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Forest management and biological conservation in old pine forests

A long-term field experiment at Effaråsen in Sweden
Part 1 2012-2018






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Summary

In 2012, The Forestry research institute of Sweden (Skogforsk) initiated together with the Swedish Forest Agency, Stora Enso Skog AB and the landowner Bergvik Skog AB a long-term study with the aim to evaluate trade-offs between biodiversity conservation and forest production in old pine forest. The field experiment is called Effaråsen and is located close to Mora in the province of Dalarna in the southern boreal vegetation zone of Sweden (central point, 600 N, 140 E, 350-400 m above sea level). Effaråsen is a relatively homogenous forest area dominated by Scots pine (Pinus sylvestris L.) with a tree age of approximately 120 years and with some much older trees. The 24 forest stands included in the project, adding up to an area of 140 hectares, are each treated with different levels of partial cutting and amount and type of environmental consideration. Thus, the forest stands demonstrate a gradient of management practices that ranges from a commonly practiced level of tree retention in Sweden to a very high level of retention. Included are also burnt areas, with or without partial cutting and untreated (i.e. without any burning or cutting) areas which represent control areas.

Baseline data include number and volumes of harvested and retained living and dead trees, logging performance, stand characteristics and species occurrence. Data on species occurrences has been recorded for wood-inhabiting fungi, mycorrhiza fungi, lichens and insects (including also pest insects). Harvesting data i.e. timber volumes, logging performance and opportunity cost constitutes the base for the economic analysis. The effects of a variety of conservation measures on forest biodiversity and on forest production will be followed for at least two decades.

In year 2014 an information project was initiated and includes three components: a website, a map-journal and a demonstration path in the forest of Effaråsen. The path runs through 10 forest stands of Effaråsen and seven information boards were produced and set up along the path. The purpose is to disseminate knowledge on the forest's environmental values and how it can be preserved and to demonstrate different forest management regimes with small or large conservation efforts. In addition, a virtual version of the forest path was made for the website www.skogskunskap.se. The website provides information about the ongoing research project.

Background

In recent years there has been much debate concerning the pine forest's conservation values and future management. Pine forests in Fennoscandia typically grow on relatively poor soils in harsh climate and have long generation times. Temporal dynamics and species turnover are slow in the absence of disturbances. The boreal pine forest is regarded as an ecosystem particularly dependent on disturbance to maintain its natural structure and diversity, with fire being the main disturbance factor historically (Angelstam 1998, Wardle *et al.* 2003, Granström 2001). Much of the values related to biological diversity in pine forests are associated to the living roots of the trees in the soil and the old coarse dead wood. In recent decades, there has been an increasing interest in the importance of dead wood and decaying trees for maintaining biodiversity in forest ecosystems. In Sweden approximately 6500 species, which is 26% of all forest species, are dependent on dead wood supply (de Jong & Almstedt 2005). Many forest species are negatively affected by forestry mainly due to the extraction of trees which results in a loss of habitat quantity, quality and dynamics (see for example Fridman & Walheim 2000; Siitonen 2001; Gibb *et al.* 2005).

During the latest 25 years there has been extensive research on tree retention and biodiversity conservation. However, in this context, the pine forest is a highly neglected forest type, with few experimental studies compared to other tree species in Northern Europe. Retention forestry and prescribed burning are measures that have been suggested and used to alleviate the negative effects of forestry on species diversity in boreal forests. For example, retention of living trees and creation of dead wood are expected to "lifeboat" species over the generation period (Franklin *et al.* 1997). Retention measures may vary in the amount, type and spatial distribution of retained trees (dispersed or aggregated) and this is of different importance for the conservation value depending on the local context and conservation target. This management approach has emerged in the last 25 years and similarities and differences between these measures and their effects on boreal forest biota have been studied previously (Martikainen 2001; Hyvärinen *et al.* 2005; Hyvärinen *et al.* 2006), for reviews see (Rosenvald & Lohmus 2008; Gustafsson *et al.* 2010). However, studies on pine forests are clearly underrepresented (Gustafsson *et al.* 2015) and the spatial distribution of the restoration efforts have been given little attention, (but see: Ranius *et al.* 2011; Schroeder *et al.* 2006). Moreover, conservation measures may negatively affect regeneration. High levels of tree retention will affect both area for regeneration and growth of seedlings and may thus hamper sustainable high wood production. Scientific evidence and practical experience on the magnitude of such production losses are lacking.

Evaluating alternative ways to manage pine forest is important as it raises an overarching question about how forest management can be carried out to fulfil both environmental (e.g. long-term conservation of forest biodiversity) and economic goals (i.e. high and sustainable wood production).

Skyview of Effaråsen. Foto: Lars Nylander

Objectives of the experiment

The overall aim of the Effaråsen project is to evaluate trade-offs between biodiversity conservation and forest production in old pine forest. Retention forestry is evaluated at different levels of intensity and prescribed burning and how it affects biological diversity and wood production.

