Master’s Thesis

Pre-emptive logging under the risk of land use restrictions

Kalle Salovaara

University of Jyväskylä

Department of Biological and Environmental Science

Ecology and evolutionary biology

5.4.2019

JYVÄSKYLÄN YLIOPISTO, Matemaattis-luonnontieteellinen tiedekunta
Bio- ja ympäristötieteiden laitos
Ekologia ja evoluutiobiologia

Kalle Salovaara:	Tekevätkö maanomistajat aavistushakkuita maankäytön rajoitusten välttämiseksi?
Pro gradu -tutkielma:	25 s.
Työn ohjaajat:	FM Eini Nieminen, Dos. Panu Halme ja Prof. Janne Kotiaho
Tarkastajat:	Dos. Atte Komonen ja FT Kyle Eyvindson
Huhtikuu 2019	

Hakusanat: elinympäristöjen tuhoutuminen, luonnonsuojelu, luonnon monimuotoisuus, soidensuojelu, suo

Korkealla luonnon monimuotoisuudella on havaittu olevan positiivinen vaikutus ekosysteemipalveluihin, ja siksi monimuotoisuuden vähenemisen pysäyttäminen on tärkeää ihmiskunnalle. Elinympäristöjen tuhoutumisen on arvioitu olevan suurin uhka maapallon monimuotoisuudelle, sillä se pienentää eliöiden elintilaa ja lisää reunavaikutusta sekä maiseman pirstoutumista. Elinympäristöjen tuhoutumista voidaan estää luonnonsuojelutoimilla, ja yksityisillä maanomistajilla voi olla merkittävä rooli suojelutavoitteiden saavuttamisessa. Monet maanomistajat eivät kuitenkaan ole halukkaita suojelemaan uhanalaisia lajeja tai elinympäristöjä maillaan, ja osa myöntää heikentäneensä monimuotoisuusarvoja jopa tarkoituksella. Tällaisia epäilyksiä on esitetty mm. puunkorjuusta ekologisesti arvokkaissa metsissä – ilmiö, jota kutsutaan aavistushakkuuksi. Aavistushakkuu-termillä viitataan hakkuuseen, jonka maanomistaja tekee silloin, kun jokin taho suunnittelee suojelualueen perustamista hänen maillensa. Hakkaamalla metsänsä maanomistaja pystyy vähentämään omistamansa kohteen suojeluarvoja ja näin välttymään suojelupäätökseltä sekä siihen liittyviltä maankäytön rajoituksilta. Tutkin, tekivätkö suomalaiset maanomistajat aavistushakkuita korvissa ja rämeillä vuoden 2013 jälkeen, jolloin heille oltiin tiedotettu, että heidän puustoiset suonsa ovat kandidaattikohteita soidensuojelun täydennysehdotuksessa (SSTE). Yhdistin Metsäkeskuksen avoimet metsävarojen ja metsänkäyttöilmoitusten paikkatietoaineistot kaikkien Suomen korpi- ja rämekohteiden osalta, ja vertasin näiden hakkuuasteita SSTE:n kandidaattikorpien ja -rämeiden hakkuuasteisiin vuosien 2013–2018 välillä. Hakkuuaste oli 9,6% korpikandidaattikohteilla ja 13,1% rämekandidaattikohteilla, kun taas vastaavat hakkuuasteet kaikilla muilla Suomen korpi- ja rämekohteilla olivat merkitsevästi korkeammat: 18,3% ja 18,5%. Tulokset osoittavat, että maanomistajien informointi potentiaalisista maankäytön rajoituksista ekologisesti arvokkailla puustoisilla soilla vaikuttaa keskimäärin suojaavan kyseisiä kohteita hakkuilta. Kuitenkin osa kandidaattikohteista hakattiin huolimatta siitä, että maanomistajat tiesivät potentiaalisista suojeluarvoista. Osa maanomistajista saattoi siis aavistushakata omistamansa kohteen. Toisaalta on myös mahdollista, että he pitäytyivät alkuperäisissä hakkuusuunnitelmissaan jättäen potentiaaliset suojeluarvot huomioimatta.

UNIVERSITY OF JYVÄSKYLÄ, Faculty of Mathematics and Science
Department of Biological and Environmental Science
Ecology and evolutionary biology

Kalle Salovaara: Pre-emptive logging under the risk of land use restrictions
MSc thesis: 25 p.
Supervisors: M.Sc. Eini Nieminen, Doc. Panu Halme and Prof. Janne Kotiaho
Inspectors: Doc. Atte Komonen and Ph.D. Kyle Eyvindson
April 2019

Search words: biodiversity, conservation, habitat loss, landowner, mire, peatland

High biodiversity is associated with positive effects on ecosystem services, so the decreasing trend of biodiversity is important to halt. Globally, habitat loss has been estimated to be the biggest threat to biodiversity, reducing the amount of living space of organisms and increasing edge effect and landscape fragmentation. Habitat loss can be avoided by establishing protected areas, and private landowners have an important role in reaching conservation goals. However, many landowners are unwilling to conserve threatened species and habitats on their land, and some have even admitted to damaging them on purpose. One anecdotal accusation of such behavior concerns deliberate timber harvesting in ecologically valuable forests – a phenomenon called pre-emptive logging. Pre-emptive logging refers to the loggings, which landowners execute when an external party aims to establish a protected area on their land. By logging their forests, landowners can reduce biodiversity values of those habitats and avoid protection. I studied whether landowners in Finland engaged in pre-emptive logging in spruce and pine mires after they were informed in 2013 that their forested mires are candidate sites for the Proposal for Supplemental Mire Conservation (PSMC). I combined the Finnish Forest Centre's open spatial forest resource data and forest use declaration data for all spruce and pine mires with mature tree cover in Finland and compared their harvesting rates to the harvesting rate of the PSMC candidate spruce and pine mires between 2013 and 2018. Harvesting rates for the candidate spruce and pine mires during the five years were 9.6% and 13.1%, respectively. These rates were significantly lower compared to the respective harvesting rates of 18.3% and 18.5% for all other spruce and pine mires in Finland. Thus, informing landowners about prospective land use restrictions on their ecologically valuable forested mires seems on average to safeguard the mires from logging. However, some of the forested candidate mires were logged regardless of the information about their biodiversity values, implying that some landowners either engaged in pre-emptive logging or retained their normal harvesting plans, disregarding the information about the potential biodiversity values.

