Temporal Variation in the Use of Clearcuts by the Brown Hares (*Lepus europaeus* Pall.) in Lithuania

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Belova O. 2003. Temporal Variation in the Use of Clearcuts by the Brown Hares (*Lepus europaeus* Pall.) in Lithuania. *Baltic Forestry*, 9 (2): 58–62.

Clearcutting is an important part of forest management and substantially changes the living conditions of wildlife. This study was performed in clearcuts of the mixed spruce-deciduous forests in Northwestern and Central Lithuania. There were 771 sample plots in 1,825 hectares. Hares least preferred cuts at the first successional stage ($\bar{I}_i$=0.00, G=0.00). Hares used these areas while running to other places. More advanced stages of regeneration were preferred; especially the coppice of the 1st age class. The older coppice was less preferred whereas hares preferred the ecotones and interval spaces ($\bar{I}_i$=1.20-1.63, G=0.45) (r=0.743, P=0.021). Differences between mountain hare (*Lepus timidus* L.) and brown hare (*Lepus europaeus* Pallas, 1778) were not investigated because there was only one occurrence of the mountain hare. The changes in hare distribution from the random to clumped showed the random into clumped one reflect the changes in favourability of the living conditions. The first case of changes in the cutover importance is "an unchanged status", the second is the "prevalence of the foraging conditions", and third case in changes is "mixed status of the area where both foraging and refuge are fulfilled.

Key words: brown hare, clear cutting, succession, changes, importance

Introduction

The clearcutting is commonly used to manage forests although it can produce noticeable changes in the living conditions of wild animals, including herbivores because of the obvious change in forage abundance. According to classic ecology theory (Odum 1986, Ricklefs 1990), the richness of environment increases through succession and the peak is in the climax stage. However, the intensive forest management including the clearcutting is a certain disturbance because the local animal populations could reduce in the size and number. In the meanwhile, populations of animals that prefer the more open lands stabilize or increase. I examined how temporal and qualitative changes in cutovers influenced the hares. I noted that brown hares (*Lepus europaeus* Pallas, 1778) occurred in both open lands and forests and therefore may benefit from clearcut. The brown hare is an important component of the Lithuanian fauna. This game species settled in Lithuania long ago, and in the 20th century hare has become widespread in conjunction with an expansion of the forest fragmentation. However, since the 1970s the brown hare population substantially decreased 3 times. Changes in land-use practice and further habitat alteration, also other human factors acted together with natural factors. As the brown hare population is a natural and indispensable element of the forest ecosystem and adjacent lands, the weakening and further loss of the species would affect other components of ecosystem through the chain reaction and feedback principle. This is the matter for the continuity of investigation of the different sides in the brown hare ecology and their settling in the forests. The question is how the successional variation of clearcuts influences the occurrence and area use by the brown hare in the mixed forest.

Materials and methods

The study was performed in the non-vegetative period on cutovers of the mixed spruce-deciduous forests. The investigation represented 3,459 hectares of the total territory, including 2,416 hectares of the mixed spruce-deciduous forests in North Western Lithuania, 56°05' N, 21°57' E, and 1,043 hectares in the Central Lithuania, 55°34' N, 24°06 E. The first area belongs to the Zemaitija (Samogitia) highland geobotanical complex of the southern taiga of the Baltic province's mixed spruce and deciduous forests. According to the phytocoenological terminology it is *Picetum-Pinetum-Betuletum-Fraxinetum-myrtillosum* and *myrtillo-oxalidosum* stands. The dominant tree species are *Picea abies* (47%), and *Pinus sylvestris*

