EXPEDITION REPORT

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Report published: November 2020

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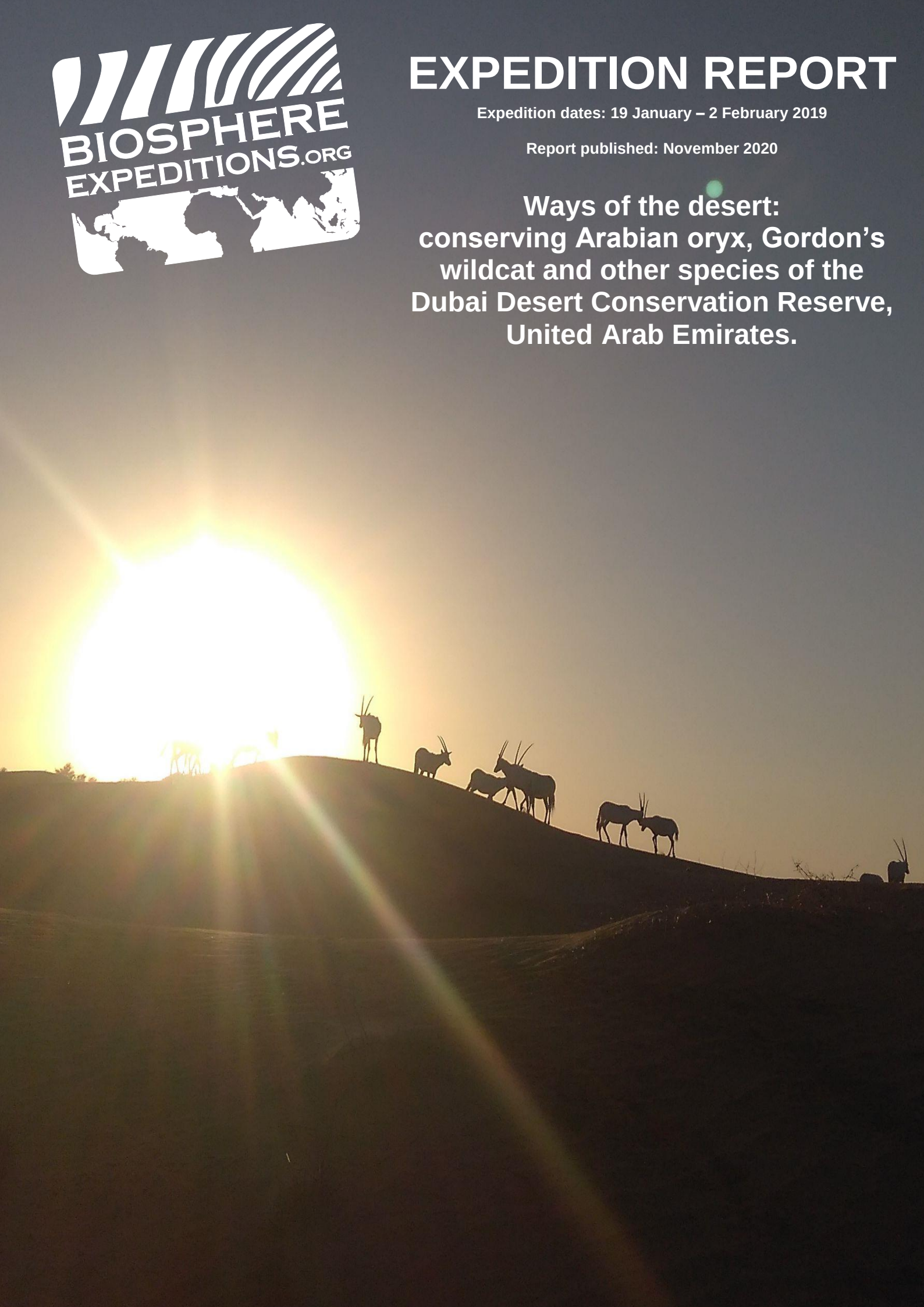

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Conserving Arabian oryx, Gordon's wildcat and other species of the Dubai Desert Conservation Reserve, United Arab Emirates.

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Abstract

The successful collaboration between Biosphere Expeditions and the Dubai Desert Conservation Reserve (DDCR), initiated in 2012, continues with citizen scientists collecting data for two weeks from 19 January to 2 February 2019. Data gathered alerted the DDCR management to several conservation issues and also allowed for informed, fact-based management decisions to be made in a showcase of how the work of citizen scientists can aid the efforts of conservation professionals.

The 2019 expedition observed healthy numbers of the following species using a variety non-independent count methods: 1,890 Arabian oryx, 1,270 Arabian gazelle, 317 sand gazelle, 1 red fox, 13 MacQueen's bustards, 15 lappet-faced vultures and 4 pharaoh eagle owls.

Arabian oryx were distributed all over the DDCR, a change from the 2018 distribution. This is mainly due to their increasing numbers and therefore competition and a subsequent need for dispersal. The predicted distribution of Arabian oryx across the DDCR is highly concentrated, mainly around the feeding points and irrigated areas, where food is easily found. **Arabian gazelles** were more widely distributed in 2019 than in 2018. They were mainly concentrated in the central and central-south parts of the DDCR in what appears to be a result of modified habitats such as the irrigated areas at old farms and plantations, which provide more food for the species. The quadrat count of 105 **sand gazelles** was similar to the 2018 result (132), albeit slightly lower. Distribution has expanded from that of 2018 and sand gazelle were recorded in most parts of the reserve. The highest concentrations are consistently in the south of the DDCR in the dunes, the preferred habitat for the species, and around the irrigated areas, which provide access to food.

19,642 **plants** were counted during circular observations: 17,422 bushes, 1,448 Ghaf trees, 514 Acacia trees, 175 date palms, mainly in farms, 66 Sodom's apple, and 14 Arta. Only three desert thorn were counted. Comparative predicted distribution of fire bush and Sodom's apple, which are both important indicator species for the reserve's habitats, showed a contraction of Sodom's apple. This is most likely due to the increasing numbers of Arabian gazelle, which browse the species.

Live traps were set for 27 trap nights by two consecutive groups, but did not capture any meso-predators.

Small mammals trapping consisted of 268 trapping nights over six grids and resulted in a total of 28 captures, which included two species: 25 Cheeseman's gerbils (16 males, 7 females, 2 unknown) and three Egyptian spiny mouse (1 male, 2 unknown). The total trapping success rate was 10%.

The **Arabian red fox** survey found 92 dens, of which 62 had been previously classified as active or inactive, and 30 newly discovered. 15 dens were classed as active, 29 as inactive and 49 as abandoned. The 2019 survey showed a 37% increase in the number of active dens compared to 2018. However, compared to 2017, 2016 and 2011 the density of red fox dens in the DDCR was lower in 2018 and 2019, which could be due to a decrease in prey abundance due to the current poor vegetation conditions.

17 **camera traps** set over 203 trapping days captured 28 wildlife species and one feral cat. Arabian oryx was the most abundant and widespread species (20,259 capture events), followed by 4,696 Arabian gazelle, 570 feral cats, 331 Arabian red fox and 3 Arabian wildcat. No sand foxes were recorded. A high number of bird species (23) was also recorded by the camera traps, including 138 capture events of lappet-faced vultures, as well as records of Pallid harrier, Bonelli's eagle, long-legged buzzard, Pharaoh eagle-owl, chestnut-bellied sandgrouse and MacQueen's bustard.

The high ungulate population within the DDCR continues to be the major challenge in its management. This is naturally a concern during dry years as there is less food available for all herbivorous species. Even more of a concern is that these high ungulate numbers will hinder recovery of the habitat even in wet years. The results in this report show that this is likely to affect adversely the small mammal and red fox populations. It is therefore a priority of the DDCR to reduce drastically the numbers of ungulates within the reserve through relocation to enclosures adjacent to the reserve. In line with this, the DDCR will, over the next five years, move to lower numbers of ungulates, but increase to increase the diversity of species through both natural processes, as the habitat quality improves, but also through some potential species re-introductions once the habitat has recovered. It is hoped that Biosphere Expeditions citizen scientists will continue to play an important role in studying the effects of these management actions.

الملخص

يستمر التعاون الناجح بين محمية دبي الصحراوية وبرنامج رحلات المحيط الحيوي منذ بدء البرنامج في العام 2012م بمساعدة المتطوعين والذين يقومون بتجميع البيانات الحقلية لمدة أسبوعين من 19 يناير 2019م وحتى 2 فبراير 2019م حيث أيدت البيانات التي تم تجميعها للعديد من الملاحظات والأنشطة من قبل إدارة محمية دبي الصحراوية وكذلك ساعدت المحمية في الحصول على العديد من المعلومات المفيدة واتخاذ قرارات صحيحة والتي تصب في صالح المحمية والتي بدورها ساهمت في تعزيز التعاون المثمر بين المتطوعين المهتمين بالحياة البرية والباحثين العاملين بالمحمية.

سجلت بعثة المحيط الحيوي لعام 2019م أعدادا صحية من الأنواع التالية وذلك باستخدام مجموعة متنوعة من طرق الإحصاء الحقلية، تم تسجيل 1890 من المها العربي، 1270 من الغزال الأدمي، بالإضافة إلى 317 من غزال الريم. بالإضافة إلى عدد واحد من الثعالب الحمراء، وعدد 13 طائر من طيور الحباري، وكذلك 15 نسر الأذون وأربعة من طيور البوم الفرعوني.
تم تسجيل المها العربي موزعا بصورة متجانسة في جميع أنحاء محمية دبي الصحراوية، مغايرا لما تم تسجيله في السنة السابقة (2018م) مما يفسر نظرية زيادة أعداد المها وبالتالي المنافسة الشديدة بين أفراد المها في تحديد نطاقاتهم مما ينتج إعادة التوزيع المسجلة. تحليل توزيع المها العربي أظهر تركيزا شديدا في مناطق محددة داخل المحمية وخاصة حول نقاط التغذية والمزارع حيث يسهل الحصول على الغذاء. وبدراسة توزيعات الغزال العربي أظهرت انتشارا أوسع للغزال مقارنة بالعام السابق وتركزت بشكل أساسي في وسط وجنوب المحمية، فيما يبدو أنه نتيجة لتحسين البيئات في تلك المناطق وكذلك لتوفر الغذاء والماء في المناطق المروية والمزارع القديمة. وبالنسبة لغزال الريم فكان العدد الإجمالي (105) قريب من تسجيل الاعداد بالسنة السابقة (132) وإن كان أقل ولكن توزيع الأعداد كان متجانسا في جميع أرجاء المحمية مع كثافة أعلي بجنوب المحمية في منطقة الكثبان الرملية والتي يفضلها غزال الريم وكذلك المناطق المنزرعة لوفرة الغذاء.
تم إحصاء 19642 فرد نباتي يتكون من 17422 شجيرة المرخ، 1448 شجرة غاف، 514 شجرة سمار، 175 شجرة نخيل (مسجلة كلها في المزارع القديمة)، 66 شجيرة العشار، 14 شجيرة الأرطة، 3 شجيرات العوسج. أظهر التوزيع المتوقع لشجيرات المرخ والعشار وكلاهما من الأنواع الهامة لبيئات المحمية. تم ملاحظة نقصان أعداد شجيرات العشار وهذا على الأرجح بسبب الزيادة المضطردة لأعداد الغزال والذي يتغذى على أوراق تلك الشجيرة.
تم تعيين المصائد الحية لمدة 27 ليلة من خلال مجموعتين متتاليتين ولكن لم يتم تسجيل أي مفترسات متوسطة الحجم.
تم وضع مصائد الثدييات الصغيرة لحوالي 268 ليلة موزعة لعدد ست قطاعات بالمحمية وأسفرت عن تسجيل ما مجموعه 28 من الثدييات الصغيرة، تضمنت نوعين وهما: 25 جربوع (16 ذكور، 7 إناث، 2 غير معروفين) ثلاثة فأر شوكي عربي (ذكر واحد، 2 غير معروفين). كان إجمالي معدل نجاح الاصطياد حوالي 10%.
كان من نتيجة حصر أوكار الثعالب تسجيل 92 وكر، تم تصنيف 62 منها مسبقا في السنوات السابقة على أنها إما نشطة أو غير نشطة بالإضافة إلى 30 وكرا تم تسجيلهم حديثا. تم تصنيف 15 وكرا على أنها أوكار نشطة و29 على أنها غير نشطة و49 أوكار مهجورة. أظهر المسح الحقلي للعام 2019م زيادة بنسبة 37% في عدد الأوكار النشطة مقارنة بعام 2018م ومع ذلك إذا تم مقارنة النتائج مع 2017م و2016م تظهر المقارنة تسجيل أقل في عامي 2018م و2019م وهو ما يمكن أن يكون بسبب قلة أعداد الفرائس بسبب ظروف الغطاء النباتي الشحيح.
تم ضبط 17 فخ كاميرا على مدي 203 يوم حيث تم تسجيل 28 نوعاً من أنواع الحياة البرية وقط بري واحد. كان المها العربي هو أكثر الأنواع وفرة وانتشارا حيث تم التقاط عدد 20259 صورة يليه الغزال العربي بعدد 4696 تسجيل ثم 570 صورة للقط الضالة و331 صورة للثعلب الأحمر و3 قطط برية و لم يتم تسجيل أي ثعالب رمال. تم تسجيل عدد كبير من أنواع الطيور (23) بواسطة مصائد الكاميرات بما في ذلك 138 صورة لنسر الأذون والباليد هاريير ونسر البونيللي والصقر طويل الارجل والبوم الفرعوني والحباري.

