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Guidelines for monitoring of population parameters of Great Bustard and of the effects of management measures

Prepared for the Memorandum of Understanding on the conservation and management of the Middle-European population of the Great Bustard under the Convention on Migratory species (CMS) by

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Introduction

Status

The Great Bustard *Otis tarda* is a globally threatened species (Collar and Andrew, 1988; Collar et al., 1994; BirdLife International, 2000; BirdLife International, 2004; BirdLife International, 2008) which suffered rapid population decline during the 20th century.

To assist the recovery of the species, a European Action Plan has been prepared (Kollar 1996) and endorsed by the Steering Committee of the Bern Convention and the Ornis Committee of the European Union. In 2001, a Memorandum of Understanding on the Conservation and Management of the Middle-European Population of the Great Bustard (MOU) was concluded under the auspices of the Convention of Migratory Species (CMS) which also includes an adopted version of the European action plan[1]. Section 6 of the Great Bustard MOU Action Plan defines the most important monitoring and research tasks (Box 1). To support the implementation of these tasks, the Signatories agreed to prepare a guideline on monitoring of Great Bustard populations as part of the Medium-Term International Work Programme (MTIWP) 2005-2010[2] and the Lebensministerium of Austria has kindly provided financial support as part of its contribution to the overall coordination of the Work Programme.

In accordance with the task identified in the MTIWP, this guideline is focusing on monitoring of Great Bustard populations, but it does not aim to provide a comprehensive overview of the available research techniques. The scope of this guideline is restricted to cover attributes of the population and its habitat which should be subject of regular surveillance in order to be able to detect threats and to trigger appropriate research and conservation measures when necessary.

As it can be noticed in Box 1, the action plan outlines a hierarchical process for monitoring. Population size and trends should be monitored at all breeding and wintering sites (6.1.1), while the effects of habitat management should be studied at well monitored sites (6.1.2). However, we believe that protected areas (including Natura 2000 sites) designated and managed for Great Bustard, often using substantial public funding, should be amongst the well monitored ones. Effects of habitat management should be understood not only at the level of population size because this represents only the final outcome of many factors, but adaptive management also needs information on breeding success and survival rates. Therefore, this guideline also reviews some techniques that can provide this information.

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1 For more details on the MOU visit http://www.cms.int/great-bustard/

2 http://www.cms.int/great-bustard/en/meetings/meetings-of-signatories

Box 1: Research and monitoring tasks identified in the Action Plan of the Great Bustard MOU*

6.1 Monitoring of population parameters and of the effects of management measures [3.1]

6.1.1 Monitoring of population size and population trends [3.1.2]
Efforts to monitor the basic parameters of all Great Bustard populations, such as size and trends, by applying methods which lead to comparable results, should be made at all breeding and wintering sites.

6.1.2 Monitoring of the effects of habitat management [3.1.3]
Studies should be carried out on the effects of habitat protection measures, implementation of agro-environmental regulations, etc. These studies should preferably be done at sites where the population has been well monitored for a number of years.

6.2 Promotion of research which is of direct application to the conservation of the Great Bustard [3.2]

6.2.1 Comparative ecological studies [3.2.1]
A comparative analysis of existing data on population dynamics, habitat requirements, effects of habitat changes and causes of decline between the populations in different Range States should be conducted in order to redefine conservation strategies in the future.

6.2.2 Promotion of studies on mortality factors [3.2.2]
All individuals found dead should be examined for the causes of mortality. This, together with field studies and monitoring of marked individuals, should help to identify the direct or indirect impact of land use on Great Bustard mortality.

6.2.3 Investigation of factors limiting breeding success [3.2.3]
The ecology of core Great Bustard populations in extensive agro-pasture systems should be studied, giving priority to the analysis of those factors that may have influence on breeding success. These should include the use of habitat and space, home range and dispersal patterns.

6.2.4 Studies on migration [3.2.4]
Studies should be made to identify the migration routes and resting habitats of the Great Bustard better and especially key sites along such routes and in wintering areas. Ringing and studies involving satellite telemetry should be planned and implemented for those purposes.

* Numbers in brackets provide cross-reference to the European Great Bustard Species Action Plan (Kollar, 1996)

Monitoring population size and trend

Point 6.1.1 of the MOU Action Plan (but also point 3.1.2 of the European Action Plan) requires Range States to take efforts to monitor the population size and trend at all breeding and wintering sites using methods that lead to comparable results. It is important to note that this action point defines some important requirements concerning the monitoring of population size and trends. First, it has to cover **all** sites, i.e. it should go beyond national estimates based on samples and extrapolation. Second, it concerns **both breeding and wintering** sites. Third, it should produce **comparable** results.

Mapping distribution and maintaining an inventory of populations

To ensure that counts happen at all sites, a **register** of Great Bustard populations should be set up (Faragó, 1990). Ideally, such a register should be maintained as a database at national and at international level. This register could be very useful to

a) ensure systematic monitoring of each population (Faragó, 2001; Faragó, 2001);
b) assist interpretation of census results (i.e. by keeping track of missing counts or newly discovered populations);
c) support retrospective comparative studies between different populations (Faragó, 1986; Faragó, 1989; Faragó, 1989)

A first step in setting up such a register at national level is to identify all **regular** breeding and wintering Great Bustard populations within the country (**Figure 1**). This can be based on a review of earlier natural history and hunting literature, but also game statistics can also provide useful information. Predictive distribution models, e.g. (Osborne et al., 2001; Suárez-Seoane et al., 2002), can also aid finding new Great Bustard populations in poorly surveyed parts of the range.

As a next step, both sites with historical records and predicted locations should be visited to confirm the presence of the species and of suitability of the habitat. The latter is especially important in the context of the Great Bustard MOU because, by signing the MOU, Range States have undertaken to "*endeavour to map the recently abandoned Great Bustard breeding habitat and implement in such areas suitable habitat management measures and agricultural practices with a view to encouraging the return of Great Bustard population fragments to those areas in the near future*" and to "*endeavour to identify and conserve potential unoccupied breeding habitats, including display sites and nesting areas, where breeding populations of the Great Bustard could be re-established in the future*".

During the above-mentioned site visits, local people working in the countryside (e.g. farmers, shepherds and hunters) should be interviewed because they can provide very useful information on the presence of the species. It is normally easy to determine the reliability of their statements by some key questions about the displaying and breeding behaviour of the Great Bustards.

