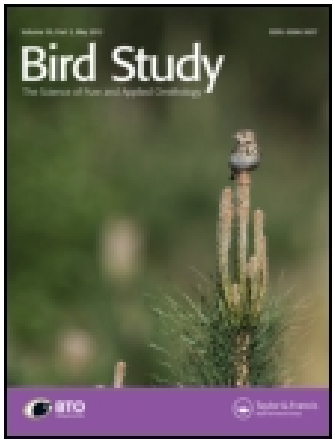

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A survey and GIS-based estimate of the breeding population of Great Snipe Gallinago media in Central Norway

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A survey and GIS-based estimate of the breeding population of Great Snipe *Gallinago media* in Central Norway

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Capsule By using a GIS-model to identify suitable breeding habitats for Great Snipe in Central Norway, we estimated a total of 276 leks holding approximately 2700 males.
Aim To estimate the size of the Great Snipe population in central parts of the species remaining breeding areas in Western Europe.
Methods GIS-analysis identified an area of 528 km^2 as suitable habitat for Great Snipe in the total study area (22 000 km^2). Complete surveys were made in 8% of these habitats by using a subset of 53 sampling areas.
Results A total of 28 Great Snipe leks were found within the sampling areas. Ten of these were found in previously known lek areas, while 18 leks were found in areas with no previous knowledge of leks. Extrapolating the lek density and the lek size found in the surveyed areas, resulted in a total estimate of 276 Great Snipe leks holding approximately 2700 lekking males. The leks were found on open fens along the forest edge and were mainly situated on base-rich bedrocks. Mean altitude of the leks was 570 m.
Conclusion The total population of Great Snipe in Norway was previously assumed to comprise 5000–15 000 lekking males or 'pairs'. By extrapolating the densities of leks found in Central Norway to a national scale, we expect the true breeding population of Great Snipe to be approximately 13 500 males. Changes in the elevation of the tree limit and increased overgrowth, as a result of reduced grazing pressure and/or global warming, are possible threats that may reduce the availability of preferred Great Snipe habitats and increase population fragmentation.

Great Snipe *Gallinago media* was previously an abundant species in northern Europe. However, during the last 150 years the population has undergone a considerable decline (Løfaldli *et al.* 1989, Ekblom & Carlsson 2007). The population decline has been attributed to a vast loss of suitable habitats in the lowlands, mainly caused by changes in agriculture as well as wetland drainage (Løfadli *et al.* 1989, Kålås 2004, Ekblom & Carlsson 2007, Naturvårdsverket 2007). Today, the West European populations of Great Snipe are restricted to the mountainous regions in south-eastern and central parts of Norway and western parts of Sweden (Gjershaug *et al.* 1994, Kålås *et al.* 1997a, Ekblom & Carlsson 2007). The population is estimated to comprise between 6000 and 17 000 pairs, and about 90% of the population is assumed to breed in Norway (Kålås 2004). Great Snipe also breed in north-eastern Europe and western parts of Siberia, and the global population is estimated to comprise about 250 000 pairs (Snow & Perrins 1998, Kålås 2004). The Scandinavian population has been found to be genetically and morphologically different from the eastern population, and should therefore be considered a separate conservation unit (Kålås *et al.* 1997b, Ekblom *et al.* 2007, Sæther *et al.* 2007). The Great Snipe is classified as 'Near Threatened' both on the Global red list of threatened species (IUCN 2013) as well as on the red lists for Sweden and Norway (Gärdenfors 2010, Kålås *et al.* 2010).

The Great Snipe is a lekking bird species. During the breeding season the males congregate at traditional areas (leks) where they perform an energy-demanding

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attraction display (Höglund & Lundberg 1987, Fiske & Kålås 1995). The display takes place during the darkest period of the night and females visits the leks for mate choice and copulation. Great Snipe arrive at their breeding areas in Scandinavia in May, and leave for the wintering grounds in Africa in August (Klaassen *et al.* 2011).

