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„The conservation status of capercaillie and black grouse in the South-eastern Alps: an assessment on the level of hunting districts“

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Myriam Promberger, BSc

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Population change of grouse (Tetraonidae) in Styria

Myriam Promberger
Department of Tropical Ecology and Animal Biodiversity
Faculty Centre of Biodiversity
Rennweg 14, 1030 Vienna, Austria

Abstract

Outdoor activities, which have become increasingly popular in the last decades, often lead to a conflict with the needs of wild animals. As consequence, a substantial number of species are threatened and endangered due to tourism and recreational activities. In this study we tried to relate increasing human disturbance and changes in forest cover to changes in populations of black grouse *Tetrao tetrix* and capercaillie *Tetrao urogallus* on the level of hunting districts in the state of Styria, Austria. Therefore, we distributed questionnaires to Styrian hunters to collect semi-quantitative data on spatiotemporal changes in the distribution of both grouse species as well as on changes in winter and summer tourism, and forest cover in hunting districts. For the decades 1990-1999 and 2000-2009, changes in grouse populations, and sources of human disturbance (hiking, mountain biking, ski hiking, snowshoe hiking) had to be ranked by the heads of hunting districts on a scale between -3 (strong decline) and +3 (strong increase), changes in the extent of forest clearings and windbreaks, and forest road density had to be ranked on scale between 0 (no change) and +3 (strong increase). Hunting districts where grouse populations vanished are located predominantly at the South-eastern margin of the species' alpine distribution ranges. Both capercaillie and black grouse showed a continuous population decline in the study period from 1990-2009, while tourism, forest clearings and windbreak areas increased. A model selection approach provided weak evidence that in time period 1990-2009 windbreaks had a positive effect and increasing forest road density had a negative effect on black grouse. In capercaillie, increased forest clearing areas appeared to have a weak positive effect. These results indicate that both grouse species may benefit from processes acting against forest maturation, at least when taking place on small spatial scales. Furthermore, our data provides evidence that recreational activities in summer (hiking + mountain biking) negatively affected black grouse and capercaillie. To stop the overall decline of both grouse species in Styria, visitor management measures, particularly in sensitive regions, may be important to reduce the negative effects of human disturbance on grouse populations.

Key words

capercaillie, black grouse, human disturbance, Styria, population change, forestry, spatial distribution

Introduction

Although all four grouse species occurring in Central Europe, hazel grouse *Bonasa bonasia* LINNAEUS 1758, rock ptarmigan *Lagopus muta* MONTIN 1770, black grouse *Tetrao terix* LINNAEUS 1758 and western capercaillie *Tetrao urogallus* LINNAEUS 1758 are not globally threatened (BirdLife International 2012), particularly populations of the last two species declined in many European countries over the last decades (BirdLife International 2004). Reasons for declines in black grouse and western capercaillie are diverse and may vary between regions and species (e.g. Suchant & Braunisch 2004).

Outdoor activities, which have become increasingly popular in the last decades, represent a particularly important threat. The search for undisturbed natural areas often leads to a conflict with the needs of wild animals. As consequence, a substantial number of species are threatened and endangered due to tourism and recreational activities in their habitats (Czech et al. 2000). In Western and Central Europe outdoor activities such as ski hiking have become a factor often discussed in conservation biology of grouses (Storch 2000, Zeitler & Glänzer 1998, Zeitler 2000). Especially natural forests often representing core areas of grouse habitats are frequently used for recreation. Compared with other European regions the pressure of recreationists on nature and, consequently, grouse species is particularly high in the Alps (Braunisch et al. 2011, Suchant & Braunisch 2004).

In capercaillie disturbed birds escape to undisturbed parts of their home ranges. This leads to a decrease of home range size (Thiel et al. 2008). A study on effects of free-riding snow sports in the Swiss Alps documented that black grouse repeatedly disturbed by ski-hikers have increased levels of stress hormones which can result in a long lasting, reduced individual fitness (Arlettaz et al. 2007). The animals need a lot of energy to handle the disturbance. This may be particularly critical in winter when energy saving is important because of reduced food resources and rough climate conditions (Arlettaz et al. 2007). Another negative aspect is that if a grouse is flushed from its snow igloo it is exposed to predators (Meile 1980, Scherzinger 1978, Storch 2000). For rock ptarmigan it has been shown, that there is a relation between its condition at the end of winter, which can be affected by disturbance, and reproduction success (Moss & Watson 1984). Also for black grouse a negative effect of stress on reproduction success has been mentioned (Gavrin 1973, Klaus et al. 1968, Klaus 1982, Müller 1977, 1980, 1982).

However, not only direct disturbance through humans but also the improvement of infrastructure such as roads or ski lifts decline habitat quality (Ménoni & Magnani 1998, Patthey et al. 2008, Storch & Leidenberger 2003). Man-made structures such as powerlines, windparks and fences represent further threats (e.g. Baines & Andrew 2003, Bevanger 1995, Zeiler & Grünsachner-Berger 2009). For example, in Norway ca. 20.000 individuals of capercaillie and 26.000 of black grouse died per year due to collisions with power lines (Bevanger 1995).

Human activities can also increase grouse mortality due to an increased predation risk. For example, in the Alps an increased density of several corvid species, which are important predators of grouse eggs and chicks, was found around tourist hotspots such as mountain huts (Storch & Leidenberger 2003). This can result in negative effects on breeding success within several kilometers around tourist stations (Moss & Watson 2001).

Black grouse and capercaillie depend on forest types of different successional stage and vegetation structure. Both species suffered due to the development of commercial forestry resulting in more even-aged forests with a reduced range of patch sizes, forest types and tree species, hence replacing the variable patch dynamics of natural forests (Angelstam 2004).

In this study we tried to relate potentially increasing pressure on grouse due to recreational activities and changes in forest use to changes in populations of black grouse and capercaillie. Because there is emerging evidence that both grouse species are potential members in a suite of umbrella species for the conservation of forest biodiversity (Roberge & Angelstam 2004, Suter et al. 2002), our results will have important implications not only for grouse conservation.