(26%) are mixed with deciduous species *Betula verrucosa* (13%), *Alnus incana* (4.4%), and *Quercus robur* (4.1%). Occasional natural meadows are interspersed between forests, hills, bogs, lakes and springs. According to the functional purposes, the total territory is divided into the several functional zones such as recreational (2.3%), protective 14.5%), conservation including strict nature reserve (4.8%) and reserves (43.3%), and commercial zone (35.1%), where investigation has been done. The study area belongs to a climatic sub-region with about 27% of winters with unstable snow cover and long-term mean depth of snow cover is 20 cm. During snowy winters the depth of snow cover reaches 0.70 – 1 m. This is critical to hares that make trouble for their moving and feeding. The spring is late. Because of the specific geographical locality, there is surplus of the moisture, and long-term precipitation on average comprises more than 850 mm while the rain factor is 41-54. The surplus moisture is accompanied by more cool weather when the long-term average temperature is 11°C in the vegetation period. The west and southwest winds prevail. These carry along the air mass of the sea. The unstable weather and total climatic situation of the area potentially is unfavourable for hares especially for the youngsters (an absence of the permanent burrows and dependence of the body temperature on the age). The second study area belongs to the mixed deciduous with spruce forests in the North district of Nevezys basin of the region of Central Plains. According to the phytocoenological terminology it is *Betuletum – Picetum – Alnetum - aegopodiosum, oxalido - nemorosum* and *carico -mixtoherbosum* stands. The dominant tree species are *Betula verrucosa* (43.6%), *Picea abies* (14.2%), *Alnus incana* (11%), *Populus tremula* (10.7%), *Quercus robur* (9%) and *Fraxinus excelsior* (8.3%). The middle-aged stands as well as sub-mature and mature stands prevail (38.5%, 22.2% and 20.7% respectively) while the young plantation comprises 18.6% of the total forest area. This area belongs to the II-nd b climatic sub-region where the winters with unstable snow cover make up 10%, thaws 45%, the long-term average depth of snow cover is 20 cm and the long-term annual precipitation is 679 mm.

The forage and shelter conditions in habitats were estimated by the belt transect route method while the route unit was 4x100 m. On the ground of the given data, I calculated the frequency of occurrence of hares on the studied area $\bar{I}_i = \sum N_s / nLG$, where N_s refers to the frequency of finding out of hare living tracks, nL is the number of route units (meter), and G is the coefficient of animal aggregation as a unit of the ratio of a single and group tracks. The additional method of sample plots was used while the plot area was 20 m², and the index of food utilization $U = C/A$ (%), where C is consumption of food and A is total number of food, was calculated. In accordance with the consumption all foods were distributed into the classes of preference: A – most preferred, 5 - 4 points (level of the consumption is high 96-100%, and good 76-95%, respectively), B – preferred moderately, or alternative, 3 – 2 points (level of the consumption is satisfactory 51-75%, and weak 26-50%, respectively), and C – least preferred or uneatable, 1 – 0 points (uneatable 0%, and bad 1-25%). The last mentioned category of foods corresponds to "stuffing" and pastime food, after A. Leopold (1933). Tree shoots were divided into three classes by the diameter of used shoots such as the I-rst class with diameter ≤4 mm, II-nd class – 5-7 mm, and III-rd class – 8-10 mm (Grigel, Moody 1980). Data of the weather conditions have been collected by the measurements of the local weather-stations. The index of the weather inclemency was calculated by Bodman formula $S_a = (I - 0.004\ T°)\ x\ (I + 0.272\ V)$, where S_a refers to the weather inclemency, $T°$ is an air temperature, and V is the speed of wind. The total number of the sample plots was 771 on the total area 1,825 hectares.

Results

In the non-vegetative period, the winter conditions considerably influenced the frequency of occurrence of hares on the cutovers. The weather conditions turn a limited factor. The main factorial indicators of the frequency of occurrence are the air temperature ($r = -0.51 \pm 0.19$), weather inclemency S_a ($r = -0.78 \pm 0.11$), depth of snow cover, H cm ($r = -0.92 \pm 0.08$), precipitation, mm ($r = -0.56 \pm 0.30$), and the duration of sun lightness, h ($r = 0.46 \pm 0.25$, $p<0.05$). The frequency of occurrence reaches $I_i = 23.0 - 62.0$ and animal grouping $G > 1$ under the conditions of inclement weather and deep snow cover in closed habitats while the frequency of occurrence on the open areas is only $I_i = 0.69$ and $G = 0.24$. That shows sporadic track of animals on the open areas. In the meantime, the frequency is positively related to the thermal factor, weather inclemency and depth of snow cover in the closed habitats ($r = 0.24 \pm 0.09$, $r = 0.30 \pm 0.20$ and 0.14 ± 0.04 respectively). The factor of the duration of sun lightness is important for the hare occurrence in the closed forest ($r = 0.83 \pm 0.31$, $p<0.05$) and relation between hare occurrence and precipitation is similar as on the open area.

