

The Impact of Moose (*Alces alces* L.) on Woody Vegetation and Potential Role of Ecological Corridors in the Transboundary Forests

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Abstract

Deer herbivory is widely recognized as a serious problem in forestry. Nevertheless, only few studies have touched upon the point of deer impact on woody plants in the transboundary areas of Lithuania and Belarus. The attractiveness of habitats and adequate animal spatial distribution depend not only on food availability including links with the edge effect, disturbance and competition, but also on the availability of thermal and hiding cover. This occurs independently of the administrative borders between neighbouring countries. Habitat similarities of the neighbouring countries allow animals to migrate between the certain border territories using certain ecological (migration) corridors. Aiming to assess the impact of deer species on woody vegetation in the transboundary forests and the potential role of ecological corridors, I used the method that integrates sample plots (50 x 2 m) with the belt transects (100 x 4 m). I have determined simultaneously the main forest characteristics of each route unit and indices of the consumption of woody plants. The key species was Moose *Alces alces* L. The main limiting factors of moose impact on woody vegetation are the duration of non-vegetative period and its changeability that determines the time and extent of animal effect on woody vegetation throughout. During the prolonged wintry period, the clumped distribution of moose entails an increased effect on pine natural regeneration and plantations. In the short warm periods, moose concentrate in the pine plantations, alongside wet forest sites because of moose thermal sensitivity. The potential ecological corridors and their functional aspect for deer species have been revealed. The actual duration of the non-vegetative period should be considered.

Key words: transboundary area, moose, impact on forest, weather, ecological corridor

Introduction

In the East and South, Lithuania shares a 660 km border with Belarus. In both countries, forests have had significant multifunctional importance for natural frameworks and state development. An inherent part of forest ecosystems is their mobile biotic component – game animals. They have a scientific, aesthetic, cultural, recreational, economical and natural heritage value that must be protected and passed on to future generations. According to the main EU environmental documents, the protection of wildlife and habitats is grounded on the objective assessment of wildlife status. Each wildlife species requires an environment in which it can live independently from country borders. In a geographical or political sense, borders between countries are clear like state borders fixed by treaties. Environment and habitats could have the same/similar or different value and richness on both sides. Border areas very often have a common history and the same culture. Borders of natural areas are often unclear, fluid and depend on the background of the ob-

server. Ecological units are not necessarily state boundaries, and nature has neither limits nor borders, and animals can distribute in the both sides of the transboundary area keeping the certain ecological corridors. These corridors are structures which facilitate the connectivity of territories joining two or more larger areas of similar wildlife habitats (Good 1998, Corsi et al. 2002, Bond 2003, Russel et al. 2003, Nat. Res. Manag. Advisory Notes 2004). The role of ecological corridors for habitat conservation in the fragmented landscape is highlighted in the EU Habitat Directive.

In our case, above mentioned connectivity is a more general expression that includes corridors and barriers, and indicates how animals can respond to the structure of the landscape. Corridors provide temporal or permanent habitats for wild animals (Van Dorp and Opdam 1987, Rosenberg et al. 1995), enable their migration, colonisation and interbreeding between local populations.

The term of ecological corridor embraces some controversy (Bissonette and Krausman 1995, Mann and

Plummer 1995) depending on differences in meaning, e.g. structural as some linear landscape element that is qualitatively different from the adjacent units or functional as some preferable routes for animal migration which provide favourable conditions for movements. For animals, an ecological corridor is some territorial entity regardless of being linear or not that provides the landscape connectivity reducing or eliminating negative effects in the landscape structure like fragmentation and artificial or natural barriers. Corridors can coincide with mosaic boundaries and different types of adjacent cover in each part forming some asymmetrical structures. Corridors may have a buffering function softening contrasts between different cover (Sastre Olmos and De Lucio 1998, Good 1998) and some of the worst effects of habitat fragmentation. The knowledge of such areas would help to maintain the diversity and provide the measures for forest protection against undesirable effects of animals to forests. The different technologies and forest management practices in Lithuania and Belarus act the formation of wildlife communities and the relationship with their environment. It causes an elimination of the certain barriers to animal dispersal and their spread in the transboundary area that has been set by human. Present natural barriers (e.g. rivers, fields, etc.) often impede animals' migration outside their range, whereas an intensive forest management allows suitable conditions for ecological corridors.

The increase in forest vulnerability under the stress of biotic factors comes known rising the number of deer populations throughout the neighbouring countries, Lithuania and Belarus (Maximenkov 2002, Shakun 2011, 2012, Belova 2011, 2012). It may be related to a number of factors including conditions of climate changes, specificity and differences in forest management that determine changes in the availability of habitats and food supply for animals. Deer species are directly related to the forest woody vegetation meeting their trophic requirements (Putman 1986, 1996, Geist 1998, Reimoser 1986, Lav Sund 1987, Gill 1992, Heikkilä and Härkönen 1996, Reimoser and Gossow 1996, Waller and Alverson 1997, Berquist et al 1999, Reimoser et al 1999, Hester et al. 2000, Scott and Palmer 2000, Stromayer and Warren 1997, Ball and Dahlgren 2002, Edenius et al. 2002, Bugmann and Weisberg 2003, Nordengren et al. 2003, Pietrzykowski et al. 2003, Reimoser 2003, Weisberg and Bugmann 2003, Olofsson et al. 2005, Mysterud 2006, Crespi et al 2007, Nikula et al. 2008, Belova 2005, 2007, 2011, 2012, Heikkilä and Tuominen 2009, et al.). The subject of an importance of ecological corridors for animal movement and selection of immigration – emigration paths depending on the conditions required for their existence, is less examined

yet despite many comprehensive investigations of deer impact on forest vegetation throughout the world.

