Proceedings of the

14th Annual Conservation Workshop for the Biodiversity of Arabia

Bioregional Planning, Species Action Planning and Wildlife Tracking

مبادرة أبوظبي العالمية للبيانات البيئية
Abu Dhabi Global Environmental Data Initiative

14th Annual Conservation Workshop for the Biodiversity of Arabia

Bioregional Planning, Species Action Planning and Wildlife Tracking

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Executive Summary

The Fourteenth Annual Conservation Workshop for the Biodiversity of Arabia was held at the Breeding Centre for Endangered Arabian Wildlife (BCEAW) in Sharjah, UAE, from the 3rd to the 6th of February 2013. The Protected Areas component of this workshop continued the theme of protected area management, first introduced in 2007, by reviewing progress on the Bioregional Planning initiative launched in 2010, and exploring the process of Species Action Planning.

A successful preliminary bioregional conservation planning session was first held in 2010 during the 11th Conservation Workshop for the Biodiversity of Arabia in Sharjah. Following on from this, at the Sharjah Conference on Biodiversity Conservation in Arabia in 2011, the Environment Agency-Abu Dhabi accepted the mandate to deliver a regional biodiversity assessment. The Abu Dhabi Global Environmental Data Initiative (AGEDI) team facilitated the Bioregional Planning session directing delegates to review the map layer produced and to refine the final assessment of Priority Focus Areas.

The Species Conservation Planning sessions reviewed the common elements and process of strategic species conservation planning at local, national, regional, and even global scales. Delegates presented and discussed regional case studies, and drafted national-level objectives, targets and actions for Arabian oryx and Arabian leopard.

The inclusion in 2013 of a wildlife-tracking workshop was a continuation of a complementary technical theme introduced in 2012 and followed from recommendations of earlier species-focussed workshop components that called for regional standardisation of data collection methods. Electronic wildlife tracking is a widely applied method to follow the movements, fates and behaviours of free-ranging individual animals. Wildlife tracking can be used to derive estimates of home range size, use, and placement, to quantify resource selection and survival rates, and to document reproductive success and other behaviours. The two-day hands-on workshop was facilitated by Dr Sean Walls of Biotrack and covered the practical aspects of equipment selection, tag attachment, and data collection, and reviewed data analysis options, including newer approaches used to evaluate resource selection and to estimate animal home range size.

Contents

Local, National and Regional Biodiversity Rapid Assessment

This summary is based on the presentation given by the AGEDI Local, National and Regional Biodiversity Assessment project team during the 14th Conservation Workshop, and the publication *Systematic Conservation Planning Assessments and Spatial Prioritization for the Emirate of Abu Dhabi, the United Arab Emirates, and the Arabian Peninsula* (Abu Dhabi Global Environmental Data Initiative - AGEDI 2013).

Introduction

"*The realization of conservation goals requires strategies for managing whole landscapes including areas allocated to both production and protection. Reserves alone are not adequate for nature conservation but they are the cornerstone on which regional strategies are built. Reserves have two main roles. They should sample or represent the biodiversity of each region and they should separate this biodiversity from processes that threaten its persistence*"

Margules, C.R. and Pressey, R. L. (2000) Nature 405:243-253

A successful preliminary regional conservation planning session was first held during the 10th Conservation Workshop for the Biodiversity of Arabia in Sharjah, resulting in the production of a draft map depicting priority conservation sites (below). Following on from this, at the 12th Sharjah Conference in 2011, the Environment Agency-Abu Dhabi accepted the mandate to deliver a regional biodiversity assessment.

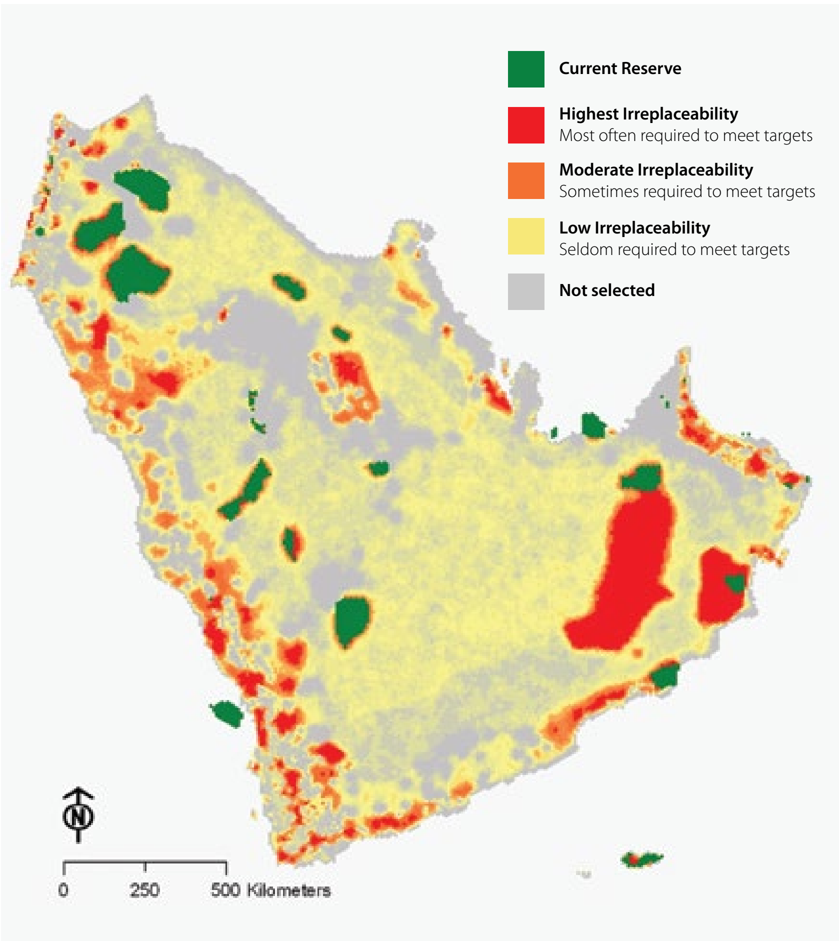
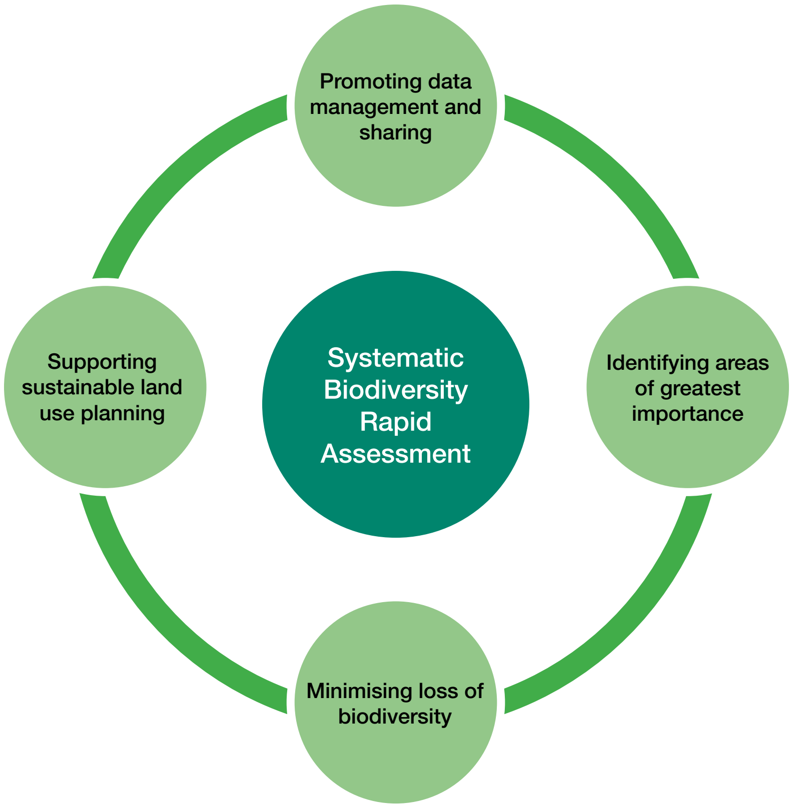


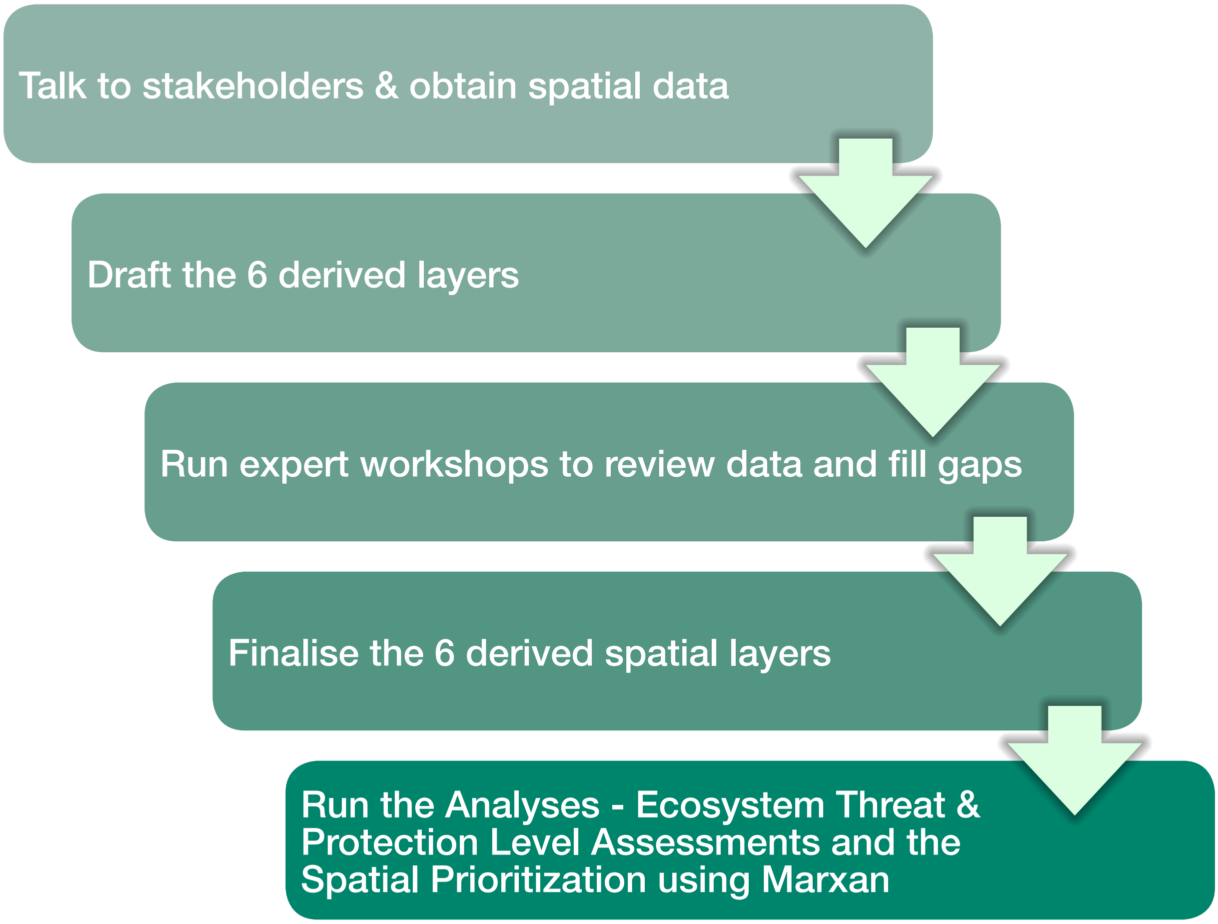
Figure 1. Output from the rapid conservation assessment for the Arabian Peninsula carried out during the 10th Conservation Workshop for the Biodiversity of Arabia.

