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EFFECT OF THE LANDSCAPE TYPES ON HUNTING SELECTION IN ROE DEER (CAPREOLUS CAPREOLUS, LINNAEUS 1758) TROPHIES IN CZECH REPUBLIC

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ABSTRACT

Czech Republic has a long tradition of hunting, and trophy hunting is important to manage game populations. In this study data was analysed from the five last trophy exhibitions in Czech Republic. Namely, hunter selection, compensatory selection, management selection, hunting pressure selection and depletion selection was tested in different landscape types. In compensatory hunting there is a difference between the landscape types; apparent differences exist between the landscape type with respect to hunting pressure. There was no hunter selection, or depletion selection, and no differences in management between landscape types. This study suggests that the landscape composition has an effect on selective hunting in Czech Republic.

Keywords: Landscapes, Hunting selection, Czech Republic, Roe deer, Capreolus capreolus

INTRODUCTION

All animals occupy landscapes, and landscapes are complex mixtures of physical and cultural unit. In Czech Republic, a landlocked country in central Europe, centuries of land-use changes have altered the landscape. The changes have, for example, occurred within open landscapes like agricultural land, and artificial landscapes like towns, railways and roads. The changes have also affected the wildlife species. The opening of the landscape has also changed the act of hunting, from hunting in forests to fields, with better visual conditions for the hunter.

An important species in the Czech landscape is roe deer (*Capreolus capreolus*). This species is distributed throughout the country, and every year, Czech hunters remove 99,000 to 121,000 specimens during the hunting season (Červený *et al.*, 2009). Roe deer is an important component of game hunting in Czech Republic, as well as for trophy hunting. In the Natura Viva exhibitions in Lysa nad Labem in 1996, 2000, 2005 and 2009, and the exhibition in Česke Budejovice in 1993 inclusive, there were 2,656 roe deer trophies recorded from the entire country (CMMJ 1993, 1996, 2000, 2005, 2009). Czech Republic has a long tradition of hunting (Bartoš, 2010), and the country is one of most coveted hunting countries in Europe. However, roe deer is not the most important game species in Czech Republic, but together with wild boar (*Sus scrofa*) the most numerous. The most important

game is the red deer (*Cervus elaphus*) and mouflon (*Ovis musimon*); especially the latter, where Czech Republic has the current world record, and have most of the leading trophies in the world (Červeny *et al.*, 2009; Varicak, 2007). Czech Republic also has a long tradition for trophy exhibitions (local, national and international), and in the local exhibitions which are held every year, all trophies are measured.

Roe deer habitat is mainly woodland, however changes in anthropogenic land use during the last millennium, with increasing urban and agricultural areas, have forced the species to utilise new habitats.

Hypothesis

In this study, the following hypotheses will be tested:

Hunting selection:

H1: *Hunters selection*; P1 hunters will select larger individuals; this will give a negative correlation between relative antler size and relative age (measured as standard deviation) (Rivrud, 2013; Coltman, 2003)

H2: *Compensatory hunting selection*: P2: money talks, hunters will pay more money for larger trophies (trophy hunting) and there will be pressure to increase the quality of trophies by harvesting lower quality specimens in lower age groups (Rivrud, 2013; Mysterud & Bichoff, 2010). This is described in Czech act of game management §6.2 (Ministry of agriculture, 2001) and Babička *et al.* (2007)

H3: *Depletion hunting selection;* P3: Trophy size will decrease over years, with no recovery when the hunting pressure becomes weaker (Coltman *et al.*, 2003; Rivrud, 2013)

H4: *Hunting pressure selection:* P4: Trophy size will decrease over time when hunting pressure is high, however the trophy size will recover when the hunting pressure becomes weaker (Vanpe *et al.*, 2007; Rivrud, 2013)

H5: *Management hunting selection*: P5: Trophy size will be stable between years (Mysterud & Bischoff, 2010), however; the sign of the quadratic selection (Walsh, 2007) can calculate a weak selection (stabilisation selection or disruptive selection). A negative sign will indicate stabilisation selection and a positive sign will indicate disruptive selection.

