Cent. Eur. J. Biol. • 7(3) • 2012 • 495-506
DOI: 10.2478/s11535-012-0031-6

VERSITA

Central European Journal of **Biology**

Long-term changes in numbers of geese stopping over and wintering in south-western Poland

Research Article

Andrzej Wuczyński[1,*], Bartosz Smyk[1], Paweł Kołodziejczyk[1], Wiesław Lenkiewicz[1], Grzegorz Orłowski[2], Andrzej Pola[1]

[1]*Institute of Nature Conservation, Polish Academy of Sciences, Lower-Silesian Field Station, 50-449 Wrocław, Poland*

[2]*Institute of Agricultural and Forest Environment, Polish Academy of Sciences, 60-809 Poznań, Poland*

Received 30 November 2011; Accepted 09 March 2012

Abstract: South-western Poland belongs to the key staging areas for geese in Europe, supporting some 100000 birds in recent years. We compared goose counts conducted in the 1970s, 1990s and during 2009-2011 in this region, and linked the findings to the recent assessments of trends in the flyway-populations. Numbers increased several dozen times between the first two counts and have stabilized to the present. More than 14% of the flyway Tundra Bean Goose (*Anser fabalis rossicus*) stopped over in SW Poland on passage. Smaller numbers of White-fronted Goose (*A. albifrons*), Greylag Goose (*A. anser*), and four other rarer species, have all increased since the 1970s. The likely factors responsible for these changes are mild weather conditions, increased availability of large water bodies and shifts in winter ranges of particular species. Temporal mismatch between SW Poland and the total flyways in Bean and White-fronted Geese was recorded when we compared the long-term and the short-term population trends. Increasing reports of other species in SW Poland match the general tendencies in Europe. These data document that regional trends are not a simple reflection of those in flyways as a whole. To understand changes in goose populations a re-established international count network is desired.

Keywords: *Population size • Long-term trends • Bird monitoring • Anser • Bean Goose • White-fronted Goose • Migration • Wintering • Silesia*

1. Introduction

Most goose species have increased dramatically during recent decades. Total numbers wintering in Europe doubled between the 1980s and 1990s. This increase is believed to be due to higher survival on the wintering grounds, rather than from an increased reproduction rate [1]. Agricultural intensification has provided increasingly abundant food, and the relaxation of shooting pressure as well as milder weather conditions on wintering and staging areas have likely supported the increase [2-7].

Changes in goose population size have broad implications. During migration and wintering these birds create huge concentrations and have a meaningful impact on human-dominated ecosystems. Geese cause damage to local, commercially grown agricultural crops [8-10], are thought to increase the risk of infectious disease outbreaks [11,12], and decrease water quality as vectors in nutrient transport [13,14]. Wild geese also benefit humans by providing important ecosystem services *via* bird-watching [15], recreational hunting [16], or grazing [17]. Therefore, increase in goose numbers is a major concern for both specialists - biologists, hunters, managers - and the general public.

The population increase is a large-scale process, recorded in both Eurasia and North America. However, in many regions this phenomenon is weakly supported by quantitative data. This relates particularly to the areas which only recently became important refuges for migrating and/or wintering geese. Local changes in numbers, however, do not necessarily reflect general population trends [18,19].

* *E-mail: a.wuczynski@pwr.wroc.pl*

Shifts in wintering distribution which are among likely factors responsible for these changes, causing different directions of local trends and different rates of change in particular areas. Simultaneous monitoring in neighboring regions coupled with available historical data can explain long-term processes in goose populations.

Goose distributions on the wintering grounds are well known in Western Europe, but much less is known further east, including south-western Poland (the Silesia region). The Tundra Bean Goose (*A. fabalis rossicus*) is the most common migrating goose species here, followed by the White-fronted Goose (*A. albifrons*). Prior to the 1990s, geese in SW Poland were observed in small numbers, mainly during migration, and only sporadically in winter [20]. With the milder winters of recent years, more and more geese stopped short to the east and north of their traditional wintering areas. A considerable increase in numbers has taken place, and Silesia with adjacent areas belongs to the most important staging and wintering regions for geese in Europe [18].

Documented changes in goose abundance in Poland are scarce, especially relating to spring migration, although important regional analyses have recently been published [21-26]. Major surveys of goose abundance and distribution in Poland were carried out in the 1970s [27] and 1990s [28]. Despite methodological differences, the results of these surveys provide valuable baseline data on numbers, although less precise data were acquired on species composition. In SW Poland, we carried out goose counts which covered autumn, winter and spring periods of 2009 to 2011 [23]. Comparative analysis covering all of these censuses has never been done before.

In this paper we compare the results of goose counts carried out in SW Poland. Specifically, we focused on three questions: 1) What was the magnitude, direction and timing of the changes in the total goose numbers and in populations of particular species? 2) Did these changes reflect trends observed in the overall "flyway" populations of these species? 3) What is the present importance of SW Poland for staging and wintering geese?

2. Experimental Procedures

2.1 Study area

Data were collected in Lower Silesia in SW Poland, the core area of an important Central European goose staging and wintering area. The major goose resorts are in the lowland part, lying along the Odra River, which is dominated by intensively managed arable land. Cropland covers 49.9% of the area, and the main crops are cereals (59.3%), rape (15.3%), and maize (9.8%) ([29], data for the area of the Dolnośląskie Province). Open waters constitute 1.6% of the area, including 18 fishpond complexes bigger than 100 ha, and 18 lakes and artificial reservoirs bigger than 50 ha. The largest water bodies (except for those in the mountains) constitute the traditional roosts for geese. Both the southern Lower Silesia with the Sudety mountain range, and the forest-covered northwestern part, are unsuitable for geese.

Analyses were undertaken at three spatial scales: i) Results from counts in the 1970s, 1990s and present were compared for the area lying within the administrative borders of the Dolnośląskie Province (DSL, Figure 1) and a small fragment (four districts) of the Opolskie Province (20 511 km^2 in total). The latter area includes four dam reservoirs along the Nysa Kłodzka River. ii) Data from the 1970s and 1990s were also compared from the area lying within the borders of the whole historical region of Silesia, which amounts to 42672 km^2. iii) Data from the 1990s were also presented for the whole of Poland divided into regions, so that the pattern in the southwestern part of the country could be compared with the other regions.

