SPACE USE AND EXPOSURE OF LESSER WHITE-FRONTED GEESE TO HUNTING IN THE HORTOBÁGY REGION IN E HUNGARY

Report on Action A.5 of the project "Conservation of *Anser erythropus* on European migration route"

ACTION A.5:
Name of action: Evaluation of space use by Lesser White-fronted Geese and exposure of Lesser White-fronted Geese to hunting in the Hortobágy area, Hungary

Compiled by

Szabolcs LENGYEL
Project Coordinator

with contributions from

János TAR
Project Manager
and
Zoltán ECSEDI
Project Coordinator

Conservation of *Anser erythropus* on European migration route
LIFE 05 NAT/FIN/000105

Hortobágy National Park Directorate

January, 2007

TABLE OF CONTENTS

SUMMARY

We studied the space use of Lesser White-fronted Geese in the Hortobágy region (E-Hungary) between 1971 and 2006. We collected and digitised all (n = 840) reliable localities of LWfG occurrences and analysed them against county-level data on hunting intensity (characterized by hunting bag data). The most characteristic change in space use over the 36 years was a north-eastern shift in the sites used for roosting and feeding. Although this shift can be explained by progressively lower disturbance and favourable changes in the habitats in central and northern sites, increasing hunting in areas of Jász-Nagykun-Szolnok county bordering Hortobágy National Park from the W and the SW is also shown to be related to the changing patterns. There are relatively few observations of LWfG on arable lands, which may be related to the fact that LWfG are often scattered in large flocks of other geese in agricultural areas. Goose hunting in areas surrounding Hortobágy National Park had increased between 1971 and 1982, then decreased and stagnated until 1997, after which there was another peak (in 2000). In some counties, goose-hunting has increased (Jász-Nagykun-Szolnok, Heves, Békés) after the 2000 peak, in some others (Hajdú-Bihar), it decreased. A detailed study of the spatial distribution of hunting from 2001 to 2004 showed that the areas where LWfG are threatened by accidental shooting lie W and SW as well as NE from Hortobágy National Park, and include the townships of Tiszacsege, Egyek, Tiszafüred-Kócsújfalu, Nagyiván and Kunmadaras, Karcag and Túrkeve to the W and Nádudvar and Hajdúszoboszló to the SE, and Hajdúböszörmény to the NE. Of all these, hunting in the areas W and SW from the National Park appear to exert the greatest influence on space use by LWfG in the Hortobágy region.

1. INTRODUCTION

According to the text of the revised application of the LIFE-Nature project "Conservation of *Anser erythropus* on European migration route", Action A.5 planned to evaluate the space use of Lesser White-fronted Geese (LWfG) and exposure to hunting in the Hortobágy area in E Hungary. This action aimed to provide basic information for the background and planning of further actions. In the first phase, we aimed to collect data as far back in time as possible on the space use by LWfG in the Hortobágy region by contacting ornithologists and previous literature sources and to digitise all reliable localities of LWfG observations. We planned to analyse these data in a Geographical Information System to identify the areas most frequently used for feeding and other activities, including night roosting. In the second phase, we set out to collect information on where and how frequently goose-hunting had been conducted in the general Hortobágy area. By analysing the spatial data, we aimed to determine the areas that LWfG frequently use and where hunting pressure is high. This information is important in the planning and implementation of other actions and in developing further conservation measures. The current report presents the summary of activities conducted and findings obtained in Action A.5 of the above project.

2. METHODS

Data on LWfG occurrences were collected and provided for the project by the Hortobágy Environmental Association. The Hortobágy Environmental Association has been collecting all reliable LWfG observations dating from 1905 in the Hortobágy region since the 1990s. Their database contains information from both literature sources and personal direct reports of all major ornithologists visiting the Hortobágy region. The total database contains nearly 900 records (897) from the years between 1905 and 2006. Obviously, data reliability and accuracy of localities increases with time as the decline of LWfG has become more well-known and interest in the species has increased among ornithologists. Due to high unreliability of the early part (1905-1969) of the period, we selected the years since 1970 (1971-2006, 36 years total) as our detailed study period. This time period corresponds to the period following the collapse of the Finnish and decline in other populations (**Figure 1.**).

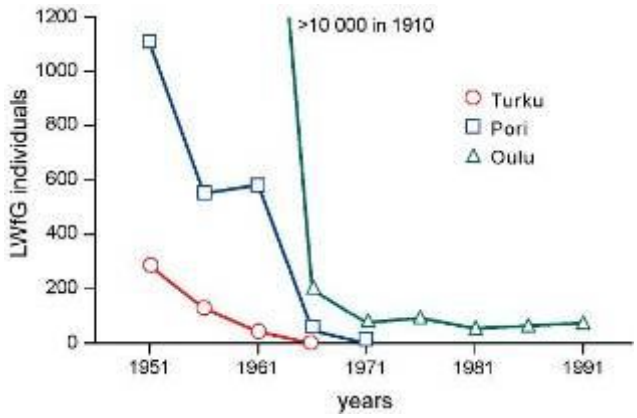


Figure 1. Estimated number of Lesser White-fronted Geese in three breeding populations in Finland between 1951 and 1991.
Source: Petteri Tolvanen

Data on the time and location of goose hunts were sought from several sources. Local hunting associations were contacted for their own records. The hunting associations that were contacted unanimously stated that all their data are available in the National Game Management Database of Hungary, maintained by the Institute for Wildlife Conservation at

St. Stephen University, Gödöllő, Hungary (http://ns.vvt.gau.hu/adattar). The head of that institute, Dr. Sándor Csányi, was contacted via email for data availability in spring and autumn 2007, and he informed us that data from the individual hunting associations are not available and that only the publicly available county-level data can be used for our purposes. Therefore, we used maps published by the above institute in their annual reports as a surrogate for data on goose hunting more detailed than the county level. We overlaid on the picture maps the outlines of Hortobágy National Park and drew conclusions on the spatial pattern of goose hunting based on such comparisons. For data on hunting bags, we used what could be retrieved from the national reports of the above database/institute. To obtain qualitative data on goose-hunting, we conducted three interviews with persons with the necessary knowledge on goose hunting in the past few decades and in the present.

