shrubs, which support numerous early successional animals species that are uncommon in forest dominated landscapes (Eldegard et al., 2015; Wagner et al., 2014).

Studies of vegetation in powerline clearings have mainly focussed on trees (*e.g.*, Luken, Hinton, & Baker, 1992; Powell & Lindquist, 2011). There have been few studies of plant communities in the field layer, although the understorey vegetation has been identified as a key driver of *e.g.* boreal forest ecosystems (Nilsson & Wardle, 2005). Wagner et al. (2014) found that overall plant species richness and cover of Asteraceae species – which are important pollen and nectar resources for insects – was significantly higher in powerline clearings than in adjacent mixed oak-pine woodland. They ascribed the differences between clearings and woodland to increased levels of human disturbance, and to increased light, heterogeneity in habitat structure and greater fluctuation in microclimate in the clearings. In Scandinavia, boreal forests of low to intermediate productivity are typically dominated by Ericaceaous dwarf shrubs, in particular bilberry *Vaccinium myrtillus*, a dominant species in the boreal forest ecosystem and an important source of food (nectar and pollen, berries, plant fodder) for many animal species (*e.g.*, Lakka & Kouki, 2009). Increased irradiance in open-canopy powerline clearing habitat should cause a decline in relatively shade adapted species such as bilberry, while giving rise to suitable habitats for drought and light tolerant species such as heather *Calluna vulgaris* (Parlane, Summers, Cowie, & Van Gardingen, 2006), which provides nectar and pollen resources for insects such as bees and butterflies (Goulson, Hanley, Darvill, Ellis, & Knight, 2005).

A group of plant species of particular conservation and management interest is species associated with semi-natural grasslands in cultural landscapes (Hamre, Halvorsen, Edvardsen, & Rydgren, 2010). Agricultural land abandonment is widespread in many countries of the northern hemisphere, including Scandinavia (Beilin et al., 2014). Whereas the use of more economically productive agricultural areas have been intensified, remote and economically unproductive farm areas have been increasingly abandoned and reforested in the rural landscapes of Europe (Beilin et al., 2014). The decreasing amount of suitable habitats for semi-natural grassland species has led to an increasing interest in identifying alternative habitats (Auestad, Rydgren, & Austad, 2011). Because forest regrowth is prevented through regular maintenance clearing, there could be a potential for light-tolerant forb and graminoid species – including semi-natural grassland species – to establish in the powerline clearings.

We assessed the plant community field layer in powerline clearings and adjacent forest at 51 sites distributed across a large geographic area in the semi-urban boreal forest landscape of southeast Norway. Our aim was: i) to quantify the difference in plant community properties between clearings and forest, focussing on response variables that are of conservation interest *per se* (species richness, diversity, semi-natural grassland species, invasive species) or important to animals that depend on floral resources (forbs, Ericaceaous dwarf shrubs); ii) to quantify the difference in species composition between clearings and forest and identify factors influencing the magnitude of this difference, and iii) to identify factors potentially determining plant community properties in the clearings.

We predicted that overall species richness and diversity, as well as richness of semi-natural grassland, invasive and shade-intolerant forb species would be greater in the clearings than in the adjacent forest (Wagner et al., 2014), whereas richness of shade-tolerant forb species would be higher in the closed-canopy adjacent forest. For Ericaceaous dwarf shrubs, we predicted a decrease in bilberry cover and an increase in heather cover in the clearings compared to forest. We predicted that the dissimilarity in species composition between clearing and forest, as well as plant community responses in the clearings, would be influenced by attributes of the powerline clearings (age, width, productivity, regrowth of trees), the degree of fragmentation of the surrounding forest landscape and climatic conditions.

2. Methods

2.1. Study sites and sampling design

The 51 study sites were distributed across the main powerline grid in south-east Norway, between latitudes 58°–61°N and longitudes 8–11°E at 25–1055 m.a.s.l (Fig. 1). We first selected 84 candidate sites by arbitrarily assigning crosses – with approximately the same distance between neighboring crosses – on a small-scale map of the main powerline grid in south-east Norway. Out of these 84 sites, 51 were randomly selected by drawing lots. Thereafter, we zoomed in on aerial photos of each location (http://norgeibilder.no/) to check if the location had a minimum of 200 m of forest perpendicular to the powerline clearing on both sides. If not, the site was moved to the nearest location along the clearing where this criterion was fulfilled. All the sites were situated in boreal forests, and the dominating tree species were Norway spruce *Picea abies* and Scots pine *Pinus sylvestris*, whereas birch *Betula* spp. were the most common deciduous trees, followed by rowan *Sorbus aucuparia*, *Salix* spp. and European aspen *Populus tremula*. In our study,

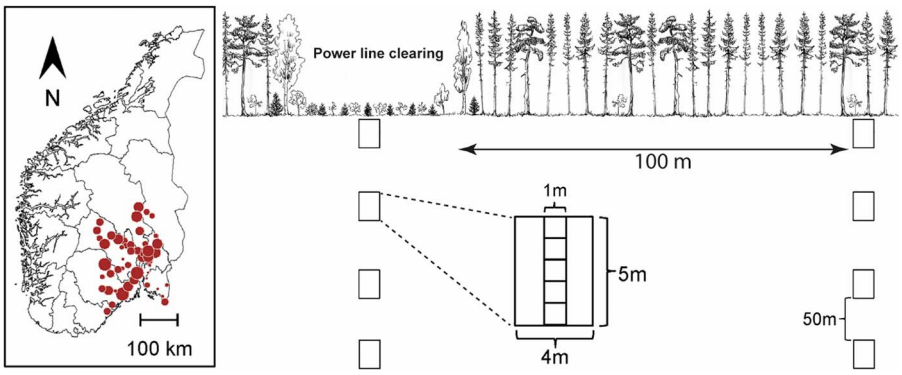

Fig. 1. The 51 study sites (bubble size reflects the relative total plant species richness) and schematic illustration of a study site showing the location of plots in the clearing centre (C) and adjacent forest (Fi). Understory cover data were collected within 1-m^2 subplots placed along the centre line of the 4 m × 5 m plots.