لا يزال زيادة أعداد ذوات الحوافر تمثل تحديا لإدارة المحمية وهذا بطبيعة الحال مصدر قلق خلال سنوات الجفاف حيث يوجد طعام أقل متاح لجميع الحيوانات العشبية. الأمر الأكثر إثارة للقلق أنه نتيجة لزيادة أعداد ذوات الحوافر تؤثر علي الموائل الطبيعية وقدرتها على الاستعادة الطبيعية حتي في السنوات المطيرة. تظهر النتائج في هذا التقرير أنه من المحتمل أن يؤثر ذلك سلبا على الثدييات الصغيرة من القوارض وكذلك بالتبعية الثعالب الحمراء لذلك فإن من أولويات المحمية التقليل بشكل كبير من أعداد ذوات الحوافر داخل المحمية من خلال نقل عدد من القطعان إلي كامب خارج المحمية لحين نقلها لمحميات أخري، وتماشيا مع هذا فإن سياسة المحمية هي تواجد أعداد أقل من ذوات الحوافر للخمس سنوات القادمة. تتوقع المحمية زيادة التنوع الحيوي مع تحسن جودة الموائل الطبيعية، وهناك أيضا توجه بإدخال أنواع أخري بمجرد استعادة الموائل لطبيعتها. من المأمول أن تستمر رحلات المحيط الحيوي في لعب دور مهم في دراسة أثار إجراءات الحماية بمحمية دبي الصحراوية.

Contents

1. Expedition review

M. Hammer
Biosphere Expeditions

1.1. Background

Background information, location conditions and the research area are as per Simkins and Hammer (2018). The aim of the expedition was to survey the distribution of Arabian oryx *Oryx leucoryx*, Sand gazelle *Gazella marica* and Arabian gazelle *Gazella gazella*, as well as to survey dens of Arabian red fox *Vulpes vulpes Arabica*, monitor the small mammal population and to record the cryptic and rare species of the Dubai Desert Conservation Reserve. Target species in addition to the ones mentioned were Arabian wildcat *Felis silvestris gordoni*, Arabian red fox *Vulpes vulpes arabica*, Sand fox *Vulpes rueppellii*, MacQueen's bustard *Chlamydotis macqueenii*, lappet-faced vulture *Torgos tracheliotos*, pharaoh eagle-owl *Bubo ascalaphus*. Also trees and tall shrubs species number and distribution were surveyed.

1.2. Dates & team

The annual survey ran over two weeks in January/February 2019 with two teams of national and international citizen scientists, professional scientists and an expedition leader. Group dates were as shown in the team list below.

The expedition team was recruited by Biosphere Expeditions and consisted of a mixture of ages, nationalities and backgrounds. They were (in alphabetical order and with country of residence):

19 – 26 January 2019: Marilyn Ashworth (UK), Jasmin Benz (Germany), Anne Dale (France), Juliane Drews (Germany), Mary Kitchen (UK), Christore Palitzsch (Germany), Benjamin Sharkey (UK), Mohamed Sultan Al Ulama (UAE), Deborah Walker (UK).

27 January – 2 February 2019: Sharon Amos (UK)*, Ulrike Faltings (Germany), Peter Goodman (UK), John Highet (UK), Areej Mustafa Jaradat (UAE)**, Elena Nardozzi (Canada), Christiane Stalschus (Germany), Anne Visser (Netherlands), Toby Whaley (Germany).

*member of the media
** local placement funded by the Friends of Biosphere Expeditions

A medical umbrella, safety and evacuation procedures were in place, but did not have to be invoked as there were no incidences.

Greg Simkins, the expedition's lead scientist, is South African by birth and has worked in the field of conservation and protected areas management since 2001. Greg began his career as a field guide in 1999. In 2001, he became a Reserve Officer in the area that later became the DDCR, and was heavily involved in the planning and implementation of eco-tourism activities within the protected area, which was created in 2003. In 2003, Greg took on his current role and was appointed Conservation Manager for the DDCR. He is now responsible for the overall management of the reserve and has been at the forefront of its

development from conception in 2003 to its current international recognition. He also plays a major role in conducting key conservation research studies throughout the DDCR. Prior to coming to the Middle East, Greg studied at the University of Natal, Pietermaritzburg in Kwazulu-Natal, where he also did graduate work, including resource assessment and allocation for a farm, soil surveys and research at an ostrich export farm in the Eastern Cape.

Moayyed Sher Shah, the expedition's field scientist, holds a zoology degree from Islamia University Bahawalpur, Pakistan. After years of working as zoologist and conservationist in Saudi Arabia, he joined the Dubai Desert Conservation Reserve, as a conservation officer in 2018. His main role is to plan, control, develop and regularly monitor the conservation practices and environmental work within the DDCR, ensuring the restoration and well-being of the flora and fauna.

Paul Franklin, the expedition leader, was born in Oxford and studied zoology at Swansea University. His Masters Degree was based on research of the migratory behaviour and ecology of amphibians. After graduation Paul spent a year working as a naturalist guide in the Peruvian Amazon. There, among other things, he was bitten by the travel bug. Since then he has led many expeditions and treks to far flung corners of the globe. Travels overseas have been interspersed with time spent in the UK working, among other things, as a Nature Reserve Warden and Environmental Consultant. Never far from a camera, many of his wildlife and travel images have been published in magazines and books. When not travelling on foot through the world's wild places his preferred modes of transport are a kayak, mountain bike or occasionally a horse.

1.3. Partners

The main partner on this expedition is the Dubai Conservation Board, a government-appointed organisation concerned with the conservation and protection of the Dubai inland desert. Other partners include the National Avian Research Centre.

1.4. Acknowledgements

This study was conducted by Biosphere Expeditions, which runs wildlife conservation expeditions all over the globe. Without our expedition team members (listed above) who provided an expedition contribution and gave up their spare time to work as research assistants, none of this research would have been possible. The support team and staff (also mentioned above) were central to making it all work on the ground. Special thanks go to Arabian Adventures for providing vehicles including fuel for expedition.Biosphere Expeditions would also like to thank the DDCR and its staff, and the Friends of Biosphere Expeditions for their sponsorship and/or in-kind support.

1.5. Further information & enquiries

More background information on Biosphere Expeditions in general and on this expedition in particular including pictures, diary excerpts and a copy of this report can be found on the Biosphere Expeditions website www.biosphere-expeditions.org.

Enquires should be addressed to Biosphere Expeditions at the address given on the website.

1.6. Expedition budget

Each team member paid towards expedition costs a contribution of € 1,480 per person per 12-day slot. The contribution covered accommodation and meals, supervision and induction, special research equipment and all transport from and to the team assembly point. It did not cover excess luggage charges, travel insurance, personal expenses such as telephone bills, souvenirs etc., or visa and other travel expenses to and from the assembly point (e.g. international flights). Details on how this contribution was spent are given below.

Income	€
Expedition contributions	23,592
Expenditure	
Expedition base includes all food & services	1,406
Transport includes hire cars, fuel, taxis in the UAE (sponsored by Arabian Adventures)	0
Staff includes local and Biosphere Expeditions staff salaries and travel expenses	3,339
Administration includes miscellaneous fees & sundries	185
Team recruitment Arabia as estimated % of annual PR costs for Biosphere Expeditions	4,981
Shortfall from 2018 expedition See 2018 expedition report	5,508
Income – Expenditure	**6,194**
Total percentage spent directly on project	**74%**

2. Desert species surveys

2.1. Introduction and background

The United Arab Emirates, and Dubai in particular, is well known for its rapid development over the past 40 years, as well as for the mega-construction projects such as the Palm Islands and the Burj Khalifa (the world's tallest building). Less well known is the diversity and beauty of the natural environment, from the dugongs and corals in the Arabian Sea, the flamingos in the khors (inlets) of the coastline, the rugged Hajar mountain range, to the serene splendour of the sandy dune inland desert. Also little known is that the largest piece of land given to any single project in Dubai was for the establishment of the Dubai Desert Conservation Reserve (DDCR), at 225 km² or 4.7% of Dubai's total land area.

The main target species for this expedition were the Arabian oryx *Oryx leucoryx*, Gordon's wildcat *Felis silvestris gordoni*, Arabian gazelle *Gazella arabica*, sand gazelle *Gazella marica*, Arabian red fox *Vulpes vulpes arabica*, sand fox *Vulpes rueppellii*, MacQueen's bustard *Chlamydotis macqueenii*, lappet-faced vulture *Torgos tracheliotos* and pharaoh eagle owl *Bubo ascalaphus*.

Previous work from 2012 to 2018 and background to the species under investigation are covered in Simkins & Hammer (2018, 2019) and in expedition reports prior to this.

2.2. Methods

Expedition participants assisted DDCR scientists in five important surveys: (1) Target species quadrant survey, which also included parts of the ungulate survey (Arabian oryx, Arabian gazelle, Sand gazelle) and the large shrubs survey (vegetation survey), (2) live trapping for medium-sized animals (targeting Gordon's wildcat and both fox species), (3) small mammal trapping, (4) Arabian red fox den survey, and (5) camera trapping. In addition to these surveys, participants were tasked to record any species observed while in the field.

After a training period that lasted one and a half days, participants were split into three groups to conduct the various surveys, in four separate zones of the DDCR, namely a North Zone, Central Zone, South Zone and Perimeter Zone (see Figure 2.2a). Each zone comprised fifteen 2 x 2 km quadrants, the perimeter zone comprised of 17 partial quadrants. These 62 quadrants together represented approximately 214 km² of the 225 km² of the DDCR (or 95%). The area included all key habitats of vegetated dunes, sand dunes and gravel plains.

Every day each group of expedition participants was tasked with surveying two to three quadrants or approximately 10-12 km². A total of 62 quadrants (214 km²) were surveyed in this way during the expedition. During surveys any target species encounters were recorded in the relevant datasheets. A total of 35 quadrants were surveyed by team 1 and the remaining 27 quadrants were surveyed by team 2.