We used ArcView 3.2 with extension Spatial Analyst to digitise data in a Geographical Information System (GIS). We aimed to maximise accuracy of the localities of LWfG observations. When exact sites were available for any record (e.g. Unit 5 on Central Fishponds), we took the central location of the site as the digitised locality. A more accurate locality would have been unfeasible and unnecessary for our purposes as LWfG often change their exact location within each site and among sites. The general error in digitising localities is estimated at 200-300 m, which was negligible when compared to the scale of the study (10-20 km).

We then used the Animal Movement Analysis software ([1]), a free extension under ArcView 3.2 to analyse space use by LWfG. We generated three different datasets: one for all spring observations from each year, another for all autumn observations from each year and a third one for all (spring + autumn) observations from any year. We then used the Animal Movement program to calculate various statistics describing the space use patterns of LWfG. The most important such characteristics were maximum polygon area of observations and the areas of kernels incorporating either 50% or 95% of the observations from any given period. We then related these measures with variables describing the intensity of hunting in areas neighbouring Hortobágy National Park.

[1] Hooge, P. N. & Eichenlaub, B. 1997. Animal movement extension to Arcview. Ver. 1.1. Alaska Science Center - Biological Science Office, U.S. Geological Survey, Anchorage, AK, USA.

3. RESULTS

3.1. LWFG OBSERVATIONS AND LWFG SPACE USE IN GENERAL

3.1.1. Changes in observation intensity with time

A total of 840 observations of Lesser White-fronted Goose in the Hortobágy region were available from the time period between 1971 and 2006. Most observations were made within Hortobágy National Park, and some were in neighbouring agricultural lands, grasslands or fishponds (**Figure 2.**).

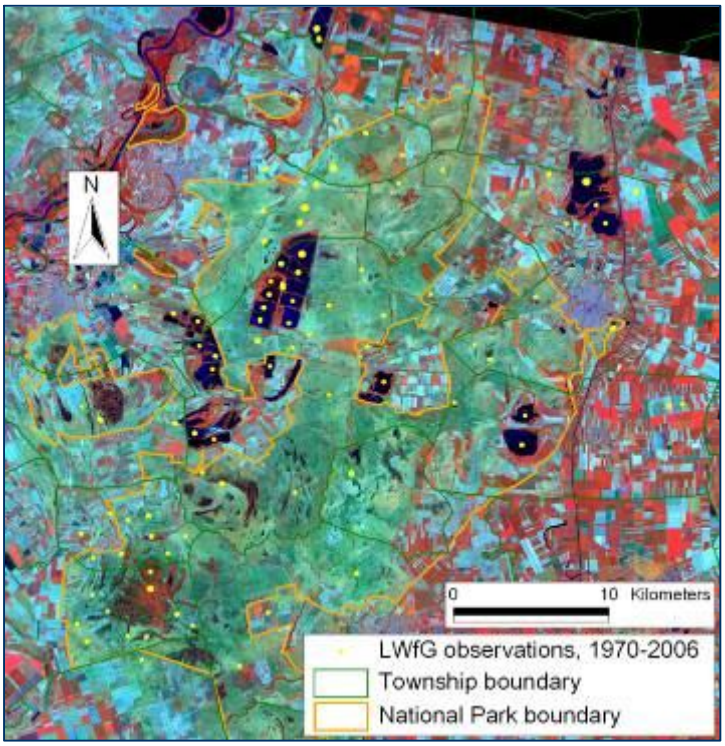


Figure 2. Localities where Lesser White-fronted Geese have been observed in the Hortbágy region in E Hungary based on 840 observations between 1970 and 2006.

The number of observations were not equally distributed among years (**Figure 3.**). Based on observation frequency, at least two time periods can be discerned. In the first period, lasting from 1971 to 1993, the number of observations ranged from a low of 1 in 1973 to a high of 33 in 1987. In the second period, starting in 1994, between 23 and 87 observations were made per year (**Figure 3.**).

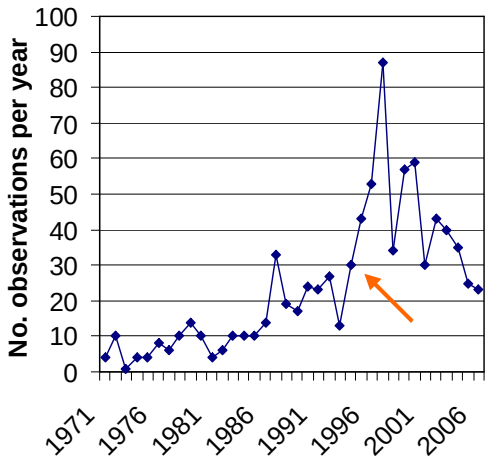


Figure 3. Number of LWfG observations per year in the Hortobágy area. The arrow indicates the year of 1994, after which the number of observations increased sharply.

The number of observations and the area over which observations were made were significantly higher in the more recent period (**Table 1.**). This increase can be attributed to a higher number of observers conducting observations over an increasingly larger area across the years. The number of observers increase considerably in the central and northern parts of the study area but not in the southern parts. Therefore, detection intensity is more constant in the southern than in the northern areas.

Table 1. Mean ± SD number of observations per year and minimum convex polygon area (in hectares) encompassing all localities over which LWfG observations were made in each year in two time periods with different observation intensity.

Period	Number of years	Number of observations (mean ± SD)	Area used by LWfG (mean ± SD)
1971-1993	22	13 ± 8.1	13 167 ± 15 816
1994-2006	13	43 ± 17.6	35 204 ± 10 074
		t = 6.979, p < 0.001	*t = 4.499, p < 0.001*

3.1.2. Changes in LWfG space use over 36 years

The space use of LWfG in the Hortobágy area has changed in the 36 years. In the first part of this period, most observations of LWfG are either from marshes and grasslands in the SW part of the national park area, from the vicinity of the village of Nagyiván, or from the Central Fishponds (**Figure 4.**). In more recent years, since the mid-1990s, most observations are from the Central Fishponds and the areas located N of the these fishponds (**Figure 4.**). This difference was more marked in the autumn migration (**Figure 4.B**), when several observations were made in 'new' (previously unused or unknown) sites, such as the Bivalyhalmi fishponds (Újszentmargita) and Virágoskút fishponds (Balmazújváros). These observations suggest that LWfG appear to have abandoned the southern areas as staging areas. There are at least three potential reasons for the north-eastern shift in staging sites:

1. Decreased disturbance by hunting in the Central Fishpond area by the early 1990s.
2. Favourable changes in northern roosting sites and grasslands, and/or unfavourable changes in the southern marshes and grasslands.
3. Increased disturbance or hunting in areas near the southern marshes.