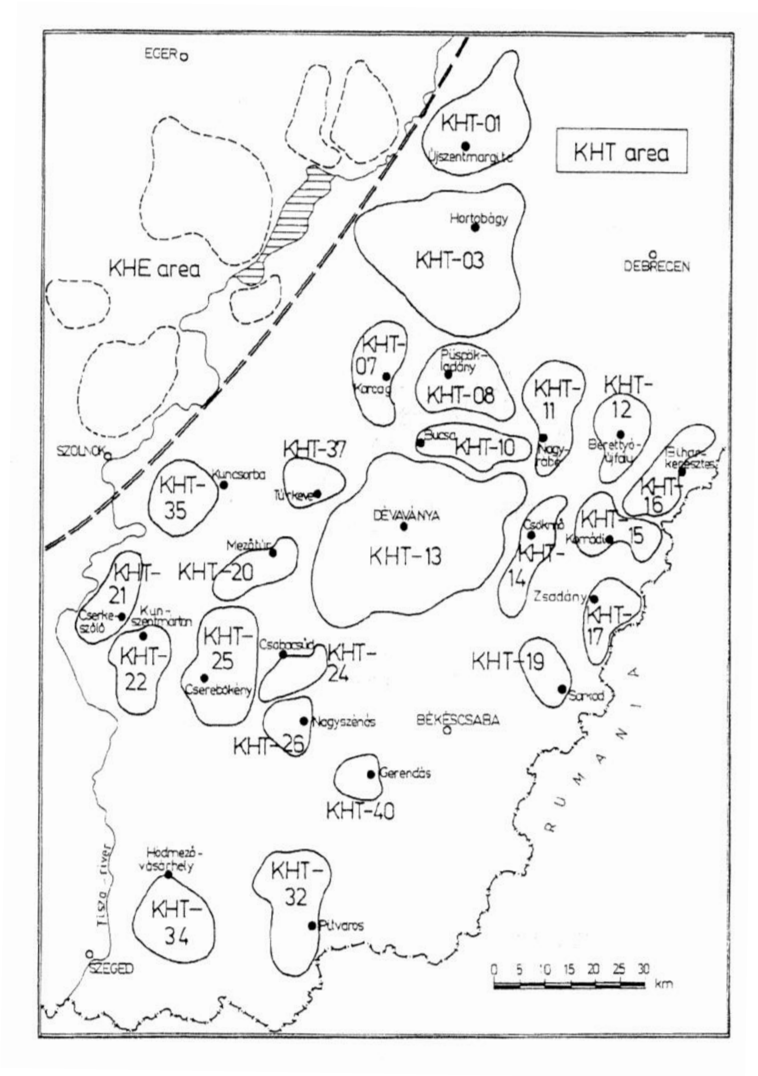

Figure 1: Map of Great Bustard populations in East Hungary (Faragó, 2001). The map delineates the area occupied by each population. In a GIS system, it can be linked to the count data and thematic maps can be retrieved.

Estimating population size

Great Bustard counts should not only be implemented at all breeding and wintering sites, but should lead to **comparable** results. The comparability of results is required both at site level, between sites at national level and between national population estimates. Without standardized methodology, the reliability of the results can be questioned and trends cannot be established with confidence (Alonso and Alonso, 1996).

In addition, figures should refer to the same segment of the population. It can lead to confusion if one country provides data on adult birds at the beginning of the breeding season, while others refer to all individuals. It could lead to further confusion if some countries are using other numbers, such as the results of autumn counts, because at that time the population includes a large number of juvenile birds, which will die before the next breeding season. National population based on winter counts may refer to populations that actually breed in another country (e.g. in the case of Austria, Hungary and Slovakia, but also in the case of Ukraine). To ensure comparability between national population estimates, the reporting form collects data both on the **number of all birds at the beginning of the breeding season** and on the **number of all birds in winter**.

These guidelines provide recommendations on (a) how to implement the fieldwork, (b) when to carry out the census and (c) how to organize them at national and, in case of transboundary populations, at international level.

Field work methods

The census methodology is most comprehensively standardized in Spain (Alonso et al., 1990) and it is generally applicable across the range of the species, although it could be particularly difficult to apply in the Russian Federation due to the very large field size there.

In this method, observers are driving through slowly (max. 30 km/h) the survey area following an established route with frequent stops (about once a km, but this depends on weather, terrain, density of birds and vegetation structure). Including the stops, the survey speed should be around 10-15 km/h. It is recommended to follow an uninterrupted zigzag route with, ideally, 700-800 m wide bands on both sides in a way that it covers the study area entirely. To achieve this, the area should be explored very carefully before the actual survey. Besides of view, accessibility should be also considered when establishing the survey route. The route should be recorded on 1:50,000 (or larger) scale maps, but nowadays they can be also stored as GPS files in the central database. (This can be especially useful when a new observer takes over the census). Concerning the band width, Alonso et al. (1990) have also noted that it can lead to missing birds if it exceeds 1,500 m. On the contrary, Osborne et al. (2007) found in their study that in the Russian Federation, where the vegetation covering is much more significant, the effective strip width for males was only 464 m and for females only 220 m, which means the distance at which as many birds were missed as detected. Considering this source of error, they used distance sampling methods (see box 2) for rectifying the population estimate.

Box 2: Short introduction of the distance sampling

Distance sampling is a widely-used group of closely related methods for estimating the density or abundance of populations. The observers perform a standardized survey along a series of lines or points, searching for objects of interest. For each object detected, they record the distance from the line or point to the object. Not all the objects that the observers pass will be detected, but a fundamental assumption of the basic methods is that all objects that are actually on the line or point are detected. Intuitively, one would expect that objects become harder to detect with increasing distance from the line or point, resulting in fewer detections with increasing distance. The key to distance sampling analyses is to fit a detection function to the observed distances, and use this fitted function to estimate the proportion of objects missed by the survey. From here we can readily obtain point and interval estimates for the density and abundance of objects in the survey area (Thomas et al. 2002).

Till now this method was tried only in Russia for the estimation of Great Bustard population size by Osborne et al. (2007). Their results suggest that the Russian Federation may hold more great bustards than previously thought. The total population could be c. 12 900 birds, rather more than the current estimate of 8,000-10,000 birds.

Although a lot of uncertainty belong to the applicability of this method, but probably it could be useful for Great Bustard estimations in larger populations and under heavy survey conditions.

Great Bustard surveys require observers who can detect the species and determine the age and sex of the observed birds. The survey should be carried out by teams of two observers, but the driver should not be involved in the counts because splitting his attention between driving and counting can lead to inconsistent results. A team should cover no more than 70-100 square kilometres a day. The survey should be carried out between dawn and sunset, but in the warmer part of the year (e.g. April to October in Spain) should be suspended during the middle part of the day (i.e. between 9:00 and 17:00) because the birds are fairly passive and partially hidden during this period. In addition, visibility can also deteriorate at this time due to haze. The observers should use at least 8x magnification binoculars and ideally minimum 20x magnification telescopes.

Locations of observed birds should be recorded on maps or in GPS devices and additional information on pre-printed data forms. It is useful if data sheets include some heading for common data for the visit. These include:

a) Place of observation
b) Date
c) Name of observers
d) Optics used
e) Weather

Data to be recorded for each observation separately include:

a) Exact location
b) Time of observation
c) Number of individuals (by sex and age if can be determined), note of any dead or injured individuals
d) Distance of the birds
e) Habitat type
f) Height of vegetation
g) Behaviour
h) Threats
i) Additional comments

To be able to establish confidence limits for the counts and to overcome the difficulty related to the huge field size in the Saratov region, Osborne and Antonchikov (*pers. com.*) have applied a distance sampling transect method (Buckland et al., 2001; Buckland et al., 2004).

Timing of censuses

Winter counts usually produce the most accurate population figures for all ages and sexes (Alonso et al., 1990; Sterbetz, 1978) because the concentration of the species is the highest at this time. Localization of flocks is also made easier because they prefer alfalfa and oilseed rape fields in winter. However, winter counts also have some disadvantages:

a) This method cannot be used in areas the birds abandon in winter (e.g. Saratov in the Russian Federation). In such situation, counts during spring or autumn are very important to provide site specific information;
b) Some mixing between different breeding populations occur at the wintering places (e.g. in case of the transboundary population of Austria, Hungary and Slovakia or Ukraine and the Russian Federation);

c) Numbers are larger than the breeding population number because some winter mortality is still to happen, especially earlier in the wintering season. Therefore, counts should be implemented towards the end of the winter (January or February);
d) In severe winters, the population may abandon its traditional wintering grounds and perform some facultative migration. In such cases, counts at the regular places would not represent the real situation of the breeding population;
e) In Central and Eastern Europe, field conditions could be very difficult and can make the completion of the count almost impossible. This can be overcome by reserving several census days and implementing the census when conditions are suitable to use dirt roads (i.e. when the soil is dry or frozen);

Spring counts are aided by the concentration of adult Great Bustards at traditional leks from late March to early May. It is far more difficult to obtain accurate population estimates because (a) the birds are less concentrated than in winter, (b) not all females turn up at the lek at the same time, (c) young birds are missing and (d) it is more difficult to see the birds from the growing vegetation. However, these counts address many of the disadvantages of the winter counts. The results of the spring counts relate more directly to the size the breeding population both at site and at national level. Therefore, it is suggested to carry out also spring counts in countries with breeding Great Bustard populations. Where there is insufficient capacity to carry out the spring counts at all leks or counts are hindered by field conditions, establishing regular counts at a representative sample of leks could still provide valuable information on trends and impacts of land use changes.