Great Snipe are food and habitat specialists, and earthworms (Lumbricidae) represent the main diet for displaying males (Løfaldli *et al.* 1992, Kålås *et al.* 1997a). Earthworms have very high energy content and the diet preference can be attributed to the costly display behaviour of the males (Höglund *et al.* 1992). Previous studies have shown that breeding Great Snipe prefer to feed in soft soil with a high abundance of earthworms (Løfaldli *et al.* 1992, Kålås *et al.* 1997a). In Scandinavia, most leks are situated on rich fens along the tree limit (Kålås *et al.* 1997a, Ekblom & Carlsson 2007). Such habitat occurs solely in mountain areas with base-rich bedrocks.

Great Snipes have a reclusive lifestyle and only expose themselves during the breeding display. The leks are situated in mountainous areas and are often remote and with difficult access. The display occurs during late spring and at night, when few people visit the mountainous areas. Up until 1997, a total of 125 Great Snipe leks were known in Scandinavia, the majority in Norway (Kålås *et al.* 1997a). Ekblom & Carlsson (2007) have recently estimated a total number of 230 Great Snipe leks in Sweden, holding a population of about 1800 males. Prior to the present study, 16 Great Snipe leks were known in our study area, the county of Nord-Trøndelag. These leks were found in the period 1970–1997 either incidentally or during general bird surveys, and most of the leks had not been verified for many years. A specific survey of Great Snipe leks has never been performed in Norway and the true population size is poorly known. However, the results of earlier investigations suggest that the study area (Nord-Trøndelag) makes up roughly 20% of the total presence of suitable habitat for Great Snipe in Norway (Kålås *et al.* 1997a).

The main goal of this study was to estimate the size of the breeding population of Great Snipe in Central Norway. This was done by developing a GIS-model to identify areas with suitable habitats within an approximate 22 000 km^2 area. Surveys were carried out to map the occurrence of Great Snipe leks and to count the number of lekking males in a subset of sites within the areas modelled as suitable for breeding Great Snipe. Based on this, we estimated the total population of lekking Great Snipe males in our study area.

METHODS

Identifying suitable habitat

We used Nord-Trøndelag County, covering about 22 000 km^2 in central parts of the Great Snipe's remaining breeding distribution in Western Europe, as our study area. Here we identified potentially suitable breeding areas for Great Snipe by the use of GIS-analysis (Østnes & Kroglund 2010). The model used to identify suitable habitats was developed using ArcGIS Desktop (version 9.2, ESRI). In the GIS-model five different criteria were combined to identify suitable habitats: (1) occurrence of base-rich bedrocks; (2) an altitude from 380 to 720 m; (3) mire or rough grazing; (4) a slope gradient from 0° to 10°; (5) a slope aspect from 90° (east) to 270° (west). The choices of these criteria were based on the following assumptions: (1) Great Snipe males need high quality food during lekking (Höglund *et al.* 1992). In the Scandinavian mountain range this means earthworms (Løfaldli *et al.* 1992), which only occur in high densities on base-rich soil (Kålås *et al.* 1997a); (2) at present, the West European population of Great Snipe is only known to breed along the tree-line (Kålås *et al.* 1997a); (3) Great Snipe only use open habitats for feeding and as nest sites, and need rather soft soil to be able to utilize their long bill for feeding (Kålås *et al.* 1997a), which means they require mires, some farmland habitats and open shrub close to such areas; (4) Great Snipe avoid steep gradients that are unsuitable as lek areas; (5) in spring, snow cover is longer on north-facing slopes and in such areas food is not available to Great Snipe early in the lekking period, at a time when energy requirements are likely to be particularly high.

The following sets of basic map data were used in the GIS-model: digital land types in the economic map series of Norway (Norwegian Forest and Landscape Institute); contour lines (Norwegian Mapping Authority); digital relief model (Norwegian Mapping Authority); administrative boundaries (Norwegian Mapping Authority); and geological map (Geological Survey of Norway). Our model identified suitable habitat mainly in the eastern parts of our study area. The GIS-analyses did, however, identify some fragmented occurrences of suitable habitat in the western part of our study area (Østnes & Kroglund

2010). These areas were not included in the calculations of suitable habitat because they were too small and fragmented to be considered as breeding areas. Thus, our study was restricted to an area covering approximately 14 600 km^2 in the eastern part of the county.