Landscapes

L1: Are there differences in strength of hunting selection between landscape types in Czech Republic? PL1:

L2: In respect to landscape composition (occurrence of urban, agricultural and natural/semi-natural land), how could it have an effect on hunting selection

L3: The effect of edge density, patch density and mean patch size (forest) and landscape diversity on hunting selection

MATERIALS AND METHODS

Material

The material consists of 2,640 roe deer trophies taken in Czech Republic in the period 1990 to 2008. The trophies were shown at the trophy exhibitions in Ceske Budejovice in 1993 and Lysa nad Labem in 1996, 2000, 2005 and 2009. Experts from Czech-Moravian Hunting Association (CMMJ) and the International council of wildlife conservation (CIC) measured the trophy specimens. The data from 2005 and 2009 are electronic and can be found at www.myslivost.cz, or in the trophy catalogues (CMMJ 2005, 2009). The data from 1993, 1996 and 2000 can be found in the trophy catalogues (CMMJ 1993, 1996, 2000); all trophies are medal bucks (CIC points above 105). The trophy measuring protocol can be found in Varicak (2007) or CIC red book (Whitehead *et al.*, 1981). All stalking locations were localised by latitude and longitude of the hunting grounds in Czech Republic. (http://apps.hfbiz.cz/apps/mysliveckyportal/honitby/view/).

Landscapes

Corine land cover 2006 version 16 (EEA, 2012) was used, as well as Q-GIS version 2.4 (QGIS, 2014). Grids measuring 40X40 km were used, along with reference system ETRS89-LAEA (EEA, 2014). The corine classes 1.1.1 to 1.4.2 were calculated as "urban"; classes 2.1.1 to 2.4.4. were calculated to "agricultural land", classes 3.1.1 to 3.1.3 were calculated to "forest", 3.2.1 to 4.2.3 were calculated to "other natural land" and 5.1.1 to 5.1.2 were calculated to "water" (see example Estreguil *et al.* 2012 or appendix for details). Every grid was recalculated to a landscape type after this triangulation, see Figure 1 and Table 1 (Estreguil *et al.*, 2012).



Fig. 1: Classifications of landscape types

Where these landscape types were recognised: Aun, An, Na and mix

Landscape type	Agricultural land	Urban	Natural
Agricultural dominated land	60-90 %	0-10 %	10-40%
with some natural land (An)			
Agricultural dominated land	60-80 %	10-30 %	0-30 %
with some urban and			
natural land (Aun)			
Mixed landscape (mix)	0-60 %	0-60 %	10-60 %
Natural dominated land with	10-40 %	0-10 %	60-90 %
some agricultural land (Na)			

Table 1: Classifications of landscape types in Czech Republic

These grids was converted to geographical coordinates (WGS84) by using the internet page http://epsg/3035/map.io.

The commonly-used landscape ecology indices were calculated (http://www.umass.edu/landeco/teaching/landscape_ecology/schedule/chapter9metrics.pdf), namely edge density:

$$\sum_{1}^{\infty} \frac{l}{A * 10000}$$

where l is total length of patch type (forest and transitional wooded scrub) and A is total landscape area (160000 ha) per grid. Patch density n/A was used, where n is number of patches (forest, wooded transitional scrub) and A is total area. Mean patch size Ai/n, where Ai is area of forest and transitional scrub and n is number of patches. Finally, Shannon diversity index was used to calculate landscape diversity.

$$SHDI = -\sum_{i=1}^{m} (P \, i * \ln P i)$$

Where m = number of patch types

 P_i = proportion of area covered by patch type (land cover class) All landscape calculations were completed in the LecoS module in QGIS (QGIS, 2014).

Hunter selection was calculated in the NUTS regions in Czech Republic and correlated to edge density, patch density, mean patch size and landscape diversity.

Hunting selection

The hunter selection was calculated (standardised CIC) with antler size and age as the independent and dependent variable, respectively. A negative slope indicates a negative hunter selection, whereas a positive slope indicates a positive hunter selection. For landscape type and for NUTS regions: CZ02: Central Bohemia; CZ03: Southwest Bohemia (Plzen and South Bohemia regions); CZ04: Northwest Bohemia (Carlsbad and Usti regions); CZ05: Northeast Bohemia (Pardubice, Hradec Kralove and Liberec regions); CZ06: South Moravia (South Moravia and Vyšocina regions); CZ07 : Central Moravia (Olomouc and Zlin regions); CZ08: Silesia-Moravia, CZ01: Prague is excluded from the analysis.