Obviously, animals must have not only habitat as a cover (shelter) from weather and predators, space for the rest, movements and mate but also for food to survive. Over the last decades, climatic anomalies and a number of atypical extreme events cause changes in animal distribution, that assumed an unusual character, and in an impact of herbivores on the environment including the transboundary area. The aim of this study was to ascertain the influence of moose on the commercial tree species (i.e. the case of the dominant species, *Pinus sylvestris* L.) in the context of potential ecological corridors in the transboundary forests. I presume that the existing forest - wetland complex is attractive to animals providing a safety (i.e. protected areas as Cepkeliai Strict Nature Reserve and Kotra Landscape Reserve) and a potential accessibility of food. In this study, I did not put aspect of ecological corridors on the central point of paper. We will continue to investigate relations between deer habitat use, their impact on woody vegetation and identified potential ecological corridors. To evaluate wildlife habitats and formulate management recommendations for foresters of the transboundary area, we need to know the basic data about habitats and their relationship with wildlife species those directly affect forest woody vegetation.

Material and methods

Study area

The study was conducted during the non-vegetative periods - at the beginning of vegetative periods 2011 and 2012 in the pine forests of southern Lithuania that belong to the boreal biogeographical region (EC 2011/84/EU) and represent the landscape group of sandy outwash plains. The study forests of all sampling locations were characterized on the ground of the forest type, delineation of territory for wildlife (Belova 1999) determining the main abiotic and biotic factors (climate, predominant soil type forest cover, forest site, stand composition, age class, etc.) of the dominant stands and climatic sub-region (3B) (after K. Kaušyla as cited in Bukantis 1994, Belova 1996, 1999) and their suitability for wildlife. Conventional symbols of the four sampling locations were selected as 54°03'24.03" N 24°24'03.3" E (M1, Marcinkonys Forestry); 53°57'10.83" N, 24°17'49.23" E (K, Kabeliai Forestry); 53°57'8"N 24°24'36"E (M2, Musteikos Forestry); 53°59'0"N, 24°6'0"E (L, Latežeris Forestry) (Figure 1 a, b).

The meteorological and forest inventory data were collected from the local Meteorological Stations and State Forest Service. Forest stands comprise 96.0% of

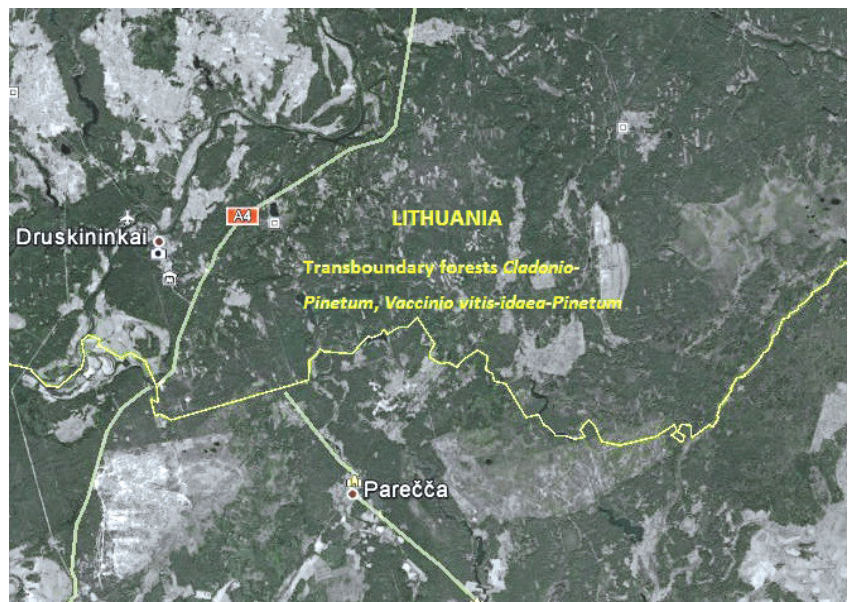


Figure 1. Study area: Location of the study area in the Europe (green dot indicated the study area) (a), and study forests (b) (*Cladonio-Pinetum*, *Vaccinio vitis-idaea-Pinetum*) on the Lithuanian-Belarusian transboundary area

the total area while non-wooded land is only 1.8% including wetlands (0.8%) and agricultural lands (0.8%). In all sample locations, the main dominant tree species is Scots pine *Pinus sylvestris* (82.47%) and rather less share of *Betula pendula* (5.84%), *Picea abies* (4.13%) and *Alnus glutinosa* (3.30%). The dominant communities are *Cladonio-Pinetum* (51%) and *Pinus-Vaccinium vitis-idaea* (33%). Forests are rather even-aged with a mean age of 55 years. The old-growth stands comprise only 2% of the total forest area. The soils are predominantly infertile sandy Arenosols. In the adjoining forests of Grodno district (Belarus), Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* Karst.) are dominant tree species in stands of all age classes comprising from 88.2% in young stands to 63.1% in mature stands. The Cepkeliai - Kotra Wooded Wetland Complex including forests, wetlands and floodplain meadows (Maksimenkov 2002, de Haro 2005), characterizes the transboundary zone along the border.