Surveyed areas

The areas identified as suitable habitats for lekking Great Snipe had a very scattered distribution. The areas used for surveys of lekking snipes were polygons (mainly squares) in the size range 1.3–5.1 km^2, and because of the scattered distribution of suitable habitats these polygons only partly included areas classified as Great Snipe lekking habitats (Østnes & Kroglund 2010). A total of 53 areas totalling 179 km^2 were surveyed, and 24% of this area was classified as Great Snipe lekking habitat (Fig. 1).

In this study, two types of areas were sampled for occurrences of lekking Great Snipe. This includes 40 areas (median size 3.4 km^2, range 1.3–5.1 km^2 and 25% of area classified as Great Snipe breeding habitats) used for estimating total number of Great Snipe leks in our study area (hereafter called random sampling areas). These areas were all without previous records of Great Snipe, and they were all situated within the areas modelled as suitable for lekking Great Snipe. The random sampling areas were spread from south to north in the study area, and with a few exceptions they were selected so they could be reached and surveyed within one day. See discussion for further evaluation of random sampling.

In addition, data on the number of lekking males at each lek (lek size) are included for 10 leks from 13 additional surveyed areas (median size 3.4 km^2, range 2.5–4.5 km^2 and 18% of area classified as Great Snipe breeding habitats) with previous known occurrence of 16 different Great Snipe leks. All these sampling areas were also situated within the areas modelled as suitable for lekking Great Snipe.

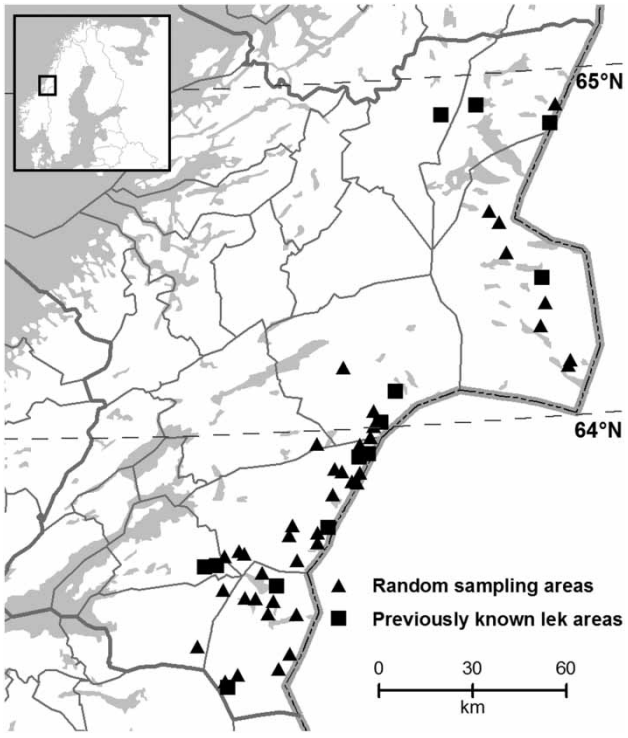

Figure 1. Location of the 53 sampling areas surveyed for Great Snipe leks in Central Norway during the breeding seasons 2007–2010. Shown are 40 random sampling areas (triangles) and 13 sampling areas with previously known Great Snipe leks (squares). Inserted map shows the geographical position of the study area.

Mapping method

All sampling areas were surveyed during the lekking season (24 May–21 June) at night (22:00–03:00 hrs. local summertime) from 2007 to 2010 using standard methods (Kålås 2000). The characteristic sound of lekking Great Snipe is unmistakable, but relatively quiet. Even under good weather conditions, the sound is normally not detectable at distances greater than 200 m. Each sampling area was surveyed by two or three observers walking slowly along parallel transect lines spaced about 200 m apart. A hand-held GPS device was used for orientation along transects. Short stops were made each 100–200 m to listen for lekking Great Snipe. No surveys were conducted on nights with heavy rain or wind above a moderate breeze.

When the sound of lekking Great Snipe was detected, the observer(s) recorded the position with a hand-held GPS device, and then slowly moved towards the lek to get an overview. Subsequently, the observer(s) walked haphazardly over the area at the same time making enough noise to ensure that any birds sitting tight would be flushed up. This type of flushing is thought to only constitute a minor disturbance to the birds, and the displaying males return to the lek shortly after flushing (Kålås *et al.* 1995, Ekblom & Carlsson 2007, own obs.). This method might result in an overestimate of males because females may also be among the flushed birds.