Compensatory hunting selection

Selective hunting figures in Czech Republic are shown in Table 2 (after Babička *et al.*, 2007).

Age	Beam length	Number of tines	Tine length	Auxiliary characters breeding
1	10 cm	2	-	The benefit is for 2-year-old is considered a length of
1	7 cm	3	1 cm	1.5 cm, with 3-year older, 2 cm in length, extremely
2	15 cm	4	3 cm	high quality in sense of high pearling, strong
2	15 cm	5	2 cm	coronets, regularity of antlers, exceptionally high
3	20 cm	6	3 cm	mass and force antler is a significant feature of
4-5	22 cm	6	4 cm	breeding at lower length of beams, with annual roe
6	23 cm	6	5 cm	deer does not consider pucks under 1 cm for the tines
Age ab	ove 6 vears old n	o restrictions		

Table 2: Selection for breeding of roe deer in Czech Republic in different age classes

For analysing compensatory hunting, the percentage of antler size (1.28 Standard deviation of the CIC) was used, and the percentage in each landscape type was analysed. An ANOVA was calculated for landscape type as factor and age as covariate, and number of +1.28 standard deviation (close to the gold challenge in the CIC system) trophies (trophy hunting) and -1.28 standard deviation (compensatory hunting). A t-test was used to compare the different landscape types. See appendix for details.

Management hunting selection

Linear regression CIC (standardized): $\alpha + \beta * year$, was used to analyse how stable the quality has been over the years, and quadratic regression distinguished stable and disruptive selection: CIC (standardized) = $\alpha + \beta * year + \beta 2 * year * year$, where β , $\beta 2$ and α are constants. If the quadratic component is negative, it is stabilisation selection, and if positive, it is disruptive selection (Walsh, 2007).

RESULTS

Landscapes

The results are shown in Figure 2. Out of 66 grids, 30 grids where classified as mixed landscape (mix); 29 grids were agricultural dominated land with natural land (An); four grids where classified as agricultural dominated land with urban and natural land, and three grids where classified as natural dominated land with agriculture (Na). The landscape grids are huge (1,600 square kilometers), so it could be variation within every grid, but it gives a rough picture of the Czech landscape composition.



Fig. 2: Landscapes in Czech Republic

4450000 4550000 4550000 4600000 4650000 4700000 4750000 4800000 4850000 4900000 4950000

Regression	intercept	slope	Standard	t-test	p-value	Significant
$age = \beta cic + \alpha$			error			(p-value <0.05)
An	-0.041	0.017	0.027	0.980	0.552	No
Aun	-0.008	-0.047	0.047	-0.963	0.336	No
Mix	0.047	-0.012	0.036	-0.348	0.728	No
Na	0.117	0.080	0.178	0.350	0.727	No
CZ02	0.300	0.016	0.056	0.290	0.770	No
CZ03	0.080	0.064	0.047	1.369	0.172	No, but weak trend
CZ04	-0.038	0.004	0.079	0.046	0.963	No
CZ05	0.143	0.012	0.045	0.259	0.796	No
CZ06	-0.074	-0.005	0.047	-0.099	0.922	No
CZ07	-0.241	-0.073	0.041	-1.761	0.079	Trend
CZ08	-0,042	-0.148	0.073	-1.994	0.048	yes

Table 3: Regressions of hunter selection

Hunter selection

Results are shown in Table 3.

The results show no hunters selection in landscape types, or in NUTS regions; however it is a trend in Central Moravia (CZ07) and significant negative selection in Moravia-Silesia. Other regions do not show a trend for hunter selection.

Complementary hunting

The results are shown in Tables 4a, 4b and 5 and in Figure 3.

