REPORT TITLE


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COVER PICTURE

New-born dorcas gazelle in the Ouadi Rimé-Ouadi Achim Game Reserve, Chad. Photo credit: Tim Wacher/ZSL.

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DEDICATION

This report is dedicated to the memory of the late Sadock Zeubobé Bourtchiakbé, member of Chad’s National Parks Service and valued collaborator of PSWS, who sadly passed away in July 2012. Que la terre lui soit légère et que Dieu l’accueille à ses côtés.
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ACRONYMS

ASG  Antelope Specialist Group of the IUCN
AZA  American Association of Zoos and Aquariums
EAZA  European Association of Zoos and Aquariums
ECWP  Emirates Centre for Wildlife Propagation
IFHC  International Fund for Houbara Conservation
IUCN  International Union for the Conservation of Nature
OROAGR  Ouadi Rimé-Ouadi Achim Game Reserve
PSWS  Pan Sahara Wildlife Survey
SCF  Sahara Conservation Fund
ZSL  Zoological Society of London
1. EXECUTIVE SUMMARY

This report summarizes the results of a 2.5-year pilot phase (December 2009 to June 2012) of the Pan Sahara Wildlife Survey (PSWS). The project, designed by the Sahara Conservation Fund (SCF) and implemented in association with the Zoological Society of London (ZSL), has been made possible thanks to the generous support of HH Sheikh Mohamed bin Zayed Al Nahyan through the Emirates Centre for Wildlife Propagation (ECWP) and the International Fund for Houbara Conservation (IFHC).

The long-term goal of the PSWS is to improve the conservation status of the highly threatened yet poorly known wildlife of the Sahara and bordering Sahel regions of Africa.

Working at all times in close collaboration with the national conservation authorities in the countries concerned, the pilot phase has successfully developed and demonstrated a rigorous, vehicle-based method to obtain scientifically valid data and information on rare desert wildlife and its habitats in the context of existing human land-use and needs, while raising local and international awareness and achieving significant capacity-building.

Minor modifications to the original programme are discussed, noting the pilot phase has achieved unprecedented, large-scale coverage of particularly hard-to-access and poorly-known areas of Africa of unique value to threatened wildlife.

The PSWS pilot phase has generated an impressive quantity of new information and data and has clearly identified well-defined follow-up actions needed to convert the knowledge and information gained into improved ecosystem health and conservation benefits for both wildlife and local communities alike.

Significant national government level support for conservation action in areas studied by PSWS has been achieved in Chad and Niger. In Tunisia, PSWS has added value by using the unique combination of captive and wild Saharan ungulates that exist there to obtain data with direct bearing on improving methods and insight for future wild oryx and gazelle conservation in the region.

Field techniques have been shown to be effective, collaboration and participation with local authorities has been very successful, new discoveries about critically endangered species have been made, the human land-use context has been consistently addressed and incorporated into recommendations. Detailed technical reports, preliminary publications and conference participation have been completed. Richly illustrated examples of all these outcomes and achievements are presented in this report.
2. INTRODUCTION

The large bird and mammal fauna of the Sahara is one of the most threatened yet poorly known on earth. Drought, desertification, habitat loss and especially over-exploitation have reduced many species to the verge of extinction. The Sahara Conservation Fund (SCF) was established in 2004 to address this urgent and challenging situation.

As part of its strategy, SCF is undertaking a series of large scale surveys across the Sahara (Box 1) in close collaboration with the environment and conservation authorities of the countries involved. The broad objectives of this Pan Sahara Wildlife Survey (PSWS) are to provide top quality and up-to-date information on the status of wildlife, habitats and associated land-use practices in selected critical areas. As well as building capacity to gather and use this information and data, PSWS is also being used to increase knowledge and interest in the area and its wildlife, and to develop recommendations for actions to improve land-use management for the benefit of both the wildlife and the people of the Sahara and bordering Sahelian grasslands.

Thanks to the generous support of HH Sheikh Mohamed bin Zayed Al Nahyan, Crown Prince of Abu Dhabi, it has been possible to launch this ambitious programme. An agreement between SCF and the Emirates Center for Wildlife Propagation (ECWP) to cover the funding for an initial pilot phase of the PSWS was signed in August 2009. A cooperative agreement between SCF and ZSL was subsequently signed, allowing the project’s leader, Dr Tim Wacher (Fig. 1), to be seconded to the programme. To help monitor progress, SCF formed a project steering committee, composed mainly of representatives of the participating organisations. The first field survey of the pilot phase of PSWS got underway with a mission to Niger in late November 2009. Fieldwork carried out under the pilot phase concluded in April, 2012.

This summary report provides a synthesis of the main achievements of the pilot phase of the Pan Sahara Wildlife Survey. Full reports on the individual surveys, in English and French, are available for download from the SCF and ZSL websites (see Annex II for details).
3. **PSWS GOALS**

The long term goal of PSWS is to improve the conservation status and chances of survival of Sahelo-Saharan wildlife, identifying conservation actions needed to achieve this.

To bring this about it is necessary, *inter alia*, to obtain up-to date information on the distribution and conservation status of key species and their habitats by:

- providing data on wildlife numbers, distribution and conservation status (Box 2), as well as threats, habitat condition and land-use practices;
- identifying and prioritizing conservation “hot spots” for urgent action, including the establishment of protected areas and species recovery and reintroduction programmes;
- Establishing a scientific basis for decision-making on consumptive and non-consumptive uses of wildlife (hunting, tourism, etc.)
- providing a practical opportunity for on-the-job training of staff from local conservation agencies, conferring genuine field experience;
- providing data to support implementation of international conventions (CBD, CCD, CMS, CITES, Climate Change, etc.);
- identifying practical measures to improve wildlife conservation prospects in study areas;
- supporting international efforts to list and raise support for the conservation of endangered desert species (IUCN Red List, Global Mammal Assessment, Species Action Plans, etc.)

**Box 2: Selected wildlife observations**

- PSWS surveys have reported on 23 species of larger mammal (>1kg adult body weight)
- 40% of these species are under recognised levels of threat according to IUCN conservation criteria
- PSWS has provided the only contemporary scientific estimates of dorcas gazelle and camel numbers in key populations of Chad and Niger
- PSWS has confirmed the extent of range reduction of the critically endangered dama gazelle
- PSWS has made the first scientific estimates of local population size in Sahelian bustard species
- PSWS has contributed important information on the distribution and breeding behaviour of highly threatened vulture species
- PSWS distribution data on >250 species of birds has been collected
- Many of these observations are totally new, applying to previously unreported regions

Examples of ways in which these goals have been achieved are highlighted in the pilot phase are described in a summary of main results and achievements (pages 9-24).

4. **SURVEY METHODS**

While exploring the feasibility of achieving the above objectives, the pilot phase was also seen as an opportunity for the development and testing of survey methods. PSWS has convincingly shown the use of vehicle-based operations to carry out reconnaissance and more formal, structured transect-based surveys is an effective tool for obtaining valuable information about desert fauna and land-use over extensive and sometimes difficult-to-access areas. Experience in the field has resulted in ongoing improvements in methodology, including data collection protocols and adaptation of original sampling designs, increased use of stratification, restricted randomisation of recording location, and introduction of systematic photographic recording of habitats to establish an historical record and baseline for future reference.
The field methodology developed so far has been focused primarily on relatively open habitats, where vehicle-based survey and transect design are possible. Survey methods for high value mountain regions, using stratified sampling of the more diverse habitat structure, and greater use of techniques such as fixed point monitoring, both for observation and camera trapping, need to be refined in a further phase of the PSWS. A description of the basic PSWS field methodology is given in Annex I.