To compensate for this we assumed that 20% of the flushed birds in the period before 10 June and 10% of birds flushed later than 10 June were females (own unpubl. data) and adjusted the numbers accordingly. The leks were visited and the males counted during the main lekking season (from 24 May to 21 June), when all territorial males are expected to be present on the leks (own unpubl. data).

RESULTS

Number of leks in the study area

Our GIS-model identified 528 km^2 as suitable habitat for Great Snipe in our study area, which amounts to 3.6% of the total area included in the model. A total of 34.4 km^2 (6.5%) of this habitat was included in the 40 random sampling areas and 18 leks were found within these areas, giving a density of 0.52 leks/km^2 suitable habitat (Fig. 2, Table 1). This density multiplied by the total occurrence of suitable habitat results in an estimate of 276 leks in the whole of our study area.

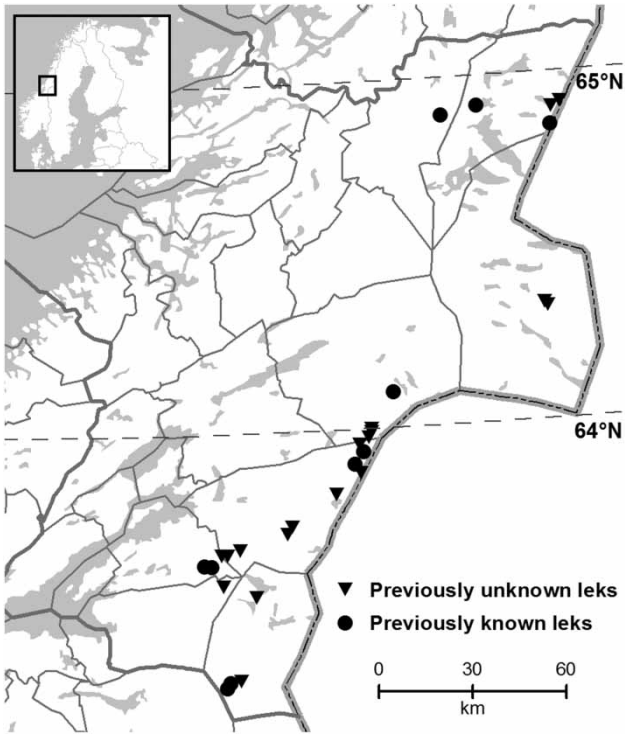

Figure 2. Location of all Great Snipe leks found in the sampling areas in Central Norway. Shown are 18 leks which were unknown prior to this study (triangles) and 10 previously known leks (circles). Inserted map shows the geographical position of the study area.

Estimate of total number of lekking males.

A total of 28 active Great Snipe leks were found in the 53 areas surveyed during 2007–2010 (Fig. 2, Table 1). A total of 18 active leks were found in the 40 areas that were randomly sampled, and a further 10 leks were located in areas that were previously known to hold active leks. The number of birds on these leks varied from 2 to 25. After adjusting for an assumed number of females, an average of 9.9 (sd = 4.5, n = 28) displaying males on each lek was calculated. The estimated number of leks multiplied by this number of males per lek gives an estimate of about 2700 lekking males in our total study area.

Location of leks in relation to modelled Great Snipe habitats

Our study included surveys of a total area covering 179 km^2, of which 43 km^2 was modelled as Great Snipe habitat. Twenty-two (79%) of the 28 leks were situated in or very close (<100 m) to areas modelled as potentially suitable Great Snipe habitats, and all of these leks were situated closer than 600 m from such habitats (Fig. 3). All the leks were found on open fens along the tree limit. The majority of the leks (85%) were situated at altitudes of 500–700 m (mean 570 m, sd = 72.4, n = 28, Fig. 4). Only 2 leks were situated at altitudes above 700 m, both in the far eastern part of our study area. With one exception all the leks were situated on base-rich bedrock (Table 1). Dominating rock types were phyllite, amphibolite, mica schist and greenschist. Most of the leks had aspects between southwest and southeast. On five leks the terrain was flat, while two leks had a weak northern aspect.

