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# Microbregma emarginatum as an indicator for coniferous forests with high conservation values

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# *Microbregma emarginatum* as an indicator for coniferous forests with high conservation values

*Microbregma emarginatum som signalart för barrskogar med höga skyddsvärden*

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## Abstract

The use of indicator species is wide spread and an important tool in nature conservation for the identification of valuable biotopes and prioritizing conservation efforts. This study aimed to test if it can be a problem to use indicator species that builds on expertise rather than documented studies. I tested this for *Microbregma emarginatum* (Coleoptera; Ptinidae), an indicator for coniferous forests with high conservation values. My questions were 1. Is the species more abundant in protected forests compared to commercial forests? 2. Does the species prefer older trees? 3. Does the species prefer sunlit trees? To answer these questions I did field inventories in two counties of central Sweden, where the presence of the species exit holes on Norway spruce (*Picea abies*) were examined. A total of 12 locations were chosen, six of them were in protected areas; nature reserves or National parks, the other six were in commercial forests. On each location, 30 trees of Norway spruce were examined along line transects. On each tree the diameter was measured to get a reference for the tree age. Sun exposure was estimated and a value representing the vegetation density was given each location. The results showed that *Microbregma emarginatum* is more abundant in protected areas where the proportion of trees with presence of the species was 51% higher compared to commercial forests. The species do seem to prefer older trees since every spruce with a diameter of 62.4 cm or more showed its presence. Also sunlit trees seems preferable because the location with the highest value for sun exposure also had the highest proportion of trees with presence of the species. This concludes that the species is a suitable indicator for higher conservation values despite the fact that it was found in some commercial forest as well, since these parts of the forests had more of a continuity.

*Keywords: indicator species, conservation biology, habitat loss, coniferous forest, forest habitats, Norway spruce, Picea abies, Coleoptera, Ptinidae*

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# 1 Introduction

Our planet is currently facing several serious environmental changes and threats to its nature that endanger the world as we know it. Recently the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) released a report raising the alarm because species extinction is happening faster than ever before and today up to 1 million species are threatened with extinction globally (IPBES 2019). Protecting biodiversity is often in conflict with socio-economical values. The expansion of urban areas, agricultural land and logging has a severe impact on ecosystems, it causes habitat loss and deterioration over vast areas (IPBES 2018, pp.10-12, 2019; World Conservation Monitoring Centre 1992). The global timber production has increased with 45% since 1970 (IPBES 2019). And in Sweden nearly 80% of all forested areas are now commercial forests (The Swedish National Forest Inventory (NFI) 2017).

Because of these changes in land use, certain habitats are disappearing and getting fragmented. To preserve important habitats, tools for identifying valuable biotopes are often asked for. One method used is indicator species, species that by their presence can indicate high conservation values (The Swedish Forest Agency 2019d). The use of this method facilitates the work of identifying key habitats and valuable biotopes. Indicator species plays an important role in nature conservation and insects are one group of organisms with several species that are very suitable for this. Because of their sensitivity to environmental changes, their population dynamics can signal changes in habitat quality before it is directly visible in other species of the community (Hallingbäck 2013; Mauricio da Rocha et. al. 2010). Old or virgin coniferous forests are biotopes that now are limited in most parts of Sweden (NFI 2018). The Swedish forest agency has identified *Microbregma emarginatum* (Coleoptera: Ptinidae) as indicator for coniferous forests or solitary trees that holds high conservation values (The Swedish Forest Agency 2019a; 2019b; 2019c )

*Microbregma emarginatum* has a somewhat uneven distribution with only local occurrences over Sweden. The population is most concentrated in the middle east of the country (Artdatabanken 2019a). The females of the 4 mm beetle lay eggs in the outer bark of older living trees of Norway spruce (*Picea abies*) (Ehnström & Axelsson 2002). The larvae live in the bark without damaging any vital parts of the tree and when fully grown it leaves exit holes around 1,5 mm visible on the bark. *M. emarginatum* is, as far as known, bound to this type of spruce. It is believed that the species prefers sunlit tree trunks and its need for warmth is confirmed by the populations cold-edge distribution range excluding the species from mountainous forests and the northernmost parts of Sweden (Ehnström & Axelsson 2002; Niklasson & Nilsson 2005). Before the year of 2005 *M. emarginatum* was on the red list, today it is considered least concerned (Artdatabanken 2019b). Despite this, there is limited knowledge about the species and no quantitative studies have been made concerning its ecology or to confirm its role as an indicator. Many species of one of the world's most diverse orders, *Coleoptera*, appear to decrease which is expected for *M. emarginatum* as well if the habitat quality decreases (Hagen et. al. 1999; Artdatabanken 2019b). Because of this sensitivity and because the species presence is easily detected *M. emarginatum* can be a most suitable indicator.