The continental climate (subtype: Eucontinental, the index of continentality is 28-46 by Conrad (1946) or 75-87% by Gorczynski (1922) predominates on the study area. The mean annual precipitation reaches 675 mm as 490 mm fall in November-March; the weather severity index (by Bodman formula $S = (I + 0.272 V) (I - 0.04 T)$, where V is the average wind speed m/s, after V. Wiese 1940 (as cited in Belova 2008) is 2.0; the average temperature of the warmest month (July) is +17.7°C while may rise at most to +37.0°C; average annual air temperature is +6.2 °C. The constant snow cover persists for approximately 75-80 days. The long-term average snow depth is 25 cm. In the beginning of winter of the study period, the snow cover was unstable and changed from 2-5 cm to 11 cm only and did not exceed the critical threshold for animals. In January, it has reached a depth of 56-68 cm and more in places but decreased sharply until February. The thermal regime was favourable for shoot browsing. At the end of winter, however, the changeable weather (i.e. rapid changes from +8°C to -23°C) was unsuitable for moose location on the open areas considering species sensitivity to the thermal stress (Tefler 1984, Renecker and Hudson 1986, Schwab and Pitt 1991, Lundmark and Ball 2008, Belova 2008, Dungan et al. 2010, Beest et al. 2012).

Methods

The survey was conducted during April-May 2011-2012. I used the pellet group count method to assess animal abundance, distribution, the age structure and sex ratio of their local populations. This method (Bennett et al. 1940, Rasmusen, and Doman 1943, McCain 1948, Neff 1968, Coulson and Raines 1985, Marques

et al. 2001, Scott et al. 2002, Campbell et al. 2004, Eckervall 2007, Rönnegård et al. 2008, Månsson et al. 2011, et al.) has been applied (Padaiga 1965) and successfully adopted in game management practice and education in Lithuania during almost five decades (Padaiga 1996, 1998, Belova 1997, 2007, 2010). The census technology of Lithuanian deer species has been created and parameters, coefficients and accuracy parameters have been determined. The method is based on the numbers of pellets deposited by deer species during the non-vegetative period, and the duration of winter foraging. After the above-cited references on this method, I will not repeat common knowledge, although this knowledge is necessary for the practical use including the time of counting (i.e. namely before the start of vegetation; non-vegetative period is the time that gives a lot of challenges and obstacles for animals, especially as in the last times because of the changeability of unusual weather that strongly affects the conditions of animal foraging and distribution). Animals produce the different number of faeces depending on the duration of non-vegetative period, respectively. In Lithuania, the usual duration of the non-vegetative period reaches 130-150 days (November – March). The number of faeces produced per day is typical of the certain animal species. This number is determined by the balance method for metabolic research measuring the amounts of food and nutrients consumed by animals and number of excreted faeces. We have performed the comprehensive physiological and biochemical investigations determining changes in the nutrient assimilation and number of faeces during the non-vegetative period complementing to the data collected from field works. The number of produced faeces directly related to the unit weight, i.e. the weight of pellet increases while the number of faeces decreases. At the same time, the content of total fibre in pellets increases.. These changes are typical of the non-vegetative period because of the low moisture content in animal foods as there are no the green herbaceous plants in animal feeding (Belova 1997). The study conditions (nature, enclosure and all that), species in the animal diet, animal age and sex should be considered too. In the different geographical locations, pellet-group deposition rate of the same animal species is different. In Lithuania, pellet-group deposition rate of moose is 2,800 or av. 22/day (Padaiga 1998, Padaiga and Marma 1979). In current study, the number of wintered animals in the certain sample territory was assessed on the ground of data of the duration of non-vegetative period, the number of pellet groups registered within belt transects, the number of pellet groups produced per day by moose (i.e. 2,800), the length (m) and area (ha) of the belt transects and the total sur-

veyed area (ha). To use this method, it is necessary to consider the ratio between areas of the census transect belt and the total territory. The number of moose, that spend their winter in the certain sample location, was calculated by the widely known formula: $M = (S \times N_m / s_l) / 2,800$ (Padaiga 1996, Belova 2005, 2010) where M is the number of animals that spend winter in the certain location, S is the total forest area of the sample location, hectares, N_m is the total number of counted pellet groups, s_l is the total area of the line transect, hectares. The density of moose was calculated as the number of animals, which have spent winter in the certain location, per 1,000 ha. On the ground of the comparative analysis, the accuracies of the different census methods have been motivated and reasoned. The error of the circuit method is $\pm 20\text{-}25\%$, while one of the pellet group count method reached $\pm 10\%$ (Belova 2010). The method allows to assess the age and sex structure of the local populations. The identification of animal age and sex is based on the prevailed shape and size of pellets in the pellet group.

The method of pellet group count within the permanent line transects (sample unit 100 x 2 m) is combined with the sample plot (50 x 2 m) method. Sample plots are established every sample unit of transect systematically. This method was verified and adopted in the monitoring system of the relationship between herbivorous mammals and woody vegetation in the different natural regions of Lithuania (Belova 2005, 2007, Belova and Šmitas 2005). Transects and sample plots were established and hiked using GPS, the compass and forest management plan maps. Transects were completed across the different forest habitats comprising on average 12 km in the total length. The total length of the route is 233.63 km and the total number of sample plots is 1,575 on the total study area of 12,146 ha.