Systematic Conservation Planning (SCP) seeks to assess biodiversity in a robust, repeatable and scientific manner and thereby identify the best places in a landscape to undertake conservation activities such as Protected Area expansion.

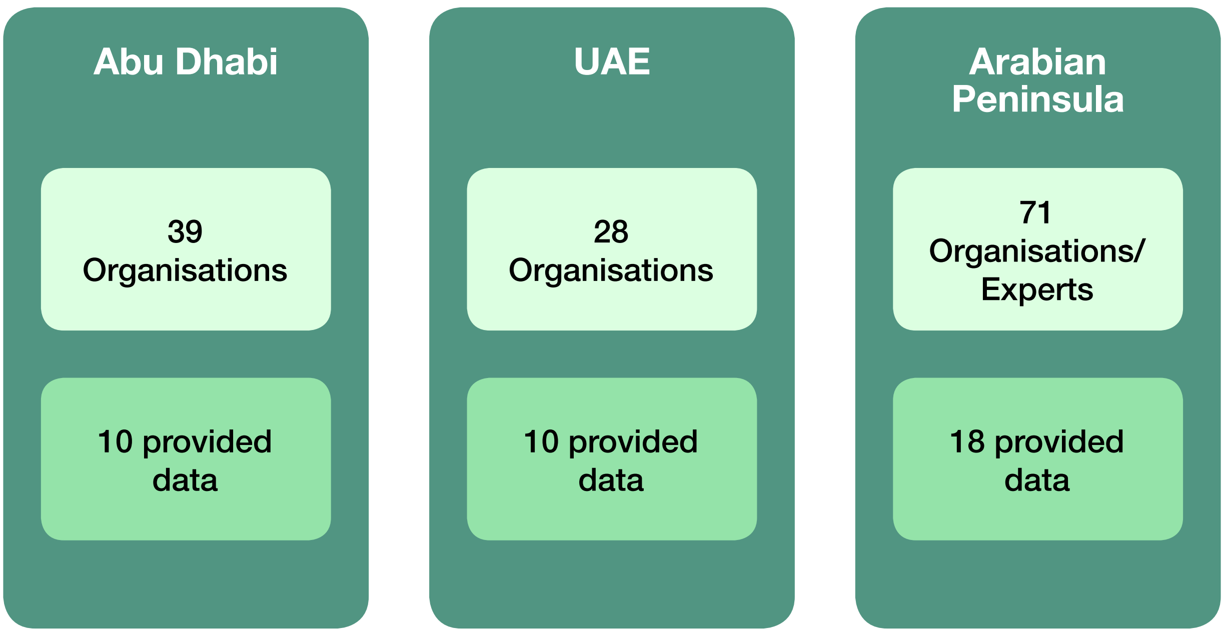


Systematic Conservation Plans were prepared using available spatial data for the marine and terrestrial areas within the Emirate of Abu Dhabi (Abu Dhabi), the United Arab Emirates (UAE) and the Arabian Peninsula region, comprising the UAE together with the Hashemite Kingdom of Jordan (Jordan), the Kingdom of Bahrain (Bahrain), the Kingdom of Saudi Arabia (Saudi Arabia), the Republic of Yemen (Yemen), the State of Kuwait (Kuwait), the State of Qatar (Qatar), and the Sultanate of Oman (Oman). The Abu Dhabi and UAE analyses were run at a finer scale than the Arabian Peninsula.

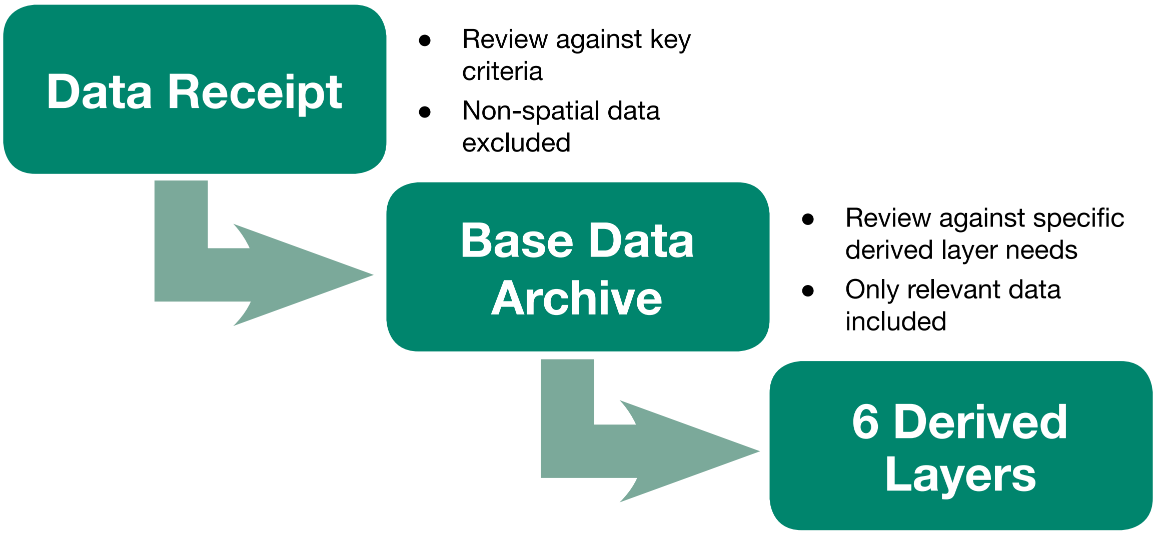
The Systematic Conservation Planning process follows a number of sequential steps. The diagram is a summary of the process that is both iterative and adaptive.



Wide ranging stakeholder involvement extended to 149 institutions and 270 individuals to obtain the range of biodiversity and other associated data from across the region.



Draft outputs were peer-reviewed through a series of technical workshops, the last of which was held as part of this 14th Conservation Workshop for the Biodiversity of Arabia. This enabled experts to improve the mapping, fill data gaps, contribute to the Spatial Prioritization, and review and confirm findings. The project collated available spatial data into six summary derived layers on GIS that were then used to run the spatial analyses.



The six derived layers were: Habitat, Habitat Condition, Protected Areas, Species, Ecological Processes, and Opportunity and Constraints.

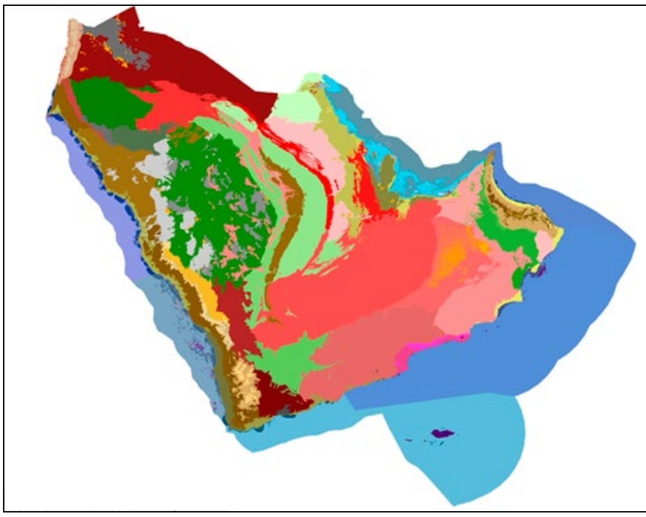


Figure 2. Marine and terrestrial habitats for the Arabian Peninsula

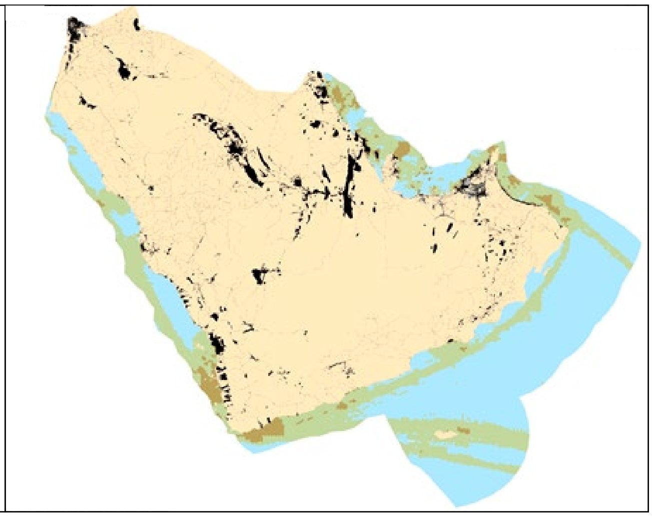


Figure 3. Land use and marine and terrestrial habitat conditions across the Arabian Peninsula

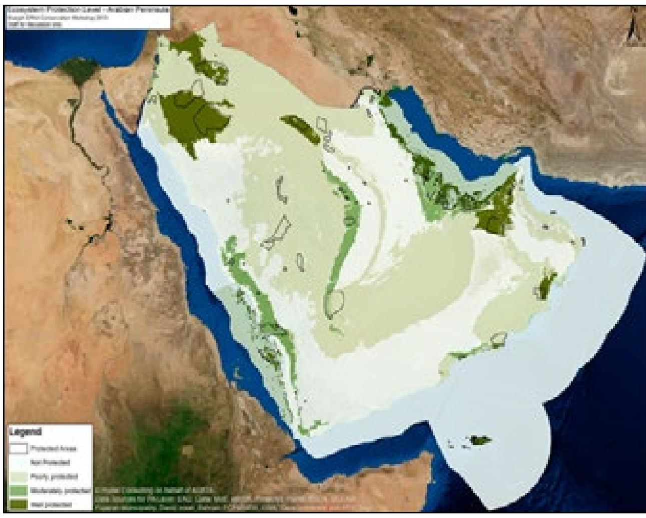


Figure 4. Protection levels across the Arabian Peninsula

Figure 5. Arabian Peninsula ecosystem threat status

Targets were set for biodiversity features including for ecosystems, habitats and species.

