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GUIDELINES FOR MONITORING OF POPULATION PARAMETERS OF GREAT BUSTARD AND OF THE EFFECTS OF MANAGEMENT MEASURES

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Birdlife International
European Division

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 has 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 the 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 trend 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 areas) 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 needs information also 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/species/otis_tarda/otis_tarda_bkrd.htm.

[2] http://www.cms.int/species/otis_tarda/meetings/GB_1/pdf/report/Annex6_Medium_Term_Int_Work_Prog.pdf

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 which 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 better to identify the migration routes and resting habitats of the Great Bustard and especially of 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 trend. First, it has to cover **all** sites, i.e. it goes 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 register is maintained as a database at national and at international level. This register can 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 reestablished 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.

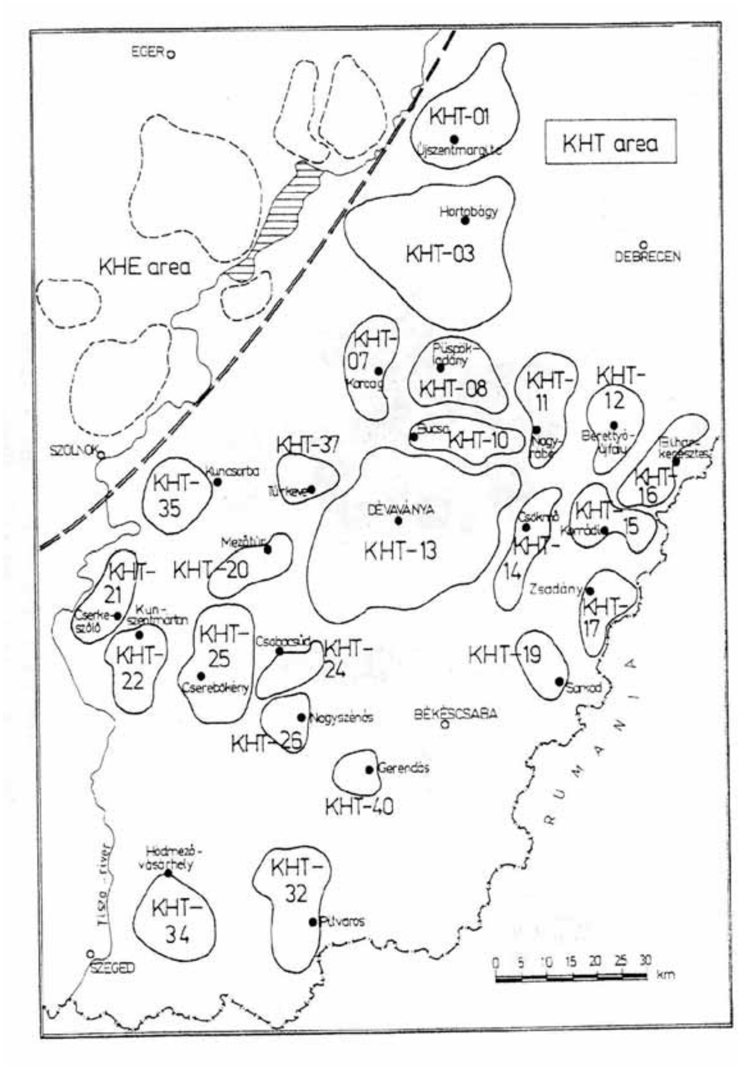

Figure 1: Map of Great Bustard populations in East Hungary (Faragó, 2001). The map delineates the area occupied by each population. In a GIS system, it can be linked to the count data and thematic maps can be retrieved.

Estimating population size

Great Bustard counts should not only 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 would 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 which actually breed in another country (e.g. in case of Austria, Hungary and Slovakia, but also in 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 Russia 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. In contrary Osborne et al. (2007) found in their study that in Russia, where the vegetation covering is much more significant, the effective strip width for males was only 464 m and for females was 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 method (see box 2) for rectifying the population estimation.