2.2 Field methods

Goose population changes in SW Poland were analyzed based on historical data gathered in two national counts; in 1969-1980 [27] and 1991-1998 [28], and in a recent regional count conducted in 2009-2011 [23].

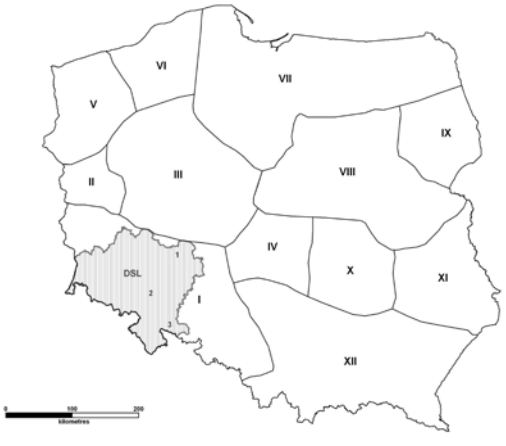

Figure 1. Location of the area studied (DSL = Dolnośląskie Province) against the background of the regional divisions of Poland used in the goose counts 1991-1998. Roman numerals match the names of regions presented in Table 1. Arabic numerals denote locations of water bodies which are mentioned in the text. 1 – fish ponds in Barycz Valley, 2 - Mietków reservoir, 3 – complex of reservoirs along Nysa Kłodzka River.

The first count was initiated within the International Waterbird Census (IWC), and was carried out in three periods: mid-November (1970-1979), mid-January (1969-1980), and mid-March (1976-1980). Counts were conducted during the day, mainly on water bodies but also on feeding grounds. Species were not identified during this first count. To obtain data from the whole of Poland, including areas with sporadic occurrence of geese, questionnaire forms were sent to observers – professional ornithologists, hunters and birdwatchers. They were asked to check for the presence of geese in a particular area and to assess goose numbers. The results were published, and apart from the summaries, detailed tabular lists of results from particular water bodies were included [27]. Based on these lists we summed up the data concerning DLS to obtain the total number of migrating and wintering geese.

The second national count was synchronized with the European census, and was carried out in two terms: mid-November (1991-1997), and mid-January (1992-1998). Geese were counted in the morning when leaving their night time roosts to go to the feeding grounds. Only 5% of the results were obtained when counting geese during the day. In good conditions, the percentage species composition was assessed. Results were published in several papers, reviewed and summarized by Staszewski and Czeraszkiewicz [28]. In addition, for the purpose of this publication, we searched through the archives of this survey, and selected the results gathered from particular water bodies in DSL. We also considered data from November 1997 and January 1998 which were omitted in the earlier summaries and publications. Unfortunately, no source data from the period 1991/92-1994/95 have been preserved, so we used only published data concerning the whole region of Silesia for these years.

The most recent survey was carried out during three periods: the second half of November 2009 and 2010, mid-January 2010 and 2011, and the beginning of March 2010 and 2011. The count was restricted to the area of DSL. The same method of counting roosting flocks was used as in the 1990s. In January and March many waters were frozen and some flocks roosted in fields. For this time period, we used additional data gathered at feeding grounds, but the data concerned only three places: one place in January 2010, and two in March 2010. An important assumption of this count was to check all potential roosts in a very short time (within two days) to avoid repeatedly counting or missing flocks moving between sites during the count. Geese were counted on almost all natural and artificial reservoirs larger than 50 ha, and – in the case of complexes of water bodies (fishponds, gravel-pits) – those larger than 100 ha. Waters fulfilling these criteria which were omitted from the survey were known to be unimportant roost sites. The detailed results from the 2009/10 migration/wintering season were presented by Wuczyński and Smyk [23].

2.3 Data analysis

Trends in goose numbers in the 1970s and 1990s were tested using the Spearman rank correlation against time (years). Due to limited number of years, the exact variant of test of significance (two-sided) for the Spearman's r_s was computed [30], using StatXact 9 (Cytel, Inc. 2010). We checked for missing data from particular reservoirs, seasons or regions. Seasons with significant gaps were omitted from the analyses. Sum totals and means were shown without rounding, despite the fact that in the field, flocks were assessed in the standard way, using round numbers.

Species composition was estimated during counts in the 1990s and 2009–2011. Individual flocks were assessed carefully and the percentages of the three dominant species determined as a representative sample to derive the total numbers of each of these species. Greylag Geese *A. anser* usually stay in compact, separate groups and it was frequently possible to count directly all birds present, especially on smaller water bodies. In March, it was not possible to determine Greylag abundance, because they occupied breeding territories relatively early and during the count, pairs of Greylag Geese were scattered over a large area. In November and January, first-year White-fronted Geese were still in juvenile plumage, but the relative abundance of this species was calculated based on the numbers of adults, assuming that the young birds constitute 27% of the population [31]. The differences in the numbers of White-fronted and Greylag Geese between seasons and counts were checked by the Mann-Whitney U test.

The occurrence of the less frequent goose species in SW Poland was analyzed based on reports from the Polish Avifaunistic Commission for the period 1984–2010. Prior to 1984, the occurrences of these species were based on information published in Dyrcz *et al.* [20]. Records of other rare species (not liable for verification by the Commission) were obtained from the lists of rarities published in Birds of Silesia (issues 9–17). The most recent sightings, not yet published, were derived from the archives of birding forums.

Population trends and abundance of the three most common goose species in SW Poland were compared with the most recent assessments presented by Fox *et al.* [19]. We used the traditional concept of bio-geographical populations or flyways [32], selecting those flyways which included geese occurring in Poland.