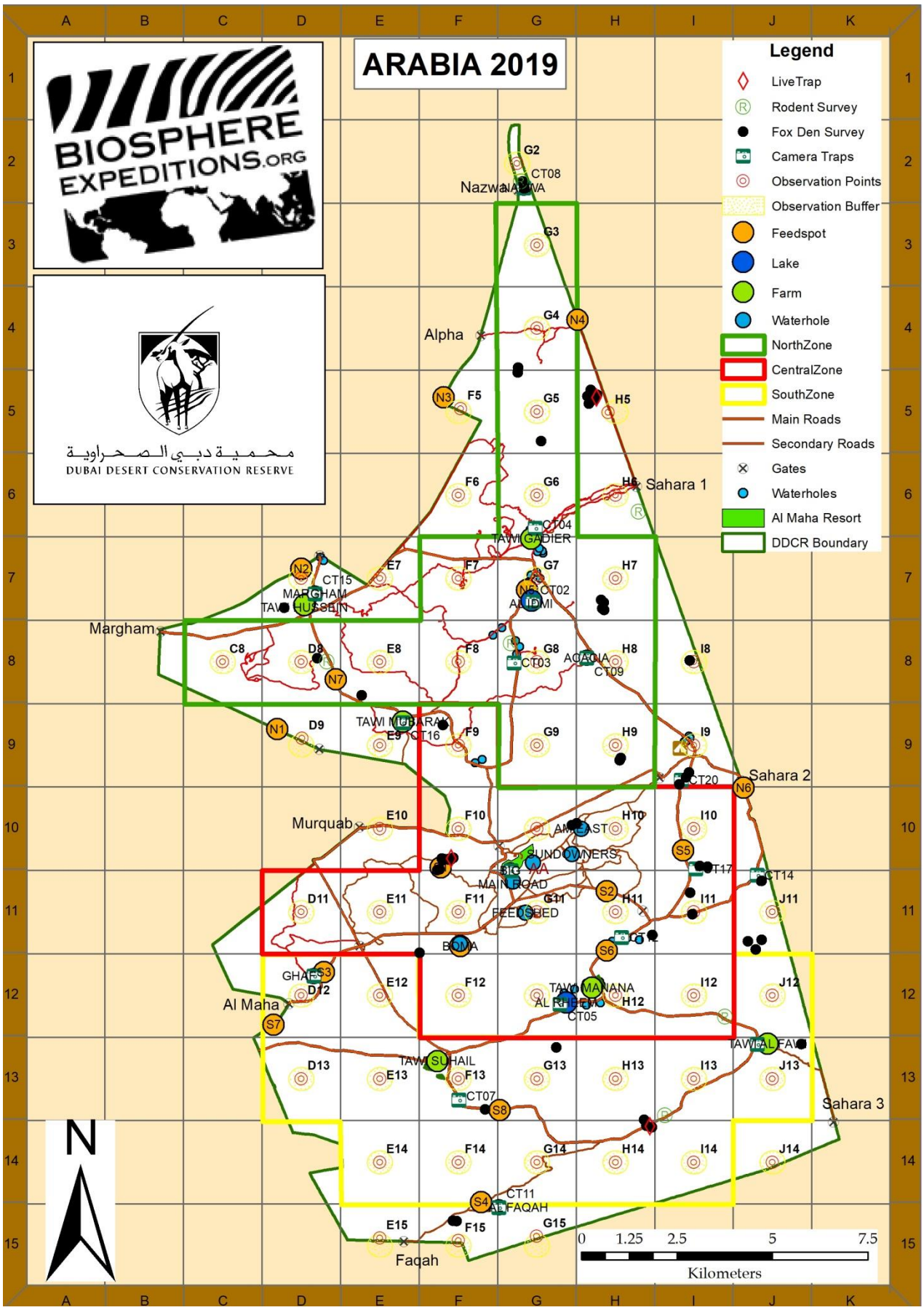

Figure 2.2a. The DDCR and its survey zones (North = green, Central = red, South = yellow). The perimeter zone comprises all other zones within the DDCR.

Target species quadrant survey

This involved the selection of one observation point within 300 m of the centre of the quadrant, which provided a good vantage point. From this vantage point a 360º circular observation of the surrounding area was carried out by three to four participants with binoculars for 30 minutes. Quadrant survey is conducted between 08:30 to 14:00 mostly.

Figure 2.2b. A quadrant survey

Target species observed during these surveys were recorded in the datasheets as follows: species name, GPS position of researcher when the species was first seen, distance and bearing from researcher to target species, time of day when the species was observed, ecological information such as number of animals, sexes etc., and additional comments. In addition, trees and large shrubs (Date palm *Phoenix dactylifera*, Sodom's apple *Caltropis procera*, fire bush *Leptadenia pyrotechnic*, Acacia trees *Acacia sp.*, ghaf trees *Prosopis cineraria* and Arta *Calligonum comosum* were counted as well (Karim and Fawzi 2007).

During analysis, IDW (Inverse Distance Weighted Interpolation) was used to predict the value (abundance and distribution of species sampled at each cell = quadrant) of cells at locations that lack sampled points (ESRI 2012). Inverse distance weighted methods determine cell values using a linear-weighted combination set of sampling points and are based on the assumption that the interpolating surface should be influenced mostly by the nearby points and less by the more distant points. The interpolating surface is a weighted average of the scatter points, and the weight assigned to each scatter point diminishes as the distance from the interpolation point to the scatter point increases. Abundance counts over the study area were used as input and predictions were applied to all the species recorded using ESRI® Arc Map 10.0 spatial analyst extensions.

Live traps for medium-sized animals

Three Tomahawk live traps were used during the expedition for the purpose of capturing Gordon's wildcat and other meso-carnivores. At the beginning of the expedition, each survey group was given a live trap to place within their allocated zones (North, South and Central zones). Each group marked the position of the live trap on a handheld GPS. The live traps were baited with tinned sardines by the first group and chicken pieces by the second group. They were left out in the field for five nights during the first and four nights during the second group, resulting in a total of 26 trap nights. The bait was placed at the very back of the trap (using an extendable reacher/grabber), forcing the animal to step onto a pressure plate, triggering the trap, to reach the bait. The pressure plate was covered with sand to give the trap a more natural appearance and to ensure that the target species would be more at ease when entering the trap.

Figure 2.2c. Baiting a Tomahawk trap.

Each morning groups set out into their zones to check each of their live traps. This involved checking the surroundings of the traps for a possible presence/absence record from tracks around the trap, to see if the trap had been disturbed or investigated by an Arabian wildcat or a feral cat. Where necessary, traps were rebaited.

Small mammals trapping

Small mammals are known as indicators of ecosystem health. With increasing grazing pressure on vegetation in the DDCR due to an increased number of ungulates in 2019, small mammals trapping was conducted to elucidate the population status of small mammals in the DDCR. Six rodents trapping sites (grids) were selected in three different micro-habitats within the DDCR: Three sites were selected on sand dunes (sandy areas), two were on gravel plains and one in rocks near Nazwa Mountain in the north (Figure 2.2a) all over the reserve. All trapping sites were between 100 m and 300 m from the main driving tracks in the reserve, in order to be easily accessible during the trapping, especially in the morning. Three trapping sites (grids) were set for five nights by group 1 and three trapping sites for four nights by group 2. Each trapping grid consisted of 10 Sherman Small mammal traps (of two different sizes) in two parallel lines of five traps each. Small mammal traps were set and baited with oats before sunset and checked early the next morning. Captured animals were identified, and pictures were taken of each captured individual for further identification. Species, sex, age and general body condition of each captured rodent was recorded and the animal was released at the point of capture. Traps were closed every morning and set again before sunset.

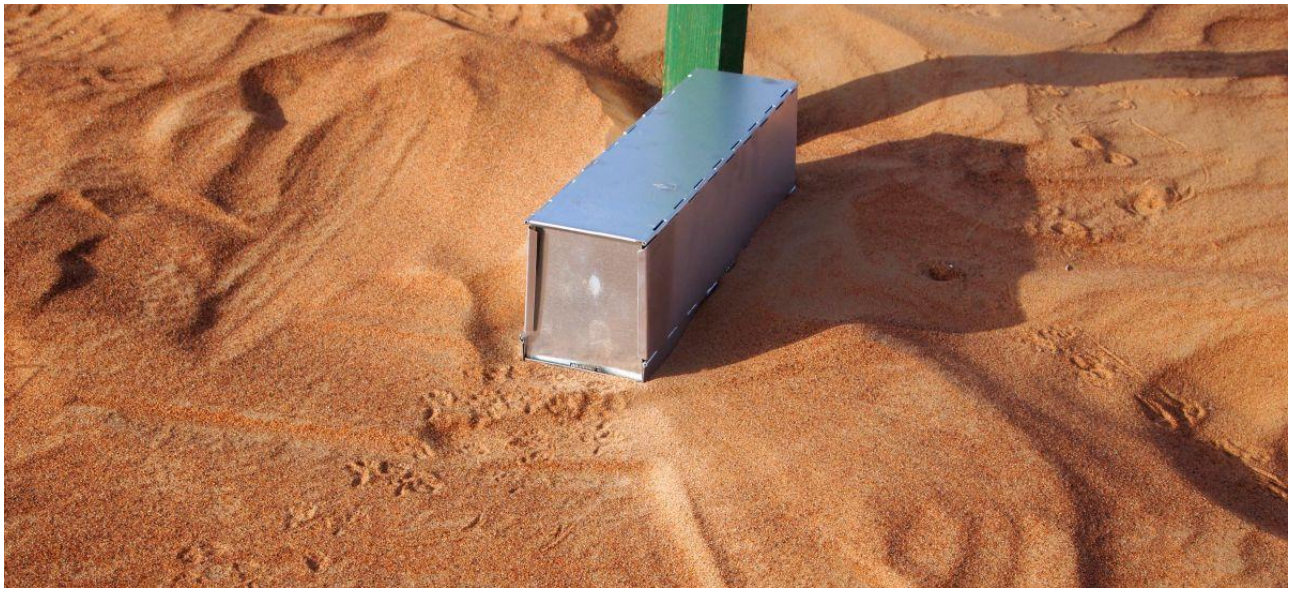

Figure 2.2d. Small mammal trap in situ at a grid marker in a sandy area.

Arabian red fox den survey

The Arabian red fox is the largest predator within the DDCR, so it is important to monitor its population. The red fox is both a nocturnal and cryptic species, so direct counts are unreliable. A better method of monitoring the population is through a count of their dens. This was initially done by DDCR staff in 2011 and then repeated in 2016 and 2018 with the help of Biosphere Expeditions, when all dens were classified as either active, inactive or abandoned based on signs of fox activity such as tracks, fresh digging, prey remains and fresh scat.

During the 2019 expedition all dens sites were revisited and once again classified based on signs of fox activity, with an additional classification of abandoned when the den had filled in with sand. Previously abandoned dens were not visited. In addition, any new dens found were recorded and classified. The density estimates of red fox dens in the DDCR were then calculated using ArcGIS software tools based on Kernel density estimates.

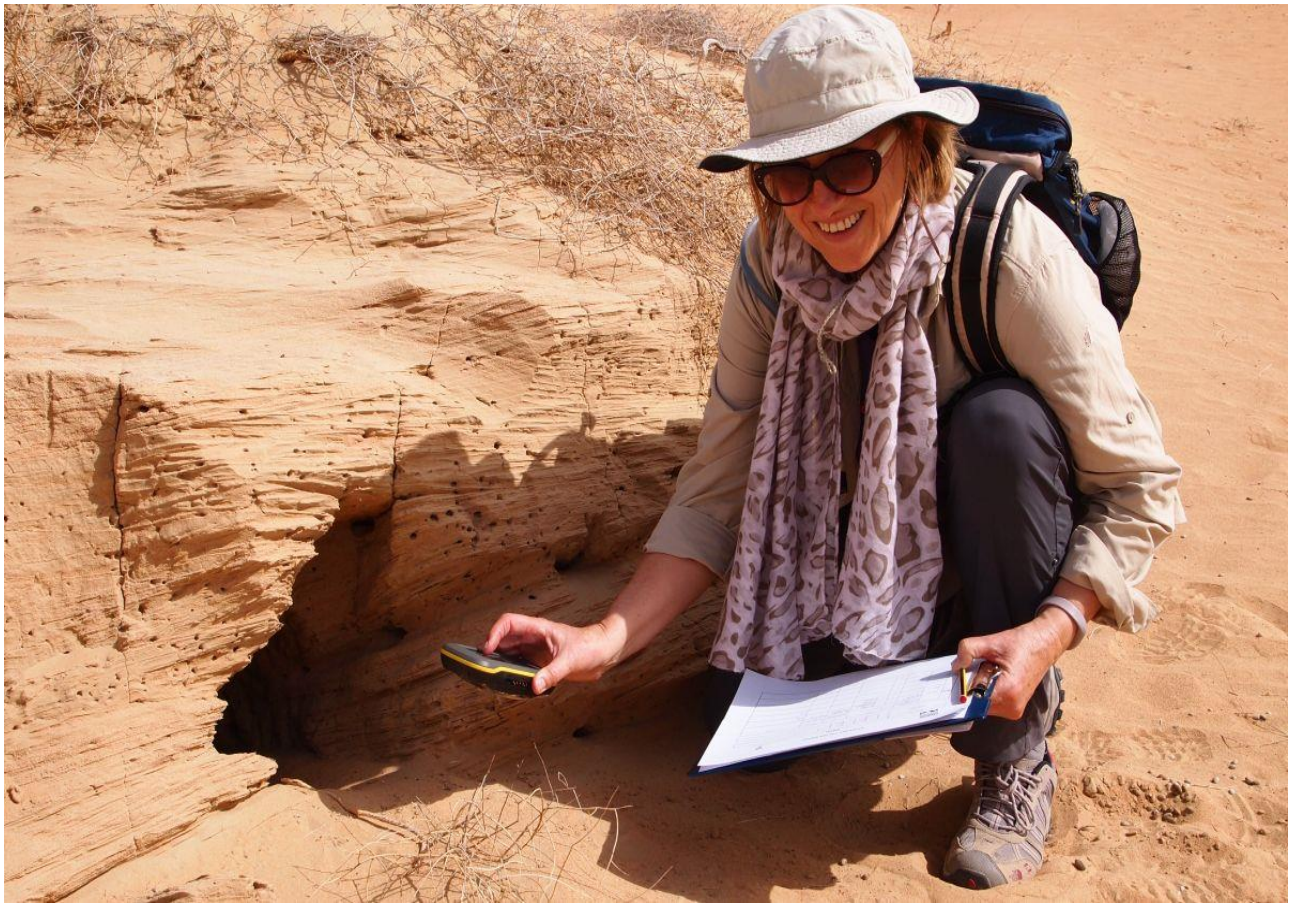

Figure 2.2e. Recording a fox den site.