The above mentioned reliable integrated method was verified and used for the monitoring of relationship between herbivores and woody vegetation (Belova and Šmitas 2005, Belova 2005, 2007, 2010). In the rectangular sample plots, woody plants and their shoots within the animal feeding area (i.e. from $h = 0.5$ to 3 m) were counted. Each tree on the sample plot was inspected for signs of damage classifying the level of shoot browsing (the number of damaged and undamaged shoots) or bark stripping (the number of damaged and undamaged stems and the area of damaged bark, cm^2). The consumption of shoots in woody species (Csh %) was calculated as the ratio of damaged to undamaged shoots. The established critical threshold in shoot consumption for the deciduous woody species is 40-50% and for the coniferous species 20-30%. These threshold levels were ascertained and approved based on investigations of the decrease in species growth and changes in the stand formation (Padaiga 1996, Belova 2008, 2010, 2012).

On Lithuanian side of the transboundary forests, the key species is Moose (*Alces alces*) while Red deer (*Cervus elaphus*) occur occasionally and their density does not exceed 1 individual per 1,000 hectares. The long-term density of the Roe deer (*Capreolus capreolus*) does not exceed 10 indiv. /1,000 ha. It usually reaches only 2-3 indiv. /1,000 ha (Figure 2).

This species distribution tends to assume uniform spacing (Belova 2011, 2012). The population size of roe deer is typical of pure pine forests of Southern Lithuania as a stable low one (Belova 1996, 1999, 2012). During the latent period in roe deer pregnancy, limiting weather factors (thermal regime and condition of snow cover – Belova 2008, 2012) were unfavourable for juvenile survival at the pre-natal stage and further. It reflects in the qualitative parameters of the local population of roe deer (e.g. the share of juveniles

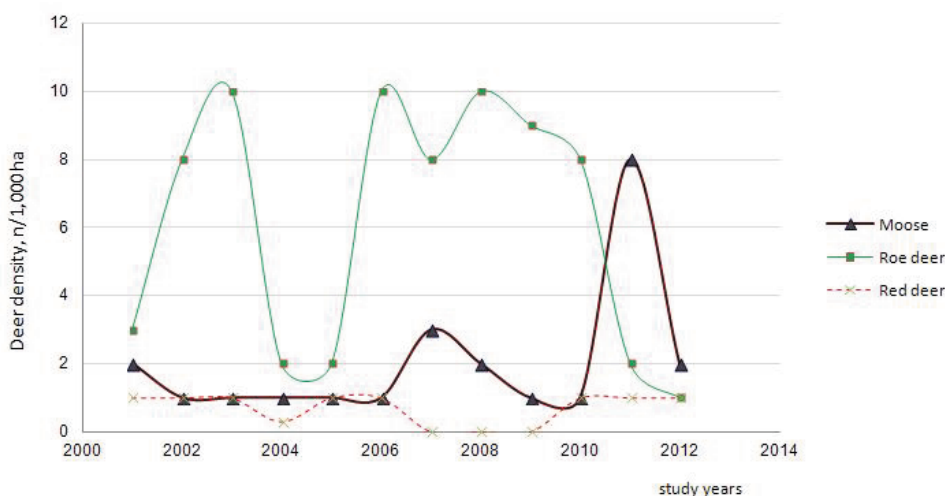


Figure. 2. The long-term density of deer species in the transboundary forests of Southern Lithuania

reaches only 5% of the local population). To identify the possible ecological paths of animals, the data on animal distribution and their impact on the forest woody vegetation were analysed and compared with the analogous data obtained from the transboundary forests in Belarus.

The data were processed using *MS Excel* and *STATISTICA8*. Multiple linear regression was used to analyze moose impact (the consumption of shoots Csh % as dependent variable) in relation to moose density in all sample locations and changes in the consumption of the main tree species depending on the changes in the average temperatures in the non-vegetative period (independent variables). I considered the changeability of the thermal factor and examined correlation coefficients for these variables. Our previous results of the monitoring ‘*herbivorous mammals-forest woody vegetation*’ (Belova and Šmitas 2005) have revealed the main abiotic criteria in the relationship as the changeability of thermal factor and the state of snow cover (Belova 2008). The latter criterion was inconsequential for moose within all study period and was not considered.

Results

Qualitative parameters of the local moose population come near to the optimum e.g. the sex structure was 1:1.4. The rate of juveniles (24%) also approached the optimal level (26%). Such parameter warrants the realization of population potential. In the previous non-vegetative period of 2010/2011 (the duration of 152 days), moose preferred pine plantations and gathered in the pre-mature and mature stands (Figures 3a, b) of the 0.4 - 0.6 stocking level. Moose most concentrated in the pine plantations at the approaches to the Čepkeliai raised bog on the area of Kabeliai and Musteikos forestries (sampling localities K and M2, respectively). Females and young animals have prevailed comprising 48% of the local population. In stands, animals have fed in the patches of natural regeneration.

In the last short (63 d.) but changeable period of 2011, the highest moose concentration was in Scots pine plantations of the different ages from the early successional to pole stage. The distribution pattern of moose apparently was clumped. The positive correlation between changes in the average temperature over the non-vegetative period and animal density (number per unit area) is revealed $r = 0.65$, $R^2 = 0.42$, $F = 4.31$, $P < 0.019$. Simultaneously, the clumped distribution determines an increase in moose impact on woody vegetation. Although an average air temperature over the non-vegetative period and the consumption of pine shoots related negatively (Figure 4 a,b),

