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Foto: Anna Ericsson

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Effekten av hästbete på skogens struktur och sammansättning på Lojsta hed, sydöstra Sverige

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Keywords: horse grazing, ground cover, height structure, Gotland, Lojsta hed

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Abstract

Livestock animals affect their environment in a number of different ways, mostly through grazing and trampling. This study focused on the effects of Gotland pony grazing on forest structure and diversity, and the impact on ground cover. To compare the fenced and grazed area with a reference area outside the enclosure a number of transects were used. The study showed that there was no significant difference in height structure and diversity between the compared sites; however, there were a significantly higher proportion of damaged trees inside the enclosure. The ground cover variables showed a higher amount of bare soil, plant litter and wood-rush (*Luzula sp.*) inside the enclosure whilst grass was more frequent in the reference area. This is probably promoting disturbance-tolerant species. However, the results do indicate that the higher amount of grazing might be homogenizing the forests undergrowth. The implications of this study suggest that the way the horses are kept need to be modified in order to continue to maintain the desired open forest structure. Due to the lack of knowledge on the horses' effect on ecosystem functions further studies on other taxa is advisable as well.

Sammanfattning

Herbivorer påverkar sin omgivning på en mängd olika sätt, bland annat genom bete och tramp. Den här studien utfördes vid Lojsta hed på Gotland och behandlar effekten av betande hästar på trädsamhällets höjdstruktur och diversitet samt marktäckningsfaktorer. Studien är en jämförelse mellan ett hägnat område som årligen betas av russ mellan juli-november, och ett referensområde utanför hägnet. Genomgående återfanns ingen effekt på höjdstruktur eller diversitet, men andelen skadade träd var högre inom det hägnade området. Marktäckningen var påverkad på så vis att det var en högre andel bar mark, förna och fryle (*Luzula sp.*) inom det hägnade området medan andelen gräs var högre i referensområdet. Resultatet antyder också att hästarna har en homogeniserande effekt på de lägre trädskikten i skogen. Hästarnas närvaro gynnar förmodligen också arter som är störningstoleranta. Studien föreslår att sättet hästarna hålls på kan behöva modifieras för att fortsätta bidra till öppethållandet av skogen. På grund av den bristande mängden kunskap om hästarnas effekt på ekosystemet är fortsatta studier i ämnet av stort intresse.

Introduction

Grazing megafauna and historic land use

A contested theory is that for thousands of years ago large mammalian herbivores like wild bovids and equids roamed Europe forming parts of the landscape into relatively open forested grasslands (Olff et al. 1999, Pykälä 2000, Donlan et al. 2005). When humans colonized these areas the grazing megafauna was hunted and became partially extinct which altered the ecosystem (Donlan et al. 2005, 2006) into a more tree and shrub dominated landscape (Fahnestock & Detling 1999, Öckinger et al. 2006). The megafauna was to some extent replaced by human agriculture and grazing by domesticated livestock such as sheep, cattle and horses (Pykälä 2000), but the amount of small-scale farming and grazing are currently declining in many parts of Europe. In Sweden about 70% of meadows and grazing pastures have been lost over the years 1891-2007 (Figure 1; Jordbruksverket 2012). The biodiversity of such areas will continue to decrease (Axelsson Linkowski 2012, Jordbruksverket 2012) and traditional ecosystem functions and cultural values are also threatened by this decline in small-scale farming. (Kuijper et al. 2010a, Axelsson Linkowski 2012).

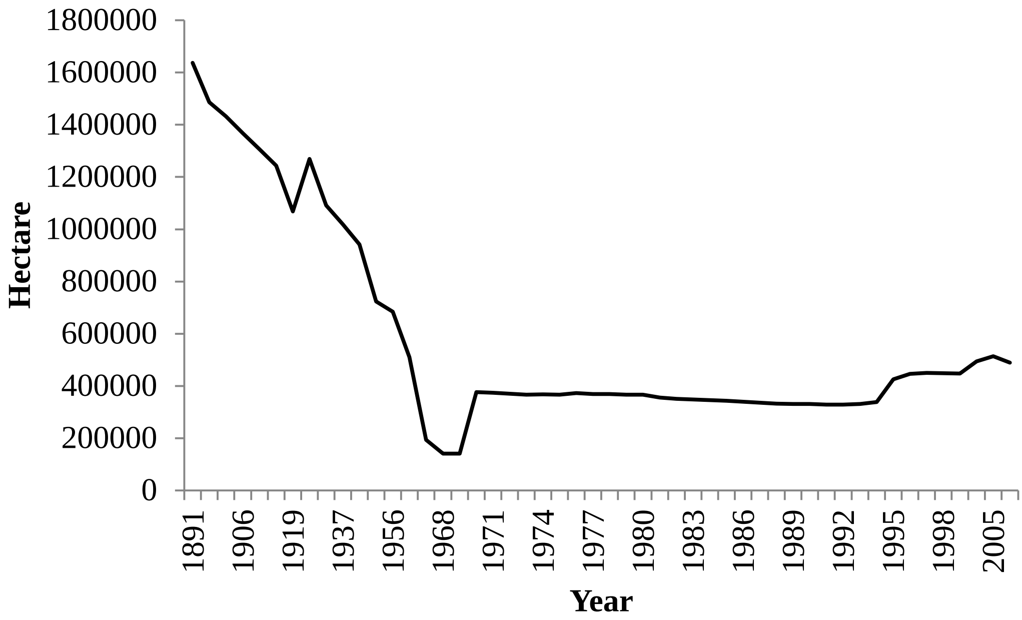


Figure 1. The decline in meadows and grazing pastures in Sweden 1891-2007 (Jordbruksverket 2008).

In Sweden there is a long history of keeping pastures and grazing in forests, all which have reassured the biodiversity of semi open landscapes. However, the declines in agricultural methods like small-scale farming and grazing pastures are now starting to worry conservationists (Axelsson Linkowski 2012). A phenomenon related to this is that for each new generation what is considered base line conditions will shift so that a degraded state is considered normal, which is known as the shifting baseline syndrome (Pauly 1995). In the Netherlands the use of free-ranging livestock, primarily cattle and horses, as an introduced part of the ecosystem is quite common (Olff et al. 1999, Kuiters & Slim 2003) but in many places the importance of traditional animal husbandry as a conservation tool is insufficiently known (Axelsson Linkowski 2009, Rigueiro-Rodriguez et al. 2012).