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Biodiversity and habitat loss

Biodiversity is considered to have three levels; genetic diversity, species diversity, and ecosystem diversity (Gaston 2000). Genetic diversity refers to the genetic variation of a species, species diversity refers to the number of species, and ecosystem diversity refers to the variation in ecosystems in which species live. Biodiversity has a major role in the functioning of ecosystems. Organisms can influence the physical formation of new habitats, the productivity of ecosystems, and the fluxes in biogeochemical cycles (Cardinale et al. 2012). The loss of an organism or group of organisms can significantly alter the structure and functioning of an entire ecosystem, especially if they serve as keystone species.

Ecosystems provide so-called ecosystem services, which refer to different kinds of material and immaterial benefits humans can get from nature (Costanza et al. 1997). Natural resources such as wood, water and foodplants, as well as climate-altering processes such as carbon sinks are examples of different ecosystem services (Cardinale et al. 2012). High biodiversity has been associated with positive effects on many crucial ecosystem services, and the decrease of biodiversity can have severe consequences on both humans and the rest of the biota. Thus, it is important to halt the decreasing trend of biodiversity.

Habitat loss can have large, consistently negative effects on biodiversity, and it has been estimated to be the biggest threat for biodiversity (Fahrig 2003, Newbold et al. 2016). It typically happens as a result of degradation of habitat quality or decrease of habitat area, caused by numerous deliberate human activities such as conversion of land for agricultural and infrastructural needs (Hanski 2011). Furthermore, humans cause a lot of unintentional damage by increasing edge effects with decreasing area and increasing fragmentation of habitats, leading to reduced connectivity. These changes can cause various harm to the biota in the form of genetic, evolutionary, and ecological consequences. However, habitat loss can be avoided by establishing protected areas. Restricting land use in ecologically important habitats protects their biodiversity values.

1.2 Mire destruction in Finland

Finland has utilized mires much more intensively than other countries in northern latitudes, which has mostly been the result of an attitude that mires are worthless if they are not managed and converted for human use (Lindholm and Heikkilä 2006). Forestry is considered the greatest threat to Finnish mire ecosystems, as over half of the total mire area in Finland has been ditched for forestry use, focusing especially on forested mires (Kontula and Raunio 2018). Additionally, the construction of forest roads has had significant effects on nearby mires, serving as dams which disrupt local water flow (Lindholm and Heikkilä 2006). Agriculture and peat extraction are other important human activities that have destroyed many mire habitats in Finland (Alanen and Aapala 2015).

As a result of these human activities, over half of mire habitat types in Finland were classified as threatened at a national level in the latest assessment of threatened habitat types (Kontula and Raunio 2018). Many formerly dominant mire habitats have become less abundant, and some important characteristics have widely disappeared, such as ecotones between mires and forests (Heikkilä 1993). The effects have been strongest in southern Finland, where few functioning mire ecosystems now exist outside of nature reserves (Lindholm and Heikkilä 2006). The remaining mires have been fragmented, decreasing the number and area of viable habitats for many mire species, and increasing isolation between those habitat patches (Kallio and Aapala 2001). Additionally, human-caused regional changes in hydrology have also affected many of the undrained mires, degrading the quality of their habitats.

1.3 Forested mires in Finland

Finnish forested mires can be divided into two categories: spruce mires and pine mires. Spruce mires are forested mires that are mostly dominated by Norway spruce (*Picea abies*). They commonly have a long forest continuum and uneven-aged tree stand structure (Hörnberg et al. 1995). Spruce mires can be important hotspots for species biodiversity owing to their typical location in the ecotones of mires and forests or mires and waterbodies, often having features from surrounding habitats (Kontula and Raunio 2018). Similarly, small-scale variation in hydrotopographical patterns, and microclimates formed by the shadowing of trees, increase the biodiversity of spruce mire ecosystems, providing a multitude of ecological niches. (Hörnberg et al. 1998, Kontula and Raunio 2018). Spruce mires are especially important habitats for many endangered liverworts and lichens (Rassi et al. 2010). In the most recent assessment of threatened habitat types, 22 out of 23 spruce mire habitat types were red-listed in Finland (Kontula and Raunio 2018).

Pine mires are forested mires that are mostly dominated by Scots pine (*Pinus sylvestris*). Tussocks, relatively unfertile soil and a thick peat layer are other typical characteristics of pine mires, and their field layer is commonly covered by various shrubs, while sedges and grasses are usually less diverse (Kontula and Raunio 2018). Pine mires are important habitats for many endangered insects, especially butterflies (Rassi et al. 2010). In the most recent assessment of threatened habitat types, 4 out of 14 Finnish pine mire habitat types were red-listed (Kontula and Raunio 2018).

1.4 Landowners' attitudes towards conservation

Landowners have varying attitudes towards conservation, which can be influenced by, for example, aesthetic preferences, economic considerations, parcel size, and various social factors (Brook et al. 2003). Landowners who prefer clean and tidy landscapes have been less likely to adopt conservation practises than those who value views of nature, animals, and forests (Benson 1991, Carr and Tait

1991). It is also more likely that landowners protect their land when conservation has economic benefits as opposed to economic costs (Benson 1991, McCann et al. 1997). Parcel size has been shown to have a positive correlation with conservation willingness if landowners believe their actions are important or they can afford to take more economic risks (Fortmann and Huntsinger 1989). However, if landowners believe they have more to lose, they are less likely to adopt conservation practises (McCann et al. 1997). Conflict, distrust and lack of communication between landowners and different conservation organisations has also been shown to have a negative effect on conservation willingness (Peterson and Horton 1995). Furthermore, some landowners have criticized conservation from a cultural point of view, referring to traditions of making a living from nature (Paloniemi and Tikka 2008). The decrease of biodiversity is also unlikely to affect landowners' everyday life and may thus seem of little importance to them (Jokinen 2002).