Each of these hypotheses are supported by some observations. First, hunting was eliminated on the Central Fishpond and neighbouring areas by the early 1990s. Even though hunting occurred on nearby, non-protected fishponds even during and after the mid-1990s (e.g. Ohati and Derzsi fishponds, 3-4 km SW from the Central Fishponds), disturbance from hunting substantially decreased in the northern areas after 1990. Second, the decrease in hunting also cooccurred with favourable changes in habitats. The reconstruction of the Dinnyés-lapos as goose habitat in 1999, was a good example of successful habitat restoration in the Hortobágy. LWfG started to use this wetland for feeding and roosting in the autumn of 1999. Although no such new habitats opened to LWfG in the southern areas, it is unlikely that the habitats in the southern part of the national park underwent unfavourable changes. Finally, even though the southern marshes and grasslands within the national park are among the least disturbed, sanctuary-type habitats, goose-hunting appears to have increased in neighbouring areas since 1990, mainly W and SW from the national park boundaries. This was found both on the long-term (see more details below, in section 3.4.) and in the period between 2001 and 2004 studied in detail (see below, **Figure 8.**).

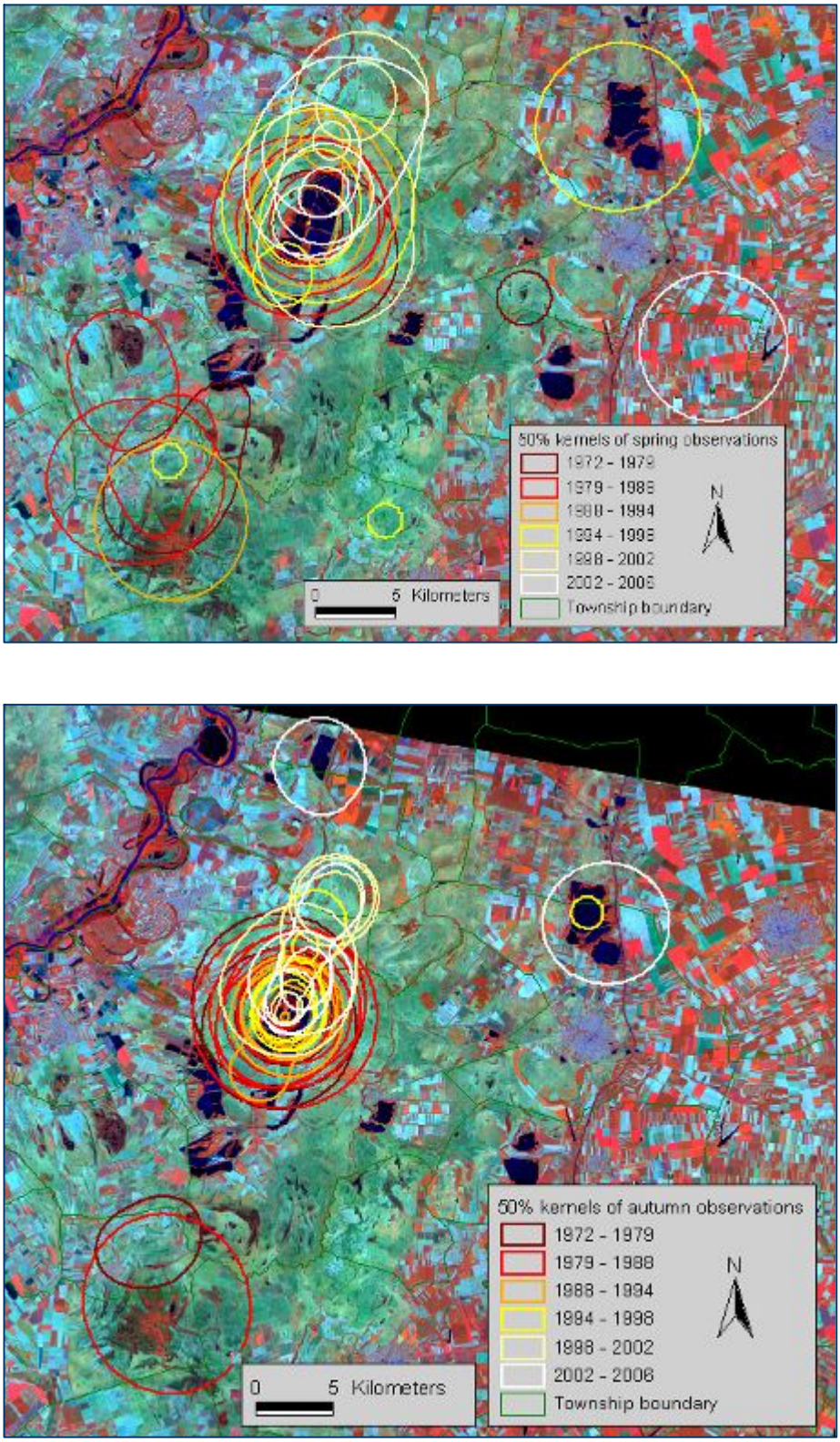


Figure 4. Space use of Lesser White-fronted Geese in the Hortobágy region based on observations on the spring migration (A) or the autumn migration (B) from the time period between 1971 and 2006. Range estimates (kernels) were calculated from point observations in either spring or autumn of all observations from any given year.

Southern marshes and grasslands were important in the spring migration before 1994, whereas their role in the autumn migration was less important even before 1994 (**Figure 4.A, B**). Correspondingly, the preference of northern sites has been more prevalent in the autumn migration than in the spring migration (**Figure 4.B**).