DISCUSSION

The 28 leks found in the sampling areas constitute only a limited portion of the total number of Great Snipe leks in our study area. This is supported by the GIS-analyses which identified the incidence of suitable habitat. Even though we carried out an extensive field study, the survey only covered 8% of the area identified as suitable habitat. Based on the survey, we estimated a density of 0.52 leks/km^2 suitable habitat. This is considerably higher than the results (0.26 leks/km^2) of a corresponding study in Sweden (Ekblom & Carlsson 2007). It should, however, be noted that the method used to identify suitable habitats is quite

Table 1. Great Snipe leks located in the sampling areas in Central Norway during the breeding seasons 2007–2010. Leks known prior to this study are shown in bold type.

Lek[a]	Year	Number[b]	Altitude (m)	Slope	Bedrock
Bindstikk I	2008	11	700	NW	Greenschist, amphibolite
Bindstikk II	2008	15	690	W	Schist, sandstone
Gåstjønna	2009	3	670	Flat	Schist, sandstone
Funnsjøen N	2007	7	514	E	Greenschist, amphibolite
Vassvollhøgda	2009	2	600	S	Mica schist, amphibolite
Revollen	2008	8–12	435	Flat	Schist, lime stone
Heglesvola	2008	12–14	550	SE	Phyllite, mica schist
Lauvlian	2007	4–6	519	S	Phyllite, mica schist
Kammarn	2007	20–25	511	SW	Phyllite, mica schist
Grønningen N	2007	6	500	SE	Mica schist, amphibolite
Spjeldberget	2008	11	620	S	Phyllite, mica schist
Kvernsjøen	2009	15	561	SW	Phyllite, mica schist
Reinsmyrhøgda	2008	9	535	S	Schist, sandstone
Strådøla	2007	23	563	SE	Mica schist, amphibolite
Heimtjønna	2009	16	600	W	Phyllite, mica schist
Bjørkvassvola	2009	10	618	NW	Schist, sandstone
Ståggådalen	2008	11	539	S	Phyllite, mica schist
Ståggåfjellet S	2008	18	568	SE	Phyllite, mica schist
Ståggåfjellet E	2008	16	538	E	Phyllite, mica schist
Ståggåfjellet N	2008	11	545	E	Phyllite, mica schist
Nausttjørna	2008	13	532	Flat	Phyllite, mica schist
Storburs S	2009	5	716	S	Amphibolite, mica schist
Storburs N	2009	10	703	S	Amphibolite, mica schist
Spunstjørna	2007	10–12	500	SW	Diorite gneiss, migmatite
Saksvatnet	2007	20	480	Flat	Greenschist, amphibolite
Midtidalen	2007	12–15	540	Flat	Phyllite, mica schist
Lybekkdalen V	2010	7	520	S	Greenschist, amphibolite
Lybekkdalen E	2010	10	590	E	Phyllite, mica schist

[a]Geograpical coordinates for the leks are given in Østnes & Kroglund (2010).
[b]Number of birds counted in the field. This number was adjusted for an assumed number of females before the average number of displaying males on the leks was calculated.

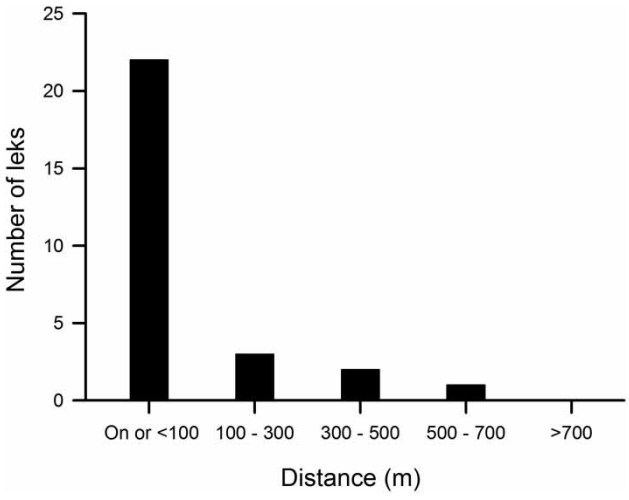

Figure 3. Distance of 28 Great Snipe leks to areas modelled as Great Snipe habitats.

