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Regional Baseline & Monitoring Programme

**Terrestrial Ecology Monitoring Standard**



Amec Foster Wheeler Energy and Partners Engineering Company – February 2021

Report for

NEOM

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# Introduction

## Background - NEOM

NEOM is one of several national ‘giga-projects’ located in the Tabuk Region of northwest Saudi Arabia, on the Red Sea and Gulf of Aqaba coasts. It covers a total area of 26,500 km2 and includes coastal Red Sea borders with Egypt and land borders with Jordan.

NEOM is a fundamentally important project for Saudi Arabia, being a key part of the transformation proposed under the Kingdom’s Vision 2030 initiative. It involves the planning, design, construction and operation of multiple urban districts and connecting infrastructure, spanning the entire region. It incorporates sustainable cities and industries, communities with a high quality of living and technology-based services, including health, education, transport, sport and entertainment.

## Regional Baseline & Monitoring Programme

NEOM encompasses areas of outstanding natural beauty, globally important heritage sites, vulnerable ecosystems and threatened species, all of which must be conserved and protected to fulfil NEOM’s aspiration of being biodiversity net positive.

Part of the mandate of NEOM Environment is the conservation of biodiversity and further information on the baseline status of flora and fauna within the NEOM region is required to inform the Land Conservation Division’s work in planning the conservation and management of protected areas, habitats and species.

The purpose of the Regional Baseline & Monitoring Programme is to develop a regional baseline, informing NEOM’s biodiversity conservation management planning. It will establish an ongoing series of survey and monitoring activities as the various NEOM development projects are initiated and mobilised, providing a baseline against which the effects of development activities are to be assessed and monitored, including as part of the planning and Environmental and Social Impact Assessment (ESIA) process.

## The Standard

This Survey Standard (terrestrial ecology) sets out guidance on the sampling methods to be applied during collection of baseline biodiversity data, with the intention of limiting the scope for differences in approach. The data collection, analyses and interpretation are intended to enable the development of ESIAs and inform impact assessment, prevention, minimisation, mitigation, compensation and monitoring. It will also inform monitoring/review of progress towards achieving NEOM’s biodiversity conservation objectives.

Taking each ecological feature (habitats/taxa) in turn the Standard includes guidance/considerations in defining survey objectives, study areas, survey equipment, personnel, and survey design and methods, including locations, timing and frequency, as well as reporting. The guidance should be interpreted and adapted to meet the specific survey objective, and in response to site-specific information, by suitably qualified personnel with the relevant specialist knowledge and experience. The standard approach will in most cases include the following steps:

* **Survey Objectives** – defining the specific objectives of the survey;
* **Study Area** – defining the extent of the study area and survey locations;
* **Desk Study** – collating and reviewing existing information on the status of the habitat/species within the Study area and surrounding areas;
* **Field Survey** – design and implement the field survey work in order to collect data that will meet the survey objectives;
* **Data Analysis –** use appropriate methods to analyse the data, based on the type of data collected and the overall survey objectives; and
* **Reporting** – a technical baseline report, detailing the survey work and associated desk-based studies, accompanied by plans/figures and raw data, to be submitted to the client in the prescribed format.

The remainder of this document is broadly structured to follow these steps, initially setting out those standards that are common to all surveys (**Section 2**): overarching survey objectives, approach to defining Study Area, desk study, and health, safety and biosecurity considerations for field survey design. It then goes on to discuss taxa-specific standards for defining survey objectives, field survey work and data analysis (**Sections 3 to 7**). The document concludes with a section on the standard for reporting outputs, which applies to all survey work (**Section 8**). A reference list of useful documents and those used to prepare this document is provide in **Section 9**.

Contractors shall submit a Survey Execution Plan (SEP) in accordance with this Standard, setting out a survey design and a suitable and proportionate approach to the survey work, including an appropriate level of sampling/coverage within each Study Area. The SEP should be revisited throughout the survey programme, with initial survey data and findings informing adjustments to methods and objectives.

It is intended that this document remains ‘live’ and that the early application of the survey approaches by ecologists/zoologists will continue to further inform and refine the Survey Standard.

# Reference Standards

There are a diverse range of standards and guidance relating to this topic arising from the wide range of habitats and species that come under this topic. Reference to appropriate standards and guidance is therefore set out within sections 3 to 7. Within this section an overview of generic standard approaches to survey are set out.

## Survey Objectives

In most cases, the overall objective of the survey work is to inform the work of NEOM Environment in developing a regional baseline and planning the management of biodiversity conservation within the NEOM Region. It will derive a baseline against which the predicted effects of the NEOM project and component development proposals are to be assessed and monitored, based on the application of a common survey standard. It will also inform schemes to mitigate for or offset adverse effects on biodiversity.

## Study Area

The Study Area is to be defined based on the survey objectives: biodiversity conservation planning and management; or defining the baseline for impact assessment (e.g. ESIA). In the former case the Study Area would include the whole of the NEOM region, possibly extending into neighbouring regions (e.g. for large mammals). In the latter case, the Study Area should include the full extent of all proposed development-related activity (‘The Site’ or development plot), plus a perimeter area that encompasses the potential Zone of Influence of the development proposals (e.g. 250m to 500m radius around the Site and development activity).

The extent of the perimeter area should be based on the potential extent of off-site impacts associated with the development proposals, as well as the requirement to capture ‘*control*’ survey locations i.e. locations that are representative of habitats within the Site but which are unlikely to be impacted by development. The Study Area may cover a wide area, therefore, survey locations may be stratified across large areas, sampling representative areas of the habitat types within the Study Area.

A wider Study Area is likely to be required for more mobile taxa that rely on larger areas, for example, large mammals with a range covering many square kilometres, or bats that may rely on key foraging resources several kilometres from the roost. The Study Area should, therefore, be reviewed based on data collected during the desk-based study (**Section 2.3**), to take account of the ecology of the species that are likely to occur within the region.

## Desk Study

The Survey work (survey designs and Survey Execution Plans) should be informed by a desk-based study that collates and reviews details of designated biodiversity conservation areas, habitats and species/groups that have previously been recorded, or are known to occur, within the Study Area and surrounding areas.

A desk-based study to inform the NEOM regional baseline, would focus on the wider Tabuk Region and neighbouring regions. For the purposes of assessing the effects of discrete development proposals, however, a smaller (e.g. 20km, expanded for highly mobile species such as large mammals) perimeter/radius around the development area (‘the Site’) may be more appropriate.

Sources of this information and biodiversity records may include, for example, consultation with relevant national (Saudi Wildlife Authority) and regional nature conservation authorities; established local wildlife recording groups; and university departments and research groups (e.g. King Saud University, Zoology Department; and Tabuk University, Department of Biology).

The desk study should include a review of relevant literature on the distribution and status of habitats and species in the Tabuk Region and neighbouring regions, for example and not limited to:

* **Habitats and plants** (Almutairi *et al* 2016; Abdullah Al-Aklabi *et al* 2016; Suliman Mohammed Alghanem *et al* 2020; Salman 2015; El-Ghanim 2010; and Moawed and Ansari 2015);
* **Mammals** (e.g. Aloufi and Amr 2018; Paray and Al-Sadoon 2018; Seddon *et al* 1997; Amin *et al* 2020; and Aloufi *et al* 2016); and
* **Reptiles & Amphibians** (Aloufi and Amr 2015; Mohammed *et al* 2016; and Aloufi *et al* 2019).

This information on the distribution and abundance of the relevant biodiversity conservation sites, habitats and species/groups within the region and nationally, will also allow the efficacy of the survey methods at detecting and evaluating the species to be reviewed, further informing survey designs and, where appropriate, enabling greater focus on those species that are not common and widespread.

Local knowledge and the emerging results from the initial application of the survey method are expected to continually refine the survey standards.

## Health & Safety

All planned survey campaigns should be the subject of a comprehensive Risk Assessment and Health and Safety Plan, with all identified measures to mitigate risks to health and safety implemented (including precautions relating to the COVID pandemic). A Point of Work Risk Assessment (POWRA) should also be completed ‘on-site’ to review risks at the start of each field visit.

Surveyors should work in pairs from a 4X4 vehicle and follow appropriate health and safety protocols, which will include carrying fully charged satellite phones and mobile phones, first aid kit, water and food, appropriate Personal Protective Equipment (PPE), robust footwear, sun screen, clothing and protection from the weather, face coverings and First Aid Kits. The surveyors should remain in regular contact with a third team member who is office-based. Surveyors should have up-to-date rabies vaccinations.

The Risk Assessment and Health and Safety Plan should be appended to the SEP.

## Biosecurity

All survey work should be subject to a biosecurity protocol, prepared in advance of the surveys and informed by a review of the prevalence of animal diseases and parasites in the region. This may involve disinfection of survey equipment and footwear in advance of surveys and before moving between survey locations and handling animals whilst wearing sterile gloves, with each animal handled with a new/clean pair of sterile gloves, as well using protective/bite-proof gloves.

The biosecurity protocol should consider both the risk of disease transmission among the wildlife population; and the risk of zoonotic disease being passed between surveyors and animals. Only surveyors with up to date rabies vaccination will handle mammals, and face coverings and sterile gloves will be worn when handling mammals or entering potential bat roosts.

Guidance in relation to the potential spread of White Nose Syndrome will be incorporated into the biosecurity protocol, as well as IUCN guidance in relation to potential transmission of coronaviruses:

* Bat Conservation Trust (2019). *White-nose syndrome: Guidance for bat workers in the UK and the Isle of Man*.
* Nuñez *et al*. (2020). *IUCN SSC Bat Specialist Group (BSG) Recommended Strategy for Researchers to Reduce the Risk of Transmission of SARS-CoV-2 from Humans to Bats. MAP: Minimize, Assess, Protect*.

The Biosecurity Protocol should be appended to the SEP.

# Habitats & Flora

## Good Practice Guidance

Detailed survey designs and the SEP should be informed by a desk-based study as set out in **Section 2.3**.

There is no definitive protocol for undertaking habitat and botanical surveys in Saudi Arabia. There are, however, various examples of the application of relevant survey techniques in Saudi Arabia, including the Tabuk region, for example Almutairi *et al* 2016; Al-Aklabi *et al* 2016; Alghanem *et al* 2020; Salman 2015; and El-Ghanim 2010.

UK survey protocols are also of relevance in terms of the overall survey approach, including JNCC 2010 (habitat classification and mapping) and Rodwell’s National Vegetation Classification (NVC) series (characterisation of vegetation communities), including the NVC users’ handbook (Rodwell 2006).

This guidance should be referred to, as appropriate, in conjunction with the methods outlined in the remainder of this section, to inform and refine the SEP.