3.1.3. Space use by the main flock of LWfG in the Hortobágy region

Both the average and maximum flock size decreased in the 36-year study period (**Figure 5.**). Besides a general decline, the average flock size showed fluctuations on shorter time scales. For example, there were slight increases between 1985 and 1988, then between 1995 and 1997, and in 2002-2003. The variation in flock size also decreased considerably since 1981, indicating that most observations after this year were likely from one jointly migrating flock, most probably the Fennoscandian breeding flock. This flock was confirmed to consist of birds of Fennoscandian origin by repeated observations of colour-ringed birds since 2000.

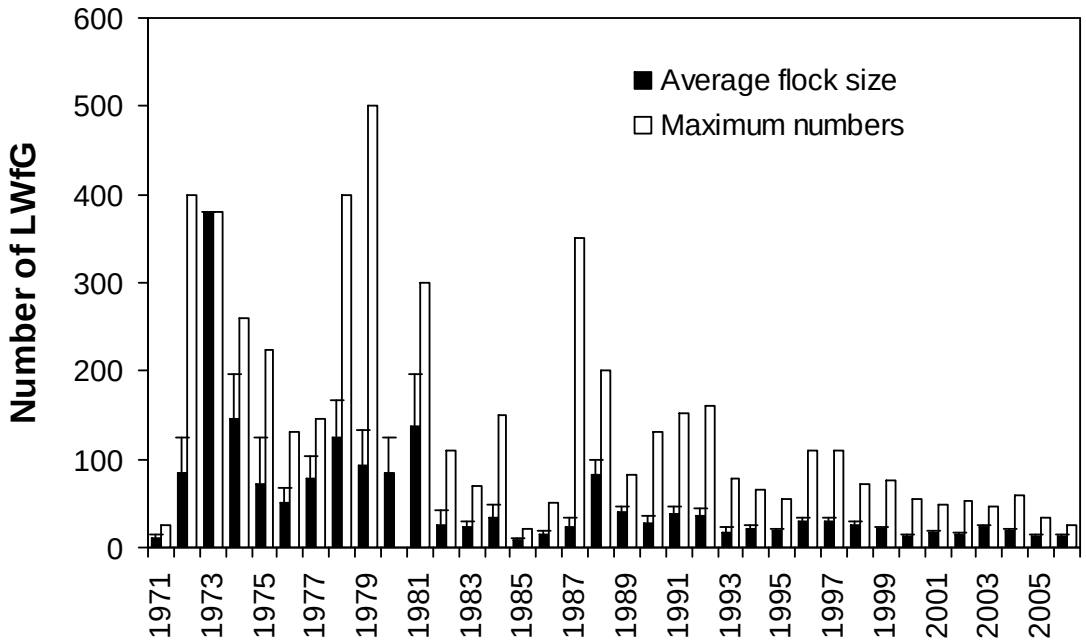


Figure 5. Average (± SE) flock size and maximum number of LWfG in any flock in each year between 1971 and 2006 in the Hortobágy region. A highly unlikely, extreme outlier datapoint from 1980 (3500-4000 LWfG reported) is omitted for clarity.

The space use of the main, presumably Fennoscandian, flock of LWfG both on spring and autumn migration could be characterized as using a central marsh or fishpond for roosting and a neighboring grassland for feeding during the day. Even early in the study period, there were several consecutive observations of LWfG on pairs of nearby roosting and feeding sites. These observations suggest that LWfG are reluctant to fly to larger distances unless they are disturbed or are in larger goose flocks. Observations of single birds, pairs or small flocks (4-6 individuals) were frequent: in 250 cases of 840 observations, 6 or fewer individuals were observed. Most LWfG observations were made at roosting sites (fishponds), and fewer were made in natural feeding areas (grasslands). It is surprising that there are relatively few observations from arable lands (**Figures 2.** and **4.**). This can be related to the finding that LWfG usually occur in large flocks of other goose species and are more difficult to observe on arable lands.

3.2. SPATIAL PATTERNS OF HUNTING

3.2.1. Goose-hunting in the Hortobágy: a short historical overview

The Hortobágy area in E Hungary has been traditionally famous for goose hunting in the early 20th century. Goose hunting was based on the very high number of geese staging in the area on autumn migration. The complex of marshes, fishponds, alkali grasslands and agricultural lands in combination with favourable, cloudy, foggy autumn weather offered excellent opportunities for goose-hunting. Several literature sources before the 1930s attest the high success rate of goose hunts, with several tens of thousands of geese shot each year. The proportion of LWfG shot was estimated by several sources at 10% of all geese shot in these decades ([2]). Sources mostly agree that several thousand LWfG used the Hortobágy area for staging every year before 1930. Goose hunting in the early 1900s has probably largely contributed to the collapse of the LWfG population in some of the Scandinavian breeding sites ([3]). Despite decreasing numbers of LWfG, goose hunting was also significant even after World War II; for example, even as recently as 1966, between 30-35 LWfG were shot ([4]).

Goose hunting was gradually phased out in the area of Hortobágy National Park. Goose hunts on fishponds within the national park were regularly conducted as recently as the early 1990s. During some of these hunts, shooting of LWfG has been observed at least several times (**Fekete P., pers. comm.**). However, exact data (time, locality) on shooting of LWfG has proved to be impossible to collect during this study.

3.2.2. Goose-hunting: national trend

The intensity of goose hunting, measured by data on annual hunting bag, rose sharply in Hungary from 1971 until 1985, and decreased back to pre-1980 levels in the 1990s (**Figure 6.**). A smaller peak in hunting intensity occurred in the wet years of 2000 and 2001, when the number of geese staging and/or overwintering was exceptionally high (**Figure 6.**).