Camera trapping

As many species in the desert environment are both nocturnal and elusive, it is difficult to gather reliable information on their populations. A camera trap triggers when an animal passes in front of an infrared and/or motion detector. This has the advantage of detecting with equal efficiency both nocturnal and diurnal activities with minimal environmental disturbance.

Seventeen camera traps (three Reconyx RC60, five Reconyx Hyperfire and nine Bushnell Trophy Cam HD) were used during the expedition and distributed across the four zones. Predetermined quadrants in each of the zones were chosen for the survey groups to set their camera traps in, close to water sources. Once again, the traps were not baited (as this tended to attract red foxes, probably resulting in Gordon's wildcats avoiding the sites) and left out in the field for 12 days over two consecutive groups, resulting in 203 trap nights in total.

2.3. Results

Species encounters

Table 2.3a Species encountered during the expedition. Encounter method S = sighting, L = live trap, C= camera trap.

Common name	*Latin name*
Birds	
Grey Francolin S C	*Francolinus pondicenanus*
Egyptian Goose S	*Alopochen aegyptiaca*
Mallard C	*Anas platyhynchos*
Grey Heron S C	*Ardea cinerea*
Purple Heron S	*Ardea purpurea*
Great Cormorant S	*Phalacrocorax carbo*
Lappet-faced Vulture S C	*Torgos trachieliotos**
Pallid Harrier S C	*Circus macrourus*
Shikra S	*Accipiter badius*
Long-legged Buzzard S	*Buteo rufinus**
Bonelli's Eagle S C	*Hieraaetus fascitus*
Common Kestrel S	*Falco tinnunculus*
MacQueen's Bustard S C	*Chlamydotis macqueenii**
Red-wattled Lapwing S C	*Vanellus indicus*
Common Moorhen S C	*Gallinula chloropus*
Black-winged Stilt S C	*Himantopus himantopus*
Green Sandpiper S C	*Tringa ochropus*
Chestnut-bellied Sandgrouse S C	*Pterocles exustus*
Feral Pigeon S C	*Columba livia*
Eurasian Collared Dove S C	*Streptopelia decaocto*
Laughing Dove S C	*Spilopelia senegalensis*
Pharaoh Eagle-Owl S C	*Bubo ascalaphus**
Eurasian Hoopoe S	*Upupa epops*
Green Bee-Eater S	*Merops orientalis*
Southern Grey Shrike S C	*Lanius meridionalis*
Arabian Babbler S	*Turdoides squamiceps*
Brown-necked Raven S C	*Corvus ruficollis*
White-eared Bulbul S	*Pycnonotus leucogenys*
Black-crowned Sparrow-lark S	*Eremopterix nigriceps*
Greater Hoopoe-lark S	*Alaeman alaudipes*
Crested Lark S C	*Galerida cristata*
Sand Martin S	*Riparia riparia*
Barn Swallow S	*Hirundo rustica*
Lesser Whitethroat S	*Sylvia carruca*
Asian Desert Warbler S	*Sylvia nana*
Common Mynah S	*Acridotheres tristis*
Eastern Back Redstart S	*Phoenicurus ochruros*
Desert Wheatear S	*Oenanthe deserti*
House Sparrow S C	*Passer domesticus*
Tawny Pipit S	*Anthus caneestris*

Table 2.3a (continued) Species encountered during the expedition. Encounter method S = sighting, L = live trap, C= camera trap.

Common name	*Latin name*
Arthropods	
Wolf Spider S	*Lycosidae sp.*
Black Scorpion S	*Androctonus crassicauda*
Arabian Death Stalker S	*Apishobuthus pterygocercus*
Striped Mantis S	*Blepharopsis mendica fabricius*
Desert Locust S	*Schistocerca gregaria*
Silverfish S	
Desert Runner (ant) S	*Cataglyphis niger*
Giant Ant S	*Camponotus xerxes*
Arabian Paper Wasp S	*Polistes watti*
Arabian Darkling Beetle S	*Pimelia arabica*
Urchin Beetle S	*Priionotheca cornata*
Silver-striped Hawk Moth S	*Hyles livornica esper*
Painted Lady S	*Vanessa cardui*
Globe Skimmer S	*Pantala flavescens*
Vagrant Emperor S	*Anax ephithenope*
Bloody Scarlet Dragonfly S	*Crocothemis sanguinolenta*
Mammals	
Arabian Oryx S C	*Oryx leucoryx**
Arabian Gazelle S C	*Gazella arabica**
Sand Gazelle S C	*Gazella marica**
Arabian Wild Cat	*Felis slivestris*
Arabian Red Fox S C	*Vulpes vulpes arabica**
Feral Cat S C	*Felis catus*
Arabian Hare S	*Lepus capensis*
House Mouse S	*Mus musculus*
Egyptian Spiny Mouse L	*Acomys cahirinus*
Cheeseman's Gerbil L	*Gerbillus cheesmani*
Arabian Jird S	*Meriones arimalius*
Reptiles	
Arabian Toad-headed Agama S	*Phrynocephalus arabicus*
White Spotted Lizard S	*Acanthodactylus schmidti*
Fringe-toed Sand Lizard S	*Acanthodactylus gongrorhynchatus*
Least Semaphore Gecko S	*Pristurus minimus*
Dune Sand Gecko S	*Stenodactylus doriae*
Sandfish S	*Scincus scincus*

*During the 2019 expedition the following target species numbers were recorded by 1,002 random observations and 62 circular observations: 1,890 Arabian oryx, 1,270 Arabian gazelle, 317 sand gazelle, 1 red fox, 13 MacQueen's bustard, 15 lappet-faced vulture and 4 pharaoh eagle owl.

Quadrant survey (including oryx, gazelles and vegetation surveys)

Over the years, the ungulate counts conducted by Biosphere Expeditions are inconsistent with those resulting from weekly counts by DDCR staff, using their established methodology. These focus mainly on wildlife support infrastructure such as feed spots, waterholes and irrigated areas. This may be a result of the differing emphases of the expeditions, year to year, which can result in skewed data (see Figure 2.3a). For example, when the expedition focussed primarily body condition scoring, citizen scientists spent more time with oryx herds, resulting higher counts than from simple observations. In 2018 it was decided to concentrate on collecting good data from all the circular observations as well as focused counts at all the feed spots, to ensure a more accurate count of the ungulate populations and to elucidate distribution.

In a nutshell, weekly feed point counts are made on the main tracks or roads in the reserve by DDCR staff while providing animal feed in the morning, so this will only count animals along the main tracks (roads) going to the feed points, water holes and farms. In contrast, during the expedition's circular observations, citizen scientists walk to the centre of each quadrant to observe and record the animals there, which provides a clearer picture of animal distribution. This, combined with the counts made by DDCR staff and also those by the expedition at feed points, yields a good overall picture of animal distribution and numbers in the reserve.

Arabian oryx

825 Arabian oryx were counted during in the 2019 expedition during circular observations and at feed spots. An emphasis was placed on collecting good data from all circular observations. Results were combined with focused counts at all feed spots in an attempt to determine an accurate count of the Arabian oryx in the DDCR. DDCR staff weekly counts recorded 667 Arabian oryx during the same period. Combining these counting methods, the Arabian oryx population is estimated to be between 700 and 850 individuals. As such, population of Arabian oryx in 2019 have increased by nearly 20% compared to the 2018 counts results (see Figure 2.3a).

Arabian gazelle

The 2019 expedition counted 167 Arabian gazelle, significantly lower than the figure arrived at by DDCR weekly counts (425), which is considered a more accurate estimate of the Arabian gazelles in the reserve and indicates a population increase (see Figure 2.3a). The 2019 expedition data yielded more a accurate distribution of Arabian gazelles and indicated a wider distribution, compared to 2018. This can be attributed to a population increase of at least 20%. Despite the differences in expedition and DDCR weekly count results, the expedition count helps DDCR management understand the distribution of the Arabian gazelle species in the reserve. In addition, it is useful to use more than one method for population estimates. The expedition quadrat survey method is particularly useful in understanding population distributions, whilst the DDCR weekly counts are most useful for population estimations.

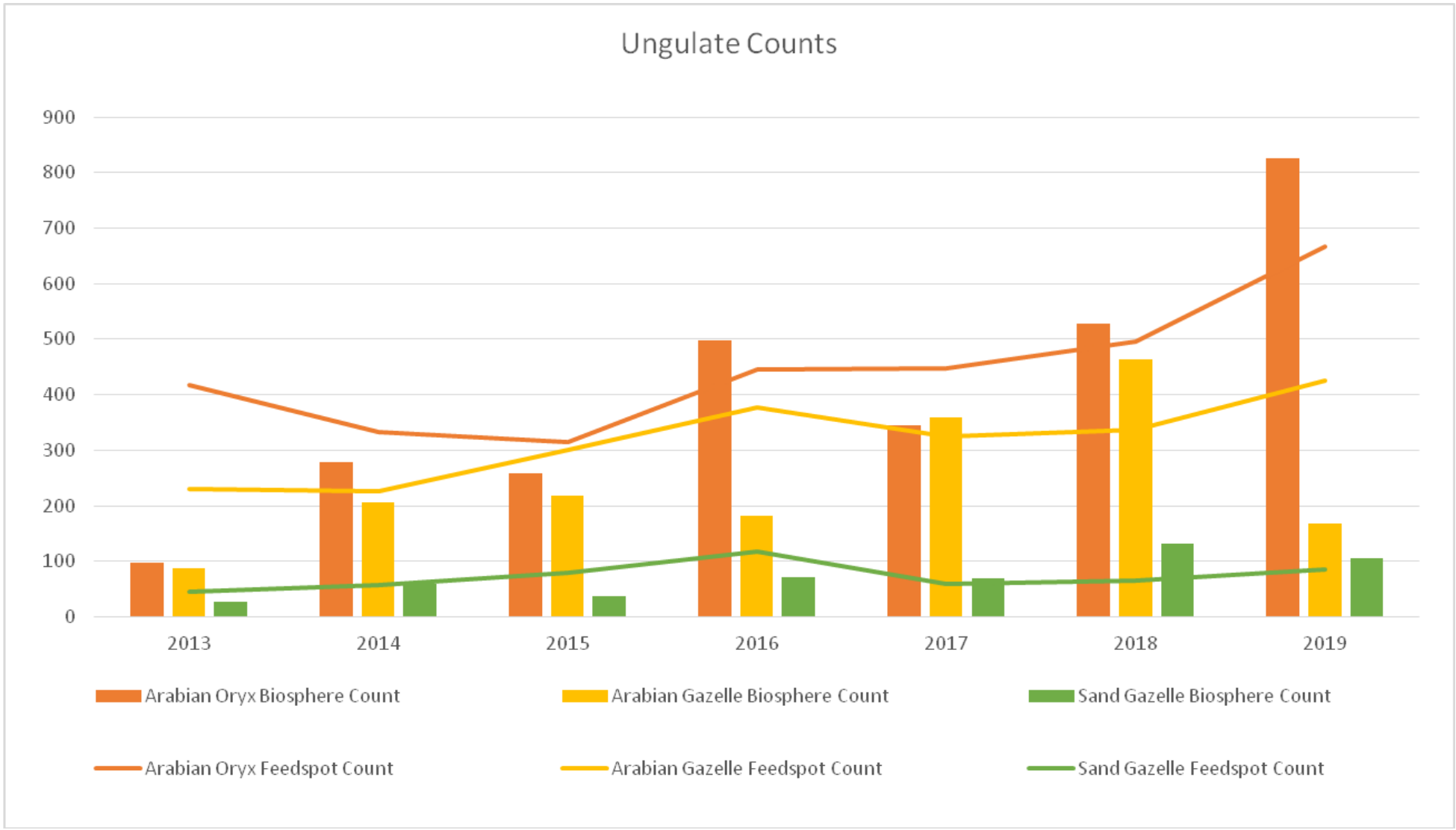

Figure 2.3a. Comparative chart of ungulate numbers recorded by the expedition (intensive survey of one to two weeks duration, once a year) and DDCR staff feedspot counts (during the same week as the expedition).