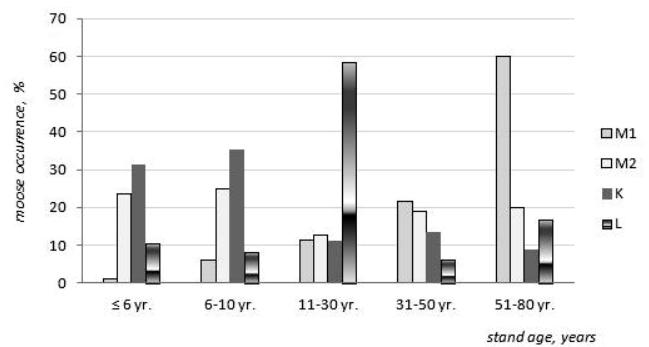


Figure 3 a. Moose (*Alces alces*) distribution in the different stand ages in the transboundary pure pine forests during non-vegetative period of 2011 (herein moose occurrence % reflects the number of registered moose pellet groups; M1 – Marcinkonys Forestry; K – Kabeliai Forestry; M2 – Musteikos Forestry; L – Latežeris Forestry)

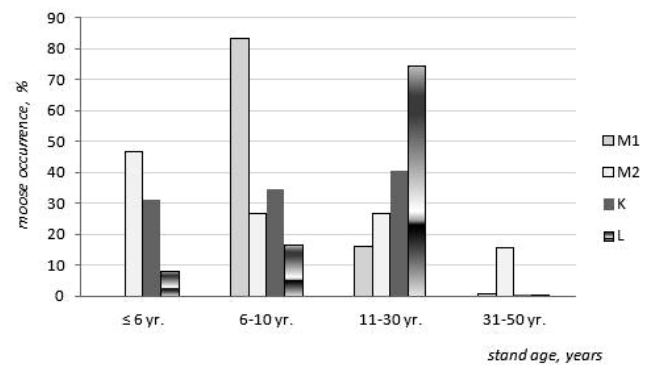


Figure 3 b. Moose (*Alces alces*) distribution in the different stand ages in the transboundary pure pine forests during non-vegetative period of 2012 (herein moose occurrence % reflects the number of registered moose pellet groups; M1 – Marcinkonys Forestry; K – Kabeliai Forestry; M2 – Musteikos Forestry; L – Latežeris Forestry)

this relation is not strong ($r = -0.31$, $F = 1.22$, $P = 0.33$, $t = 2.31$) and shows a trend of the decrease in pine consumption at rising air temperature.

The above fact turns back us to the change in animal distribution in stands and plantations. As the result of moose concentration in the pre-mature and mature stands (M1 sampling locality), the average and heavy and very heavy damage levels of the natural regeneration in Scots pine (consumption of shoots Csh = 40.7%, significant at $P < 0.050$, $R^2 = 0.59$, $SEE = 3.10$) exceed the critical threshold for coniferous species (20-30%) during the prolonged and changeable period of 2011. However, in the subsequent year it decreases in the pre-mature and mature stands and, at the same time, increases in the pine plantations of the adjacent sampling localities (Figure 5).