We also compared the long-term and the short-term rates of change in population size between SW Poland and the total flyways, in these three species. For this purpose, we adopted the procedure and the scale of rate proposed by Fox *et al.* [19]. The regional rates of change were assessed by regressing the log-transformed autumn population estimates on year. The slope (in percentage terms) of the regression models expressed the scale of rate. We assumed that the long-term rates of change in total goose population (all species combined) were representative for the Bean Goose. Due to limited data the long-term rates of change in Greylag and White-fronted Geese were assessed intuitively, based on autumn numbers obtained in consecutive counts, and on published information [20,33].

3. Results

3.1 Seasonal dynamics of goose numbers

3.1.1 Autumn

Less than 5000 geese were counted in DSL in any given year in the 1970s, although numbers increased significantly, particularly after 1975 (r_s=0.88, P=0.001, N=10 years, Figure 2). Aggregations of more than 1000 birds (max. 2689) were recorded only after 1976. Mean goose counts increased several dozen times between the 1970s and 1990s in DSL. In the nineties the increasing, marginally significant trend in goose numbers continued, except for the Greylag Goose (Table 1). Strong population growth was noted in the Łódź region, however the numbers registered there were markedly lower than in Silesia. Excluding Silesia,

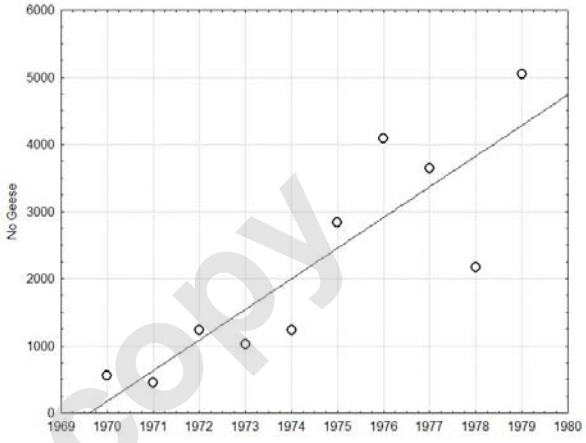

Figure 2. Changes in goose population in the Silesia region (denoted I in Figure. 1) in November of 1970-1979.

Region (code)	All species combined				*A. fabalis*		*A. albifrons*		*A. anser*	
	Mean no. of geese/1000 (range)	No. of years	r_s	P	r_s	P	r_s	P	r_s	P
V	75.8 (46.4-12.1)	5	-0.70	0.233	-0.70	0.233	-0.50	0.450	0.10	0.950
II	64.5 (33.6-12.0)	6	0.14	0.803	0.14	0.803	-0.14	0.803	0.71	0.136
I (Silesia)	47.5 (12.0-106.3)	5	0.90	0.083	0.90	0.083	0.90	0.083	0.50	0.450
III	6.2 (3.2-8.3)	6	0.60	0.242	0.60	0.242	0.31	0.564	0.09	0.919
VII	2.4 (0.06-5.6)	6	-0.26	0.658	-0.60	0.242	-0.26	0.658	-0.18	0.767
IV	2.1 (0-5.1)	6	**0.94**	**0.017**	**0.94**	**0.017**	**0.94**	**0.017**	**0.94**	**0.017**
VI	0.2 (0-0.6)	6	0.26	0.594	-0.16	0.833	0.39	0.450	-0.21	0.733
XII	0.1 (<0.1-0.5)	6	0.43	0.419	0.44	0.433	**-0.99**	**0.005**	0.81	0.072
IX	0.1 (0-0.2)	6	0.64	0.200	0.30	0.600	0.81	0.072	0.80	0.117
VIII	0.05 (0-0.2)	6	0.09	0.883	0.09	0.883				
XI	<0.01	6	-0.16	0.833	-0.14	0.533	-0.39	0.667	0.07	0.933
X	<0.01	6	0.65	0.333	0.65	0.333			0.65	0.333
W Poland (I-VI)	179.7 (97.5-250.3)	6	0.31	0.564	0.48	0.356	-0.60	0.242	0.48	0.356
E Poland (VII-XII)	2.6 (0.3-6.0)	6	0.60	0.242	0.14	0.803	-0.20	0.714	**0.89**	**0.033**
Poland	182.3 (99.6-251.0)	6	0.31	0.564	0.48	0.356	-0.71	0.136	0.48	0.356

Table 1. Spearman's r_s correlation coefficients between year and the number of geese in November 1991-1996 in separate regions of Poland. Significant correlations are in bold type. Goose numbers were obtained from [28]. Regions are arranged in descending order of goose numbers. Roman numerals correspond with the labels on Fig. 1: I – Silesia, II – Ziemia Lubuska, III – Wielkopolska, IV – Łódź Region, V – Western Pomerania, VI – Central Pomerania, VII – North-Eastern Poland, VIII – Mazowia & Nizina Południowopodlaska lowland, IX – Nizina Północnopodlaska lowland, X – Ziemia Kielecko-Radomska, XI – Lublin Region, XII – South-Eastern Poland

the total abundance of geese and the abundance of the Bean Goose were stable, the abundance of the White-fronted Goose decreased, and the abundance of the Greylag Goose increased (Figure 3). None of these trends was significant (Spearman correlations). Goose numbers in November 2009 and 2010 were comparable with the data from the 1990s in DSL, which suggests some stabilization in the last decade (Table 2).

3.1.2 Winter

Before 1980, geese wintered in SW Poland irregularly and in low numbers. More than 100 birds were counted in only three out of 12 winters. Goose numbers fluctuated without a trend (r_s=0.05, P=0.88, N=12 years). By the 1990s, SW Poland had become an important wintering area for geese, supporting up to 70000 birds (all species combined). Numbers still fluctuated, without showing a clear trend for all species combined, nor separately for the Bean Goose (r_s=0.37, P=0.50, N=6 years) or the White-fronted Goose (r_s=-0.14, P=0.80, N=6 years). After 2000, geese still wintered in SW Poland in great numbers [34]. Unfortunately, the only recent counts were those conducted in January 2010-2011 and coincided with severe weather in both years. The January 2010-2011 counts revealed low numbers (Table 2) and are probably not representative of recent years.