The PSWS format has been sufficiently flexible to allow additional inclusion of a remote sensing methodology, not planned at the outset, permitting a detailed historical survey of habitat productivity trends at a key site in Chad, where PSWS ground surveys indicated justification for high value conservation action.

5. PROGRAMME PLANNING

The programme plan submitted with the original PSWS proposal called for surveys in Niger, Chad, Tunisia and Algeria, with exploration of options for surveys in Egypt and Senegal. Key points are summarised below:

* **Niger and Chad:** During the first nine months of the pilot project the proposed schedule was followed exactly, with a series of surveys in different parts of Niger. Minor changes to the proposed programme were subsequently introduced when it became clear that surveys in Chad were likely to be particularly productive, with strong support from national institutions ensuring work could be developed rapidly.

* **Tunisia:** As a consequence of programme modifications, the scheduled Tunisian survey was postponed until November 2011, when PSWS-funded work provided the first formal survey of slender-horned gazelle status in Senghar National Park, generated important data on slender-horned gazelle field recognition from tracks, and summarised a unique database analysing scimitar-horned oryx behaviour under extensive fenced management in North Africa.

* **Senegal:** The proposal to explore options for survey work in Senegal was carried out with the authorities but implementation postponed in the light of expanded operations in Chad and also to avoid duplication of effort with other parties already engaged in that country (Spanish scientists).

* **Algeria:** Although a scoping visit to Algeria was completed successfully and a survey planned, this was cancelled by the Algerian authorities shortly before fieldwork was due to commence. In spite of this and the rather complex institutional framework, Algeria is still considered a high priority for PSWS.

* **Egypt:** Although initial contacts with Egyptian counterparts made in 2010 were very favourable to PSWS activity, on-going modifications to the programme, coupled with political developments in Egypt in early 2011, meant this has yet to be followed up.

Although the geographic range of the PSWS pilot phase has been smaller than originally expected, the surveys completed provide a unique overview of Sahelo-Saharan wildlife across a very large contiguous area. This has allowed acquisition and reporting on a set of coherent results of a type and on a scale never before achieved at this level of detail. The deliberate geographic clustering of PSWS interventions has generated additional benefits from its trans-boundary context and provides a model for extension to other regions of the Sahara, where accurate knowledge and awareness of species’ trans-boundary distribution is an important factor in effective conservation planning.
With some elements of the pilot phase not completed for the practical reasons explained above, it was possible for PSWS, through its association with the Zoological Society of London and ZSL’s Institute of Zoology, to expand the remit in a new direction. A study of monthly vegetation productivity over 25 years at a key PSWS field site, the Ouadi Rimé-Ouadi Achim Game Reserve in Chad, was completed, providing a basic component supporting feasibility assessment for one of the key conservation action outcomes recommended by PSWS – the rehabilitation of the game reserve and reintroduction of scimitar-horned oryx.

6. SITE SELECTION AND CONSERVATION VALUES

The PSWS pilot phase has completed highly productive surveys at six sites in Niger and Chad, and two sites in Tunisia (Fig. 2). All sites were selected for their known or suspected importance for desert biodiversity and were in line with the priorities identified by the national conservation authorities with which PSWS partnered.

A key element of the PSWS concept is to use survey results to stimulate well-informed conservation action. An overview of recommendations and actions emerging from the pilot surveys is given for each site below:

**Niger - Termit/Tin Toumma:** The only known site in the Sahara where addax, dama gazelle, dorcas gazelle, cheetah, Barbary sheep, and significant bustard populations are still found together\(^1\). PSWS provided critical technical support and training for the development and implementation of a

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\(^1\) A list of the common and scientific names of all species mentioned in the text can be found in Annex IV.
wildlife and habitat monitoring programme for ungulates, bustards and large raptors. Data acquired has been fundamental in supporting the process for the area’s successful gazettment as the Termit and Tin Toumma National Natural Reserve by the Nigerien government in early 2012 (Fig. 3). At 97,000 km², the reserve is the largest in Africa.

*Niger - Gadabeji Game Reserve*: Gadabeji is an established wildlife and forest reserve retaining good quality Sahelian habitat, but which has lost a significant proportion of its large mammal diversity. The reserve was previously targeted as a site for scimitar-horned oryx reintroduction, though this has yet to happen. The protected area acts as a significant reserve for trees and timber, and also provides very important dry season and drought period grazing for livestock.

PSWS has carried out the most comprehensive dry season status survey of Gadabeji wildlife and livestock ever undertaken. It is essential to conduct a repeat survey in the wet season to establish the importance of annual transhumance movements to livestock and wildlife. Socio-economic factors will require highly skilful management for any renewed conservation action because of the intense human/livestock presence and utilisation, which has been quantified by PSWS. A fenced reintroduction, perhaps with options for *in situ* release in event of excessive population growth, may be the most realistic option for scimitar-horned oryx, but will risk diminishing the effective size of the pastoral zone and grazing resource. A larger scale strategic overview of ecological linkages between Gadabeji and the surrounding areas is essential before any form of oryx reintroduction is attempted.

*Niger - Gadafaoua/Taguedoufat*: This is a large zone used for many years as an extensive sport hunting concession but never before surveyed. The site was visited by PSWS at the specific request of the Nigerien wildlife authorities keen to assess its potential for further hunting development.

PSWS has shown the south-west and central parts of the zone to be very important livestock grazing areas, including an active traditional camel-based trading route through Taguedoufat village. Wildlife resources are low compared to other areas surveyed by PSWS and exploitation of gazelles and other wildlife is being undertaken without control (Fig. 4). Intervention to protect wildlife will be necessary as a part of a proper management plan for wildlife utilisation (also in need of development). The PSWS survey highlighted for the first time the essential need to ensure that interventions to control the target area for managed utilisation do not push illegal activities into the biologically more sensitive, valuable and recently gazetted Termit region.
Chad - Manga and Eguey: An area of extensive Sahelo-Saharan habitats, currently without formal protection, holding significant wildlife (bustards, dama and dorcas gazelles, addax), known only from brief reconnaissance surveys carried out in 2001 and 2006 (Monfort et al. 2004, Newby 2006). PSWS work in this area provided the first formal estimates of gazelle, bustard and livestock density and confirmed the continued presence of dama gazelle after a 10-year interval when no surveys took place. As elsewhere in the Sahelo-Saharan region, it was recommended that development of local capacity to monitor critically endangered wildlife is a priority, especially for areas holding important endangered wildlife populations and offering unique potential for Sahelo-Saharan wildlife restoration. Establishment of a Chadian monitoring team, using PSWS methods to make annual surveys of the Manga and Eguey to survey critical dama, bustard and addax populations would be an ideal next step. A summary of the resources required to establish monitoring capacity has been supplied to the relevant authorities.