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 Russia 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 bigger 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 age and sex (Alonso et al., 1990; Sterbetz, 1978) because the concentration of the species is the highest at this time. It also makes easier the localization of flocks that 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 Russia). 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 Russia);
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 their 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 slower, 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 a lot of birds can still hide in rank vegetation in Central Europe where maize and sunflower is grown at large proportions of the land and 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 make 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).

Organising national censuses

As it 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 who 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 equipments and skilled observers even further.

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

a) Setting the **dates** (especially in case of synchronised 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 equipments 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 situation 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 equipments. 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 that these rapid reports can be produced almost automatically.

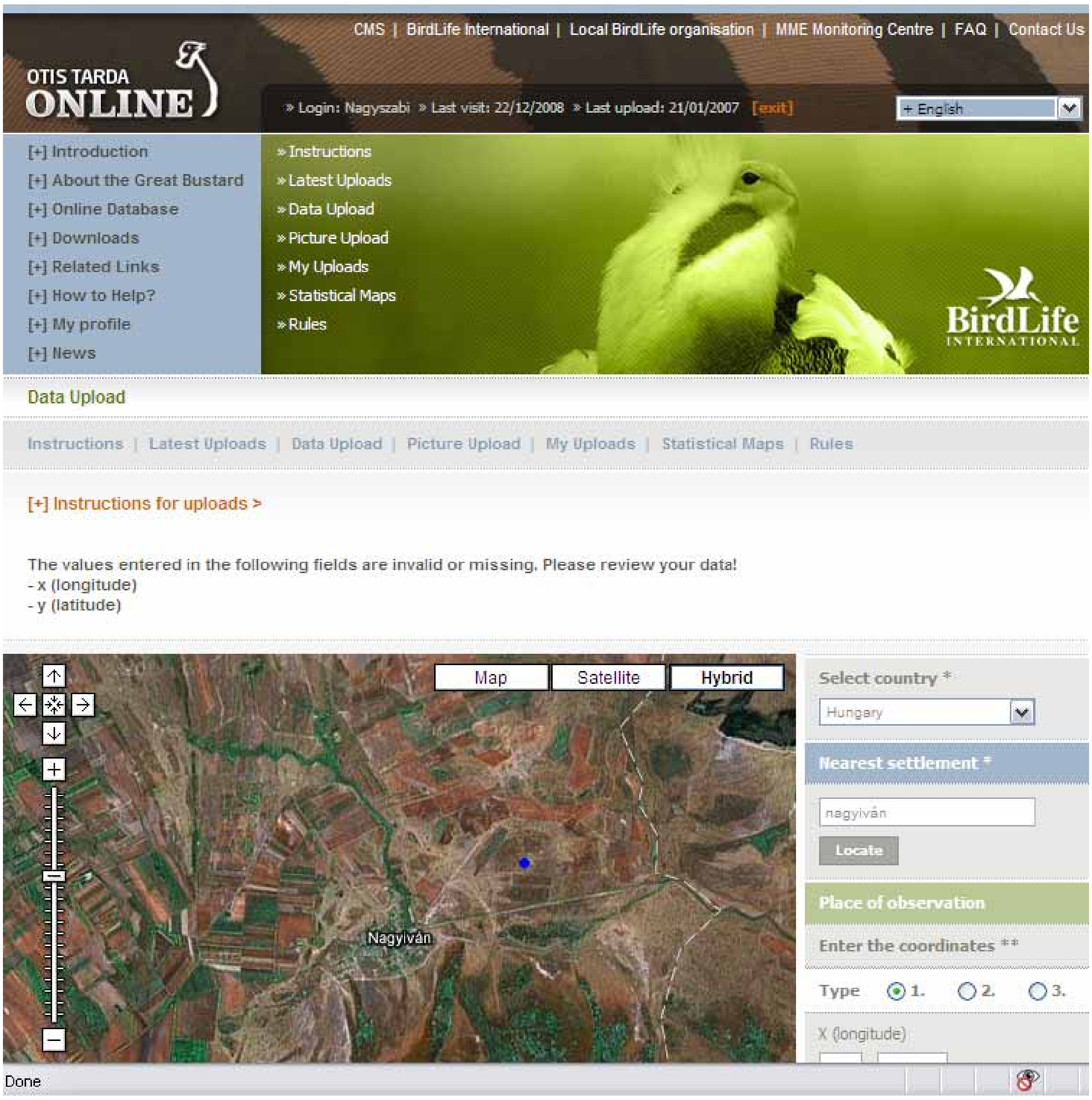

Figure 2. The Otis Tarda Online database has been set up to collect Great Bustard observations. The database can be accessed already in several languages and it can be further expanded on request. It uses Google Maps to assist correct recording of the location.