3.1.3 Spring

Numbers of geese stopping over in spring in SW Poland are available from the period 1976-1980 (incomplete) and in 2010-2011. Goose numbers in the 1970s probably did not reach even a few thousand birds. Thirty years later, numbers have changed dramatically, peaking at 130000 in March 2010. During the next spring, numbers were halved and probably were closer to annual numbers stopping over in SW Poland during spring.

3.2 Changes in species abundance and composition

Each year and season, the Bean Goose was the dominant species, especially in winter, amounting to 99.7% of all geese in January 2010. All of the identified birds belonged to the *rossicus* subspecies. Bean Goose numbers staging in SW Poland seem to have been stable since the 1990s. The contribution of White-fronted Geese to the total reached up to ±15%, but the total numbers and the percent sampled in flocks were higher in the 1990s than recently, both in autumn and winter (Tables 3,4). January data are difficult to compare due to strong differences in the weather conditions of 1995-1998 and 2009-2011. The percentage share of White-fronted Goose in autumn 2009-2010 was lower than in spring 2010-2011 (Table 3), but the difference was not significant (Mann-Whitney U test, z=-0.26, P=0.80).

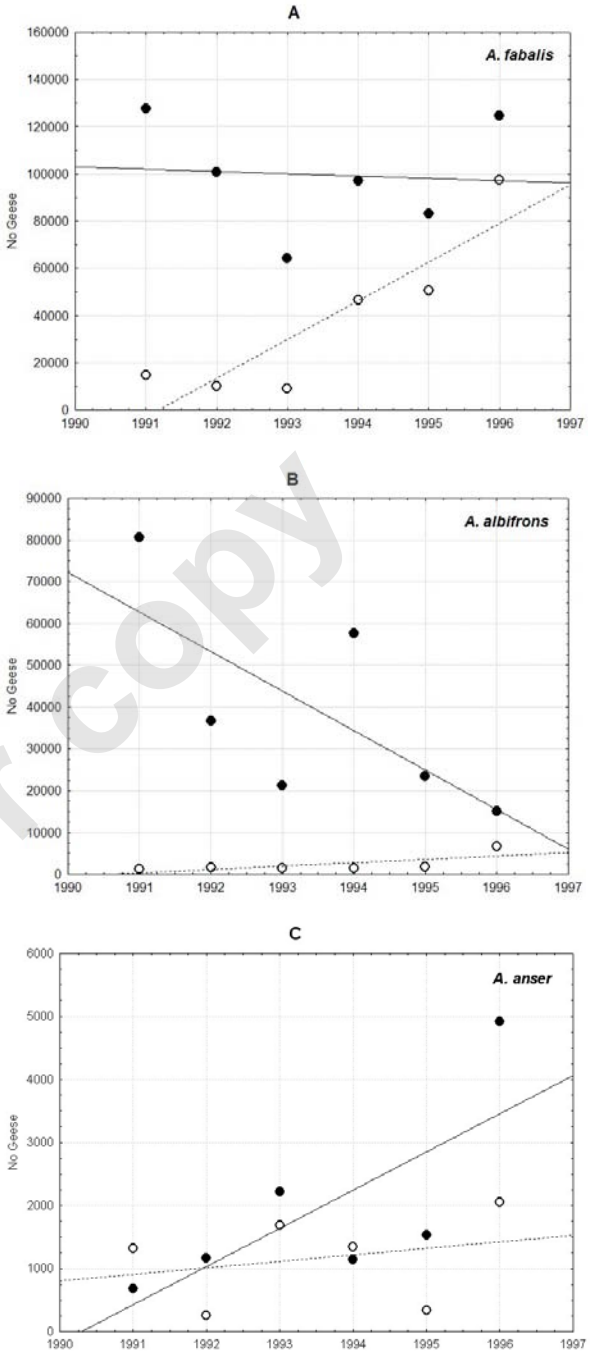

Figure 3. Changes in populations of the three dominant goose species in the Silesia region (denoted I in Figure. 1, open circles) and in the remaining areas of Poland (filled circles) in November of 1991-1996. A – *A. fabalis* (exact Spearman correlation for the remaining area of Poland: r_s=-0.26, P=0.658, N=6 years, test results for the Silesia region – see Table 1), B – *A. albifrons* (r_s=-0.71, P=0.136, N=6 years), C – *A. anser* (r_s=0.71, P=0.136, N=6 years).

Greylag Geese were relatively rare during each survey. However, in autumn flocks, numbers rose from 1.2% in the 1990s to 3.4% in November 2009-2010 (Table 3). These numbers probably underestimate the true maximum numbers passing through Poland because the peak autumn migration of this species is almost one month earlier than the November count [20]. Wintering Greylag Geese were occasionally reported in the 1990s, but the species was observed every year after 2000. The Barycz Valley is the most important refuge of this species in SW Poland.

Other goose species were noted sporadically, but with increasing frequency (Figure 4). During the 1990s, four *Anser* and *Branta* species were recorded compared to 10 in 2009-2011. Among 504 records of rare geese (N = 1054 birds) collected after 1970, 414 records and 786 birds were reported after 2000. The Barnacle Goose *B. leucopsis* and the Pink-footed Goose *A. brachyrhynchus* showed particularly strong increases (but only after 2005). There was also a consistent increase in the number of observations of the Lesser White-fronted Goose *A. erythropus* and the Red-breasted Goose *B. ruficollis*.