## Survey Objectives

The objectives of the survey will, in most cases, be to map (using standard colour codes and acronyms) the distinct habitat types within and bordering the Study Area, applying appropriate and standardised habitat nomenclature, and habitat definitions and descriptions. Additional or follow-up survey work will inform more detailed characterisation and evaluation of the plant communities within these broad habitat types.

## Field Survey Design

### Personnel & equipment

The survey team should be familiar with the main vegetation communities and habitat types of northern Saudi Arabia and the Tabuk Region and be experienced in botanical survey and plant identification. Surveyors should work in pairs and follow appropriate health and safety and biosecurity protocols, which will inform some of the equipment requirements (as described in **Sections 2.4 and 2.5**).

Field survey equipment requirements should be reviewed by the survey teams, based on the specific details of the SEP, but are likely to include: rucksacks; maps; clipboards; pencils/pens; tablets populated with data collection templates and base mapping; camera; clinometer; binoculars; spare batteries; SD cards; zip-lock bags; field identification (ID) guides; tape measure; quadrats; string.

Where appropriate, equipment and materials for collection and preservation of herbarium or voucher specimens should be available at the fieldwork base, e.g. herbarium press, herbarium paper, blotting paper, corrugated cardboard and labels (Forman and Bridson 2009, and Royal Horticultural Society 2021).

### Survey locations and sampling effort

Broad habitat types throughout the Study Area should be identified and mapped as accurately as practicable from Remote Sensing and aerial imagery in accordance with the relevant NEOM Standard [NEOM Standard: Remote Sensing].

Where practicable the whole of the Study Area should also be surveyed in the field to verify/clarify the habitat mapping. In circumstances where this is impractical (large expanses of uniform habitat), targeted ‘ground-truth’ surveys of representative areas of each habitat type are appropriate, stratified across the Study Area or habitat area/block. Transects are an appropriate ‘survey unit’, with the length (e.g. 5km to 10km) dependent on terrain and capacity for the transect to be completed within the survey period.

The number of ground-truth ‘survey units’ (transects) should be defined to adequately sample representative areas of each of the main habitat types within the Study Area and should be scaled-up, according to the extent of each habitat block, to provide adequate survey coverage.

Follow-up, more detailed botanical surveys should be undertaken to characterise the vegetation communities within representative plots (quadrats) within each of the survey units and to record notable/uncommon plant communities.

### Habitat categorisation and mapping

Based on this combination of Remote Sensing and transects (ground-truthing) through representative areas of each habitat type, the survey should categorise and map the different habitat types throughout the Study Area, applying standard habitat nomenclature, definitions and descriptions, and using standardised keys (colour codes and acronyms). A similar survey approach adopted in the UK is described by JNCC 2010.

Habitat/vegetation types and plant species identification should be informed by the most relevant field guide (examples include Zahran 1982; Chaudhary 1999–2001; Collenette 1999).

During the habitat mapping survey, notable observations should also be mapped and recorded in a series of accompanying (numbered) ‘*Target Notes’*. This should include, for example, summary descriptions of habitat and vegetation characteristics, features of potential biodiversity conservation importance, substrates, terrain/topography and noting characteristic, prominent and uncommon species.

Rare plant species as well as invasive and non-native species (Thomas *et al* 2016) should also be recorded in Target Notes. Any fauna and/or evidence of faunal activity observed (including feral and domestic livestock) should be similarly mapped and recorded in Target Notes, along with any habitat features likely to be suitable for notable and/or uncommon species. Each target note should include a numeric reference (corresponding to the mapped location), GPS reference, description (habitat/species/feature) and representative photograph(s).

Collection and preservation of herbarium or voucher specimens should be undertaken in accordance with good practice (e.g. Forman and Bridson 2009; and Royal Horticultural Society 2021), with a target note corresponding to each specimen and collection location. Additional follow-up survey work will inform more detailed characterisation and evaluation of the plant communities within these broad habitat types.

### Classification of plant communities

Additional follow-up survey work should be undertaken to inform more detailed characterisation and evaluation of vegetation communities within the different habitat types. This is typically achieved via detailed sampling of quadrats. Examples of the classification of habitat and vegetation communities include Al-Aklabi *et al* 2016 and El-Ghanim 2010.

Quadrats should be randomly deployed within representative areas of each habitat type, for example at intervals along the habitat survey transects. The number of quadrats deployed (e.g. 2 to 5) within each habitat block will depend on habitat variability, size and complexity.

Quadrat sizes vary and should be adequate to record and describe representative samples of plant communities within each target habitat type. Relevant botanical surveys (e.g. Almutairi *et al* 2016; Al-Aklabi *et al* 2016; Alghanem *et al* 2020; Salman 2015; and El-Ghanim 2010) deployed quadrats ranging in size from 10m x 10m to 25m x 25m, although smaller sizes may also be appropriate in cultivated and more densely vegetated areas.

Within each quadrat the following parameters are recorded:

* quadrat number & size;
* GPS reference;
* altitude;
* date and surveyor name;
* photograph reference;
* habitat type;
* percentage (%) cover of each plant species;
* number of individuals of each plant species;
* percentage (%) cover of bare substrate;
* substrate characteristics/soil depth;
* terrain/topography;
* slope (clinometer); and
* other observations, e.g. vegetation structure, height, density, zonation, dominant species, succession, characteristic species, uncommon species.

Quadrat surveys are to be recorded in a suitable survey proforma (e.g Rodwell 2006), to be designed and appended to the SEP. Soil sampling (e.g. pH and electrical conductivity are not covered in this Standard, although it may be appropriate to co-locate any soil sampling with botanical survey locations).

### Survey timing

The habitat and botanical surveys should be undertaken during the main growth season for plants i.e spring to early summer, with the optimum period being March to May.

## Data analysis

Experienced botanists will, in many cases, be able to assign quadrat survey data to botanical communities previously recorded in the region without use of statistical software packages. Various statistical analysis packages are, however, available to inform the accurate comparison and categorisation of plant communities, for example TWINSPAN (Rodwell 2006; El-Ghanim 2010). These statistical software packages define distinct vegetation groups/categories based on statistical similarities and differences, with a first step being construction of floristic tables that summarise frequency and abundance values of the constituent species among the samples. Statistical analyses should be carried out on quadrat data where deemed necessary to identify and classify vegetation communities.

Calculation of biodiversity Indices such as Shannon Wiener Index and Marglef Index may also be appropriate for some surveys, for example to inform comparative evaluation of two areas of similar habitat.

# Large Mammals

## Good Practice Guidance

The detailed survey design and SEP should be informed by a desk-based study as set out in **Section 2.3**.

There is no definitive protocol for undertaking large mammal surveys in Saudi Arabia. There is, however guidance on the application of survey techniques in general, including the following examples.

* van Berkel (2014) *Expedition Field Techniques: Camera Trapping for Wildlife Conservation*;
* Rovero and Zimmermann (2016) *Camera Trapping for Wildlife Research*
* Jackson *et al* (2011) *Camera-Trapping Manual for the Arabian Leopard*;
* Hoffman *et al* (2010) *Field methods and techniques for monitoring mammals*.

This guidance should be referred to in conjunction with the methods outlined in the remainder of this section, to inform and refine the SEP.

## Survey Objectives

The objectives of the survey will, in most cases, be to determine the presence or likely absence (and distribution) of large mammal species within the Study Area. Additional or follow-up survey work may be required to inform a more detailed evaluation of the relative size and status of the populations of mammal species.

## Field Survey Design

### Personnel & equipment

The survey team should be experienced in visual identification of mammals, including evidence of mammal activity, such as footprints, tracks, scrapes, scats etc. Surveyors should work in pairs and follow appropriate health and safety and biosecurity protocols, which will inform some of the equipment requirements (as described in **Sections 2.4** and **2.5)**.

Field survey equipment requirements should be reviewed by the survey teams, based on the specific details of the SEP, but are likely to include: rucksacks; laptop and hard drive; clipboards; pencils/pens; tablet populated with data collection templates and base mapping; camera; binoculars; range finder; high-powered torches; head torches; spare batteries and bulbs; SD cards; ID guides; spade; protective gloves; mallet, tape measure; cable ties; string; ziplock bags; canes and reflective tape (location markers) and camera traps (**Table 4.1)**.

Any collection of DNA samples (e.g. scats or samples of dead animals) and associated collection, storage and handling protocols are to be agreed in advance with the relevant laboratory and set out in the SEP.

Table 4.1 Camera traps (examples)

| Trap summary |  |
| --- | --- |
| Camera traps:  Camera traps or Trail cameras with passive Infrared (PIR) sensors that trigger the camera to record when an animal passes.  There are various models and prices, e.g. Reconyx and Bushnell, which are cited as examples in the Camera Trapping Manual for Arabian Leopard (Jackson *et al* 2011).  Cameras must be operated in accordance with manufacturers’ instructions.  The camera models selected emit no noise and minimal light (‘no glow’) and have an infrared flash to avoid detection by wildlife.  Cameras are to be deployed securely at c.30cm to 40cm height and can be fastened to an existing structure or mounted to a pole/stake driven into the ground or on a tripod, avoiding any movement (e.g. due to wind or vegetation), which could trigger the camera.  Additional security provision in circumstances where there is risk of interference include, for example, camouflage and locking metal boxes with padlocks, typically obtained from the manufacturers/suppliers. Deployment of cameras in the afternoon and prompt removal the following morning also restricts interference.  Deployment should avoid directing cameras at the rising or setting sun and avoid moving vegetation that could trigger the camera.  Cameras should be tested before deployment, including in the field. | **ReconyxTM** |
| **BushnellTM** |

### Survey locations and sampling effort

Prior to the surveys the habitat types within the Study Area should be identified from baseline habitat mapping (aerial imagery & ground-truthing).

Wherever possible a walkover survey of the whole of the Study Area plot should be undertaken to record evidence of mammal activity, along with deployment of camera traps. However, for large uniform expanses of habitat this is potentially impractical. In those circumstances a targeted approach employing ‘survey units’ (e.g. transects) may be more appropriate.

The number of survey units should be defined to adequately sample representative areas of each of the main habitat types (that are suitable for large mammals) within the Study Area. The number of survey units should be scaled-up, according to the extent of each habitat type, to provide adequate survey coverage.

### Presence or likely absence survey (example methods)

A single ‘survey unit’ would comprise a transect (e.g. 5km to 10km in length) through suitable mammal habitat, which should be subject to walkover survey visits as well as having camera traps positioned at intervals (e.g. 2km to 5km). Where necessary a marker (e.g. pole or cane) should be positioned next to the traps, and/or along the transect. Additional security provision (e.g. camouflage and locking steel boxes) may be necessary where cameras are prone to disturbance or interference. Alternatively, cameras could be deployed in the afternoon and promptly removed the following morning to limit the risk of disturbance/interference.