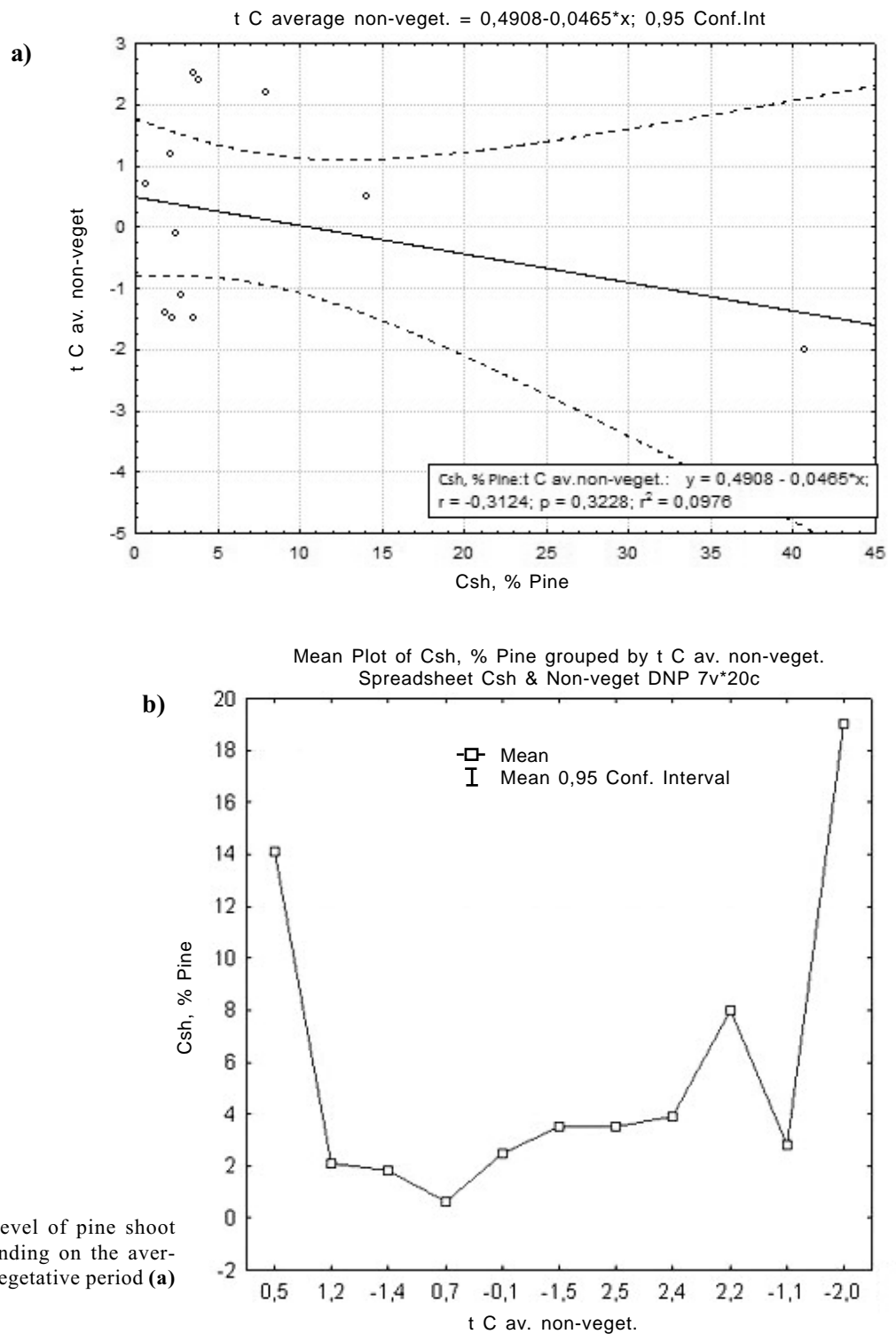


Figure 4. Changes in the level of pine shoot consumption (Csh %) depending on the average temperature in the non-vegetative period (a) and their mean errors (b)

The main cause of the high damage levels was moose concentrations in the certain patches of the good accessibility in pine stands and plantations, as a rule, in the closest vicinity to forest compartment lines and roads. Concentration points become traditional for the local moose population. In these patch-

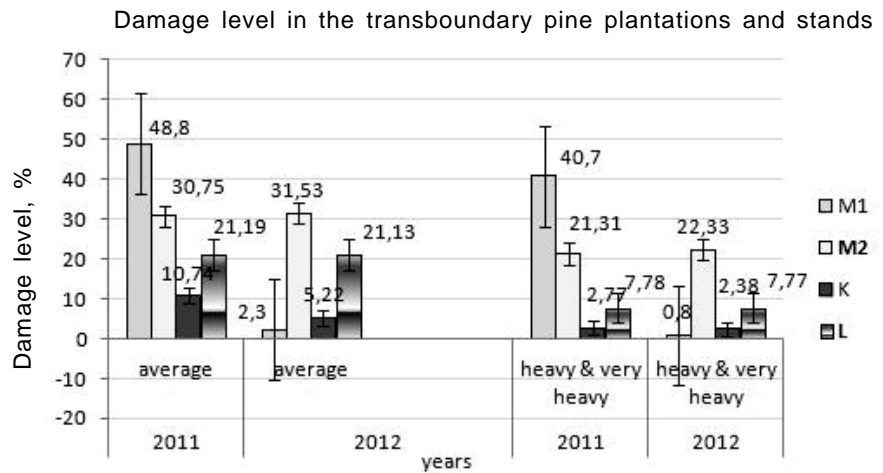
es, the density of moose exceeds the permissible (1-2/1,000 ha) and ecological (2-3/1,000 ha) densities 6-8 times. Consequently, the damage of pine also exceeds the averagely damaged (20-30%) and reaches the heavily damaged (30-50% and more up to the category of dead trees) too. The repeated damage is characteris-

tic in all cases. Correspondingly, moose density positively moderately correlates to the consumption of shoots (Figure 6) and shows a trend of increase in the pine damage level.

The most obvious damage caused by moose to the pine plantations occurs in the adjacent forest units

Territories of the above mentioned forestries, M2 (Musteikos), L (Latežeris) and M1 (Marcinkonys) are distinguished by the fluctuated level of damage to pine plantations caused by moose, which have increased in the density during the non-vegetative period. Above mentioned territories appear as the certain zone

Figure 5. Damage levels of Scots pine *Pinus sylvestris* L. in the transboundary pine plantations and stands (M1 – Marcinkonys Forestry; K – Kabeliai Forestry; M2 – Musteikos Forestry; L – Latežeris Forestry)



Changes in the consumption of pine shoots and moose density 2011-2012

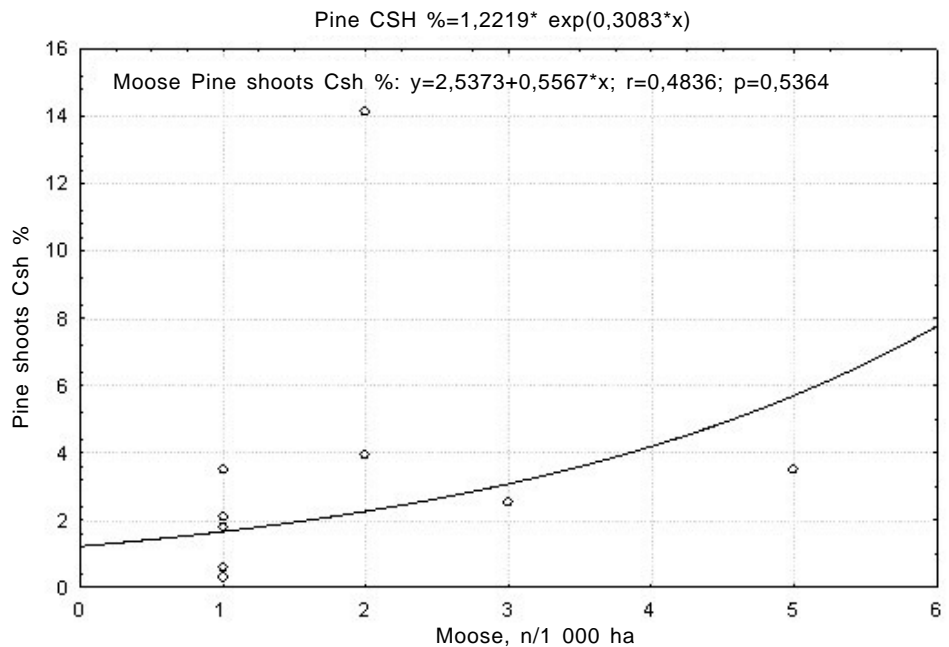


Figure 6. Changes in the consumption of pine shoots Csh% and moose density in 2011-2012

as Musteikos Forestry (M2) close to the Čepkeliai Raised Bog and Latežeris Forestry (L). These areas are directly merged into the border between Lithuania and Belarus (Figure 7).