Condition thresholds	Less than target (25%) Good/ Natural	Less than target +20% (45%) Good/ Natural	Less than 80%* Good/ Natural & Fair/ Degraded	More than 80%* Good/ Natural & Fair/ Degraded
Ecosystem threat status	Critically Endangered	Endangered	Vulnerable	Least threatened

Purpose:

- Allow relative evaluation of habitat types
- Ensure representative reserve network
- Strategic or political objectives for protected area expansion

Base Targets:

- CBD Target
    - 17% terrestrial habitat types
    - 10% of marine habitat types

Exceptions:

- Higher targets for key and rare habitats
- e.g. 80% for mangroves

The analysis phase of the project had three major components: Ecosystem Threat Status assessed the proportion of ecosystems that were in a natural or intact state compared to targets. Protection Level assessed the representation of ecosystems within the current Protected Area network (i.e. a gap analysis).

Derived Layer	Ecosystem Threat Status	Ecosystem Protection	Marxan Spatial Prioritization
Habitats	X	X	X
Pressure/Condition	X		X
Protected Areas		X	X
Species			X
Ecological Processes			X
Opportunities & Constraints			X

Spatial Prioritizations using MARXAN were generated using the six derived layers. The outputs of the MARXAN analyses were used to identify Priority Focus Areas to undertake area-based conservation activities such as Protected Area expansion and other mechanisms for securing areas for biodiversity and managing them sympathetically.

Proportion of Protection target met in a protected area

Zero of less than 5% of protection target	5-49% of protection target	50-90% of protection target	>90% of protection target
Not protected	Poorly protected	Moderately protected	Well protected

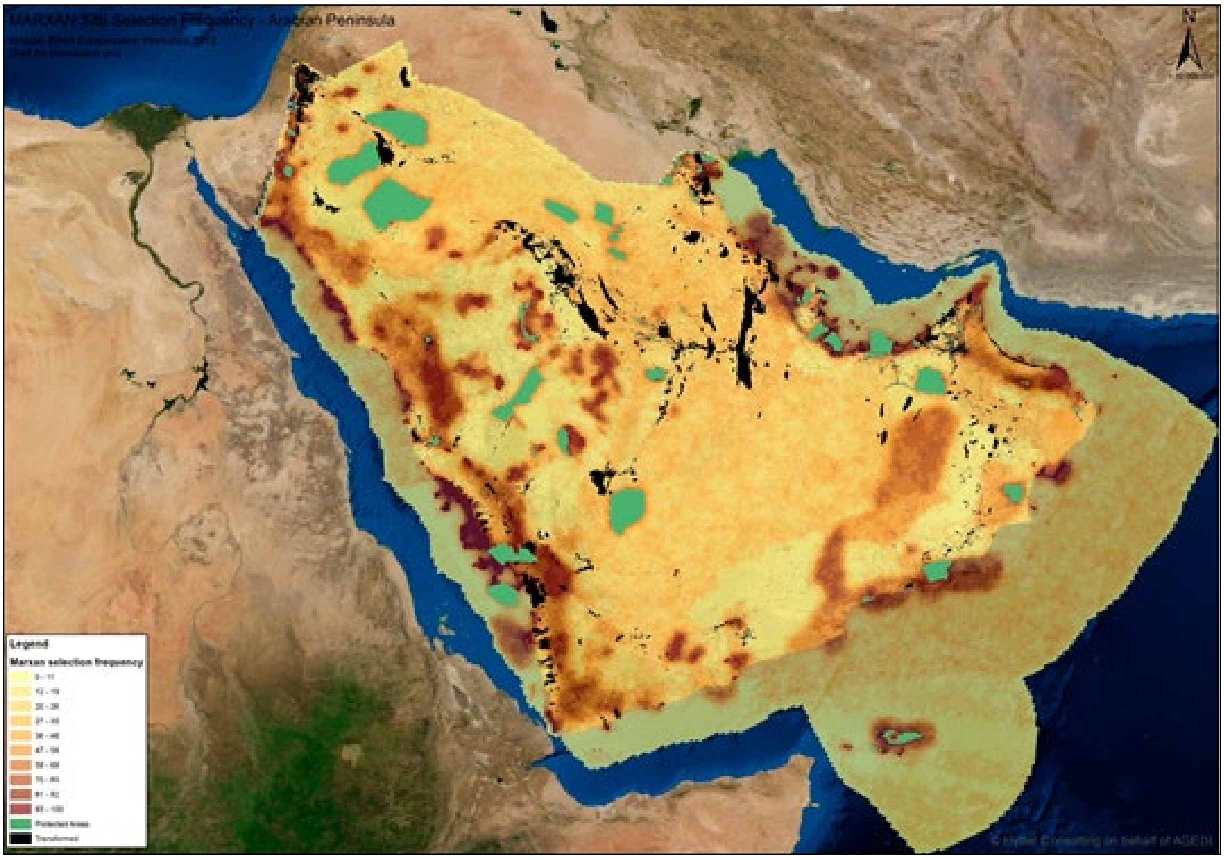


Figure 6. MARXAN site selection frequency for the Arabian Peninsula

In total 35 Priority Focus Areas were identified across the Arabian Peninsula. The derived layers, particularly Habitat, Protected Area and Habitat Condition for the Arabian Peninsula have a value beyond the SCP analyses.

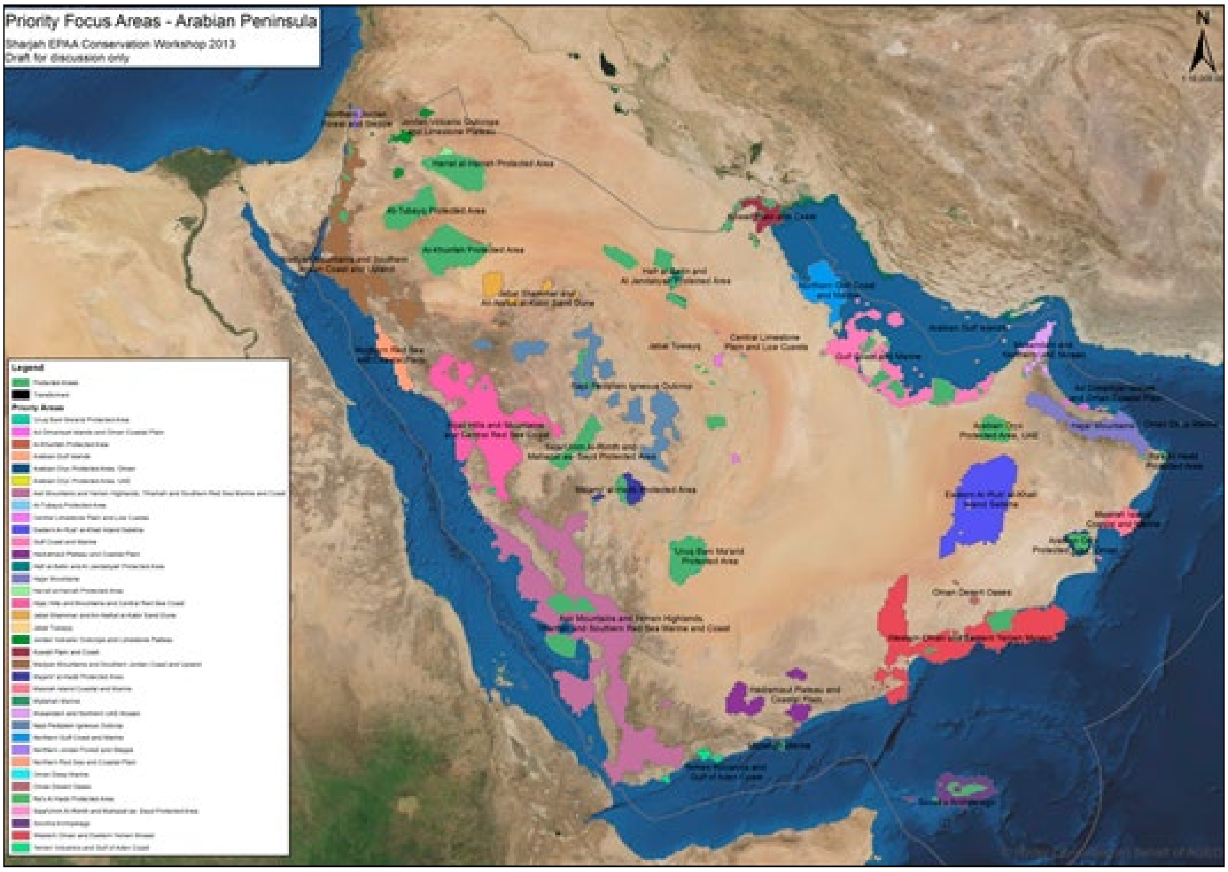


Figure 7. Priority Conservation Focus Areas for the Arabian Peninsula

The Arabian Peninsula Habitat map is the first comprehensive map of its kind for the region and useful for many aspects of ecology work including survey design and stratification. The headline indicators from the Ecosystem Threat Status and Protection Level assessments are the first objective measure of conservation priority for Arabian Peninsula ecosystems and are linked to the emerging process of Ecosystem Red Listing. These indicators potentially form the basis for the biodiversity component of national State of Environment reporting and national biodiversity assessments. The Spatial Prioritizations provide products for planners to use in determining local spatial priorities, including identifying national and transboundary priority areas for Protected Area expansion.