Camera traps are to be selected to have passive Infrared (PIR) sensors (trigger the camera when an animal passes) that emit no noise and no/minimal light (‘no glow’) and have an infrared flash to avoid detection by wildlife. Detailed examples of cameras and camera settings are included in the Camera Trapping Manual for Arabian Leopard (Jackson *et al* 2011). This is useful reference material in defining camera settings and operation.

Cameras are to be deployed, e.g. at c.30cm to 40cm height, secured to an existing structure or mounted on a pole or stake driven into the ground or on a tripod, avoiding risk of movement due to wind or vegetation, which could trigger the camera. Avoid pointing cameras at rising or setting sun. Cameras should be tested before deployment, including in the field. Locally sourced bait (e.g. chicken or other meat) could be deployed within the camera’s field of vision to attract carnivores and scavengers.

Camera trap locations should be selected to minimise risk of disturbance by people or livestock and targeted to maximise the likelihood of recording larger mammals, for example near wadis, water, shade, vegetation, linear habitats, such as ‘funnels’ between rock outcrops and escarpments; boundaries between habitat types; edges of rock escarpments; caves and overhangs; and areas that are likely to be comparatively undisturbed by people, traffic or hunting. Account should also be taken of previous records or evidence of large mammals and their movements.

Cameras should be left operational for as long as reasonably practicable within the limits of the battery life and SD cards (e.g. 7 to 15 days), before the batteries are changed/recharged and the data downloaded, unless it is deemed necessary to collect the cameras each morning as a security precaution.

A combination of survey methods may appropriate, based on the following examples.

* Starting at around dawn, walkover survey of the transect route, with surveyors walking a sinuous route and keeping c.50m apart, minimising noise and vibration, to record and map mammal sightings and evidence of mammal activity (e.g. tracks, burrows, dens; scats, feeding remains). Suitable locations for camera traps should be identified during this survey and, where appropriate, reflective transect markers should be deployed to mark the transect to assist follow-up transect surveys at night.
* Starting after dusk, walkover survey of the transect route, broadly repeating the method adopted during the morning transect survey, using high-powered torches and head torches to detect ‘eye shine’ in order to record and map mammal sightings. In the event the daytime survey units are unsuitable for surveys after dark, alternative transect routes can be selected for night-time surveys.
* Deploy and activate camera traps and subsequently download data from SD cards at intervals of 5 to 15 days, before replacing batteries and redeploying the traps, or removing traps following completion of the survey programme.

All survey parameters (**Table 4.2**) are to be recorded in a suitable survey proforma, to be designed and appended to the SEP. This includes all incidental observations. Mammals and evidence of mammal activity are to be photographed, where possible, with all photographs mapped and georeferenced, and allocated a unique identification reference. Species identification should be informed by the most relevant field guide (e.g. Harrison and Bates 1991). Incidental observations of other fauna and flora of interest should be similarly recorded, where practical, for example sightings of reptiles, small mammals and domestic livestock, or notable species of birds, invertebrates and plants.

Table 4.2 Mammal survey parameters to be recorded

| Survey parameters | Mammal record | Habitat |
| --- | --- | --- |
| Date | GPS and camera number | Habitat type |
| Time (survey start/finish) | Species (genus) and numbers  (*or description of evidence of mammal activity)* | Substrate |
| Surveyor | Male/female | Topography |
| Survey Unit (Transect reference) | Adult/juvenile | Vegetation |
| Weather | Other observations | Moisture (type/extent) |
| Temperature (start/end) | Photograph reference |  |

### Population studies

An estimate of relative population sizes of large mammals may be appropriate in some circumstances, for example to inform more detailed assessment of the effects of large-scale losses of habitat. The survey approach would be a scaled-up version of the presence or likely absence survey. For example, scaling-up the size of camera trapping areas (e.g. stratified over a survey grid) and the number of survey units and increasing the repetition of survey events. Population studies of large mammals can require considerable resources, extending over larger areas and for prolonged periods. Any proposals for population studies should be set out in detail in the SEP, with specific justification and objectives.

### Survey timing and frequency

Mammal detection is enhanced by repeating the survey of each survey unit, for example, the survey event outlined could be repeated at each survey location at different times of the year. Repeating surveys may be particularly important in certain circumstances (low animal densities; low capture or detection rates; trap disturbance; anomalous weather), also recognising that mammal populations may use different habitats and alter their geographic ranges at different times of the year, in some instances migrating across large distances to exploit a specific seasonal resource.

Population studies of large mammals can extend over large areas and for prolonged periods, for example the Arabian Leopard Camera Trapping Manual cites an example of a 500km survey unit, with 4 traps per 100km area, operating for 40 to 50 nights continuously, increasing to c. 100 nights for population studies. The rationale, design and approach to any more detailed population surveys should be detailed in the SEP, informed and refined by desk-based study as set out in **Section 2.3**.

## Data analysis

The survey will initially seek to establish and map presence/absence and distribution of mammal species. Analysis of relative population sizes of large mammals may be appropriate in some circumstances, for example to inform more detailed assessment of the effects of large-scale habitat losses or to develop further insight into mammal population densities across the NEOM region.

The appropriate data analyses will depend on the target species, informed by desk-based study and presence/absence survey, as well as the survey objectives. Camera trapping studies of large mammals often rely on Capture-Mark-Recapture approaches. This statistical analysis derives population estimates from the proportion of marked (previously captured or photographed) to unmarked (newly captured or photographed) individuals across consecutive sampling occasions and is described by various authors (examples in **Section 4.1**). This approach requires the identification of individual mammals from unique markings and typically necessitates large numbers of traps to be operated over long survey periods.

Distance sampling is a method for estimating animal density or abundance, based on the recorded distances to animals from survey transects or observation points. The underlying concept is that the probability of detecting an animal decreases as its distance from the observer increases. Statistical modelling of the probability of detecting an animal, given its distance from the transect, is used to derive abundance/density estimates. This approach is described by various sources (e.g. Buckland et al 2015).

Any detailed population studies investigations would need to be set out in detail at the outset in the SEP, including clear justification, objectives, survey design, sampling effort and planned data analysis.

# Small Mammals (excluding bats)

## Good Practice Guidance

The detailed survey design and SEP should be informed by a desk-based study as set out in **Section 2.3**.

There is no definitive protocol for undertaking small mammal surveys in Saudi Arabia. There is, however, guidance on the application of survey techniques in general, including the following examples.

* Bennet et al (1995) *Expedition field techniques: small mammals (excluding bats)*;
* Hoffman *et al* (2010) *Field methods and techniques for monitoring mammals*; and
* Gurnell *et al* (2019) *Live trapping small mammals. A practical guide*.

This guidance should be referred to in conjunction with the method outlined in the remainder of this section, to inform and refine the SEP.

## Survey Objectives

The objectives of the survey will in most cases be to determine presence or likely absence (and distribution) of small mammal species within the Study Area. Additional or follow-up survey work may be required to inform a more detailed evaluation of the relative size and status of small mammal species populations.

## Field Survey Design

### Personnel & equipment

The survey team should be experienced in visual identification, and trapping and handling of small mammals. A more experienced survey team should minimise the need for collection of live specimens and/or intrusive DNA/tissue sample collection. Surveyors should work in pairs and follow appropriate health and safety and biosecurity protocols, which will inform some of the equipment requirements (as described in **Sections 2.4** and **2.5**).

Field survey equipment requirements should be reviewed by the survey teams, based on the specific details of the SEP, but are likely to include: rucksacks; laptops; clipboards; pencils/pens; tablet populated with data collection templates and base mapping; camera; binoculars; high-powered torch; head torches; spare batteries and bulbs; SD cards; ID guides; spade; protective gloves, sterile gloves; mallet, tape measure; cable ties; string/rope; ziplock bags; cloth or plastic bags to temporarily hold animals; weighing scales and callipers; canes and reflective tape (location markers) and traps. Examples of the main types of small mammal traps are provided in **Table 5.1**.

Any collection of DNA samples and the associated collection and storage protocols are to be agreed in advance with the relevant laboratory, avoiding routine intrusive sample collection, which could result in unnecessary and avoidable harm to mammals. This protocol should be set out in the SEP. Collection of faeces and dead mammals are appropriate non-intrusive techniques, while buccal swabs may be appropriate for some species, providing they can be collected without harming or causing undue stress to the animal.

Table 5.1 Small mammal traps (examples)

| Trap type and summary | Illustrative example |
| --- | --- |
| Pitfall trap:  Buckets, with lids (to allow temporary sealing and deactivation of traps). Buried so the rim of the bucket is at or slightly below ground level.  It is preferable to operate pitfall traps in conjunction with drift fences, with the edge of the trap in contact with the fence.  It is preferable to install traps (sealed/deactivated) pitfall traps approximately one week prior to the survey, opening the traps on the evening of the survey.  Traps should be emptied frequently to avoid harming fauna i.e. this can be every two hours for daytime surveys in hot climates.  Where there is a risk fauna will be subject to heat stress, some shade should be incorporated into the trap (also limiting predation of trapped animals), as well as a sponge (soaked in water) and cover or refuge e.g. shredded newspaper.  These traps should be deployed as part of a combination of survey methods. | **Image:** Ribeiro *et al* (2008). |
| Walk-in traps (e.g. Sherman trap):  Rectangular ‘walk-in’ traps that are sealed by a ‘trap-door’ when activated by entry of a small mammal.  In the absence of natural linear features to guide small mammals to the traps, capture rates may be improved by operating traps in conjunction with drift fences.  Traps should be emptied frequently (this can include trap checks every two hours when surveying during the day in hot climates) to avoid harming fauna.  Where there is a risk fauna will be subject to heat stress - traps are to be provided with shade, as well as a sponge (soaked in water) and cover/refuge e.g. shredded newspaper.  Traps may need to be tethered to avoid displacement.  Deployed as part of a combination of survey methods and using a variety of trap sizes. | A picture containing engineering drawing  Description automatically generated**Image:** Bioquip Products (https://bioquipinc.com/catalog/collecting-equipment-supplies/traps/sherman-traps/) |
| Wire/mesh trap (e.g. Tomahawk trap):  Rectangular, wire/mesh ‘walk-in’ traps for medium-sized mammals, that are sealed by a ‘trap-door’ when activated by entry of a mammal.  Targeted use at survey locations and in habitats, where medium-sized mammals are likely to be encountered.  Traps to be emptied frequently in hot climates to avoid harming fauna. Where there is a risk fauna will be subject to heat stress – traps are to be provided with cover or shade, as well as a sponge (soaked in water).  To be deployed as part of a combination of survey methods and using different trap sizes. | A picture containing handcart, cage, building  Description automatically generated  **Image:** https://www.nhbs.com/tomahawk-collapsible-live-traps |

### Survey locations and sampling effort

Prior to the surveys the habitat types within the Study Area should be identified from baseline habitat mapping (aerial imagery & ground-truthing). The number of survey units should be defined to adequately sample representative areas of each of the main habitat types (that are suitable for small mammals) within the Study Area. The number of survey units should be scaled-up, according to the extent of each habitat type, to provide adequate survey coverage.