However, the issue that we seem use indicator species as a tool that builds on expertise, with no documented studies to support the knowledge, is concerning when it plays such an important role in conservation planning.

This study aims to assess *Microbregma emarginatum* as an indicator, a quantitative study to support or reject the hypothesises concerning the species and its ecology. To do this I will compare commercial forests with forests within protected areas, with the hypothesis that *M. emarginatum* should be more abundant within the protected areas and these forests should thereby have a higher proportion of Norway spruce with presence of the species. Also *M. emarginatum* can be expected to prefer older trees with sunlit trunks and thereby the proportion of trees with presence of the species should increase with increasing tree diameter and locations with a larger amount of sun exposure should have a higher abundance of *M. emarginatum.* This again concludes that the forests of protected areas should be more attractive to the species than commercial forests.

# 2 Methods

## *2.1 Collection of data*

The data in this study was collected during fieldwork in two counties (län) of Sweden, Stockholm and Uppsala. A total of 12 locations in conifer dominated forests were studied. In each county there were six locations, three within protected areas; nature reserves or national parks and three with commercial forest. See Table 1 for details about the different locations. For the commercial forests, mainly locations with stands in or near final felling age were chosen. Some stands however are younger than this to get a wider range of trees to examine, e.g. Lövsta 2. The areas within nature reserves and national parks were chosen because they were not only conifer dominated but had a large proportion of older spruces (*Picea abies*).

At each location 30 spruce trees were inventoried along line transects of six meters in width, walked straight through the stands middle from the edge. This was done with help of a compass. If more than one transect were needed they were walked in a direction that covered as much of the tree stands area as possible and thereby getting a wider range of samples. The diameter of each tree was measured in chest height. A pilot study showed that *M. emarginatum* seldom lives on trees smaller than 30 cm in diameter (Gille & Thunell). Therefore, the minimum diameter of 19 cm were chosen for this study. For every tree the presence of the species were noted by observing the presence of the coleopteran exit holes on the bark ridges. This was examined on the two lowest meters of the tree trunk. The different locations were each given an estimated value between 1-5 for the density of the vegetation i.e. the amount of sunlight that reached the examined trees, where the value 5 represent the highest amount of sun exposure. To estimate this I was looking at distances between the trees and how dense the canopy coverage was.  The distance walked in the transects were noted as a measurement for the density of spruce trees. Bark samples from three different locations were collected to rear indoors for verification of the species and that the exit holes actually belongs to *Microbregma emarginatum.*

Table 1.Characteristics of the locations in two counties of Sweden. Uppsl: Uppsala; Sthlm: Stockholm. The diameters are presented in centimetres. Age class shows the ages of the trees most representative of the stand. - : no information about age was found. Sun exposure: score between 1-5 where 5 is the highest amount of sun.