Ungulates and their effect on their environment

Both wild and domesticated ungulates affect their environment directly or indirectly, either as grazers who feed primarily on grass and forbs or as browsers, which prefer to feed on woody vegetation (Holdo et al. 2009). The effects mammalian herbivores have on plant communities vary with a number of factors and the plants response will also differ depending on herbivory type, timing, intensity and frequency (Fahnestock & Detling 1999, Pykälä 2000). The environmental resources available for growth will also affect the plants (Fahnestock & Detling 1999).

A study made by Kuijper et al. (2010a) at Bialowieza Primeval Forest in Poland shows that browsing ungulates such as moose (*Alces alces*) and roe deer (*Capreolus capreolus*) and intermediate feeders such as European bison (*Bison bonasus*) and red deer (*Cervus elaphus*) influence both total tree recruitment and species composition of trees recruiting into a size class of >50 cm. Kuijper et al. (2010a) also suggest that the composition of the mature tree stands probably are affected by the pressure carried out by ungulates on trees in early life stages.

Horses (*Equus sp.*) are considered typical grazers and mostly affect their surroundings by trampling and grazing on grass and herbaceous plants (Duncan 1992). They also affect their environment through seed dispersal, thereby favoring the establishment of disturbance-dependent and/or grazing tolerant species (Kuiters & Slim 2003). A study made by Kuiters & Slim (2003) showed that horses, in conformity with browsing ungulates, can prevent the regeneration of trees through grazing, but since free-ranging horses are rather selective in habitat use and prefer grasslands over woodlands the total impact on the tree community may not be as large as expected. However, Olff et al. 1999 showed that horses grazing unselectively on grass could unintended graze on small seedlings, affecting the recruitment of trees.

The Gotland pony and Lojsta hed

The Gotland pony is believed to have arrived to Gotland about 5000 years before present as indicated by archaeological findings of horse remains from the Iron Age (Ejendal & Hollström 2004, Hollström 2010). How the pony came to Gotland is uncertain, but since there is no evidence of a former land bridge between Gotland and the mainland (NE.se 2013) the ponies are likely brought to the island by humans (Hollström 2010).

The ponies were used for farm work, but there were also free roaming ponies all over the forested areas of southern Gotland. There were no fences and the ponies fed on whatever they could find (Lojstahedrussen.se 2013). During the later parts of the 19th century there was a severe decline in the free-roaming population due to hunting and selling of the ponies. During early 20th century there were only about 150 free roaming individuals left, and in the 1910s the breeding in the wild had stopped completely and only eight ponies remained. These ponies were rounded up and protected within a 100 hectare fenced area named Lojsta hed and all living Gotland ponies originate from these eight individuals (Hollström 2010, Lojstahedrussen.se 2013). In 1932 the fenced area at Lojsta hed was extended to cover about 450 hectares (Hollström 2010).

The current pony population at Lojsta hed

Today Lojsta hed is a reserve where the ponies are kept under relatively feral conditions. Since 1984 the reserve covers about 650 hectares of forest in various succession stages, mires and more open but still forested areas. During the year the horses are moved between three enclosures in the reserve depending on season. Since overall size of the enclosures varies, the density of animals in them also varies (Table 1; Lojstahedrussen.se 2013).

This keeping of horses, where the ponies are semi-domesticated and are born, live and die on Lojsta hed, is unique in Sweden. They are only rounded up a few times every year to get hoof care, change enclosure, be evaluated for the studbook or have the foals separated from the herd. The overall ambition with this horse facility is to conserve the breed in a historical form, involving genetics and the cultural heritage of “free roaming” horses on Gotland (Ejendal & Hollström 2004, Hollström 2010). According to the County Administrative Board (2004) the horses also play an important role in keeping the forest in a desired open stage in the nature reserves at Lojsta hed.

The Gotland pony is one of the last of Sweden’s native horse breeds, classified as endangered by the European Union (Lojstahedrussen.se 2013). As for all other European horse breeds it is believed that the Gotland pony originated from the wild tarpan (*Equus ferus ferus*) (Ejendal & Hollström 2004, Hollström 2010). In the reserve the horses feed on the available vegetation, except during winter when they are supplementary fed with hay every other day. In the spring during the foaling period the mares also get concentrated fodder (Ingvar Andersson, pers. comm. 2013).

There are about 50 mares in the pony reserve during winter, so when the foals arrive the herd expands up to approximately 80 animals. Each year between June and late August a stallion also joins the herd to facilitate reproduction (Ejendal & Hollström 2004). The number of horses in the herd is regulated through the removal of foals during fall. A couple of filly-foals are saved in the herd to compensate for losses due to age, while the rest of the foals are sold on the open market to become riding ponies or pony trotters. Old broodmares who are no longer productive are put down after two years of not having a foal (Ingvar Andersson, pers. comm. 2013).

Table 1. Residential time and density of ponies in the different enclosures.

Enclosure	Duration	Size (ha)	Density/1000 ha	Notes
Fall	July-November	300	167-266	One stallion, around 50 mares and 30 foals
Winter	November-June	150	333	About 50 mares and youngsters
Summer	June-July	200	250-400	One stallion, around 50 mares and 30 foals

Aim of the study

The aim of this study was to determine if the ponies on Lojsta hed through their grazing and trampling are affecting the plant community, focusing on tree and shrub height structure, composition of woody plants and ground cover. The following hypothesises were tested:

1. The ponies are affecting the forest structure by altering the recruitment of young (small) tree plants into the tree community either directly through their feeding activities or indirectly through trampling.

2. The diversity of trees and shrubs in the enclosed area should be higher than in the reference area due to the ponies feeding and trampling activities.

3. Feeding activities by high density of ponies should result in a lower amount of grass inside the enclosure. Furthermore, due to trampling the proportion of bare ground should be higher inside the enclosure.

Materials and method

The study area

The study area is located on the island of Gotland (N 57°30', E 18°33') outside the Swedish southeast coast (Figure 2). Mean precipitation is about 600 mm per year and the area has a mean year temperature of 7^{o} C (SMHI 2009). The inner parts of the island have continental climate and the island is quite windy all year round (SMHI 2013). The bedrock of Gotland consists mainly of limestone and the soil types both inside the enclosure and in the reference area are till and washed sediments (SGU 2013).

Figure 2. The location of Gotland and the study area Lojsta hed (Lojstahedrussen.se 2013).

In addition to horses there is also roe deer and European hare (*Lepus europaeus*) browsing in the area. Mountain hare (*Lepus timidus*) and common rabbit (*Oryctolagus cuniculus*) are also present on the island, but whether or not they occur within the survey area is unclear.