Our study region is the state of Styria in southeastern Austria. In Styria tourism and habitat change were already emphasized as the main factors responsible for the decline of black grouse and capercaillie (Sackl & Samwald 1997). The number of people who visited Styria for recreation increased continuously since the beginning of the 1970s. For example, the number of tourists increased from around 0.8 Mio in the winter season 1990 to more than 1.3 Mio in 2009 (Amt der Steiermärkischen Landesregierung 2009). To quantify changes of grouse populations in Styria during the last decades and to identify possible threats we used questionnaires addressed to Styrian Hunters. In spite of problems related to data collected by questionnaires our close cooperation with the "Styrian Hunting Association" was the only possibility to achieve statewide information on the species' status and population development. Most of the involved hunters have long-time experience with grouse numbers in their hunting district due to an annual count of male black grouse and capercaillie. Furthermore, due to their experience in their hunting districts they are also familiar with general habitat changes due to prominent changes in forestry measures, and other potential threats to grouse such as constructions of roads and ski lifts.

Furthermore, the collected data were used to evaluate if spatiotemporal changes in the distribution of both grouse species are more pronounced at the southeastern margin of their alpine distribution range. Black grouse and capercaillie are widely distributed in Styria except of the lowlands in southeastern part of the state (compare Sackl & Samwald 1997). As documented for capercaillie in the Bavarian Alps, populations on the border of the Alps respond more sensitive to declining habitat quality at the edge of their distribution ranges, most likely because small size of local populations at the range margin makes them vulnerable to stochastic events (Segelbacher et al. 2003b). For example, while populations of black grouse and capercaillie appear to thrive in the boreal forest core of their range in Sweden, both have already gone extinct from the periphery of their distribution in Sweden (Svensson et al. 1999). In case both species show a distinct decline in Styria, we therefore

expect that it is especially prominent towards the species' range margins in the Southeast of the state.

Material and Methods

Study area and grouse distribution

The study area, the state of Styria, has a total area of 16,401 km². The highest elevation is 2,995 m asl (Amt der Steiermärkischen Landesregierung 2011a). A total of 76 % of the area is classified as mountainous and 57 % are covered with forest (Amt der Steiermärkischen Landesregierung 2011b). The North-western and North-eastern parts of the country are mountainous regions with a rough climate characterized by low temperatures in winter and medium temperatures in summer. Average yearly temperatures range from 0°C on the higher mountains to 6°C in the valleys. The mountain regions have a high precipitation (up to 2,400 mm per year) and up to 200 rainy days per year. These mountain regions shield the rest of the country from high amounts of rain. The Eastern part of the country is a lowland area with a more continental climate. The average yearly temperature is 10°C and the amount of rain is much lower. The Central part of Styria contains valleys with a milder climate than in the Northern and Western parts and mountain regions with a typical inner alpine climate with less rain and higher temperatures. The timberline in this area is around 300 m higher than in the Northern regions of the state (Pilger et al. 2010).

In Styria the black grouse can be found in subalpine areas with a main vertical distribution between 1,500 to 1,900 m asl. (Sackl & Samwald 1997). The capercaillie has a similar distribution, but occurs predominantly at lower elevations between 900 to 1,500 m. Both species are only completely absent from the lowlands in the east of Styria (Sackl & Samwald 1997).

The Questionnaire

To collect semi-quantitative data on the population change of black grouse and capercaillie in Styria, we designed a questionnaire distributed to the heads of the hunting districts (called "Hegeringe"). To get a good number of returns, we tried to create a questionnaire as short and simple as possible and easy to understand. In Austria hunting of grouse is managed by law. In each district in Styria the number of shot male grouses must be less than the overall mortality per year. This harvest ratio is identical for black grouse and capercaillie. As this ratio did not change in the last decades, we do not think that hunting pressure changed prominently within our considered study period (years 1980–2009). Therefore and because of the sensitivity of this issue we did not include questions on hunting intensity and hunting practices in our questionnaire.

Questionnaires were sent to the heads of a total of 202 hunting districts not considering lowland regions from which the two grouse species were never recorded according to the Styrian Hunting Association and the Styrian atlas of

breeding birds (Sackl & Samwald 1997). In total 105 questionnaires were returned, of which one questionnaire had to be eliminated from our analysis due to very incoherent statements.

To fill the questionnaire, hunters had to estimate for their own hunting district the change of (1) black grouse and (2) capercaillie populations, changes in forest cover through (3) forest clearings and (4) windbreak, changes in (5) forest road density and changes in recreational activities such as (6) hiking, (7) mountain biking, (8) ski hiking and (9) snowshoe hiking. Changes had to be estimated for the three time periods 1980–1989, 1990–1999 and 2000–2009. Changes of grouse populations and recreational activities had to be classified on a scale ranging from -3 (strong decline) to +3 (strong increase). Zero indicated no change. Changes of forest road density, the extent of forest clearings and windbreak areas had to be classified on a scale ranging between 0 (no change) to +3 (strong increase).

Data analysis

Only the last two decades were considered because most of the hunters have not worked in their hunting district before and we decided not to trust data provided for the first decade (1980–1989), except data on the occurrence (incidence data) of grouse species. To evaluate if population change (ranked on a scale between -3 and +3) of grouse species differed between the decades 1990–1999 & 2000–2009 a paired Wilcoxon test was calculated only considering hunting districts for which data on both decades were available.

Maps showing the changes of capercaillie and black grouse populations in the considered hunting districts were made to evaluate if population changes followed a spatial pattern. To visualize recent population changes only data covering the last two decades (1990–1999 and 2000–2009) were considered. Consequently, population changes are only figured for hunting districts, from which data was available for both decades. Maps show the net population change quantified as sum of the population change values for 1990–1999 and 2000–2009. Therefore, values can range from -6 (strong population decline in both decades) to +6 (strong increase in both decades). Zero values can indicate a stable population or can be the result of a change in the first decade, which was compensated by an opposite change in the second decade.

Because of multicollinearity of hunting district variables and to decrease the number of predictor variables (to avoid over-parameterization of GLMs; see below), we combined the variables hiking + mountain biking and ski hiking + snowshoe hiking as measure for human disturbance during breeding and post-breeding season and winter season, respectively, by adding their values. Therefore, values of both new variables hiking + mountain biking and ski hiking + snowshoe hiking can range between -6 and +6. To test for differences between the decades 1990–1999 and 2000–2009 a paired Wilcoxon test was calculated for all variables only considering hunting districts for which data on both decades were available.