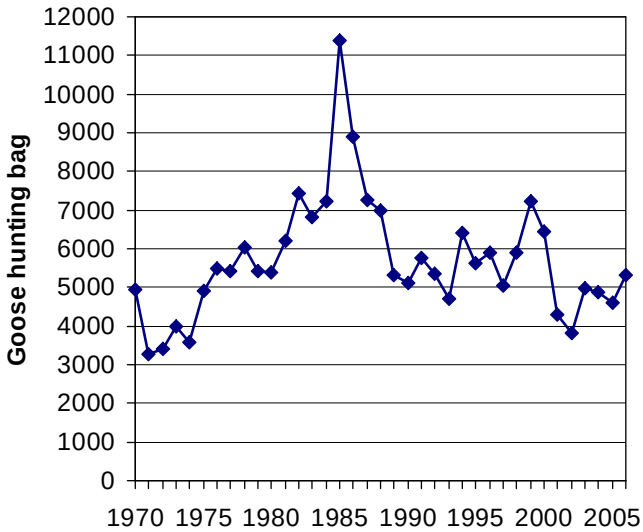


Figure 6. Goose hunting bag in Hungary between 1970 and 2005. Source: National Game Management Database (http://ns.vvt.gau.hu/adattar).

[2] Nagy 1924, Szomjas 1919, Tarján 1922, In: A Hortobágy madárvilága [Birds of Hortobágy]. Ecsedi Z. (szerk.), 2004.
[3] Kovács és Tar 2004, In: A Hortobágy madárvilága [Birds of Hortobágy]. Ecsedi Z. (szerk.), 2004.
[4] Sterbetz 1972, In: A Hortobágy madárvilága [Birds of Hortobágy]. Ecsedi Z. (szerk.), 2004.

3.2.3. Spatial patterns of goose-hunting: county trends

Two species of geese have been allowed for hunting in Hungary in recent years, Pink-footed Goose (*Anser fabalis*) and Greater White-fronted Goose (*Anser albifrons*). The hunting of wild geese showed variation between 1970 and 2006 in the four focal counties of eastern Hungary addressed by this study (**Figure 7.**). Hajdú-Bihar county, where most of Hortobágy National Park lies, is of central importance in goose hunting in the region, and the hunting bag is slowly decreasing despite a recent peak in 2000. Most geese in Hajdú-Bihar county are shot in agricultural areas just outside the border of Hortobágy National Park. In the other three counties, goose hunting was traditionally less important than in Hajdú-Bihar, but has been increasing since the early 1990s (**Figure 7.**). In Békés county, goose hunting is mostly confined to the area of the Biharugra fishponds in the NE corner of the county, whereas in Heves county, goose hunting is exclusively conducted on Tisza Lake. In Jász-Nagykun-Szolnok county, most goose hunting takes place in the E part of the county, in areas bordering Hortobágy National Park (**Figure 7.**).

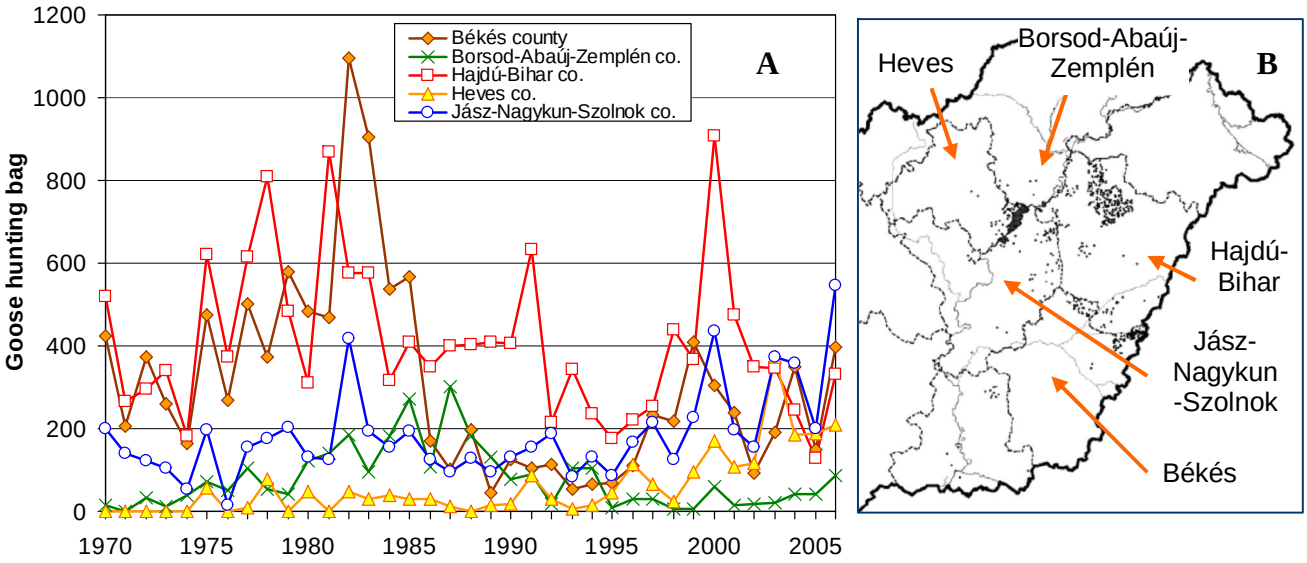


Figure 7. Goose hunting intensity measured by hunting bag data between 1971 and 2006 (A) from the five counties in eastern Hungary where goose hunting is most important (B). One dot on the map indicates one individual of Greater White-fronted Goose (*Anser albifrons*) shot in the hunting season of 2001. Source: National Game Management Database, Hungary (http://ns.vvt.gau.hu/adattar).

The number of geese shot in Hajdú-Bihar county was positively correlated with the number of geese shot in Békés county (correlation analysis, Pearson $r = 0.401$, $n = 36$ years, $p = 0.015$), but was not related to that in Heves or Jász-Nagykun-Szolnok counties (correlation analysis, n.s.). Goose hunting bags in the latter two counties, however, were strongly and positively related ($r = 0.610$, $p < 0.001$). Furthermore, the correlation between Békés and Jász-Nagykun-Szolnok counties was also positive ($r = 0.392$, $p = 0.018$). Goose hunting bag in Borsod-Abaúj-Zemplén county was not related to that from any other county. In conclusion, hunting intensity appears to be related between the two eastern counties (Hajdú-Bihar and Békés), and between the two western counties (Heves and Jász-Nagykun-Szolnok).