Chad - Ouadi Rimé-Ouadi Achim Game Reserve: This is one of the largest protected areas in the Sahel (77,950 km²), and the last stronghold of scimitar-horned oryx before its extinction in the wild in the 1980-90s. The reserve had not been surveyed since the 1970s except for a single reconnaissance in 2001 (Monfort, Newby et al. 2003), when it was found to be still holding significant populations of dorcas gazelle and bustards.

PSWS visited the reserve in mid dry season (January-February), late wet season (September) and late dry season (April). In addition, an analysis of 25 years of monthly vegetation productivity via satellite imagery was undertaken (Fremantle 2012).

PSWS results highlight the reserve has maintained a slow increase in vegetation productivity over its southern half, supports large numbers of nomads and their livestock, using growing numbers of well sites, but also holds the world’s most important dorcas gazelle population (in the 10s of thousands at least) as well as healthy populations of bustards and other species. Significantly, a very small population of dama gazelle has persisted with little direct conservation activity, though the emblematic species of the region, the scimitar-horned oryx, has been lost.

PSWS reports have documented the scientific evidence for these observations and recommended that the reserve requires an integrated management plan to insure continued productivity of the habitat for both people and wildlife, mitigating the current risk of habitat loss through ad hoc and inappropriate development. The broad proposal, including reintroduction of scimitar-horned oryx as a flagship for the reserve, received strong local and national government endorsement in an SCF-sponsored workshop to discuss the reintroduction of oryx in May, 2012 (Bemadjin & Newby et al. 2012).
**Tunisia - Senghar National Park:** This southern Tunisian park lies in the mixed gravel plains and dune systems at the eastern margin of the Grand Erg Oriental, close to the international border with Algeria. The presence of addax in the area at the end of the 19th century through to the 1930s is well documented (Sclater and Thomas 1898, Kacem *et al.* 1994). The park was created in the 1990s to develop infrastructure and desert tourism in southern Tunisia, act as a reintroduction site for addax, and to protect Saharan landscape and fauna, including notable indigenous populations of dorcas and slender-horned gazelle (IUCN Endangered).

PSWS worked with a team of Tunisian colleagues to complete the first systematic survey of slender-horned gazelle status in the park since its creation. Results showed signs of gazelles to be widespread, but extreme elusiveness was consistent with strong hunting pressure. This has since been confirmed by significant numbers of Internet-based images. As elsewhere, rangers were trained in field survey methodology (Fig. 5). A notable result has been the creation of a data set confirming reliable criteria for distinguishing dorcas tracks from slender-horned gazelle tracks, comparing hoof print measurements from unseen wild animals with hoof prints from certainly

![Images of rangers conducting surveys in the desert.](image_url)

*Fig. 5* PSWS has trained counterparts from partner organizations in Tunisia, Niger and Chad.
identified managed stocks of both species.

*Tunisia – Sidi Toui National Park:* This park lies in the pre-Saharan coastal steppe of Tunisia, near the border with Libya. It is a 6000 ha fenced area, which has supported a reintroduced population of scimitar-horned oryx since 1999.

PSWS provided an opportunity to maintain and analyse results of a unique study of scimitar-horned oryx behaviour based on systematic data collection over a 5-year period on movements and social organisation of known individuals. The resulting report is the most comprehensive description of scimitar-horned breeding behaviour and social structure in an extensive enclosure system, including comparisons with wild East African and reintroduced Arabian oryx data. Key management issues for fenced populations arising from natural oryx behaviour are also identified. Results also provide insights and predictions for larger scale scimitar-horned oryx reintroductions and have contributed significantly to the forthcoming chapter on scimitar-horned oryx in the soon-to-be-published Mammals of Africa (Kingdon and Hoffman 2013).

### 7. SUMMARY OF MAIN ACHIEVEMENTS

Work in the eight sites selected for action during the pilot phase of the Pan Sahara Wildlife Survey has resulted in a substantial list of achievements, many of them unique:

- Field techniques and methodologies for wildlife survey have been refined and developed, clearly demonstrating their value at large scales and in a variety of habitat, land-use and development contexts (unprotected areas, hunting concessions, prospective wildlife reserves, established protected areas, etc.) (Fig. 6).
- Excellent collaboration and support from respective national wildlife and protected area authorities was established at all study sites.
- Twenty-three people from Niger, Chad and Tunisia, representing eight established or prospective protected areas or hunting concessions, have been trained in a broad range of survey and monitoring techniques and gained direct field experience by full participation in PSWS field work.
- Unique and significant new information on the wildlife resources of Chad, Niger and Tunisia has been obtained in a unified fashion on a scale never before attempted in these regions.
- PSWS surveys have been distinctive in systematically gathering data on both wildlife and livestock and human land-use activity, critical to understanding and developing acceptable and integrated conservation initiatives.
- By adjusting the pilot phase programme and focusing primarily on two adjacent countries (Niger and Chad), a coherent overview the most important remaining wildlife region in the entire Sahelo-Saharan zone has been achieved.
- The potential for replication and expansion of the PSWS approach over a wide range of sites and countries in the Sahara and Sahel has been demonstrated.
- In collaboration with Al Ain Zoo, and the Zoological Genetics Unit, Royal Zoological Society of Scotland, information on the genetics of wild dama gazelle, one of the region’s most striking and critically endangered flagship species, is being improved with direct implications for future conservation management in captivity and in the wild.
- The first formal survey of slender-horned gazelle in Tunisia’s Senghar National Park has been completed and techniques for discrimination of slender-horned gazelle field signs from those of sympatric dorcas gazelle have been developed and tested; a valuable tool to improve reliability in north African gazelle monitoring.
• The most comprehensive description to date of scimitar-horned oryx behaviour in an extensive fenced area of Tunisia, based on a five-year database of individual monitoring records, has been completed.

• A comprehensive review of trends in vegetation productivity at the Ouadi Rimé-Ouadi Achim Game Reserve in Chad, using NDVI analysis of monthly satellite imagery over the last 25 years, has been completed, showing increasing productivity in the south, decreasing productivity in the north, and a hardening boundary between desert and Sahel in this region.

• PSWS data played a key role at a national workshop on the reintroduction of the scimitar-horned oryx to the Ouadi Rimé-Ouadi Achim Game Reserve, held in N’Djamena, Chad in May 2012, leading to strong formal support for reserve rehabilitation and oryx reintroduction.

• PSWS activity and results have been published on-line in a series of comprehensive, technical reports (available on the SCF and ZSL websites), through presentations in scientific fora (SSIG, ZSL, Oxford Deserts Conferences 2010 and 2012, EAZA 2012, AZA 2012), and through articles, i.e. IUCN Antelope Specialist Group Gnuletter, ZSL Wildabout magazine, African Bird Club Bulletin, SCF Sandscript newsletter (see Annex III).

• PSWS steering committee planning meeting held at Zoological Society of London, July 2011, reviewing progress to date and recommending an expanded and continuing programme.

• Development of a proposal for the consolidation of PSWS, incorporating recommendations of the steering committee, including expansion to new survey areas and on-going support to help realise conservation actions recommended in outputs of the pilot phase, notably protected area establishment in Niger, dorcas gazelle studies and scimitar-horned oryx reintroduction in Chad.