Autumn counts are useful to estimate breeding success (Alonso et al., 1990). During these censuses observers should drive more slowly, stop more frequently to scan through the fields to find females with their chicks. Choosing the right time for these counts is important because in August many birds can still hide in rank vegetation in Central Europe where maize and sunflowers are grown on large proportions of the land and are used for hiding especially by moulting birds. In late autumn, however, it becomes more and more difficult to separate females and their chicks and they concentrate increasingly, which makes it more difficult to establish a connection between breeding success and the factors influencing it. In addition, the timing of the count can also influence the productivity estimates due to the effect of relatively high chick mortality. Therefore, it is important to define a relatively narrow period when autumn counts should be implemented (e.g. last two weeks of September).

Organizing national censuses

As is obvious from the previous sections, the census of Great Bustard populations requires the involvement of a number of well equipped (cars, binoculars and telescopes) and skilled observers that can carry out the census according to the established standards. If there is a significant movement between sites, it is especially important to organise synchronised counts, which increases the demand for equipment and skilled observers even further.

The followings are the key tasks for organising the national censuses:

a) Setting the **dates** (especially in case of synchronized counts) or periods when the counts should be implemented. Obviously, counts should be implemented more or less in the same period of the year under similar weather and field conditions to be comparable. In countries where the implementation of counts is significantly influenced by the field conditions, contingency dates should be set.
b) Developing **national standards** for the field work and ensure that they are implemented at each site accordingly. These standards should include not only the description of the field methodology, but also the standard data forms to be used by the observers. It is

highly recommended to write down and publish the national standards and forms in a simple publication, which should be made available to each observer. Nowadays, the guidelines could be published through the Internet, which minimises the costs involved.

c) Identifying, training and checking the skills of the **observers** are crucial elements of organising the national counts. This process should ensure that there are enough observers to carry out the counts within the available time; they have adequate skills and equipment for the job. Identifying enough skilled observers might be challenging in countries with less birdwatchers and wardens. In Hungary and several other countries, this problem has been overcome by involving hunters at the beginning of the census. However, in such situations, training is even more important. The training should focus on identification skills, especially determining age and sex accurately, and applying the field work methodology correctly. Both should be validated by the national coordinator on the field otherwise systematic observer error could bias the results. In some countries, special efforts should be made by the national coordinator to provide the necessary equipment. Just like Great Bustard populations, observer networks are neither stable in their composition. Therefore, the national coordinators shall ensure that observers are replaced by other, equally skilled ones when necessary. This can be achieved through regular contact with the observers well before the censuses and having some overlap between the old and the new observers. It is also important to hand over a copy of the earlier observations and maps to the new observer.

d) **Data management and analysis** is also an important task of the national coordinators. Field forms and maps should be collected shortly after the census and the data should be stored in databases and ideally also in Geographic Information System. If a commercial GIS software is not affordable, location data can be projected in Google Earth. The database on Otis Tarda Online has been developed to assist storing data of Great Bustard observations (Figure 2). The data submission process can be made easier for the coordinator by using Excel datasheets or web-based data submission systems in countries with well advanced information technology infrastructure (i.e. widespread use of PCs, palm tops and broadband Internet connection). Ideally, the data is stored in a central, national database for each population. The scope of the data analysis depends mainly on the scope and rigour of data collected. Nevertheless, it is important from both conservation and networking point of view to produce a rapid report that summarises the main outcomes of the census. The use of databases and GIS systems make it possible for these rapid reports to be produced almost automatically.

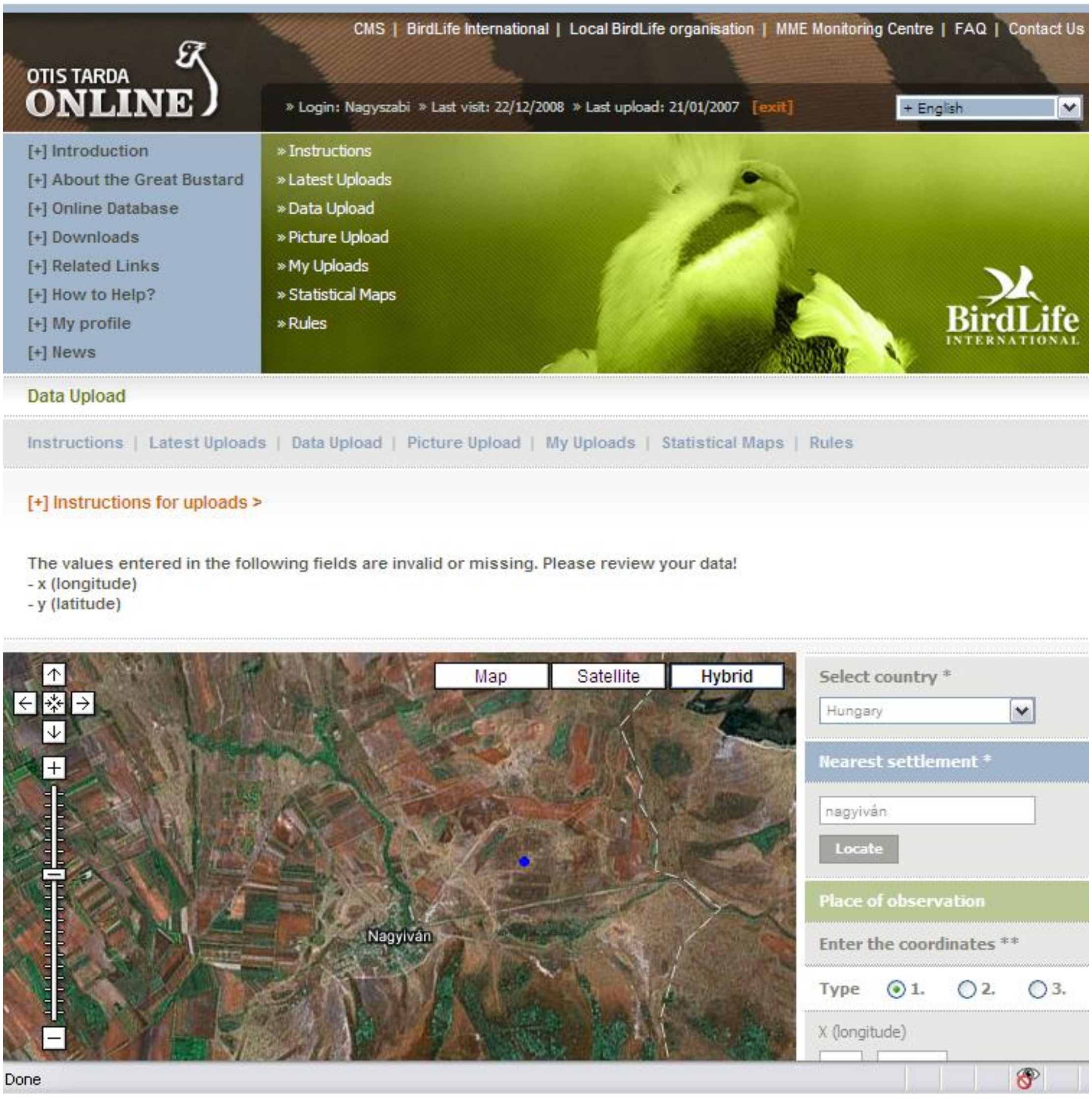

Figure 2. The Otis Tarda Online database has been set up to collect Great Bustard observations. The database can be accessed already in several languages and it can be further expanded on request. It uses Google Maps to assist correct recording of the location.

Estimating population trend

Repeating the counts using the same, standard methodology ensures that data are **comparable** at least at site level even if the estimates of the absolute numbers are somewhat inaccurate.