Sand gazelle

The count of 105 sand gazelle was similar to the 2018 result (132), albeit slightly lower. The expedition number broadly agrees with the weekly DDCR counts, which estimate a sand gazelle population of 80-120 individuals within the DDCR.

Large shrub (vegetation) survey

A repeat survey following the 2017 methodology described in Simkins and Hammer (2018) counted nearly 19,642 plants during circular observations in 2019. During the survey the dominant species were the fire bush (17,422), followed by Ghaf trees (1,448), widely distributed Acacia acacia trees (514), date palms, mainly in farms (175), Arta (14) and Sodom's apple (66). Only three desert thorn were counted during the 2019 survey.

Live traps for medium-sized animals

Three traps were set for five nights for a total of 15 trap nights during the first group and three traps were set for four nights for a total of 12 trap nights during the second group. The 2019 expedition did not result in any meso-carnivores being captured. Tracks of red foxes and cats were recorded around the traps, but no individuals entered. In the second week the bait was also changed from canned sardine fish to chicken pieces to attract the targeted species, but without success. The northern trap was triggered with no capture, and due to strong winds fox or cat tracks were seen.

Small mammals trapping

Small mammals trapping consisted of 268 trapping nights over six grids and resulted in a total of 28 captures, which included two species: 25 Cheeseman's gerbils (*Gerbillus cheesmani*) (16 males, 7 females, 2 unknown) and 3 Egyptian spiny mouse (*Acomys cahirinus*) (1 male, 2 unknown) (Figure 2.3b). The total trapping success rate was 10%. 10 traps were triggered without captures being made, representing a 3% trapping failure rate (false trigger) (Table 2.3c)

The largest number of successful captures were recorded in area RS3, where 13 Cheeseman's gerbils were captured. The next highest number was recorded in area RS4 with 11 of the same species captured. Both sites were within the sandy dune habitat. In the rocky area (RS5), three Egyptian spiny mouse were captured. One Cheeseman's gerbil was captured in the RS2 gravel area. In the RS1 gravel area and RS6 sandy area no small mammals were captured, although tracks of small mammals were recorded around traps in RS1 and RS6.

Of the 28 total captures, 18 rodents (64%) were made by long Sherman traps and ten rodents (36%) were captured by the more commonly-used short Sherman traps. Both types of trap were effective and successful in trapping gerbils and spiny mouse but, no jird species were trapped with either.

Table 2.3c. Results of small mammals trapping 2019.

Trapping area	Habitat	Group	Trap nights	Individuals captured	Success rate	Failed traps	Failure rate	Species captured
RS1	Gravel	2	40	0	0%	4	10%	None
RS2	Gravel	1	50	1	2%	1	2%	Cheeseman's gerbil
RS3	Sand	2	40	13	33%	0	0%	Cheeseman's gerbil
RS4	Sand	2	38	11	29%	0	0%	Cheeseman's gerbil
RS5	Rocky	1	50	3	6%	0	0%	Egyptian spiny mouse
RS6	Sandy	1	50	0	0%	5	10%	None
		Total	**268**	**28**		**10**		

Figure 2.3b. Cheeseman's gerbil (top) and Egyptian spiny mouse (bottom) captured during trapping sessions.

Arabian red fox den survey

Results of the survey can be found in Table 2.3b. In total 92 dens were surveyed by the 2019 expedition team of which 62 had previously been classified as active or inactive (53 in 2018, 9 in 2017). In addition, 30 new dens were identified. Results found 15 dens active, 29 dens inactive and 48 dens abandoned. The 2019 survey shows a 37% increase in the number of active dens compared to 2018, including 1 inactive den, which became active again. New den sites identified in 2019 increased to 30 (11 active and 19 inactive) compared to only 15 new sites found in 2018 (Simkins and Hammer 2018). Dens recorded as abandoned during previous years were not included in the survey.

Table 2.3b. Results of the Arabian red fox den surveys in 2011 and 2016-2019.

Status	2011	2016	2017	2018	2019
Active	66	59	24	11	15
Inactive	95	52	40	42	29
Abandoned	0	57	138	167	48
TOTAL	**161**	**168**	**202**	**220**	**92**
Status changes					
Unchanged		55	65	138	18
New Active		4	14	7	11
Inactive to Active		25	2	2	1
Abandoned to Active		0	0	2	-*
New Inactive		3	24	8	19
Active to Inactive		24	3	10	2
Abandoned to Inactive		0	5	11	-*
New Abandoned		0	7	0	0
Active to Abandoned		12	43	17	6
Inactive to Abandoned		45	39	25	35
Not Surveyed		0	11	10	167*

* Old Abandoned dens not surveyed in 2019.

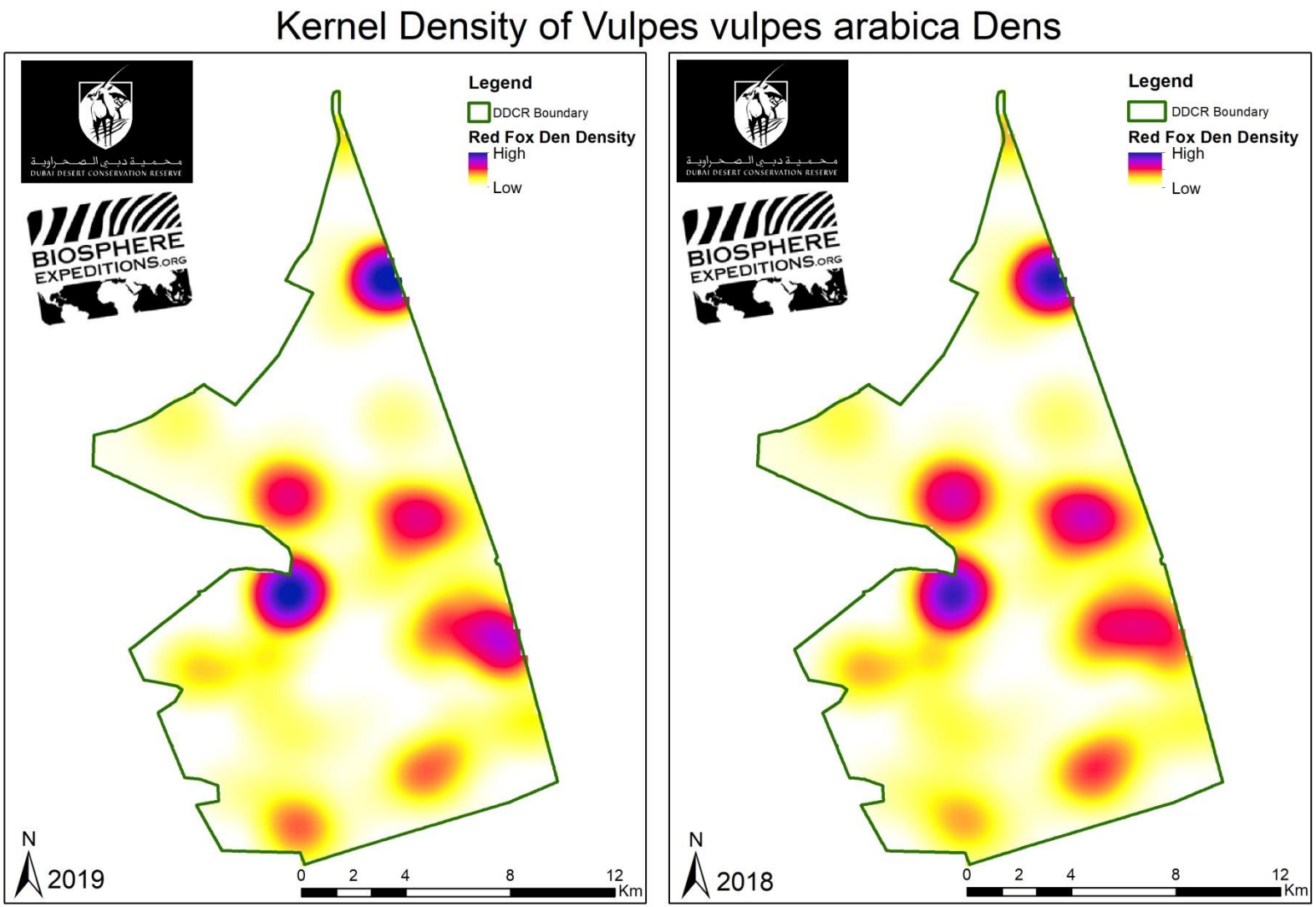

Figure 2.4f. Arabian red fox den distribution in 2019 and 2018.

Camera trapping

Of the 17 traps set, camera trap no. 2 malfunctioned and images recorded by this camera trap were discounted. A total of 203 trapping days captured 21,697 images of which 17,079 contained an identifiable subject. 14,515 individual records (Images) of naturally occurring native fauna were recorded, as well as 2,137 of humans or vehicles (Figure 2.3c). 28 wildlife species and one feral species (a feral cat) were captured during the trapping effort.

A large number of bird species (23) was recorded this year. The most significant bird or captured were lappet-faced vultures from three camera traps. Important records of pallid harrier and Bonelli's eagle were also made (Table 2.3d). A single record of a MacQueen's bustard was made (Figure 2.3d). Large numbers of Eurasian collared doves (3,913) were recorded over 12 different camera trap locations. An additional 19 bird species were also recorded on identified from the photos camera traps (Table 2.3d).

Arabian oryx was the most abundant and widespread species, with 20,259 recorded capture events (total number of oryx in all the photos) from photos from almost all the camera traps. The following recordings of the other target species were made: 4,696 Arabian gazelle from 14 traps, 2,202 sand gazelle from eight traps, 331 Arabian red fox from 10 traps (2.3e), and also 570 Feral cats from one trap. Three images of the same Arabian wildcat were also captured by camera trap no. 11 (2.3f).