4. Discussion

4.1 Methodological remarks

Long-term changes in goose numbers may be subject to bias relating mainly to differences in monitoring schemes and uneven count data coverage or availability [35]. In the 1990s and during 2009-2011 geese were counted at roosting places, which is the recommended method due to its effectiveness and low bias [36,37]. The results of these two counts are fully comparable. In contrast, the IWC system used in the 1970s was inadequate for surveying geese, and data obtained could underestimate the true numbers present. However, assuming a constant level of bias it was possible to compare data within this decade. Thus, we succeeded in documenting the increasing trends in goose population, lasting as early as in the 1970s. Moreover, the total numbers, as well as the reported maximum concentrations of geese in the 1970s, differed by orders of magnitude from those undertaken later. This suggests that the bias arising from the differences in methods was probably much lower than real differences in goose numbers. However, in this paper we refrain from quantitative comparisons between

	1969-1980		1995-1998		2009-2011	
	mean ± SD	range (N)	mean ± SD	range (N)	mean	range (N)
November	1946 ± 1546.7	380 – 4905 (10)	71002 ± 27927	51100 – 102929 (3)	65632	59825 – 71438 (2)
January	101 ± 198.1	0 – 701 (12)	33091 ± 35130	0 – 69956 (3)	11001	6776 – 15225 (2)
March	436 ± 309	6 – 831 (5)	not counted	not counted	89833	60463 – 119203 (2)

Table 2. Number of geese (all species combined) in the Dolnośląskie Province during three census periods. N refers to the number of years.

Species	Month	1996-1998			2009-2011			U	P
		sum of inspected geese (N flocks)	mean sample size ± SD	%	sum of inspected geese (N flocks)	mean sample size ± SD	%		
A. albifrons	November	6891 (7)	984 ± 649.1	14.7	4231 (37)	114 ± 163.6	8.5	58.0	0.02
A. albifrons	January	4116 (4)	1029 ± 952.5	6.4	6638 (10)	664 ± 1610.1	2.6	3.0	0.01
A. albifrons	March	-	-	-	6466 (95)	68 ± 110.2	11.6	-	-
A. anser	November	210209 (25)	8408 ± 10327.9	1.2	32587 (117)	279 ± 1174.0	3.4	810.0	0.000
A. anser	January	98812 (10)	9881 ± 12157.0	0.1	15871 (21)	756 ± 2147.0	0.6	87.0	0.47

Table 3. The percentage of *A. albifrons* and *A. anser* in mixed flocks of geese in SW Poland (DSL). Data are divided into two periods and three seasons.

Species	1995-1998		2009-2011		
	November	January	November	January	March
A. fabalis	59766	30946	57807	10645	79406
A. albifrons	10406	2124	5610	284	10419
A. anser	829	21	2211	71	not counted
A. brachyrhynchus					5
A. erythropus					3
A. indicus			1		1
B. canadensis			1		
B. leucopsis	1	+	1	2	3
B. bernicla					1
B. ruficollis			1		
Total	71002	33091	65632	11002	89838
Population estimate	71000	33000	66000-70000	11000-12000	90000-95000

Table 4. Comparison of goose species numbers obtained in two consecutive counts in SW Poland (DSL). The figures of the first three species relate to mean values from the years 1995-1998 and 2009-2011. The figures of the last six species relate to maximum values from particular counts.

the first and the further counts. We conclude that while the increase of goose abundance in south-west Poland was a matter of fact, the extent of this phenomenon resulted from three reasons: biological fact, differences in methods of collecting data and different spatial range.

Most of the source count data from the 1970s and 1990s were not available, and we faced limited possibilities for carrying out some analyses, like TRIM. However, in this paper we concentrated on a regional or national (in the 1990s) scale, and such aggregated regional data were published or could be calculated.

To show the trends in populations we emphasized migration periods, especially autumn [19]. Autumn censuses are particularly recommended for the Bean Goose because the birds are more concentrated then and easier to count [38]. In contrast, traditional mid-January counts originating from the IWC, are less reliable in regions with irregular weather, due to a strong dependence on temperature and snow conditions. Fluctuations in numbers of wintering geese in 1970s and 1990s were possibly caused by irregular weather conditions.

4.2 Trends in goose populations

Goose numbers in SW Poland increased dramatically during the last few decades, suggesting a redistribution

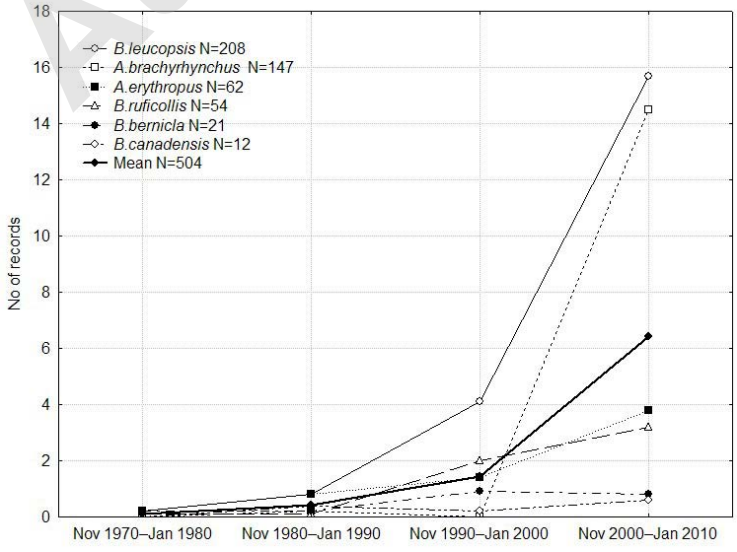

Figure 4. Frequency of occurrence of rare goose species in the Dolnośląskie Province. Symbols refer to the decadal means of records for particular species, N – total number of records; some of records refer to more than one individual.

of wintering areas and stopover sites. From the 1960/70s until the second half of the 1990s, the local population increased several dozen times [27,28], although results from 2009-2011 suggest some stabilization of the population size in very recent years. Increases occurred during the migration and wintering periods. For the first time since the 1970s, the last census provided spring passage data on goose abundance. Contrary to earlier fragmentary information [39] and results from the 1970s, the current spring migration is no less intensive than that of the autumn. In both 2010 and 2011 March counts, goose numbers were higher than in preceding November counts. However, the figure in March 2010 was probably over-representative. Presumably, this high numbers resulted from weather deterioration and the sudden return of winter weather, which halted the migration at the time when the survey was conducted.