Fig. 3: Trophies in age and quality in the landscape types









d) Landscape: Na (n= 60)

Source of Variation	DF	SS	MS	F	Р	
Landscape	3	14,792	4,931	3,024	0.062	
Age	5	13,708	2,742	1,681	0.200	
Residual	15	24,458	1,631			
Total	23	52,958	2,303			

 Table 4a: ANOVA compensatory hunting Low quality trophies (compensatory hunting)

The difference in the mean values among the different levels of landscape is not great enough to exclude the possibility that the difference is due only to random sampling variability, after allowing for the effects of differences in age. There is not a statistically significant difference (P = 0.062), however is it a trend.

The difference in the mean values among the different levels of age is not great enough to exclude the possibility that the difference is due only to random sampling variability, after allowing for the effects of differences in landscape. There is not a statistically significant difference (P = 0.200).

Source of Variation	DF	SS	MS	F	Р	
Landscape	3	1791,500	597,167	10,526	< 0.001	
Age	5	949,333	189,867	3,347	0.031	
Residual	15	851,000	56,733			
Total	23	3591,833	156,167			

 Table 4b: High quality trophies (trophy hunting)

The difference in the mean values among the different levels of landscape is greater than would be expected by chance, after allowing for effects of differences in age. There is a statistically significant difference (P = <0.001). A multiple comparison procedure was used to isolate which group(s) differ from the others.

The difference in the mean values among the different levels of age is greater than would be expected by chance, after allowing for effects of differences in landscape. There is a statistically significant difference (P = 0.031).

Table 5: Comparing landscape types and compensatory hunting

Comparing landscape	t-test	Degrees of	p-value	
types		freedom	_	
An vs Aun	1.484	1654	0.138	Trend
An vs mix	0.783	2118	0.434	Not significant
An vs Na	1.645	1377	0.100	Trend
Aun vs mix	1.949	1138	0.052	Strong trend
Aun vs Na	2.101	397	0.036	Significant
Mix vs Na	1.418	861	0.157	Trend

Management hunting selection

The results are shown in Table 6

Landscape	Intercept	slope	Quadratic	SE	t-test	F-ratio	p-value	Stable	Disruptive or
type									Stabilisation
An	-15.146	0.008		0.004	1.689		0.091	Yes, (x)	
(linear)									
An	-6589.40	6.584	-0.002			2.951	0.053		Stabilisation
(quadratic)									
Aun	-42.79	0.021		0.011	1.922		0.055	Yes, (x)	
(linear)									
Aun	-18646.2	18.63	-0.005			3.926	0.021		Stabilisation
(quadratic)									
Mix	13.31	-0.007		0.006	1.087		0.277	Yes	
(linear)									
Mix	-3452.22	3.46	-0.001			0.834	0.435		Stabilisation
(quadratic)									
Na	14.909	-0.008		0.017	-0.449		0.449	Yes	
(linear)									
Na	-14942.6	14.95	-0.004			0.681	0.510		Stabilisation
(quadratic)									

Table 6: Management hunting selection

(x - but trend for increasing)

The trophy qualities are stable from year-to-year in all landscape types, however there is a trend for increasing quality in agricultural dominated landscapes (Easier to manage?) The selection is stabilisation in all landscape types.

Depletion hunting selection

Number of entries per year (harvested trophies) is showed in Figures 4-6 and Table 7.

T 11 T	T1 (*0* /*	641 1	1 *	• 41	•	• •	•
Table 7	: Identification	n of fhe br	eaking i	noint by	using	niecewise	regression
I able /	· Identification	i or ene or	Curring 1		wonn b	prece mise	regression

Results f	Results for the Overall Best-Fit Solution:							
R	Rsqr	Adj Rsqr	5	Standard Error	of Estimate			
0.8179	0.6690	0.6028	2	44,1090				
	Coe	efficient S	td. Error	r t	Р			
y1	143,857	71 31,9	9238	4,5063	0.00)04		
y2	46,362	27 22,1	1444	2,0937	0.05	537		
y3	241,000	00 23,1	1194	10,4241	<0.00)01		
T1	1995,687	72 1,3	3671	1459,7584	<0.00)01		
	Analysis	of Varianc	e:					
	DF	S	SS	MS				
Regressi	on 4	389519,8	8956	97379,9739				
Residual	15	29184,	1044	1945,6070				
Total	19	418704,0	0000	22037,0526				

Corrected for the mean of the observations:								
	DF	SS	MS	F	Р			
Regression	3	58991,6851	19663,8950	10,1068	0.0007			
Residual	15	29184,1044	1945,6070					
Total	18	88175,7895	4898,6550					

Decreasing in the period 1990-1995, and increasing in the period 1996-2008.