Private landowners play an important role in reaching conservation goals (Knight 1999). Many landowners would be able to help endangered species and habitats via conservation, restoration, or improvement of habitats, but few are willing to act (Wilcove et al. 1996). In Finland approximately 60% of forests in forestry use are owned by private landowners (Metsäyhdistys 2016). A study in 2008 surveyed Finnish landowners' views and experiences on conserving biodiversity, and how compatible they were with national conservation policies (Paloniemi and Tikka 2008). Only 15% of landowners participating in the study expressed willingness to protect their land, whereas two thirds expressed no willingness, or thought their land to be without conservation values. Similarly, in another Finnish study published in 2004, almost two thirds of landowners thought that the current level of conservation based on land expropriations was adequate, whereas a fifth considered it too high (Metsäntutkimuslaitos 2004). Property rights and self-determination are considered very important, and thus conservation methods that are either more flexible or voluntary were preferred over land expropriations (Metsäntutkimuslaitos 2004). Collaborative conservation methods that take landowners' preferences in consideration lead into more easily acceptable results

(Paloniemi and Tikka 2008), as landowners are often hostile towards outside interventions on land use matters (Napier and Camboni 1988).

Private landowners are sometimes blamed for intentionally destroying biodiversity values in order to prevent land use restrictions, which nature conservation would cause. Brook et al. (2003) studied landowners' conservation attitudes in the United States, concerning an endangered rodent *Zapus hudsonius preblei*. Approximately half of the landowners forbade inventories of the species on their land, and 14% of landowners admitted to deliberately harming the species' habitat. Another study in the US investigated landowners' forest harvesting practices to avoid costly land use restrictions caused by the Endangered Species Act, which prohibits killing endangered species and damaging their habitats (Lueck and Michael 2003). It was found that a plot's proximity to a habitat colonized by an endangered red-cockaded woodpecker (*Leuconotopicus borealis*) increased the probability of the plot getting harvested, while also decreasing the age at which the plot was harvested. This implies that landowners destroyed habitats pre-emptively. Some other cases of pre-emptive behavior have also been reported (e.g. Gidari 1994, Innes 2000).

Private landowners are in control of their resources and thus have an advantage over agencies that plan to restrict land use (Lueck and Michael 2003). This enables landowners to pre-empt land use restrictions. An example of pre-emptive behavior is pre-emptive logging, which concerns timber harvesting in ecologically valuable forests. It refers to a logging, which landowners execute when an external party aims to establish a protected area on their land. By logging their forests, landowners can reduce the existing biodiversity values and thus avoid land use restrictions that protection would cause. The phenomenon has been discussed and even encouraged in the Finnish media (e.g. Metsäblogi 2012, Demokraatti 2014, Tripodien Aika 2016, Maaseudun Tulevaisuus 2017), but it has not been scientifically studied in Finland, and thus no previous scientific evidence exists for or against it.

1.5 The Proposal for Supplemental Mire Conservation

The conservation of Finnish mire ecosystems is regionally uneven (Kaakinen and Salminen 2006). The preparation of the Proposal for Supplemental Mire Conservation (PSMC) began in the autumn 2012 when the Ministry of the Environment appointed a working group to determine all Finnish mires of nationally important biodiversity values (Alanen and Aapala 2015). The working group was tasked with making a proposal for supplementing the network of protected mires and increasing the area and connectivity of protected mire ecosystems, and to come up with a plan to execute the proposal in practice (Alanen and Aapala 2015). Although the PSMC is unlikely to actualise in the near future due to changes in environmental politics during the past years, it can be considered a prime example of a situation where Finnish landowners may have engaged in pre-emptive logging on their land.

1.6 Study questions

The goal of this study was to investigate whether the harvesting rates of the PSMC candidate spruce and pine mires differed from the harvesting rates of other spruce and pine mires in Finland. The PSMC candidate mires are the mires proposed for protection by the PSMC working group. Based on comments in the Finnish media (e.g. Metsäblogi 2012, Demokraatti 2014, Tripodien Aika 2016, Maaseudun Tulevaisuus 2017), I hypothesised that the harvesting rates of the forested PSMC mires would be higher than the respective harvesting rates of other forested mires, which could imply that pre-emptive logging is a true phenomenon. Furthermore, I studied whether the regional harvesting rates on the PSMC mires correlate with associated landowners' resistance to protection on those mires, to see if landowners' attitudes towards conservation is related to the harvesting rates. The wider aim of the study was to generate more information about landowners' conservation behaviour under the risk of land use restrictions, which is important when trying to optimise conservation methods and predict their success.

2 METHODS

2.1 Describing the data

I used four sets of spatial data, which I viewed and processed using the geographic information system program ArcMap 10.5.1. The first two datasets, forest use declaration data and forest resource data, were downloaded from the Finnish Forest Centre’s webpage (https://www.metsaan.fi/).

According to the 14 § of the Finnish Forest Act, a forest use declaration must be submitted no later than ten days before an operation is started at a forest stand (Finnish Forest Centre, 2018). In the forest use declaration, a landowner declares the forest stand that is planned for logging, states the purpose of the logging, and describes some general properties of the land, such as area, forest development class, and habitat type. The forest use declaration data contained all the information written into the submitted forest use declarations, as well as the date the declaration arrived.

The forest resource data contains more extensive information on the properties of forests. It has been gathered and compiled by the Finnish Forest Centre, using both remote sensing methods and forest inventories in the field (Finnish Forest Centre, 2018). The forest inventories are repeated every ten years. The stand-based forest resource data has been generated primarily from forests owned by citizen landowners, and includes stands owned by e.g. municipalities or parishes only if they have signed up to the Finnish Forest Centre’s online service, to which the forest use declarations are mostly submitted.