Experimental design

In 2012, The Forestry research institute of Sweden (Skogforsk) initiated a long-term study in Effaråsen close to Mora in Dalarna. The area of Effaråsen encompasses a total of 24 forest stands (mean size of 5 ha) adding up to 140 ha of old pine forest:

- **Final felling with retention**: 12 forest stands represents a system with partial felling with different amount of green-tree retention including dead and dying wood creation. These stands represent a gradient ranging from very low retention (c. 3 %) to very high retention (c. 50 %). Depending on the purpose of the different subprojects, the stands can be grouped differently and hence represent a minimum of 3 repetitions of each retention level. The cutting was conducted in the winter of 2012-2013.
- **Simulated fire treatment**: 3 forest stands represent an alternative to prescribed burning i.e. the harvester machine created lying and standing dead wood and girdled trees (i.e. slowly dying trees) to mimic a disturbance, such as fire. No wood was extracted.
- **Prescribed burning**: 6 stands were burnt of which 3 were harvested (c. 50 % of standing volume) before burning. Prescribed burning of forest areas were made in the summer of 2013.
- **Control areas**: 3 forest stands without any burning or cutting.

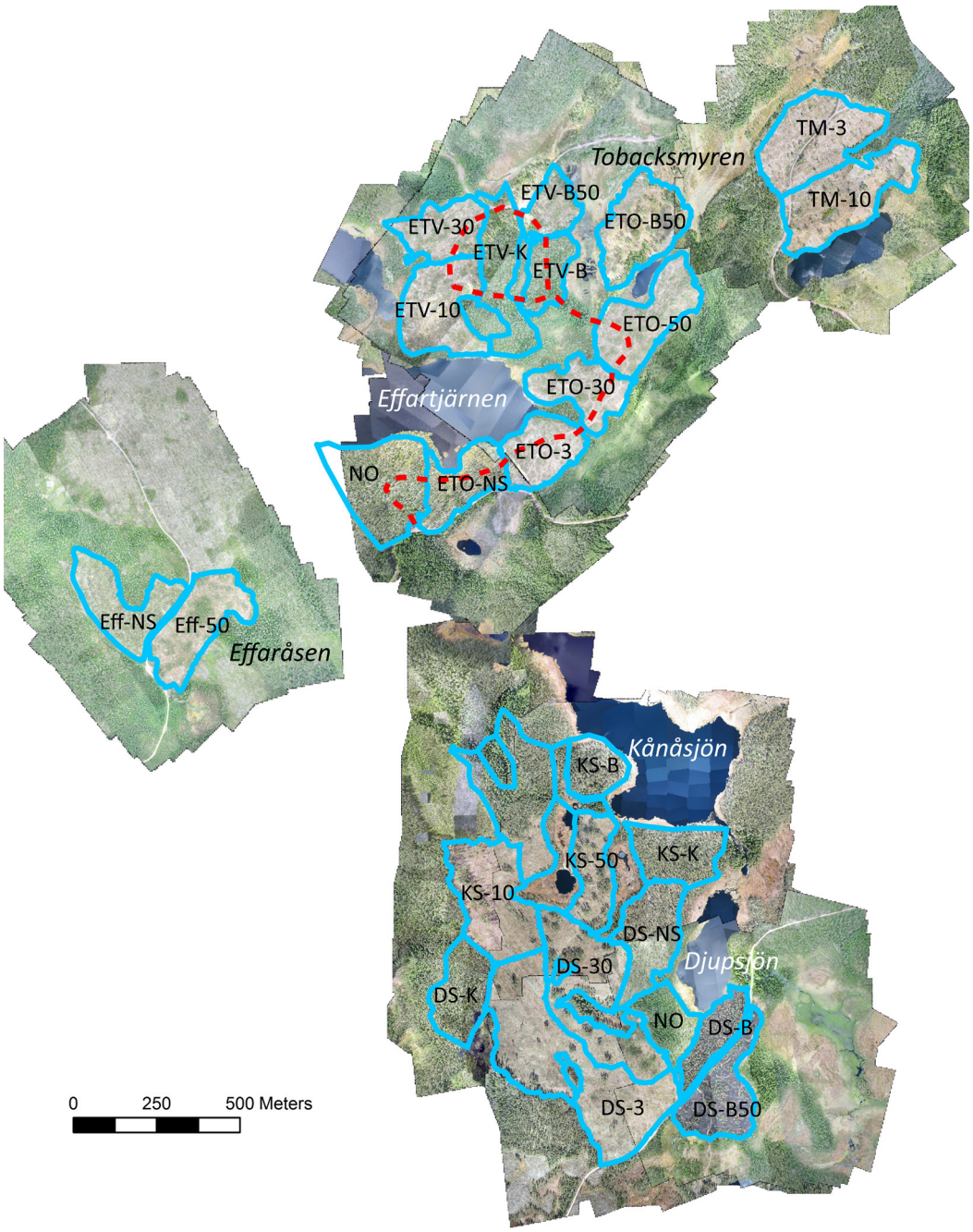

Figure 2. Effaråsen and its different stands and different treatments, se table 1 for explanation. The red dotted line is the location of the educational forest trail (Figure 3).

