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Prescribed Fire as a Restoration Tool and its Past, Present and Future Use in Västernorrland County, Sweden

Introduction

Before the beginning of modern forestry fire was the dominant disturbance agent in boreal forests. Fire created a diversity of stand structures and successional stages. Results from several important studies have provided us with an understanding of the natural and historical fire regime (Zackrisson, 1977; Engelmark, 1987; Niklasson and Granström, 2000; Carcaillet et al., 2007). These studies show that fire suppression began in the late 1800s and dramatically reduced the frequency and extent of forest fires. Today a very small area of the forest landscape is burned annually and the fire interval has become longer (Niklasson and Granström, 2000; Granström, 2001). As a consequence of both intensive forestry (Linder and Östlund, 1998; Axelsson and Östlund, 2001; Kouki et al 2001) and fire suppression (Essen et al. 1997, Linder et al 1997, Kouki et al. 2001, Uotila et al 2002), the dynamics and structure of the boreal forest has changed, especially during the last 50 years. Today the boreal forest is dominated by large areas of young even-aged coniferous monocultures. As forest fire is a natural component in boreal landscape many species have specific adaptations to this disturbance, for example insects, plants and fungi (Rowe, 1983; Wikars, 1992, 2001; Granström and Schimmel, 1993; Penttilä and Kotiranta, 1996; Hyveräinen et al., 2006). One important feature of fire disturbance is the ability to create large inputs of dead wood (Spies et al., 1998; Linder et al., 1998; Siitonen, 2001). Dead wood is a key factor for biodiversity in forest ecosystems (Harmon et al., 1986; Spies et al., 1988; Siitonen, 2001; Jonsson et al., 2005). Dead wood is also important for forest nutrient cycling, carbon balance and structural heterogeneity (Harmon et al., 1986; Spies et al., 1988; Siitonen, 2001; Jonsson et al., 2005). However, intensive forestry and fire suppression have caused a dramatic decrease in dying trees, dead wood and burned wood which has been negative for many wood-living species (Linder and Östlund, 1998; Sippola et al., 1998; Jonsson, 2000; Siitonen, 2001; Jonsson et al., 2005) and resulted in that many species are considered threatened (Berg et al. 1993, Rydin et al., 1997; Gärdenfors, 2000). In order to recreate a fire prone forest and promote fire dependent species controlled fires have been increasingly used in Sweden to meet specific management objectives. According to the Swedish Forest Stewardship Council (FSC) standard all certified forest owners must burn an area corresponding to 5% of their annually logged area (Anonymous, 2000). In addition the local County Administration performs burnings in nature reserves, with the main objective to restore stand structure and compositions in forest where fires have been suppressed for a long time, but also with the objective to provide habitats for species that benefit from forest fire.

Prescribed fire in the County of Västernorrland

The fire history of the county follows the same pattern as fire history in the rest of northern Sweden. Before the middle of 1800 an average of 1% of the forest area in Sweden burned every year (Zackrisson and Östlund, 1991; Nilsson, 2005; Paulsson, 2007). In our county we have an average fire return interval of around 40-60 years in pine dominated forests (Linder, 1988; Granström, 1996; Jonsson, 1999; Rydkvist, 2003 [unpubl.]; Rydkvist, 2005 [unpubl.]). The average fire return interval in spruce dominated forests is quite longer (Jönsson, 2007; Paulsson, 2007; Granström, 1996). With the latest fire in the end of 1800 we are lacking 2-3 fires in almost every pine dominated nature reserve and that results in denser, darker, cooler and moister forests, due to an increase in number of spruce trees. To calculate, showing and spreading information about the need of fire we are using the Fire Return Interval Departure (FRID) method (Anonymous, 2004).

Since the first burn in a protected area, the County of Västernorrland has experienced quite a change in the way fire is used during the 15 years. In the county, the past and present use of prescribed burnings could be described as a story in different chapters. Looking in to the future use of fire, hopefully the story never ends.

Chapter 1

Chapter 1 in the fire history of the county starts with the first prescribed fire in a protected area in Sweden. We are proud to say that Västernorrland was the first county that introduced fire in a protected area. The first fire was done in 1993 in Jämtgaveln nature reserve, where 35 hectares were burned. In the years of 1995 and 1996, 23 and 19 hectares respectively were burned in the same nature reserve. These three initial burnings were done on heavily logged areas, more like stands of seed trees than an ordinary stand, and thus producing very little biodiversity.

Chapter 2

Chapter 2 is short but very important and it begins but also ends with a prescribed fire in Helvetesbrännans ("Hell-burn" in English) nature reserve in 1999 when 120 hectares were burned. The objective was chiefly for the first time to burn an unlogged forest and to reshape the forest structure. This burning was truly a turning point when it comes to using fire in protected areas also on a national level. Several other counties came to follow with prescribed burnings in nature reserves. This burn is still to our knowledge the largest prescribed fire in a protected area in Sweden.