The third and fourth datasets concerned the PSMC candidate sites and were provided by the Ministry of the Environment. The third one was the location data of the spruce and pine mires that were candidate sites for protection in the PSMC. The working group designing the PSMC chose the candidate mires based on inventories done in the field (Alanen and Aapala, 2015). The fourth dataset consisted of regional county-level data of landowners' percentual resistance to mire protection.

2.1 Processing the data

The forest use declaration data contained all declarations, which landowners had submitted through the Finnish Forest Centre's online service. Respectively, the forest resource data contained all forest stands that had been digitized into the Finnish Forest Centre's open spatial data. However, only forest development classes of advanced thinning stands and mature stands with a habitat type classification of spruce or pine mire were relevant to the study question. I focused solely on the forested mires of those two development classes, as they are the most attractive mires for logging because of their economic value. Because the forest development class and habitat type information were absent from many stands in the forest use declaration data, I complemented it by uniting it with the forest resource data, which is more complete in terms of the properties of forests. However, the union of the two datasets resulted in a high number of so-called sliver stands, which I dissolved to form larger stands based on their habitat type. Following the union, I split the created data according to the habitat type: spruce mires and pine mires. Furthermore, all stands with development classes other than advanced thinning and mature stands were removed from both spruce and pine mire data, resulting in two sets of data consisting of all recorded mature spruce and pine mires in Finland.

The spatial data for the PSMC candidate sites did not specify the forest development classes or the exact locations of the spruce and pine mires within the sites. Instead, the whole site was classified as a spruce mire or pine mire if there was at least one such habitat somewhere within the site, even if most of the site consisted of other habitat types. Therefore, I had to use the Finnish Forest Centre's datasets to locate the forested mires. However, the forest use declaration and forest resource datasets did not cover all the PSMC candidate sites, so I clipped the missing parts out of the candidate sites, excluding all such areas that I could not confidently classify as mature spruce or pine mires. As a result of these steps, the total area of the studied PSMC candidate sites was 10 718 hectares, out of the 325 377 hectares in the original PSMC candidate site data.

To study the area of logged forests in spruce and pine mires since the introduction of the PSMC, I selected all stands for which forest use declarations had been submitted between January 2013 and June 2018 or the period during which landowners had been aware of the conservation plans. However, some stands had more than one forest declaration submitted for them between years 2013–2018, in which case I only accounted for the most recent declaration. To prevent the data from becoming too small, I also included forest use declarations submitted for all types of operations, including stands where the operation information was missing. In order to separate the number of hectares cut on the PSMC sites and on all other sites, I split both datasets into two new ones, the one including the cut area within the PSMC candidate sites, and the other the cut area within all other sites. I then used these new datasets to calculate and compare the amount of cut area within the PSMC sites and within all other sites, in proportion to the total area of each.

Data of landowners' resistance to protection was calculated from a survey that was sent to landowners of the PSMC candidate sites in 2015 by regional environmental offices (Alanen and Aapala 2015). The survey included all counties except Lapland, North Ostrobothnia, and Kainuu, and its response rate was 42%.

2.2 Data analysis

I calculated hectares for all cut and uncut spruce and pine mires, and hectares separately for the cut and uncut PSMC candidate sites and for other cut and uncut sites. Using the R (v. 3.3.0) statistics program, I allocated the number of the total cut hectares randomly to the total hectares of spruce and pine mires and replicated this 1000 times. By dividing the total cut hectares with the total hectares, I was able to calculate the harvesting rate for each replicate. I compiled the harvesting rates of the replicates into distributions to which I compared the real harvesting rates on the PSMC candidate sites, seeing whether the PSMC harvesting rates fit into the 95% confidence intervals (Figures 1 and 2). This enabled me to test whether the harvesting rates on the PSMC candidate sites could be a result of a random variation, rather than being a real phenomenon.

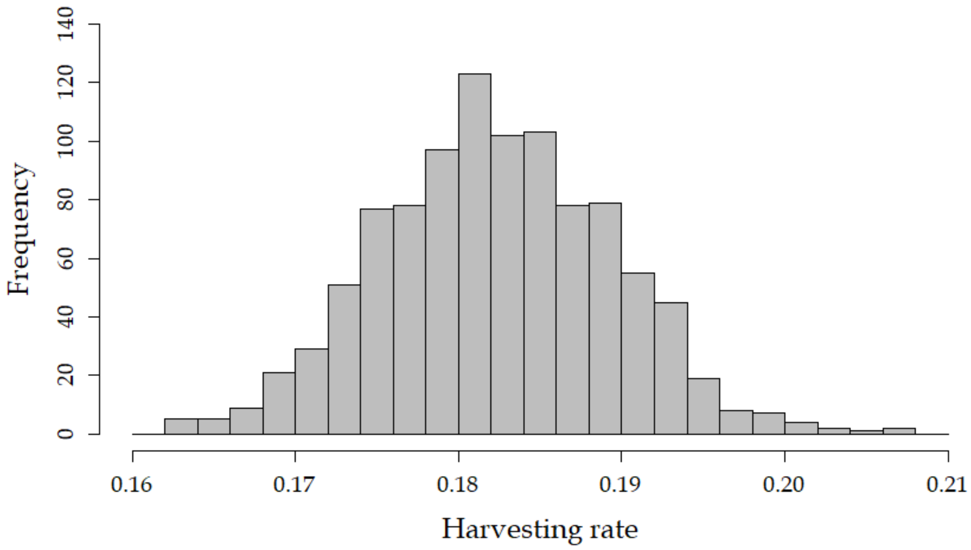

Figure 1. Spruce mire harvesting rate distribution generated from 1000 replicates.