Table 1. Descriptive data of the 24 forest stands. ID represent stand name and indicate position in the landscape and treatment. DS- stands for Djupsjön, Eff- Effaråsen, ETO- Effartjärnen east, ETV- Effartjärnen west, KS- Kånåsjön, TM- Tobacksmyren (see figure 2).

	ID	Altitude (m a.s.l.)	Area (ha)	Stand age (yr)	Fertilized (yr)	Stems n/ha	Treatment
1	DS-30	376	8.9	117	1992, 2000	490	Harvest with 30 percent retained
2	DS-3	378	14.2	117	1992, 2000	488	Harvest with 3 percent retained
3	DS-NS	374	5.0	117	1992, 2000	475	Created dead and dying wood
4	DS-B50	374	5.6	134	1992, 2000	401	Burnt with 50 percent harvest
5	DS-K	377	4.1	117	1992, 2000	636	Control area
6	DS-B	368	3.2	100	1992, 2000	446	Burnt
7	Eff-50	391	5.7	111	1992	411	Harvest with 50 percent retained
8	Eff-NS	385	4.9	111	1992	312	Created dead and dying wood
9	ETO-30	385	4.0	121	1992	414	Harvest with 30 percent retained
10	ETO-3	382	4.1	108	1992	212	Harvest with 3 percent retained
11	ETO-50	389	5.5	121	1992	375	Harvest with 50 percent retained
12	ETO-NS	380	4.0	108	1992	395	Created dead and dying wood
13	ETO-B50	389	5.5	121	1992	470	Burnt with 50 percent harvest
14	ETV-10	378	5.9	137	1992	283	Harvest with 10 percent retained
15	ETV-30	388	3.9	137	1992	316	Harvest with 30 percent retained
16	ETV-B50	393	3.0	137	1992	297	Burnt with 50 percent harvest
17	ETV-B	390	2.8	137	1992	511	Burnt
18	ETV-K	391	5.6	137	1992	264	Control area
19	KS-K	368	4.2	128	1992, 2000	664	Control area
20	KS-B	366	2.3	156	No fertilizing	259	Burnt
21	KS-10	391	7.4	117	1992, 2000	488	Harvest with 10 percent retained
22	KS-50	370	3.9	117	1992, 2000	449	Harvest with 50 percent retained
23	TM-10	402	7.7	134	1982, 1992	422	Harvest with 10 percent retained
24	TM-3	405	7.2	134	1982, 1992	539	Harvest with 3 percent retained

Sub-projects

Sub-project	Time period	Status
Effects of partial cutting on logging productivity, economic returns and dead wood in boreal pine forest	2012-2013	Publication: Santaniello *et al*. 2016 and Djupström L. & Weslien J. 2016
Preservation of old dead wood	Post-harvest: Juli-Sept. 2014 Pre-soil preparation: May-June 2016	Publication: Santaniello *et al*. 2016 and Weslien & Westerfelt 2017
Simulated long-term effects of varying tree retention on wood production, dead wood and carbon stock changes.	2016-2017	Publication: Santaniello *et al*. 2017a
Climate impact of retention forestry in a Swedish boreal pine forest	2017-2018	Publication: Cherubini *et al*. 2018
Large proportion of wood dependent lichens in boreal pine forest are confined to old hard wood	Sept. 2014	Publication: Santaniello *et al*. 2017b
Wood dependent fungi	2012 and 2013	Publication: Kirppu 2012 & 2013 (in Swedish) and ongoing project
Effect of varying tree retention on mycorrhizal community	Before treatment, Dec. 2012 and May 2013 and after treatment Sep 2017	Ongoing
Community and richness of wood dependent beetles in dead wood after felling	2014-	Ongoing
Pest insects- effect of varying tree retention	2013-2014-	Ongoing
Regeneration in pine forest with varying tree retention	2016-	Ongoing
Prescribed burning and the development of dead wood and effect on flora and fauna	2015-	Ongoing
Information project – Educational forest trail	2014-	www.skogskunskap.se

Educational forest trail

The demonstration trail, which is approximately 2.3 km long and runs through ten forest stands, is possible to visit with or without excursion leaders. In September 2014, seven information boards were produced and set up along the forest trail (Figure 3). The boards contain information about the project and about the different management strategies that has been practiced.

Figure 3. Forest trail, coordinates: 60°58'30.8"N 14°01'44.7"E

Participating organisations, scientist and students

Effaråsen is a collaboration project between Skogforsk, the Swedish Forest Agency, Stora Enso and the landowner Bergvik Skog (one of Sweden's biggest forest companies). The project in Effaråsen is one of few studies that covers a broad range of management strategies which also is practiced and demonstrated with entire forest stands.

OTHER COLLABORATIONS

The Swedish University of Agricultural Sciences (SLU), Uppsala

The County Administrative Board of Dalarna County (Länsstyrelsen, Dalarna)

Industrial Ecology Programme, Department of Energy and Process Engineering, Norwegian University of Science and Technology (NTNU), Trondheim, Norway

PHD STUDENTS

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Slingans start. Följ slingan på webben: https://www.skogskunskap.se/planera-skogsbruk/demonstrationsytor/effarasen---malbilder-for-miljohansyn/demonstrationsslingan-start/

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