Unfortunately, comparability of data is impaired by (a) observer errors, (b) missing counts, (c) year effects and (d) methodological changes over time. This makes interpretation of the data especially difficult (Alonso and Alonso, 1996). Unfortunately, neither simply indexing the counts to a start year or the traditionally applied linear and logarithmic regression methods are not able to take these factors into account. Thus, data are sometimes [skewed/ missing word?!] by statistically not justifiable "corrections". An advantage of the regression methods is that it is easier to compare the slope of the regression line (i.e. the instantaneous rate of increase) than simple indices if the counts have started at different times. However, the slope of the regression line is just a simple measure of the average rate of change in numbers over the span of the time of the data (Greenwood and Robinson, 2006). This means that the overall trend for a recovering population will still remain negative for several years.

Luckily, the TRIM model (Pannekoek et al., 2005), used as the standard package for by the European Bird Census Council partners, is able to estimate (input) missing counts and to take time-effect into account. It estimates the missing counts on the basis of counts from other areas in the same year and within the site in other years. TRIM can be used both for complete census (time-effect model, but overdispersion switched off) and for sample data (time-effects model with overdispersion on). It can be also used to test "change points" in the overall trend instead of just looking at one overall trend over the period (van Strien and Soldaat, 2008). Amongst other outputs, TRIM produces automatically two trend estimates (one based only on the date, the other including imputed values), where the multiplicative slope of the model is the annual growth rate of the total population and it assesses the overall trend and its significance. This value can be extrapolated (Pannekoek and van Strien, 2001) e.g. to 20 years or to three generations (i.e. 3x14=42 years according to BirdLife International, 2004) and compared against the IUCN Red List criteria to assess the threat status of the national population (IUCN S.S.C., 2001).

Nevertheless, TRIM has also some limitations. One is that counting errors, especially in larger populations, may strongly influence the results. Therefore, it is better to use population units that can be covered by the counts and make missing counts explicit. Another problem is that fit of the model for individual populations can be poorer than of the overall model especially if local populations show opposing trends as it happens often with Great Bustard (Alonso et al., 2003; Pinto et al., 2005; Práger, 2005). In such situation, it might be worth using covariates (e.g. core and marginal populations) to improve fit of the model.

Monitoring age and sex structure of the population

It is well known that there is a considerable time-lag before the decline of a long-lived species follows adverse environmental changes (Morrison et al., 2006; Sterbetz, 2000). Monitoring the age and sex structure of the population, however, can highlight threats much earlier (Alonso et al., 1990). E.g., too few or a declining proportion of immature males in the winter flocks can indicate poor or deteriorating breeding conditions. Low or declining proportions of adult males can point to illegal trophy hunting.

Age and sex structure of the population can be most easily monitored in winter flocks. In other seasons, some age and sex cohorts (e.g. young males) might be less recognizable and this can lead to biased estimates. (However, the general limitations of the winter flocks also apply for estimating age and sex structure).

To describe the sex ratio of the population, Faragó (2001) suggested using the total number of males versus the total number of females rather than focusing on adult birds. He based this suggestion on the consideration of the practical difficulty of separating mature and immature females in the field. Overestimating the number of adult females can lead to errors both in sex ratio estimates and in population viability models. Nevertheless, assessing the viability of the population would require some estimation of the real number of adult females. This can be assisted by counting separately old and immature males. The number of old females can be estimated if we assume that the proportion between old and immature females is the same as in case of males. However, this method can only be applied in large populations where demographic stochasticity is negligible.

Considering the importance of sex and age structure in the management of Great Bustard populations, national coordinators should make efforts to train their observers in these skills.

Annex 1 Guidelines to determine the age of Great Bustard in the field provides an illustrated description of the main field marks to assist this process and improve observer skills.

Monitoring mortality

Point 6.2.2 of the MOU Action Plan calls for promoting studies into mortality factors and requires examination of all individuals for the cause of mortality and using marked individuals. From a conservation point of view, it is important to estimate not only the relative importance of mortality factors, but also the mortality rate of the population. Together with information on reproduction, survival, immigration and emigration rates, it helps diagnosing the causes of population decline and devising remedial actions (Aebischer et al., 2000; Green, 2002).

Monitoring mortality factors

As the Action Plan requires, efforts should be made to examine all dead individuals. It is useful to establish, preferably official, procedures for reporting dead Great Bustards to the competent conservation authorities. Observers should liaise with people on the field such as hunters and farmers to be notified when dead Great Bustards are found. This is especially important if there are no official procedures in place. It is highly recommended to draw up, with veterinary help, (a) a checklist of data to be collected as field history in case of mortality events, (b) some guideline how to collect samples and include them into the national monitoring guidelines. Results of the examinations with proper documentation (i.e. photographs, necropsy report if cause of death is not apparent) should be entered into a national or international database either directly or through the national coordinator.

More detailed studies into certain factors (e.g. collision with power lines, mowing, predation) can help gaining a more complete understanding of the magnitude of the mortality the factor may cause. Austria is an example of how the collision with power lines could be monitored. In all Great Bustard areas local people are involved in the conservation project. In total more than 700 people (farmers and hunters) are involved in a monitoring scheme. Regularly meetings between the project coordinator and the local people ensure that most of the dead Great Bustards are reported to the project coordinator immediately via mobile phone and then the cause of death can be checked in detail.

Unfortunately, an obvious shortcoming of such studies is that the relative importance of certain factors is biased by sampling efforts. In addition, the likelihood of finding dead birds killed by different factors is very different (Cooper 2004). Radio telemetry studies can help find more dead individuals and thus can lead to less biased samples although some limited bias is associated with the technique itself if birds are not captured and the transmitters are not mounted carefully on them. However, another guideline produced under the auspices of the MOU helps minimizing these problems (Alonso, 2008).

Estimation of mortality rate

Monitoring mortality rate (or survival rate, equal to 1 – mortality rate) is not explicitly required by the action plan, but it would be useful to try it at as many sites as possible, especially in declining ones. Mortality rates can be estimated using (a) observed mortality, (b) change in population size, (c) age structure, (d) through mark-recapture methods (Sutherland, 2000).

Mortality rates can be reliably estimated based on **observed mortality** only if the fate of individuals is well known. This can be the situation in small, intensively monitored populations with no interactions with others (e.g. in Germany) or in telemetry studies if missing animals are located and their death is confirmed. If the total number of individuals (*n*) at the beginning of the study and the number of dead (d) and alive (a) individuals at the end of the period is known, the mortality rate (q) can be calculated as q = d/q. If the study period is one year, it gives the annual survival rate. The standard error of the survival rate is

$$s.e. = \sqrt{\frac{ad}{n}}$$

If no migration into or out of the population occurs and the young of the year can be distinguished from older birds (as in case of Great Bustard with the caveats mentioned under "**Monitoring age and sex structure of the population**"), then mortality between two censuses can be estimated based on the **change in population size**. The mortality between times *t* and *t+1* can be estimated based on the population size at time *t* and the number of surviving birds from time *t* at time *t + 1*. E.g. if the total number of birds was 25 (1st winter: 5, older birds: 20) at time *t*, and 27 (1st winter birds: 10, older birds: 17) at time *t+1*, the survival rate can be estimated as 17/25= 0.68, which equals to 0.32 mortality rate. The standard error can be calculated the same way as for observed mortality.

Methods based on **age structure** assume that (a) the population can be aged accurately and (b) there has been no change in the average birth and death rates over time at the level of the population as a whole, hence the age structure is stable. Unfortunately, assumption (a) holds mainly for the first years of males, while (b) does not hold at all. Most Great Bustard populations have very good and very bad years for reproduction and mortality. Hence, birth and death rates are not stable (Morales et al., 2002).