The outputs are not the final conservation plans and represent only the first iteration of a continually evolving process that can be strengthened by improved data inputs. Key data gaps include species data collected through atlas work and well-designed surveys, aspects being promoted within the Sharjah Conservation Workshop series. There is also an urgent need to better measure marine condition and terrestrial degradation. A critical impact on terrestrial ecosystems that is currently underestimated in these analyses is that of overgrazing.

Reference

AGEDI (2013) *Systematic Conservation Planning Assessments and Spatial Prioritization for the Emirate of Abu Dhabi, the United Arab Emirates, and the Arabian Peninsula*. Abu Dhabi

You can access the [Project Outcome Booklet] and associated technical reports, and derived layer shapefiles via the links on the AGEDI website www.AGEDI.ae under either Global Collaborations or For You/Reports.

Species Conservation Planning

Their importance, with international & regional case study examples for the Arabian Peninsula

Introduction

Species Action Plans (SAPs) remain one of the most important tools in the conservation of biological diversity. Since they were first instituted in the late 1960s over 60 have been published (IUCN 2008). They provide the required focused attention to address the threats facing threatened species and prove to be an invaluable sources of information on the distribution, status, habitats, association with other species, threats facing them, actions to be implemented, and the identification & prioritization (mostly of the biological components) of required gaps in the knowledge base. They also provide the important baseline to measure conservation action success or not. They have also proved a very useful means for funding species conservation action. However, they are rarely effective in delivering on their objectives (IUCN/SSC 2002). This primarily arises from:

- **Lack of definition of the target audience**: With most plans drafted by IUCN Specialist Groups with different views on what the plans should achieve results in a lack of focus for the actual implementing institutions.
- **Lack of inclusivity**: Drafted by specialist with limited resources often results in inadequate consultation of the broad stakeholders, thus providing a less than perfect product.
- **Lack of planning guidelines**: A lack guidelines in how to formulate the actions has created inconsistent end products.
- **Inadequate link to actions**: An inadequate link between the status review and threats to required and prioritized actions is hugely problematic in motivating for support.

The IUCN (2008) strategic planning guidelines attempted to rectify this through the provision of a well articulated framework. Strategic species conservation is important as it does provide a global framework for all partners, coordination of action in response to prioritized threats at such a scale, avoids duplication of effort, as well as providing the basis for developing national specific action plans, where the actual conservation effort will in theory take place. As with all such plans they need address three fundamental questions:

- **Where are we now?**: This requires a status assessment of the species .
- **Where we want to go?**: This is formulated in the strategy component.
- **How do we get there?**: This relates to the detailed action plans.

It is accepted that the scope of these species conservation plans can be broad depending upon: the geographical distribution of a species (from local to regional to global); its taxonomic scope from single species (e.g. Arabian Leopard (Breitenmoser *et .al.* 2008)), to multiple species (Marine turtles (Pilcher 2009)) with the former more common. In theory, the planning process can cover any number of species, but there is a clear trade-off between single species detail verses less inclusivity and poorer depth of multiple species plans.

Although the IUCN SSC has played a pivotal role in the development of SAPs & SCPs, other organizations (such as WWF, Bird Life International, Council of Europe, WCS Rangeland etc.) have developed their own set of species plans, many driven by international conventions/legal agreements through to national legislation which can lead to an apparent duplication and overlap and confusion (Table 1). In addition, at the national level a range of such plans are called by different names (species action plans, recovery plans, recovery project, conservation project etc.). The important point is that there is no totally correct approach – it's the principle that need be the same.

Table 1. A diversity of Species Action/Conservation Plans under different international conventions, national legislation.

Legal base/ Convention/Advocate	Strategic	Implementation
CBD	National Biodiversity Strategies & Action Plans (NBSAP) Biodiversity Management Plans (BMP)	Recovery plans
Australian legislation	Endangered Species Programme	Recovery Plans
NZ Conservation Policy	Species Recovery Programme	Recovery Plan
UK conservation policy	Species Recovery Programme	Recovery Project
Pan European Biological Land Division strategy	Species Action Plan	Projects
IUCN	Species Conservation Plan Conservation Action Plan	Conservation project
WWF	Species Conservation Plan	Conservation project

The key elements common to all the strategic species conservation planning initiatives include the need for:

- Should be based upon sound scientific evidence;
- Should include a threat or problem analysis;
- The core structure of the plan should follow a logical step wise process from visions, objective to actions;
- Requires an inclusive partnership across government, experts/NGO, private sector and local community involvement;
- The objectives need address the highest threats;
- The threats are prioritized;
- Action are developed in terms of target, time allocation, responsibility & ideally budget;
- Most international conservation planning programmes expect the development of national action plans from the more generic global/regional ones.
- And above all it requires common sense.

It is important that national action/recovery plans optimize conservation action on the ground. This requires a full appreciation of the legislative environment, protected area/conservation management arrangements and support and effectiveness, active NGOs, sufficient conservation resources (financial & human capacity), budgets, and an appreciation of transboundary requirements or opportunities for species planning and conservation. These plans would cover a suite of issues as: the identification of the species, development of the objectives, stabilise it's the species decline, expand its range, reduce fragmentation, restock where required, educate, coordinate, monitor, budget and adapt accordingly.

As mentioned above one of the most important components of developing species conservation plans is the need to provide clear, easily read documents with attainable visions and goals and implementable objectives and actions. Figure 1 briefly displays the logical flow from vision to actions.

Thus any strategic species conservation plan and associated action/recovery plans need be inclusive documents, with strong political support. The recommendations need be practical and achievable by implementing staff with the resources to deliver on prioritized actions. The delivery on these should be regularly reviewed as part of the adaptive learning process.

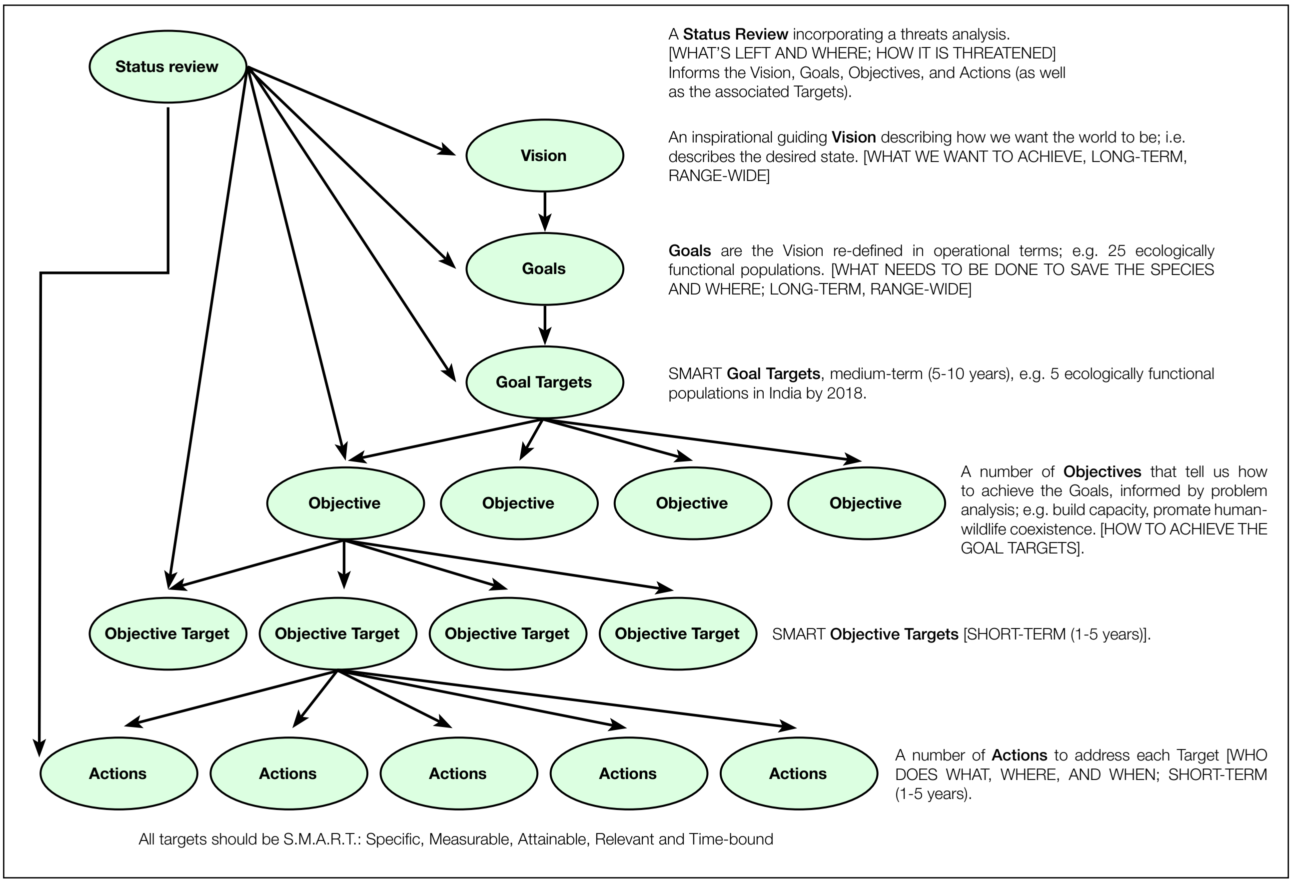


Figure 8. Logical hierarchy of objectives required in SCPs.

Three regional species plans exist for the Arabian Peninsula, namely the Arabian leopard (Breitenmoser *et .al*. 2008), the Arabian Oryx (AED 2010) and the Sociable Lapwing (AEWA 2004) exist and formed the basis of the workshop.

Aims

The aims of this component of the 14th Conservation Workshop were to review the state of strategic species conservation planning in the region, through a combination of national feedbacks and detailed assessments of a number of existing regional plans, and highlight the importance of using comprehensive guidelines.

Outline and Process

This component was divided into four parts with an introductory session by Drs D Mallon and M Knight on the importance of strategic conservation planning and national species plans, respectively, highlighting their history, importance, objectives and lessons learnt. The second part involved country report backs on the state of species plans in their countries. This involved feedback on the understanding of the existence or not of such plans, their operationalisation or not into conservation management, an indication of how effective they have been, any local implementation examples and what has been learnt in the process.