Fig. 6 PSWS has demonstrated ability to work in a variety of Sahelo-Saharan habitats, e.g. Termit Massif, Niger (top), seasonal wetlands of the Bahr Al Ghazal, Chad (middle), Abu Tuyoor, Chad.
8. SELECTED KEY RESULTS OF THE PAN SAHARA WILDLIFE SURVEY

8.1 New information on the dama gazelle

In visiting five widely-separated locations of prime dama gazelle range, PSWS has confirmed this fine gazelle’s continued presence, albeit in small populations, at three of them.

In Chad, these include the Manga and the Ouadi Rimé-Ouadi Achim Game Reserve, sites that have been entirely dependent on PSWS for survey work in recent years. The discovery of dama gazelles in the reserve is the first formal confirmation of its presence there in over 30 years, providing a favourable indicator that the reserve remains viable for large antelopes. This has positive implications for the reintroduction of the scimitar-horned oryx and other species.

In collaboration with Al Ain Zoo and the Zoological Genetics Laboratory in Edinburgh, PSWS has enabled collection of genetic material from dama gazelles in three widespread locations (Termit, Manga, and Ouadi Rimé-Ouadi Achim) across two countries, Niger and Chad, permitting genetic comparison of wild stocks with captive animals (Fig. 7). This is a particularly valuable contribution to developing the best captive management and conservation planning strategy for this critically endangered but phenotypically variable species, and will be valuable in decision-making on potential reinforcement of wild populations from appropriate captive stocks.

Fig. 7 Confirmed presence of dama gazelle at three sites in Niger and Chad (top left), collection of faecal samples for genetic analysis (top right), and adult female gazelle observed in the Termit Massif of Niger (bottom).
8.2 **Support for addax conservation**

Through survey work, design of monitoring programmes and data analysis, PSWS has provided major support to the only initiative currently underway to conserve the critically endangered addax antelope in the wild.

By systematically taking account of human activities within target areas, PSWS methods have achieved a unique record of physical impacts of oil industry exploration and development in the heart of the last known addax range in Niger (Fig. 8).

At the same time, PSWS methods have shown their flexibility to enable tracking of wide ranging addax as they move in response to changes in range condition and human activity. The systematic, scientific approach to wildlife and landscape monitoring, providing a solid evidence base for recommendations to protect the Termit Tin Toumma system, played a key role in ensuring approval for official reserve gazettement in early 2012.

Fig. 8  Distribution of the addax in relation to oil developments in the Termit & Tin Toumma National Nature Reserve, Niger, between 2008 and 2012.
8.3 **New information on dorcas gazelles**

PSWS has recorded dorcas gazelles in all survey areas, showing very low encounter rates in a hunting zone, very low densities where livestock numbers are high, but also highlighting very significant populations in some areas, underlining the gazelle’s ability to cohabit with traditional pastoralism (Fig. 15).

PSWS methods have also provided the most extensive and in most instances the first scientific estimates of dorcas population size and density in the region (Fig. 9), demonstrating major strongholds of dorcas still exist in Chad’s Manga (>8000 estimated) and Ouadi Rimé-Ouadi Achim Game Reserve (>10,000 estimated within only a 5% sample of the area of the reserve). High densities were confirmed over repeat visits, making the reserve the best known global population centre for the species. Seasonal survey has also shown strong evidence of differential seasonal use according to vegetation and shade distribution, prompting a detailed proposal for a satellite telemetry study of dorcas in relation to habitat productivity and human activities.

Evidence of a desert hunting trade focused on slaughter of dorcas in the interior of the Sahara, supported by motorised transport (motorcycles and pick-up trucks) to achieve probable sale in towns and countries to the south has been highlighted.

![Confirmed presence and density estimates of dorcas gazelle in Niger and Chad (top left), dorcas gazelle calf (top right) and typical gazelle herd in Chad (bottom).](image)
8.4 New information on slender-horned and dorcas gazelles in North Africa

The PSWS field survey of slender-horned gazelle provided evidence that although widespread and readily detected at the edge of the Tunisian Erg Oriental, this species (IUCN Red List ‘Endangered’) is currently under severe hunting pressure. PSWS also enabled development of a tool to support the objective discrimination of slender-horned gazelle tracks from those of dorcas gazelle. This is of particular value because the two species are sympatric over a large part of both their ranges at the edge of the major North African ergs and identifying tracks reliably is a key to understanding presence and distributions (Fig. 10).

![Comparison of slender-horned gazelle footprint size data (blue points in graph at top left) with dorcas gazelle footprint size data (yellow points), and unseen wild gazelle tracks (grey) showing 90% decision limits (dotted parallel lines) of a logistic regression model giving probabilities to assign unknown tracks to one species or the other.](image)

**Fig. 10** Comparison of slender-horned gazelle footprint size data (blue points in graph at top left) with dorcas gazelle footprint size data (yellow points), and unseen wild gazelle tracks (grey) showing 90% decision limits (dotted parallel lines) of a logistic regression model giving probabilities to assign unknown tracks to one species or the other.
8.5 Behaviour of scimitar-horned oryx

PSWS enabled extension of detailed systematic data collection on scimitar-horned oryx behaviour in a 6,100 ha fenced natural park to five years. The resulting analyses confirmed territorial behaviour by adult male oryx, more wide-ranging and socially flexible behaviour of adult females, isolation by females for calving, choices in consortship by oestrous females moving between territorial males, and high conflict and social changes associated with territory establishment by maturing males. Similarities to natural behaviour of other oryx species has been illustrated; potential problems of conflict and distorted breeding success arising from installation of artificial feeding stations and fencing restriction have been highlighted and comparative information giving insight to possible behaviour in future unfenced releases is now available (Fig. 11).

Fig. 11 Spatial records of 6 adult male scimitar-horned oryx at Sidi Toui National Park, 2010-2011. Oryx were living at a density of ~0.5 oryx /km² during these observations and individual adult females travelled widely throughout the available space in groups, moving through male territories. At post-partum oestrous females have also been documented isolating from herds and visiting more than one territory.
8.6 New information on bustards

PSWS surveys have provided the first scientific estimates of large Sahelian bustard abundance in extensive areas of Niger and Chad. The most widespread and abundant species encountered, Nubian bustard, returned conservative local population densities of around 1 bird/2-5 km² found over separate >1000km² study blocks in the Chadian Manga and OROAGR (Fig. 12).

Fig. 12 Population density estimates of Nubian bustard as derived from surveys across contiguous blocks in Niger and Chad.

A positive trend in Nubian bustard encounter rates at Termit, previously heavily hunted, was detected over three years from data collected using PSWS methods.

Although both Tunisian surveys occurred within the range of Houbara bustard, the failure to detect even signs of this species in either survey marks a notable contrast to the Sahelian situation.

Significant seasonal changes in Nubian bustard group size (largest in mid-dry season) have been recorded and new information on bustard predation gathered. In one case, in the Manga region of western Chad, a Nubian bustard was attacked and killed in flight by a large eagle, later identified as a golden eagle *Aquila chrysoetus*, the first record of the species in this part of the country (Fig. 13).