of the potential ecological corridors or wildlife dispersal corridors that as landscape linkages connect animal habitat patches on the both sides, Lithuanian and Belarusian.



Figure 7. The potential ecological corridors of the movement of deer species in the transboundary area between Lithuania and Belarus (slightly bluish dots indicate the potential ecological corridors)

Discussion and conclusions

The results presented in this paper show that moose distribution in the patches of the optimal foraging and sufficient conditions for shelter depends on the thermal regime. The clumped distribution determines an increase in the animal impact on woody plants. Supposedly, the thermal regime in winter is less important for deer (Demarchi and Bunnell 1993) in comparison with the snow cover and its condition determining habitat selection and food availability. Snow cover depth influences habitat use and animal impact on forest vegetation (Belova 1995, 1996, 2008, Heikkilä and Härkönen 1996, Mysterud et al. 1997, et al.). In this study, moose prefer pine plantations that adjoin forest roads and compartment lines that warrant better accessibility during the snowy winter. The duration of the non-vegetative period was unstable displaying marked fluctuations (namely, from 152 days in 2011 to 63 days in 2012). The weather of usual long non-vegetative period of 2010/2011 was wintry and snowy. The changeable non-vegetative periods force moose to select habitats that could satisfy demands in suitable microclimatic conditions because of animal thermal sensitivity and necessity to reserve energy for movements. The first part of the last (2011/2012) short non-vegetative period was distinguished by the warm weather that has altered with the cold and wintry prolonged contrary part. If we will consider well-known seasonal changes in deer physiology including the metabolic changes and an increase in the foetal development, the severity in the second part of non-vegetative period and February thaws are drivers of the bark stripping. Snow crust and weather contrast cause frequent changes in moose daily activity and

refuge. In that case, animals lose more energy and feeding helps them compensate for energy loss in winter. This situation strongly affects moose distribution and their relationship with woody plants. The long and wintry period predisposes an increase in moose effect on the natural regeneration and pine plantations because of the clumped distribution of moose. In the warm and short periods moose concentrate in the pine plantations alongside the wet forest sites. It was noticed that the average daily demand in food is higher in summer than in winter (Renecker and Hudson 1985, Renecker and Schwarz 1998). As example, the average consumption of food by moose is 10 kg in winter and 30-40 kg in summer (Renecker and Hudson 1985; Persson et al 2000) assuming that the duration of winter period is 180 days. However, animals can select more species of preferable food during the summer months in comparison with winter period. It could be particularly important in the pure pine forests with limiting food supply excluding pine (frequency of occurrence reaches 74.4% while the birch is rarer (14%) and other species comprises rather few share of available food (up to 1.3-5%). In the Belarusian territory, Scots pine comprises 70%, birch 15%, black alder 8%, oak 2% and Norway spruce 4% (Shakun 2012). Therefore, on the study area and adjacent land, the pine is the main food for moose in the non-vegetative period. It is an important point of damage caused to pine plantations and natural regeneration. Belovsky G.E. and Jordan P.A. (1978) indicated that in summer, thermal conditions strongly limit moose activity and correlation reaches $r^2=0.92$ between time of feeding and air temperature. It is known that thermal stress is more critical for moose if temperature rises in winter (Schwartz and Renecker 1998). It could certainly occur also be-

cause of the high summer temperature (Renecker and Hudson 1990, Lenarz et al. 2009). However, there is not strong behavioural response to an increase in air temperature (i.e. more than -5°C in winter and more than 14°C in summer) (Lowe et al. 2010). In this study, the air temperature and level of pine damage negatively correlated during the non-vegetative period but this relation is not strong ($r=-0.31$). Animals are able to adapt to such situations changing habitats. It follows from the moose distribution patterns on the transboundary area and their concentrations close to the contiguous raised bog and wet forest sites. Moose distribution patterns correspond with our previous conclusions of the strong and direct dependence of distribution pattern on the thermal regime and condition of snow cover (Belova 2008, 2011, 2012).

Although pine plantations are most vulnerable to damage but during the certain periods, the natural pine regeneration becomes more attractive to moose as animal concentrated in the mature and pre-mature stands where the heavy damage level exceeding its critical threshold 40%. According to the official gradation of deer damage caused to pine forest plantations (Anon 2001), the bag limit for hunting would be raised if the average damage by shoot browsing and stem breaking exceeds 15.1% and if the debarking damage exceeds 8.1%. It shows that not only the average consumption of pine shoots significantly exceeds the critical level for coniferous trees (20-30%) within the monitoring network of the relationship between herbivorous mammals and woody vegetation but also the level of damage assessing the whole damage of tree including browsing, stem breaking and debarking by the annual assessment of damage done by foresters in the plantations before the vegetation period. The impact of browsing damage unambiguously induces synchronization of nearby forest stands. This allows the browsing pressure to be spread out over a larger area in the period when trees are vulnerable to damage, keeping the pressure below the level where serious harm is done. It is important to manage the moose stock correctly during this vulnerable period. In such cases, the main indicator of animal abundance as the average density per area unit could mislead us because of the highest density of deer in the most suitable patches and single marks of their presence in other patches. Usually, reducing moose density is the important measure of the successful pine regeneration without additional protective measures as fencing or repellent treatment. As a rule, these are not eco-friendly measures. The relationship between moose density and their damage rates, and impacts of other features of forest habitat on this relationship, are clearly understood (Putman 1996, Putman and Fluek 2011).