| Location | County | Forest type | Coordinates | Diameters min – max | Mean of Diameter | Age Class | Sun Exposure |
|---|---|---|---|---|---|---|---|
| Årike-Fyris | Uppsl | Protected | 59°49'04.0"N 17°39'56.3"E | 21.5-81.0 | 36.2 | 200 | 4 |
| Kronparken | Uppsl | Protected | 59°50'20.7"N 17°38'26.9"E | 19.7-85.6 | 55.2 | 253 | 5 |
| Pattons Hage | Uppsl | Protected | 59°49'03.9"N 17°36'46.0"E | 24.2-55.1 | 42.0 | - | 3 |
| Krusenberg | Uppsl | Commercial | 59°46'08.8"N 17°40'10.8"E | 26.1-60.5 | 34.5 | 85, 60 | 3 |
| Lövsta 1 | Uppsl | Commercial | 59°50'46.1"N 17°48'43.3"E | 21.6-56.0 | 35.1 | 95, 110, 90 | 3 |
| Lövsta 2 | Uppsl | Commercial | 59°50'03.4"N 17°49'37.1"E | 22.6-46.8 | 30.9 | 60, 70, 75 | 2 |
| Tyresta | Sthlm | Protected | 59°10'33.7"N 18°15'34.7"E | 22.3-43.0 | 31.7 | - | 4 |
| Törnskogen | Sthlm | Protected | 59°27'53.0"N 17°56'11.5"E | 21.0-54.6 | 33.9 | - | 3 |
| Sätraskogen | Sthlm | Protected | 59°17'41.8"N 17°55'03.2"E | 20.7-55.1 | 31.6 | - | 4 |
| Norrhall | Sthlm | Commercial | 59°39'24.3"N 18°19'46.0"E | 21.3-43.3 | 30.2 | 50, 70, 95 | 2 |
| Hallstavik | Sthlm | Commercial | 60°03'52.3"N 18°31'16.5"E | 19.4-51.2 | 31.6 | - | 1 |
| Kolbotten | Sthlm | Commercial | 59°08'45.5"N 18°24'07.6"E | 26.2-51.9 | 32.7 | - | 2 |

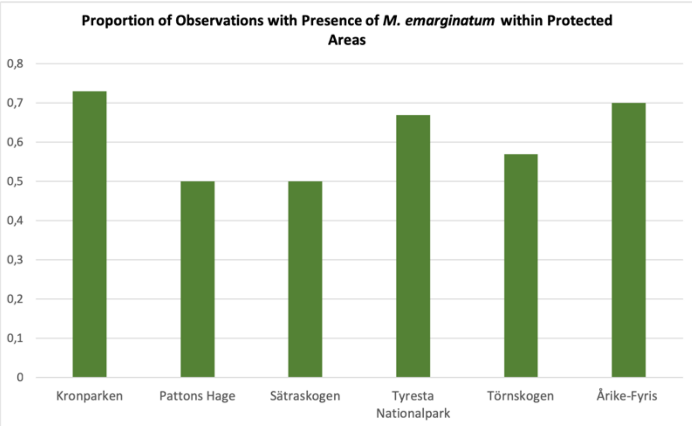
## *2.2 Data analysis*

The collected data was analysed to answer the questions this study is based on. The proportion of spruces with presence of the species were calculated for each location and presented in bar charts. These results were then combined to calculate a mean of proportion for protected and commercial forests, respectively. To answer the question whether *M. emarginatum* prefers older trees, the measured diameter of all the observed trees (360 spruces) were divided in to classes of diameter with three centimetres in each class and presented in a linear diagram. This was also done for the separate locations but with four centimetres in each diameter class. The estimated values for the sun exposure in the tree stands were plotted against the proportion of presence for each location. The calculations and plots were made using Microsoft Excel 16.25 for Mac.

A logistic regression model (General linear model assuming binomial distribution and with a logit link) was made, where presence or absence of *M emarginata* per tree was explained by diameter and forest type. An alternative model including location as explaining variable did not converge due to that two sites had no occurrence at all of the species, why this model could not be used. Variables were regarded as significantly explaining if $p<0.05$.

# 3 Results

The results of this study showed that the locations within protected areas all had a larger proportion of spruces with the presence of *Microbregma emarginatum* compared to the locations with tree stands of commercial forest. The minimum proportion for protected areas was 0.5 and the maximum was 0.73 (Fig. 1) compared to the minimum and maximum of 0.0 and 0.2 for the commercial forests (Fig. 2). The mean of the total diameters did not differ that much between the two forest types (Fig. 3). However, the average diameter does differ more when comparing the different locations to each other (Table 1).