### Presence or likely absence survey (example methods)

A single ‘survey unit’ may comprise, for example, a transect (e.g. 150m in length) through suitable small mammal habitat, with Sherman traps positioned at intervals (e.g. 10m to 15m). In the event that trapping rates are high, the number of traps should be increased e.g. deploying the Sherman traps in pairs along the transect. The traps should vary in size. Where necessary a marker (e.g. pole or cane) should be positioned next to the traps, and at the start and end of the transect. Sherman traps could be deployed alongside an array of pit-fall traps and/or, with targeted use of wire/mesh traps, as appropriate, where there is likelihood of encountering larger mammals.

Where possible, and where there is a low risk of traps being disturbed by livestock or people, the traps should be deployed in a deactivated state and pre-baited for two or three days in advance of the survey. This can attract small mammals and allow them to become habituated to the equipment, increasing capture rates once the traps are activated. Baits to be sourced locally can include, for example oats, nuts, peanut butter, fruit and meat, ensuring there is an adequate/substantial food source for any small carnivores that have high metabolic rates. The choice of bait is to be informed by the desk-based study of the small mammal species recorded within the Tabuk region and use of different baits should be trialled over the course of the survey programme.

Traps should be activated and baited shortly before sunset and checked at or shortly after sunrise, with the animals recorded and released. The traps should be reactivated, with another inspection completed in late morning, with the traps then temporarily closed/deactivated and reactivated again before sunset. This procedure would continue throughout the trapping period (e.g. 3 to 5 days). In the event trapping is to be continued throughout the day the frequency of checks would need to be increased, for example every two hours to avoid harm or heat stress to animals.

Traps should be emptied into a large cloth or plastic bag, and handling of animals should be in accordance with good practice (Bennet et al 1995; and Hoffman et al 2010) to avoid harming animals. Protective (bite-proof) gloves and sterile gloves (gloves to be changed or sanitised between trap checks) and face coverings should be used, as appropriate, and all animals should be released at the capture location. Handling animals should be in accordance with the biosecurity protocol (**Section 2.5**).

Traps should be thoroughly cleaned after the survey and before deploying to a different survey location. Notably the decision to clean or not to clean traps between survey events can influence (positively or negatively) capture rates.

All survey parameters (**Table 5.2**) are to be recorded in a suitable survey proforma, to be designed and appended to the SEP. This includes all incidental observations. Small mammals and/or evidence of mammal activity are to be photographed, with all photographs mapped/georeferenced and allocated a unique identification reference. Species identification should be informed by the most relevant field guide (e.g. Harrison and Bates 1991). Incidental observations of other fauna and flora of interest should be similarly recorded, for example sightings of reptiles, small and large mammals, and domestic livestock, or notable species of birds, invertebrates and plants.

Table 5.2 Small mammal survey parameters to be recorded

| Survey parameters | Mammal record | Habitat |
| --- | --- | --- |
| Date | GPS and trap number | Habitat type |
| Time (survey start/finish) | Species (genus) and numbers  (*or description of evidence of mammal activity)* | Substrate |
| Surveyor | Male/female | Topography |
| Survey Unit (Transect reference) | Adult/juvenile | Vegetation |
| Weather | Trap type (pit-fall trap, Sherman trap; cage trap) or other observations *(e.g. running; burrowing*) | Moisture (type/extent) |
| Temperature (start/end) | Photograph reference/ID |  |

### Population studies

An estimate of relative population sizes of small mammals will be appropriate in some circumstances, for example comparison of different sites or habitats, or to inform more detailed assessment of the effects of large-scale losses of habitat. The survey approach would be a scaled-up version of the presence or likely absence survey, for example scaling-up the size of trapping areas (e.g. stratified over a survey grid) and the number of survey units, and increasing the repetition of survey events. Capture-Mark-Recapture studies (fur clipping) can be employed to inform population estimates. Collection of data in relation to animal weight (e.g. using Pesola spring balance) and size (measured using callipers) can contribution to an assessment of population structure. The rationale, design and approach to any detailed population surveys should be detailed in the SEP.

### Survey timing and frequency

Small mammal detection is enhanced by repeating the survey of each survey unit, for example, the trapping period (e.g. 3 to 5 days) outlined above could be repeated at each survey location at different times of the year. Repeating surveys may be particularly important in certain circumstances (low animal densities; low capture/detection rates; trap disturbance; anomalous weather), also recognising that small mammal populations may use different habitats and alter their geographic ranges at different times of the year.

It would be preferable to avoid trapping during the period June to September where there is an increased risk of heat-stress to trapped animals, and also avoiding surveys at higher altitudes during colder weather i.e. December to February.

## Data analysis

The appropriate data analyses will depend on the target species, informed by desk-based study and presence/absence survey, as well as the survey objectives. The survey will initially seek to establish and map presence/absence and distribution of small mammal species.

Subsequent calculations of densities of each species across a survey grid would allow more detailed comparison of relative population sizes/densities between study areas that have been subject to similar survey effort. This comparative evaluation of populations is likely to be increasingly informative as increasing levels of survey data become available for the NEOM region, or through the desk study i.e. comparison with similar studies in similar habitats and regions.

Capture-Mark-Recapture studies may be appropriate in some circumstances to collect detailed population data. This approach derives population estimates from the proportion of marked (previously captured) to unmarked (newly captured) individuals across consecutive sampling occasions and is described by various authors (e.g. Romairone *et al* 2018; Bennet et al 1995). In its simplest form the approach involves capturing and marking (harmlessly e.g. fur clipping) a number of small mammals (‘A’) before releasing them back into the population. On repeating the survey it is possible to calculate the estimated population size (N) based on the number of marked individuals that are recaptured (R) and the total sample size (marked and unmarked) captured by the second survey (B): **N = (A\*B) / R**

Plotting information on standardised size and weight measurements and size distribution within small mammal populations can also yield information on population health, mortality and recruitment.

Any detailed population studies investigations would need to be set out in detail at the outset in the SEP, including clear justification, objectives, survey design, sampling effort and planned data analysis.

# Bats

## Good Practice Guidance

The detailed survey design and SEP should be informed by a desk-based study as set out in **Section 2.3**.

There is no definitive or standard good practice protocol for undertaking bat surveys in Saudi Arabia. There is, however, guidance on the application of a variety of survey techniques in different countries and different ecosystems, for example:

* **Australia** – Commonwealth of Australia (2010). *Survey guidelines for Australia’s threatened bats. Guidelines for detecting bats listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999*.
* **Europe** – Battersby, J. (comp.) (2010). *Guidelines for Surveillance and Monitoring of European Bats. EUROBATS. Publication Series No. 5. UNEP / EUROBATS Secretariat*.
* **United Kingdom** – Collins, J. (ed.) (2016). *Bat Surveys for Professional Ecologists: Good Practice Guidelines (3rd edn)*.
* **Southeast Asia** – Southeast Asian Bat Conservation Research Unit SEABCRU: Cave Bat Survey Protocol for Southeast Asia.
* **South Africa** – Sowler et al. (2017). *South African Good Practice Guidelines for Surveying Bats at Wind Energy Facility Developments - Pre-construction: Edition 4.1. South African Bat Assessment Association*.

Survey methods, design and considerations are also described in full detail in:

* Kunz, T.H. and Parsons, S. (ed.s) (2009). *Ecological and behavioural methods for the study of bats. 2nd edition*. The Johns Hopkins University Press, Maryland.

These publications should be referred to in conjunction with the method outlined in this document, to inform the SEP.

## Survey Objectives

The overall aim of the survey work will, in most cases, be to identify the bat species that occur in the Study Area and understand their status and distribution, and how they use the Study Area. There may be combinations of specific survey objectives, such as:

* identify the bat species present, including species that are rare (or of economic value);
* identify the presence of target groups of species (e.g. species associated with a specific habitat);
* establish if a specific species is breeding in the Study Area;
* establish which species use the Study Area for foraging;
* identify maternity roost sites and obtain roost count data at confirmed maternity roosts;
* identify important flight corridors;
* identify important drinking/water sources; and/or
* establish home range and foraging distances of a bat colony (e.g. targeting a maternity roost).

Bat surveys are an iterative process, each survey stage informs the next and the objectives should be refined throughout the survey programme.

The survey work will inform the work of NEOM Environment in developing a regional baseline and planning the management of biodiversity conservation within the NEOM Region. It will also derive a baseline against which the predicted effects of the NEOM project and component development proposals are to be assessed and monitored, based on the application of a common survey protocol. It will also inform schemes to mitigate or offset adverse effects on biodiversity.

## Field Survey Design

### Personnel & equipment

The survey team should be experienced in visual and aural identification of bats and handling bats (with minimum stress to the animals) to collect biometric data and assess reproductive condition. The team should be experienced in the survey techniques that are to be adopted and should hold any requisite licences/permits to carry out these techniques in their home countries, as an indication of competence.

Field survey equipment requirements should be reviewed by the survey teams, based on the specific details of the SEP, but may include:

* **General field survey equipment:** rucksack, GPS, compass, clipboard/survey forms, pencils/pens, tablet populated with data collection templates and base mapping, camera (spare batteries and SD cards), binoculars, head torch (spare batteries and bulbs), thermo-hygrometer, ID guides, tape measure, ziplock bags, Eppendorf tubes, string, canes and reflective tape (location markers), sterile gloves.
* **Biosecurity & PPE:** to be identified by the risk assessment and biosecurity protocol, as described in **Sections 2.4** and **2.5**.Task-specificequipment will also be specified, such as aerial access equipment (harnesses, ropes, caribiners, prussic loops, strops).
* **Survey equipment:** powerful torch (spare batteries and bulbs), torch with red light filter, bat handling gloves (various thickness for different species), extendable mirror, ladder, endoscope, handheld radios, handheld bat detector, automated bat detector and earphones, temperature/ humidity data loggers, counter, infrared camera and infrared lamp (with tripods, SD card and power source), hand net, callipers, drawstring bags (to hold bats), weighing scales, hand lens (magnifier), fine scissors, mist nets (inc. poles, pegs, guy ropes), mallet, harp traps (inc. guy ropes), acoustic lure (and laptop loaded with call library as required to run it), curved blunt-ended scissors, radio transmitters, surgical glue, cotton bud, portable soldering iron and solder, receivers, headphones and antennae.