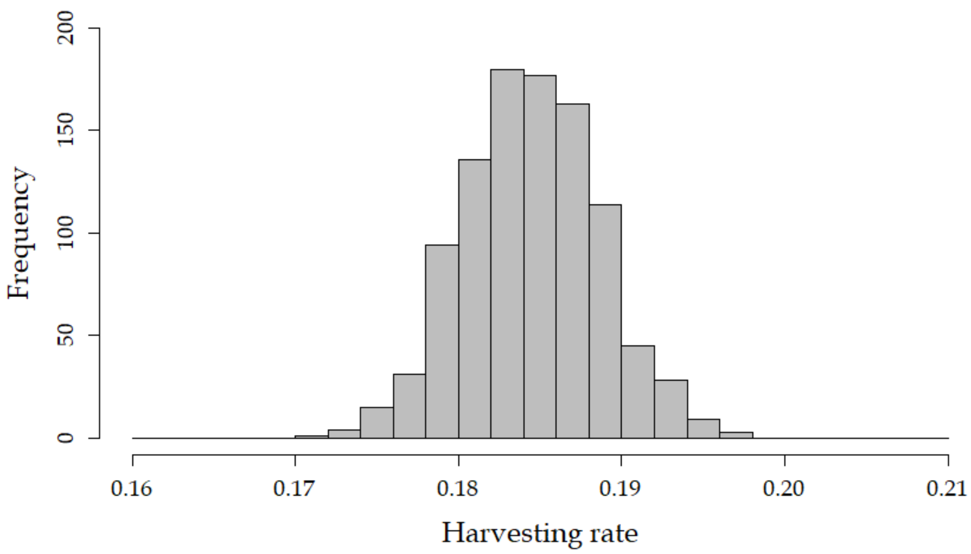

Figure 2. Pine mire harvesting rate distribution generated from 1000 replicates.

Additionally, I calculated the regional harvesting rates on the PSMC candidate sites for each county and ran a linear regression analysis with Microsoft Excel (2016) to study whether the harvesting rates correlate with the landowners' resistance to protection in each county.

3 RESULTS

On the PSMC candidate spruce mires 268 hectares of the total area was cut, and 2 527 hectares remained uncut, whereas on all other spruce mires 79 710 hectares of the total area was cut and 358 760 hectares remained uncut, respectively (Table 1). Therefore, the harvesting rate in 2013–2018 for the PSMC candidate spruce mires was 9.6%, while the harvesting rate for all other spruce mires in Finland was 18.3% (Figure 3). On the PSMC candidate pine mires 1 034 hectares of the total area was cut, and 6 890 hectares remained uncut, while the respective numbers on all other pine mires were 136 492 cut hectares and 607 048 uncut hectares. The harvesting rate for pine mires in 2013–2018 had a similar trend as spruce mires, with 13.1% of the PSMC candidate pine mires being cut, and 18.5% of all other pine mires being cut (Figure 4). The harvesting rates of the PSMC candidate spruce and pine mires did not fit into the 95% confidence interval of the generated distributions, and thus the harvesting rates were different to what one would expect if their cuts happened randomly.

Table 1. Total numbers and percentages of uncut and cut hectares on the PSMC sites and on all other sites.

	Spruce mires (ha)	Spruce mires (%)	Pine mires (ha)	Pine mires (%)
Uncut (PSMC)	2 527	90.4	6 890	86.9
Cut (PSMC)	268	9.6	1 034	13.1
Uncut (Other)	358 760	81.7	607 048	81.5
Cut (Other)	79 710	18.3	136 492	18.5

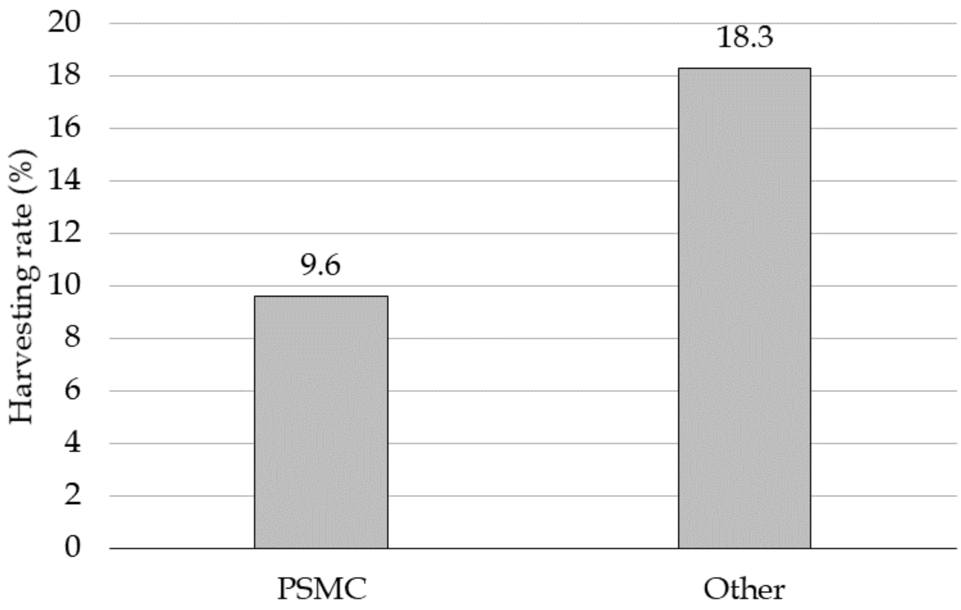

Figure 4. Harvesting rate on the PSMC spruce mires and on other spruce mires.