Chapter 3

Chapter 3 starts after a five year break in continuity in the use of fire. In the year of 2004 we conducted our first prescribed fire in Stormyran-Lommyran Nature Reserve (SLNR). The main objective in SLNR is to restore the forest back to pre-industrial conditions i.e. more open stand structure. This will be accomplished by logging of surplus spruce trees in order to create a more open stand type, and then the stands will be burned. Other objectives are for example increasing the amount of dead wood, favoring fire dependent and fire favoured species e.g. *Stephanopachys linearis* and *S.substriatus*, *Aradus* sp, but also other taxa (Reunanen, 2007) like fungus, and vascular plants according to various Species Action Plans (Rydkvist, 2007b). For some species we don't have enough knowledge about their relationship to or dependence on fire. This is something we must face with a serious and responsible use of fire (Kouki, 2007).

Especially, we lack information on effect of burning for red-listed fungal species (however, see Penttilä et al., 1996; Junninen, 2008; Olsson, 2008). For wood fungi the effects of fire can be divided in direct and indirect effects. Direct effects are charred-, resin-impregnated- and fire-killed wood. Indirect effects are open forest stands, deciduous stages and the regeneration of trees. The distinction of these effects could have extremely important management implications. For example if indirect effects prove to be more important for fungal species, they may be achieved by methods less risky and sometimes even less costly than prescribed burning. High quality resin-impregnated wood, as seen in old pine snags, can probably only be achieved by multiple disturbances (Olsson, 2007).

Therefore it is also important to burn very young stands and give the trees their first injury in very young ages. This calls for a low-intensity surface fire, preferable early in the season when the humus layer is not dried out, which could cause high mortality due to severe root damages.

The restoration method used in SLNR is both logging and prescribed fire. The average stand density in the area with more than 850 stems per hectare is substantially high compared to a natural fire prone forest with an average of less than 200 dominant trees/hectare (Pahlén, 2000). The high stem density is an effect of lack of forest fires for more than 120 years. With an average fire return interval of around 40 years we are missing 2-3 fires. From 2004 to 2006 we have burned more than 150 hectares during six different burns in this reserve. The restoration fires in this area in particular but also fire in other areas has triggered some very fruitful collaboration with the local university, Mid Sweden University, Sundsvall.

In a Research project "Restoration burning as a conservation tool for wood-decaying fungi in Boreal forest" at Mid Sweden University, direct and indirect effects of fire for wood fungi are studied. Further, in the project, information on fire dependent wood fungal species will also be achieved. With this information altogether, management guidelines can be set in order to protect or to adjust management methods in favouring red listed fungal species. The collaboration allows for a long-term field experiment not only in SLNR but also in many other nature reserves. In the experiment, the colonizing fungal community is followed on burned and unburned spruce and pine logs after fire. The experiment will answer questions such as which species of wood-fungi are dependent on burned wood, how the pattern of species succession looks like after fire and if there are any differences in species composition between burned spruce and pine wood. For example if there are no differences between burned and unburned wood, the wood itself is important for the fungi. If so, creation of more dead wood in open forest stands will be an important management method. On the other hand if there are clear differences between burned and unburned wood, it will be important to create more such substrates through prescribed fires.

Chapter 4

Chapter 4 is maybe the greatest step of them all since we started to introduce fire in more valuable stands. It actually overlaps chapter 3 since we will be working with both types of burning for a long period. This phase is probably the most vital one since we have to maintain the biological diversity related to fire and not losing any values previously created by fire. A stand with high value regarding biological diversity is a stand that looks like it would have looked prior to the era of dimension cutting. A pine dominated forest in the beginning of 1800 would be a multi-layered forest (Linder and Östlund, 1992) and still have an open stand structure. There would be a huge heterogeneity when it comes to ages and dimensions and also to important features like resin-impregnated snags that could last several hundred years and downed wood. There would be a number of species dependent or favored by open stand structure i.e. high temperature and high amount of sun radiation.

A prescribed fire in a highly valuable stand takes all your effort and skill since there is a great risk of losing valuable features and substrates for endangered species during the burn. It is definitely something that needs a good planning and a reliable organization. One of the reasons why we chose to start with burning these kind of stands is that we need to learn more in how to handle fire in order to reach more complex objectives. One intelligent person once said: “If you want to use fire you must know the science as well as the art”, and this is so true. The science you can learn by reading, the art you must learn by doing and by doing it repeatedly.