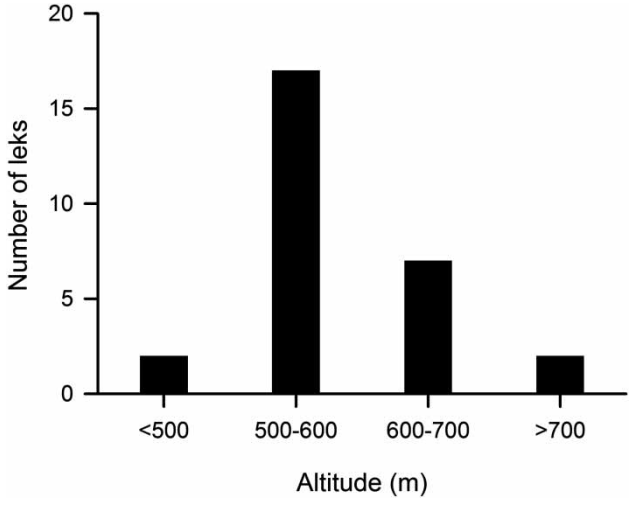

Figure 4. Location of 28 Great Snipe leks found in Central Norway in relation to altitude.

different in the two studies. Ekblom & Carlsson (2007) used detailed vegetation maps to identify suitable habitats, while we used a GIS-model to combine a set of different habitat requirements.

To identify suitable habitats by the GIS-analysis, it was important to select criteria which fulfil the habitat requirement of Great Snipe. Since the model used to identify suitable habitats require that all the criteria are fulfilled, the limitations can exclude some areas with leks. It is also important to point out that the quality of the basic map data can restrict the quality of the analysis. The criteria of land types and slope angle were fulfilled for all the 28 lek localities. One lek locality did not fulfil the criteria for base-rich bedrocks. This lek was found on bedrocks consisting of granite and gneiss. It should, however, be noted that the bedrock map used in the analysis was relatively imprecise with a scale of 1:250 000. Thus, this lek is probably also situated on local occurrences of base-rich bedrocks, or rock debris transported by glaciers, which not were identified on the maps. Previous studies have shown that the majority of Great Snipe leks are south-oriented (Ekblom & Carlsson 2007, own unpubl. data). Thus, aspects from 90° to 270° were used in the GIS-analysis. Two of the leks did not fulfil this criterion since they were north-oriented. All leks fulfilled the criteria for altitude. With respect to this it should be noted that 24 of the 28 leks were found at altitudes from 500 to 700 m. This is in accordance with the tree limit in most of the study area (Moen 1999). The climatic tree limit increases eastwards, and in the far eastern part of our study area, where two leks were found at altitudes above 700 m, the tree limit is 700–800 m (Moen 1999). In a corresponding study in Jämtland in western parts of Sweden the leks were identified at altitudes from 660 to 840 m, which is close to the tree limit of 720–840 m in that area (Ekblom & Carlsson 2007).

A mean of 9.9 males on each lek is in good accordance with similar studies in Sweden (Ekblom & Carlsson 2007) and southern Norway (own unpubl. data). However, there are some elements of concern that need to be considered regarding counts of males. Since it is not possible to discriminate between sexes of flushed birds the percentage of females was considered to be between 10% and 20%. During the mating period, when relatively many females visits the leks, the number of males might be overestimated by flushing the birds. In other parts of the lekking period, however, this method can result in an underestimation. Some of the leks were visited by only one person, and in such cases it can be difficult to flush all the birds. Thus, the number of males at each lek is considered as a minimum estimate. Since the leks were visited only once during the study period, the number of males also has to be considered as a brief snapshot. The number of males at the leks can vary according to both the time of day and time of year in addition to annual population fluctuations (Kölzsch *et al.* 2007). As our counts were done at night (22:00–03:00 hrs.) and during the main lekking season (24 May–21 June), when all males are expected to be present on leks, we expect our estimate of number of males at the leks to be reasonably accurate. Nevertheless, underestimation is possible if an observer fails to flush all of the birds that are present at the lek.

