BRIEF REPORT

# Early Changes of Ground Vegetation in Fallow Deer Enclosure

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*Abstract*

The aim of the study was to examine the influence of enclosed fallow deer on forest vegetation, undergrowth, herb cover and mosses. Investigations were carried out in the fallow-deer enclosure in Mikieriai forest district of Anykščiai State Forest Enterprise in the north eastern part of Lithuania. Three permanent sample plots were set up in the enclosure. An area of each sample plot was 100 $m^2$. Each sample plot was divided into 25 record subplots (2x2 $m^2$ area). In 2005 and 2007 in these subplots undergrowth trees, shrubs were counted, species composition and percentage projection cover for each species of dwarf shrubs, herbaceous plants and mosses were also determined. We used non-parametric Wilcoxon signed-rank test to compare vegetation projection cover and amount of saplings and shrubs in 2005 and 2007. Results have shown that the average projection cover of undergrowth trees, shrubs, herbs and dwarf shrubs decreased. Average projection cover of *Calamagrostis arundinacea, Carex digitata, Deschampsia cespitosa, Fragaria vesca, Luzula pilosa, Maianthemum bifolium, Mycelis muralis, Oxalis acetosella, Rubus idaeus* and *Vaccinium myrtillus* decreased. Average projection cover of mosses increased close to the feeder, while it remained unchanged further from the feeder. During 3-year period of fallow deer settlement in enclosure, their strongest impact was on undergrowth trees and shrubs, slightly less impact was on herbaceous cover and the least impact was observed on mosses.

**Key words**: herbs, projection cover, undergrowth, ungulate

## Introduction

Forest ungulates affect woody plant species in many ways as by removing shoots and leaves, stripping bark, fraying, trampling, defecation and urination. High densities of ungulates have a significant impact on plant populations, forest structure, composition and succession (Strauss 1991, Gill 1992, Padaiga 1996, Augustine and McNaughton 1998). Ungulates alter regeneration processes; reduce the profitability of wood production. In natural forests ungulates impact regeneration processes and biodiversity (Gill 1992, 2001, Baines et al. 1994, Padaiga 1996, Hobs 1996, Bradshaw 2003, Motta 2003).

Ungulates damage forest regeneration in three main ways: by fraying, bark stripping, and browsing (Gill 1992). Ungulate browsing affects the most palatable species. It is generally accepted that the intensity of browsing is associated with ungulate density (Augustine and McNaughton 1998).

Long-term heavy grazing leads to the decline of most palatable species and to the spread of unpalatable and grazing-tolerant species. Grazing eliminates species by trampling or altering nutrient cycling in the forest ecosystem (Miller et al. 1992, Gill 1992, 2001, Baines et al., 1994, Hobs 1996, Rooney and Dress 1997, Morecroft et al. 2001, Rooney 2001, Rooney and Walter 2003).

Introduction of ungulates species affects established ecological equilibrium. Introduction could strangle or displace native species. There are numbers of examples of negative consequences causes by introduced animals. Prime example is the introduction of wild rabbits to Australia from Europe in 1859, when widely spread rabbits heavily damaged nature of the continent (Schesnakov 1989).

Fallow deer (*Cervus dama* LINNE, 1758) were the first animal species introduced to Lithuania. Most likely it occurred in the XVII century. Fallow deer were bred in parks as decoration, and in hunting forests as val-

uable game species. The next stage of introduction of fallow deer started in 1976-1977, when 90 fallow deer were moved to enclosures (Petelis 1998, 2004). Presently only introduction of fallow deer is going on in Lithuania.

Released fallow deer are quite settled and their elementary population could reach extensive density (Navasaitis and Petelis 1998). High densities of animals heavily impact the forests. Moreover, the effect of newly introduced species, for example fallow deer, on different species of forest flora can be stronger than that of native species, such as roe and red deer. Before releasing, fallow deer are usually kept enclosed, where they pass the first stages of acclimatization. After fallow deer were settled in a newly set up enclosure, their density is rapidly increasing. Such a situation forms perfect conditions to observe their impact on separate species of forest vegetation. In Lithuania, the process of fallow deer introduction has been studied extensively (Petelis 1997, 1998, Petelis and Brazaitis 2005), while no studies about the influence of fallow deer on vegetation have been performed.