A predominance of the Bean Goose and the relatively restricted abundance of the White-fronted Goose in Silesia is a feature which differentiates this region from other important staging and wintering areas in Poland. In spring, White-fronted Geese dominate in neighboring Wielkopolska [24], in Western Pomerania [21] and in Podlasie [22,25], in contrast to Silesia, where the Bean Goose is dominant. Increases in numbers of these two species in Silesia were more conspicuous and lasted longer than in other parts of Poland. Data from the 1990s indicate contrasting trends in Silesia compared to those in other important (virtually western) regions of Poland.

The Bean, White-fronted, and Greylag Geese passing through SW Poland come from six different wintering populations (two populations for each species) (Table 5). Obviously, changes in numbers in these populations are reflected in SW Poland. However, we compared our results with recent assessments of trends on a wider scale by Fox *et al.* [19], and there was little concordance. The Tundra Bean goose population was estimated at 600000 birds in 1990s and was believed to be stable between 1970-1990 [32,38]. At the same time, numbers increased very rapidly in SW Poland. In contrast, in the last two decades the number of geese staging in DSL seemed to be stable, whereas the core Tundra I flyway in NW Europe witnessed a rapid increase, implying that the burst of the Bean Goose numbers in DSL preceded the increase noted at present in NW Europe. In turn, the much smaller Tundra II population wintering in Central Europe has undergone a prolonged decline, confirmed simultaneously in Hungary [40,41], Slovenia [42], Austria [38] and in the Czech Republic [43]. This decline may suggest that the increase of Bean Goose in SW Poland resulted from the shift of the wintering population further north, as suggested by van den Bergh [38].

White-fronted Geese are also supposed to have shifted wintering areas further north and west [44]. Numbers recorded in northwestern Europe during the last four decades have increased [45,46]. Similarly, in SW Poland the species was only occasionally recorded before 1980 [20], whereas large flocks of a few thousand

Species	Population	Population size estimate 2007/08	Long-term trend	Short-term trend	Percent of total population occurring in DSL			Long-term trend in DSL (1970s-1990s)	Short-term trend in DSL (1990s-2011)
					Autumn	Winter	Spring		
A. fabalis	Tundra I (wintering range: Baltic, North See)	522000	? increasing	rapidly increasing	10.5	1.9	14.4	very rapidly increasing	stable
	Tundra II (wintering range: C Europe)	28500	? decreasing	decreasing					
A. albifrons	Baltic-North Sea	1200000	very rapidly increasing	increasing	0.4	<0.1	0.8	? rapidly increasing	decreasing
	Pannonic	110000	data not available	data not available					
A. anser	NW Europe	610000	very rapidly increasing	very rapidly increasing	0.3	<0.1	-	rapidly increasing	rapidly increasing
	C Europe	56000 (2006/07)	data not available	very rapidly increasing					

Table 5. The percent of the total population of *A. fabalis, A. albifrons*, and *A. anser* occurring in the Dolnośląskie Province (numbers taken from Table 4), and trends in the abundance of these species. The international data on population size and trends are derived from [19].

individuals were observed in the 1990s. Since the mid-1990s, the Baltic-North Sea population has continued to increase, in contrast to SW Poland where declines have been noted (despite the opposite trend recorded locally, for example in the Barycz Valley).

Increasing reports of other goose species in SW Poland reflect the general trends in Europe [18,19]. Nowadays, these species are being recorded in DSL much more frequently than in the past. More frequent reports result from real increases in population size (e.g. Greylag and Barnacle Geese), greater bird-watching activity [47], good optical equipment being commonly available, and also from better knowledge of diagnostic features of goose species in the field (e.g. Lesser White-fronted and Pink-footed Geese). Only the Brent Goose *B. bernicla* and Canada Goose *B. canadensis*, showed no clear increase in numbers during the last 40 years, although their records throughout inland Poland are sporadic.

To conclude, trends in Poland were not a simple reflection of those in flyways as a whole. Temporal mismatch between population wide and regional trends in the Bean and White-fronted Goose was of particular importance, since these two species create the bulk of the regional goose population. SW Poland is located between the two areas which used to be the core wintering grounds in Europe (the Baltic-North Sea, and the Pannonic area, [44]). At present, Central Europe which includes SW Poland has large wintering populations of its own, and thus, the potential to affect the neighbouring populations.

4.3 The importance of the staging and wintering areas in SW Poland

There are several reasons that make SW Poland attractive for migrating and wintering geese. It is the warmest region of the country, characterized by intensive agriculture, and situated near the traditional wintering and staging areas for the White-fronted and Bean Goose in Central Europe. These facts made it rather easy to be settled in case of a shift in wintering areas. The availability of large and safe water reservoirs, especially several big artificial lakes, is particularly significant. Six important reservoirs (totaling up to 55.4 km^2 of open water when full) were built after 1970, which coincided with the demographic explosion of goose populations and have become the main goose roost strongholds in Central Europe, supporting up to 64500 birds (Mietków Reservoir, [39]).

SW Poland is currently one of the most important regions for geese in Europe, as far as migration periods and the Tundra Bean Goose are concerned. More than 10% of the entire *rossicus* population stages here, probably exceeding 20% in March 2010. The region is less important for other goose species, as it supports less than 1% of their total populations. It is reasonable to assume that SW Poland supports some 100000 geese in many migration periods and tens of thousands during mild winters. Moreover, these numbers have been produced by summing up maximal counts within a short time-window, thus ignoring turnover. In fact, numbers of geese migrating through, and stopping over in SW Poland are much higher.

Predicting the future development of the goose population in SW Poland is difficult. No significant environmental changes are predicted, so it may be assumed that for the next several years at least, the region will continue to be important for geese. These birds are considered both as species of conservation concern and as pests of agriculture [10,48]. There is a clear need to develop a framework for effective management of large goose populations as well as their staging sites [9,49,50]. At present, such a framework is lacking in many key areas of Central Europe. For such purposes current assessment of the size of goose populations is necessary. We are keen to reestablish the goose count coverage which used to be good in Poland until the 1990s. Steps are being undertaken to include goose counts in the national system of bird monitoring. Moreover, these counts are to be included into the renewed European count network. This is particularly important in regions where staging and wintering areas are divided by national borders, like in SW Poland. Finally, the future development of goose stocks will be regularly and properly monitored, and the methodological problems we faced when preparing this paper, will be overcome.