Equipment requirements associated with different survey techniques are summarised in **Appendix A.**

### Animal welfare

All survey work should be designed and implemented in a way that minimises stress and disturbance to bats. As such, non-intrusive survey methods such as passive observation (e.g. using infrared camera equipment) or acoustic recording should be the preferred techniques. Intrusive methods that are likely to cause stress to the animal should be employed only when there is no alternative way to achieve the survey objective, the objective is fundamental to the aim of the work and the value of the data outweighs the potential effects on bats.

In applying this principle, consideration must also be given to the duration of the survey event, as well as the specific method. For example, a single visit of short duration to a roost is unlikely to have a notable disturbance impact, whereas repeated visits by multiple surveyors with torches may cause a bat colony to abandon a roost.

The most invasive methods are those requiring bats to be captured. Traps must not be left unattended for long periods. Mist nets must be attended constantly, and harp traps checked at least every hour (more frequently if an acoustic lure is used). Bats should be released as soon as the data has been collected, always at night, and surveyors should observe each bat as it flies away, ensuring that it does not fall to the ground, which can be a problem on cooler nights.

The data to be collected from each bat should be considered in terms of handling time and risks to the bats. It may be desirable to collect a full set of biometric measurements from every bat captured, however it may be concluded that a reduced data collection protocol is adequate for heavily pregnant bats or females carrying pups, in order to minimise handing time and stress that might otherwise lead to abortion or separation of mothers from dependent young.

Any collection of DNA samples and the associated collection and storage protocol are to be agreed in advance with the relevant laboratory, avoiding routine intrusive sample or tissue collection, which could harm bats. This protocol should be set out in the SEP. Collection of faeces, fur clippings or wing swabs are appropriate non-intrusive techniques. Buccal swabs, wing biopsies and fur plucking may be appropriate for some species providing that the data collected is essential and can be collected without causing undue harm or stress to the bat.

### Survey design and locations

The survey design and SEP should be informed by a desk-based study as set out in **Section 2.3**, including a review of information on the ecology (roost and habitat preferences, diet, reproductive strategy and echolocation calls) and conservation status of bat species that could occur in the Study Area.

The habitat types within the Study Area should be identified from baseline habitat mapping (aerial imagery & ground-truthing), to identify areas to be targeted by the survey work:

* foraging habitats - based on type and distribution of vegetation;
* foraging/commuting habitat features - e.g. wadis, escarpment perimeters and ecotones; and
* roost features (natural and built structures) - e.g. caves, tombs and trees.

The survey should adequately sample representative areas of each of the main habitat types (that are suitable for bats) within the Study Area. The survey should be scaled-up, according to the extent of each habitat type or feature, to provide adequate survey coverage. Existing information relating to bat roost sites and bat activity in the Study Area may identify focal points for the survey work.

Tailored combinations of survey techniques should be employed to address specific survey objectives as outlined in **Table 6.1**. The survey methods are summarised in the following sections and described in detail in the good practice guidance documents referenced (**Section 6.1**).

A general good practice approach throughout field surveys is that any data that can be collected as a matter of routine, without creating any additional disturbance or effect on the bat(s), should be done so. For example dropping samples should be collected during roost surveys, avoiding the need to revisit a roost to collect samples. Similarly, if a captured bat produces a dropping, the sample should be collected and labelled.

All survey methods, locations, habitat types, roost features, samples and trapped bats should be documented, with supporting photographs. The environmental conditions during the survey and over the preceding days should be recorded. Samples and photographs should be appropriately labelled (date, time; location/GPS co-ordinates, surveyor and species).

Table 6.1 Survey objectives and selection of survey methods

|  | Preliminary assessment | Roost inspection (structures/trees) | Emergence/ re-entry survey | Vantage Point Survey | Walked transect | Driven transect | Automated monitoring (activity) | Automated monitoring (habitat feature) | Trapping at a roost (hand net) | Trapping (harp trap or mist net) | Radio tagging/ tracking |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Identify bat assemblages | X | X | X |  | X | X | X | X | X | X |  |
| Assess bat activity levels | X |  |  |  | X | X | X |  |  |  |  |
| Assess breeding status | X | X |  |  |  |  |  |  | X | X |  |
| Assess foraging activity | X |  |  |  | X | X | X |  |  | X |  |
| Identify roosts | X | X | X |  |  |  |  | X |  |  | X |
| Characterise roosts | X | X | X |  |  |  |  | X | X | X | X |
| Roost count | X | X | X |  |  |  |  |  |  |  |  |
| Identify flight corridors | X |  | X | X | X | X |  | X |  |  | X |
| Identify drinking sources | X |  |  | X | X | X | X | X |  |  | X |
| Home ranges and foraging distance | X |  |  |  |  |  |  |  |  |  | X |

### Survey techniques

Survey methods for bats are well-established and described in detail in the documents referenced in **Section 6.1**. As such, only an overview of each method is provided here.

#### Preliminary assessment/ walkover

A walkover survey of the Study Area is invaluable in helping to inform the design of follow-on survey work. This should record any habitats or habitat features that are likely to be suitable for roosting, commuting and foraging bats, also taking account of features that connect the Study Area with the wider landscape. Potential sources of artificial lighting should be recorded, as these can influence habitat suitability for bats and affect bat behaviour. This survey method is described for the UK in Collins (2016).

#### Internal roost inspection (e.g. natural or man-made structures, trees)

This involves entering a potential bat roost, for example a cave or mine, or climbing into the loft of a building. Noise and light disturbance must be kept to a minimum and use of red light filters over torches should be considered. The interior of the roost should be systematically searched for roosting bats. The bats may be hanging in the open, flying, or concealed in cracks/crevices. Evidence of bat activity may be apparent, such as dead bats or droppings. Large clusters of bats can be photographed to inform a subsequent count estimate, in order to minimise time spent inside the roost.

An internal roost inspection may also include use of a torch or endoscope to inspect the interior of crevices that are not large enough for a human to enter, such as a crack in a rock face or a tree. A ladder, or rope and harness (aerial climbing techniques) may be used to reach such features.

The survey should aim to identify: species using the roost; actual or estimated numbers of bats; the parts of the feature that are used by bats; the roost access points; type of roost (e.g. are young or breeding bats present and do the adult bats include both males and females?). Details of the roost entrance in terms of surrounding vegetation, shelter and lighting should also be recorded.

This method may be combined with automated monitoring or trapping with a hand net to collect further data from inside the roost. Dropping samples may also be collected for subsequent analysis. Consideration should be given to deploying data loggers inside the roost to record internal conditions (temperature and humidity). The method is well described for the UK, in Collins (2016).

#### Emergence/re-entry survey

Observation of potential or known roost exit and entry points at sunset or sunrise can detect bats emerging from or re-entering a roost. This may confirm the use of a roost that could not be safely/fully inspected or inform roost characterisation (e.g. species identification, roost count, or establish roost exit points). Surveyors should quietly take their positions 30 minutes before sunset to minimise disturbance around the roost entrance, which may affect bat behaviour. Full spectrum bat detectors with recording capabilities should be used to assist surveyors in hearing and identifying bat species. An infrared or thermal imaging camera should be used to aid observation of bats after dark, particularly those that may exit the roost without echolocating. Surveys of unconfirmed roosts should continue for 120 minutes after sunset to record late-emerging species.

Re-entry survey work adopts similar methods but should commence 120 minutes before sunrise and continue until 15 minutes after. The method is well described for the UK, in Collins (2016).

This survey should be replicated to sample the roost at least once in each season, in order to establish how the roost is used at different times of year. In the event of a negative result, replication of the surveys may be required to provide confidence in the negative result.

A combination of emergence and re-entry surveys should be carried out. The level of survey effort would depend on the type of roost and the combination of other survey techniques being adopted, for example, large and complex structures or structures that cannot be inspected internally are likely to require more survey visits to allow confidence in a negative result. In the case of a simple structure with a single exit point, that has been subject to a full internal inspection that recorded no evidence of roosting bats, a single emergence survey may be sufficient.

#### Vantage Point Survey

Bespoke vantage point surveys, employing a similar technique but focussing on non-roost features and using night vision camera technology can also be useful. This may, for example, involve watching a potential bat flight-line or observing bats’ directional movements.

#### Walked transect

Surveyors walk predetermined transect routes at a consistent pace, observing, listening for and recording bats in flight, using hand-held bat detectors and recorders. Transects should sample all habitats with potential to be of value to bats, including ‘control’ areas. Transect lengths should allow two or more circuits to be completed over a period of approximately 150-180 minutes, starting at sunset (or a similar period before sunrise), so that each location is sampled at more than one point in time. A useful guide is 3-5km in length, depending on terrain, although this will be considerably shorter if stopping points are used.

Light levels permitting, qualitative data can be recorded, such as bat size, flight style, speed and height, and direction of flight, which can indicate species, behaviour/habitat use (commuting or foraging) and potential direction of roosts. Quantitative data (number of bat registrations per defined section of transect) are recorded to indicate relative bat activity levels (identifying species based on echolocation calls where possible). Transects surveyed simultaneously provide a quantitative means of comparison between locations. Transect surveys that are replicated in different months can provide a quantitative means of assessing temporal variation in bat activity. Comparisons between locations or time periods must employ the same recording equipment, as different detectors function in slightly different ways, which affects the data recorded. Full spectrum bat detectors with built in recording capability will ensure the best data quality.

Surveyors can pause at predefined stopping points along the transect to record and observe for a short period (e.g. 60-180 seconds). This can be particularly useful where surveyors are walking through habitat that creates a lot of high frequency noise, which might mask bat echolocation calls, such as tall grassland. The method and equipment should however be consistent across locations and recording periods to collect comparable data. This method is biased towards species with louder calls. Echolocation calls can only be identified to species in some cases, and where a call reference library is available (see **Section 6.4**). Where safe to do so, surveyors should walk without using artificial light, or should use a torch with a red filter, to minimise the risk of influencing bat activity.

This survey should be replicated at least once in each season, in order to assess variation in bat activity at different times of year. The method is described by Collins (2016), Battersby (2010) and Sowler *et al.* (2017).

#### Driven transect

Driven transects are employed in a similar way to walked transect, allowing a much larger area to be covered. This will, however, bias the survey to focus on the accessible road network. High frequency sounds emitted by vehicles can cause interference with the bat detection equipment, adding further bias against recording quieter species. A number of ‘practice runs’ to test and establish the optimal recording set up will be required, and it may be advisable to use an extension cable to mount the microphone on a pole that is held out of, and directed away from, the vehicle. Driving speed alters recorded peak frequencies due to Doppler Shift and this can result in misidentification of species. Vehicles should, therefore, be driven at a constant slow speed (no more than 25km/hr). Vehicle headlights are likely to deter some bat species, so consideration should be given to using dimmed headlights if possible, however, driving in the dark is unlikely to be safe or legal in most cases.