The aim of our study was to investigate the impact of enclosed fallow deer on forest vegetation. We pose hypothesis, that high density of animals in the enclosure decreases the amount of undergrowth and shrubs, affects the cover of some herbs and moss species.

## Methods and material

Investigations were performed in an enclosure of fallow deer. This enclosure was established in 2005 at the Šimonys forest (51 and 63 blocks) of Mikieriai forest district, Anykščiai State Forest Enterprise in the north eastern part of Lithuania (Fig. 1). An area of enclosure is 62.9 ha including 48.4 hectares of forest; 7.0 ha of clearings, 7.3 ha – meadows, grasslands, forage grounds and 0.2 ha of water pond. The feeder for the supplementary feeding of the fallow deer was established in the southern part of the enclosure. Initially 20 fallow deer were placed into enclosure in 2005, and there were 36 individuals in 2007.

In 2005 three permanent sample plots were set up including one in the mixed spruce and birch forest stand (near 20 m from the feeder); next in the stand dominated by spruce in the middle of enclosure (near 0.5 km from the feeder); and the last one in the mixed spruce, pine and birch stand at the end of enclosure (near 1 km from the feeder). An area of each sample plot was 100 $m^2$. Each sample plot was divided into 25 record subplots (2x2 $m^2$ area). Sampling was performed in 2005 before fallow deer were placed into enclosure and in 2007. We treated samples taken in 2005 as controls and analysed time trend from this time point when the first fallow deer were settled. We identified the species of all undergrowth trees and shrubs and counted all individuals in the subplots. According to the degree of damage all undergrowth trees and shrubs were divided into two groups: healthy individuals and browsed ones. Species composition and percentage of projection cover for each species of dwarf shrubs, herbaceous plants and mosses were determined in subplots. We used non-parametric Wilcoxon signed-rank test to compare vegetation projection cover and amount of saplings and shrubs in 2005 and 2007.

## Results

In plots, average coverage of undergrowth of shrub layer, herb layer and mosses was 10.87 %, 0.43 %, 14.06 % and 25.57 %, respectively (Table 1). Three years after the settlement of fallow deer undergrowth decreased in the mixed spruce and birch forest stand at 20 m from the feeder and in the stand dominated by spruce in the middle of enclosure at 0.5 km from the feeder. There was no significant change of undergrowth in the mixed spruce, pine and birch forest stand at the end of enclosure at 1 km from the feeder. Cover of shrub and herb layers decreased in all plots. Cover of moss layer significantly increased

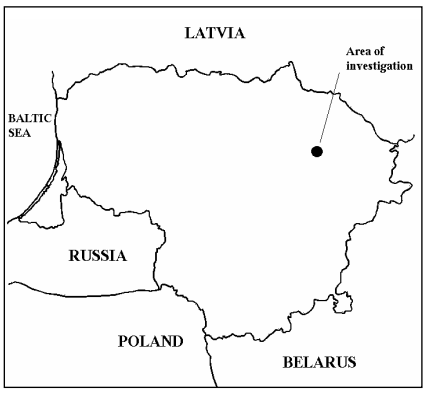


**Fig. 1.** Area of investigation

**Table 1.** Average projection cover of ground vegetation

| Forest layer | Relative change (2007-2005) % | | | Average projection cover in all plots, % | Standard deviation |
|---|---|---|---|---|---|
| | A | B | C | | |
| Undergrowth | -48* | -33* | -2 | 10.87 | 13.95 |
| Shrub layer | -91* | -86* | -87* | 0.43 | 0.45 |
| Herbs | -63* | -59* | -51* | 19.69 | 14.06 |
| Moss | 209* | 3 | 3 | 31.02 | 25.57 |

* - Wilcoxon signed-rank test $p<0.05$,
A - mixed spruce and birch forest stand (20 m from the feeder), B - the stand dominated by spruce in the middle of enclosure (0.5 km from the feeder), C - mixed spruce, pine and birch forest stand at the end of enclosure (1 km from the feeder)

in the mixed spruce and birch forest stand at 20 m from the feeder, while there was no significant change in other plots.