For both grouse species generalized linear models (GLMs) with ordinal-multinomial error structure and logit-link function were developed to assess the effects of hunting district variables on population changes. GLMs were calculated including all variables and all possible subsets. To identify predictor variables

with the strongest influence on population changes of grouse species, models were ranked according to their information content quantified by the corrected Akaike's information criterion (AIC_c) (Burnham & Anderson 2002, Crawley 1993). For all models within 2 AIC_c values of the best model (with lowest AIC_c), we calculated their AIC_c weights as a relative measure of support for a model (Burnham & Anderson 2002). The higher the AIC_c weight, the higher is the relative likelihood of a model compared to competing models (Wagenmakers & Farrell 2004). For both species, GLMs were calculated for the time period 1990–2009 and the decade 2000–2009. To quantify population changes of grouse species and changes of habitat variables for the time period 1990–2009, for all variables the sums of the values of both decades 1990–1999 and 2000–2009 were used. These two different time scales, the last decade and the last two decades, were used to evaluate if the importance of habitat variables for predicting population changes of grouse species differs depending on the considered time scale. To describe effects of variables that affected population changes after controlling for other variables, β coefficients were used. All statistical analyses were calculated with Statistica 7.1 (Statsoft 2005).

Results

Changes of grouse populations

In the time period 1980–1989 the black grouse occurred in 91 of the 104 considered hunting areas. In the time period 1990–1999 the species became extinct in one area, in 2000–2009 it disappeared from another five areas. Hence, during the last two decades the species got extinct at 6.6 % of the hunting districts, where it still occurred in the 1980ies, but did not colonize new areas or re-appeared in areas where it vanished. The species mean population change classified for each hunting district on a scale between -3 and 3 was around -0.30 in 1990–1999 and about -0.50 in 2000–2009. This indicates a slight but continuous decrease of black grouse populations during both decades (Fig. 1a), which did not differ significantly between the two decades (paired Wilcoxon test: $T = 385.00$, $Z = 0.832$, $N = 83$, $p = 0.406$).

In the 1980ies the capercaillie occurred in 94 of the 104 considered areas. The species became extinct in one hunting district in the time period 1990–1999 and in a second district in 2000–2009. As in black grouse, the species did not appear in new areas or re-colonize areas where it became extinct during the last two decades. The mean population change of capercaillie per hunting district was -0.25 and -0.1 in 1990–1999 and 2000–2009, respectively, indicating a weak decline during the last two decades (Fig. 1b). The small difference between both decades did not achieve a significant level (paired Wilcoxon test: $T = 286.50$, $Z = 1.444$, $N = 89$, $p = 0.149$).

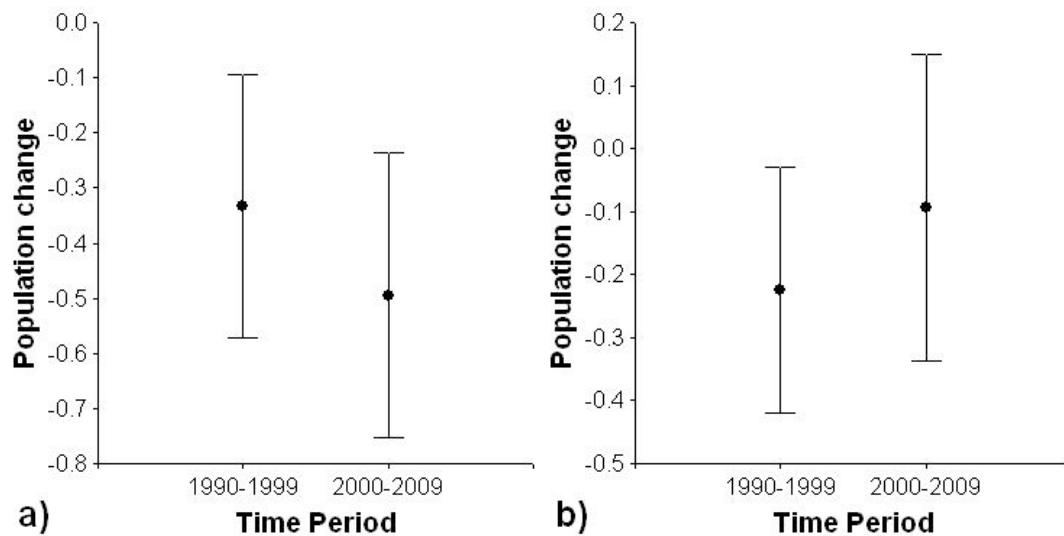


Figure 1. Mean change of (a) black grouse (N = 83 hunting districts) and (b) capercaillie populations \pm 95% CI (N = 89) in the decades 1990-1999 and 2000-2009.

Spatial pattern

The spatial patterns of population changes of black grouse and capercaillie have a great deal in common in some regions but also show pronounced differences in others (compare Fig. 2). Both species show relatively stable populations in the central mountain ranges, particularly in northwest Styria. Obvious declines can be observed along the large valleys of river Mürz (northeastwards from Leoben) and Mur (southwestwards from Leoben). Hunting districts where grouse species became extinct during the last two decades are located at the species' range margin in the Southeast of Styria (Fig. 2). The northeast of the state appears to be a remarkable stronghold for capercaillie (Fig. 2). While the black grouse declined in several hunting districts, our data does not indicate changes of capercaillie populations in this part of Styria.