Although our sampling areas were not selected by strict random sampling we suggest that they are fairly representative for the true density of leks in the areas modelled as suitable habitat. The 40 random sampling areas were located in areas with no previous knowledge of Great Snipe occurrences. They were spread out through the study area, and held various amounts of habitat modelled as suitable for Great Snipe. Based on the lek density and the mean number of males at leks, we obtained a total estimate of 2700 males in Nord-Trøndelag. Given an equal sex ratio this results in an estimate of about 5400 individuals. Our data do allow us to estimate quantitative error rates for this population estimate. The uncertainty in our model has two main causes. One is the estimate of mean number of males at leks (see previous paragraph). The other is the reliability of our sampling design, i.e. the estimate of the total area of suitable habitat versus the properties of the habitat of the sampling areas. Although complete surveys were made in 8% of the areas identified as suitable habitats, the lek densities may be slightly different in the areas that were not included in the surveys. To further strengthen our lek density estimates we propose a supplementary study to assess the presence/absence of leks in a number of new sampling areas selected by random sampling.

The total population of Great Snipe in Norway is previously assumed to comprise 5000–15 000 lekking males or 'pairs' (Kålås 2004). Based on the presence of suitable Great Snipe areas published by Kålås *et al.* (1997a), our study area makes up roughly 20% of the total Great Snipe area in Norway. If we then extrapolate the densities of leks and number of males at leks found in Central Norway to a national scale, we expect the true Norwegian breeding population of Great Snipe to be approximately 13 500 males.

Displaying males were present at 10 of the 16 leks known prior to this study. Previous studies have shown that Great Snipe leks can be relatively unstable. On Dovrefjell in southern Norway less than 50% of the leks existed at the same place for more than 10 years (Kölzsch *et al.* 2007, own unpubl. data). The lack of birds on six previously known leks should therefore not be regarded as an indication of a population decline. Leks can relocate from one year to another without having an effect on the number of lekking males. During the end of the lekking period it is also common that some of the males leave the main lek and congregate in small groups at new locations (own unpubl. data). These are 'leks' that may exist for only a week or two, and often no lekking birds are found at these locations during the following breeding season. There are several reasons why Great Snipe were not found at some of the previously known leks. One of these leks was found in a clear-felled area which opened the landscape, and seedling forest is at present re-established making the habitat less suitable. Two other leks may have been affected by changes in the landscape caused by building of cabins. There is also a chance that two of the former known leks did not represent main displaying grounds, but rather areas on which the birds congregate during the spring migration, or at the end of the displaying period. The dates at which lekking birds were seen on these areas supports such a judgement. On one of the six former known leks there are no evident explanations for the lack of displaying birds. However, this lek was situated in an area with a relative high density of leks, and it is possible that the birds have relocated between these leks.

Loss of suitable habitats in lowland wetlands, and a subsequent fragmentation of the population, is probably the main reason for the disappearance of Great Snipe in large parts of north-western Europe (Løfaldli *et al.* 1989, Kålås 2004, Naturvårdsverket 2007). The results of this study, and other studies, shows that the remaining West European population of Great Snipe is restricted to open habitats along the tree limit (Kålås *et al.* 1997a, Ekblom & Carlsson 2007). To maintain the population of Great Snipe it is important to protect these habitats. Changing elevation of the tree limit and loss of open areas in the mountains caused by global warming is regarded as a possible threat. This can reduce the areas of suitable habitat, and cause a further fragmentation of the population (Kålås 2004). The current main threat to leks in our study area is from overgrowing of sites below the tree limit. In areas which are treeless as the results of man's activities, overgrowing has resulted following the cessation of mountain farming and grazing.

The population dynamics in Great Snipe are assumed to be more influenced by the environmental conditions on the breeding grounds than on the wintering grounds in Africa (Kölzsch *et al.* 2007). It is therefore important to prevent deterioration of the remaining breeding grounds. In the international action plan for conservation of Great Snipe it is reported that less than 5% of the displaying grounds are within protected areas, and the goal is to increase this portion to 10% (Kålås 2004). At least 10% of the areas modelled as Great Snipe habitat in Nord-Trøndelag are situated within protected areas. The majority of the leks are also assumed to have a 'natural protection' since they are situated in areas with little human disturbance. The immediate risk for deterioration of these leks as a consequence of human activity seems therefore to be low.

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