#### Automated monitoring

Automated, static detectors are deployed and left unattended to automatically record all bat calls between sunset and sunrise, over a period of several nights, onto a high capacity SD card. Where a call reference library is available (see **Section 6.4**), species can be identified through analysis of the recordings. The recordings also provide an index of relative bat activity levels. As with data from walked transects, this can be used to compare bat activity spatially and temporally. Like transect surveys this method is biased towards recording species with louder calls.

Static bat detectors may be deployed to sample a Study Area randomly and/or systematically (e.g. on a grid system) or focused on habitat features that are likely to be focal points for bat activity. The latter approach will often be combined with static detectors deployed in other, more representative (‘control’) locations. Detector microphones should be positioned to maximise efficacy of recording, limiting the risk of surrounding vegetation blocking or deflecting calls and interference by nearby sources of high frequency sound such as running water. There may be opportunities to deploy the detector at height. The position of the detector will also be influenced by risk of disturbance by people and livestock (trampling or biting).

This method allows data to be collected over a longer period with minimal effort. A minimum recording and analysis period of five consecutive nights is recommended. Comparisons between locations or time periods must employ the same recording equipment, as different detectors function in slightly different ways, which affects the data recorded. Full spectrum bat detectors with built in recording capability will ensure the best data quality. This survey method should be replicated at least once in each season, in order to establish how the variation in bat activity throughout different times of year. The method is described by Collins (2016), Battersby (2010) and Sowler *et al.* (2017).

Automated monitoring can also be used to collect focussed data to contribute to the understanding of specific features, such as deployment inside a building or at the entrance to a cave to better understand the use of the structures. Paired static detectors can be deployed on potential flight lines to confirm commuting behaviour.

#### Trapping (hand net)

Hand-held nets with long telescopic handles can be used to capture bats inside a roost or at the roost exit. This method is only applicable at a roost where a small sample of individuals can be captured, to confirm species and breeding status, and then promptly released without causing undue stress. This is a more effective method in cooler climates, when bats can be sampled in torpor. Active bats should not be pursued around the inside of a roost as this will typically lead to roost abandonment.

Capture of bats in flight with a hand net should never be attempted because the wings can be easily damaged. A sample of bats can be captured by placing the hand net in a static position over all or part of a roost exit point at dusk.

This method should not usually be replicated, due to the potential impact of repeated disturbance at a roost site. The method is described in Kunz and Parsons (2009).

#### Trapping (harp trap or mist net)

Harp traps typically consist of a rectangular aluminium frame with monofilament (fishing line) strung vertically in two, three or four offset banks. A canvas catch bag is positioned below the frame. Bats fly into the fishing lines and slide down into the catch bag, where they are extracted by the surveyor.

Mist nets are typically made from nylon or terylene, with a mesh size of 30–50 cm. Mist nets may be less effective at capturing some bat species, but tend to be more versatile as they are available in a range of sizes, are more suitable in open habitat and are lightweight and easily transported. Bats fly into the net and become entangled and are carefully extracted by experienced surveyors, without harming the bats.

Mist nets must be monitored constantly, as captured bats will try to escape, which may cause them to be more entangled and can lead to considerable stress. Mist nets should not be used to capture bats at the entrance of caves or mines unless there is prior knowledge of the number of resident bats. Therefore, an emergence survey must always be conducted at a cave entrance prior to any trapping effort.

Harp traps and mist nets can be used in combination, typically positioned along linear features that might be used by commuting bats, or in front of known or potential roost entrances. They may also be used next to water features or in other potential foraging habitat. Trapping can be used to confirm species identification, particularly for species with quiet or undocumented echolocation calls, or to determine gender and breeding status. The method may also be used to capture bats that will be subject to marking or radio tagging.

Repeat trapping is required to be confident in detecting the species present. Survey replication is also recommended to sample across different seasons. The need for repeat trapping must however be balanced against the invasiveness of the method. These techniques are described in Kunz and Parsons (2009).

#### Acoustic lures

Harp traps and mist nets may be used alone or in combination with an acoustic lure. These electronic devices simulate bat vocalisations and can be effective in luring bats to a trap in areas where there is no obvious focal point for bat activity in which to position traps. The effect of acoustic lures on bat populations is poorly understood but there is evidence that they can cause stress in some cases. These devices should, therefore, be used with caution:

* avoid use within 50m of known or likely roost sites (including caves, tombs or mines);
* do not play bat distress calls;
* do not play calls at abnormally high volumes;
* turn the lure off while extracting bats from mist nets; and
* do not use a lure at the same trapping location or within the same habitat parcel for more than three days in one month.
* professional judgement should be employed, erring on the side of caution, to avoid detrimental effects on bat welfare.

#### Marking and recapture

Captured bats can be marked so that they can be recognised on recapture, or simply identified as a previously captured bat. Short-term marking, such as identifying recaptures within the same week, can be achieved with minimal effect on the bat by taking a small but recognisable fur clipping. Longer term marking of individuals, however, may require the attachment of a metal band, engraved with a unique code, on the bat forearm. This method is very invasive and may cause injury to the bat. As such this method should only be employed where essential to meet the survey objective, and only if a long-term project is proposed.

There are many methods for marking bats, each with pros and cons and each suited to different scenarios. These are discussed in detail in Kunz and Parsons (2009).

#### Radio tagging/tracking

Radio-tracking is an invasive survey method, but in some cases may be the only means of meeting the survey objective, e.g. establishing the home range of a maternity roost. It requires the tagging of a bat with a radio transmitter, and subsequent use of radio-telemetry to obtain location data. Radio transmitters should be no more than 5% of the bat body weight and should not be attached to bats that appear unhealthy or injured, or heavily pregnant or those with dependent young. This method should only be used by experienced surveyors who have a good working knowledge of this method and the associated welfare considerations.

Surveys to establish habitat use and activity patterns of a breeding colony should tag at least 5% of the estimated population to obtain a representative sample. This may increase to 25% for rarer species or where development impacts are likely to be high. Each tagged bat should be tracked for at least three nights, ideally for longer, to establish activity patterns. A longer period of tracking is recommended where the aim is to identify roost sites, as the bat may switch roosts after a few days, allowing additional roosts to be identified. More detail on radio tagging/ tracking bats is provided in Kunz and Parsons (2009).

### Survey timing and frequency

Replicated sampling will typically be required, to allow confidence in concluding presence or likely absence (or low abundance) of bats, to collect sufficient data to characterise roosts and/or to fully evaluate temporal and spatial variation in bat activity.

There is no published guidance on the number or type of repeat surveys that are adequate for detecting and evaluating bat assemblages in Saudi Arabia or the Middle East, therefore the required survey effort should be determined based on professional judgement and a review of guidance available for other regions. Sampling can be replicated spatially (different locations at the same time) and temporally (same location at different times) or a combination of both (different locations at different times).

Repeat surveys at different locations will often be necessary to detect populations that are at low densities or have a clumped distribution, especially where the area of favoured habitat is large, or the habitat preferences of the target taxa are variable or poorly known. It also allows comparison of relative levels of bat activity across different areas or habitats. When comparing bat activity at different locations, sampling at the same time reduces the effects of other variables. Comparison with ‘control’ survey locations, is often appropriate.

Temporal replication of surveys can record fluctuation in abundance, occurrence or detectability of bat species, or variation in use of the Study Area over time. This may be important because highly mobile species may occupy parts of their range for only brief periods of the year. Similarly, a bat colony may depend on different resources at different times of the year. In these circumstances, surveys within a restricted time period may fail to identify features of importance to bats. Sampling across different periods of the year is usually necessary, for example seasonally (typical minimum), monthly or more than once a month.

Environmental conditions at the time of the survey may affect the validity of the findings, for example, bats may not fly in strong winds, or may adapt their behaviour by avoiding open habitat and remaining in more sheltered areas. In contrast, bats may be more active after a spell of wet weather causing greater availability of invertebrate prey. Therefore, where practicable, surveys should be carried out during weather conditions that are representative of the season at the survey location, as well as taking account of any likely habitat preferences or behavioural responses of target species.

## Data analysis

#### Analysis of acoustic recordings

Recordings of bat vocalisations are analysed using specialist software to look at the spectrograms. Some species produce calls with widely overlapping call parameters, however, making it almost impossible to reliably distinguish between them. Identification of bats from their calls also requires prior knowledge of the calls of all bat species in the Study Area. There are established reference libraries of calls for some regions, however, the information available for Saudi Arabia is not comprehensive. As such, bat calls must be identified to species-level with caution and, in many instances, it will be appropriate to identify calls to genus or species-group. Strict quality control over the analysis is necessary, with two experienced surveyors undertaking the analysis and spot-checking one another’s outputs to ensure consistency.

#### Analysis of bat activity survey data

All bat registrations on bat detectors should be identified to determine the number of ‘passes’ per species/species group at each sampling location and in each sampling period. This information can be converted into a relative index of bat activity e.g. bat passes/recordings per night (automated monitoring) or bat passes per hour (walked or driven transects). Depending on the objectives of the survey, a bat activity index can be assigned to species and/or analysed in relation to habitats and/or seasons. It is important to recognise that bat passes, or registrations, do not provide a measure of bat abundance. A single bat may pass the microphone 100 times, or 100 bats may each pass the microphone once, and the data collected would be the same (i.e. 100 passes).

Statistical analyses of bat activity survey data may aid interpretation of large datasets. Collins (2016) compares statistical analysis methods that could be adopted in different scenarios. This includes identifying associations between species and habitat types (e.g. using a chi-squared test).

#### Presentation of roost data

Roost data will typically be presented as symbols on a map, representing species and roost type, with supporting count data across different times of the year. This should be supported by qualitative data, including details of roost features, exit/entry points, internal conditions, aspect and height above ground, as well as photographs.

#### Analysis of radiotelemetry data

There are a number of methods for estimating the home ranges and core areas of bats. The most common are minimum convex polygons (MCP), cluster analysis and kernel contours. The selection of analysis tool should be the most appropriate to the species of interest, for example kernel contours may be more appropriate for slow-flying species that make only small movements, whereas MCP and cluster analysis may be more appropriate for fast-flying species that make use of habitats across a wider landscape area. Kenward (2001) provides detail of these methods.

# Reptiles & Amphibians

## Good Practice Guidance

The detailed survey design and SEP should be informed by a desk-based study as set out in **Section 2.3**.

There is no definitive protocol for undertaking reptile and amphibian surveys in Saudi Arabia. There is, however, guidance on the application of a variety of survey techniques in different countries and different ecosystems. This includes the following examples.

* Bennet (1999) *Expedition Field Techniques: Reptile and Amphibians*;
* McDiarmid *et al* (2012) *Reptile biodiversity: Standard methods for inventory and monitoring*;
* Sadlier *et al* (2004) *Survey guidelines for Australia’s threatened reptiles*;
* Gent and Gibson (2003) *Herpetofauna Workers’ Manual*; and
* Froglife (1999) *Reptile survey. An introduction to planning, conducting and interpreting surveys for snake and lizard conservation*.