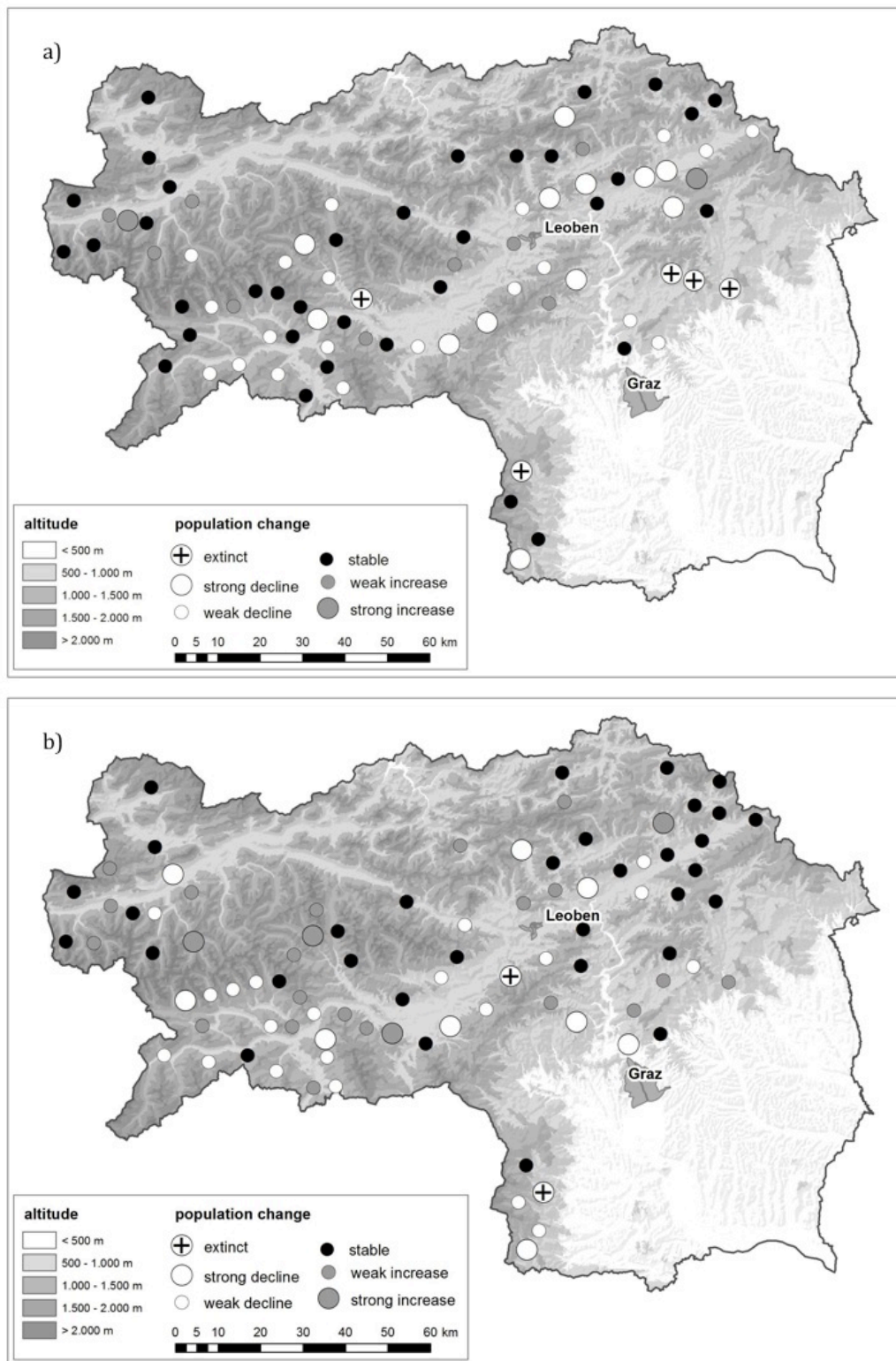


Figure 2: Maps of Styria indicating population changes from 1990-2009 for (a) black grouse and (b) capercaillie on the level of hunting districts. Values for population changes were added up for the two decades 1990-1999 and 2000-2009. Population changes visualized in the maps are defined as strong decline (values of population change between <-2), weak decline (-2 to -1), weak increase ($+1$ to $+2$) and strong increase ($>+2$). Zero values were classified as indicating stable populations.

Temporal changes of variables potentially affecting grouse populations

Recreational activities during the summer period (hiking + mountain biking) and winter period (ski hiking + snowshoe hiking) significantly increased during the last two decades (Fig. 3). Furthermore, windbreaks and forest clearings significantly increased, while the density of forest roads did not significantly change (Fig. 3).