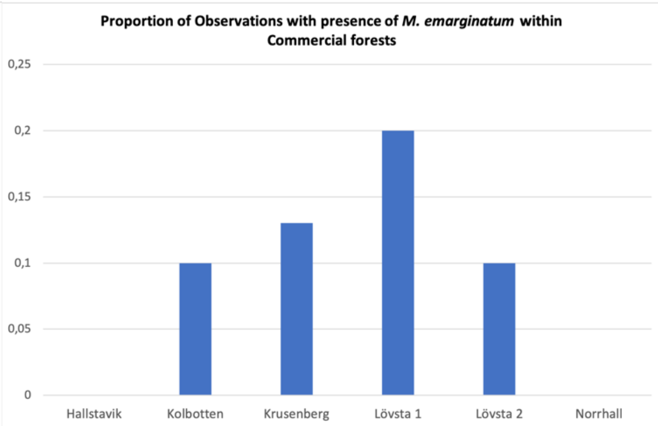




Figure 1 and 2. The y-axis shows the proportion of trees with presence of from *M. emarginatum*. The different locations are listed on the x-axis. Figure 1 shows the locations within protected areas to the left. Figure 2 shows the different locations within commercial forests to the right.

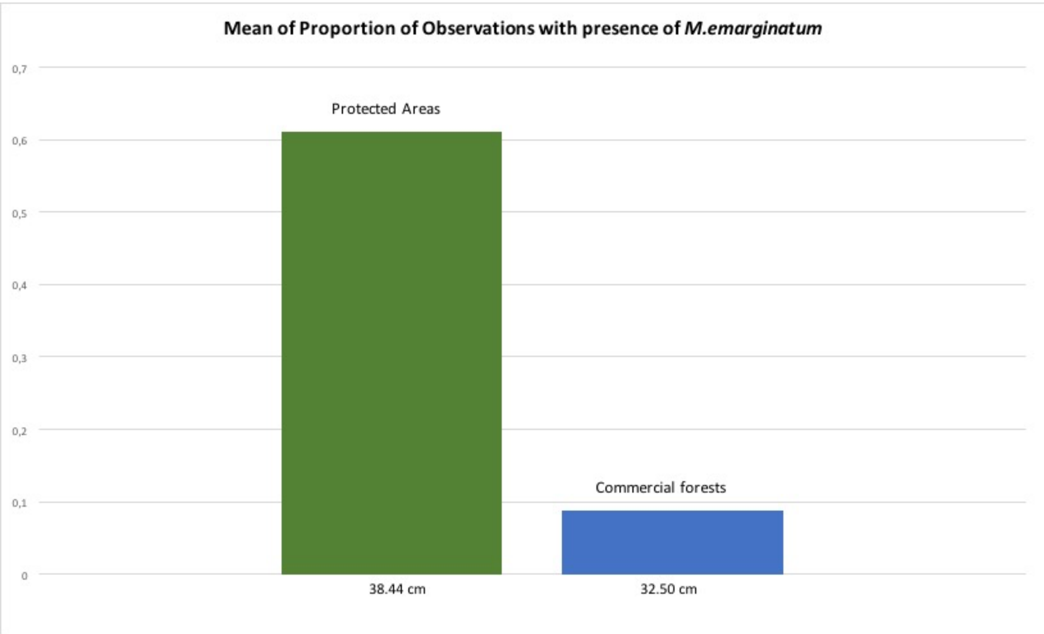



Figure 3. Mean of total proportion of trees with the presence of *M. emarginatum* in protected areas versus production forests.. The y-axis shows the values for proportion. On the x-axis the total mean of the diameters per forest type. Protected areas are shown in green and commercial forests in blue.

There was a positive correlation between the presence of the species and diameter of the host trees (Fig. 4). Despite this, the results are less significant when looking at the different locations separately. The two extremes are presented, Tyresta Nationalpark (Fig. 5) that shows no relation between the two variables, and Sätraskogen (Fig. 6) where the correlation is the strongest.