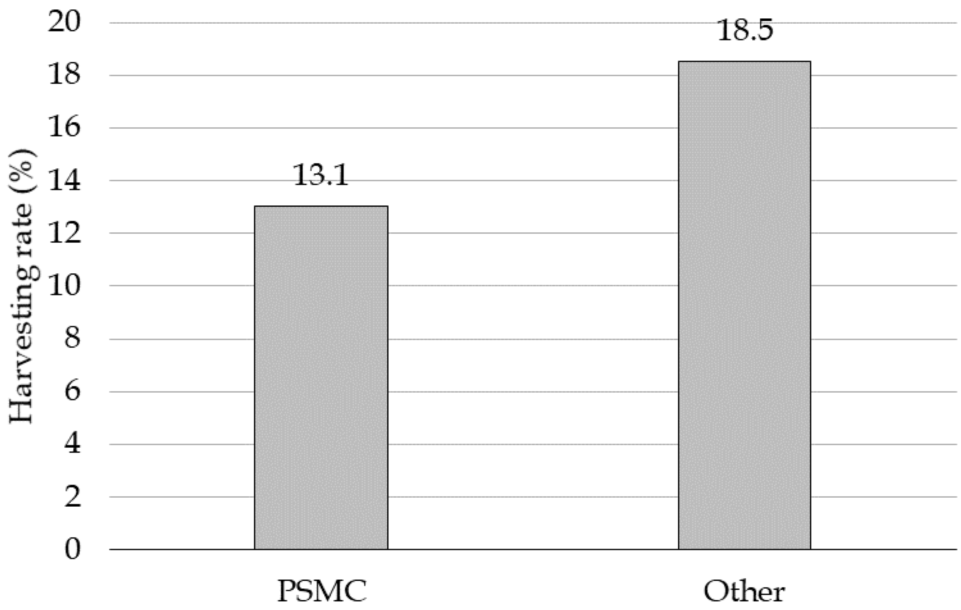

Figure 5. Harvesting rate on the PSMC pine mires and on other pine mires.

I calculated the harvesting rates on the PSMC candidate spruce and pine mires for each county (Table 2). The linear regression analysis of harvesting rates on the PSMC candidate sites and landowners' resistance to protection yielded no significant results (Table 3). The Pearson correlation coefficients were negative, being −0.38 (r^2 = 0.146, N = 10, p = 0.28) for spruce mires and −0.55 (r^2 = 0.299, N = 10, p = 0.10) for pine mires, respectively.

Table 2. Harvesting rates on the PSMC candidate spruce and pine mires and landowners' resistance to protection in each county.

	Spruce mires (%)	Pine mires (%)	Resistance to protection (%)
South Ostrobothnia	11.7	12.2	30.1
Uusimaa	4.9	9.8	25.3
Pirkanmaa	5.7	11.2	19.4
Southeast Finland	9.8	11.0	19.3
Tavastia	8.1	13.4	18.9
Finland Proper	16.4	11.0	17.8
Northern Savonia	10.5	9.6	17.7
Central Finland	15.1	16.8	12.9
Southern Savonia	23.5	13.0	12.6
North Karelia	6.4	15.6	12.3

Table 3. Pearson correlation and linear regression analysis of harvesting rates on the PSMC candidate sites and landowners' resistance to protection on spruce and pine mires.

	Correlation coefficient	r^2	N	*P*-value
Candidate spruce mires	−0.38	0.146	10	0.28
Candidate pine mires	−0.55	0.299	10	0.10

4 DISCUSSION

4.1 Implications of the results

The harvesting rates on the PSMC candidate spruce and pine mires were lower than the respective rates elsewhere in Finland. This was contrary to my initial hypothesis based on the comments found in the Finnish media (e.g. Metsäblogi 2012, Demokraatti 2014, Maaseudun Tulevaisuus 2017), and thus no systematic trend of pre-emptive logging was found. These results indicate that informing landowners about potential future land use restrictions due to the high biodiversity value of their forested mires seems to safeguard mires from logging, rather than lead to an increased harvesting rate.

Contrary to my study, the findings of Lueck and Michael (2003) indicated that prospective land use restrictions in the US based on the Endangered Species Act resulted in pre-emptive habitat destruction. However, this could be explained by differences in economic compensation relating to land use restrictions between the US and Finland. Endangered Species Act has been reported to provide little compensation for landowners (Thompson 1997), whereas Finnish landowners of the prospective PSMC candidate sites would have been compensated according to the value of land area and tree stand (Alanen and Aapala 2015). Endangered Species Act also permits fully uncompensated government restrictions on private land uses that harm the habitats of endangered species (Innes 2000), which could serve as a large incentive for pre-emptive behaviour in the US.

However, between 2013 and 2018, 9.6% of the candidate spruce mire area and 13.1% of the candidate pine mire area were cut, showing that some landowners cut their forested mires despite of the status of the PSMC candidate site. This implies that informing landowners about possible land use restrictions did not always guarantee the integrity of biodiversity values on the PSMC mires. Instead, landowners might engage in pre-emptive logging or just retain their normal harvesting plans, disregarding the information about the potential biodiversity values. Such behaviour in similar cases could explain the comments concerning pre-emptive logging found in the Finnish media (e.g. Metsäblogi 2012, Demokraatti 2014, Maaseudun Tulevaisuus 2017), even if pre-emptive logging might not be a widespread phenomenon in Finland.

Paloniemi (2008) found that Finnish landowners' resistance to protection has been decreasing over the past two decades as a result of e.g. improved legislation, growing focus on voluntariness, and increased dialogue between landowners and conservation agencies. Though the PSMC candidate sites were to be protected via land expropriations rather than voluntary methods, the offered financial compensation and the changing direction in general conservation attitudes might have resulted in lower harvesting rates on the PSMC mires than other mires. However, a survey from 2014 showed that Finnish landowners were less likely to respect rules and regulations concerning forests than ordinary citizens in cases where they did not see a point to them (Valkeapää 2014). Some landowners that disagreed with the conservation plans and the associated land use restrictions might have logged their forested PSMC candidate site mires pre-emptively.

Interestingly, there was no positive correlation between the regional harvesting rates on the PSMC candidate sites and landowners' resistance to protection. This could be explained by e.g. regional differences in the intensity of timber harvesting. South Savonia, for example, has a history of very intensive timber harvesting (Haatanen et al. 2014). It is possible that South Savonia has a particularly active forest management association that actively lobbies forest stands for logging and could thus explain the high harvesting rates despite landowners' relatively low resistance to protection in comparison to many other counties. Other factors that could affect the harvesting rates besides resistance to protection are demographic characteristics such as the age, sex, education, and income of landowners (Joshi and Mehmood 2011).