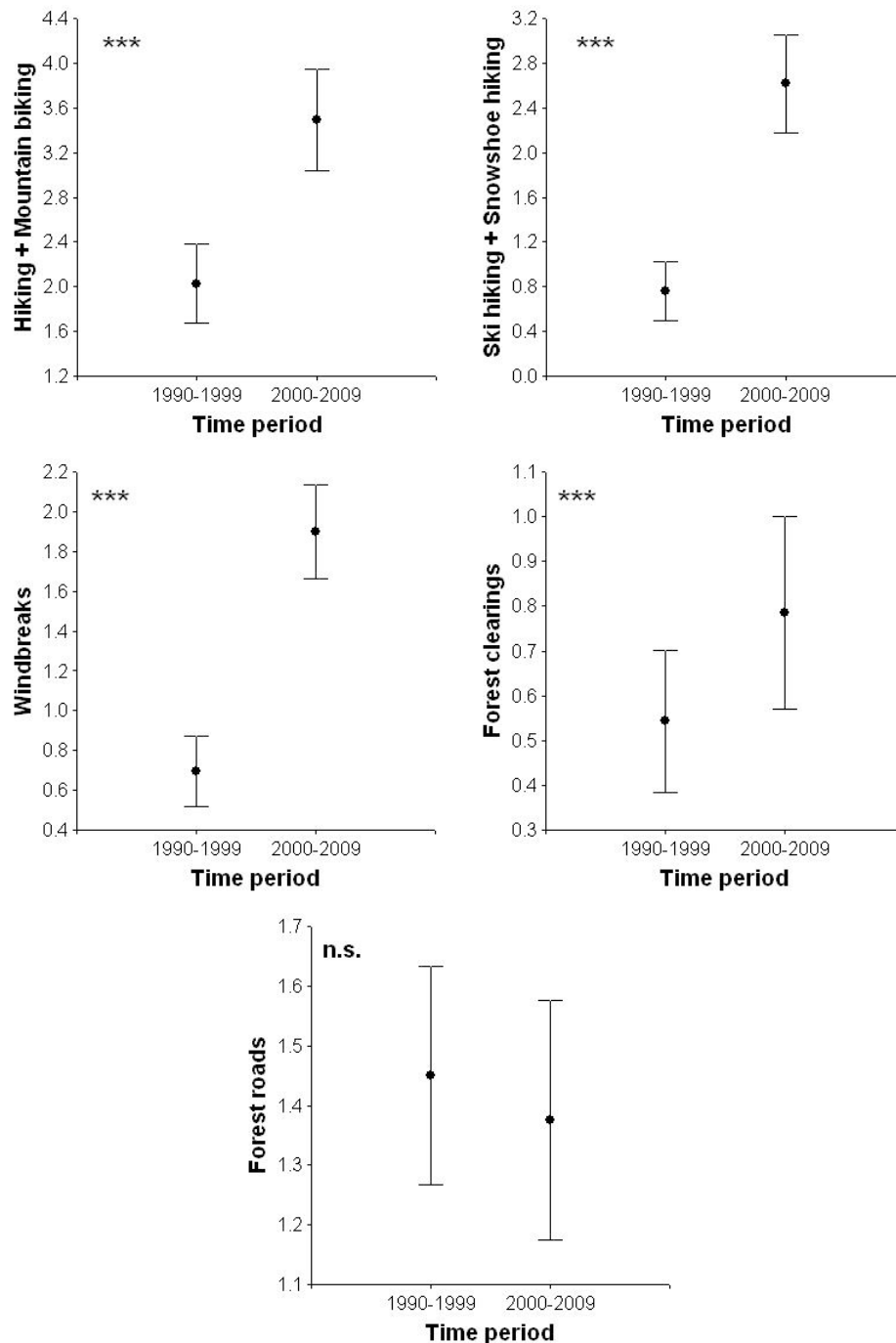


Figure 3. Changes of different parameters potentially affecting grouse populations in the last two decades. Shown are means \pm 95 % CIs. Furthermore, results of paired Wilcoxon tests are shown (n.s. = $p > 0.05$, *** $p < 0.001$).

Effects of human disturbance and forest cover on population change

GLMs including all variables and possible subsets indicate that for the time period 1990-2009 windbreaks and forest roads both seem to have a major effect on black grouse populations (Table 1). Both variables are represented four times in the five best models. The β coefficient ranging between 0.176 and 0.210 for windbreak indicates a positive effect on black grouse populations. Forest road density had a negative effect ($\beta = -0.53$ to -0.205). During the last decade (2000-2009) recreation activities in summer (hiking + mountain biking) appeared to have a particular strong effect. Black grouse populations were negatively affected by summer recreational activities ($\beta = -0.293$ to -0.303). However, the small AIC_c weights and the small multiple R^2 values indicate a relatively poor model performance and low explanatory power, respectively.

Table 1. Best GLMs testing for effects of disturbance by recreational activities during summer (hiking + mountain biking) and winter (ski hiking + snowshoe hiking), changes of forest cover (windbreaks, forest clearing) and density of forest roads on change of black grouse populations during the time period (a) 1990-2009 and (b) 2000-2009.

Variables included	df	AIC _c	AIC _c weight	<i>p</i>	mult. <i>R</i>	mult. <i>R</i> ²
(a) time period 1990-2009						
Windbreaks ($\beta = 0.176$), forest roads ($\beta = -0.205$)	2	233.06	0.140	0.039	0.239	0.057
Hiking + mountain biking ($\beta = -0.160$), windbreak ($\beta = 0.210$), forest roads ($\beta = -0.153$)	3	233.76	0.099	0.046	0.280	0.078
Forest roads ($\beta = -0.166$)	1	234.07	0.085	0.068	0.166	0.028
Ski hiking + snowshoe hiking ($\beta = -0.105$), windbreak ($\beta = 0.198$), forest roads ($\beta = -0.172$)	3	234.86	0.057	0.076	0.257	0.066
Hiking + mountain biking ($\beta = -0.211$), windbreak ($\beta = 0.191$)	2	234.82	0.058	0.094	0.241	0.058
(b) time period 2000-2009						
Hiking + mountain biking ($\beta = -0.293$)	1	189.99	0.245	0.013	0.293	0.086
Hiking + mountain biking ($\beta = -0.303$), windbreaks ($\beta = 0.027$)	2	191.41	0.120	0.032	0.295	0.087
Hiking + mountain biking ($\beta = -0.301$), forest roads ($\beta = 0.026$)	2	191.93	0.093	0.041	0.294	0.087

For the time period 1990-2009 recreation activities in summer (hiking + mountain biking) and forest clearing seems to have the strongest effect on capercaillie populations (Table 2). Hiking + mountain biking had a negative effect on population numbers, indicated by the β coefficient ranging from -0.263 to -0.291 . Forest clearings had a positive effect with a β coefficient ranging from 0.297 to 0.306 . For the time period 2000-2009 recreation activities in summer (hiking + mountain biking) seems to have the major influence on capercaillie populations. The β coefficient for recreation activities in summer is ranging from -0.265 to -0.312 indicating a negative effect on capercaillie populations.

Table 2. Best GLMs testing for effects of disturbance by recreational activities during summer (hiking + mountain biking) and winter (ski hiking + snowshoe hiking), changes of forest cover (windbreaks, forest clearing) and density of forest roads considering on change of capercaillie populations during the time period (a) 1990-2009 and (b) 2000-2009.

Variables included	df	AIC _c	AIC _c weight	<i>p</i>	mult. <i>R</i>	mult. <i>R</i> ²
(a) time period 1990-2009						
Hiking + mountain biking ($\beta = -0.263$), forest clearing ($\beta = 0.306$)	2	242.96	0.279	0.008	0.343	0.117
Hiking + mountain biking ($\beta = -0.275$), forest clearing ($\beta = 0.299$), windbreak ($\beta = 0.048$)	3	244.49	0.130	0.016	0.345	0.120
Hiking + mountain biking ($\beta = -0.291$), forest clearing ($\beta = 0.297$), ski hiking + snowshoe hiking ($\beta = 0.068$)	3	244.86	0.108	0.019	0.348	0.121
(b) time period 2000-2009						
Hiking + mountain biking ($\beta = -0.265$)	1	209.78	0.190	0.027	0.266	0.071
Hiking + mountain biking ($\beta = -0.273$), forest clearing ($\beta = 0.194$)	2	210.79	0.115	0.049	0.329	0.108
Hiking + mountain biking ($\beta = -0.303$), windbreak ($\beta = 0.111$)	2	211.293	0.089	0.0634	0.285	0.081
Hiking + mountain biking ($\beta = -0.312$), ski hiking + snowshoe hiking ($\beta = 0.115$)	2	211.674	0.074	0.0767	0.286	0.082
Hiking + mountain biking ($\beta = -0.278$), forest roads ($\beta = 0.042$)	2	211.775	0.070	0.0807	0.269	0.072