Survey method

The possible effects of ponies on the vegetation was surveyed in transects 50 m long and 2 m wide, with 25 transects inside the enclosure and 23 outside (Figure 3). For the survey the enclosure used by the horses during July-November was chosen. This area was chosen for three reasons; 1) here the horses spend the most amount of time, 2) the northern parts of the enclosure, where the survey was done, is a nature reserve where no forest management actions have been done for a long time (County Administrative Board 2004) and 3) the ponies are not supplementary fed during this time period (Ingvar Andersson, pers. comm. 2013). The forest in the survey area consisted of older forest dominated by pine (*Pinus sylvestris*) in the canopy and alder buckthorn (*Rhamnus frangula*) and juniper (*Juniperus communis*) in the undergrowth (County Administrative Board 2004).

The reference sites were preferentially without traces of forestry and resent grazing from livestock animals.

The starting points for the transects inside the enclosure were randomly chosen using a 100x100m grid covering the selected forest type, this was done using the software ArcGIS 10. The starting points for the reference sites were chosen in a similar biotope. The direction of the transect from the starting point was randomized in advanced with eight possible outcomes – S, N, W, E, SE, SW, NE and NW.

Trees

Variables collected along each transect included:

- Species (trees and shrubs)
- Height in classes (0,2-3 m (seedlings), 3-5 m (saplings), 5-10 m, 10-15 m, 15-20 m, 20> m)
- Damage (browsed twigs, gnawing on bark and undefined damage was separated)
- Diameter at breast height (for trees ≥1,3 m)
- Status (Alive, dead standing, dead fallen)

Trees were counted if more than half the trunks width was inside the transect border (within one meter from the measuring tape). Fallen trees were counted if the butt was located inside the transect. If a tree was split underneath ground surface it was counted as two or more individuals, and if it was split above ground as one.

Ground cover

Variables of presence/absence included:

- Ground coverage (Table 2) beneath metre marking 0-49 m, 50 points/transect
- Faeces from horse and roe deer, if the measuring tape ran over it

Coordinates of the starting point were noted from the GPS, which was placed at the starting point in the beginning.

All data was logged in Allegro field collector and all maps were made using ArcGIS 10.

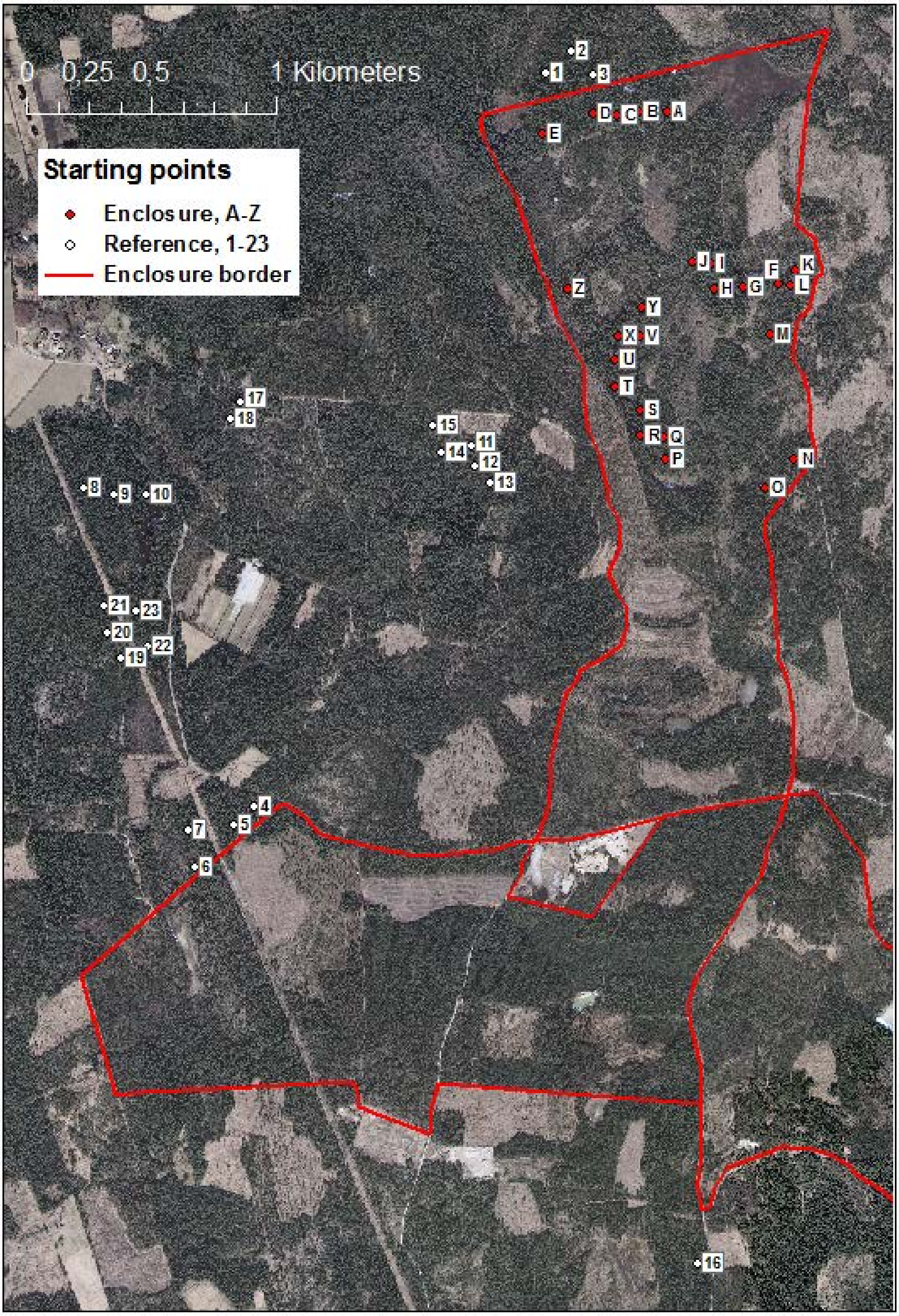


Figure 3. The starting points of each transect.

Data analysis

Effects on height structure

Trees were assigned to different height classes to evaluate the effect of pony feeding activities on height structure. Because of the higher amount of seedlings (<3 m) and the much smaller amount of saplings and older trees (>3 m), only seedling size classes were included in the analysis. Dead standing trees was included in the analysis and the trees <3 m were divided into classes. To test for differences in forest structure between the enclosure and the reference area, hypothesis one, the mean number of individuals in each height class was plotted in a Student's t-test assuming equal variance. The four most occurring tree and shrub species inside the enclosure was also analyzed separately in the same way. Furthermore, the coefficient of variation (CV) for all individuals <3m, and for the four most common species was also calculated.