This guidance should be referred to in conjunction with the method outlined in the remainder of this section, to inform and refine the SEP.

## Survey Objectives

The objectives of the survey will in most cases be to determine presence or likely absence (and distribution) of reptile and amphibian species within the Study Area. Additional or follow-up survey work may be required to inform a more detailed evaluation of the relative size (e.g. low, moderate, high, exceptional) of populations of individual herpetofauna species.

## Field Survey Design

### Personnel & equipment

The survey team should be experienced in visual identification and handling of reptiles and amphibians, avoiding the need for collection of live specimens and/or intrusive DNA/tissue sample collection. Surveyors should work in pairs and follow appropriate health and safety and biosecurity protocols, which will inform some of the equipment requirements (as described in **Sections 2.4** and **2.5**).

Field survey equipment requirements should be reviewed by the survey teams, based on the specific details of the SEP, but are likely to include: rucksacks; clipboards; pencils/pens; tablet populated with data collection templates and base mapping; camera; binoculars; high-powered torch; head torches; spare batteries and bulbs; SD cards; ID guides; callipers; spade; protective gloves, sterile gloves; mallet, tape measure; cable ties; string; ziplock bags; canes and reflective tape (location markers), traps and cover boards. The main types of herpetofauna traps are summarised in **Table 7.1**.

Table 7.1 Herpetofauna traps (examples)

| Trap type and summary | Illustrative example |
| --- | --- |
| Pitfall trap:  Buckets, with lids (to allow temporary sealing and deactivation of the traps). Buried so that the rim of the bucket is at or slightly below ground level.  In the absence of natural linear features to guide herpetofauna into the traps, it is preferable to operate pitfall traps in conjunction with drift fences, with the edge of the trap in contact with the fence.  It is preferable to install traps (sealed/deactivated) approximately one week prior to the survey, opening the traps on the evening before the survey.  Traps should be emptied frequently (this can include trap checks every two hours when surveying during the day in hot climates) to avoid harming fauna.  Where there is a risk fauna will be subject to heat stress - traps should incorporate shade (also limiting predation of trapped animals), as well as a sponge (soaked in water) and cover or refuge e.g. shredded newspaper.  Traps should be deployed as part of a combination of survey methods and using larger sizes for larger animals. | **Image:** Ribeiro *et al* (2008). |
| Cover boards:  Squares of cardboard, wood (c.1.0m2) or similar material to create an artificial refuge for herpetofauna.  Weighted down on one edge/corner as necessary to avoid displacement (wind etc).  Preferable to deploy one week prior to the survey to allow ‘bedding-in’ and where this is feasible with minimal risk of disturbance by people and livestock.  Deployed as part of a combination of survey methods and using larger sizes for larger animals. | A picture containing outdoor, ground, sky, dirt  Description automatically generated  **Image:** Miller (2014). |
| Funnel trap[[1]](#footnote-1):  Cylindrical traps, with funnel entrances at both ends, narrowing towards the trap interior, allowing herpetofauna to enter the trap and impeding escape. Laid on the ground surface or with partial cover/burial.  In the absence of natural linear features to guide herpetofauna into the traps, it is preferable to operate traps in conjunction with drift fences, with the trap laid longitudinally along (in contact with) the fence.  Traps should be emptied frequently, especially in hot climates to avoid harming fauna. Where there is a risk fauna will be subject to heat stress - traps are to be provided with shade (also limiting predation of trapped animals), as well as a sponge (soaked in water) and cover/refuge e.g. shredded newspaper.  Traps may need to be tethered to avoid displacement (wind etc).  To be deployed as part of a combination of survey methods and using a variety of sizes e.g. to capture lizards and snakes. | **Image:** Thompson and Thompson (2007). |
| Mammal trap (e.g. Sherman trap):  Rectangular ‘walk-in’ traps that are sealed by a ‘trap-door’ when activated by entry of a reptile or small mammal.  In the absence of natural linear features to guide herpetofauna into the traps, herpetofauna capture/detection rates may be improved by operating traps in conjunction with drift fences.  Traps should be emptied frequently in hot climates to avoid harming fauna. Where there is a risk fauna will be subject to heat stress - traps are to be provided with shade, as well as a sponge (soaked in water) and cover/refuge e.g. shredded newspaper.  Traps may need to be tethered to avoid displacement.  To be deployed as part of a combination of survey methods and using a variety of trap sizes. | A picture containing engineering drawing  Description automatically generated**Image:** Bioquip Products (https://bioquipinc.com/catalog/collecting-equipment-supplies/traps/sherman-traps/) |

All snakes should be treated as venomous as a precaution. Contents of traps should be handled with snake bite-proof gauntlets, until absence of snakes is confirmed, where necessary emptying the trap contents into a cloth bag. A snake hook, tongs, snake-handling gauntlets (bite-proof) and other snake handling equipment, should be available for use by any team member who is suitably experienced in handling snakes.

Any collection of DNA samples and the associated collection and storage protocol are to be agreed in advance with the relevant laboratory, avoiding routine intrusive sample collection, which could result in unnecessary and avoidable harm to reptiles and amphibians. This protocol should also be set out in the SEP. Collection of faeces and shed skin are appropriate non-intrusive techniques. Buccal swabs may be appropriate for some species providing they can be collected without harming or causing undue stress to the animal.

### Survey locations and sampling effort

Prior to the surveys the habitat types within the Study Area should be identified from baseline habitat mapping (aerial imagery & ground-truthing). The number of survey units should be defined to adequately sample representative areas of each of the main habitat types (that are suitable for reptiles) within the Study Area. The number of survey units should be scaled-up, according to the extent of each habitat type, to provide adequate survey coverage.

### Survey unit (example)

It is preferable to employ a combination of survey techniques, including trapping and transect surveys. A single ‘survey unit’ may comprise, for example:

* A transect of between 1km and 2km in length, depending on terrain and the capacity for a full transect walkover survey to be completed within the target survey period, for example during the period from sunrise to 2 to 3 hours after dawn; and/or within the period 2 to 3 hours before sunset.
* Trapping areas at intervals (e.g. 3 to 5 per transect, at 300m to 400m spacing) along each transect, for deployment of a combination of traps (e.g. pitfall traps, funnel traps, cover boards and Sherman traps). These more detailed sampling areas could cover, for example one hectare (100m x 100m), with 10 separate traps deployed at each one.

Trap combinations and configuration are to be tailored to suit the Study Area and based on desk-based study of herpetofauna species recorded within the Tabuk region, as well as descriptions of the trapping techniques (e.g. Bennet 1999; McDiarmid *et al* 2012; Ali *et al* 2018). Pit-fall traps are appropriate for soft substrates. Larger funnel traps are more suitable for snakes. Sherman traps catch a variety of lizards as well as small mammals. Pitfall traps and funnel traps are potentially the most effective (Thompson and Thompson 2007), particularly in circumstances where reptiles and amphibians are guided into them by following boundary and linear features or drift fences. The benefits and practicalities of deploying drift fences in conjunction with traps should be considered on a site-by-site basis, recognising that their use can significantly enhance herpetofauna detection and capture rates.

### Presence or likely absence survey (example methods)

A combination of survey techniques should be employed, for example a single survey of a single survey unit may comprise:

* Day 1 (morning). Starting at around sunrise, walkover survey of transect route, with surveyors walking a sinuous route and keeping c.20m apart, minimising noise and vibration, to record and map herpetofauna sightings and evidence of herpetofauna activity (e.g. tracks, burrows, droppings, skins). Pausing at intervals (e.g. 200m to 300m) for 20 minutes (sit-and-watch). Identify areas (e.g. x3 to x5; 100m x 100m) for more detailed survey. Trap (and transect) locations selected to minimise risk of human disturbance. Where necessary, reflective transect markers should be deployed to mark the transect to assist follow-up transect surveys at night[[2]](#footnote-2);
* Day 1 (night). Starting after sunset, walkover survey of the transect route, minimising noise and vibration, to record and map herpetofauna sightings using high-powered torches and head torches – high powered torches to be turned off for the majority of the survey to limit disturbance to herpetofauna - in favour of good quality head torches to detect ‘eye shine’. In the event the survey units are unsuitable for surveys after dark, alternative transects can be selected for night-time surveys, for example in closer proximity to tracks or vehicle routes.
* Day 2 (afternoon). Starting from 2 to 3 hours before sunset, walkover survey of the transect route, minimising noise and vibration, to record and map herpetofauna sightings. Deploy/activate traps and cover boards (e.g. x10 at each trapping location of approximately 1 hectare). It is recommended that pit-fall traps (dry) are opened, having been installed (sealed) one week in advance. It is also preferable for coverboards to be deployed one week in advance, providing they are not likely to be disturbed by people or livestock.
* Day 3 (day). Starting at sunrise, check all traps and cover boards, and record and release herpetofauna. Repeat the trap checks at late morning and late afternoon/before sunset. In each case replace the wet sponge. Deactivate (remove, close or securely seal) the traps immediately following the final check.

Depending on the outcome of the habitat survey, any wetland/water features within the Study Area should also be targeted by the surveys, for example repeat transect surveys (day and night), targeting wadis/wetland features in spring to record breeding amphibians and/or spawn/eggs or tadpoles/larvae.

All survey parameters (**Table 7.2**) are to be recorded in a suitable survey proforma, to be designed and appended to the SEP. This includes all incidental observations. Reptiles/amphibian and evidence of herpetofauna activity are to be photographed, with all photographs mapped/georeferenced and allocated a unique identification reference. Species identification should be informed by the most relevant field guide (e.g. Arnold 1986). Incidental observations of other fauna and flora of interest should be similarly recorded, for example sightings of reptiles, small and large mammals, and domestic livestock, or notable species of birds, invertebrates and plants.

Table 7.2 Reptile and amphibian survey parameters to be recorded

| Survey parameters | Reptile record | Habitat |
| --- | --- | --- |
| Date | GPS and trap number | Habitat type |
| Time (survey start/finish) | Species (genus) and numbers  (*or description of evidence of reptile activity)* | Substrate |
| Surveyor | Male/female | Topography |
| Survey Unit (Transect reference) | Adult/juvenile | Vegetation |
| Weather | Trap type (cover board, pit-fall trap, funnel trap, Sherman) or other observations *(e.g. basking; running; burrowing*) | Moisture (type/extent) |
| Temperature (start/end) | Photograph identification reference |  |

### Population studies

An estimate of relative population sizes of reptiles and amphibians will be appropriate in some circumstances, for example to inform more detailed assessment of the effects of large-scale losses of reptile habitat. The survey approach could be a scaled-up version of the presence or likely absence survey, for example scaling-up the size of trapping areas (e.g. stratified over a survey grid) and the number of survey units and survey events. This may inform a more detailed evaluation/categorisation of the relative size (e.g. low, moderate, high, exceptional) of populations of individual herpetofauna species.