Discussion

The current conservation status of black grouse and capercaillie in Styria

Populations of black grouse and capercaillie appeared to be relatively stable or even increased in some regions of Styria during the last two decades. Our data indicate a continuous overall population decline of both grouse species in the South-eastern part of the Austrian Alps. Although the negative population trends appear to be only weak, their continuation over two decades certainly resulted in a substantial reduction of the species' total population size and finally caused several local extinctions at the species' range margin. Furthermore, both black grouse and capercaillie did not colonize new areas and did not re-colonized areas from which they vanished during the last two decades. This may have been either caused by habitat loss, the species' limited dispersal ability or a combination of both. Although it is assumed that black grouse populations are declining in most alpine countries and the status of the Austrian population was classified as stable (Storch 2007). This positive assessment is not supported by our data. We do not expect that our results are biased by population cycles. In contradiction to black grouse and capercaillie populations in northern latitudes, cyclic abundance fluctuations are not found in Central European populations (e.g. Cattadori & Hudson 1999).

For local dynamics of fragmented populations dispersal is a key factor. In English black grouse a median natal dispersal distance of 9.3 km was found for hens, while cocks showed very high site fidelity and did not disperse more than 1

km (Warren & Baines 2002). In the southern French Alps c. 80% of radio-tracked first-year females nested 5–29 km from their site of capture (Caizergues & Ellison 2002). Because most juvenile hens emigrated from the area studied in the French Alps, immigration appears to be extremely important to maintain local breeding numbers of hens (Caizergues & Ellison 2002). This may explain why more isolated populations at the range margin have a higher risk of local extinction than interconnected populations in the Alps, where even valleys of unsuitable habitat (up to 12 km wide) may be frequently crossed by dispersing hens (Caizergues & Ellison 2002). Juvenile males may not substantially contribute to exchanges between populations, but this should not cause demographic problems in a polygynous species like the black grouse. Exceptions may be regions where harvest rates are very high (Caizergues & Ellison 2002). Then, in highly isolated populations with a low immigration rate the shooting of single males may cause local extinctions, e.g. in years when other stochastic factors (such as bad weather conditions) reduce breeding success or enhance mortality. Therefore, we recommend banning the common hunting practice in Styria in hunting districts with small and highly isolated populations. Such populations are frequently found at range margins, where species often show much lower population densities than in core areas of their distribution range (e.g. Brown 1984, Newton 2003). For capercaillie from the Bavarian Alps, there is genetic evidence that populations at the periphery of their alpine range show sink characteristics with immigration exceeding emigration (Segelbacher et al. 2003b). Therefore, such populations, when getting isolated from larger source populations, may face a high extinction risk. This may explain the spatial aggregation of local extinctions of capercaillie and black grouse populations at their range periphery in the eastern part of Styria.

Effects of human disturbance

Both black grouse and capercaillie are potentially at risk from increased human recreational disturbance (Baines & Richardson 2007). However, perhaps a certain extent of human disturbance can be tolerated or at least is below a detectable level as demonstrated by a study on effects of different disturbance regimes on black grouse (Baines & Richardson 2007). In our study area, recreational activities such as hiking, mountain biking, and ski and snowshoe hiking dramatically increased during the last two decades in hunting districts with black grouse and capercaillie occurrence. While spatial differences of recreational activities during winter apparently did not or only weakly affect grouse populations on the level of hunting districts. Our calculated GLMs indicate a clear negative effect of the variable hiking + mountain biking on the populations of both black grouse and capercaillie.

The peak season of hiker and mountain biker corresponds to the breeding season of black grouse and capercaillie and disturbance can cause the total loss of eggs and can increase chick mortality (Klaus 1990). Visitors may also interrupt the courtship display at lekking sites. This can also have strong negative effects because copulation only happens after days of undisturbed courtship display. In capercaillie courtship behavior can be observed from March until July and hence corresponds with the hiking season (Klaus et al. 1986).

Visitors searching for mushrooms and berries are another factor of disturbance during summer (Sackl & Samwald 1997).

Other studies provide clear evidence that human disturbance during winter has negative effects on grouse survival (capercaillie: Ménoni et al. 1994). That winter recreation was not or only very weakly related to changes in grouse populations in our study could have been caused by the used spatial scale. While our data is on the level of hunting areas, studies from the Swiss Alps which documented a strong negative impact of winter tourism on black grouse abundance, used a much higher spatial resolution (e.g. 25 x 25 m raster map: Braunisch et al. 2011; 1.5 km transects: Patthey et al. 2008). That our data could detect a clear effect of summer tourism on grouse populations may be due to the fact that summer tourism is affecting landscapes more equally on larger spatial scales. In contrary, effects of winter tourism are more clustered, e.g. a high proportion of visitors depend on infrastructures such as ski lifts and may avoid areas, which are difficult to access during the winter season.

Another indicator for the intensity of human disturbance may be the density of forest roads. They are used by hikers and mountain bikers and may indicate the intensity of forest use. The enhanced access of forest areas in hunting districts with a higher density of forest roads may cause an increased human disturbance with a potentially negative effect on grouse. Indeed, our models considering the time period 1990-2009 indicate a substantial negative impact of increased forest road density on black grouse populations. This result corresponds with the finding that chick-rearing female black grouse avoid roads, forest tracks and walking paths (Patthey et al. in press).

Changes of forest cover

An analysis of the change in black grouse abundance in Scotland suggested that maturation of conifer forests accounted for 58–78% of the population decline between 1990 and 2002 (Pearce-Higgins et al. 2007). In our study, a positive effect of windbreaks, counteracting forest maturation, on black grouse populations was found. Windbreaks are mostly characterized by an irregular pattern, which increases landscape patchiness and vegetation heterogeneity. Both black grouse and capercaillie can benefit from the resulting mosaic of forests of different age and particularly early succession stages that can represent a habitat rapidly colonized by black grouse (Nopp-Mayr & Grünschnacher-Berger 2011).