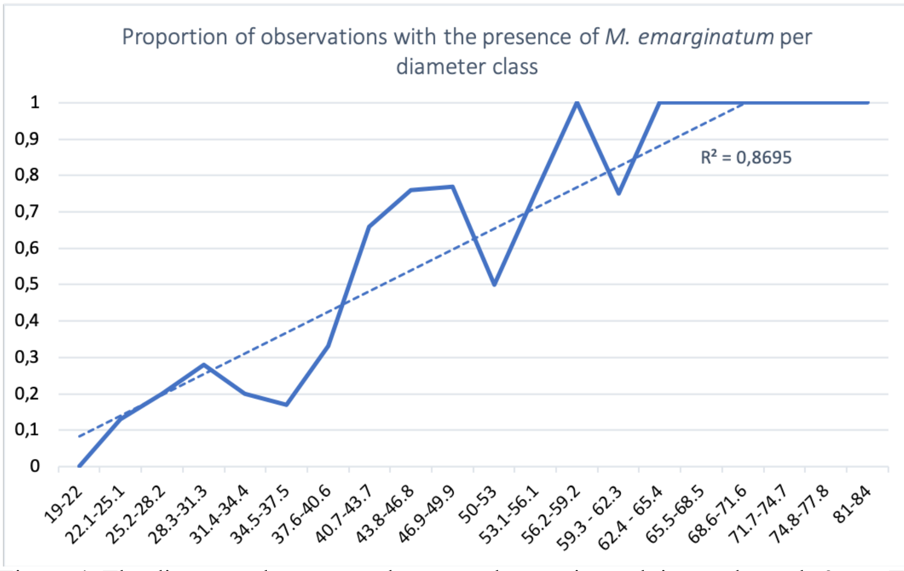



Figure 4. The diameter classes are shown on the x-axis, each interval equals 3 cm. The y-axis shows the proportion of spruce trees with presence of *M. emarginatum* for every diameter class. Class 77.9 – 80.9 cm were excluded since there were no observations in this interval.

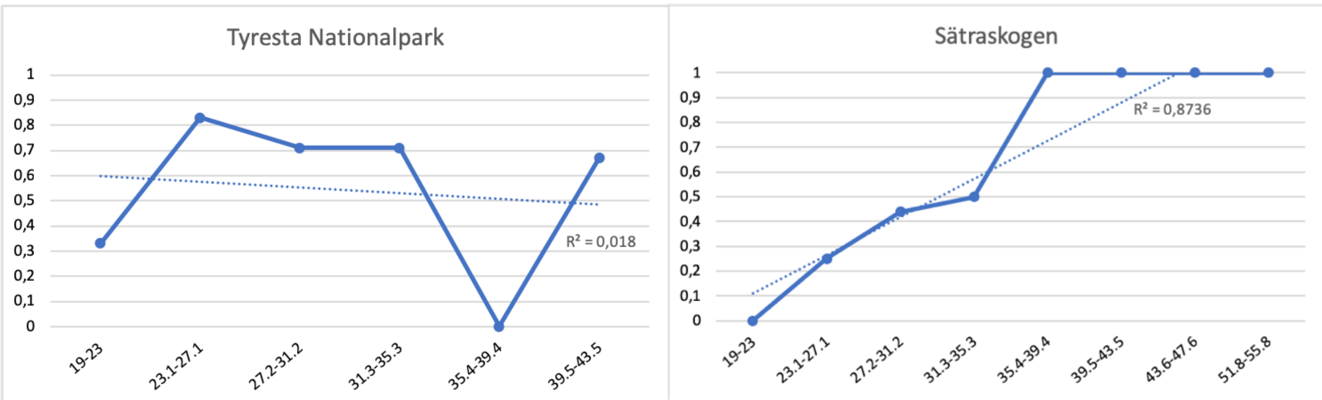



Figure 5 and 6. The diameter classes are shown on the x-axis, each interval equals 4 cm. The y-axis shows the proportion of spruce trees with presence of *M. emarginatum* for every diameter class. Class 47.7-51.7 cm were excluded from Figure 6 since there were no observations in this interval.

The analysis of the logistic regression model showed that both forest type and diameter significantly explained presence of *M.emarginatum* meaning to where the species is found, see details of the results in Appendix 1. Protected areas has a larger proportion of trees with presence at smaller diameters, already between 20-30 cm the proportion increases at a high rate. The same values are not reached until circa 50 cm for the commercial forests (Fig. 7).