Fig. 13 PSWS surveys in Chad and Niger have both recorded the extremely rare golden eagle in both countries. In one case in Chad’s Manga region, a golden eagle was observed bringing down and eating a fully grown adult female Nubian bustard.
At OROAGR, strong seasonal changes in distribution and relative abundance of the three largest bustard species, Nubian, Denham’s and Arabian, have been recorded indicating differing local migration and breeding strategies with season (Fig. 14). Peak densities of Arabian (0.39/km²) and Denham’s (0.25/km²) were recorded in September when evidence of breeding by Arabian, but not Denham’s, has been found; peak Nubian bustard density (0.25/km²) occurred in mid dry season (January-February).

Fig. 14 Strong seasonal changes in distribution and relative abundance of the three largest bustard species, Arabian, Nubian and Denham’s have been recorded.
New information on livestock and land-use

The PSWS methodology has allowed scientific estimates of livestock numbers in four extensive locations to be developed. Reconciling livestock development with wildlife conservation is one of the most critically important and pressing concerns today. PSWS methodology is uniquely placed to collect data on wildlife and livestock presence and abundance simultaneously and objectively over large areas.

Extreme livestock densities, (up to 40-50 tropical livestock units/km² at Gadabeji) have been demonstrated in association with very low gazelle numbers (0.07 dorcas/km²) and extirpation of oryx and dama in a small protected area in Niger (Fig. 15).

High livestock densities (5 camels/km² in the Manga – from 3-20 camels/km² locally in different parts of OROAGR) have been demonstrated sharing areas with very significant populations of gazelles (6 dorcas/km²), remnant populations of dama gazelle and other species (Fig. 16). The PSWS surveys have helped document the extensive expansion of well development relative to the 1970s, when oryx and dama were numerous in the OROAGR (Fig. 17). But PSWS has also shown important wildlife stocks remain in large protected and unprotected areas in Chad where traditional pastoralism still predominates (Fig. 18).

Fig. 16 PSWS surveys pay particular attention to livestock and pastoralism as part of land use appraisals. Over stocking of livestock and the accompanying problems of soil erosion and desertification will need careful management to ensure wildlife populations recover and prosper.
Fig. 17 Wells and oryx sightings in the 1970s (top) and wells in 2012 with 1970s oryx distribution overlaid for comparison. Ouadi Rimé-Ouadi Achim Game Reserve, Chad.

Fig. 18 Water drawn from traditional hand-dug well (left) and more modern cement-lined wells (right) continue to sustain many pastoralists and their livestock in central Chad and other Sahelo-Saharan nations.
8.8 **Local participation and capacity building**

All PSWS surveys have been carried out in close cooperation with the relevant wildlife and protected areas authorities. During survey work, twenty-three representatives of national government authorities have fully participated in all stages of fieldwork and data collection, gaining practical, hands-on experience of easily learned and replicable survey techniques (Fig. 5). In all protected area surveys, local protected area managers, and in some cases representatives of other protected areas have likewise participated in full.

On return from the field, local counterparts have participated in initial compilation of results and in some cases presentation of preliminary results and conclusions to departmental directors and ministerial staff.

As part of its fieldwork, PSWS has also maximized opportunities for contact with local people, both as a way of collecting valuable information on wildlife but also as part of a dialogue with them on how best to conserve key species and their critical habitats. This is seen as a fundamental part of any wildlife conservation action and especially efforts to restore species that have disappeared, such as the scimitar-horned oryx (Fig. 19).

In November, 2012, PSWS surveys and survey methods were featured in a regional training workshop organized by the Food & Agricultural Organization (FAO) for wildlife biologists and managers in the North Africa and Near East regions.

![Fig. 19 Discussions with Uled Rashid herders in central Chad about the possible reintroduction of scimitar-horned oryx.](image)
8.9 Valuable contributions to land-use planning

The integrated survey approach used by PSWS has provided simultaneous and rigorously collected data on wildlife and livestock/human activity, providing insight into interactions between the two and recommendations on future conservation options.

At Gadabeji in Niger effective protection of pastoral resources was demonstrated, but very high levels of livestock grazing at the periphery and lack of data on connectivity of the reserve’s resources to the surrounding areas makes restoration of larger wildlife difficult.

The first systematic overview of wildlife status in a projected hunting area highlighted the critical need to ensure that management control for a hunting area would not displace illegal hunting into the adjacent, biologically more important region, recently gazetted as a protected area. The survey also indicated that wildlife levels cannot support hunting until improved control of illegal wildlife off-take has been implemented and population sizes have increased.

PSWS has provided the major source of up-to-date information on the current status of land-use and wildlife in Chad’s OROAGR and provided initial recommendations for a programme of restoration and oryx reintroduction focused in the eastern part of the reserve (Fig. 20). The information was presented at a national workshop to consider scimitar-horned oryx reintroduction, attended by representatives of the region, senior government members and international experts. The workshop concluded with a declaration of support for oryx reintroduction, including provisional agreement on the focal area identified by PSWS.

PSWS input contributed to the formal proposal to gazette Termit Tin Toumma region as a protected areas, successfully enacted by the Government of Niger in March, 2012.

![PSWS-derived plan for the rehabilitation of the Ouadi Rimé-Ouadi Achim Game Reserve, Chad, in preparation for the reintroduction of the scimitar-horned oryx.](image)
8.10  **Capacity for regional overview**

PSWS surveys have provided a unique, large scale appreciation of the distribution and relative abundance of key Sahelo-Saharan wildlife species.

PSWS results are already being sought by IUCN Specialist Groups to assist with updating of Red List status assessments, notably for Data Deficient species, such as pale fox and Nubian bustard. PSWS personnel were co-signatories to a recent letter in the influential journal *Science* drawing attention to the comparative neglect of desert ecosystems by the world conservation community (Durant, Pettorelli, et al. 2012) and also contributed to successful adoption of a resolution (M023) supporting large mammal conservation in the Sahara at the World Conservation Congress at Jeju, Korea (IUCN 2012). However much still needs to be done to disseminate data and information on the wildlife of the Sahara and Sahel. Recent publications e.g. Davies, Poulsen et al. 2012, systematically ignore or are ignorant of the area, simply failing to identify the significance of this very specialist Sahelo-Saharan desert-adapted flora and fauna.

PSWS is providing valuable information at a continent-wide level in the case of rapidly growing concern about African vulture populations (Fig. 21). These critical indicators of ecosystem function and health are believed to be in rapid decline over most of their range. PSWS has provided completely new and up-to-date information on their relative abundance across a wide swathe of rarely visited range and made an important contribution to improved understanding of their breeding biology and habitat use. PSWS raptor counts and observations of bird migration have similar importance.

![Fig. 21 Vultures: white-backed and lappet-faced (top left), juvenile Rüppell’s (top centre), adult Rüppell’s (top right), group of Rüppell’s on a dead camel (bottom).](image-url)
Similarly, data is collected systematically on a daily basis on all bird species encountered, with conservation-dependent groups like vultures, birds of prey (Fig. 22) and bustards (Fig. 23) getting special attention. Information on more than 250 bird species is stored in a geo-referenced database.

Fig. 22 Top row: grasshopper buzzard, lanner falcon, red-necked falcon; Bottom row: secretary bird, swallow-tailed kite, Montagu’s harrier.