In capercaillie forest clearing measures appeared to have a clear positive effect on populations within the time period 1990-2009. Forest clearings are emphasized as having a negative impact on capercaillie populations (Hafner & Hafellner 1995). On a large spatial scale they can lead to habitat fragmentation and therefore to an isolation of populations and the related negative effects on population structure (Segelbacher et al. 2003a). However, small spatial scale forest clearings of different age may have similar positive effects on capercaillie as windbreaks on black grouse. The capercaillie needs a habitat rich in structures and ecotones creating a diversity of different vegetation structures, which can fulfill the species requirements. These can change in relation to the considered behavioral context or seasonally. Particularly, smaller forest clearing

areas generating a high density of forest edges of different age can enhance habitat diversity (Klaus et al. 1986).

Future threats

In the state of Styria a total of 30-40 locations for windparks were discussed. The high percentage of overlap of windpower plants with lek sites of black grouse in alpine regions potentially causes a serious future threat for the species (Zeiler & Grünsachner-Berger 2009). Because there may be strong resistance to windparks in the lowlands or populated valley floors, they may be planned and realized on mountain ridges. There they can represent an important threat for existing lekking sites, which may be abandoned due to construction activities, increased disturbance along supply roads and the noise produced by the wind turbines (Zeiler & Grünsachner-Berger 2009). Furthermore, mortality may increase due to collisions, especially under foggy conditions (Zeiler & Grünsachner-Berger 2009).

Climate change and habitat loss due to anthropogenic activities are emphasized as the most important threats to global biodiversity (e.g. Travis 2003). A study on Scottish black grouse and capercaillie provides evidence for a high degree of synchronization between the availability of moth caterpillars, a preferred food of chicks, and their peak hatch (Baines et al. 1996). In non-migratory birds such as black grouse and capercaillie global warming may cause a mismatch between hatching of chicks and peak food availability when regional climatic change is seasonally asymmetric. This factor may have been responsible for the severe decline in breeding success and population size of black grouse over the last decades in Finland (Ludwig et al. 2006).

To what extent alpine grouse populations will be affected by regional climate change is unknown. But most likely the altitudinal shift of vegetation belts and changes in plant species composition along the altitudinal gradient (e.g. Grabherr et al. 1994, Pauli et al. 2001, Theurillat & Guisan 2001) will cause a significant habitat loss, particularly in black grouse (Nopp-Mayr & Grünsachner-Berger 2011).

Conclusions and conservation implications

Our semi-quantitative data provides clear evidence for a slight but ongoing decline of black grouse and capercaillie in Styria. Recreational disturbance, which significantly increased during the last two decades in our study area, apparently had a negative effect on grouse populations. Several other factors known to have negative effects on grouse populations were not considered in our study. Although they may be of relevance in Styria such as habitat fragmentation (e.g. Kurki et al. 2000) or an increased predation risk around hotspots of tourism (Moss & Watson 2001, Storch & Leidenberger 2003).

Visitor management may help mitigating potentially negative effects of increased recreational disturbance on grouse populations (Baines & Richardson 2007). Because black grouse populations may respond negatively to recreational disturbance at winter feeding areas, in England human access was excluded from winter feeding areas from 1st October to 31st March

(Warren et al. 2009). Also in the Swiss Alps the implementation of visitor steering measures were recommended for identified zones of potential conflict for black grouse and capercaillie even in winter refuges where human access is strictly limited or even banned and (Braunisch et al. 2011, Patthey et al. 2008, Sachot et al. 2006). At least for areas of Styria where only small remaining populations exist, we also recommend to implement an appropriate visitor management to avoid that grouse will be frequently disturbed at known winter feeding sites and lek sites.

The integration of habitat needs into forest management plans was stressed as precondition to successfully stabilize remaining grouse populations (Segelbacher et al. 2003a). Adequate forestry measures were also emphasized as one of the most important conservation activities for maintaining capercaillie populations in Styria (Sackl & Samwald 1997). To improve habitat quality for forest grouse, small-scale felling resulting in a high level of vegetation heterogeneity and the subsequent natural regeneration of trees were recommended as best forest management measures (Klaus 1991). Such measures should maintain an open forest structure (Sachot et al. 2006) and should create edges and gaps with a rich bilberry cover, which develops best in stands with a canopy cover of about 50% (Storch 1994). Preliminary attempts in the Swiss Alps suggest that habitat suitability for capercaillie can be improved through forest rejuvenation of cutting at reasonable costs (Sachot et al. 2006).

In Styria only male grouse can be legally shot. Several studies indicate that legal hunting of black grouse only represents a minor mortality factor or at least current hunting regimes apparently do not have a discernable effect on black grouse abundance (e.g. in France: Caizergues & Ellison 1997; in Switzerland: Patthey et al. 2008). However, it is largely unknown to what extent hunting affects local population dynamics and survival of grouse (Patthey et al. 2008). But it has to be considered that these studies were conducted in regions where hunting was only allowed in the post-breeding season. In contrary, in Austria grouse are shot in spring. Hunting can potentially cause a distorted adult sex ratio. Population growth in black grouse was shown to be influenced more by adult survival than by either survival of juveniles or reproductive success (Caizergues & Ellison 1997). Therefore, besides banning shooting of grouse in areas with only small and isolated populations, it was recommended to reduce harvests in years of poor reproduction (Caizergues & Ellison 1997). This should be also considered for hunting districts with low grouse densities in Styria.

Bird populations are often held at lower level by predators. The removal of predators of birds, generally increases hatching success, post-breeding numbers and breeding density (Côté & Sutherland 1997, Newton 1994, 1998). Also in grouse species breeding success is closely related to the density of potential predators such as corvids (e.g. Manzer & Hannon 2005, Summers et al. 2004). The legal control of predator abundance proved to have positive effects on grouse productivity and, therefore, was recommended as one conservation measure for grouse (e.g. Summers et al. 2004). In Scotland, capercaillie reared more young in forests with lower predator densities and they bred more successfully when some foxes and most crows were killed (Baines et al. 2004). On islands in the northern Baltic the killing of martens and foxes

increased breeding success and population size of both black grouse and capercaillie (Marcstrom et al. 1988). Therefore, in areas with small and isolated grouse populations, which potentially face a high extinction risk, predator management should be also considered in Styria.