Mark-recapture methods require that individuals can be identified individually. This can be achieved by either using biological markers or by marking birds. Available techniques for the latter are described in the other MOU guideline (Alonso, 2008). Biological markers include either visible features of the individuals or molecular markers. Both can be used to identify individuals without actually catching and marking them. Although external signs would be the cheapest option to follow the fate of individuals, its application on Great Bustard is limited to plumage aberrations (e.g. partly or fully albino individuals) according to our current knowledge, which provides too few samples for robust statistical analysis and survival of albino birds cannot be considered as representative, anyway. On the other hand, the DNA fingerprinting is a promising opportunity (Wink et al., 1999). Samples for genetic analysis can be obtained from eggs, faeces and feathers and can be collected systematically at leks, breeding and wintering sites. However, the application of this technique requires dedicated laboratory capacity and can be costly.

Regardless of the marking method, mark and recapture methods require following the fate of the individuals. In reality, the method does not require recapturing the marked individuals. They can be resighted or radio signals can confirm that they are still alive or can be recovered as dead to build their life history. Freely available computer packages (e.g.

MARK) can be used to estimate survival rates and their standard error from these life histories. This approach has been successfully applied in Spain to obtain survival estimates and to analyse the importance of various mortality factors (Martin et al., 2007).

Monitoring breeding success

Point 6.2.3 of the MOU Action Plan calls for investigating the factors limiting breeding success. This can be only done, if breeding success is systematically monitored. The necessity of evaluating the effectiveness of agri-environmental measures, which often aim to improve breeding conditions, also calls for more information on breeding success.

The minimum information for assessing the reproductive success is **fertility** which is the number of young birds raised by the population over some period of time, usually a year or a breeding season. As it is usually sufficient to study the female segment of the population, fertility is usually expressed as young females produced per female in the population. In case of Great Bustard, fertility can be best estimated during the autumn counts (Alonso et al., 1990) as described earlier in the chapter on "**Monitoring population size and trend**s". It is relatively easy to collect and sufficient to assess the viability of the population. Thus, it is recommended to monitor it at as many sites as observer capacity allows. Studying other parameters of reproduction such as hatching success, nesting success, number of eggs, fertility is necessary only if monitoring data indicates that fertility is low or declining.

Monitoring of habitat use and availability

Point 6.1.2 of the MOU action plan requires monitoring the effects of habitat management including protection measures. However, studies on breeding success and mortality factors should be also linked to habitat conditions under action points 6.2.2 and 6.2.3. However, there are many ways of studying the relationship between Great Bustards and their habitat (Faragó, 1986; Faragó, 1989; Alonso et al., 1990; Lane et al., 2001; Faragó, 1983; Faragó, 1988; Faragó, 1991; Faragó, 1992). This guideline only aims to highlight methods that can help monitoring of the change in habitat use and availability.

Monitoring habitat use by Great Bustard requires recording the exact locations of the observed birds (or other signs of occurrence such as pellets, feathers, etc.) together with information on the habitat where the observation happened. The minimum information to be recorded on maps is field structure, cover type and the location of infrastructure (e.g. roads, power lines, wind farms, moving irrigation systems). Because the farmed landscape is changing dynamically over the year, it is necessary to record the status of the vegetation at several times during the year. E.g. the monitoring programme of the Hungarian LIFE project has required recording the status of the parcels at three times (15 April, 15 August and 15 December). This can be obtained either by following the same survey route described in the chapter on "**Monitoring population size and trend**" or obtained from remote sensing. In case of studying the impact of habitat management, more frequent recording of the status of vegetation, agricultural works and other human activities might be also necessary. Areas subject of specific conservation measures (e.g. protected areas, fields under certain agri-environmental measures) should be also recorded.

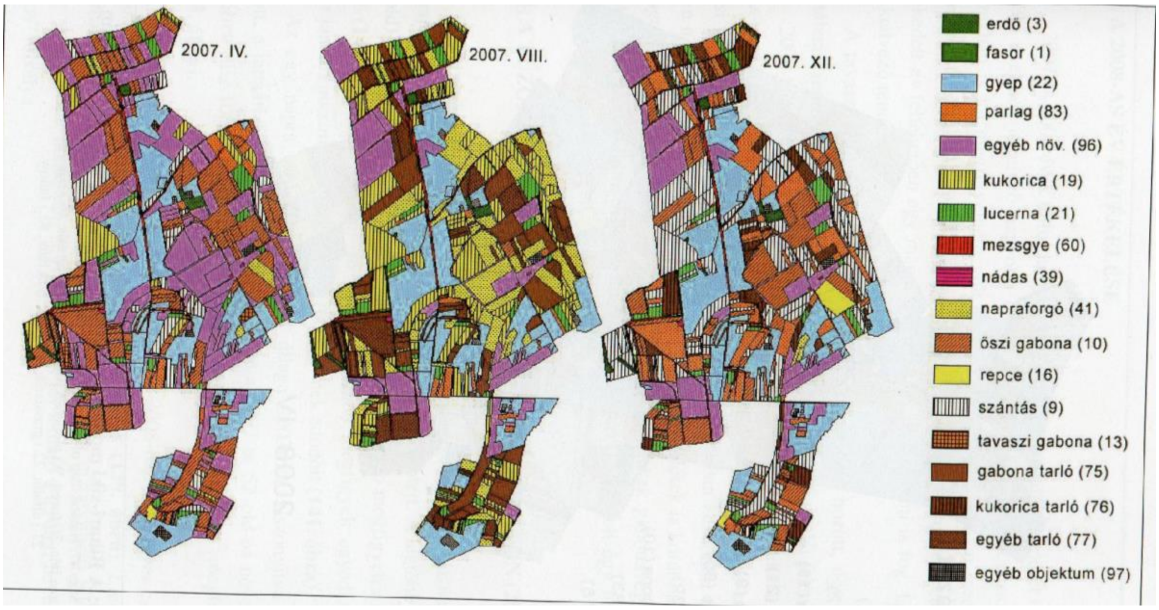

Figure 3. Habitat mapping implemented under the Hungarian LIFE project (Kalmár and Faragó, 2008)

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Annex 1

of the Guidelines for Monitoring of Population Parameters of Great Bustard and of the Effects of Management Measures

Guidelines to determine the age of Great Bustard in the field

Photo: Jozef Timar

Prepared for the Memorandum of Understanding on the Conservation and Management of the Middle-European Population of the Great Bustard under the Convention on Migratory Species (CMS) by

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February 2009 (Updated in March 2018)

Determining the age of Great Bustards in field is not easy. Very often we can record them only as “sex and age unknown”. For a proper age determination, good light conditions, high quality scope and relatively short distance as well as some experience are required. However, , these guidelines help you with the first steps in age determination of Great Bustards.

It is possible to deduce the age of the chicks from the stages of their development. At the age of one week (Figure 1), their primary feathers begin to grow, at the age of two-three weeks, the tail and the body feathers are growing faster respectively, and as they are one month old, the first moult has nearly finished (Figure 2). The young Great Bustards acquire the ability to fly, when they are five-six weeks old, although they rather squat in danger then fly in this age (Figure 3). From this time their growth is roughly constant until they reach the size of their mother generally in September. Since this time to distinguish the juvenile from an adult undoubtedly is difficult in field, except the juvenile male, because they grow further, their size will increase, their neck will be broader usually in October compared to the females (Gewalt, 1959, Cramp & Simmons 1980).

Figure 1: An approximately one-week old Great Bustard chick.

Figure 2: A female Great Bustard with her c. 4-week old juvenile.

Figure 3: A squatting chick which would be able to fly due to its development.

Figure 4: This juvenile Great Bustard has just acquired the ability to fly.

The age of a hand-reared Great Bustard is surely exact, and its growth is observable. A wild juvenile can be compared to it for a better age estimation, although the development of the juveniles in artificial circumstances are never the same as in nature. Photos about hand-reared juvenile Great Bustards in different ages are shown in Figures 5 and 6.

Figure 5: The growth of male (left) and female (right) juvenile Great Bustards in the first four weeks. The birds are standing in front of a 10×10 cm grid. Photos: Henrik Watzke, Förderverein Großtrappenschutz e.V.