Fig. 23 PSWS has contributed significantly to information and knowledge on the seasonal distribution of Denham’s bustard in the Sahelian grasslands of central Chad.
Through regular use of short term camera trapping (Fig. 24), PSWS has been able to present new information on the distribution and relative abundance of elusive nocturnal small carnivores (Fig. 25), at the same time as monitoring the more prominent diurnal species.

Fig. 24 The camera trapping used during PSWS surveys has brought to light many rarely seen species. Top: African lynx or caracal, common genet; bottom: fennec, pale fox.

Fig. 25 PSWS opportunistic nocturnal camera trap results, comparing total events recorded for livestock and main groups of small predators showing highest diversity of carnivores at OROA and highest numbers of jackals at sites recording the largest numbers of livestock.
The very generous support provided by HH Sheikh Mohamed bin Zayed Al Nahyan has been instrumental in allowing the Sahara Conservation Fund and its partner the Zoological Society of London to address long-standing deficiencies in data and knowledge about the conservation status of wildlife in some of Africa’s most extensive biomes, the Sahara desert and the bordering Sahelian grasslands.

Not only is the area vast, but the extreme climate requires the associated plants and animals to exhibit remarkable and largely irreplaceable adaptations to survive there. The conservation of this suite of specialist species and associated vegetation remains essential to insuring the productivity and sustainability of a huge area on which very large numbers of African pastoralists depend. Accessing these areas and executing systematic scientific work is virtually impossible without the level of strong support provided by the project’s sponsor.

The pilot phase of the Pan Sahara Wildlife Survey, undertaken from 2009-2012, has been hugely successful in creating a robust and practical survey and monitoring tool that can be realistically adopted by national institutions of the region and which with appropriate up-scaling of capacity and resources could be applied across many Sahelo-Saharan countries. It has convincingly demonstrated both the feasibility and the value of the project, providing a wealth of new and valuable information and data on a whole series of endangered and conservation dependent species and their habitats.

While effectively laying the path for the project’s continuation and development into a truly Pan Saharan initiative, the pilot phase has also underlined the need to return to key target areas on a seasonal or annual basis to obtain a meaningful overview of the situation under the particularities of the Sahelo-Saharan conditions of climate, annual rainfall and resulting variability in distribution of pasture and wildlife.

The care with which the project has been able to collect and integrate information on both the wildlife resources and the associated human socio-economic activities is of tremendous value in understanding the dynamics involved and in finding solutions that will benefit both wildlife and humans alike.

In similar fashion, PSWS has taken great care in establishing the linkages between research and data collection, and conservation outcomes. In all cases, the results of survey work have been presented to and discussed with the wildlife authorities in the countries concerned with a view to identifying viable solutions to conservation issues as identified by the authorities themselves.
10. REFERENCES


ANNEX I

PAN SAHARA WILDLIFE SURVEY METHODS

INTRODUCTION

The Pan Sahara Wildlife Survey provides information on wildlife, livestock, habitat and human land-use practices in a range of Saharan and Sahelian landscapes.

The target areas are selected for a variety of reasons but primarily on the basis of some known or suspected importance to wildlife and natural resources. Study sites may therefore be very variable in size and habitat, and in some cases actual ground conditions are poorly known prior to commencing field work. At the same time, a key PSWS goal is to employ data collection methods that are scientifically valid, presentable in formats accessible to all stakeholders, and replicable for future comparison. Further considerations are practicality and cost in an effort to encourage often cash-strapped wildlife departments to repeat and/or expand survey work without significant external support beyond initial training and outlay.

As a consequence, PSWS methodologies need to be consistent but adaptable, allowing appropriate responses to varying conditions. A primary mechanism to cope with this is to make a clear distinction between transect and reconnaissance survey modes of data collection. In the former, line of travel along a structured grid of transect lines is determined in advance and must be strictly adhered to, a requirement that is greatly relaxed in reconnaissance mode. At the same time, PSWS seeks to ensure that at the largest scale, observations can be compared as far as possible within the common reference framework of a GIS using decimal degrees.

TYPICAL TEAM COMPOSITION AND EQUIPMENT

- 1 Recorder/team leader
- minimum of 2 Observers, but typically 4-6 (mix of specialist scientists, foresters, trainees, guides, etc.)
- 3 drivers (including at least 1 driver mechanic)
- cook, guides as necessary

BASIC EQUIPMENT (Fig. 26)

- 3 well-maintained 4x4 vehicles with fuel, camping equipment and supplies for extended periods of independent operation in often isolated and difficult terrain
- good quality binoculars for principle observers (8-10 x magnification)
- Trimble Nomad hand-held computer
- 3 Garmin GPS units (various models are available)
- 2 Leica 1200 laser rangefinders
- 2 good quality bearing compasses (Suunto/Silva)
- 2 Kestrel 4000 hand-held weather stations.
- 2 Reconyx HC600 covert infra-red camera traps or similar
- 2 Bushnell camera traps with video capacity
- 2 good quality SLR camera bodies with telephoto lenses (300 mm is practical for wildlife shots)
- 2 Canon G12 cameras or similar for general photograph, habitats, etc.
- Associated cables and adaptors to maintain camera battery charges
• supply of appropriate AA (alkaline and lithium) and AAA batteries to maintain all camera traps and other equipment
• 12 volt battery chargers or 12 volt/220 volt inverters
• laptop computer with cigarette lighter power adaptor and appropriate cables and software to download camera imagery, GPS results and maintain backup copy of Cybertracker sequence in the field
• at least 1 pair of walkie-talkies to allow communication between vehicles and between vehicles and foot transect teams
• head torches for all team members
• voice recorder
• satellite telephone

GENERAL PRINCIPLES OF RECONNAISSANCE AND TRANSECT SURVEYS

An overriding general principle for all modes of PSWS fieldwork is to ensure all observations are georeferenced and all survey effort, in terms of time and distances covered within defined geographical units, is recorded and used in analysis and presentation of results.

All direct observations of large wild mammals and selected large birds are recorded throughout all stages of PSWS surveys, including approach and departure to and from survey sites and intermediary positioning. Within survey target zones and study blocks, additional observations on wildlife tracks and signs, camera trapping, habitat condition, and all human activity and livestock are also recorded.

SURVEY PLANNING

When approaching a new target area, a hierarchy of preparatory activities is employed:

• review of existing remote sensing imagery of the area, e.g. Google Earth satellite imagery
• if available, consultation of conventional printed topographical maps
• discussion with national authorities and partners at central government and local management level is a key part of preliminary survey planning
• employment of local guides is also used where need and opportunity arise

A mix of planning strategies is used depending on circumstances. In very large, previously unexplored areas, the entire survey may be carried out as a general reconnaissance, with a view to achieving general coverage and defining key areas and methods for more detailed future survey work depending on terrain and results obtained. A ‘best case’ coverage route is planned, which will generally seek to guide the route centrally though pre-selected survey units (i.e. half degree squares of approximately 3,000 km²) approximating a similar survey effort within each. But flexibility is expected where logistics and terrain dictate that adjustment must be made. During reconnaissance all observations falling under a standard set of pre-planned categories (habitat, human activity and livestock, wildlife observations) are recorded.