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Zusammenfassung

Es ist bekannt, dass touristische Aktivitäten einen negativen Einfluss auf viele wildlebende Tiere haben können. Zu diesen potentiell bedrohten Arten zählen auch Auerhuhn *Tetrao urogallus* und Birkhuhn *Tetrao tetrix*. Sie sind störungssensibel und leiden daher unter der zunehmenden Popularität von Freiluftsportarten im alpinen Bereich. Nicht nur durch direkte Störungen von Menschen, auch durch Infrastruktureinrichtungen wie Schilifte oder Straßen wird die Qualität der Lebensräume eingeschränkt. Wir versuchen in dieser Studie die steigenden Störungen durch Menschen und Änderungen in der Bewaldung mit Änderungen in den Beständen von Auerhuhn und Birkhuhn in Zusammenhang zu bringen. Die Studie wurde auf Ebene von Jagdgebieten, sogenannten Hegeringen, im gesamten Gebiet des Landes Steiermark (Österreich) durchgeführt. Es wurden Daten erhoben um geographische Zusammenhänge der Bestandsveränderungen, Änderungen in Winter- und Sommertoursismus und Entwicklungen in der Bewaldung festzustellen. Für die Zeitabschnitte 1990-1999 und 2000-2009 sollten Änderungen in Raufusshuhnbeständen, Änderungen in der Intensität der touristischen Aktivitäten (Wandern, Mountainbiking, Schitouren, Schneeschuh wandern) mit Zahlen von -3 (starke Abnahme) bis +3 (Starke Zunahme) bewertet werden. Änderungen die Intensität von Kahlschlägen und Windwürfen, wie auch die Forststraßendichte betreffend, konnten in Kategorien von 0 (keine Änderung) bis +3 (starke Zunahme) angegeben werden.

Die Analyse des geographischen Zusammenhanges der Bestandsveränderungen ergab, dass in der Steiermark die eindeutigsten Abnahmen bei beiden Arten an der südöstlichen Grenze ihres alpinen Verbreitungsgebietes auftraten. Isolierte Populationen an Verbreitungsgrenzen sind häufiger von Rückgang und Aussterbeereignissen betroffen als gut vernetzte Gebiete in inneralpinen Bereichen. Wir konnten feststellen, dass die Bestandszahlen sowohl von Auer- als auch von Birkhuhn im Beobachtungszeitraum (1990 bis 2009) rückläufig waren. Zeitgleich sind Tourismus und forstliche Aktivität gestiegen.

Ein auf Modell-selektion basierter Ansatz brachte das Ergebnis, dass im Beobachtungszeitraum 1990-2009 Windwurf einen leicht positiven und Forststraßendichte einen leicht negativen Einfluss auf Birkhuhnpopulationen hatte. Für Auerhuhn ergab sich ein leicht positiver Effekt von Kahlschlägen auf die Bestandszahlen. Diese Ergebnisse legen nahe, dass forstliche Eingriffe die einen positiven Effekt auf die Strukturiertheit eines Waldes haben, sich auch positiv auf Auer- und Birkwild auswirken. Ein reich strukturierter Wald der alle Bedürfnisse der Tiere erfüllt, kann durch kleinräumige forstwirtschaftliche Eingriffe geschaffen werden.

In dieser Studie konnten wir touristische Aktivität im Sommer (Wandern und Mountainbiken) mit einem Rückgang von Bestandszahlen von Auer- und Birkhühnern in Zusammenhang bringen. Um den Rückgang von Auer- und Birkhuhn in der Steiermark entgegen zu wirken, könnten Besuchermanagement und Aufklärung in sensiblen Gebieten einen Beitrag zur Reduktion von Störungen leisten.

Myriam PROMBERGER

4802 Ebensee, Audorf 44/2

+43 680 50 22 782

myriam.promberger@gmx.at

LEBENS LAUF

Geburtsdatum	15.11.1983
Geburtsort	Bad Ischl
Nationalität	Österreich

AUSBILDUNG

09/1990 – 06/1994	Volksschule in Bad Ischl (VS Ost)
09/1994 – 06/1998	Unterstufe des Bundesrealgymnasiums in Bad Ischl
09/1998 – 06/2003	Bundeshandelsakademie Bad Ischl (Matura)
10/2003 – 09/2004	Diplomstudium Kultur- und Sozialanthropologie an der Universität Wien
10/2003 - 10/2006	Diplomstudium Biologie (erster Abschnitt) an der Universität Wien
10/2006 – 09/2010	Diplomstudium Anthropologie (Stzw) an der Universität Wien
09/2010 – 10/2010	Bachelorstudium Biologie an der Universität Wien
20/2010 – 09/2011	Masterstudium Naturschutz und Biodiversitätsmanagement an der Universität Wien
09/2011	Diplomarbeit „The conservation status of capercaillie and black grouse in the south-eastern Alps: an assessment on the level of hunting districts“

BERUFSERFAHRUNG

01/2009 – 03/2009	Praktikum im Nationalpark Gesäuse
02/2010	Praktikum in der Abteilung Naturschutz der Landesregierung Oberösterreich
05/2008 – 08/2011	Mitarbeit in der zoo-pädagogischen Abteilung im Tiergarten Schönbrunn

SPRACHEKENNTNISSE

Deutsch	Muttersprache
Englisch	fließend in Wort und Schrift
Französisch	Grundkenntnisse
Isländisch, Bulgarisch	Grundkenntnisse

EDV-Kenntnisse

Office	Microsoft (Word, Excel, PowerPoint, Access), Open Office, Mac (Pages, Keynote)
Statistik	Statistika, SPSS, R
GIS	ESRI ArcMap

BESONDERHEITEN

1989 – 1999	Leistungssport Schifahren
1996 – 2002	Leistungssport Kunstturnen
12/2010 bis dato	Kassierin im Verein Austrian Biologist Association
Führerschein Klasse B	
Erste Hilfe Kurs	

HOBBIES

Bergsteigen, Schwimmen, Schifahren, Mountainbiken, Lesen