Acknowledgements

The valuable comments made by Łukasz Ławicki and three anonymous reviewers helped to improve the manuscript. We thank Beata Orłowska and Józef Witkowski for the unpublished data of goose counts from the Barycz Valley, Artur Staszewski for some source data from the 1990s, and Mary Lewandowska for the linguistic revision of the text. The counts in 2009-2011 were carried out by the Lower-Silesian Field Station of the Institute of Nature Conservation PAS.

References

[1] Fox A.D., Madsen J., Introduction, In: Madsen J., Cracknell G., Fox A. (Eds.), Goose populations of the Western Palearctic. A review of status and distribution, Wetlands International Publication 48, Wageningen, The Netherlands, 1999
[2] Ebbinge B.S., Factors determining the population size of arctic-breeding geese, wintering in Western Europe, Ardea, 1985, 73, 121–128
[3] Svazas S., Possible impacts of climatic conditions on changes in numbers and in distribution of certain breeding and staging wildfowl species in Lithuania, Acta Zool. Lit., 2001, 11, 163–182
[4] Béchet A., Giroux J.-F., Gauthier G., Nichols J.D., Hines J.E., Spring hunting changes the regional movements of migrating greater snow geese, J. Appl. Ecol., 2003, 40, 553–564
[5] Fox A.D., Madsen J., Boyd H., Kuijken E., Norriss D.W., Tombre I.M., et al., Effects of agricultural change on abundance, fitness components and distribution of two arctic-nesting goose populations, Global Change Biol., 2005, 11, 881–893
[6] Van Eerden M.R., Drent R.H., Stahl J., Bakke J.P., Connecting seas: western Palearctic continental flyway for water birds in the perspective of changing land use and climate, Global Change Biol., 2005, 11, 894–908
[7] Jefferies R.L., Drent R.H., Bakke J.P., Connecting Arctic and Temperate Wetlands and Agricultural Landscapes: The Dynamics of Goose Populations in Response to Global Change, Ecol. Studies, 2006, 190, 293–314
[8] Patterson I.J., Conflict between geese and agriculture: does goose grazing cause damage to crops?, Ardea, 1991, 79, 179-186
[9] Hake M., Månsson J., Wiberg A., A working model for preventing crop damage caused by increasing goose populations in Sweden, Ornis Svec., 2010, 20, 225–233
[10] Rosin Z.M., Skórka P., Wylegała P., Krąkowski B., Tobolka M., Myczko Ł., et al., Landscape structure, human disturbance and crop management affect foraging ground selection by migrating geese, J. Ornithol., (in press), DOI: 10.1007/s10336-011-0791-1
[11] Kilpatrick A.M., Chmura A.A., Gibbons D.W., Fleischer R.C., Marra P.P., Daszak P., Predicting the global spread of H5N1 avian influenza, PNAS USA, 2006, 103, 19368–19373
[12] Olsen B., Munster V.J., Wallensten A., Waldenström J., Osterhaus A.D., Fouchier R.A., Global patterns of influenza A virus in wild birds, Science, 2006, 312, 384-388
[13] Post D.M., Taylor J.P., Kitchell J.F., Olson M.H., Schindler D.E., Herwig B.R., The role of migratory waterfowl as nutrient vectors in a managed wetland, Conserv. Biol., 1998, 12, 910-920
[14] Olson M.H., Hage M.M., Binkley M.D., Binder J.R., Impact of migratory snow geese on nitrogen and phosphorus dynamics in a freshwater reservoir, Freshwater Biol., 2005, 50, 882–890
[15] Whelan C.J., Wenny D.G., Marquis R.J., Ecosystem services provided by birds, Ann. N.Y. Acad. Sci., 2008, 1134, 25–60
[16] Ankney C.D., An Embarrassment of Riches: Too Many Geese, J. Wild Manage., 1996, 60, 217-223
[17] Maron J.L., Estes J.A., Croll D.A., Danner E.M., Elmendorf S.C., Buckelew S.L., An introduced predator alters Aleutian island plant communities by thwarting nutrient subsidies, Ecol. Monogr., 2006, 76, 3–24
[18] Madsen J., Cracknell G., Fox A.D. (Eds.), Goose populations of the Western Palearctic. A review of status and distribution, Wetlands International Publication 48, Wageningen, The Netherlands, 1999
[19] Fox A.D., Ebbinge B.S., Mitchell C., Heinicke T., Aarvak T., Colhoun K., et al., Current estimates of goose population sizes in western Europe, a gap analysis and an assessment of trends, Ornis Svec., 2010, 20, 115–127
[20] Dyrcz A., Grabiński W., Stawarczyk T., Witkowski J., Birds of Silesia [Ptaki Śląska: monografia faunistyczna], University of Wrocław, 1991, (in Polish)
[21] Ławicki Ł., Staszewski A., Czeraszkiewicz R., Migration and wintering of the Bean Goose Anser fabalis and White-fronted Goose A. albifrons in Western Pomerania in 1991–2008 [Wędrówka i zimowanie gęsi zbożowej Anser fabalis i gęsi białoczelnej Anser albifrons na Pomorzu Zachodnim w latach 1991–2008], Ornis Polon., 2010, 51, 93–106, (in Polish)
[22] Ławicki Ł., Wylegała P., Polakowski M., Wuczyński A., Smyk B., New data of Bean Goose Anser fabalis and White-fronted Goose Anser albifrons migration and wintering in Poland, Goose Bull., 2010, 11, 10–14
[23] Wuczyński A., Smyk B., Numbers and distribution of geese in Lower Silesia during migration and wintering in 2009/2010 [Liczebność i rozmieszczenie gęsi na Dolnym Śląsku w okresie