To analyze the degree of damage on trees, a regression analysis between height and proportion of damages, including both browsed twigs and gnawing on bark, was made. Also a Student's t-test was done for the difference in damage amount of the compared sites.

Distribution of tree data was tested for normality and if found necessary log-transformed to achieve normality. F-tests were used to determine if there were equal or unequal variances in the datasets. All tests were done in Microsoft Office Excel.

Diversity of trees and shrubs

The diversity of each area was calculated using Simpson's index of diversity, calculated through the following equation:

$$Ds = 1 - \sum_{i=1}^{S} \frac{n_i\,(n_i - 1)}{(N(N-1)}$$

Where n is the total number of individuals in a particular species and N the total number of individuals of all species. In this analysis all trees <3 m were included.

Effects on ground vegetation

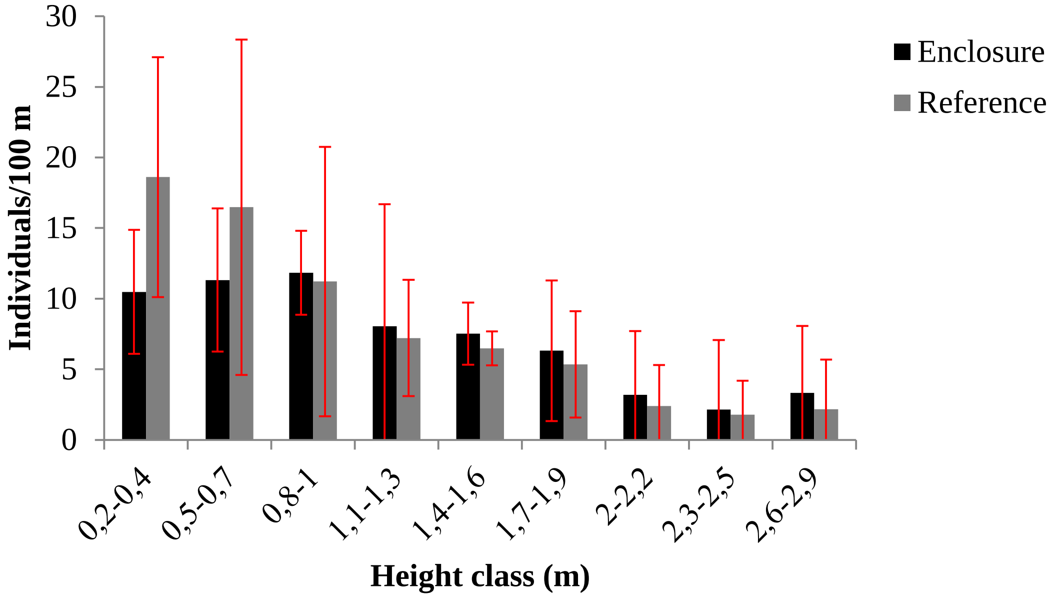
At first the proportion of each ground cover variable were calculate and then to analyze the factors gathered the non-parametric test Mann-Whitney was used. In the analysis only variables which occurred more than 10 times in either of the areas were included.

Results

Effects on tree height structure

Although it seemed, by visual interpretation, to be a lower mean number of tree and shrub individuals/100 m^2 in height class 0,2-0,4 m and 0,5-0,7 m inside the enclosure than in the reference area, however, there was no significant difference (P>0,05, Figure 4a). The CV is displayed in Figure 4b.

4a)



4b)

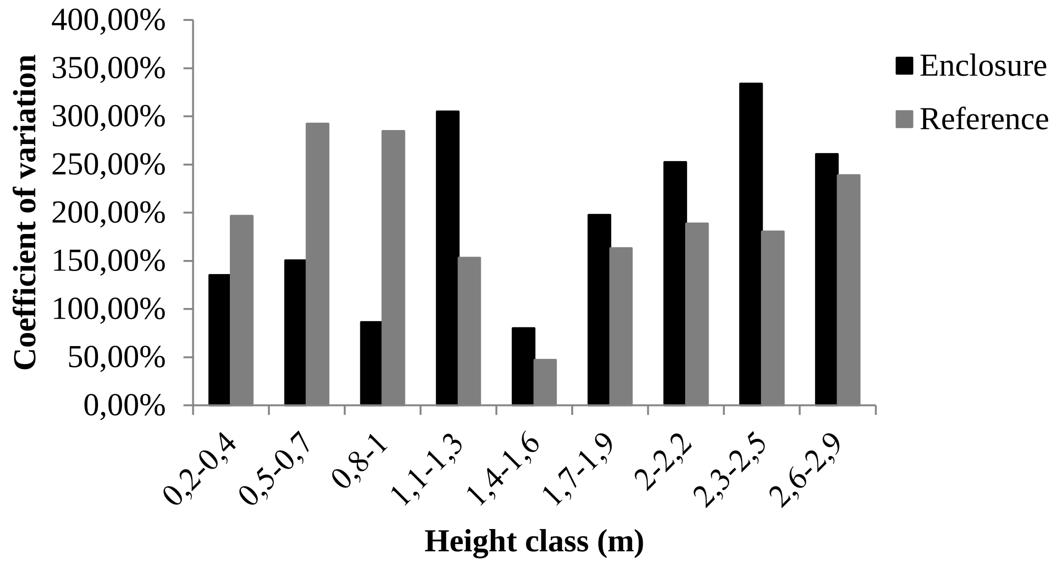
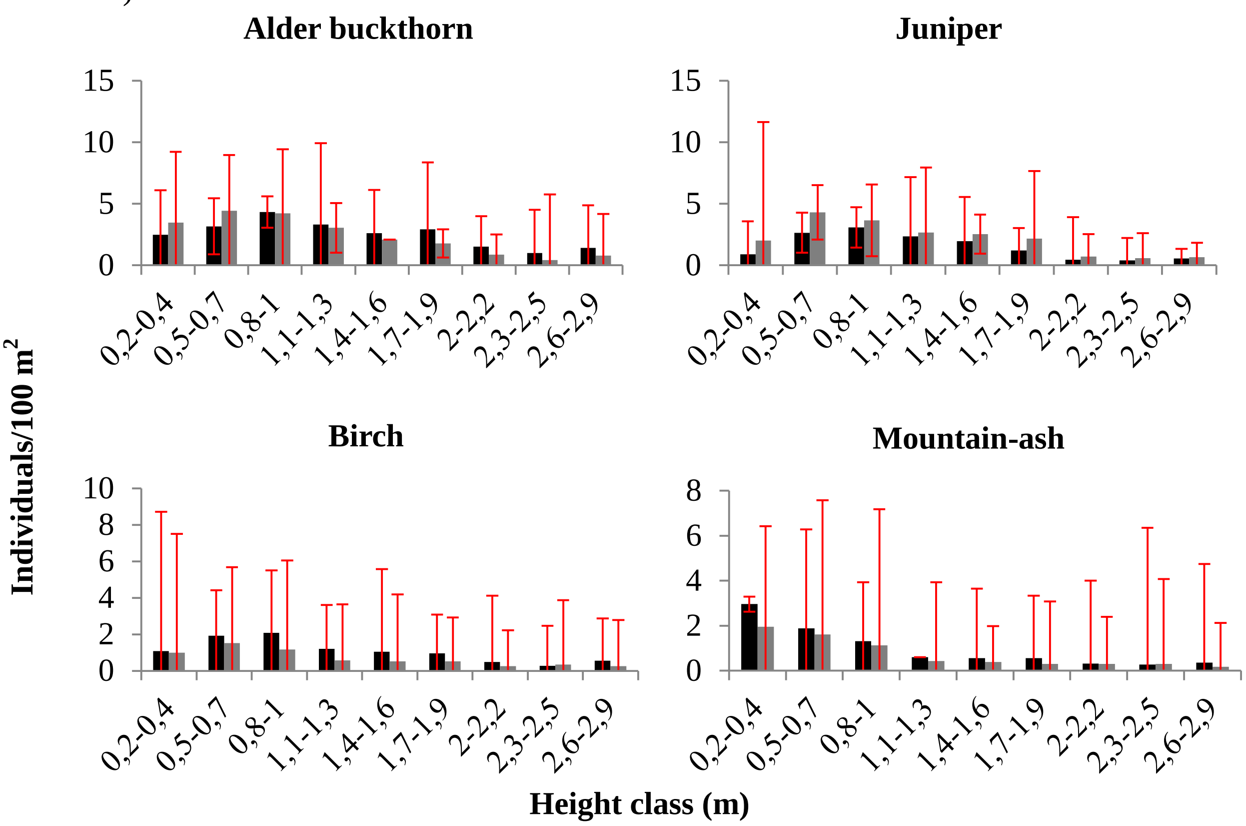