The following undergrowth tree species were identified in the study area: *Alnus incana, Betula pendula, Picea abies, Populus tremula* and *Quercus robur. Picea abies* was the most abundant species. During the study period the number of healthy *Picea abies* saplings decreased, while the number of damaged trees significantly increased (Table 2). The amount of *Alnus incana*, *Populus tremula* significantly decreased.

The following shrubs species were recorded: *Corylus avellana, Frangula alnus, Rhamnus cathartica, Ribes rubrum, Salix cinerea* and *Sorbus aucuparia*. The number of *Sorbus aucuparia* individuals significantly decreased during three year period of fallow deer settlement, while no significant changes were observed in the number of individuals of other shrub species (Table 2).

**Table 2.** Average amount of undergrowth tree and shrub species

| Name of species | Relative change (2007-2005) % | | | Average amount in all plots, unit/m$^2$ | Standard deviation |
|---|---|---|---|---|---|
| | A | B | C | | |
| *Alnus incana* | -76.92* | - | - | 0.03 | 0.05 |
| *Alnus incana*$^{br}$ | 800.00* | - | - | 0.02 | 0.04 |
| *Betula pendula* | -100.00 | -66.67 | - | 0.01 | 0.01 |
| *Betula pendula*$^{br}$ | 0.00 | 100.00 | - | 0.02 | 0.05 |
| *Picea abies* | -87.70* | -56.03* | 100.00 | 1.99 | 2.46 |
| *Picea abies*$^{br}$ | 95.77* | - | 0.00 | 0.39 | 0.56 |
| *Populus tremula* | -100.00 | - | - | 0.01 | 0.02 |
| *Populus tremula*$^{br}$ | -100.00* | - | - | 0.02 | 0.04 |
| *Quercus robur* | -100.00 | -100.00 | - | 0.01 | 0.02 |
| *Quercus robur*$^{br}$ | 0.00 | - | -100.00 | 0.01 | 0.01 |
| *Corylus avellana* | - | -100.00 | - | 0.00 | 0.00 |
| *Frangula alnus*$^{br}$ | -100.00 | -85.71 | - | 0.02 | 0.03 |
| *Rhamnus cathartica*$^{br}$ | 100.00 | - | - | 0.02 | 0.03 |
| *Ribes rubrum* | 16.67 | - | - | 0.02 | 0.03 |
| *Salix cinerea*$^{br}$ | -100.00 | - | - | 0.00 | 0.01 |
| *Sorbus aucuparia* | -100.00* | 0.00 | -100.00 | 0.03 | 0.05 |
| *Sorbus aucuparia*$^{br}$ | -72.22* | -64.44* | 18.18 | 0.18 | 0.14 |

br - browsed,
* - Wilcoxon signed-rank test $p<0.05$,
A - mixed spruce and birch forest stand (20 m from the feeder), B - the stand dominated by spruce in the middle of enclosure (0.5 km from the feeder), C - mixed spruce, pine and birch forest stand at the end of enclosure (1 km from the feeder).

The most abundant species of herbs (cover > 1 %) were *Calamagrostis arundinacea, Pteridium aquilinum, Oxalis acetosella, Rubus idaeus, Vaccinium myrtillus* (Table 3). The average projection cover of *Calamagrostis arundinacea*, *Carex digitata, Deschampsia cespitosa, Fragaria vesca, Luzula pilosa, Maianthemum bifolium, Mycelis muralis, Oxalis acetosella, Rubus idaeus* and *Vaccinium myrtillus* significantly decreased during the study period. The cover of *Pteridium aquilinum* was quite abundant in two plots, and did not significantly change (Table 3).

The most abundant species of mosses were *Hylocomium splendens, Pleurozium schereberi, Plagiomnium sp.* The average projection cover of *Hylocomium splendens* and *Pleurozium schereberi* significantly increased in the mixed spruce and birch forest stand located at 20 m from the feeder. The cover of mosses did not significantly changed in the stand dominated by spruce in the middle of enclosure at 0.5 km from the feeder and in mixed spruce, pine and birch forest stand at the end of enclosure at 1 km from the feeder (Table 3).