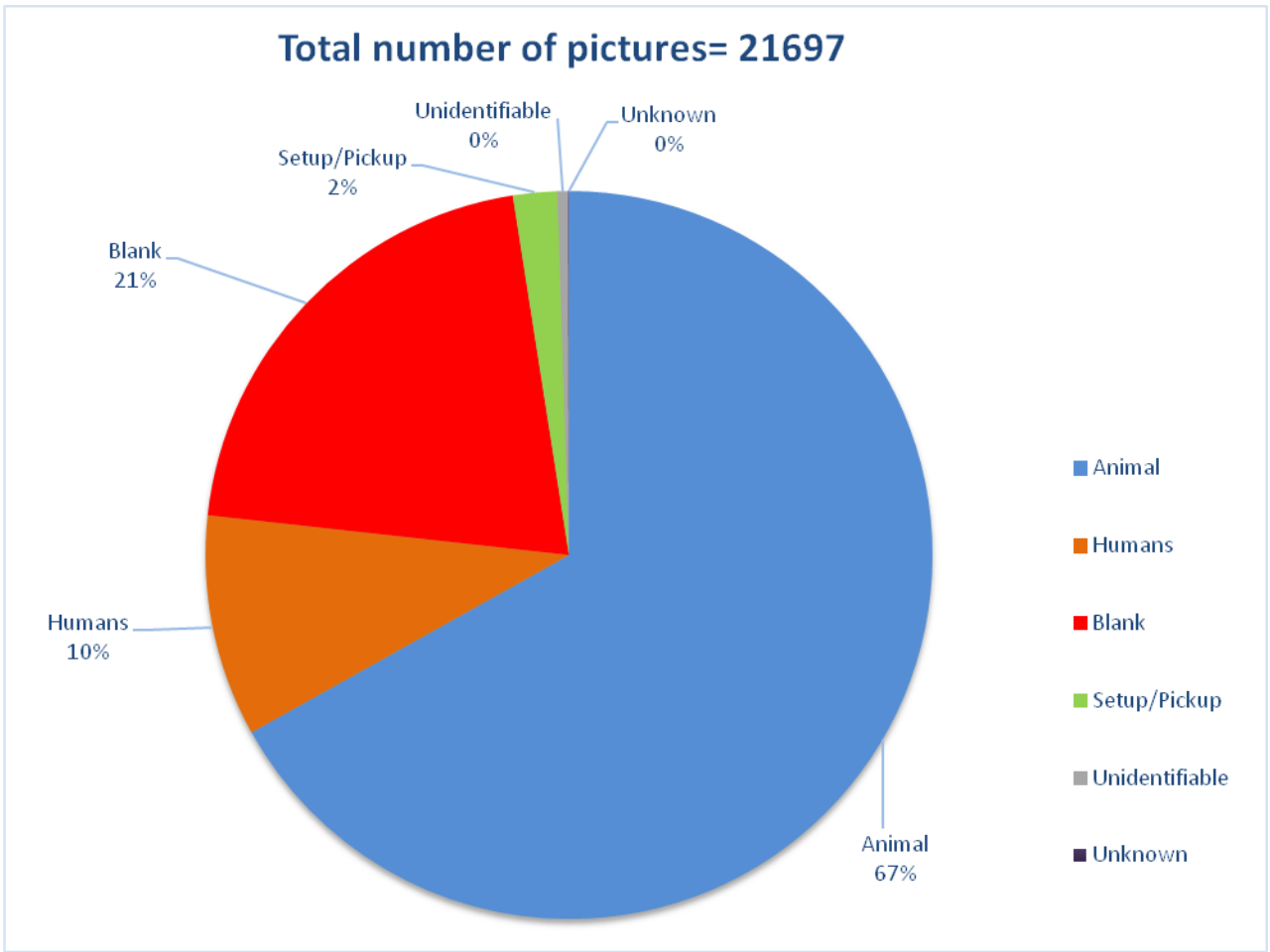

Figure 2.3c. Results of camera trapping 2019.

Table 2.3d. Results of camera trapping 2019.

Camera trap number	Latitude	Longitude	Arabian oryx	Arabian gazelle	Sand gazelle	Arabian red fox	Arabian wild cat	Feral cat	Lappet-faced vulture	Pallid harrier	Bonelli's eagle	Asian houbara	Black-winged stilt	Red-wattled lapwing	Chestnut-bellied sandgrouse	Rock dove	Eurasian collared dove	Laughing dove	Eagle owl	Great grey shrike	Total
02	55.664883	24.883596										Malfunction									
03	55.660494	24.869189	331	1	0	1	0	0	0	0	0	0	0	0	0	0	0	19	0	0	**352**
04	55.665463	24.900862	138	8	32	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	**181**
05	55.671316	24.788967	78	52	36	0	0	0	9	0	0	0	0	12	0	0	0	0	0	0	**187**
06	55.717717	24.779527	64	95	97	26	0	0	0	0	12	0	0	0	0	0	495	67	0	0	**856**
07	55.647524	24.766422	5065	146	835	74	0	0	0	11	0	0	0	0	35	481	146	174	6	3	**6976**
08	55.662777	24.980824	946	187	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	**1140**
09	55.677639	24.870299	301	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**304**
11	55.656984	24.74116	2135	0	671	14	3	0	123	3	0	0	0	0	0	0	15	39	0	24	**3027**
12	55.685833	24.804671	50	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	**56**
13	55.659817	24.8203	12	2234	0	33	0	571	0	0	0	0	0	90	0	216	279	14	0	0	**3449**
14	55.717691	24.819276	712	209	0	90	0	0	0	0	0	0	0	0	0	0	117	27	0	0	**1155**
15	55.613695	24.885371	545	24	0	4	0	0	6	12	0	0	1	0	0	0	6	15	0	0	**613**
16	55.634344	24.855114	3033	1157	161	82	0	0	0	0	0	0	0	0	0	0	277	62	0	0	**4772**
17	55.703251	24.820728	3010	29	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	**3042**
19	55.613408	24.795528	3541	482	369	4	0	0	0	0	0	0	0	0	0	61	2536	39	0	0	**7032**
20	55.699843	24.841635	298	69	1	3	0	0	0	0	0	0	0	0	0	0	26	15	0	6	**418**
		Total	**20259**	**4696**	**2202**	**331**	**3**	**571**	**138**	**26**	**12**	**1**	**1**	**102**	**35**	**758**	**3913**	**473**	**6**	**33**	**33560**

Figure 2.3d. A single MacQueen's was bustard also captured in Tawi Ruwayan irrigated area by camera trap number 4.

Figure 2.3e. Red fox captured near a water point by camera trap number 14.

Figure 2.3f. Arabian wild cat captured at camera trap number 11.

2.4. Discussion and Conclusions

Quadrant survey (including oryx, gazelles and vegetation surveys)

The relatively high numbers of ungulates within the DDCR continues to be a challenge in terms of the need to balance animal welfare with the health of the desert ecosystem. Supplying supplementary feed for the oryx herd addresses both of these aspects, by making additional food available to individuals while limiting the impact of overgrazing on the ecosystem. The 2019 Expedition quadrant survey contributed to understanding the current distribution of all three ungulates species in DDCR. The DDCR staff weekly counts show a clear increase of nearly 20% in the Arabian oryx and Arabian gazelle populations in 2019 when compared to 2018 counts.

Good nutrition results in higher breeding success and can lead to faster population growth, which is not sustainable long-term. To reduce the number of ungulates on the reserve this year, management have succeeded in gaining approval for ungulate holding enclosures outside the DDCR. In addition, efforts are being made to translocate animals to other reserves within the natural home range of the species.

Arabian oryx

In 2019 Arabian oryx were distributed all over the DDCR, a change 2018 patterns. We believe this is mainly due to their increasing numbers and therefore competition and a subsequent need for dispersal. The predicted distribution of Arabian oryx across the DDCR is highly concentrated, mainly around the feed points and irrigated areas (Figure 2.4a), where food is easily found.

Arabian gazelle

The main concentration of Arabian gazelle is in the central and central south parts of the DDCR and appears to be as a result of the adapted habitats such as the irrigated areas at the old farms and tree plantations, which provide more food for the species (Figure 2.4b).

Sand gazelle

The predicted distribution of sand gazelle has expanded from that observed in 2018. Sand gazelle were recorded in most parts of the reserve. Higher concentrations are consistently observed in the south of the DDCR in the dunes, which is the species' preferred habitat, as well as around the irrigated areas (see Figure 2.4c), where there is food to be found.

Large shrub (vegetation) survey

Predicted distributions of two shrub species (fire bush and Sodom's apple, both important indicator species for the reserve's habitats), based on 2019 observations, were compared with those from 2017 (see Figures 2.4d & e). Sodom's apple shows a reduction in predicted distribution (see Figures 2.4f), due to increasing numbers of Arabian gazelles, which are often observed browsing on this species. There was no change in predicted fire bush distribution.

Live traps for medium-sized animals

Over a total of 27 trapping nights, no meso-carnivore species were trapped in 2019. In comparison, in 2018, two red foxes and one feral cat were captured over only 15 trapping nights. It may be that the number of red foxes and wild cats in the DDCR is decreasing. More research would be needed to determine this. A larger trapping effort through increasing the number of traps in all three zones will be made during future Biosphere Expeditions surveys, in an attempt to capture the target species of Arabian wild cat, sand fox and red fox.

Small mammal trapping

Small mammal trapping resulted in the capture of 28 individuals from two species; namely Cheeseman's gerbil and Egyptian spiny mouse. No Baluchistan gerbil, Arabian jird and Sandevall's jird were captured, although Arabian jirds were recorded by expedition team members in south of DDCR. Two different sizes of Sherman trap were used during the small mammal during 2019, which improved our understanding of which traps are more effective for different species.

Red fox den survey

High den densities were found, as expected, within relatively well-vegetated areas, dominated by large shrubs, in particular *Leptadenia pyrotechnica,* which meet the habitat requirements of providing a stable soil substrate supported by the shrub's root system. No major changes were seen in den densities from 2018 to 2019, although more active and inactive dens were recorded in the south of the DDCR (Figure 2.4g). In the central part of the DDCR more active dens were recorded than in 2018.

In 2019 only active and inactive dens were surveyed and additional training was provided on the identification of fox dens and their classification. In 2019, 30 new den sites were discovered, compared to 15 new sites in 2018 (Simkins and Hammer 2018b). But compared to 2017, 2016 and 2011 the density of red fox dens in the DDCR decreased in 2018 and 2019. This could be due to a decrease in the prey base because of the current unfavourable vegetation conditions. Vegetation is deteriorating due to a combination of reasons including drought and large numbers of ungulates which exceed the optimum vegetation carrying capacity. In return this affects the small mammal population, which is the main prey base for red foxes. However, a good number of red fox pictures (331) were captured from 10 different camera traps this year, which is a positive indicator of the status of the red fox population and their distribution in the reserve.

Camera trapping

The camera traps provided an excellent return of pictures, with the 2019 expedition being of the most successful for camera trapping. The majority of pictures captured were of native fauna (67%). Double the camera trapping effort (13 trapping days) of previous years, yielded a record number of pictures: 21,697, showing 29 species. The most frequently recorded species was Arabian oryx with 10,571 pictures. Photos of the lappet-faced vulture using the waterhole for bathing are significant records for this species, of which little is known of their ecology in the northern Arabian Peninsula. Among the target mammal species within the DDCR, the rare Arabian wildcat was recorded and confirmed once and red foxes were also recorded by several camera traps. Among the other important species captured by camera traps this year were the Pallid harrier, Bonelli's eagle, long-legged buzzard, Pharaoh eagle-owl and chestnut-bellied sand grouse. No Sand fox were recorded by camera trap this year. Continued camera trap surveys are therefore still needed to monitor the presence of these important species in DDCR.

Management considerations

The high ungulate population within the DDCR continues to be the major challenge for its management. This is naturally a concern during dry years as there is less food available for all herbivorous species. Even more concerning is the fact that these high ungulate numbers will hinder recovery of the habitat even in wet years. Results presented here support the notion that this is likely to be affecting the small mammal and red fox populations as well.

Therefore, it is now a priority to drastically reduce the numbers of ungulates within the reserve. As it has not been possible to translocate animals to other protected areas at a rate that would reduce or even maintain the DCCR population, and because there is an on-going genetic study of the Arabian oryx, it has been decided that the majority of oryx will be relocated to enclosures adjacent to the reserve and the sexes separated, to prevent a further increase in the population while at the same time relieving pressure on the natural habitat within the DDCR. Implementation of this plan will start in February 2020 upon the completion of the enclosures.

Overall, the DDCR plans over the next five years to move to lower numbers of ungulates, but increase the diversity of species through both natural processes, as the habitat quality improves, but also through some potential species re-introductions once the habitat has recovered. It is hoped that Biosphere Expeditions citizen scientists will continue to play an important role in studying the effects of these management actions.