3.3. GOOSE-HUNTING IN AREAS NEAR HORTOBÁGY NATIONAL PARK (2001-2004)

Data on the geographical location of goose hunts in or near Hortobágy National Park were available only in the form of picture maps for three hunting seasons (beginning in 2001, 2003, 2004, respectively) (**Figure 8.**). Goose-hunting was intense throughout the three years in the Tisza Lake region (W part of the national park), with considerable hunting also within the national park boundaries in 2001 and 2003 (**Figure 8A, B**). The intensity of hunting was initially high NE from the national park (area of Balmazújváros and Hajdúböszörmény), where the important goose roosting site of the Virágoskút fishponds are located, and decreased progressively in later years (**Figure 8.**). Goose hunting was also intense along the W border of the base area of the national park (from N to S: areas of Tiszacsege, Egyek, Tiszafüred-Kócsújfalu, Nagyiván, Kunmadaras). Hunting was especially intense in the Tiszafüred-Kócsújfalu and northern Nagyiván region in 2003 and 2004 (**Figure 8B, C**). The area SW from the national park (area of Karcag and Túrkeve) became progressively more important in goose-hunting by 2004 (**Figure 8.**). Areas towards the SE had intense goose hunting in some years. For example, in 2003, intense hunting occurred apparently within the national park itself (areas of Nagyhegyes, Hajdúszoboszló and Nádudvar), and farther away from the national park boundaries (in the area of Nádudvar and Kaba) in 2004 (**Figure 8.**). Finally, goose hunting was very intense throughout the three years near the Biharugra fishponds farther SE from the Hortobágy region (lower right corner of maps in **Figure 8.**), where LWfG also regularly occur.

It has to be noted that the data shown on maps may not be a highly reliable estimate for where goose hunting took place. First, hunting clubs are required to maintain exact records only since 2001, and many of the records were admittedly wrong. For example, hunting by single persons or by small groups are less likely to be recorded in the official books than hunting by large groups. It is regular practice that official books are not updated in a timely manner, which can result in confusion over the exact time and location of the hunt. Second, there is often confusion as to the exact identification of the individuals shot. For example, Pink-footed Geese are usually rare in migratory flocks of geese in E Hungary, still, considerable numbers of this species are reported shot every year by the hunters (440, 439 and 278 in 2001, 2003 and 2004, respectively, in the four counties combined). On **Figures 7** and **8.** we only give numbers and maps for individuals shot and identified as Greater White-fronted Goose. Finally, goose hunts sometimes go unsuccessful and are thus not recorded in any official format. However, even unsuccessful hunts present considerable disturbance to geese and other waterfowl, therefore, the effect of hunting on geese is probably underestimated by considering only hunting bag data.

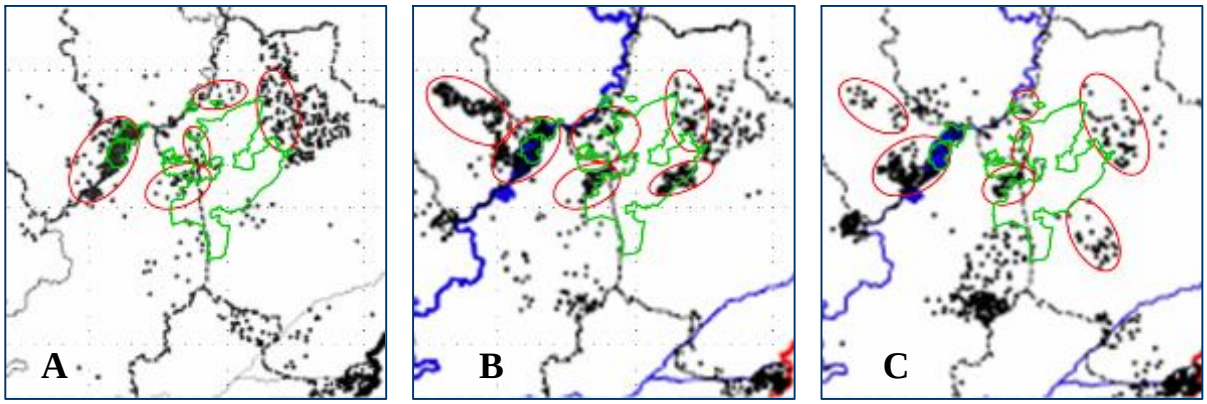


Figure 8. Spatial pattern of the intensity of goose hunting in and near Hortobágy National Park in E Hungary as shown by the geographical locations where Greater White-fronted Geese were shot (1 dot = 1 individual) in the hunting season of 2001/2002 (A), 2003/2004 (B) and 2004/2005 (C). Counties are as in **Fig. 7B**. Goose-hunting areas of concern are shown in red and the approximate location of national park boundaries are shown in green. Source of data on goose hunts: National Game Management Database, Hungary (http://ns.vvt.gau.hu/adattar).

3.4. CORRELATIONS BETWEEN GOOSE-HUNTING AND LWFG SPACE USE

We studied the relationship between variables describing space use and variables describing hunting intensity in multiple linear regression models in which space use variables were dependent variables (**Table 2.**) and county-level hunting bag data were independent variables.

Our analyses suggest that the northeastern shift in annual space use observed in the 36 years (see also above) was strongly correlated with increasing hunting pressure in Jász-Nagykun-Szolnok county (**Figure 9.**). This relationship was mainly because the areas used by LWfG shifted to the N and to the E in four years when hunting pressure was high in JNSZ county (2000, 2003, 2004, 2006). Such a tendency, however, could also be seen in years of lower hunting pressure (hunting bag < 250 individuals shot). In one early year (1982), hunting pressure was high (419 individuals shot), but was not associated with northward or eastward shift in the areas used during migration (**Figure 9.**). These results suggest that one of the most important factors influencing changes in space use is increasing hunting pressure in areas of Jász-Nagykun-Szolnok county neighbouring the SW part of Hortobágy National Park.