ANCOVA period 1990-1995

Fig. 5: Adjusted Means with 95% Confidence Intervals



There are no significant differences between landscape types during the period 1990-1995. **ANCOVA: period between 1996-2008**



Fig. 6: Adjusted Means with 95% Confidence Intervals

Natural land shows negative slope during the decreasing and increasing periods; this is some indication for depletion in this landscape type.

Hunting pressure hunting selection 1990-1995 (decreasing hunting pressure)

Period	Age group	Landscape	intercept	slope	SE	t-test	p-value	Significant (p<0.05)
1990-19	Young	An	309.85	-0.156	0.090	-1.728	0.090	trend
95	(age<4	Aun	1.843	-0.001	0.146	-0.007	0.995	No
	years)	Mix	-577.66	0.290	0.202	1.434	0.177	trend
		Na	Due to fev	v observatio	ons, the anal	ysis was not	able to be c	carried out
			during this	s period				
	Medium (4	An	20.15	-0.010	0.050	-0.203	0.839	No
	and 5	Aun	-163.99	0.082	0.090	0.908	0.370	No
	years old)	Mix	257.88	-0,129	0.052	-2.032	0.046	yes
		Na	-296.48	0.149	0.097	1.531	0.223	No
	Old (age	An	-82.34	0.041	0.052	0.816	0.416	no
	>6 years	Aun	-35.10	0.017	0.136	0.129	0.899	no
		Mix	38.99	-0.020	0.077	-0,253	0.801	No
		Na	-11,78	0.006	0.130	0.043	0.973	No

Period	Age group	Landscape	intercept	slope	SE	t-test	p-value	Significant (p<0.05)
1996-20	Young	An	45.898	-0.023	0.021	1.091	0.277	no
08	(age<4	Aun	189.68	-0.095	0.047	-2.017	0.051	Strong trend
	years)	Mix	45.737	-0.023	0.021	-1.112	0.269	No
		Na	2.155	-0.001	0.078	-0.016	0.988	No
	Medium	An	32.96	-0.016	0.013	-1.305	0.193	trend
	(4 and 5	Aun	-5.60	0.029	0.009	0.100	0.921	No
	years old)	Mix	39.48	-0.029	0.016	-1.232	0.219	No
		Na	24.45	-0.012	0.028	-0.447	0.660	No
	Old (age	An	35.13	-0.018	0.017	-1.015	0.311	No
	>6 years	Aun	67.00	-0.033	0.037	-0.908	0.367	No
		Mix	40.71	-0.020	0.019	-1.056	0.292	No
		Na	73.265	-0.037	0.044	-0.836	0.416	No

1996-2008 (increasing hunting pressure)

8 out of 11 shows a more negative slope in the increasing period, so the hypothesis is partially supported.

Correlation matrix hunting selection coefficients (HUNS) vs landscape factors and landscape indexes

	%	%	%	Other	%	Edge	Patch	Mean	Shannon
	Urban	Agriculture land	Forest	natural	Water	density	density	patch	diversity
		-		land			-	size	index
HUNS	-0.243	-0.076	0.111	0.191	-0.010	0.013	-0.096	0.268	0.051

The results show negative hunter selection in areas with high occurrence of urban areas, agricultural areas and high patch density. Positive hunting selection was identified in areas with high occurrence of forest, other natural land and how diverse the landscape is.

DISCUSSION

In recent years, there have been several studies concerning the topic of hunting selection (examples include Mysterud, 2011, 2007; Rivrud *et al.*, 2013; Hedrick, 2012; Festa Bianchet, 2003). One of the most complete studies, Rivrud *et al.* (2013), concerning a long term study of red deer in Hungary, identified a support for hunter selection since trophy hunters shoot larger males. In this study, it was found that foreign hunters took 76.36 percent of harvested 9 year old bucks, although there was considerable variation. A study by Festa-Bianchet, however, claims that horn size in big horn rams (*Ovis canadiensis*), was decreased by hunter selection.