Figure 4. a) Mean number of tree and shrub individuals in each height class per 100 m^2. Red bars represent the standard error of the mean. b) CV in each height class.

The four most occurring tree and shrub species inside the enclosure was alder buckthorn, juniper, birch (*Betula sp.*) and mountain-ash (*Sorbus aucuparia*). There was no significant difference in the height structure for either of the species (P>0,05; Figure 5a). The co-variance is displayed in Figure 5b.

5a)



5b)

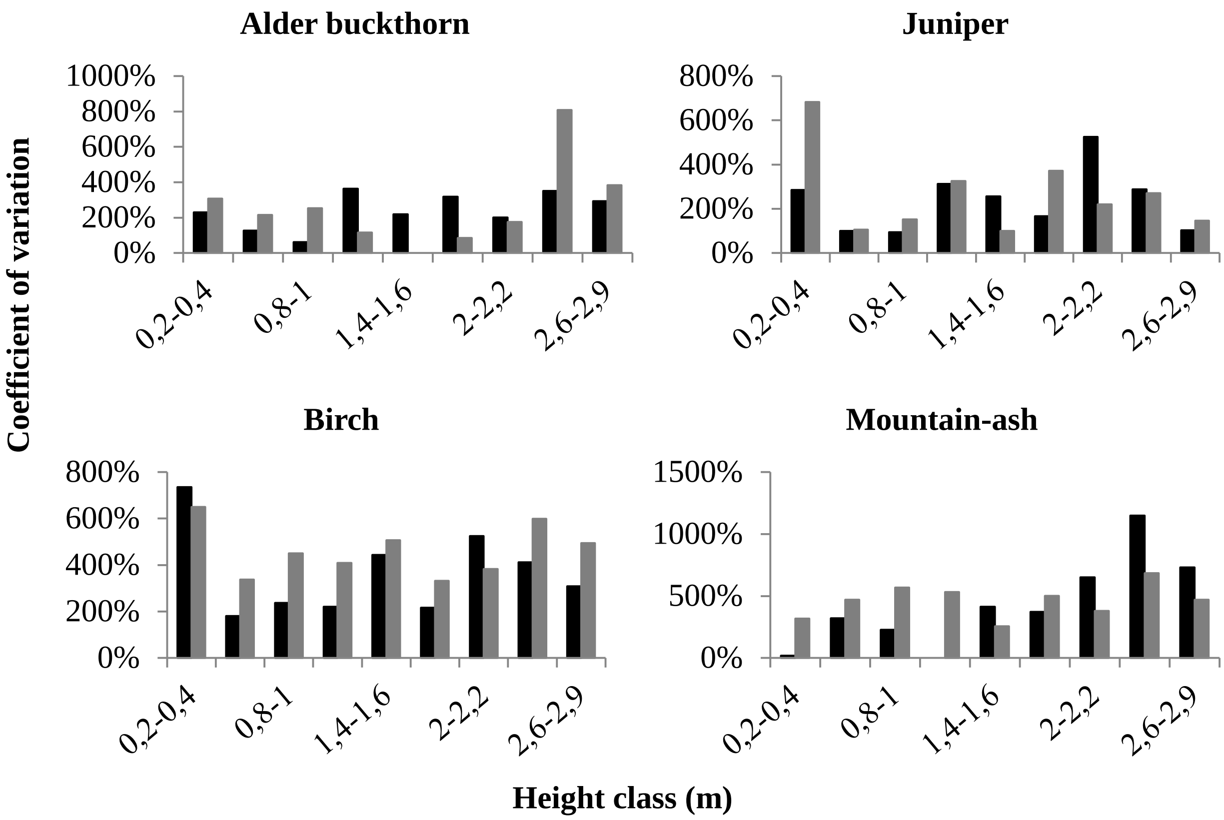


Figure 5. a) Mean number of individuals of the four most common species' in each height class per 100 m^2. Black bars represent the enclosure, grey bars the reference area and red bars the standard error of the mean. b) CV in each height class.

Damage to trees

There was a significantly higher proportion of damaged tree and shrub individuals inside the enclosure (P=0,03). The amount of trees damaged through browsing or gnawing on the bark decreased with increasing height (Figure 6).