The third section asked delegates who had been divided into four groups to review two of three regional plans against the principles for good strategic species conservation planning as outlined in the introduction. Questions that were asked included:

- Does it comply with the IUCN Strategic Planning for Species Conservation overview?
- Is their a logical structure & flow?
- Does it address the right audience?

- Do objectives address threats?
- Are Targets & Actions identified?
- Are the threats realistic?
- Does the regional plan provide an understanding of what to do at the national level?
- Has there been any national translation of these?
- How could one improve these plans?

The last section focused on the importance of developing a clear and logical hierarchy of objectives for national action plans. Delegates were required to select any two objectives from the regional oryx or leopard plans and develop their own national level objectives, targets, actions, responsibilities and timelines.

Regional Case Studies

In general terms there was an overall awareness of global/regional species conservation plans for threatened/ important species in the region (Table 2). However, there was considerable variation in the degree to which these regional plans were translated into national action plans, with some countries having the full suite to those with none at all. This could be indicative of varied opinions of the importance of such species plans to national conservation efforts. There was also considerable diversity of opinion as to whether their national conservation action plans (APs) have been successful or not. There was a leaning to being less successful than hoped.

The most important lessons learnt from the process included (Table 2):

- The need for greater collaboration within national conservation authorities and between government departments is essential for better cooperation.
- Broad consultative engagement is crucial in developing and implementing the APs.
- The need for good communication with all stakeholders throughout the process.
- Provision of sufficient resources (human & financial) to deliver on the APs.
- Important to remain flexible throughout the process to adjust depending upon changing circumstances.
- Species plans provide good motivations for potential funders.
- Well articulated and prioritized objectives.
- The need to be innovative.
- Having political support and will is essential.

Table 2. Use of species conservation plans within the Arabian Peninsula region.

Country	Are you aware of global/regional/ national species action plans	Do you use these plans?	Implementation of these plans (good, moderate, poor) and if not why	Any local examples of implementation	Lessons learnt & any positive things and emerged
Jordan	Very much aware of the range of plans from global, through regional to national	National Plans: Azraq killifish, Persian squirrel, Roe deer, Syrian Serin, Blanford's fox.	Azraq killifish,: Good Persian squirrel: Poor Roe deer: Good -70% success Syrian Serin: Poor Blanford's fox: Good	Blanford's fox. Recorded at 5 localities, under range of management authorities which requires increased coordination & cooperation. The AP has 5 themes. Is participatory in nature, science based, with resources provided.	• Prioritising management objectives critical • Be innovative in the process and learning by doing. • Inclusive collaborative process essential. • Government buy-in required, ideally with policy and legislative support

Country	Are you aware of global/regional/ national species action plans	Do you use these plans?	Implementation of these plans (good, moderate, poor) and if not why	Any local examples of implementation	Lessons learnt & any positive things and emerged
Oman	Leopard & Oryx regional plans. No national plans yet although called for	Leopard: Some organizational level APs developed by some individuals. Oryx: 5-6 clearly explicit APs developed but poorly communicated.	Leopard: Poor & estimated about only 20% (mainly on research, threats & designated reserve) implemented owing to lack of intra-organisational collaboration Oryx: Poor as seen Oryx reserve reduce in size and erection of fencing.	Leopard: One reserve. Oryx: Arabian Oryx Sanctuary	• Lack of collaboration within & between organizations responsible for conservation • Decisions made without consultation with all stakeholders • Poor communication of APs undermines their usefulness.
Saudi Arabia	Fully aware of them (Leopard, Arabian, Oryx, Sea turtles) National APs: Leopard, Oryx, Green sea turtles, Houbara (draft), ostrich (pending)	Local APs are used. Most are quite clearly and explicitly written.	All rated according to indicators as moderately successful.	Two research centres (Taif & KKWRC) with former got 4 established programmes & latter one. Houbara: 4 release areas with links to other cooperative projects (Bald Ibis)	• APs have made conservation actions much simpler to understand & prioritise. • APs have provided means to motivate for support. • APs need be flexible to adjust to changing socio- political circumstances Require dedicated staff with NGO playing increasing role.
UAE	Seven Regional/ National plans. Fully aware of regional plans	Leopard: Regional plan used, no national AP. Oryx: Use regional plan but unclear of national AP status. Dugong: MOU UNEP- CMS, Conservation Action Plan in place. Arabian Tahr: Suiker & Sooty Falcon: UNEP- CMS due in 2013. Indian Ocean sea turtles: International MOU, Regional plan and national level actions with commendation. Osprey: National AP.	Leopard: Poor-moderate. Focus has largely been on the captive population which has grown but requires better cooperation in line with the regional plan between parties to improve the genetic diversity of the captive population. Limited attention to reintroduction. Oryx: Good. Given positive conservation actions the species has been down listed to Vulnerable (IUCN SSC Antelope Specialist Group 2011). Arabian Tahr: Poor. 2006-9 working group existed but stopped before	Well established captive breeding leopard programme in place. Provision of artificial nesting platforms to enhance breeding performance of Ospreys in particular.	• Regional Plans and national AP have a growing place in the national conservation programmes. • Improve and maintain coordination and cooperation between different conservation organizations and private entities to optimize sharing of breeding animals in captive programmes.

Country	Are you aware of global/regional/ national species action plans	Do you use these plans?	Implementation of these plans (good, moderate, poor) and if not why	Any local examples of implementation	Lessons learnt & any positive things and emerged
			drafting an AP. Suggested holding back until more regional data accumulated on the free living population. Osprey: ?. Artificial nest platforms erected and new legislation in place. Sea turtles, Suiker & Sooty Falcons & Dugongs: ?		
Yemen	Regional plans: Leopard, Sea turtles	No written national documents, with regional 'actions' being implemented Focused on species assessments and key locations, & raising conservation awareness with local communities	Leopard: Using recommended regional actions but poorly implemented. Lack capacity (human & financial).	Leopard: in 3-4 areas. Trained 4 persons in use of camera trapping. Raised local awareness. Also have involvement of local NGO.	• Need national APs. • Lack of organizational appreciation for need for APs • Require dedicated staff with NGO playing increasing role.

Critical review of Arabian Leopard & Oryx Regional Species Conservation plans

Feedback from the four groups are summarized in Table 3. Both plans were considered to be relatively well presented with a strong conservation and science focus – the apparent main focus audience for the report. Both showed limited appreciation for social or ethical issues which may have arisen from the composition of the makeup of the group drafting the plans. The need for greater inclusivity with local community involvement is an essential requirement. In addition it was felt that those drafting the plans should include actual implementers. Besides the general lack of attention to social threats to these species, the threat analyses in the plans were generally quite well presented and reflected in the objectives. However, there was a general consensus that the objectives need considerable tightening up in line with SMART principles. The actions & targets were thought to be more aspirational and as such not measurable and difficult to review. The point of having well articulated objectives came to the fore on numerous occasions.

Such plans should not be once-off developments but should be flexible and regularly reviewed. This would only be achieved if they were institutionalized within the conservation authorities. The need for national champions would be an essential step in this regard. Although considerable emphasis has been placed upon developing national APs, these should not lose sight of the transboundary conservation issues and the need to engage regionally for more efficient conservation outcomes. Considerable emphasis was made about the possible commercialization of some of the conservation efforts as a means of increasing the sustainability of species conservation efforts.

Detailed objectives for national action plans

The need for explicit objectives with clearly defined and measurable targets and actions was identified as an crucial part of any conservation strategy and action plan. Given their importance in the development of an understandable and executable plan, focus should always be given to developing such objectives (IUCN 2008). This point was stressed in the sections above.

Table 3. Summary of the review of the regional Arabian Oryx and Leopard Species Conservation plans.

Species Conservation Plan	Does it comply with IUCN guidelines & have a logical flow?	Does it address the right audience?	Do the objectives address the threats & are they realistic?	Are Actions & Targets identified?	Is it suitable in informing national APs?	Any improvements?
Regional Arabian Leopard Species Conservation Plan	Yes	Good conservation & scientific communities focus, international decision making bodies. BUT maybe not the regional audience, nor the local communities	Threats appeared relevant except lacks emphasis of social & commercial ones. Should be more interdisciplinary in nature. Need prioritise the threats. Objects are not SMART.	Needs realistic time –frames that reflect threats with immediate actions prioritized. Actions may not closely align with threats.	Good framework National responsibility not clearly articulated.	Need more frequent revision to adapt accordingly National APs need be as inclusive as possible and developed from the ground upward Need national champions, that could also be NGO run. Needs greater emphasis on transboundary conservation opportunities. Need address ethical values and possible compensation
Arabian Oryx Conservation Strategy and Action Plan	Yes	More focused on national conservation agencies, but not explicit. More science focused.	Vision clear but goals are too vague. Objectives appear too vague & are not measurable, with no timelines & difficult to monitor. Appear to be linked to threats.	Targets appear difficult to measure and thus review.	Simple outline for national APs, with limited input on structure or possible responsibilities. Only one national AP has been produced.	Need more precise framework for national APs with need for responsibilities, time lines & budget.

Figure 9 lists three examples of how some regional strategic species conservation plan objectives were reworked. It illustrated the issue of making them as SMART (specific, measurable, attainable, relevant, time bound) as possible.

Conclusions

Strategic species conservation plans, and their national action or recovery plans derivatives should play such pivotal roles in the conservation of rare and threatened species. These plans are important in consolidating the relevant biological, socioeconomic information of a species, assessing the current pressures and threats and logically presenting the hierarchy of objects from vision through objectives, targets, actions and responsibility to address the threats. However, the effectiveness of the plans are dependent upon the degree to which they are institutionalized or not and implemented on the ground.

The review of the range of regional strategic species plans revealed that there was a need for greater collaboration within national conservation authorities and between government departments with overlapping environmental portfolios to improve upon the support and delivery of these plans. In many cases consultation

A.

Objective

International Cooperation and Partnership

To secure effective cooperation and partnership among the range states, their relevant agencies and with international partners to secure the conservation of the Arabian leopard in Oman.