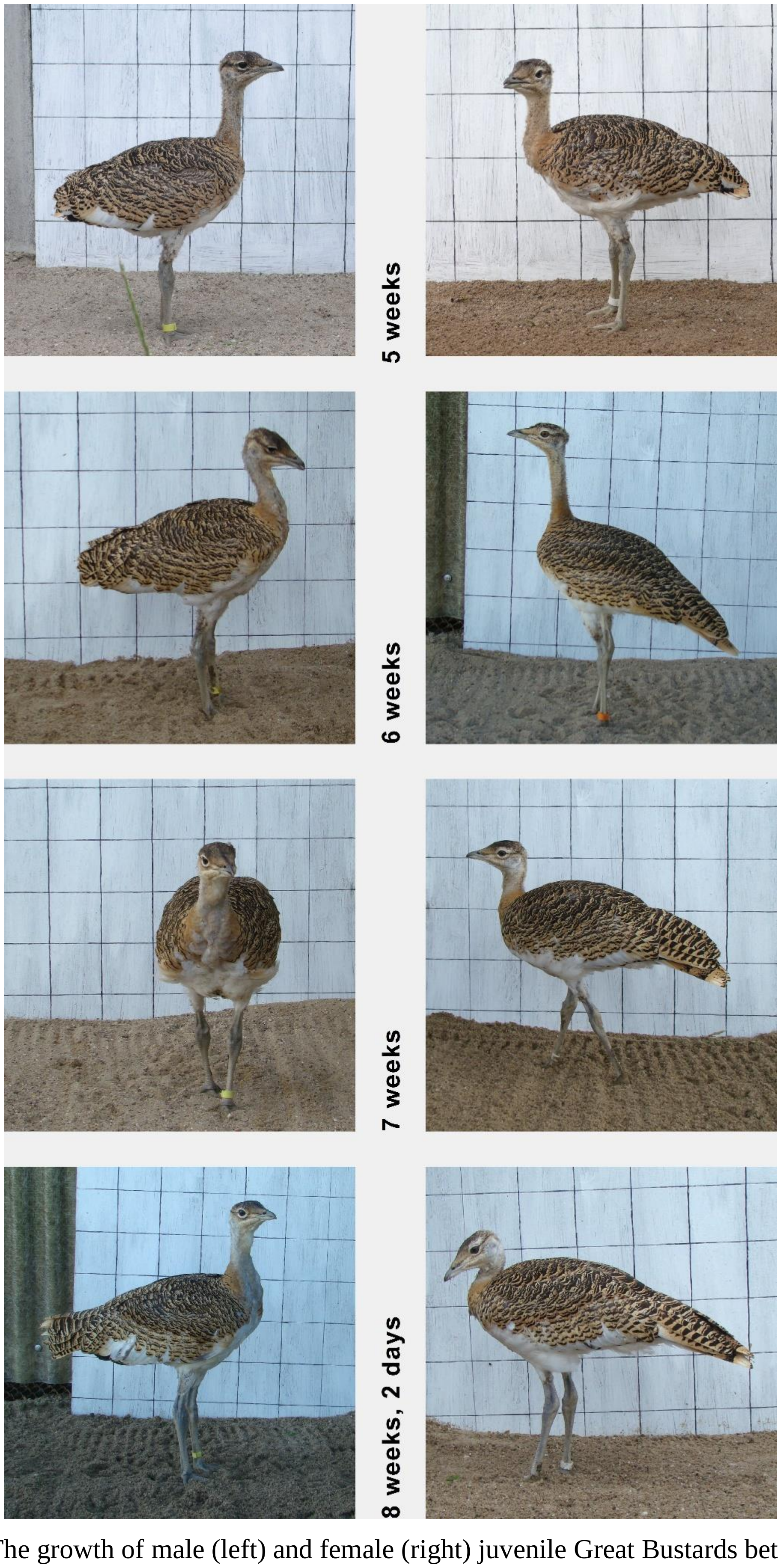

Figure 6: The growth of male (left) and female (right) juvenile Great Bustards between the 5th and 8th weeks of life. The birds are standing in front of a 10×10 cm grid. Photos: Henrik Watzke, Förderverein Großtrappenschutz e.V.

Till this point of time it is relatively easy to determine the age of a Great Bustard chick, but because of their usual hiding behaviour, generally most of the chicks grow up “invisibly”, thus the occasional observations are not enough to draw a conclusion about breeding success of a population.

But in turn, the determination of the age of the Great Bustard males in the mating period (from the beginning of March till the end of May) is possible with approximate precision, insofar as they have signs on their body in correlation to their maturity, and thus their age. By individual-based monitoring with radio and satellite telemetry, Spanis’ scientists won wide knowledge in this field, their publication titled as ‘***Field determination of age in male Great Bustards (*****Otis tarda*****) in spring’ (Alonso et al, 2006)*** contains the most important details, some parts are cited below. (We must note that there are plumage differences between the central European and Iberian populations; in the Central European population, the chestnut neck base collar is more open in younger adults, increasing in width with age and reaching almost half the total height of the neck in very old males (Gewalt, 1959), so the description of the Spanish scientists should be a bit modulated. Furthermore, according to the field experts, Great Bustard males in Central Europe probably develop faster and mature earlier.)

Juvenile males acquired full adult plumage between their fourth and seventh years. The main changes occurred at the neck, coinciding with the onset of sexual maturity. The grey colour typical of immature males turned to ivory white around the fourth to fifth spring, and a gradual increase was noticed in adults in the brightness of the white colour of the upper neck and in the contrast between this and a progressively more intense chestnut brown at the neck base. Based on earlier studies (Gewalt, 1959) and on our own experience from a preliminary study with marked birds at Villafáfila, we established the following four moustache development categories and the following four neck patterns:

- Moustaches 0: No moustache feathers.
- Moustaches 1: Poorly developed, exceeding a few centimetres beyond the rear on the bill gapes.
- Moustaches 2: Viewing the head from the side, the moustaches reach the nape outline.
- Moustaches 3: The moustaches clearly exceed the nape outline.
- Neck 0: Relatively thin, uniform grey spotted with brown at the base, with a slim fringe of brown colour at the neck base on its dorsal face.
- Neck 1: Somewhat thicker, with a brown wide band at the lower half and grey at the upper half, of lighter shade than in the previous category.
- Neck 2: Notably thicker, with wide brown, chestnut-coloured band at the base, a broad intermediate creamy-yellow band and upper neck of a whitish to very light greyish colour that grades to grey under the lower mandible. The three bands of the neck, lower chestnut, intermediate creamy-yellow and upper whitish, are approximately of the same height.
- Neck 3: A thick, substantially bulkier neck, with well-developed, hanging breast feathers, very intense chestnut-coloured basal band, not as wide as in the previous category, bordered upwards by a narrow creamy-yellow fringe, above which there is an intense ivory to pure white upper neck reaching the chin.

Each spring throughout the study period, after observing each individual several times in the morning display activity through the main display phase between late March and early May, we obtained for each bird a mean annual value of moustache and neck categories and plotted the resulting series of values on a graph ranging between ages 1 and 10 years.

Figure 7 shows the development of sex traits with age in male great bustards. Males developed short moustache feathers already in their second spring after hatching, i.e. during their third calendar year (Fig. 7, left). At the age of three years, the moustaches exceeded the nape outline in only one male and just reached it in another male, out of 15 birds. Between the third and sixth springs, the average moustache category increased rapidly with age, reaching maximum values in the seventh spring in most birds. However, interindividual variability was relatively high during this age interval (2–6 years). As for the neck category, it scored 0 in all birds in their first and second springs, increasing to values around 1 in all birds in the third spring (Fig. 7, right). In the fourth spring, only one bird scored 1, most being close to value 2. Between that age and the seventh spring, neck values increased regularly and with lower interindividual variation than in the moustache category. Maximum neck scores were reached in birds aged eight years or more.