In smaller areas, a preliminary reconnaissance may be followed by development of a formal transect survey if opportunity and time permit. When returning to large areas that are already known, moving directly to detailed transect survey mode is often appropriate.
Fig. 26 Basic equipment used for data collection in standard PSWS survey and monitoring work
PSWS SURVEY SCALES, TRANSECT ORIENTATION AND TIMING

- In extensive survey zones, data from both reconnaissance and transect modes are generally presented across half degree square units, though this scale may on occasion be reduced to 10x10km UTM units at smaller survey sites.
- Transect surveys are designed to sample defined habitat blocks, endeavouring to follow standard rules of transect orientation relative to any dominant habitat gradients to minimise bias. Local transect navigation details are usually planned and prepared using the Universal Transverse Mercator (UTM) system. Use of UTM is not obligatory, but in general provides a direct way to manage waypoints and distances in metric units in the field, which can be advantageous for easy communication about distances, or when unforeseen circumstances (such as wildfires or significant new local information on a target species) require modification and quick manipulation of waypoint arrays in the field. Results are generally plotted in latitude/longitude.
- So long as habitat structure allows, transects are usually designed to run north-south, which tends to be less obviously biased by typical ENE-WSW wind directions in Sahelian latitudes. In such circumstances, transects are aligned to traverse the centres of 10km x 10km UTM grid squares with a distance of 10km run within each. But other transect orientations can be used if habitat or logistics require.
- Locations for habitat recording and walked transects are selected in advance at 5km intervals, which are then displaced by 0-2kms in either direction using random numbers to achieve randomised sample points while preserving average sampling rate. It is useful to display preselected habitat recording sites with green symbols and habitat + walked transect sites with red symbols on GPS colour screen displays for ease and accuracy of interpretation in the field.
- Because surveys are extensive, it is generally necessary to make observations throughout the morning from about 07.00 hrs. to 12.00 hrs., and from around 14.30 hrs. to dusk (c. 17.00 hrs.), regardless of expected animal activity patterns.
- To date, the largest ‘standard’ transect survey blocks used in PSWS have been 80x40km (3,200 km²), with eight 40km transects systematically spaced at 10km intervals. Smaller blocks with transects spaced systematically at 5km have also been used in response to detailed information about wildlife distribution gathered during reconnaissance. Reduction in the spacing of transects focuses the search effort, useful as a means of gathering information on a locally distributed or rare species and introduces stratification to the survey design, reducing variance. Use of line transect methodology for collecting data on focal species (antelopes, bustards, livestock) results in variation in the achieved sample fraction according to detectability for each species but these transect layouts typically return sample effort in the range 3-6 % in open desert habitats for observations falling within 150m each side of the vehicle.

SURVEY OPERATION

Certain general data-collection rules are always applied:

- A typical PSWS survey team operates in three vehicles travelling in single file (Fig. 27, Fig. 28). When in target areas the lead vehicle is crewed by a driver/navigator, recorder and at least two observers (left side, right side). The positions and responsibilities are discussed and defined at the start of fieldwork, and if necessary may be practised en route to the target area. The second vehicle may contain additional observers who communicate with the lead vehicle/recorder via short-range radio. Observations made by observers in the second vehicle are thus incorporated in the single master record of the survey maintained by
the recorder in the lead vehicle. Vehicle two usually acts to confirm sightings made from vehicle one but also to spot animals missed by vehicle one or put up by its passage. Typically the third vehicle carries logistics support, fuel, water, etc. and does not participate directly in data collection, but should closely follow the route taken by the two lead vehicles to avoid disturbing the area. Convoys of more than three vehicles are possible but will increase logistical considerations (food, water, fuel, disturbance) that must be weighed against survey objectives, efficiency and desired autonomy. If large numbers of people are to be involved, it is better to organize simultaneous survey of contiguous blocks, something that has value in overall assessments of large areas.

- A Trimble Nomad hand-held computer, operated by the recorder, acts as a platform for a customised Cybertracker sequence (www.cybertracker.org) which automatically standardises geo-referencing and management of data collection in the field. The Cybertracker sequence allows clear definition of the survey mode (vehicle reconnaissance, vehicle or foot transect, casual encounter, etc.) at all times and contains extensive menu options to achieve standardised data collection under the four chosen main headings of habitat, human activity, livestock and wildlife.

- All wild mammal observations are recorded by date, time, location and number of individuals, in all circumstances (inside and outside target areas), categorised by survey mode.

- All raptor and certain categories of large non-passerines (bustards, storks, pelicans) are recorded in the same way in all circumstances (inside and outside target areas), categorised by survey mode and indicating whether birds were in flight or perched. Distance measurements on transects are only taken for bustards.

- Human activity and livestock observations are only recorded within target areas, categorised by survey mode.

- Full bird species lists are made at each midday and evening stop while in the field to facilitate subsequent allocation of total species lists to each half degree grid square covered.

**Transect mode**

- When traversing pre-defined transects, data on large mammals, bustards, livestock and encampments are collected in line-transect format. Perpendicular distances are measured relative to the transect line as often as possible by laser range-finder\(^2\), facilitating analysis of density and numbers by standard line-transect or strip-width methods.

- If need arises to break away from a transect (e.g. to locate a camp site, find water, seek consultation with local people, visit an interesting feature off transect) a waypoint is taken and used as a reference point to restart the transect subsequently and change in observation mode noted accordingly in Cybertracker. Camp sites should be made at least 2km from the transect line to reduce unnecessary disturbance, preferably away from an area to be visited the following day.

- Accurate vehicle-based navigation is achieved by using the route function of a Garmin GPS unit, set to large scale and clearly displayed to the lead driver, who with assistance from the recorder navigates the preselected route.

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\(^2\) In most surveys, perpendicular distance to wild animals is measured by agreeing a reference point where target species were first seen, waiting until the vehicle is abreast of the original sighting point, and measuring the distance directly at right angles with the vehicle positioned on the transect line.
• A second GPS unit used by the recorder displays perpendicular displacement from the transect line and combines the route display with colour-coded waypoints planned for habitat records (green) and foot transect locations (red).

• In transect mode, a visual record of habitat type and condition is taken at these preselected waypoints, by matching visual assessment to prepared status codes on Cybertracker menus (e.g. for herb layer phenology: 0=absent 1=dry, 2=half green, 3=green). Habitat recording locations are selected along the line of the transect, on a restricted random basis as discussed above.

• In transect mode, a 500m foot transect stop is made at every second habitat record point (averaging 10km intervals). At foot transects a geo-referenced photograph of habitat type and condition is taken along the line of the transect and a 500m transect (defined by projecting a GPS point 500m from the start point along the line of the transect) is walked on foot by a team of 4-5 observers moving in line abreast over a width of c.50m. All direct observations of wildlife and livestock made during foot transects are recorded in line transect format, but the principle objective is to score the number of tracks and signs of any wildlife species encountered into categories: ‘not seen’, ‘few’ (1-5 sets), ‘many’ (6-20), ‘abundant’ (>20). Details of dominant plant species present and condition are added on completion of the foot transect. This process tends to provide valuable additional information, particularly on distribution of rarer or elusive larger species, such as dama gazelle or striped hyaena.