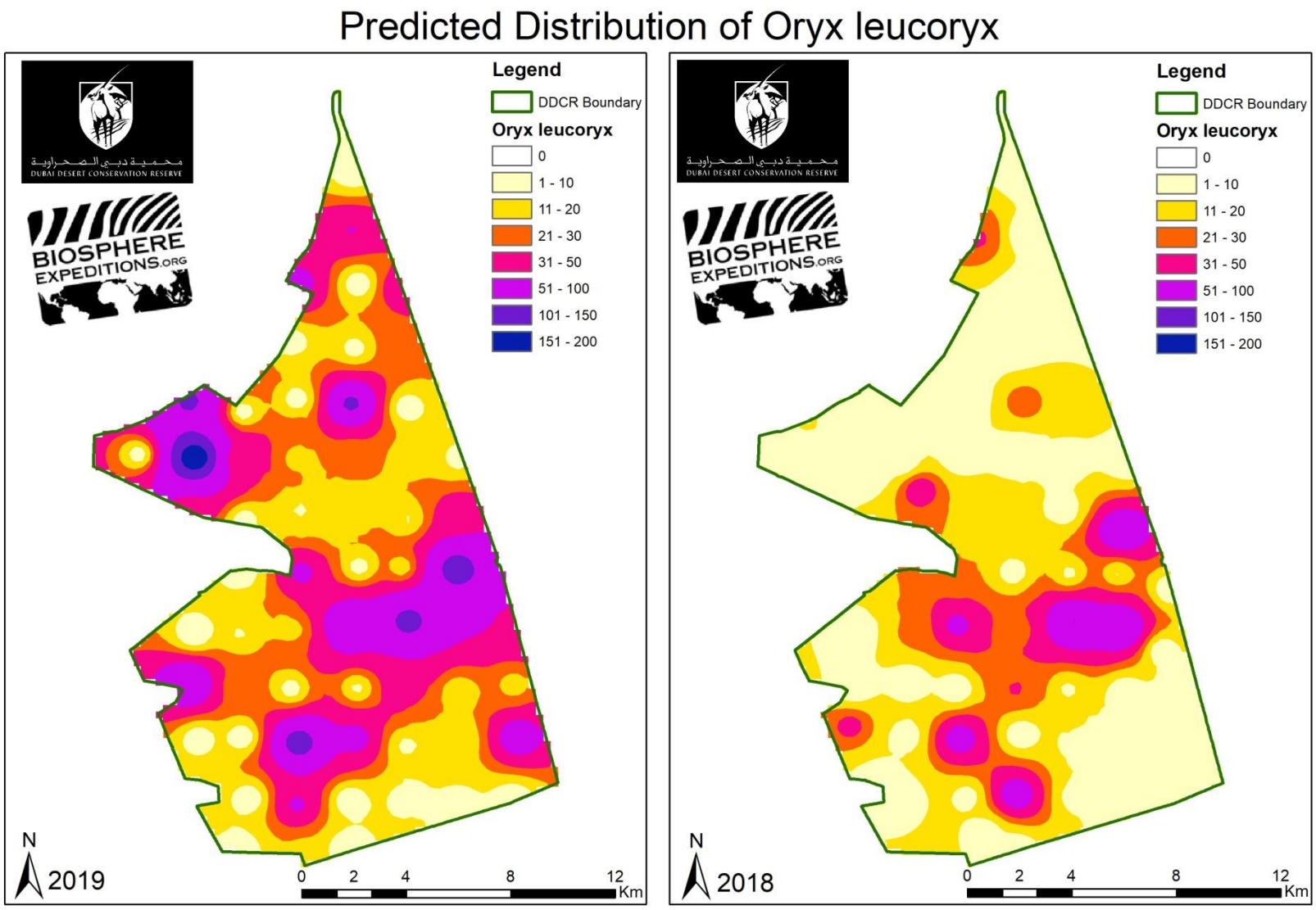

Figure 2.4a. Arabian oryx distribution 2019 vs. 2018. Predicted distribution calculations are based on a combination of both random and circular observation data.

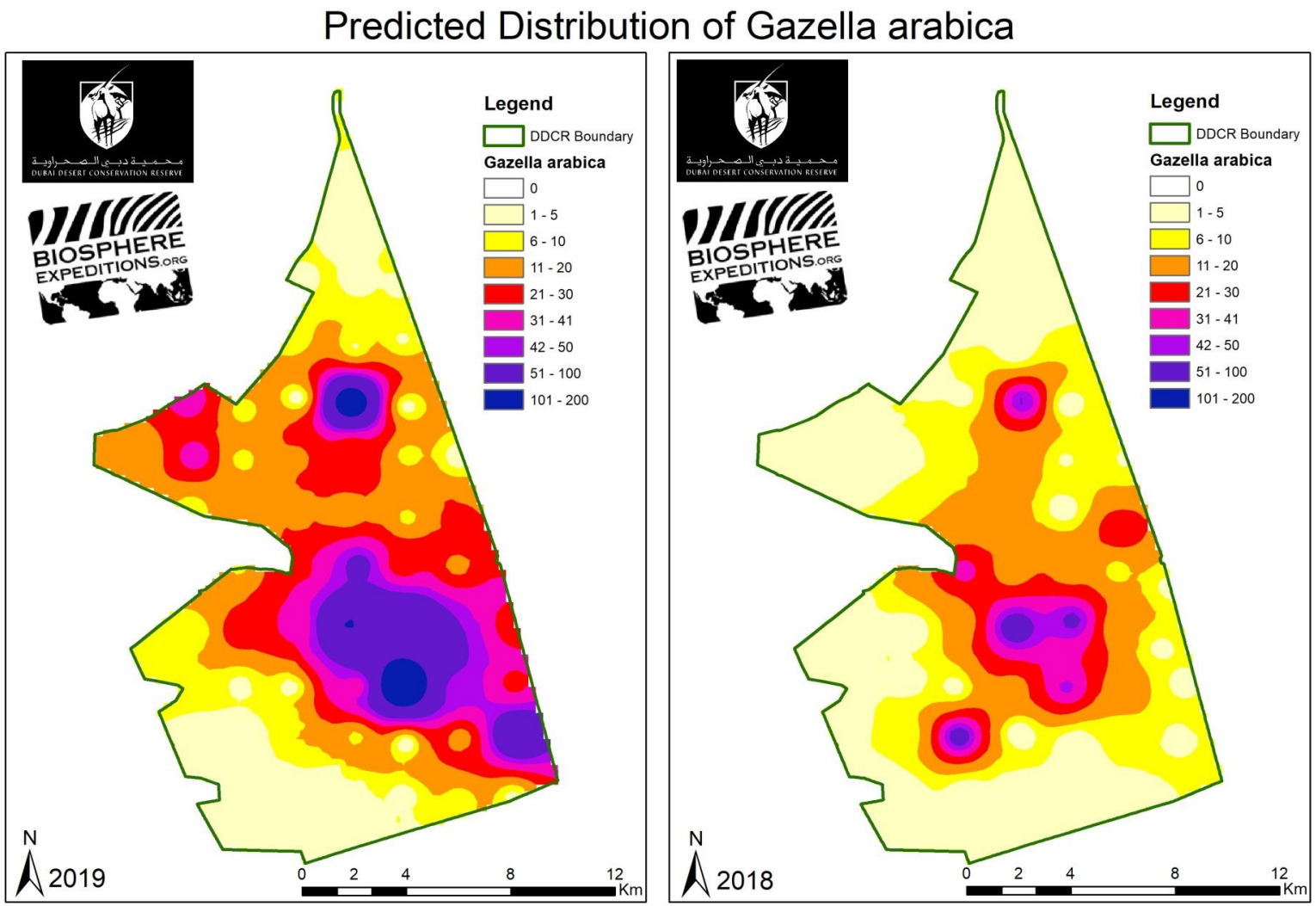

Figure 2.4b. Arabian gazelle distribution 2019 vs. 2018. Predicted distribution calculations are based on a combination of both random and circular observation data.

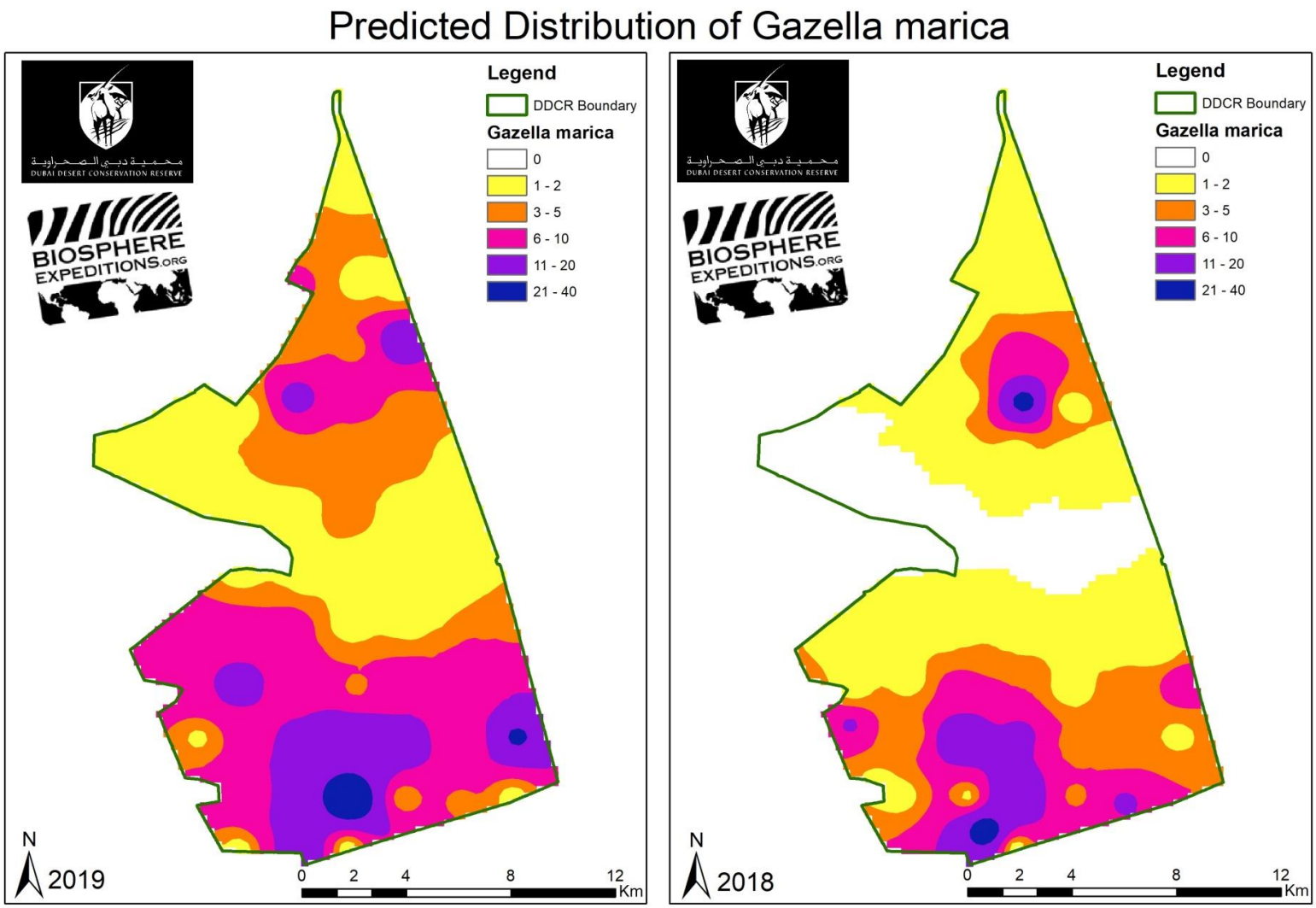

Figure 2.4c. Sand gazelle distribution 2019 vs. 2018. Predicted distribution calculations are based on a combination of both random and circular observation data.