Target

Produce an MOU

1. Action

Establish national working group involving al stakeholders with a TOR including timeframes and responsibilities

Timeline
By September 2014

Responsibility
Conservation authority

2. Action

Get commitment from Oman to share experiences, resources and data with range states

Timeline
By April 2015

Responsibility
Interdisciplinary integrated task force

3. Action

Get commitment from Oman to enhance efforts to protect leopards in the country

Timeline
By December 2013

Responsibility
Integrated task force

B.

Objective

Community involvement

Ensure support from relevant stakeholders in protecting and conserving Arabian leopards in Oman.

Target

Local communities integrated into leopard conservation programme

Actions

1. Stakeholder analysis
2. Assess impact of leopards
3. Establish compensation mechanism
4. Develop awareness programme
5. Monitor progress

Timeline
By December 2014

Responsibility
Conservation authority

Target

An effectively running outreach programme in place and functional

Actions

1. Engage local communities
2. Capacitate staff
3. Establish protected areas forum
4. Develop local conservation management plan
5. Evaluate success

Timeline
By April 2015

Responsibility
Conservation authority, local community leadership

C.

Objective

Enhance and increase Arabian Oryx populations:

To ensure Jordan has a secure and growing population of Arabian Oryx.

Sub Objective

Secure public support for the oryx programme through active participation, awareness and conflict resolution

Target

X number of schools visited

Actions

1. Engage education authorities
2. School programme developed & introduced
3. Media campaign
4. Awareness programme at ecotourism centres
5. Monitor number school visits to reserves

Timeline
5 years (December 2018)

Responsibility
RCSN Jordan

Sub Objective

....

Target

Sub Objective

....

Figure 9. Three (A, B, C) redrafted examples of some national objectives, actions, target & responsibilities for the Arabian Oryx and Leopard species conservation plans.

was inadequate, not including local communities. This appeared to be a major design flaw within most of the plans reviewed. As with all such plans they need become an integral part of conservation authorities operations or they face the prospect of being forgotten or sidelined. The presence of national champions to drive the process is an important action and can not be underestimated in keeping these plans and species actions alive and focused. Given that many of these species range across international borders, planning and delivery must endeavour to not become too parochial, considering transboundary opportunities at all times. Giving the plans a life of their own will require them to be flexible enough to adapt to changing circumstances, as well as being innovative in meeting the new challenges. As the plans can and have in some cases become important motivations for funding, their relevance should be constantly reviewed.

Translating the regional plans into national action/recovery plans has not been consistently delivered on in the region, which questions their perceived importance. As noted this could arise from the difficultly in formulating clear and explicit objectives with listed actions, identified responsibilities and time lines. This crucial step in any strategic planning exercise remains one of the most challenging, especially in delivering on useful documents. Every effort should be done to develop national action plans.

It is recommended that the current regional species plans should be reviewed in a logical manner, and translated into national action plans where they do not exist and reviewed where they do.

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Wildlife Tracking Workshop

The information in this section was compiled from a range of sources, including White & Garrot (1990), Kenward (2001), Milspaugh and Marzluff (2001), and the notes supplied by Sean Walls (Lotek) and Yolanda van Heezik (University of Otago).

Introduction

Following on from the successful sessions on camera trapping held during the 13th Conservation Workshop in 2012, the technical theme was continued in 2013 with sessions on wildlife telemetry. The aim was, as with the camera trapping sessions, to share knowledge and to enhance technical capacity in the region. This was run over a day and half as a hands-on workshop covering the practical aspects of equipment selection, attachment, and survey design, and reviewing data analysis options. Delegates shared their own experiences applying VHF and GPS tracking technology, viewed some of the latest equipment available, and had the opportunity to use this equipment in a tracking exercise.

Outline

These proceedings are intended to be a resource for those using, or considering the use of, some form of wildlife tracking technology. They include:

- Summary history of the development of wildlife telemetry
- Review of the types of studies that are possible with tagged individuals
- An overview of analytical techniques
- The advantages and disadvantages of different equipment options
- A list of equipment suppliers, along with references and/or links to other resources, including books, papers, guidelines, reviews and manuals.

A brief history of telemetry

In 1959 the first publication appeared reporting on the use of pulsed radio signals to locate study animals on demand. This marked a critical shift on the options available to study free-ranging wildlife as up until that time animal tracking relied on sightings and sign, meaning that specific individuals could not be located as and when required. For rare or cryptic species in particular this meant that reliable information on status, distribution and population trends was hard to come by, likely biased, and in many cases virtually non-existent. By capturing a sample of the target species and attaching a simple radio transmitter that emitted a pulse of VHF radio waves that could be detected with a tuned receiver from some distance, a wildlife researcher could now at least attempt to locate study animals at any time of the day or night, to estimate their location without causing disturbance, and if necessary to attempt to make a visual confirmation that the animals was alive, healthy, with conspecifics or young, in a specific habitat, or accessing certain prey items, depending on the nature of the research. This seemed to be a panacea for wildlife research, holding out the promise of detailed, unbiased information on free-ranging animals.

But, as with any technical development, the reality was not so straightforward. As early as the 1960s there was a growing realisation that radio-tracking studies were vulnerable to a number of sources of bias, principal among these were the inability to distinguish between transmitter failure, animal mortality and tag loss, or dispersal from the study area, all meaning that crude estimate of survival rates could be underestimates. It was also understood that attaching the early, bulky radio tags to wild animals could have an impact, changing behaviours and even increasing the risk of mortality.

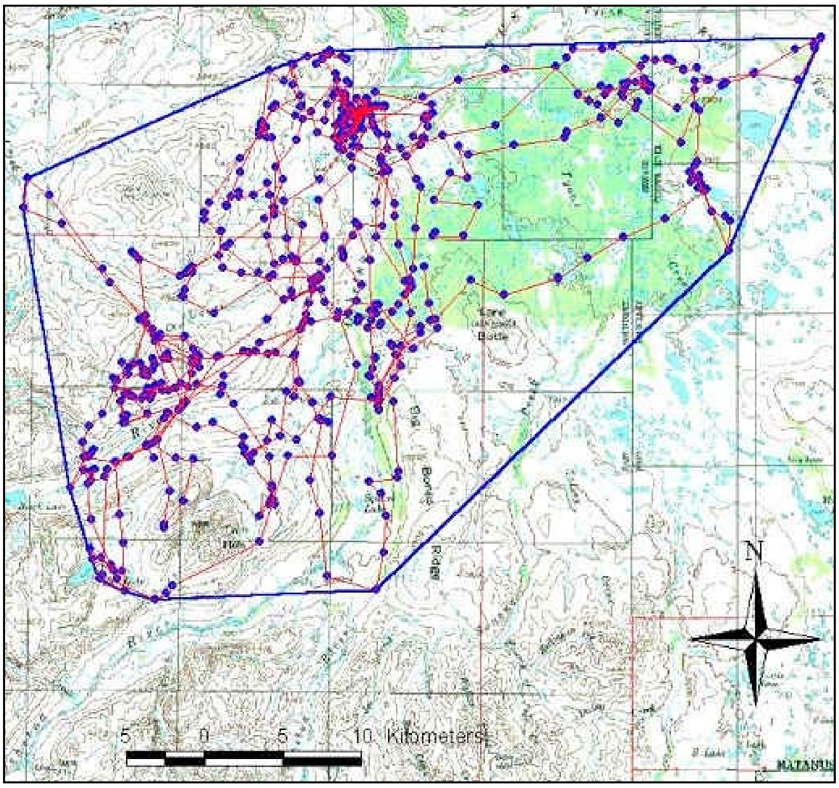


Figure 10. A 100% Minimum Convex Polygon (MCP) (example shown above) encompasses all the locations obtained over some period of time for a given individual, but due to outlying locations that extend the polygon a 100% MCP will include proportionately large areas that are never or perhaps only seldom used by the animal.

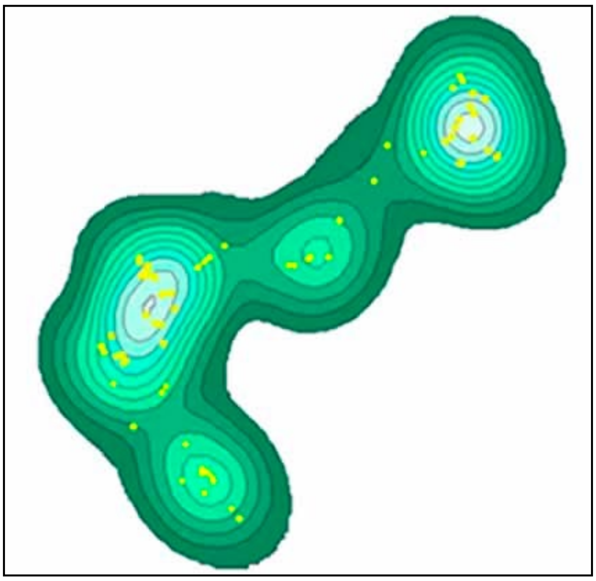
Early approaches for analysing animal movements were descriptive and crude by today's standards. A 100% minimum convex polygon (MCP) was used to depict and animal's home range – home range being itself an evolving concept (Burt 1943, but see Powell for more recent definitions).

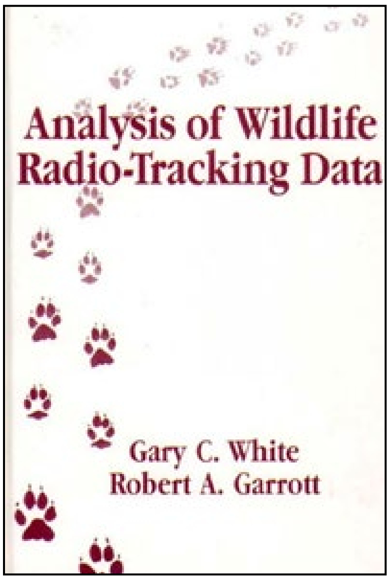
But balancing these negative aspects was improving tag reliability, focussed studies to increase the understanding of tag impacts and to improve tag design and attachment methods, and the developing sophistication of habitat selection analyses using radio-telemetry data.

By the 1980s new analytical approaches could be applied to telemetry data within a mark-recapture framework to derive robust estimates of survival rates, and software packages became available for the delineation of home ranges as a series of cores of activity. In 1986 White and Garrott published the first comprehensive book on analysing radio-tracking data.

Kernel home range analysis identifies cores of activity as areas encompassing high densities of animal locations (example below) under the assumption that these represent areas of greatest use by an animal within the wider area over which to roams.