Collection of data in relation to animal size (measured using callipers) can inform an assessment of population structure, although this is unlikely to be routine other than in relation to detailed population studies of certain target/uncommon species.

Capture-Mark-Recapture studies are not expected to be undertaken routinely. Intrusive, potentially harmful techniques (e.g toe or scale clippings or branding/tattooing) should be avoided. Use of harmless paints as part of Capture-Mark-Recapture studies may be an option in relation to certain reptile species and specific survey objectives, however this is seldom likely to be necessary. Routinely photographing the dorsal and ventral surfaces of reptiles/amphibians may allow individuals to be identified/distinguished to assist in any more detailed population studies e.g. Capture-Mark-Recapture. The rationale, design, objectives and approach to any detailed population surveys should be detailed in the SEP.

### Survey timing and frequency

Reptile detection is enhanced by repeating the survey of each survey unit, for example, the survey method outlined could be repeated on multiple occasions, with the end of the transect at which the survey starts being alternated between surveys. Alternatively, Day 3 of the above survey event could be replicated on Day 4 and Day 5, having reactivated the traps on the evening of Day 3. Repeating surveys may be particularly important in certain circumstances (low herpetofauna densities; low capture or detection rates; trap disturbance; anomalous weather), also recognising that herpetofauna populations may use different habitats and alter their geographic ranges at different times of the year, e.g. amphibian movements between aquatic habitats and terrestrial refuges.

It is preferable for the reptile surveys to cover the period between October and May (targeting the period March to May), avoiding trapping outside of this period where there is a risk of heat-stress to trapped animals and avoiding surveys at higher altitudes during the period December to February.

Any wadis/wetland features within the Study Area should also be targeted by the surveys, for example repeat transect surveys (day and night), in spring to record breeding amphibians and/or spawn/eggs or tadpoles/larvae.

## Data analysis

The appropriate data analyses will depend on the target species, informed by desk-based study and presence/absence survey, as well as the survey objectives. The survey will initially seek to establish and map presence/absence and distribution of reptile and amphibian species.

A scaled-up version of the presence or likely absence survey, for example scaling-up the size of trapping areas and the number of survey units and survey events may inform evaluation/categorisation of the relative size (e.g. low, moderate, high, exceptional) of populations of individual herpetofauna species. Similarly, calculations of densities of each species across a survey grid may allow more detailed comparison of relative population sizes/densities between study areas that have been subject to similar survey effort and design. Comparative evaluation of populations is likely to be increasingly informative as increasing levels of survey data become available for the NEOM region, or through the desk study i.e. comparison with similar studies in similar habitats and regions.

Capture-Mark-Recapture studies are not expected to be undertaken routinely. Where necessary for specific species this would rely on photographic records (and seldom paints/markers). This approach derives population estimates from the proportion of marked/photographed (previously captured) to unmarked (newly captured) individuals across consecutive sampling occasions. In its simplest form the approach involves capturing and photographing a number of animals (‘A’) before releasing them back into the population. On repeating the survey it is possible to calculate the estimated population size (N) based on the number of photographed individuals that are recaptured (R) and the total sample size (marked and unmarked) captured by the second survey (B): **N = (A\*B) / R.**

Plotting information on standardised size measurements and size distribution within herpetofauna populations can yield information on population health, mortality and recruitment.

Any detailed population studies investigations would need to be set out in detail at the outset in the SEP, including clear justification, objectives, survey design and sampling effort.

# Reporting

The survey work (and desk study) are to be detailed in a concise, factual baseline report, setting out the following information.

* **Introduction**: background to the work, aims and objectives, and relevant literature and guidance.
* **Desk study**: details (location, type of record) of relevant habitats, species and biodiversity conservation areas previously recorded, or known to occur, within the Study Area and surrounding areas (see **Section 2.3**)
* **Methods:** description of the survey methods, including Study Area, sources of data, equipment, field techniques, sample size, timing and duration, laboratory analysis, data analysis and software. Survey limitations and/or constraints should be also described.
* **Results:** factual description/explanation of the results, with supporting data summaries in tables, figures and graphs.
* **Evaluation:** interpretation of the results, setting out the available information on the baseline status of each habitat/species/group recorded within the Study Area and within the context of its regional and national status, presented in a matrix or tabular format where possible. This may include: international (including but not necessarily limited to IUCN designation/status), national (Saudi Arabia) and regional (Tabuk) population status and status within the NEOM Region, including threats and population trends. Summary details relating to the ecology of each species should be included where possible and appropriate (obtained from survey work and/or desk study): habitat type; key habitat requirements; prey; breeding behaviour; and activity patterns. The efficacy of different survey techniques should be considered, along with the effect this may have on the accuracy and representativeness of the data collected.
* **Conclusion**: a brief summary of the survey outcomes and conclusions and next steps, where appropriate e.g. recommendations for further survey work or adjustments to survey protocols and standards.
* **References:** details of sources of information and references that informed the survey work.
* **Appendices:** tables (raw data) and figures/plans at an appropriate scale, showing survey locations, survey results and species records.

All survey parameters, data and photographs are to be stored in manner that is compatible with the NEOM Environment GIS database.

# References

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1. Indicative Bat Survey Equipment

Table A.1 Indicative bat survey equipment for different survey techniques

|  | Preliminary assessment/ walkover | Internal roost inspection (walk in sites) | Aerial roost inspection (e.g. trees or rock faces) | Emergence/re-entry or vantage point survey | Walked transect | Driven transect | Automated monitoring | Trapping from roost (hand net) | Trapping survey (harp trap or mist net) | Marking individuals | Radio tagging/ tracking |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| General field survey equipment |  |  |  |  |  |  |  |  |  |  |  |
| Rucksack | X | X | X | X | X | X | X | X | X | X | X |
| GPS | X | X | X | X | X | X | X | X | X | X | X |
| Compass | X | X | X | X | X | X | X | X | X | X | X |
| Clipboard with paper/survey forms and pencils/pens | X | X | X | X | X | X | X | X | X | X | X |
| Camera (spare batteries and SD cards) | X | X | X | X | X | X | X | X | X | X | X |
| Binoculars | X | X | X | X |  |  |  |  |  |  | X |
| Head torch (spare batteries and bulbs) | X | X | X | X | X | X | X | X | X | X | X |
| Thermohygrometer | X | X | X | X | X | X | X | X | X |  |  |
| Field guides/ publications | X | X | X | X | X | X | X | X | X | X | X |
| Tape measure | X | X | X | X | X | X | X | X | X |  | X |
| Ziplock bags | X | X | X | X | X | X | X | X | X | X | X |
| Eppendorf tubes | X | X | X | X |  |  |  | X | X | X | X |
| String |  |  |  |  |  |  | X | X | X |  |  |
| Canes (location markers) | X | X | X | X | X | X | X | X | X |  | X |
| Reflective tape | X | X | X | X | X | X | X | X | X |  | X |
| Sterile gloves | X | X | X | X | X | X | X | X | X | X | X |
| Biosecurity & PPE (indicative – refer to risk assessment) |  |  |  |  |  |  |  |  |  |  |  |
| Face covering | X | X | X | X |  |  |  | X | X | X | X |
| Disinfectant kit | X | X | X | X |  |  |  | X | X | X | X |
| First aid kit | X | X | X | X | X | X | X | X | X | X | X |
| Helmet/hard hat |  | X | X |  |  |  |  |  |  |  |  |
| Rope access equipment (harnesses, ropes, caribiners, prussic loops, strops) |  |  | X |  |  |  |  |  |  |  |  |
| Food and water | X | X | X | X | X | X | X | X | X | X | X |
| Sunscreen, hat and suitable clothing | X | X | X |  |  |  | X | X |  |  | X |
| Layers of warm clothing |  |  |  | X | X | X |  | X | X | X | X |
| Satellite phone | X | X | X | X | X | X | X | X | X | X | X |
| Robust footwear with ankle support | X | X | X | X | X | X | X | X | X | X | X |
| Specific survey kit |  |  |  |  |  |  |  |  |  |  |  |
| Powerful torch (spare batteries and bulbs) | X | X | X |  |  |  |  | X | X |  | X |
| Torch with red light filter |  | X | X | X | X | X |  | X | X | X | X |
| Bat handling gloves (various thickness for different species) |  | X |  |  |  |  |  | X | X | X | X |
| Extendable mirror | X | X | X |  |  |  |  |  |  |  |  |
| Ladder |  | X | X |  |  |  |  |  |  |  |  |
| Endoscope | X | X | X |  |  |  |  |  |  |  |  |
| Handheld radios |  |  |  | X | X | X |  |  |  |  | X |
| Handheld bat detector | X | X |  | X | X | X |  | X | X |  |  |
| Automated bat detector and earphones |  | X |  |  |  |  | X |  |  |  |  |
| Temperature/ humidity data loggers |  | X |  |  |  |  |  |  |  |  |  |
| Counter |  | X |  | X |  |  |  |  |  |  |  |
| Infrared camera and infrared lamp (with associated tripods, SD card and power source) |  | X |  | X |  |  |  | X | X |  |  |
| Hand net |  |  |  |  |  |  |  | X |  |  |  |
| Callipers |  |  |  |  |  |  |  | X | X |  |  |
| Drawstring bat holding bats |  |  |  |  |  |  |  | X | X | X | X |
| Weighing scales |  |  |  |  |  |  |  | X | X | X | X |
| Hand lens (magnifier) |  |  |  |  |  |  |  | X | X |  |  |
| Fine scissors |  |  |  |  |  |  |  |  | X |  |  |
| Mist nets, poles, pegs, guy ropes, mallet |  |  |  |  |  |  |  |  | X |  |  |
| Harp traps, guy ropes |  |  |  |  |  |  |  |  | X |  |  |
| Acoustic lure (and laptop loaded with call library if required to run it) |  |  |  |  |  |  |  |  | X |  |  |
| Curved blunt ended scissors |  |  |  |  |  |  |  |  |  | X | X |
| Radio transmitters, surgical glue, cotton bud, portable soldering iron and solder, receivers, headphones and antennae |  |  |  |  |  |  |  |  |  |  | X |



1. Funnel trap example: https://terrestrialecosystems.com/funnel-traps-order-form/?xhxcclop=465583 [↑](#footnote-ref-1)
2. More intrusive habitat searches, such as searching under rocks and debris may be appropriate and effective survey techniques in many circumstances, however, in circumstances where these refuges are a limited resource this approach is not recommended as a default survey method, to avoid displacing reptiles from important refuge habitat. [↑](#footnote-ref-2)