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 simple 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 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 time. 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 remain still 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 (imput) 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 "changepoints" 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 declining proportion of immature males in the winter flocks can indicate poor or deteriorating breeding conditions. Low or declining proportion 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 recognisable 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 on 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 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 schema. 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 than the cause for the 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 finding back more dead individuals and thus can lead to less biased samples although some limited bias is associated with the technique itself if birds not captured and the transmitters not mounted carefully on them. However, another guidelines 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 rate can be estimated using (a) observed mortality, (b) change in population size, (c) age structure, (d) through mark-recapture methods (Sutherland, 2000).

Mortality rate 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 (1^{st} winter: 5, older birds: 20) at time t, and 27 (1^{st} 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 to 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”. 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 of 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.

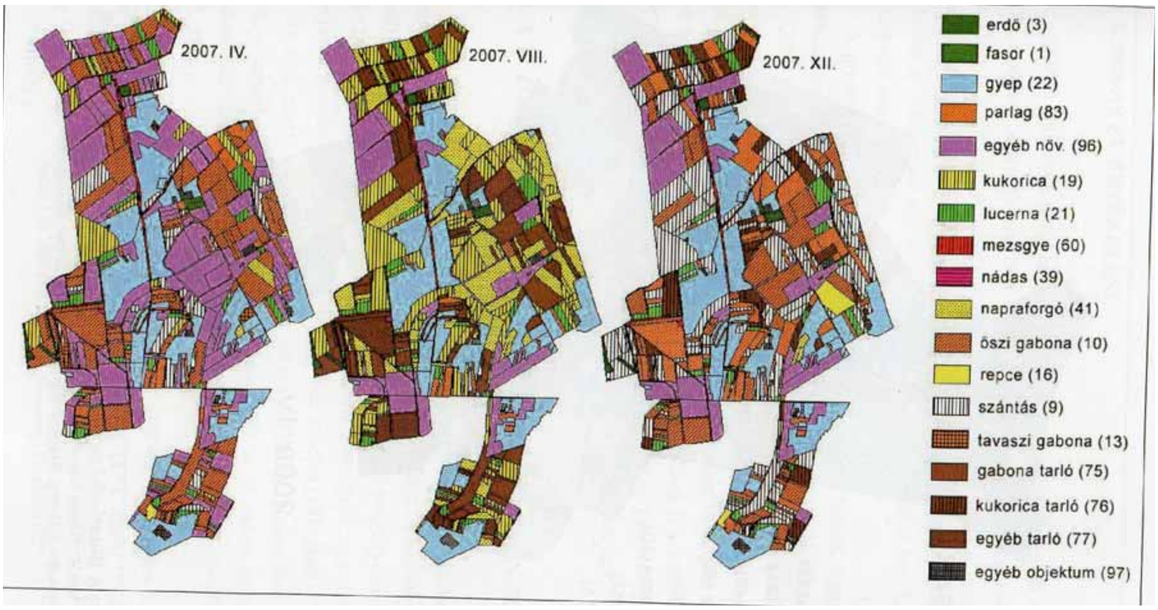

Figure 3. Habitat mapping implemented under the Hungarian LIFE project (Kalmár and Faragó, 2008)

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Annex 1: Guidelines to determine the age of Great Bustard in field

Annex 2: Guidelines for Great Bustard nests