We have forced ourselves to use wet-lines through standing forest instead of enlarging the area to more natural firebreaks. We have tested various methods in building a safe fire break with preference of a wet-line instead of a mineral guard. Our efforts have paid off since we now know that we can make a secure line even in difficult terrain.

Figure 1. View of the first prescribed fire in Fageråsen Nature Reserve, Sundsvall commune, on 14 June 2006. The fire size was 7 ha and aimed at restoring the forest to a more "natural condition" with the main objective to kill surplus spruce trees. Photo: T. Rydkvist.

Figure 2. Same prescribed burn as in Figure 1: A low-intensity surface fire. Photo: T. Rydkvist.

Figure 3. Second prescribed fire in Fageråsen Nature Reserve, 5 July 2007. The objective of this burn was to reduce the number of living trees per hectare by at least 50%, targeting spruce. The fire had to be intense enough to kill of the spruce trees but low enough to keep the pines alive. Photo: T. Rydkvist.

Figure 4. This picture was taken one week after the second prescribed fire in Fageråsen Nature Reserve. In moist areas of the burn site the ground is dry enough to burn just around the trunk of the trees due to the fact that the canopy has protected the ground from rain. Spruce trees in this kind of moist environment cannot be killed with a high-intensity fire. The ignition of the fuelbed close to the trunk will start a smoldering fire that will kill the trees, which will fall over with the first heavy winds after the burn. Photo: T. Rydkvist.

Figure 5. One day after the Fageråsen 2007 fire the results of expected mortality of spruce can already be assessed. This permanent observation plot was established on a site with a stocking density of more than 900 trees per hectare. Photo: T. Rydkvist.

Chapter 5

We have tested fire-fighting additive like foam, gel, and various types of wet-water (Rydkvist, 2007a), to strengthen fire breaks but also to protect important features. We must cope with the demand to protect important features like old pine trees with fire-scars, snags, high stumps and old stumps with fire scars. These kinds of features are not only important to various species (Lowe, 2006), but they are also important for historical reasons and as a vital ingredient in a fire prone forest.

Since there has been an almost disturbance free period of more then 120 years, many of the trees, snags and stumps that have fire scars have become rotten and therefore very sensitive to fire. We must therefore put a lot of effort in securing many of these features during prescribed fire. Since one of our objectives with burning is to produce more injured trees and creating more fire scars, causing the pines to produce resin, it would be foolish to leave those we already have to waste because of bad planning or bad performance. We must conduct a thorough assessment and take coordinates of important features with a GPS, thus producing a map of "Features at Risk". The Ignition Specialist (person in charge of firing technique and pattern) carries a GPS and can easily check what is coming ahead on the fire field and then alter the ignition pattern if necessary to reduce the risk of consumption. During the hole 20th century there hasn't been any disturbance that could cause the pines to produce resin-impregnated wood, something we believe is very vital to a number of species especially wood-living fungi. Mid Sweden University's research project (se above) includes a decay experiment in which burned and unburned substrate requirements for selected fungal species will be studied at laboratory. Both common and red-listed fungal species will be used. The aim is to search for fire dependent wood fungal species. In the experiment resin- impregnated and charred wood will be used. Differences between species ability to decay different wood types is a first sign to species adaptation to a certain wood type. Further, in combination to the laboratory experiment, they will establish field sample plots at our burns. The expected results will show the importance of fire created wood for common and red-listed wood fungi and the importance of fire disturbance for creation of different wood types.´

This means that we have to plan to use prescribed fire in young stands and burn them in a way that will injury them but keeping them alive and thus produce resin to defense themselves against fungus and insects.

In the near future we are also planning to conduct a prescribed fire in a spruce dominated stand (Granström, 2007) with the sole purpose of a stand replacing fire. Hopefully we will be able to trigger a succession dominated by deciduous trees, which has become very rare in Sweden (Granström, 1996). We are going to increase our collaboration with our neighboring county of Jämtland, since we are going to write a joint strategy on prescribed fire and fire use in protected areas, which covers both counties. We will work very close together when it comes to education, training and actual burning procedures. We must use our equipment in the best way and this is probably best if we do it in an even larger area than in one county. Both counties have the will to boost up the area burned annually and to burn a variety of stand types in order to create as much heterogeneity as possible (Kuuluvainen et al., 2002). We do believe that we can reach this goal much easier if we do it together.

IFFN contribution by

Mr. Tomas Rydkvist
Nature Conservation Office
County Administrative Board of Västernorrland
Pumpbacksgatan 19
Härnösand
Sweden

e-mail: Tomas.Rydkvist@y.lst.se

and

Mrs. Anna-Maria Eriksson
Department of Natural Sciences, Engineering and Mathematics
Mid Sweden University
Holmgatan 10
Sundsvall
Sweden

e-mail: Anna-Maria.Eriksson@miun.se

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