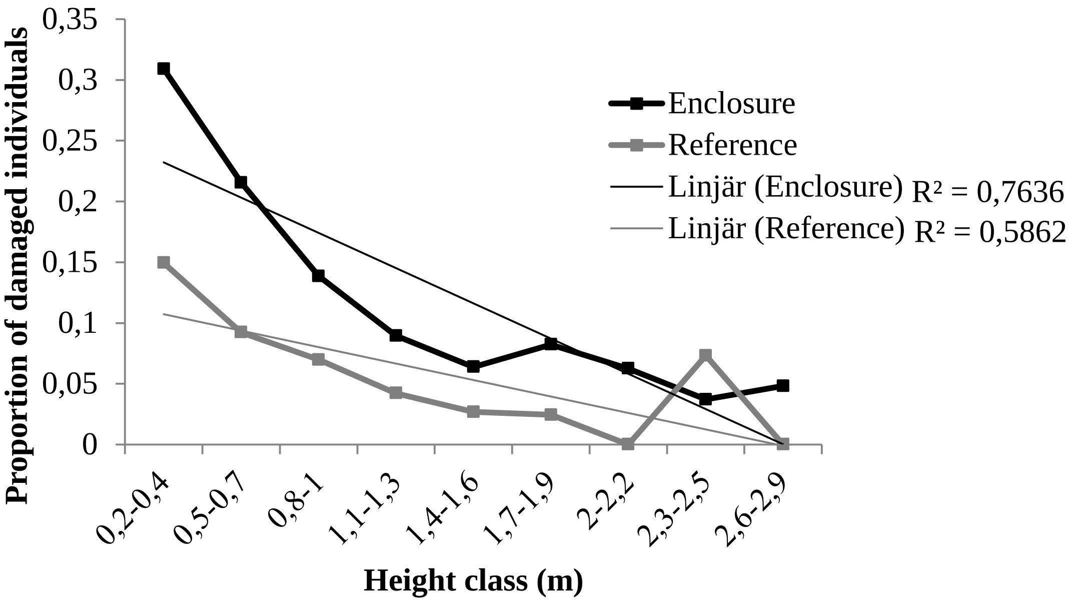


Figure 6. Correlation between tree height and proportion of damaged trees.

Diversity of trees and shrubs

The diversity of each height class was compared between the sites, but there was no clear difference (Figure 7).

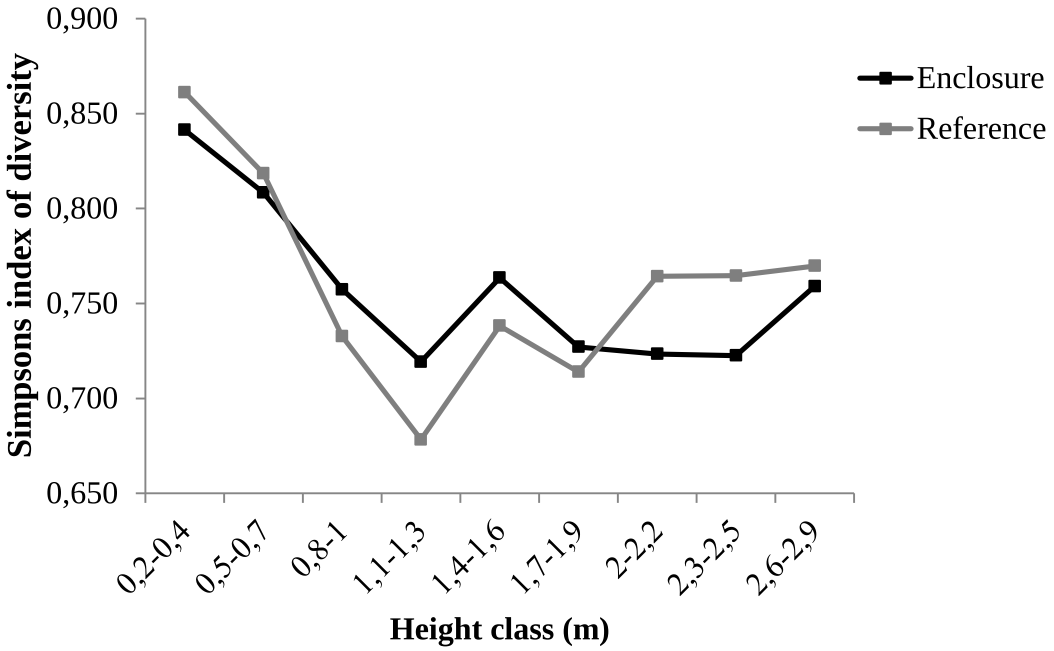


Figure 7. Simpsons index of diversity for each height class.

Effects on ground vegetation

All collected ground cover variables are displayed in Table 2. Plant litter, bare soil and wood rush were significantly more frequent in the enclosure (Plant litter; P<0,001, bare soil; P=0,029, wood rush; P<0,001), however grass was more frequent in the reference area (P<0,001, Figure 8).

Table 2. Number of points with occurrence of different ground cover variable.

Ground cover	**Enclosure (n=25)**	**Reference (n=23)**
Bryophytes	264	222
Grass	261	475
Plant litter	195	82
Snow	158	61
Common bracken (*Pteridium aquilinum*)	84	65
Blueberry (*Vaccinium myrtillus*)	61	97
Lingonberry (*Vaccinum vitis-idaea*)	56	43
Common hepatica (*Anemone hepatica*)	42	44
Wood-rush (*Luzula sp.)*	34	6
Bare soil	28	4
Dead wood	16	8
Common heather (*Calluna vulgaris*)	13	19
Horse faeces	7	0
Water	7	1
Juniper (*Juniperus communis*)	6	8
Lycopodiophyta sp.	6	5
Birch (*Betula sp.*)	4	1
Stone	3	3
Spruce root	2	1
Bark	1	1
Birch root	1	0
Spruce (*Picea abies)*	1	0
European strawberry (*Fragaria vesca*)	0	3
Scots pine (*Pinus sylvestris*)	0	1
Sum	**1250**	**1150**