4.2 Remarks concerning the spatial data

The used spatial data by Finnish Forest Centre posed a few problems for the study. The forest use declaration data and the forest resource data differed in both area and the precision of their forest stand borders, which resulted in a high number of sliver stands following the union of the datasets. It would have been more informative to study also the number of stands in which loggings were executed instead of just the number of cut hectares, but the true number of stands was inevitably lost during the uniting and dissolving of the datasets. This problem could have been avoided if the open forest use declaration data included all information for all stands, as the forest resource data would then have been unnecessary to use. Similarly, the forest resource data was also missing habitat type information for some stands, so it is possible that I clipped some spruce and pine mire stands away from the final data. Thus, the number of spruce and pine mires in the final data might be slightly smaller than it is in reality. If the number of stands with missing habitat type information is uneven on the forested PSMC candidate mires and all other mires, it could potentially affect the harvesting rates by creating some bias. This could happen as a result of a relatively higher number of mires being excluded from the PSMC candidate sites than all other sites, or the other way around. Furthermore, the forest data is incomplete in terms of other than land owned by citizen landowners. Most of the stands owned by municipalities, parishes, and the Finnish state were missing from the data. Thus, the results are only representative for the actions made by citizen landowners.

The forest use declaration data was missing information regarding the type of operation for many stands. Not all stands for which forest use declarations were submitted were cases of regeneration logging, and instead some forest use declarations may have been submitted for other operations, such as thinning. Removing all stands that lack information regarding the type of operation, or only including stands that state the operation as regeneration logging, would have made the data too small. Thus, the total areas of cuts can be slight overestimations, especially for sites other than the PSMC candidate sites as they are likely to be more heavily managed. However, operations other than regeneration logging are less likely to happen on mature stands than younger stands. Furthermore, even if a forest use declaration was submitted for an operation other than a regeneration logging, it still suggests that the landowner is managing the forested mire, potentially for future loggings. On the PSMC candidate mires, operations other than regeneration loggings might imply that landowners are retaining their original land use plans, or that landowners want at least some profit from their forested mire while refraining from destroying some of its biodiversity values.

Also, this study did not account for the accessibility of the PSMC candidate sites. Some of the PSMC candidate sites might be less accessible for forestry use than other sites owing to a more remote location or difficult terrain. Such could be e.g. sites that are surrounded by large bogs or located far away from roads, making them less attractive and costlier for logging. These forested mires may have been spared from logging and remained pristine, thus containing more biodiversity values and making them good sites for protection, as well as explaining their lower harvesting rates.

5 CONCLUSIONS

The aim of this study was to determine whether landowners engaged in pre-emptive logging in spruce and pine mires after being informed that their lands were candidate sites for the PSMC. Even though no systematic trend of pre-emptive logging was found on the PSMC candidate mires, not all candidate mires were spared from logging. In the light of this study, the fact that the harvesting rates on the PSMC candidate mires were significantly lower than on other sites indicates that informing landowners about land use restrictions in advance was still a worthwhile procedure. However, as no positive correlation was found between landowners' resistance to protection and the harvesting rates on the PSMC candidate mires, further studies are needed to determine what factors might affect the harvesting rates. More studies are also needed to account for the actions of forest owning agencies other than citizen landowners, as they were almost completely excluded from this study. Approximately 40% of Finnish forests are owned by other than citizen landowners, so their inclusion would bring further insight on the topic.

ACKNOWLEDGEMENTS

I wish to thank The Finnish Foundation for Nature Conservation for funding my master's thesis. I also want to thank all my supervisors for their excellent commentary during different stages of my thesis, and Doc. Anssi Lensu for offering guidance in the use of the ArcMap program.

REFERENCES

Alanen A. & Aapala K. 2015. Soidensuojelutyöryhmän ehdotus soidensuojelun täydentämiseksi. *Ympäristöministeriön raportteja* 26/2015.

Benson D.E. 1991. Values and management of wildlife and recreation on private land in South Africa. *Wildlife Society Bulletin (1973-2006)* 19: 497-510.

Brook A., Zint M. & De Young R. 2003. Landowners' responses to an Endangered Species Act listing and implications for encouraging conservation. *Conserv Biol* 17: 1638-1649.

Brooks T.M., Mittermeier R.A., Mittermeier C.G., Da Fonseca G.A., Rylands A.B., Konstant W.R., Flick P., Pilgrim J., Oldfield S. & Magin G. 2002. Habitat loss and extinction in the hotspots of biodiversity. *Conserv Biol* 16: 909-923.

Cardinale B.J., Duffy J.E., Gonzalez A., Hooper D.U., Perrings C., Venail P., Narwani A., Mace G.M., Tilman D. & Wardle D.A. 2012. Biodiversity loss and its impact on humanity. *Nature* 486: 59.

Carr S. & Tait J. 1991. Differences in the attitudes of farmers and conservationists and their implications. *J Environ Manage* 32: 281-294.

Costanza R., d'Arge R., De Groot R., Farber S., Grasso M., Hannon B., Limburg K., Naeem S., O'Neill R.V. & Paruelo J. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387: 253.

Demokraatti. 2014. Aavistushakkuista mehevä kiista: ”Metsähallituksen ainaista filosofiaa” vai ”vuosikymmenten takaista historiaa”? https://demokraatti.fi (accessed on 19.3.2018).

Fahrig L. 2003. Effects of habitat fragmentation on biodiversity. *Annual review of ecology, evolution, and systematics* 34: 487-515.

Fortmann L. & Huntsinger L. 1989. The effects of nonmetropolitan population growth on resource management. *Society & Natural Resources* 2: 9-22.

Gaston K.J. 2000. Global patterns in biodiversity. *Nature* 405: 220.