With increasing use of wildlife radio tracking there was a greater incentive for new equipment companies and more investment into the development of specifies specific tags. By the 1990s a large range of radio tags was available, enabling low impact tagging of even small-bodied species, though unit life remained greatly restricted by the available battery power options.





Major limitations to the accuracy of conventional radio tracking remained however. To locate a tagged animal researchers had to spend time in the field searching, and once a signal had been found the location of the animal had to be determined, either through direct sighting that risked disturbing the animal changing its behaviour, or through the triangulation of signals from three or more tracking points. Thus there tended to be a bias in locating animals during daylight hours, during conditions and in areas that were safe for a researcher, and even well triangulated radio signals could have errors of several hundreds of meters. The arrival in the 1990s of satellite-based animal tracking devices that could be attached to wild animals started a major shift in the way wildlife location data could be collected. Platform Transmitter Terminals (PTTs) used the French ARGOS satellite system to calculate the approximate location of an animal anywhere on Earth, but the accuracy of locations could be poor making PTTs suitable only for very wide ranging, dispersing or migrating species. More versatile was the Global Positioning System (GPS) using the USA NAVSAT satellite constellation. Now ubiquitous in everyday life, GPS tags used in the 1990s were large, heavy devices that could be reliably carried only by large species, but which could store positional data at any time of day. This data was however, purposely degraded through Selective Availability (SA), meaning that civilian devices had errors of many meters, even after differential correction. Nevertheless, GPS wildlife tags allowed a researcher to obtain a more complete picture of where their study animal roamed, day and night, in any terrain. Early devices could store hundreds of locations, but have to be retrieved for the data to be downloaded, meaning animal capture and recapture remained a challenge for many species.

Figure 11. New Zealand teal fitted with lightweight, backpack mounted radio tag.

Figure 12. Elephant seal fitted with a Platform Transmitter Terminal (PTT) device using the ARGOS satellite system

The removal of Selective Availability by the US military meant that by the 2000s extremely accurate GPS-based animal locations could be gathered. Both VHF radio tags and GPS devices became smaller and lighter, hugely expanding the range of species that could be tracked, while improvements in battery technology, the development of more efficient power management, and the commercial production of reliable solar-powered telemetry devices enabled longer deployments of tracking devices.

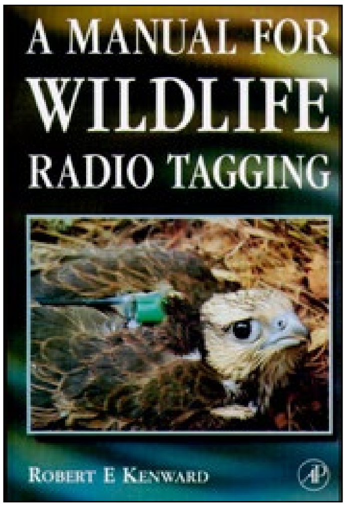
Figure 13. Examples lightweight tag deployments on invertebrates, and solar-powered unit configuration for raptors.

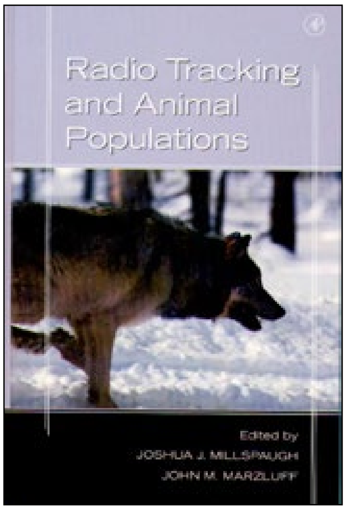
Further enhancements started to use cell phone (GSM) networks to remotely download GPS data, or combined satellite systems allowing the collation of accurate GPS-based locations and the remote satellite based download to the computer of a researcher comfortably waiting in their office. Only unit price remained a major obstacle to greater use of GPS devices, in part because although the use of GPS in tracking wildlife had expanded greatly, it was still a minuscule part of the global use of GPS so that relatively few companies were producing GPS wildlife tags and Research and Development costs remained high. Even today GPS tags costs thousands of dollars each and only well-funded projects can afford to tag more than a few animals.

Cheaper types of tags started to enter the market, trading off location accuracy against unit cost. Geolocators use the timing of changes in ambient daylight intensity to estimate global locations to within 10s or even 100s of km. Not good for detailed analyses of shorter range movements, but with a units costs equivalent to that of a simple VHF radio tags it became possible to tag and track 100s of animals for the price of only a few GPS tags, plus geolocator tags are small, light, and can be deployed for periods in excess of a year. Geolocators do have to be retrieved to obtain any data, but with lower per unit costs the loss of a proportion of tags became more acceptable.

In 2001 two influential books appeared on the market: Robert Kenward's A Manual for Wildlife Radio Tagging, and Joshua Millspaugh and John Marzluff's Radio Tracking and Animal Populations. Between them they charted the development of animal telemetry equipment, field methods for device attachment, sampling and retrieval, and the analysis of tracking data to obtain key information on animal movements, habitat use, and population vital rates.

Figure 14. Sabine gull with geolocator attached to a leg ring.





The last 10 years has seen the development of even lighter types of all types, the greater use of the information that can be contained in a radio signal, and the inclusion of a wide range of sensors that can be combined and deployed with location devices simultaneously to monitor environmental conditions (e.g. temperature, depth), or animal behaviour (activity) or physiology (body temperature, heart rate). Analytical tools for the calculation of utilisation distributions, and survival rates improved too, and the commercial availability of improved satellite imagery, such as IKONOS and QuickBird, allowed the production of detailed habitat maps to support resource selection analyses.

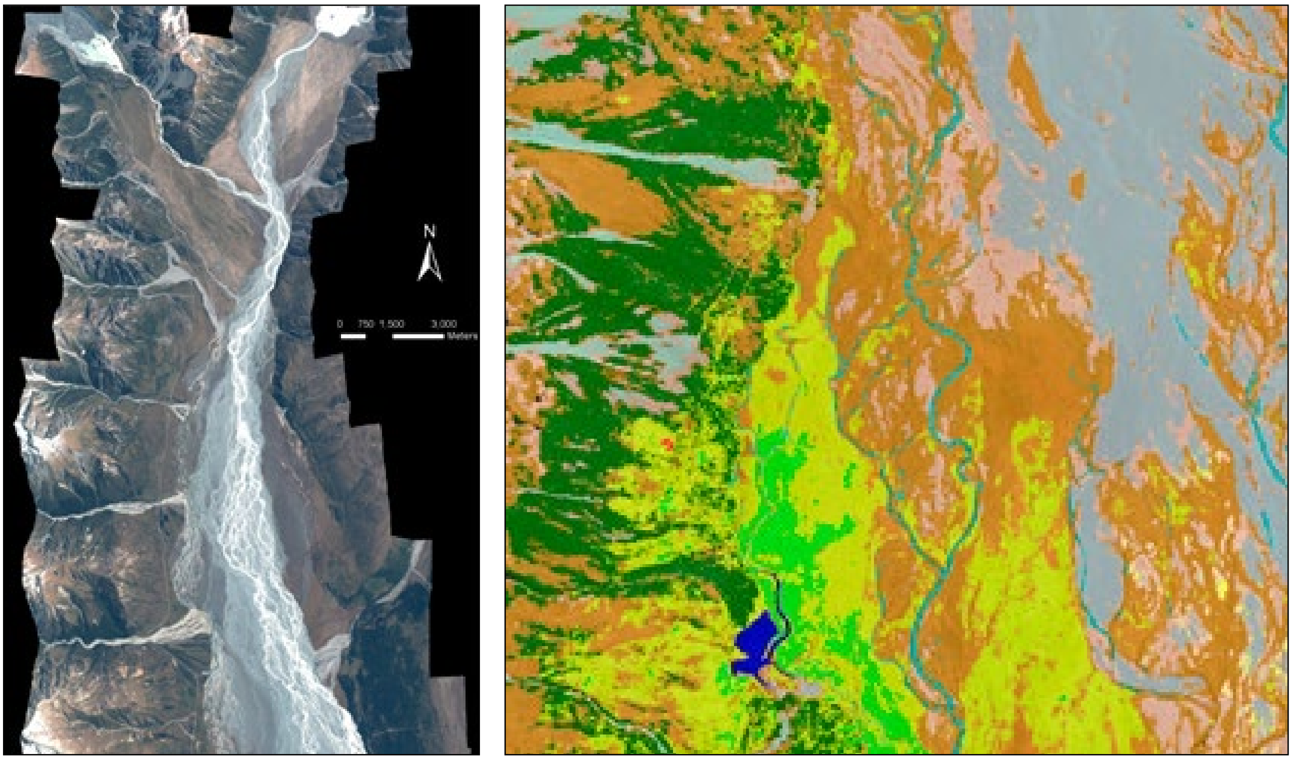


Figure 15. IKONOS satellite image of the Tasman Valley in Central South Island New Zealand showing near aerial photo precision (left) and processed false colour habitat map detail (right).

Why use electronic tracking?

Electronic tracking of free-ranging animals can provide data on vital rates (survival, dispersal, reproduction), on other behaviours such as predation or conspecific interactions, and on resource use. It is important to be clear of your study objectives before starting to select the right equipment or to plan your fieldwork and sampling protocols. Tracking individuals to derive estimates of survival rates avoids the bias arising from reliance on finding or confirming deaths and allows for estimates that are age, habitat, density and cohort specific. Rapid location of recently dead animals can allow cause of death to be determined to distinguish between risks arising due to, e.g. disease, predation, or accident in formal survival analyses. Similarly age-, habitat, density and cohort-specific breeding success can be assessed, along with estimates of the proportion of a population that does not breed. Robust estimates of survival rates and fecundity form the basis for assessment of population status and trends, enabling modelling of the probability of population persistence under changing management (e.g., harvest or pest management) or environmental conditions (e.g., climate change).

By tracking individual animals it is possible to document patterns of activity, dispersal or exploratory movements, interactions with conspecifics, predation events, and detailed use of homes range areas and other resources is possible (see also Analyses overview below).

Overview of tracking equipment options

Equipment options for tracking wildlife come down to four possibilities: VHF radio tracking, Platform Transmitting Terminals (PTTs), Global Positioning Systems (GPS), or geolocators.