In this study, significant hunter selection was not identified in the landscape types; within the Moravia-Silesia region there was a negative hunter selection, in central Moravia NUTS region there was a trend for negative hunter selection, and in Southwest Bohemia there was a trend for increasing quality by hunter selection. Mysterud (2011) examined 26 studies in the literature and only three of these studies lead to directional selection. Monteith *et al.* (2013) analysed different game species under the Boone and Crocket system used in North America, and found positive temporal trends in Canada moose (*Alces a. americana* and *A.a.andersoni*), Muskox (*Ovibovis moschatus*), Pronghorn (*Antilocapra americana*), and Rocky mountain goat (*Oreannos americanus*). Other horned and antlered game showed

negative trends, but found no support for desire to submit smaller, yet eligible trophies, but found a support for selective harvest against genes for large trophy specimens. The results show a negative correlation between hunter selection coefficients and the occurrence of urban areas, agricultural areas and patch density. Within agricultural areas, the landscape is open and the hunter would have time to take a selective decision before shooting an animal. Higher patch density will not give the roe deer enough cover, and if the hunter is waiting close to the paths between the patches, he could have enough time to take a selective shot. Urban areas, however, or more precisely closeness to urban areas, or other artificial constructions, enable the hunter to access the hunting grounds more easy and spend more time in the field. In the forests, the time for selection is shorter; however, there is also a target for the gamekeeper to increase the quality of game within forest habitat. Patch size will provide more cover and reduce the time for selection. There are surprisingly few studies concerning the landscape effect of selective hunting. Mysterud et al. (2006) found a difference between local and foreign roe deer hunters in Poland; local hunters were hunting within closer proximity to the forest than foreign hunters, which preferred agricultural areas. However, more research is necessary, especially in the species mouflon and red deer that are the most attractive game species in Czech Republic.

The Czech act of game management supports compensatory hunting, and the Czech Moravian hunting association (CMMJ) described the criteria for breeding (Babička et al., 2007). This study supports this, however, there is a difference between the landscape types, where agricultural land differs from mixed landscape and natural landscape. A possible explanation for this could be that it is easier to manage roe deer in the agricultural landscape, or that the agricultural landscape is more attractive to roe deer hunters than other landscapes. A combination of both theories is likely, because there are more roe deer in the agricultural landscape and therefore a higher probability for a successful hunt. Due to the openness of the landscape, the gamekeepers can more easily select bucks for breeding. That does not mean that the hunter cannot select a large trophy buck, but it is expensive, a gold medal buck in Czech Republic costing in excess of 2000 euro (http://elovni.cz). Rivrud et al. (2013) found that, in Hungary, foreign hunters harvest larger stags than local hunters. Hungary has much of the same hunting rules and hunting traditions as Czech Republic. Mysterud & Bischoff (2010) developed a model for compensatory hunting without negative effects of trophy hunting, where low quality individuals can be harvested during an early life stage to facilitate sustainable trophy hunting. Babička et al. (2007) shows this in practice.

Trophy quality was consistent from year-to-year, however in in the agricultural areas there is a trend for increasing trophy quality. It is also suggested that the stability is a result of stabilisation selection, not disruptive selection. Rivrud *et al.* (2013) supported this, particularly in Hungary, but with periods of decline, it was not always the case.

In the period 1990 to 1995 there was a declining in number of entries, which could be an effect of decreasing population. In 1996 to 2008 the population increased. This followed a decrease in hunting pressure between 1990-1995, which subsequently increased during 1996 to 2008. Differences between or within landscape types were not found with respect to depletion, so the depletion hypothesis is therefore rejected. The same was found during a red deer study in Hungary (Rivrud *et al.*, 2013). During 1990 to 1995, in young bucks there was a negative trend in the agricultural dominated with natural landscape, but in mixed landscape, there was a significant decline. In the period 1996 to 2008 there was negative trend in young bucks in agricultural dominated land with natural and urban, and medium sized bucks in agriculture dominated land with natural land. However, 8 of 11 age/landscape classes did

have a stronger negative trend in the period 1996 to 2008, so the hunting pressure hypothesis cannot be rejected, but neither supported.