migracyjnym i zimowym 2009/2010], Ornis Polon., 2010, 51, 204–219, (in Polish)
[24] Wylegała P., Krąkowski B., Numbers and distribution of geese during migration and wintering in the Wielkopolska region in 2000-2009 [Liczebność oraz rozmieszczenie gęsi w czasie migracji i zimowania w Wielkopolsce w latach 2000–2009], Ornis Polon., 2010, 51, 107–116, (in Polish)
[25] Polakowski M., Broniszewska M., Jankowiak Ł., Ławicki Ł., Siuchno M., Numbers and dynamics of spring migration of geese in the Biebrza Basin [Liczebność i dynamika wiosennego przelotu gęsi w Kotlinie Biebrzańskiej], Ornis Polon., 2011, 52, 169–180
[26] Ławicki Ł., Wylegała P, Wuczyński A., Smyk B., Lenkiewicz W., Polakowski M., et al., Distribution, characteristic and conservation status of geese roosts in Poland [Rozmieszczenie, charakterystyka i status ochronny noclegowisk gęsi w Polsce], Ornis Polon., 2012, (in press, in Polish)
[27] Dobrowolski K., Krzyśkowiak A., Nowak E., Nowicki J., Geese wintering in Poland, Aquila, 1984, 91, 47–60
[28] Staszewski A., Czeraszkiewicz R., Distribution and abundance of geese during autumn migration and wintering in the years 1991-1997 [Rozmieszczenie i liczebność gęsi w Polsce podczas jesiennej migracji i zimowania w latach 1991-1997], Not. Orn., 2001, 42, 15–35, (in Polish)
[29] Statistical Office in Wrocław, Statistical Yearbook of the Dolnośląskie Voivodship [Rocznik statystyczny województwa dolnośląskiego], Wrocław, 2009, (in Polish)
[30] Mundry R., Fischer J., Use of statistical programs for nonparametric tests of small samples often leads to incorrect P values: examples from Animal Behaviour, Anim. Behav., 1998, 56, 256–259
[31] Mooij J.H., Faragó S., Kirby J., White-fronted Goose Anser albifrons albifrons, In: Madsen J., Cracknell G., Fox A.D. (Eds.), Goose populations of the Western Palearctic. A review of status and distribution, Wetlands International Publication 48, Wageningen, The Netherlands, 1999
[32] Wetlands International, Waterbird Population Estimates, 4th ed., Wetlands International, Wageningen, The Netherlands, 2006
[33] Tomiałojć L., Stawarczyk T., The avifauna of Poland. Distribution, numbers and trends [Awifauna Polski. Rozmieszczenie, liczebność i zmiany], PTPP "pro Natura", Wrocław, 2003, (in Polish)
[34] Anonymous, Faunistic observations [Obserwacje faunistyczne], Ptaki Śląska, 2008, 17, 91–107, (in Polish)
[35] Sparks T.H., Tryjanowski P., The detection of climate impacts: some methodological considerations, Int. J. Climatol., 2005, 25, 271–277
[36] Majewski P., Engel J., Method of estimation of wild geese numbers in non-breeding season [Metoda oceny liczebności dzikich gęsi w okresie lęgowym], Not. Orn., 1987, 28, 81–85, (in Polish)
[37] Ławicki Ł., Staszewski A., Gęsi, In: Sikora A., Chylarecki P., Meissner W., Neubauer, G. (Eds.), [Monitoring ptaków wodno-błotnych w okresie wędrówek. Poradnik metodyczny], GDOŚ, Warszawa, 2011, (in Polish)
[38] van den Bergh L., Tundra Bean Goose Anser fabalis rossicus, In: Madsen J., Cracknell G., Fox A.D. (Eds.), Goose populations of the Western Palearctic. A review of status and distribution, Wetlands International Publication 48, Wageningen, The Netherlands, 1999
[39] Dyrcz A., Kołodziejczyk P., Martini K., Martini M., Birds of Mietków Reservoir [Ptaki Zbiornika Mietkowskiego], Ptaki Śląska, 1998, 12, 17–80, (in Polish)
[40] Faragó S., Gosztonyi L., Population Trend, Phenology and Dispersion of Common Waterfowl Species in Hungary Based on a Ten Year Long Time Series of the Hungarian Waterfowl Monitoring, Acta Silv. Lign. Hung., 2009, 5, 83–107
[41] Faragó S., Numbers and distributions of geese in Hungary 1984–2009, Ornis Svec., 2010, 20, 144-154
[42] Vogrin M., Geese Anser spp. in northeastern Slovenia during autumn and winter, Berkut, 2004, 13, 202–204
[43] BirdLife International, Birds in Europe: population estimates, trends and conservation status, 2nd ed., BirdLife International, Cambridge, 2004
[44] Scott D.A., Rose P.M., Atlas of Anatidae Populations in Africa and Western Eurasia, Wetlands International Publication 41, Wageningen, The Netherlands, 1996
[45] Kuijken E., Verscheure C., Courtens W., Meire P., Long-term trends in numbers and distribution of wintering geese in the Oostkustpolders, Flanders (Belgium), In: Boere G.C., Galbraith C.A., Stroud D.A. (Eds.), Waterbirds around the world, The Stationery Office, Edinburgh, UK, 2006
[46] Wille V., Doer D., Hackstein M., Population trends of arctic geese in Northrhine-Westphalia from

1997/98 to 2003/04 [Bestandsentwicklung der arktischen Wildgänse in Nordrhein-Westfalen von 1997/1998 bis 2003/2004], Charadrius, 2007, 43, 130–142, (in German)

[47] Sparks T.H., Huber K., Tryjanowski P., Something for the weekend? Examining the bias in avian phenological recording, Int. J. Biometeorol., 2008, 52, 505–510

[48] Drent R., Fox A., Stahl J., Travelling to breed, J. Ornithol. 2006, 147, 122-134

[49] Jensen R.A., Wisz M.S., Madsen J., Prioritizing refuge sites for migratory geese to alleviate conflicts with agriculture, Biol. Conserv., 2008, 141, 1006–1018

[50] Klaassen M., Bauer S., Madsen J., Possingham H., Optimal management of a goose flyway: migrant management at minimum cost, J. Appl. Ecol., 2008, 45, 1446-1452