**Table 3.** Average projection cover of herbs, dwarf shrubs and moss species

| Name of species | Relative change (2007-2005) % | | | Average projection cover in all plots, % | Standard deviation |
|---|---|---|---|---|---|
| | A | B | C | | |
| *Agrostis capillaris* | -99.00 | - | - | 0.04 | 0.10 |
| *Calamagrostis arundinacea* | -61.44* | -32.20 | -65.51* | 7.24 | 9.30 |
| *Carex digitata* | -100.00 | -80.94* | -98.75 | 0.28 | 0.50 |
| *Cystopteris fragilis* | -65.57 | - | - | 0.03 | 0.05 |
| *Deschampsia cespitosa* | -75.80* | - | - | 0.21 | 0.40 |
| *Dryopteris carthusania* | -52.97 | - | -39.75 | 0.59 | 0.75 |
| *Fragaria vesca* | -99.38* | - | -49.69 | 0.13 | 0.16 |
| *Lamiastum galeobdolon* | - | - | -42.62 | 0.22 | 0.36 |
| *Luzula pilosa* | 0.00 | -98.13* | -97.50 | 0.04 | 0.06 |
| *Maianthemum bifolium* | -64.43 | -99.49* | - | 0.42 | 0.62 |
| *Mycelis muralis* | - | -99.29* | -100.00 | 0.10 | 0.23 |
| *Oxalis acetosella* | -58.11* | -49.31* | -28.87* | 5.68 | 3.23 |
| *Pteridium aquilinum* | 10.00 | - | -17.41 | 3.15 | 4.59 |
| *Pyrola rotundifolia* | - | -97.50 | - | 0.01 | 0.02 |
| *Rubus idaeus* | -78.37* | - | -50.65* | 1.03 | 1.10 |
| *Rubus saxatilis* | - | -26.89 | -7.90 | 0.75 | 0.61 |
| *Stellaria nemorum* | -99.83 | - | - | 0.04 | 0.10 |
| *Trientalis europaea* | -96.41 | - | -87.50 | 0.03 | 0.05 |
| *Vaccinium myrtillus* | -100.00 | -57.93* | -42.86* | 2.03 | 2.15 |
| *Vaccinium vitis-idaea* | - | -31.67 | - | 0.03 | 0.05 |
| *Viola riviniana* | -98.36 | - | - | 0.02 | 0.05 |
| *Atrichum undulatum* | 133.33 | - | - | 0.07 | 0.12 |
| *Dicranum scoparium* | -100.00 | 0.00 | - | 0.11 | 0.16 |
| *Eurhynchium angustirete* | - | 15.15 | - | 0.47 | 0.74 |
| *Hylocomium splendens* | 150.00 | 3.50 | -6.58 | 11.80 | 13.63 |
| *Plagiomnium sp.* | 589.00* | -7.37 | 50.00 | 3.08 | 3.38 |
| *Pleurozium schereberi* | 182.95* | 3.03 | 2.65 | 10.99 | 7.35 |
| *Polytrichum commune* | 25.00 | - | - | 0.06 | 0.09 |
| *Rhytidiadelphus triquetrus* | - | -8.06 | - | 0.79 | 1.23 |

* - Wilcoxon signed-rank test $p<0.05$,
A - mixed spruce and birch forest stand (20 m from the feeder), B - the stand dominated by spruce in the middle of enclosure (0.5 km from the feeder), C - mixed spruce, pine and birch forest stand at the end of enclosure (1 km from the feeder)

## Discussion

Our results revealed that the impact of enclosed fallow deer on forest ground vegetation had been already obvious after three years. Although the undergrowth trees were intensively browsed all over enclosure, the strongest impact was observed near the feeder where the proportion of damaged spruce undergrowth was highest. *Sorbus aucuparia* was the mostly browsed shrub species.

The projection cover of herbs also decreased in all sample plots. *Vaccinium myrtillus, Calamagrostis arundinacea* and *Rubus idaeus* were the mostly browsed species. The reduction of projection cover of other species (*Carex digitata, Deschampsia cespito-*

*sa, Fragaria vesca, Luzula pilosa, Maianthemum bifolium, Mycelis muralis, Oxalis acetosella*) could be related to the indirect impact of animals, or to particular fluctuations. Other species either did not alter (*Pteridium aquilinum*) or the number of individuals was too small to detect any significant changes.