The cutover of the first succession stage, i.e. have been recently cut, is least preferred by hares ($\bar{I}_i = 0.00$, $G = 0.00$) (Figure 1). Hares use these places while running to other places leaving sporadic pellets or pellet

groups in the places of the acceptable grassy cover of the yester season. Hares prefer *Compositae* (*Artemisia campestris, Artemisia absinthium, Tanacetum vulgare, Tussilago farfara, Cirsium spp., Cichorium intybus, Taraxacum spp., etc.*) (preference reached 93-100%), *Leguminosae* including *Medicago falcate* (100%), *Trifolium spp.* (98.5%), and less *Lupinus polyphyllus* (30.0%), *Gramineae* including *Dactylis glomerata* (93%), *Phleum pratense* (90.5%) and other (for choice, 76.4%). The scattered living tracks of hares were found.

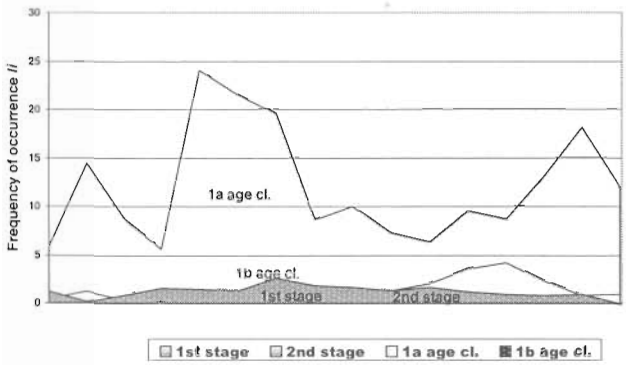

Figure 1. The frequency of occurrence (I_i) of hares on studied area of the different succession stages

The edges of the above-mentioned cutovers were used more intensively ($\bar{I}_i$=0.01-0.06, G=0.04, r = 0.83 ± 0.16, p<0.05) because of the nearness of possible refuges depending on the ambient stand conditions such as the species composition, age, forest site type, closure of canopy, undergrowth state, etc. The frequency of occurrence is closely linked with the density of undergrowth and the closure of canopy of the stand avoiding the dense thickets as well as the forest habitats with thin undergrowth (r = 0.53 ± 0.08, h = 0.61, P<0.05). Hares prefer the neighbouring stands with the grouped distribution of undergrowth both thicket and mean dense one. In these cases there are favourable shelter and feeding conditions. Stands with grouped distribution of the undergrowth have been preferred as the edges of cutovers and neighbouring stands.

The 2nd stage of succession, that is the first sapling stand, aged until 5 years, is more significant for hares' foraging ($\bar{I}_i$=0.46, G=0.04). Hares use these areas mostly at the end of non-vegetative period (February – April) and in December. The hare occurrence is more scattered because of the species-specific linear character of the foraging along the food source

The further succession stage of the regenerated area (the second sapling stand, aged until 10 years) is most preferred because of the realization of both foraging and shelter conditions ($\bar{I}_i$=14.40, *max* 24.0 and G=0.20, *lim* 0.20-0.81). Grouped distribution of the food source is favourable for hares (r = 0.74 ± 0.21, P< 0.05).

The older thick young stands (pole stand) are less preferred while hares prefer the ecotones and interval spaces ($\bar{I}_i$ = 1.63, *max* 2.65, G = 0.45) then r= 0.743, P=0.021.

The habitat use positively related to the tree density, meanwhile, negatively – to their height (≥1.5 m). 7 species of fodder trees, shrubs and subshrubs belong to the A utilization class including 5 tree and shrubs species as well as 2 subshrubs, 9 species – of B class, 7 – of C class (Table 1). The bark is less preferred and is used from February to the second part of March as well as in winter while there are no snap thermal fluctuations. The shoots are used from November to May and marginally in summer and autumn. Dried grasses of the yester season are acceptable in the green winter using the overground parts of plants. In snowy winters hares use acceptable dried parts of grasses over the snow cover (Table 1). Hares get the most food from 2 - 4-year-old woody plants until their height is less than 1.5 m. Hares choose annual shoots and bark of older trees in the reduced foraging conditions and because of snowfall. Thus under such feeding conditions, the willows are used until 8 year-old, other species – until 2-4-year-old while annual shoots and bark of the fall or felled trees – since 10 year-old within the feeding space of hares (Table 2). Hares prefer thinner shoots (I-rst and II-nd classes of diameter, < 4 mm and 5-7 mm in diameter, respectively (Table 3).