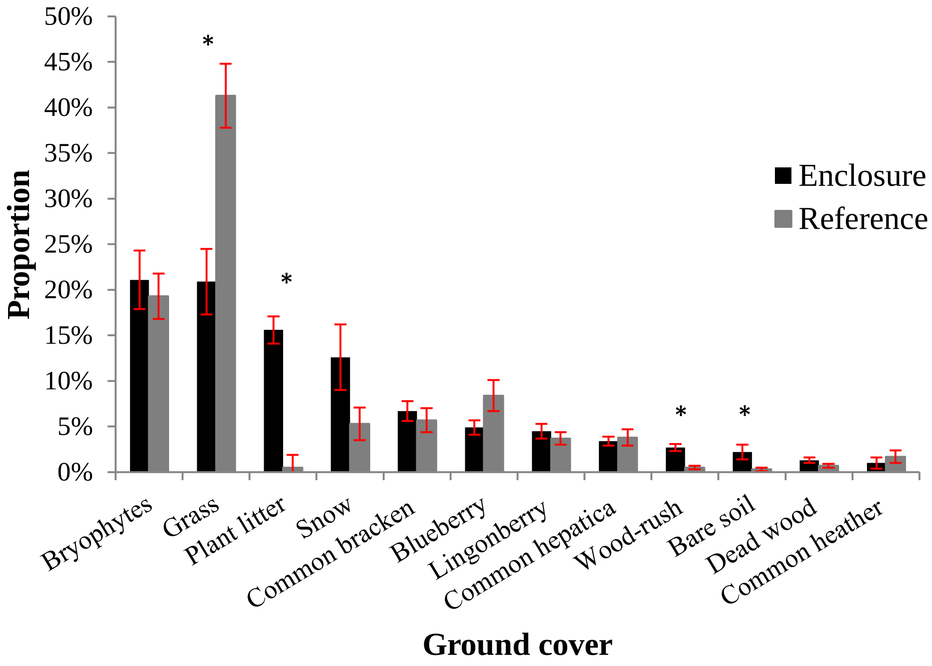


Figure 8. Arithmetic mean and standard error of mean (red bars) for the different ground cover types.

Discussion

Effect on height structure and damaged trees

There were no significant differences in tree and shrub height between the compared sites; the first hypothesis could therefore not be verified. The fact that there was no significant difference might depend on that horses due to their feeding ecology in most cases do not graze directly on woody plants (Duncan 1992). This result is in contrast with earlier studies made by Kuiters & Slim (2003), Buttler et al. (2008) and Kuijper et al. (2010a), but in line with a study made by Vandenberghe et al. (2007). Vandenberghe et al. (2007) concludes that cattle, which in conformity with horses are primarily grazers, affect the biomass of trees, but not necessarily the regeneration of small seedlings.

The variance of the mean, and the CV, was much larger for individuals in the reference area, particularly in the 0.8-1 m class when all trees were included. This indicate that the horses' presence, or the combined effect of horses and roe deer, could have a homogenizing effect on the height structure, which has been shown by Mathisen et al. (2010) on browsing animals such as moose.

The impact of horses on the tree and shrub community might have been stronger and/or different if the density of horses had been as high as the current population during the whole time period. Fluctuations in herbivore density were suggested by Kuijper et al. (2010b) to allow more natural and diverse forest development, whilst constant size of population could lead to single species, even aged stands.

The fact that the horses are moved between the enclosures during the year could also affect the outcome of the result. As showed by Kuiters & Slim (2003) there is a shift in habitat use as the grazing season proceeds, with a higher preference for grazing in more forested areas later in the season. The horses would also seek shelter in the woodlands during night, but during this time they would mostly rest, not graze.

Trampling by the ponies probably affect the seedlings, which is in line with the findings of Liss (1988), that other livestock, such as cattle, mostly damages trees through trampling. Furthermore, Mayer et al. (2006) suggested that cattle also cause damage while scratching themselves on available woody plants. This could probably also be applied on the horses in this study, although this was not surveyed.

Diversity among trees and shrubs

The second hypothesis, concerning diversity among trees and shrubs, was not confirmed. Both inside and outside the enclosure the diversity was highest in the lowest height classes and decreased with increasing height. The amount of damage on trees and shrubs also follows the same pattern. Several studies has shown that an intermediate disturbance enhances diversity (Collins et al. 1995, Mathisen et al. 2010, Mayor et al. 2012), which might suggest that the amount of grazing both inside and outside the enclosure is of intermediate nature.

The effect of the ponies might be more obvious in a study focusing on other vascular plants, rather than trees. There could also be effects on other taxa, as shown in Öckinger et al. (2006) where both vascular plants and butterflies were positively affected by grassland management actions like grazing.

Ground cover

The significant differences in the proportion of grass and bare soil indicate that the horses, as stated in the third hypothesis, have a defined impact on the ground cover. Since horses graze primarily on grass (Duncan 1992) the logical outcome is that grass is less common in a grazed area. Observations made in the field also support that the differences in the amount of bare ground is due to trampling. This probably benefits species able to cope with a disturbed environment, which has been shown in previous studies (Kuijper et al. 2010b, Rigueiro-Rodriguez et al. 2012).

There could also be secondary effects of the horses' presences in the area; they are likely to facilitate seed dispersal and soil fertilization through their excrements, which has been showed in studies concerning other livestock animals. The work of Fisher et al. (1996) showed that during one summer one sheep could transport up to 8500 seeds from a number of different vascular plants, whilst Buttler et al. (2008) showed that excrements from cattle modified diversity by facilitating more nitrophilous species in areas with faeces and liquid excrements.

Further notions

It is important to remember that the historical land use on Gotland may have influenced the study. It is hard, if not impossible, to find forests that are not affected by forest management and/or historical agriculture. Horses have also been roaming freely on the island for about 5000 years, but only been fenced in this area for about 80 years. This may have affected the reference sites.

Conclusion

According to the County Administrative Board (2004) the ponies play an important part in the maintenance of the nature reserve in the northern part of the fall enclosure. The action plan states that the ponies contribute to keep the forest in a desired open stage, but since this survey did not completely support this theory the management actions of the nature reserve is questionable. It may therefore be relevant to modify the way the horses are kept so they can continue to contribute to the openness of the forest.

The rotation between the enclosures, and the supplementary feeding in the winter enclosure, probably prevents some of the impacts that could be done by the horses. Winter is the time when the ponies are expected to graze mostly in woodlands (Kuiters & Slim 2003), and therefore apply the most pressure on the vegetation. As the rotation and supplementary feeding proceeds these effects could be partially undermined, or even prevented, which in turn could influence the positive effects on diversity. Furthermore, the effects on diversity in one area could affect that of another, since the source and dispersal possibilities of different plant species may be altered.

Other livestock animals, such as goats, would probably have a more pronounced effect on the recruiting trees since they feed more intense on all available vegetation (Wood 1987). Trampling, excrements and grazing all contribute to creating a more heterogeneous habitat, which in the long run should facilitate higher biodiversity among both flora and fauna.

That the horses do not seem to influence the regeneration of trees opens up for an expansion for this type of horse keeping, and maybe for other grazers and intermediate feeders as well. For example, it could be combined with horsemeat production and/or rewilding projects with horses.