The projection cover of mosses increased in the plots located near the animal feeder, while it did not change significantly in other plots. Probably, it was caused by the increased amount of light and the reduced density of spruce undergrowth. Thus, the distance to the feeder (a place, where fallow deer were supplementary fed) seemed to be an important factor. Fallow deer stay and feed near the feeder, and we observed strongest their impact on vegetation near the feeder.

Studies in other countries showed that under the impact of cervids, palatable species - *Vaccinium myrtillus, Rubus* sp. *Lonicera periclymenum* decreased primarily, while unpalatable and poisonous species (*Pteridium aquilinum*, *Glechoma hederacea)* outspread. Grazing-tolerant species, mostly grasses, became more prevalent (Pigott 1983, Putman et al. 1989). Some herb species could be affected by trampling. Grime et al. (1988) indicated, that *Mercurialis perennis* suffered because of trampling, therefore their abundance decreased in areas where trails of animals or their gathering places originated.

While destroying forest litter cervids improve the conditions for spreading of some species, namely ruderal species (*Mycelis muralis*, *Rumex* sp., *Senecio jacobea, Sonchus oleraceus*) (Kirby 2001). Under of impact of animals favourable conditions develop for nitrophylic species (*Urtica dioica, Galeposis* sp*., Chelidonum majus*) (Putman et al. 1989, Grime et al. 1988, Chytry and Danihelka 1993). Elimination of undergrowth trees and shrubs also creates favourable conditions for tall species (*Angelica sylvestris, Filipendula ulmaria)* (Grime et al. 1988).

## Conclusions

1. During three-year period of fallow deer settlement the impact of fallow deer in enclosure was strongest on undergrowth trees and shrubs, slightly less impact was on herbaceous cover and the least impact was observed on mosses.

2. The average projection cover of undergrowth trees and shrubs decreased in the deer enclosure. Amount of *Alnus incana*, *Picea abies* and *Sorbus aucuparia* saplings decreased.

3. The projection cover of herbs and dwarf shrubs decreased in the deer enclosure. The average projection cover of *Calamagrostis arundinacea,* Carex *digitata, Deschampsia cespitosa, Fragaria vesca, Luzula pilosa, Maianthemum bifolium, Mycelis muralis, Oxalis acetosella, Rubus idaeus* and *Vaccinium myrtillus* decreased.

4. The average projection cover of mosses increased near the feeder while it remained unchanged further from the feeder.

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## ИЗМЕНЕНИЕ РАСТИТЕЛЬНОСТИ В ЗАГОНЕ ЛАНЕЙ

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*Резюме*

В работе показано воздействие ланей на растительность леса: моховой, кустарничково-травянистый покров, подлесок и подрост. Изучение проводились в 2005 и 2007 годах в загоне ланей лесничества Микиеряй в лесхозе Аникшчай в северно-восточной части Литвы. Постоянные пробные площадки были подобраны в трех древостоях. На пробных площадках описаны компоненты фитоценозов: кустарничково-травянистый покров, подлесок и подрост. Для оценки влияния зверей на компоненты фитоценозов использован тест Wilcoxon.

Установлено, что проекционное покрытие подлеска, подроста и кустарничково–травянистого покрова уменьшилось. Уменьшилась численность *Alnus glutinosa, Picea abies* и *Sorbus aucuparia,* также проекционное покрытие кустарничково-травянистого покрова. Уменьшилась численность *Calamagrostis arundinacea, Carex digitata, Deschampsia cespitosa, Fragaria vesca, Luzula pilosa, Maianthemum bifolium, Mycelis muralis, Oxalis acetosella, Rubus idaeus, Vaccinium myrtillus.* Проекционное покрытие мохового покрова повысилось только в местах, расположенных рядом с местами подкормки, тогда как на других площадках не изменилось.

**Ключевые слова:** копытные звери, подлесок, проекционное покрытие, травянистые растения