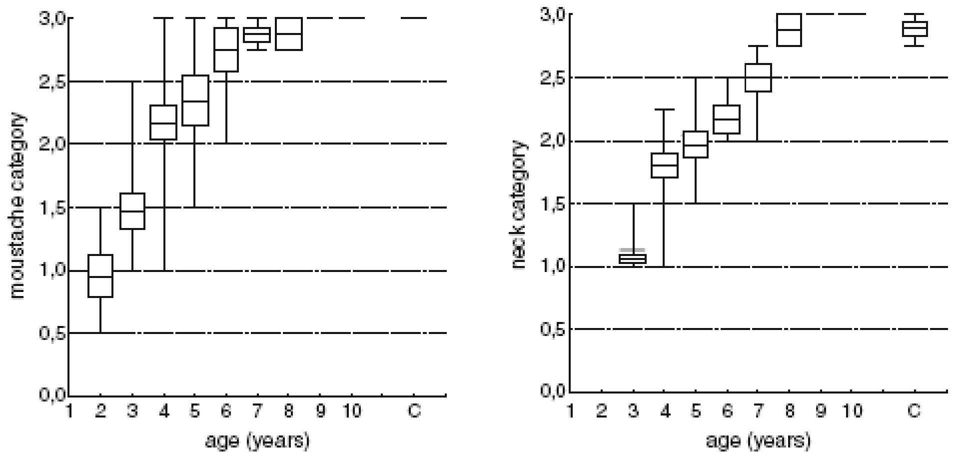

Figure 7: Development of moustache and neck categories with age in male Great Bustards. Means±1 S.E., minimum and maximum values of both sex traits during the mating period (late March–early May) are represented. Birds aged 1 were about to be 1 year old that spring, i.e. in their second calendar year. To confirm the categories for ages >8 years, for which our sample of birds marked as chicks was too small, we used a control sample of five males captured as adults and tracked throughout 5–7 years. Their mean moustache and neck values for the springs when they were of ages 8 years or more are represented under C in both graphs.

Our results confirmed that average moustache length and neck categories increased with age in male great bustards. We suggest that four post-juvenile age classes can be distinguished through their neck plumage designs in spring (Figure 8). The first corresponds to two-year-old birds, which can usually be distinguished from 1-year-old birds (hatched on the previous year) by the more apparent brown spots at both sides of the neck base. First-year males strongly resemble adult females, with whole neck and central chest pale ash-grey and brown only on the lower hindneck, extending to both sides of the upper chest, but spots in the foreneck base usually absent or much less marked than in two-year-old birds. In addition, none of our marked birds had moustaches when they were one year old, whereas all had already grown short moustaches at the age of two years. The differentiation of one- and two-year-old males is sometimes difficult even for experienced observers, and behavioural traits may be helpful in such cases. First-year males are typically associated to females during the spring of their second calendar year, in contrast to two-year-old males, who tend to aggregate in male flocks with individuals of their same or subsequent immature cohorts.

Figure 8: Development of spring neck plumage with age in post-juvenile male Great Bustards (drawings by J.C. Alonso).

The second age class that can be recognized corresponds to three-year-old birds. The upper half of their neck is grey, of a lighter shade than in younger males, but clearly different from the ivory white of older males. The lower half of the neck is chestnut brown, forming at the neck base a collar of much wider extension and notably duller shade than in older males. The chestnut colour of hindneck almost reaches the nape. A key character of this neck pattern is the absence of a creamy-yellow fringe separating the upper grey half from the lower chestnut-brown half.

The third age class includes males aged four–seven years. It is interesting to note that this change in plumage pattern coincides with the acquisition of sexual maturity and access to females (4–5 years). Males aged ≥4 years can be distinguished from younger birds by the white throat and upper foreneck and the broad intermediate creamy-yellowish band, which grades to intense chestnut brown on the chest. Each of these three bands, white, yellowish and chestnut, occupy approximately one third of the neck's height, and the chestnut colour is much more brilliant than in neck category 1. The neck base is also bulkier due to the longer, hanging breast feathers, which according to Gewalt (1959) grow after the partial moult in winter to more than double their length of the non-breeding season. This provides the necks of adult males with their typical massive, powerful appearance.

Figure 8: Adult males are fighting in spring. From this point of view the male in the right seems younger likely than the others, ranked to the second or the third age class.

Finally, our fourth age class comprises males aged eight years or more (see the front cover of this annex and Figure 8). The white colour of the neck is much brighter at this age than in younger males, particularly at the neck sides, extending approximately over the upper two thirds of the neck height. The chestnut colour of the neck base is also much more intense, and the intermediate yellowish band separating white from chestnut is typically reduced to a thin fringe. This produces a highly contrasting white–chestnut pattern and makes the chestnut collar appear narrower than in younger males. In addition, the chestnut collar is open in the front so that the pure white colour of the upper foreneck reaches the lower breast, notably increasing the overall extent of the white plumage surface. The white colour of the upper neck is most visible when the male is in rest or alert posture and under good light conditions. When males inflate their neck during display, the stretched front neck feathers may show up a more creamy-yellowish colour and appear less white.

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Annex 2

of the Guidelines for Monitoring of Population Parameters of Great Bustard and of the Effects of Management Measures

Guidelines for Great Bustard Nests

Prepared for the Memorandum of Understanding on the Conservation and Management of the Middle-European Population of the Great Bustard under the Convention on Migratory Species (CMS) by

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February 2009

(Updated in March 2018)

The nest of a Great Bustard is generally only a shallow, 25-35 cm wide depression in the ground, deliberated bushing has not been observed yet. Wheresome plant pieces line the nest, this is assumed to be accidental. The clutch is usually two, more rarely one or three eggs. The olive-brown, olive-green or rarely pale blue, and well blotched with brown eggs are elliptical. The nests are usually in grass or crops, mainly in winter cereals (Figure 1), Papillionaceae or in other crops, but the fallows (see the photo in the front cover) are also a very frequent nesting site (Faragó, 1983, Morgado & Moreira 2000), although sometimes the eggs are laid in extremely unusual places (Figure 2).

Figure 1: Great Bustard nest in winter wheat

Figure 2: Great Bustard nest in a new potato field.

How can we find a Great Bustard nest? Although the eggs, the nest, moreover the female on the nest are considered relatively large, they are very hard to notice due to their colour camouflage being so bewildering. The nest is nearly impossible to see from a distance of 10-20 metres, if the vegetation reaches the 50-cm height (Figure 3). We notice the nest or the hatching female only if the bird takes wing just before we step on it. In such a case, the female very often drops into the nest (Figure 4). It usually escapes from an approaching machine similarly in the last moment; moreover, it sometimes stays calm sitting on its nest, while the machine passing above it, to expose itself to the danger. Hawk-eyed and patient bird watchers are able to find nests also like that they keep watch on the female, which is sitting on its nest or sneaking to the nest, but in tall vegetation it is very hard to glimpse a female in this way. A female can easily reveal her nearby nest with her typical behaviour; the females are hectic, worried, confused and often examine the sky during the time when they abandon the nest. However, when we can see a female sitting on its nest, we can measure the nest with the help of two or more observation directions – for which a GPS appliance could be very useful, – accurate to within a few metres?.

Figure 3: Great Bustard nesting site in fallow (Bromus grass). In the foreground there is a nest with two eggs, roughly one metre from the point, where the photo was taken.

Figure 4: The female defecated in her nest, while she escaped.

At times we received information about a Great Bustard nest only indirectly or afterwards. Farmers, shepherds, tractor drivers or hunters can give these reports, which are often irreplaceable, that is why it is very important to collect them. If we meet these people during our work, we should ask them about their experiments in reference to the Great Bustards. In this way we can be informed about an "unknown" breeding sites, and due to the nest site fidelity of the females (Alonso et al. 2000), we presumably will find nest in the same field in the future. As we found, they even notify us immediately as they find a nest for a small reward. This needs of course preliminary education, in the course of which we have to tell them what to do if they find a nest.