Future studies

It would be highly interesting to further look in to the processes and interactions between these animals and their environment. This pilot study opens up for further investigations on how the ponies affect the diversity, soil, flora and fauna.

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References

Axelsson Linkowski, W. 2009. Utmarksbete, främst skogsbete, och dess effekter på biologisk mångfald. Centrum för biologisk mångfald. Uppsala.

Buttler, A., Koher, F. and Gillet, F. 2008. The Swiss Mountain Wooded Pastures: Patterns and Processes. *Agroforestry in Europe*. 6:377–396.

Collins, S L., Glenn, S M., and Gibson, D J. 1995. Experimental Analysis of Intermediate Disturbance and Initial Floristic Composition: Decoupling Cause and Effect. *Ecology*. 76(2):486-492

County Adminsistrativ Board. 2004. Länsstyrelsen Gotlands län, Beslut om bildande av naturreservatet Botes källmyr, Gerum och Linde socknar, Gotlands kommun.

Donlan, J., Berger, J., Bock, E C., Bock, J H., Burney, D A., Estes, J A., Foreman, D., Martin, P S., Roemer, G W., Smith F A., Soulé M E. and Greene H W. 2005. Re-wilding North America. *Nature*. 436:913-914

Donlan, J., Berger, J., Bock, E C., Bock, J H., Burney, D A., Estes, J A., Foreman, D., Martin, P S., Roemer, G W., Smith F A., Soulé M E. and Greene H W. 2006. Pleistocene rewilding: An optimistic agenda for twenty-first century conservation. *The American Naturalist*. 168(5):660-681.

Duncan, P. 1992. Horses and grasses – The nutritional ecology of equids and their impact on the Camargue. Ecological studies 87. Springer Verlag, New York.

Ejendal, B. and Hollström, H. 2004. De gotländska skogsrussen. Dialogos förlag, Stockholm.

Fahnestock, J T. and Detling J K. 1999. The influence of herbivory on plant cover and species composition in the Pryor Mountain Wild Horse Range, USA. *Plant Ecology*. 144:145-157

Fischer, S F., Poschlod, P. and Beinlich, B. 1996. Experimental studies on the dispersal of plants and animals on sheep in calcareous grasslands. *Journal of Applied Ecology*. 33:1206–1222.

Holdo, M R., Holt, R D. and Fryxell, J M. 2009. Grazers, browsers, and fire influence the extent and spatial pattern of tree cover in Serengeti. *Ecological Applications*. 19(1):95-109

Hollström, H. 2010. Skogsrussen på Lojsta hed. Dialogos förlag, Stockholm.

Jordbruksverket. 2008. Jordbruksverkets statistikdatabas. Historisk statistik. Kap.1 Företag och ägoslag. http://statistik.sjv.se/Database/Jordbruksverket/databasetree.asp 2013-05-07

Jordbruksverket. 2012. Jordbruket i siffror 1866-2007.

Kuijper, D P J., Joris, P., Cromsigt, G M., Jedrzejewska, B., Miscicki, S., Churski, M., Jedrzejewski, W. and Kweczlich I. 2010a. Bottom-up versus top-down control of tree regeneration in Bialowieza Primeval Forest, Poland. *Journal of Ecology*. 98:888-899.

Kuijper, D P J., Jedrzejewska, B., Brzeziecki, B., Churski, M., Jedrzejewski, W. and Zybura, H. 2010b. Fluctuating ungulate density shapes tree recruitment in natural stands of the Bialowieza Primeval Forest, Poland. *Journal of Vegetation Science.* 21:1082-1098

Kuiters, A T. and Slim, P A. 2003. Tree colonisation of abandoned arable land after 27 years of horse-grazing: the role of bramble as a facilitator of oak wood regeneration. *Forest Ecology and Management.* 181:239-251

Liss B.-M. 1988. Der Einfluss von Weidevieh und Wild auf die natürliche und künstliche Verjüngung im Bergmischwald der ostbayerischen Alpen. *Forstwissenschaftliches Centralblatt* 107(1):14-25

Lojstahedrussen.se. 2013. www.lojstahedrussen.se 2013-04-29

Mathisen, K M., Buhtz, F., Danell, K., Bergström, R., Skarpe, C., Souminen, O. and Persson, I L. 2010. Moose density and habitat productivity affects reproduction, growth and species composition in field layer vegetation. *Journal of Vegetation Science.* 21:705-716

Mayer, A C., Stöckli, V., Konold, W. and Kreuzer, M. 2006. Influence of cattle stocking rate on browsing of Norway spruce in subalpine wood pastures. *Agroforestry Systems*. 66:143-149

Mayor, S J., Cahill, J F., He, P., Solymos, P. and Boutin, S. 2012. Regional boreal biodiversity peaks at intermediate human disturbance. *Nature Communications.* 3:1142

NE.se. 2013. Landbrygga. http://www.ne.se/lang/landbrygga 2013-04-29

Olff, H., Vera, F W M., Bokdam, J., Bakker, E S., Gleichman, J M., de Maeyer, K. and Smit, R. 1999. Shifting mosaic in grazed woodlands driven by the alternation of plant facilitation and competition. *Plant Biology.* 1:127-137

Pauly, D. 1995. Anecdotes and the shifting baseline syndrome of fisheries. *Tree.* 10:430

Pykälä, J. 2000. Mitigating human effects on European biodiversity through traditional animal husbundry. *Conservation Biology*. 14(3):705-712

Rigueiro-Rodriguez, A., Mouhbi, R., Santiago-Freijanes, J J., del Pilar Gonzáles-Hernández, M. and Mosquera-Losada, M. 2012. Horse grazing systems: understory biomass and plant biodiversity of a *Pinus radiata* stand. *Scientia Agricola.* 69(1):38-46

SMHI Klimatdata 1961-1990, 2009. www.smhi.se 2013-04-17

SMHI. 2013. Gotlands klimat http://www.smhi.se/kunskapsbanken/meteorologi/gotlands-klimat-1.4887 2013-05-13

SGU. 2013. Sveriges Geologiska Undersökning, Kartgeneratorn. www.sgu.se 2013-05-02

Vandenberghe, C., Francois Freléchoux, F., Moravie, M., Gadallah, F. and Buttler A. 2007 Short-term effects of cattle browsing on tree sapling growth in mountain wooded pastures. *Plant Ecology.* 188:253-264

Wood, G M. 1987. Animals for biological brush control. *Agronomy Journal.* 79(2):319-321

Öckinger, E., Eriksson, A., and Smith, H G. 2006. Effects of grassland abandonment, restoration and management on butterflies and vascular plants. *Biological conservation.* 133:291-300

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