Gidari A. 1994. The Endangered Species Act: Impact of Section 9 on Private Landowners. *Environmental Law* : 419-500.

Haatanen A., den Herder M., Leskinen P., Lindner M., Kurttila M. & Salminen O. 2014. Stakeholder engagement in scenario development process–bioenergy production and biodiversity conservation in eastern Finland. *J Environ Manage* 135: 45-53.

Hanski I. 2011. Habitat loss, the dynamics of biodiversity, and a perspective on conservation. *Ambio* 40: 248-255.

Heikkilä, R. 1993: Threatened types of peatland. *Forestry Environment Guide*. Appendix 3. Finnish Forest and Park Service

Hörnberg G., Ohlson M. & Zackrisson O. 1995. Stand dynamics, regeneration patterns and long-term continuity in boreal old-growth Picea abies swamp-forests. *Journal of Vegetation Science* 6: 291-298.

Hörnberg G., Zackrisson O., Segerström U., Svensson B.W., Ohlson M. & Bradshaw R.H. 1998. Boreal swamp forests: biodiversity "hotspots" in an impoverished forest landscape. *Bioscience* 48: 795-802.

Horne P., Koskela T. & Ovaskainen V. 2004. Metsänomistajien ja kansalaisten näkemykset metsäluonnon monimuotoisuuden turvaamisesta. *Metsäntutkimuslaitos*.

Innes R. 2000. The economics of takings and compensation when land and its public use value are in private hands. *Land Econ*: 195-212

Jokinen A. 2002. Free-time habitation and layers of ecological history at a southern Finnish lake. *Landscape Urban Plann* 61: 99-112.

Joshi O. & Mehmood S.R. 2011. Factors affecting nonindustrial private forest landowners' willingness to supply woody biomass for bioenergy. *Biomass Bioenergy* 35: 186-192.

Kaakinen E. & Salminen P. 2006. Mire conservation and its short history in Finland. *Finland – land of mires, The Finnish Environment* 23: 229-238.

Kallio M. & Aapala K. 2001. Suoluonnon alueellisen rakenteen muutos ja suojelualueverkon merkitys. *Soidensuojelualueverkon arviointi, Suomen ympäristö* 490: 15-44.

Knight R.L. 1999. Private lands: the neglected geography. *Conserv Biol* 13: 223-224.

Kontula T. & Raunio A. 2018. Suomen luontotyyppien uhanalaisuus 2018. *Luontotyyppien punainen kirja*. Osa 2: Luontotyyppien kuvaukset.

Lindholm T. & Heikkilä R. 2006. Destruction of mires in Finland. *Finland – land of mires*: 179-190.

Lueck D. & Michael J.A. 2003. Preemptive habitat destruction under the Endangered Species Act. *The Journal of Law and Economics* 46: 27-60.

Maaseudun Tulevaisuus. 2017. Metsäkeskus ropsautti yksityismetsänomistajille yli 200 000 hehtaaria suojeluehdotuksia. https://www.maaseuduntulevaisuus.fi (accessed on 19.3.2018).

Metsäblogi. 2012. Metsähallituksen kesäiset aavistushakkuut. https://metsablogi.wordpress.com (accessed on 19.3.2018).

Metsäkeskus. 2016. Oikeudet ja velvollisuudet. https://www.metsakeskus.fi (accessed on 11.3.2018).

Metsäyhdistys. 2014. Metsätietopaketti. https://www.smy.fi (accessed on 19.3.2018).

McCann E., Sullivan S., Erickson D. & De Young R. 1997. Environmental awareness, economic orientation, and farming practices: a comparison of organic and conventional farmers. *Environ Manage* 21: 747-758.

Napier T.L. & Camboni S.M. 1988. Attitudes toward a proposed soil conservation program. *J Soil Water Conserv* 43: 186-191.

Newbold T., Hudson L.N., Arnell A.P., Contu S., De Palma A., Ferrier S., Hill S.L., Hoskins A.J., Lysenko I. & Phillips H.R. 2016. Has land use pushed terrestrial biodiversity beyond the planetary boundary? A global assessment. *Science* 353: 288-291.

Paloniemi R. 2008. Luonnonsuojelu arjessa: maanomistajien näkemyksiä ja kokemuksia yksityismaiden tilapäisestä luonnonsuojelusta ja sen uudistumisen prosessista. *Environmentalica Fennica*.

Paloniemi R. & Tikka P.M. 2008. Ecological and social aspects of biodiversity conservation on private lands. *Environ Sci & Policy* 11: 336-346.

Peterson T.R. & Horton C.C. 1995. Rooted in the soil: How understanding the perspectives of landowners can enhance the management of environmental disputes. *Quarterly Journal of Speech* 81: 139-166.

Rassi, P., et al. 2010. The 2010 red list of Finnish species. *Ympäristöministeriö & Suomen ympäristökeskus*, Helsinki 685.

Raunio A., Schulman A. & Kontula T. 2008. Suomen luontotyyppien uhanalaisuus–Osa 2: Luontotyyppien kuvaukset. *Suomen ympäristö* 8/2008.

Salomaa A., Paloniemi R., Hujala T., Rantala S., Arponen A. & Niemelä J. 2016. The use of knowledge in evidence-informed voluntary conservation of Finnish forests. *Forest policy and economics* 73: 90-98.

Thompson Jr B.H. 1997. The endangered species act: a case study in takings & incentives. *Stanford Law Rev* : 305-380.

Tripodienaika. 2016. 6 tapaa tehdä aavistushakkuu kaava-alueella. http://tripodienaika.blogspot.fi (accessed on 19.3.2018).

Valkeapää A. 2014. Values, fairness and legitimacy: In the context of Finnish forest and nature conservation policy. *Publications of the Department of Social Research.*

Wilcove D., Bean M., Bonnie R. & McMillan M. 1996. Rebuilding the ark. *Environmental Defense Fund, Washington, DC*.