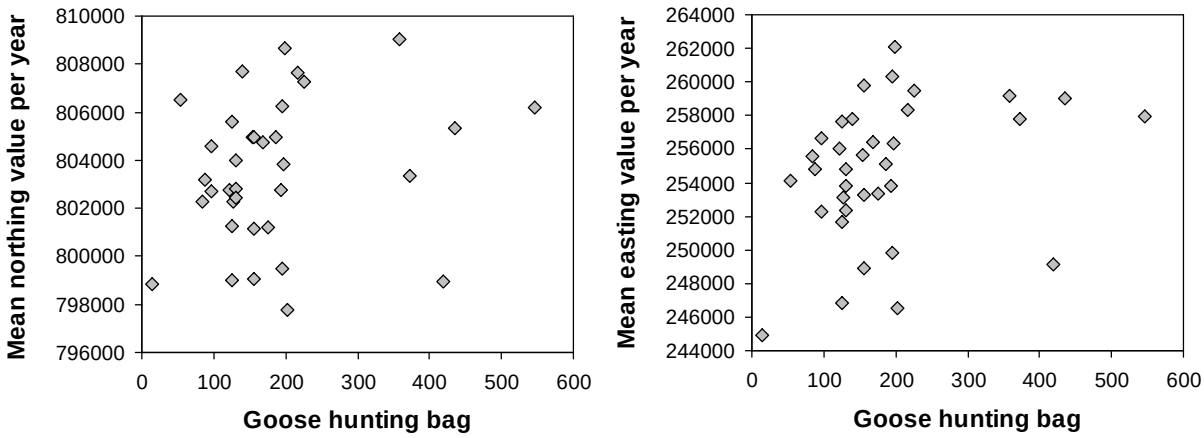
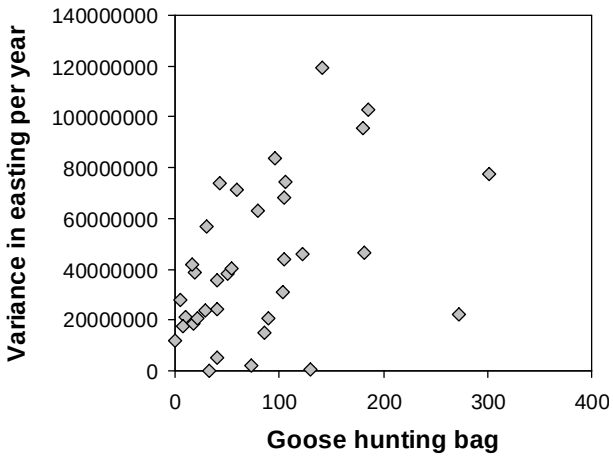


Figure 9. The relationship between either the latitudinal (mean northing values, A) and longitudinal (mean easting values, B) aspects of space use by LWfG in the Hortobágy region as a function of hunting pressure in Jász-Nagykun-Szolnok county in 36 years.

The north-eastern shift in space use also was related, negatively, to hunting pressure in Békés county. This relationship is more difficult to explain but may indicate that LWfG used areas in the southern Hortobágy region more in years when hunting was intense in areas near Biharugra (the most important goose staging site in Békés county). Hunting pressure in Hajdú-Bihar county was also correlated negatively with the north-eastern shifting, most likely because most geese in this county are shot in the NE part of the county (e.g. **Figure 8A**), which may have slowed down the NE-ward shift in space use.

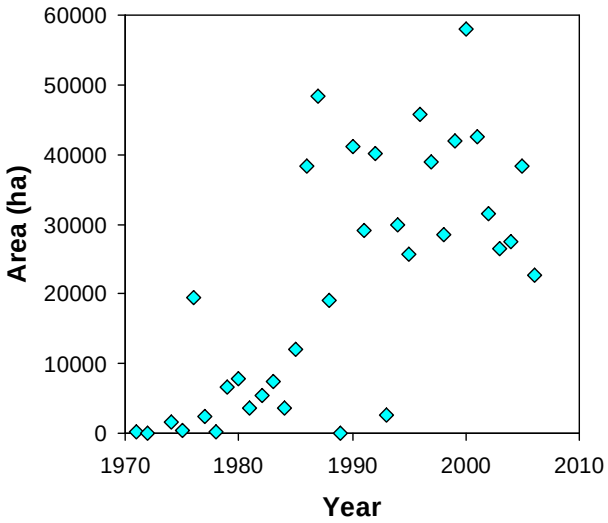
Interestingly, the latitudinal variance in space use (variance in the northing of the mean coordinates across years) was not influenced by hunting pressure. However, the longitudinal variance (variance in the easting of the mean coordinates across years) was related to hunting pressure in Borsod-Abaúj-Zemplén (BAZ) county. The relationship showed that in years when hunting pressure in this county was high, the geese tended to use more easterly areas (**Figure 10.**).

Figure 10. Longitudinal variance in space use by LWfG as a function of hunting pressure in Borsod-Abaúj-Zemplén county.



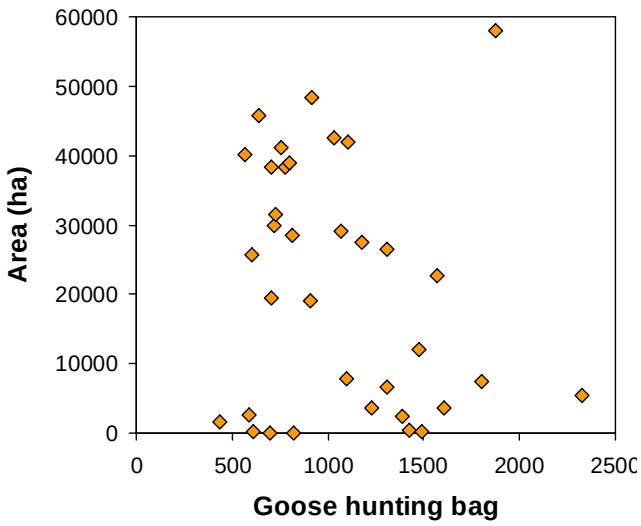
The size of the area where LWfG was observed in any year (minimum convex polygon area) increased with time (**Figure 11.**). In years between 1971 and 1987, the area over which LWfG was observed increased exponentially (**Figure 11.**). However, this increase could be attributed to the increase in the number of observations (and number of observers) in this period (**Figure 3.**). Since 1990, there has been a decreasing tendency, indicating that LWfG concentrated in smaller areas in more recent years (**Figure 11.**).