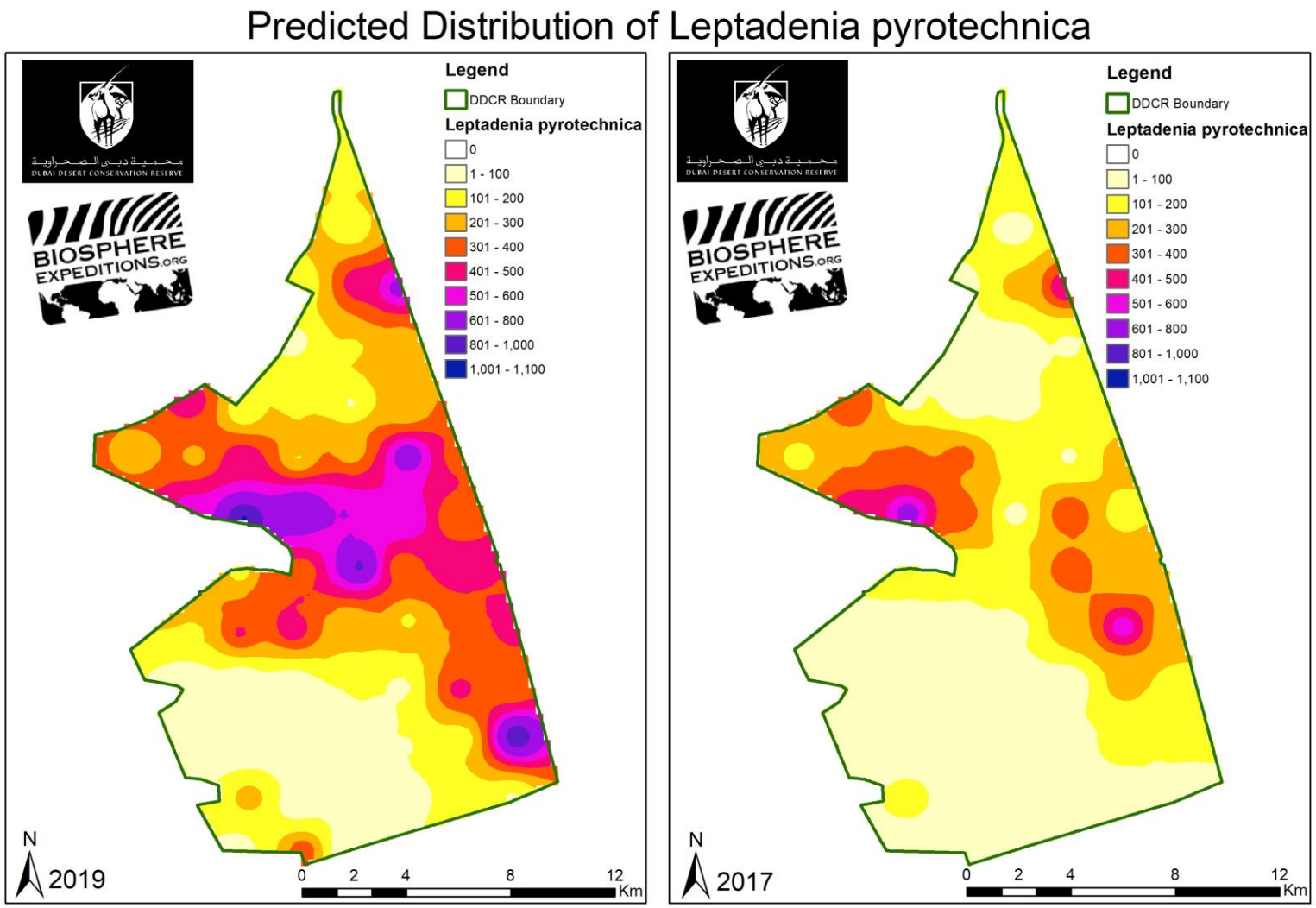

Figure 2.4d. Fire bush distribution 2019 vs. 2017.

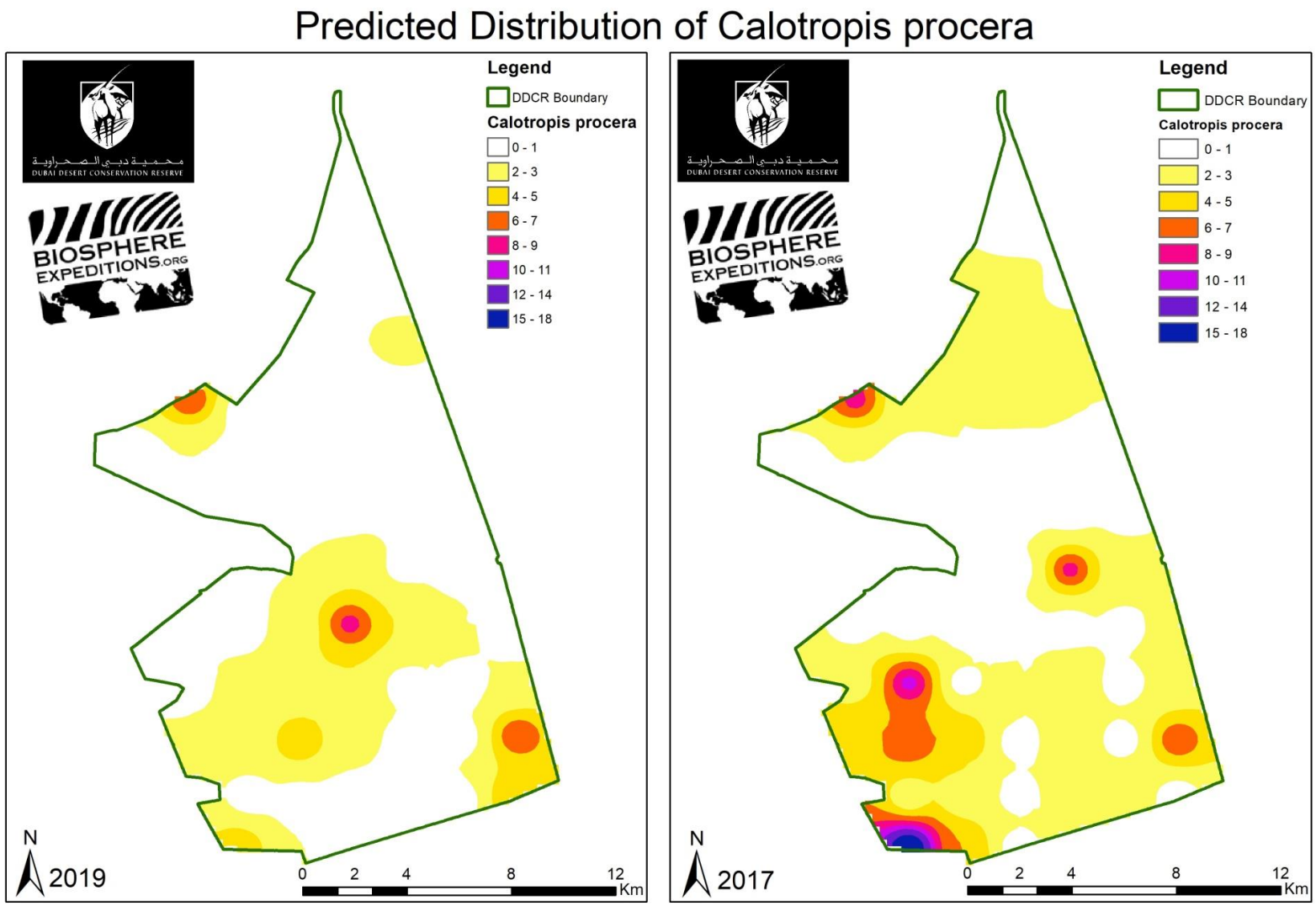

Figure 2.4e. Sodom's apple distribution 2019 vs. 2017. Predicted distribution calculations are based on observation data.

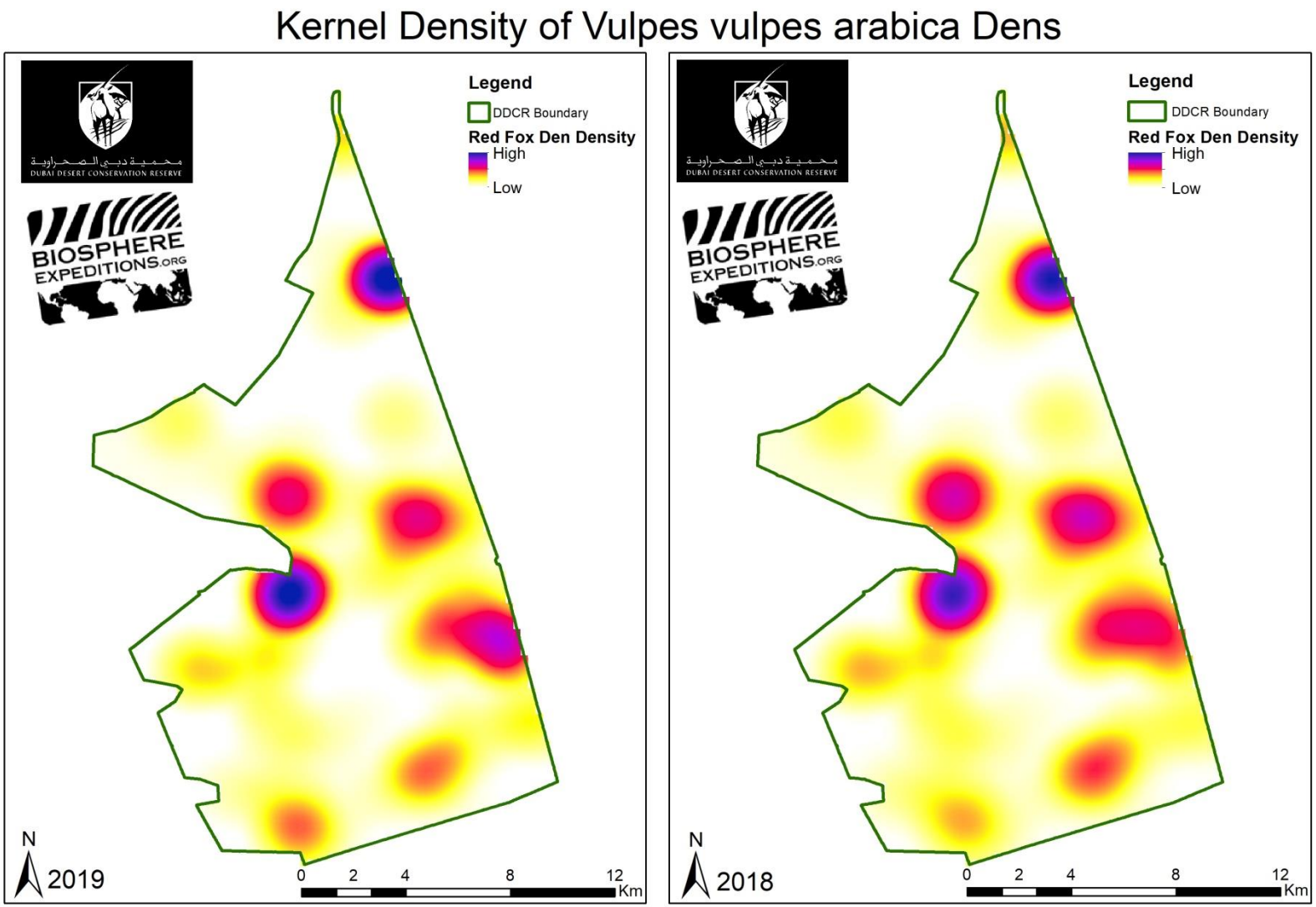

Figure 2.4f. Arabian red fox den distribution in 2019 and 2018.

Recommended activities and actions for the 2020 expedition

The kind of citizen science projects run by Biosphere Expeditions are ideally suited to the DDCR's research needs, which require a large area to be surveyed in a short period of time. Therefore:

- Due to the drastic reduction in active dens, the red fox den survey will again be of particular importance in 2020, as continued declines in the number of active dens could be significant for the reserve's population of red fox. Additional training will be provided for the identification of fox dens and their classification. This will include recording new dens, as 30 new dens were found during the 2019 expedition.

- Camera trapping will be continued as we survey the DDCR for the presence and distribution of Gordon's wildcat and sand fox.

- We will continue to do live trapping for Arabian wildcat as well as Sand fox in the reserve, increasing the trapping effort (number of traps) in each zone. Emphasis will also be placed on the collection of morphological data of individuals captured within the DDCR as little is known about the morphology of the species from the wild.

- Small mammal trapping will be continued in 2020. We will change the locations of two of the survey grids, and increase the number of traps per grid, to investigate the distribution of small predators' prey species. Also, if possible, morphological data from the captured individuals will be collected as limited information on the morphology especially of jird species is available from DDCR.

- Fixed point photography will be added as one of the main activities of the 2020 expedition. This will take place on pre-selected locations in the DDCR to record changes in vegetation condition due to grazing pressure.

- We will continue the quadrant survey with circular observations as carried out in 2019. This provides the DDCR management with valuable data on the size and distribution of many species across the entire reserve.

2.5. Literature cited

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Appendix I: Expedition reports, publications, diary & further information

Project updates, reports and publications:
https://www.researchgate.net/project/UAE-Protecting-desert-habitats-and-species-of-the-Dubai-Desert-Conservation-Reserve-through-citizen-science

All expedition reports, including this and previous expedition reports:
https://www.biosphere-expeditions.org/reports

Expedition diary/blog:
https://blog.biosphere-expeditions.org/category/expedition-blogs/arabia-2019/

Expedition details, background, pictures, videos, etc.
https://www.biosphere-expeditions.org/arabia