Large individual differences in the dispersal distance and home range size are characteristic to moose. However, for long periods, that often lasting several years, some moose rarely move outside an area of only 4-5 km² (Cederlund et al. 1987). Usually, food resources are heterogeneously distributed within animal habitats and animals need different home ranges to meet their foraging requirements. Some publications (Koops and Abrahams 2003, Lykkja et al. 2009) indicated the existence of the certain conditional free distribution that depends on the above mentioned requirements assuming that animals are "free" to go wherever they will do best (Lykkja et al. 2009).

The snow track survey of deer species was simultaneously performed on the Belarusian side (Shakun 2012) using GPS receiver and fixing the general and daily distances of animal movements, the number and species of damaged plants, the number of pellet groups, urination signs and resting points. This survey has revealed habitats, which animals have crossed, and the direction and distances of animal movement. An intensive migration of animals relates to the seasonal feeding and reproduction and with hunting activities on the Belarusian side. During the autumn-winter period, deer species as moose, roe deer and red deer tend to concentrate on the cutting areas in Belarus. Calving was also registered mostly on the Belarusian territory. However, during the hunting season, animals move to the Lithuanian side where hunting is less intensive because of the protection regime (Maximenkov 2002). The wetland complex is distinguished by rich diversity of flora and fauna and is attractive for many mammal species including moose. The most important ecological corridors for deer species were determined on the ground of the analysis of the cartographic database and data obtained during field works. In the transboundary forests, V. Shakun (2012) has distinguished ten continuous forest patches which are an important for animal migrations and comprise 14% (i.e. 97 km) of the total length of the state border between Lithuania and Belarus. The most attractive for animals were the mixed coniferous - deciduous and temporally overmoistured deciduous mature forests that provide an important habitats for animal feeding, shelter and undisturbed movements. For moving, animals preferred such habitats within mono-dominant pine stands and sites of the higher altitude, interspersed with wet stands. In the total 19 ecological forest corridors were identified as the main paths for animal movement (Shakun 2102) while moose have not used all of them.

In the transboundary area, the levels of moose damage to forest and their concentrations in the certain localities show the areas of the potential ecolog-

ical corridors (Figure 7). These localities correspond to the concentrations indicated in the Belarusian territory. Distinguished ecological corridors are or will be of a great importance for undisturbed movement of moose across the border within the large forest complexes. We should consider that animals usually have several traditional movement paths through their home ranges and use them repeatedly in the same repetitious patterns year in year out. It becomes a behavioural tradition of the local populations (Belova 2001). This study shows that, however, most of corridors are still potential as deer species exist at the low density here. Considering the high functional aspect of ecological corridors for animals, distinguished area of the potential ecological corridors should be under consideration of foresters implementing and assigning forest protection measures.

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ВЛИЯНИЕ ЛОСЯ (*ALCES ALCES* L.) НА РАСТИТЕЛЬНОСТЬ ТРАНСГРАНИЧНЫХ ЛЕСОВ И ПОТЕНЦИАЛЬНАЯ РОЛЬ ЭКОЛОГИЧЕСКИХ КОРИДОРОВ**О. Белова***Резюме*

Растительность оленьих повсеместно признается как серьезная проблема в лесном хозяйстве. Однако только отдельные исследования коснулись влияния этих зверей на лесную древесную растительность в трансграничной зоне Литвы и Беларуси. Атрактивность местообитания и соответствующее пространственное размещение зверей зависит не только от доступности пищи, в том числе эффекта опушки, беспокойства и конкуренции, но также от доступности термального покрова и укрытия. Эта очевидность проявляется независимо от административных границ между соседними государствами. Подобие местообитаний соседних государств позволяет зверям мигрировать между определенными приграничными территориями определенными экологическими (миграционными) коридорами. С целью оценки влияния оленьих на трансграничные леса и потенциальной роли экологических коридоров использовался комплексный метод ленточных трансект (100 x 4 м) и пробных площадок (50 x 2 м). Одновременно определялись основные характеристики древостоя каждой единицы трансекты и индексы потребления древесных растений. Ключевым видом был лось *Alces alces* L. Основными лимитирующими факторами влияния оленьих на лесную древесную растительность являются продолжительность невегетационного периода и его переменность, которые определяют время и степень воздействия зверей на лесную растительность повсеместно. В продолжительные и суровые зимние периоды групповое размещение лосей вызывает увеличение их воздействия на естественное возобновление сосны обыкновенной в древостоях и в посадках. В теплые и непродолжительные периоды лоси, будучи термочувствительные, группируются в сосновых насаждениях, прилегающих к влажным местопроизрастаниям леса. Выявлены потенциальные экологические коридоры и их функциональный аспект оленьим зверям. Необходимо учитывать действительную продолжительность невегетационного периода.

Ключевые слова: трансграничная территория, лось, воздействие на лес, погода, экологический коридор