Discussion and conclusions

The indicators of the deviation from the optimal living conditions are values of indices $\bar{I}_i \leq 1$ and $G \leq 0.1$. Values $G \leq 0.1$ indicate the scattered visiting of hares, G= 0.2 – 0.5 – are the mean values, and $G \geq 0.5$ – are high values. The noticeable grouping of animals shows a deviation from the optimal conditions. The index of grouping $\delta^2 / \bar{I}_i < 1$ indicates the random distribution of hares (criterion of the significance of ratio $\delta^2 / \bar{I}_i \geq (\leq) 1$). Changes towards the clumped distribution are revealed while the index of grouping is $\delta^2 / \bar{I}_i > 1$ = 3.41-6.77, confidence ρ' = 0.011-0.069, the dispersion δ^2 = 16.12 – 24.13, standard deviation δ = 4.01 – 4.91, in the preferred places depending on the favourability of foraging and shelter conditions. The changes of the hare distribution from random to clumped show the favourability rate of the foraging and shelter conditions on the corresponding area. The intermediate habitats with single tracks of hare activity interpose into the areas of the clumped distribution of hares while the dispersion of the mean frequen-

Table 1. Character of the utilization of food in brown hare on the cutovers during the non-vegetative period

Plant species	Preference		Utilization		
	part of plant	age	share, %	points	class
Pine *Pinus sylvestris*	shoots, needles	2-8	28.0	2	B
Spruce *Picea abies*	shoots, needles	2-4	1.5	1	C
Oak *Quercus robur*	shoots, bark	1-3	95.3	5	A
Ash *Fraxinus excelsior*	shoots, bark	2-3	35.8	2	B
Aspen* *Populus tremula*	shoots, bark	1-3	98.5	5	A
Aspen** *Populus tremula*	bark, shoots	1-3	76.2	4	A
Aspen** *Populus tremula*	bark, shoots	≥10	52.9	3	B
Birch * *Betula spp*	shoots	1-3	19.0	2	C
Birch** *Betula spp.*	shoots	>3	45.2	2	B
Lime *Tilia cordata*	shoots	1-4	85.3	4	A
Maple *Acer platanoides*	shoots	1-3	64.8	3	B
Black alder *Alnus glutinosa*	shoots	2	2.3	1	C
Rowan *Sorbus aucuparia*	shoots	2-3	2.0	1	C
Goat willow *Salix caprea*	bark, shoots	1-3	66.3	3	B
Common sallow *Salix cinerea*	shoots	1-3	95.6	5	A
Hazel *Corylus avellana*	shoots	1-3	74.1	4	B
Alder buckthorn *Frangula alnus*	shoots	2-3	15.3	1	C
Sea buckthorn *Hippophaë rhamnoides*	shoots	2-3	12.3	1	C
Wahoo *Evonymus verrucosa*	shoots	2-3	32.1	2	B
Green broom *Cytisus scoparius*	above-ground part	1	100.0	5	A
Black currant *Ribes nigrum*	shoots	1-3	28.0	2	B
Raspberry *Rubus idaeus*	shoots	1	99.6	5	A
Bilberry *Vaccinium myrtillus***	shoots	1	2.9-76.3	1-4	C-A
Dried yesteryear grasses: *Compositae*	stems,	1	93.0-	4-5	A
Chenopodiaceae	remains of	1	100.0	3	B
Cruciferae	leaf	1	66.3	2	B
Carex spp.	stems, seed	1	28.3		
Compositae	stems, seed	1			
Leguminosae	stems, leaf	1			
	stems, leaf				
	stems, leaf				

* - growing tree;
** - felled or fall tree left on the cutover;
*** - depending on the snow cover in the non-vegetative period

Table 2. Feeding space parameters of the woody plants consumed by the brown hare

Feeding space parameters	
Height from the ground, (h) m	0.2 - 1.0
Shoot: - diameter of shoot, optimal / *lim*, cm	0.2 / 0.2 - 1.0
- class	I
Bark: - width from 1 tree, cm^2, *lim*	10 - 50
- height from the ground, (H)m	0.5 - 0.7

Table 3. Diameter and height from the ground of the tree shoots consumed by the brown hare

Tree species	Parameters	
	diameter, *lim* cm	height from the ground, *lim* m
Oak *Quercus robur*	0.1-0.6	20-100
Ash *Fraxinus excelsior*	0.1-0.4	30-60
Aspen *Populus tremula*	0.2-0.4	20-100
Birch *Betula* spp.	0.1-0.4	20-120
Willows *Salix* spp.	0.2-0.5	15-120

cy of occurrence is more than the average value. In this case the relations between hares are non-antagonistic, animals disregard the individual distances and different behavioural acts are contemporised (Belova 2001). The hares are undisposed to keep lasting relations and their distribution is significant on the level less than 5%. This distribution shows the significant influence of the habitat factors and unevenness of the habitat. The evidence of random distribution is revealed in the favourable places with intervening transitive biotopes. That is appreciable by the above-mentioned confidence values of the grouping index.