• Note that development and improvement of the Cybertracker menu system is an important on-going and iterative activity.

Reconnaissance mode

• Outside fixed transects, observations are collected as geo-referenced waypoint records. Observations of large mammals may be accompanied by a visual estimate of distance from the vehicle but are analysed only as encounter rates.

• Visual assessment of habitat type and condition is taken at approximate 5km intervals as gauged by GPS.

• In a reconnaissance only survey, 500m foot transects are undertaken at least twice in each reconnaissance survey unit (half or quarter degree square), spaced by at least 10km.
1. Taking an observation with rangefinder and binoculars.

2. Foot transect in line with regular vehicle-based transect.

3. Searching for dama gazelle tracks and other signs.

Fig. 27 PSWS survey methods: counting animals and measuring distance from observers (top), foot transect (middle), searching for tracks and other signs (bottom).
Fig. 28 PSWS survey work: setting camera trap (top), vehicle-based survey with 3 vehicles in line (middle), typical campsite (bottom).

1. Checking camera trap before taking it down.

2. Typical SCF/PSWS survey convoy (two vehicles for personnel and one for fuel, camp, etc.).

3. Campsite in the grasslands of Central Chad.
OTHER OPERATIONS

DNA sampling

Where collaboration agreements and funds for analysis are in place, PSWS survey teams carry plastic tubes for dry collection of faecal (and where opportunity arises, dry skin and flesh samples) of selected species. Existing collaborations include work on dama gazelle conducted with the Al Ain Wildlife Park & Resort and the Zoological Genetics Unit, Royal Zoological Society of Scotland.

Camera trapping

Typically two Reconyx HC600 cameras are used on each survey

In most circumstances (reconnaissance and transect modes) the objective can only be to maximise chances of detecting the presence of elusive nocturnal species at single point locations on overnight stops. In this circumstance cameras are baited. Opportunities to deploy camera traps without bait for longer periods monitoring features of special interest (carnivore burrows, water points, regularly frequented tracks) are also taken when travel pattern allows. In future, the use of formal camera trap grids to monitor rare species and mountainous terrain may be explored within PSWS.

Whenever possible, cameras are set up in the field on all nights. Of necessity in a mobile survey, cameras can only be set up close to sunset and removed shortly after sunrise each day, since the survey is continually moving on to new areas. Because these are single night deployments at new locations each night, all cameras are baited with sardine to improve chances of photographing small predators. It should be noted, however, that while experience suggests sardine bait is highly attractive to small canids, the situation is less clear for other groups. The possibility that some species might in the worst case be repelled by sardine has not yet been investigated. Because cameras are baited, data reporting is limited to simple presence/absence information for mapping and total number of events by image subject.

Meteorology

Basic daily weather data are collected at 3-hourly intervals from 06.00-18.00 each day using a Kestrel 4000 handheld weather station, with units set to automatic hourly recording to obtain night time data. Particular attention is paid to wind strength and direction for display in relation to survey team movements and wildlife observations.

PSWS REPORTING AND MONITORING

To encourage comparability, PSWS technical reports of field survey work follow a broadly similar structure and data analysis process.

Cybertracker software is used to sort and assemble data under the four main headings of habitat condition, human activities, livestock and wildlife.

Mapping is conducted by entering Cybertracker outputs into ESRI ArcMap (www.esri.com) or more frequently Surfer 11 (http://www.goldensoftware.com/products/surfer/surfer.shtml) software.

Reports are introduced with cover page, contents page, details of sponsors and acronyms. The main report is structured into a short Summary, followed by Introduction, Methods, Results, Conclusions and Recommendations. Final sections specify Acknowledgements, References, Annexes and Plates.
Habitat data are presented as simple frequencies and distribution maps of key species where possible.

Reconnaissance survey data are analysed by plotting exact routes and observations over the half degree grid. Simple encounter rates may be added to maps as a symbol proportionate in size to the encounter rate, centred on the appropriate sample unit, making a visual display of where observations were more and less frequent. In some cases, encounter rates may be plotted using median and 25%-75% inter-quartile ranges and compared using non-parametric tests (e.g. Mann–Whitney median test), where reasonably equivalent data sets can be assembled.

Transect survey data are analysed in line transect format using the software Distance 5.0 (http://www.ruwpa.st-and.ac.uk/distance/) where sample sizes are adequate to construct detection functions (>40 groups encountered) within transect surveys. Where sample sizes are smaller, population estimates may be derived by cropping sightings to a fixed width (150m or 500m each side, depending on landscape, visibility and data) and using a conventional strip sampling format with the lognormal estimator of variance following the method advocated by Milner-Gulland and Rowcliffe, 2007.

Population size estimates are only derived for dominant target antelope and bustards, and livestock, noting that special problems of sampling and detectability apply in differing degrees and significance across these groups.

Camera trap data are analysed by species and number of events. An ‘event’ is scored whenever a species appears at the camera for the first time and may comprise one or several pictures (depending on behaviour and camera settings). A new event is scored subsequently only when the species reappears after an interval of more than one hour since the end of the previous event. The situation where a species turns up regularly at half hour intervals through the night would need special consideration, but has not yet arisen in many hours of camera trapping.

To provide a general overview, all technical reports give tabulated lists of all mammal and bird species seen in the survey target area. Mammal observations are further broken down into how many individuals were observed directly, how many events occurred at camera traps, and how many and which half degree grid squares were found positive for a given species across all detection methods (sightings, tracks and signs, camera traps).

Similar tabulations are made for vultures and bustards as focal bird species of special interest. All birds species seen are listed with indication of which half degree grid squares occurrence was confirmed.

Summary comments (as an Executive Summary) on key results and outcomes of the survey are provided with recommendations for follow-up conservation action in light of the new information obtained.
ANNEX II

PSWS Pilot Phase Technical Reports (available on SCF and ZSL websites).


ANNEX III

Published articles and conference presentations in support of the Pan Sahara Wildlife Survey and its findings.

Articles to date with significant input from PSWS


Conferences and presentations


Websites

PDF copies of all PSWS reports are available on:

SCF Website: http://www.saharaconservation.org/?-Reports-

### ANNEX IV

List of common and scientific names of species mentioned in the text.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
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<tbody>
<tr>
<td>Arabian Bustard</td>
<td><em>Ardeotis arabs</em></td>
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<tr>
<td>Nubian Bustard</td>
<td><em>Neotis nuba</em></td>
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<tr>
<td>Denham’s Bustard</td>
<td><em>Neotis denhami</em></td>
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<td>Lappet-faced Vulture</td>
<td><em>Chlamydotis undulata</em></td>
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<td>Rüppell’s Griffon Vulture</td>
<td><em>Torgos tracheliotus</em></td>
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<td>White-backed Vulture</td>
<td><em>Gyps rueppellii</em></td>
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<td>Secretary Bird</td>
<td><em>Gyps africanus</em></td>
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<td>Lanner Falcon</td>
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<td>Caracal or African Lynx</td>
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<td>African Wild Cat</td>
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<tr>
<td>Fennec</td>
<td><em>Vulpes zerda</em></td>
</tr>
<tr>
<td>Striped Hyaena</td>
<td><em>Hyaena hyaena</em></td>
</tr>
</tbody>
</table>