According to the observations in Germany, where the Great Bustard females can breed securely in the fenced area, but cannot do so outside due to the high predation pressure and the intensive egg collection, the loyalty to the breeding place has an effect on breeding success. After successfully breeding, the females used to breed in the same area year by year, and this is typical in the fenced enclosure. On the other hand, shortly after the loss of the clutch the females look for another place and breed somewhere else next time. However, if the female loses the first egg, she usually lays the second egg nearby in another hollow, but still in the same field (T. Langgemach pers. comm.).

The females are very sensitive to disturbance during hatching. In the first days in the hatching period, it is imaginable in some cases that they abandon the nest forever after the first disturbance. Even more, according to the theory of several experts, if we walk to a nest, our tracks can lead predator mammals to the eggs , but it happens regularly that Corvids follow us, and steal the eggs if we chase the female away from the nest (Figure 5). Accordingly let us never endanger the nests of the Great Bustards as far as possible. Only if we have a well justified reason, should we approach the nest! Simply for scientific reasons and only if it is very important. Do not forget, that this activity has to be permitted!

Figure 5: A female Great Bustard is sitting on eggs, in front of a lurking Hooded Crow.

Figure 6: Eggs are hidden to avoid the nest being raided by predatory birds.

But if we find a Great Bustard nest accidentally, or we have to search for the nest to rescue the clutch, then let us try to note the surroundings and fix the location, and leave the nest as soon as possible to open the door to the female to come back to the nest soon. A Hungarian practice for avoiding the robbing by Corvids is covering the eggs by a handful of plants (Figure 6). It is preferable to come back to the locality 26 days later, when the hatching has finished surely. There are many signs which allow us to draw conclusions at a retrieved or posterior found nest, too. If the transfer of the eggs is necessary, we have the possibility to take more measurements. Let us try to use the measurements to answer the following questions:

- Discovering of the nest:
  - Date and time of the discovering.
  - The location of the nest. If possible, set the coordinates of the nest by a GPS appliance, but signal the location on a map in any case. If it is necessary, use direction lines of observation for the localization. (Handle this information secretly, for fear of that it falls into the hands of incompetents, avoid the simple publication!)
  - Who found the nest and how?
- The stage of the hatching:
  - Is the nest active or abandoned or robbed or successful?
  - If it has been robbed, what animal might have been responsible and when? What kind of signs can be seen?
  - If it is active, how old could it be? (This is difficult, but some signs can provide an indication. E. g. the base of a young nest is novel, slightly trodden. "Cheeping" or cracked eggs show that hatching is imminent.)
  - Are there Great Bustard droppings in the nest or very close to it?
  - If the hatching was successful, when approximately did the offspring hatch?
- The clutch:
  - The number of eggs.
  - The size of each egg: width, length, weight.
  - The colour of the eggs.
  - Are the eggs fertile or sterile? (Only ascertainable afterwards!)
- The environment of the nest:
  - vegetation type,
  - habitat structure (the coverage) and the height of the vegetation,
  - plant species around the nest and their abundance.
  - If it is possible, draw a map about the habitat within 1 km around the nest, like in Figure 7.
  - Obtain information about the disturbance factors in the neighbourhood of the nest.
  - Where are nests of Corvids and lairs of foxes/badgers? What kind of potential nest robbers can be seen nearby?
- Was the sitting female possible to see? What did she do while we were at the nest?
- Activities:
  - Write down, what we did at the nest. Taking photos, measuring the eggs, covering the eggs against predators, etc.,
  - What kind of agricultural activities happened? What is the size of the buffer zone?
  - Later on what happened at and around the nest till the end of the hatching?
- The examination of the nest with a thermos-logger: a thermos-logger is a small gadget, which can be hidden in a nest of a Great Bustard easily without the thermos-logger disturbing the bird during hatching, and it records the temperature of the nest repeatedly, and later this database can show us the process of the hatching and the time, when the chicks hatched or when the female abandoned the nest. However, this procedure can also cause problems.
- Other remarks.

A photo can be very useful not only for simple documentation, but also for answering subsequent questions. Take photos of the nest and its environs. Nowadays a simple digital camera offers an inexpensive opportunity to document every detail plentifully.

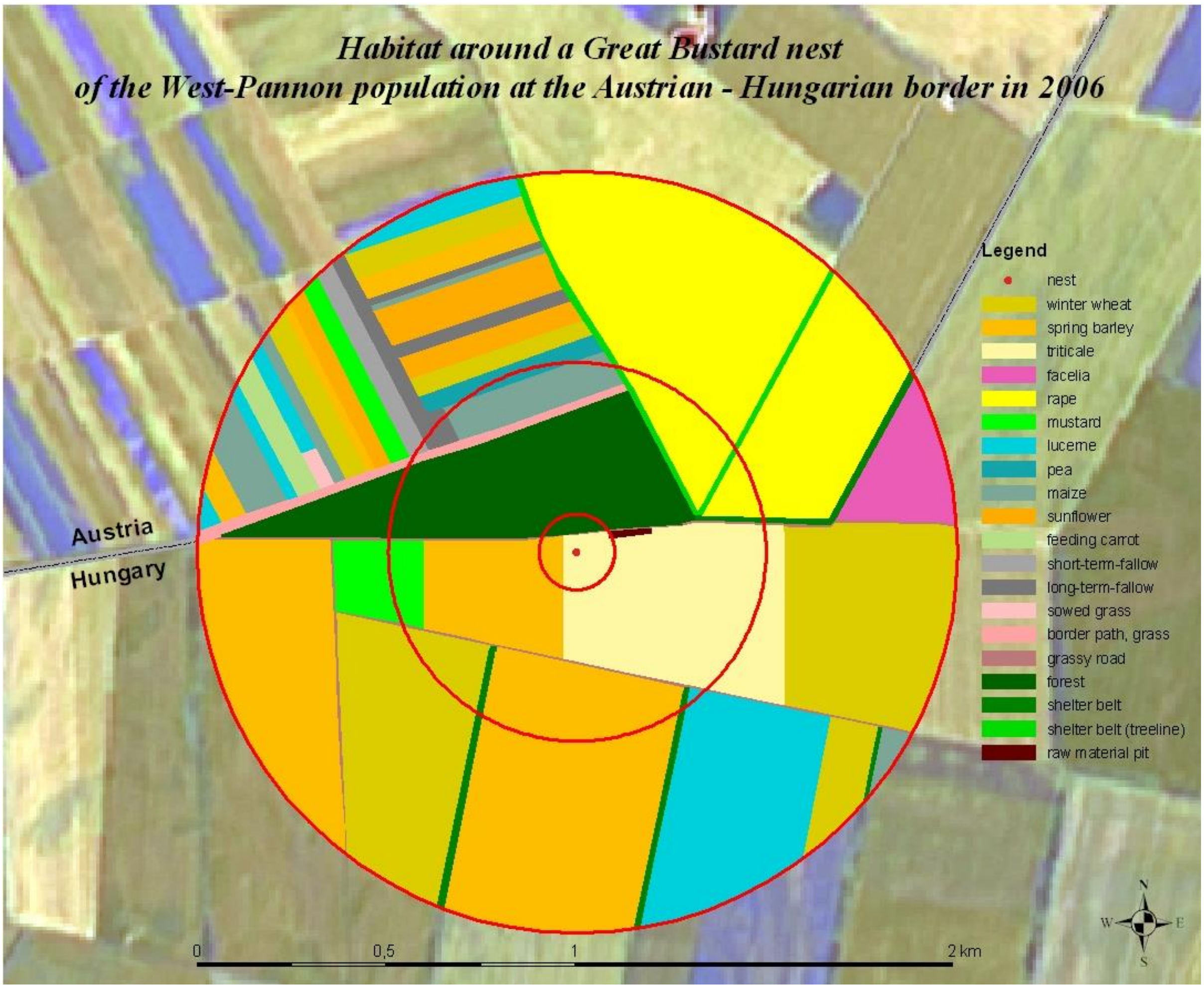

Figure 7: Habitat around a Great Bustard nest of the West-Pannon population at the Austrian – Hungarian border in 2006.

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