The differences between mountain hare (*Lepus timidus* L.) and European hare (*Lepus europaeus* Pallas, 1778) have not been found because of scattered cases of occurrence of the mountain hare in the studied territory. There, the average densities of the both mountain and brown hares made up 0.4 and 22 animals per 1,000 hectares on the investigated area respectively.

Hares get the most food from the 2-4-year-old woody plants until their height is less than 1.5 m. Age of the cutover is just a convenient way of keeping track of succession. Usually, shoots of older trees are less acceptable for the hare because of the limit of feeding space, and really, shoots of these trees are not used. In the case of the reduced foraging conditions, the utilization of shoots of the older birch reaches 45.2% and should be classified to B preference class. Meanwhile, the height of trees is probably a better index of habitat conditions than age. Use of the stuffing and pastime food and prevailing of the alternative food, is the indicator of feeding decompensation while the foods of B and C preference classes comprise 50,9% in the hare feeding. The increase of shoot diameter in the point of bite is the indicator of inauspicious foraging ($r = 0.6 \pm 0.07$).

The results of this study show that the changes in the importance of cutovers depend on the regeneration on the stand. First, the main status of the area does not change and the main species remain the same. In this situation the area could be used both for the foraging and for cover. Second, foraging conditions could become prevalent if the preferred deciduous

species predominate. The third possible case in the changes in the importance is the intermediate, when the area became of the mixed status such as "foraging – refuge" status. The brown hare is the successional species that prefers forest of the secondary succession, and euritopic animal because of use a forest, ecotones and open areas.

This investigation indicates that the changes in the brown hare ecology testified the species adaptability in the changed living conditions. It is important to continue research revealing causes of the decline of hare population and possibilities to adapt in the various habitats.

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Received 07 July 2003

ВРЕМЕННАЯ ВАРИАЦИЯ ИСПОЛЬЗОВАНИЯИ ЛЕСОСЕК ЗАЙЦЕМ-РУСАКОМ (*LEPUS EUROPAEUS* PALL.) В ЛИТВЕ

О. Белова

Резюме

Лесосеки сплошных рубок значительно изменяют жизненные условия зверей. Исследования проведены на вырубках разной стадии сукцесии в лесах Северо Западной и Центральной Литвы. Общее количество опытных площадок 771 на площади 1825 га. Менее всего зайцем-русаком предпочитаются вырубки первой стадии сукцесии (индекс встречаемости $\bar{I}_i$=0.00, коэффициент агрегации G=0.00). Звери использовали такие территории в качестве переходных местообитаний. Следующая стадия после посадки культур более предпочитаемая, особенно посадки лесных культур до 10-летнего возраста. Молодняки старшего возраста менее предпочтительны, тогда как зайцы концентрируются на экотонах и просветах ($\bar{I}_i$=1.20-1.63, G=0.45) (r=0.743, P=0.021). Индикатором отклонения от оптимальных условий являются показатели $\bar{I}_i \leq 1$ и $G \leq 0.1$. Такой коэффициент агрегации указывает на одиночные посещения зверей, G= 0.2–0.5 – средние показатели, и $G \geq 0.5$ – высокие показатели агрегирования. Но одновременно последний является также и показателем отклонения от оптимума. Индекс группирования $\delta^2/\bar{I}_i$ <1 указывает на случайное распределение зайцев (критерий значимости соотношения $\delta^2/\bar{I}_i \geq (\leq) 1$). Изменения распределения от случайного до группового показывает категорию благоприятности кормовых и защитных условий на определенной территории. При этом значимость вырубки может остаться прежней, во втором случае преобладают кормовые условия, и изменения в третьем направлении выражены комплексным проявлением кормовых и защитных условий.

Ключевые слова: заяц-русак, лесосеки, сукцессия, значение