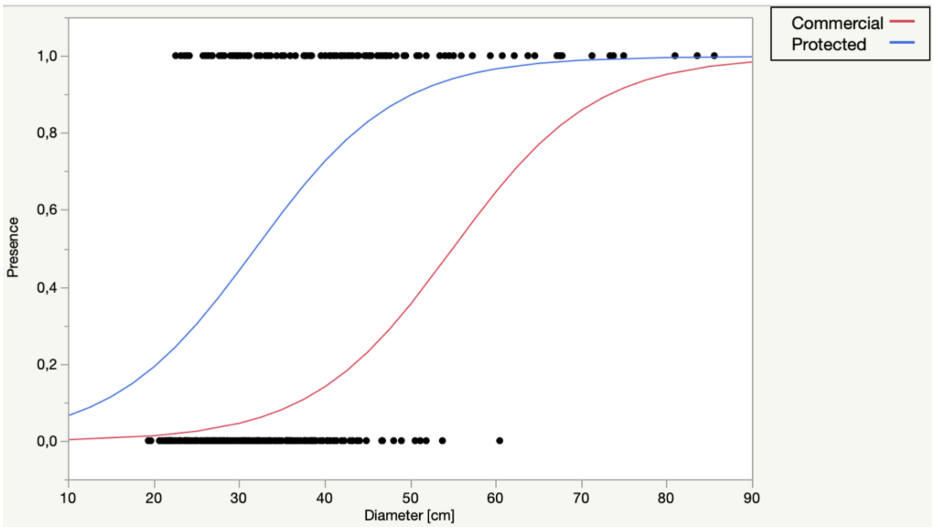



Figure 7. Probability that a tree with a certain diameter hosts *M. emarginatum* for the different forest types, commercial forests shown in red and protected forests in blue. Proportion of trees with presence of *M. emarginatum* shown on the y-axis and diameters in centimetres on the x-axis. The black dots represent the diameters found in the two forest type, respectively.

There was a correlation between the estimated sun exposure value and the proportion of trees with presence. For example, the location with the highest sun exposure value also has the largest proportion of trees with presence of the species (Fig. 8: Kronparken).

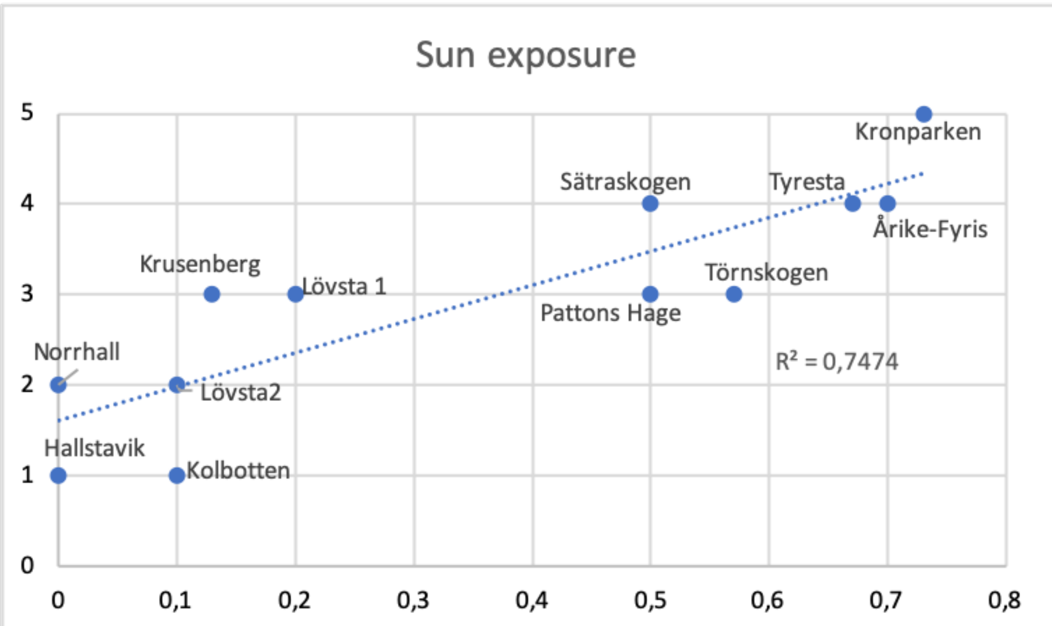



Figure 8. Shows the relation between sun exposure (y-axis) and proportion of trees with presence of *M. emarginatum* for each location (x-axis).