Other factors

Environmental selection can also affect antler quality. Climatic variation, especially severe winters (cold and snowy winters) will decrease the surplus of antler development, and mild winters will increase the antler quality. Heldrick (2012) analysed desert big horn, and the decline was not only caused by hunting selection, but also variation of rainfall and inbreeding depression. Other factors could be population dynamics, where high density produced more density-dependent competition and lower trophy quality. This is because changes in the landscape (namely changes in land use) will affect the quality of habitats; like home range, nutrient quality and cover, however more research is required to investigate this topic. Josef Hromas (1998) investigated what could have effects on trophies in the former Czechoslovakia; soil type, forest type, climate (temperature, precipitation, days of snow cover, snow depth, clear days and length of growth season) will all affect the development of trophy specimens.

An interesting question is; can researchers use trophy books as a source to investigate trends in populations. Pellitier *et al.* (2012) claims that data from selective harvest underestimate temporal trends in quantitative traits. This question was discussed at the 60^{th} CIC general assembly in Budapest in 2013, and Professor Csanyi (pers. comm. 2013) claimed that the trophy books can be used; they are biased, but contain valuable data, which can be used over successive years.

Implications for management and conclusion

The effect of trophy hunting has grown to be an important field of wildlife biology the last decade. The works of Professor Mysterud and Professor Festa-Bianchet have been important in increasing understanding of this topic. However, all the processes work together in management of game species, and it is desirable to make a model that takes population dynamics, habitat quality, landscape ecology, climate data and hunting selection into consideration. It could be expressed by making a structural equation model (SEM). Using this model, it is possible to make decisions at a local or regional level with respect to trophy quality. The landscape will have an effect on selective hunting, and open areas like agricultural areas will make it easier to make decisions. However, more research is necessary to understand the dynamics between game management and landscape ecology.

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Datum converter: http://epsg.io/3035/map

APPENDIX

Corine Land Cover

CODE	DESCRIPTION	classified to	in CZ ?
111	Continuous urban fabric	urban	yes
112	Discontinuous urban fabric	urban	yes
121	Industrial or commercial units	urban	yes
122	Road and rail networks and associated land	urban	yes
123	Port areas	urban	yes
124	Airports	urban	yes
131	Mineral extraction sites	urban	yes
132	Dump sites	urban	yes
133	Construction sites	urban	yes
141	Green urban areas	urban	yes
142	Sport and leisure facilities	urban	yes
211	Non-irrigated arable land	agriculture	yes
212	Permanently irrigated land	agriculture	yes
213	Rice fields	agriculture	no
221	Vineyards	agriculture	yes
222	Fruit trees and berry plantations	agriculture	yes
223	Olive groves	agriculture	no
231	Pastures	agriculture	yes
241	Annual crops associated with permanent	agriculture	Ves
241	Complex cultivation patterns	agriculture	ves
242	Land occupied by agriculture, with some of natural vegetation	agriculture	yes
244	Agro-forestry areas	agriculture	no
311	Broad-leaved forest	agriculture	yes
312	Coniferous forest	forest	yes
313	Mixed forest	forest	yes
321	Natural grasslands	forest	yes
322	Moors and heathland	other natural land	yes
323	Sclerophyllous vegetation	other natural land	yes
324	Transitional woodland-shrub	other natural land	yes
331	Beaches, dunes, sands	other natural land	yes
332	Bare rocks	other natural land	yes
333	Sparsely vegetated areas	other natural land	yes

Engan J. H.: Effect of the landscape types on hunting selection in roe deer (*Capreolus capreolus, Linnaeus 1758*) trophies in Czech Republic

CODE	DESCRIPTION	classified to	in CZ ?
334	Burnt areas	other natural land	yes
335	Glaciers and perpetual snow	other natural land	no
411	Inland marshes	other natural land	yes
412	Peat bogs	other natural land	yes
421	Salt marshes	other natural land	no
422	Salines	other natural land	no
423	Intertidal flats	other natural land	no
511	Water courses	water	yes
512	Water bodies	water	yes
521	Coastal lagoons	water	no
522	Estuaries	water	no
523	Ocean	water	no

Antler characteristics in Czech Republic used in this study. CIC measurement: Mean: 115.46 Standard deviation: 10.26