Figure 11. Total area where LWfG was observed in the years between 1971 and 2006. The area was calculated for the minimum convex polygon incorporating all observations within a year.



These patterns were strongly related to hunting pressure. For example, even though there was a general decrease in hunting pressure in the region since the early 1980s, the year 2000 had exceptionally high hunting intensity (**Figure 7.**). The area over which LWfG were scattered was also at its maximum in 2000, and decreased slightly afterwards (**Figure 11.**). This pattern was closely related with the total hunting pressure in the region (measured by hunting bag data totalled for the five counties studied) (**Figure 12.**). The negative relationship between total area and hunting intensity suggested that in years when hunting pressure was high, LWfG were concentrated in smaller areas (**Figure 12.**). One exception appears to be the year 2000, when hunting pressure was very high and the area where LWfG were scattered was also the highest (**Figure 12.**). This can be explained by the fact that in 2000, most of the southern grasslands of Hortobágy National Park were artificially inundated as part of flood control measures and roosting sites and feeding sites were available in unprecedented numbers.

Figure 12. Total area where LWfG was observed in the years between 1971 and 2006 as a function of hunting intensity (hunting bag summed over the five counties of the study region).



In summary, hunting was related to several measures of space use by LWfG. First, the northeastern shift in sites and the decreasing total area used were correlated with increasing hunting intensity in areas W and SW from Hortobágy National Park, i.e., in areas belonging to Jász-Nagykun-Szolnok county (**Table 2.**). Second, there was a negative correlation between hunting intensity in Békés county and use of north-eastern sites and total area, indicating that in years when hunting pressure in Békés county (sites directly to the SE) was high, LWfG used sites in SW Hortobágy more and were scattered over a larger area than in years when hunting in Békés county was less intense. Third, hunting intensity in Borsod-Abaúj-Zemplén county was positively related to longitudinal variation in space use, so that in years when hunting in this county was intense, space use by LWfG varied more along an eastern-western axis than when hunting was less intense. This result indirectly draws attention to the potential importance of sites in BAZ county. The Borsodi Mezőség, an area consisting of extensive wetlands, grasslands and agricultural areas on the western bank of river Tisza, very close to northern Hortobágy, has long been suspected as an important staging site, but there has been no observations from this area. Surprisingly, hunting in Heves county was not related to any aspect of LWfG space use. This is interesting because Tisza Lake, a complex of wetlands and oxbow lakes, which lies almost entirely in this county, has been previously suspected as an unknown staging site for LWfG. The finding that hunting in this area was not correlated with any aspect of space use suggests that this area is less important than others for staging. As a consequence, although goose hunting at this large area has been increasing since the early 1990s (**Figure 7.**), this appears to present no immediate risk to the LWfG staging population.

Table 2. Variables and trends describing the space use of LWfG in the Hortobágy region between 1971 and 2006. X and Y are coordinates corresponding to latitude (utm northing, X) or longitude (utm easting, Y). Long-term patterns are determined by annual changes in the variable of concern during the 36 years (see **Figure 4.**). The relationship of space use and hunting pressure is inferred from multiple linear regression models using hunting bag data from five counties as predictor variables. "+" indicates a statistically significant ($p < 0.05$) positive relationship, "–" indicates a negative relationship, whereas parentheses indicate marginally non-significant ($0.05 < p < 0.1$) relationships.

Variable	**Description**	**Long-term pattern**	**Relationship with hunting pressure ***
Mean of X	Mean value of x coordinate (northing)	northward shift	JNSZ: + Békés: – HB: –
Mean of Y	Mean value of y coordinate (easting)	eastward shift	JNSZ: + Békés: – BAZ: (–)
X Variance	Variance of X coordinates (northing)	none	
Y Variance	Variance of Y coordinates (easting)	decrease with eastward shift	BAZ: + Békés: (+) HB: (+)
Duration	Total number of days per dataset	none	
R^2	Mean squared distance (MSD) from the center of activity (measure of dispersion)	none	
MCP area	Minimum Convex Polygon area (ha): area covering all points in dataset	increase to max. in 2000, then decrease	JNSZ: + Békés: –
Ellipse area	The bivariate normal 95% ellipse	slight increase	Békés: (–)

* JNSZ: Jász-Nagykun-Szolnok, HB: Hajdú Bihar, BAZ: Borsod-Abaúj-Zemplén county

4. CONCLUSIONS AND CONSEQUENCES FOR LWFG CONSERVATION

The results of this report are important for conservation of LWfG at the Hortobágy migration staging sites. Even though the intensity of goose-hunting generally is decreasing in neighbouring areas, there is still a slight chance that LWfG get shot when they accompany large goose flocks in the autumn. This chance is rather small, considering that since 2004, goose-hunting in the areas E of river Tisza is only allowed after December 1 each year, by which time most LWfG usually leaves the area to staging or overwintering sites further south. Our study of the past, however, shows that goose-hunting in the Hortobágy region may have contributed to the general decline of the Fennoscandian population of LWfG. For example, intense hunting in the early 1980s probably contributed to the sharp decline observed in the population during this period. There are signs that LWfG have been shot as recently as the mid-1990s and there was also a high risk in 2000, when goose hunting bags hit a record high in several counties. Hunting in 2000 in E Hungary and in other staging sites may have contributed to a further decline in the Fennoscandian population from 2000 to 2001.

The most important conservation implication of these results is that it is necessary to further decrease the chance that LWfG are shot by coordinating several habitat management actions to keep them within safe, no-hunting areas inside the boundaries of Hortobágy National Park. Especially suitable for this purpose are the sites in the northern part of Hortobágy as hunting appears to increase in areas around the southern part of Hortobágy. These habitat management actions need to extend to providing safe roosting sites and safe feeding sites, both on arable lands and on grasslands, for LWfG. There is also a further need to collect more data on the space use of the species through monitoring, both in relation to the planned habitat management actions and also to gain more knowledge of habitat-preference. This study also identified some areas (e.g. Borsodi Mezőség) that can be important in staging, but have not been monitored regularly. Finally, hunting associations in the general area need to be informed of and asked to contribute to the ongoing efforts to save the Fennoscandian population of LWfG from extinction.