# 4 Discussion

The study shows that the species *Microbregma emarginatum* is much more abundant in forests within protected areas and seldom occurs in commercial forests. Nevertheless, the species was found in four of six locations of commercial forest even if the proportion was much smaller. These locations also had stands containing older trees where a few exit holes of the species was found. This was often in parts of the forest where some natural succession occurred leading to a lesser dense vegetation and thereby more sun reaching the tree trunks. These things indicates the indicating values of this species. It seem to be able to signal when the habitat quality increases, at an early stage. This is confirmed by the fact that the results also point at *M. emarginatum* seeming to prefer older trees (Figs. 4, 7, Appendix 1). What is interesting is that protected forests has a larger proportion of the species presence at much smaller diameters compared to commercial forests. A possible explanation can be that spruces in commercial forests has a higher yearly growth rate compared to spruces within national parks or nature reserves. The reasons to why these spruces are able to grow to up to over 250 years is probably because they grow in leaner soils and during a stronger competition under a closed canopy. One example of this is the location Tyresta Nationalpark where the mean diameter is 31.7 cm but the location still has a large proportion of the species presence and therefore Tyresta Nationalpark has no correlation between diameter and presence. Over all stands, the correlation is strong. These two aspects suggests that the species demand continuity which can be a trait that an indicator species should have.

When it comes to the question concerning the sun exposure the results show a strong correlation between the value for sun exposure and the proportion of trees with the presence of *M. emarginatum.* Kronparken which have the highest value for sun exposure also has the largest proportion of the species presence and Hallstavik which has the least amount of sunlight has no presence of the species. However, the locations with a high sun exposure value are also the oldest, several of them. It is also harder to make out a clear result for the mid values, e.g. the locations Krusenberg, Lövsta 1, Pattons Hage and Törnskogen all has the estimated value of 3 but still had very different proportions of the species presence. A thought this brings is whether the sun exposure is of lesser importance than continuity. This could be tested by comparing spruce trees of similar age and different sun exposure to discover which type of tree *M. emarginatum* seem to prefer.

In conclusion this study suggest that the species *Microbregma emarginatum* is suitable as an indicator species for coniferous forest with high conservations values. However, the study was completed over a 10 week period and more thorough studies are needed to give a more certain answer to these questions. A question this study raises is whether it can be the structure of the bark that is of more importance when evaluating the species occurrence, and indirectly the age of the trees? Also there is the question if it can be some risk of confusing *M. emarginatum* with some other species, since the bark samples collected in this study gave no certain verification that the species studied was indeed *M. emarginatum.* Last, the question whether it can be other aspects that affects the species population dynamics and distribution cannot be ignored.

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Appendix 1

**Generalized Linear Model Fit**
Response: Presence
Distribution: Binomial
Link: Logit
Estimation Method: Maximum Likelihood
Observations (or Sum Wgts) = 360

**Whole Model Test**

| Model | -LogLikelihood | L-R ChiSquare | DF | Prob>ChiSq |
|---|---|---|---|---|
| Difference | 93,2678061 | 186,5356 | 2 | <,0001* |
| Full | 139,812984 | | | |
| Reduced | 233,08079 | | | |

| Goodness Of Fit Statistic | ChiSquare | DF | Prob>ChiSq |
|---|---|---|---|
| Pearson | 324,1580 | 357 | 0,8932 |
| Deviance | 279,6260 | 357 | 0,9991 |

| AICc |
|---|
| 285,6934 |

**Effect Summary**

| Source | LogWorth | | PValue |
|---|---|---|---|
| Type | 20,831 | | 0,00000 |
| Diameter [cm] | 15,991 | | 0,00000 |

**Effect Tests**

| Source | DF | L-R ChiSquare | Prob>ChiSq | |
|---|---|---|---|---|
| Type | 1 | 90,948219 | <,0001* | |
| Diameter [cm] | 1 | 68,928923 | <,0001* | |

**Parameter Estimates**

| Term | Estimate | Std Error | L-R ChiSquare | Prob>ChiSq | Lower CL | Upper CL |
|---|---|---|---|---|---|---|
| Intercept | -5,23109 | 0,6587961 | 99,796549 | <,0001* | -6,591161 | -4,002736 |
| Type[Commercial] | -1,392831 | 0,1708295 | 90,948219 | <,0001* | -1,745606 | -1,072725 |
| Diameter [cm] | 0,1206425 | 0,0177127 | 68,928923 | <,0001* | 0,0875327 | 0,1570927 |