Radio-tracking equipment comprises a VHF radio tag that emits a radio signal pulse at some predetermined interval on a predetermined radio frequency; a receiver tuned to receive the appropriate signal frequency, an antenna attached to the receiver to enhance signal reception, and of course someone to capture the study animal, attach the radio tag, then carry the receiving equipment into the field to locate signals from the tagged animal.

Considerations for tags include the size and weight relative to the study animal (see also Transmitter effects of animals), the method of attachment, the expected life and range of the tag. Heavier units will generally have longer life and greater range, but may be too heavy for an animal to carry without some impact. Receivers must be portable, robust and rainproof to survive field conditions. They must have easy frequency control and a signal strength meter, have long internal power supplies and possibly an external power supply option. Some receivers can rapidly scan through large numbers of pre-programmed frequencies to enable efficient searching for large numbers of tagged animals. Automated receiving systems are possible for animals with restricted and relatively small ranges.

Antennae range from a simple dipole, to loops, H-shapes, Yagi, or null-peak arrays, representing increasing receptive range.

Radio tag receptive range will be determined by unit antenna length, the longer the better, and current and pulse range. Short pulses will help conserve tag life by using less power, but will also reduce reception range. Longer, more powerful pulses are easiest to track but drain power faster and thus have shorter life than units using short pulses. Similarly, a fast pulse rate is easier to track but has shorter life than a slow pulse rate. Short pulses and long pulse intervals are harder to track. Use of a micro controller can enable units to be switched off at set times, or to vary the pulse interval to allow an individual signature code for many units using the same frequency.

PTTs and GPS units, and geolocators do not have the same issues as VHF radio tags around signal pulses and reception, and can store locations on board the unit for direct or remote download. But units vary in the

Figure 16. Antennae images (from top left): loop, H-Adcock, null-peak array, and 3-element Yagi.

accuracy of their locations, their minimum size and weight, and their unit cost. In the end the best type of unit will depend on your target animal, your study objectives and your project budget (Table 4).

Table 4. Pros and cons of four animal tracking systems

Feature	VHF	PTT	Geolocator	GPS
Tag weight	down to 0.2g	>5g	>0.4g	>20g
Accuracy	1m – 1km	300m+	100km+	10-30m
Locations possible	Tag life dependent	Satellite passes	1/day	Frequent
Fieldwork	Attach + Track	Attach only	Attach + retrieve	Attach + poss. retrieve
Tag cost	>US$200	>US$1500	US$200	>US$1500
Data cost	US$700-2000	US$20/month + $10/ tag/day	None	Retrieval or ARGOS/ GSM
Best suits	Short & medium movements	Migration patterns	Long-distance migrations	All types of movements

Study design considerations

Every researcher should start planning for any study by considering the five steps of the basic scientific method:

1. Define the scope of the problem
2. Study the information that exists about the problem
3. Formulate specific hypotheses
4. Collect the data
5. Analyse the data

By defining the scope of the problem it is possible to frame explicit objectives for the study. On the basis of this objective a researcher considering a wildlife-tracking study is then able to ask and answer five key questions:

1. Is electronic tracking the best approach to reach my objectives?
2. Can I catch, and if necessary re-catch, enough animals?
3. Can they be tagged with the chosen device?
4. Can I collect the appropriate data using the chosen device?
5. Can I afford it?

A “no” to any of these questions should signal the end of consideration of applying electronic tracking.

Tracking studies follow one of three basic conceptual designs: descriptive, correlational, or manipulative. Descriptive studies observe natural processes and often lack any attempt at formal hypothesis formulation or testing before the data are collected, hence they are limited to learning what an animals does but not why it is doing it. Correlational studies are guided by a hypothesis and seek to determine whether the association between the observed behaviours and other factors support the hypothesis; the limitation is that a relationship between two variables does not imply cause and effect. In manipulative studies the system is somehow perturbed, requiring an experimental approach with consideration of treatments, controls and replicates; the reliability of inference is the strongest from manipulative studies.

Estimating animal locations

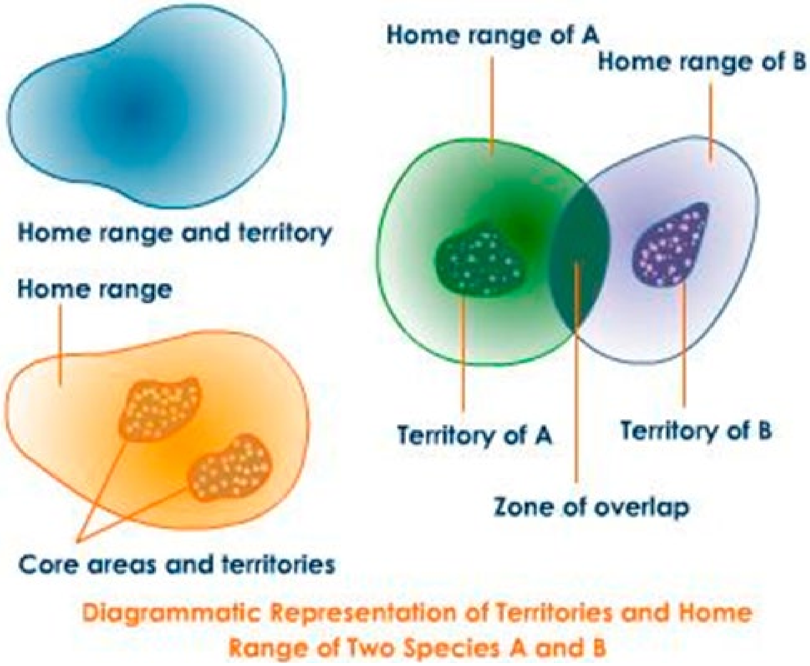
The location of an animal can be determined using either triangulation of radio signals, or a range of non-triangulation methods. Non-triangulation techniques include the use of GPS or PTT tags, or homing in on the signals from a radio-tagged animal either by air (Seddon and Maloney 2004) or on the ground. Aerial radio tracking can be an efficient way to locate many tagged animals over large areas and/or rugged terrain, and can enable to collection of accurate animal locations with only minimal disturbance. Homing in on the ground can be time-consuming, could change the behaviour or location of the target animal, but may be essential if the status of the animal or its tag must be determined. Visual confirmation of a tagged animal will yield precise locations.

Triangulation of a radio signal can be done with two or more bearings from known points. The more bearings that can be taken and the greater the angle between bearings, the greater the confidence in the estimated location. Even using a null-peak antenna array each bearing will be an estimate with some associated error. The intersection of each bearing will therefore form an error polygon within which the target animal is presumed to be located. The area of the error polygon is a measure of the precision of the point estimate derived form the intersection of two bearings. The precision of the estimate is a function of the distance from the receiver to the tag, the precision of bearings, and the angle of intersection of two bearings. A number of factors will influence the accuracy of estimated locations, including radio signal bounce off trees, hills and buildings, electromagnetic interference, mapping errors, equipment faults, and animal movements. This last can be a major problem if only one person is taking sequential bearings. The amount of acceptable error depends on the study. It is important to test the accuracy and precision of the system to determine: the error associated with directional bearings; whether a system is capable of producing estimates of sufficient accuracy to answer a biological question; a suitable field protocol to be used in data collection. Prior to any study a researcher should conduct a beacon test by placing tags at known locations in the study habitat and estimating their locations. This can be used to relate linear error to a number of variables, e.g., distance to tx, temperature, geometry of bearing intersections, and to produce a spatially explicit map of tracking accuracy for the study area and can quantify the accuracy and precision of the tracking system.

Overview of analysis techniques

Home range

The original concept of an animal's home range was defined by Burt (1943) as: " the area traversed by an animal in its normal activities of food gathering, mating and caring for young". This very general definition requires that a researcher defines the time frame of interest and determines what is "normal", and more recent conceptions of the range of an animal do not require that all activities are captured, and that the range may vary over time. It is understood that different parts of the wider home range may be used with different intensity and that one or more core areas (territories) may be maintained.



Home range estimators fall into three basic groups: polygon methods; probabilistic methods, and grid cell methods. The oldest and most common polygon method connects the outermost locations to form a minimum convex polygon (MCP). A 100% MCP uses all available points, including extreme outliers, and hence will encompass large areas seldom used by the animal.

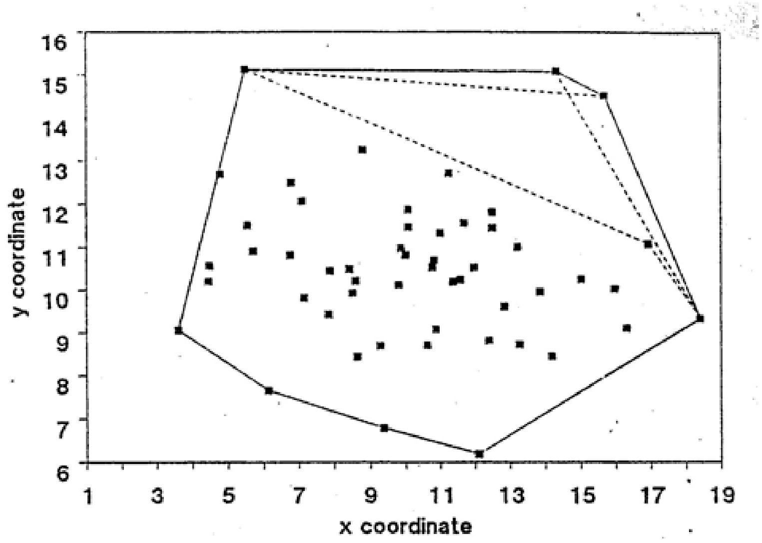


Figure 17. The influence of outliers on the size of the polygon; here both extreme outliers are deleted (from White & Garrott 1990)

While the use of MCPs is simple and easy to calculate, they do have a number of disadvantages, including that the size of the home range estimate increases indefinitely as the number of locations increase because it calculates total area used, not the area used in normal movements. Therefore the estimate is not comparable if one is based on 100 data points and another on 500. One approach is to use a 95% MCP to eliminate outliers, but this doesn't work if the outliers are close together. Removing outliers to create smaller, e.g., 95% MCPs may better reflect actual space use, but may still include areas never accessed by the animal, such as lakes, or areas outside fenced reserves.

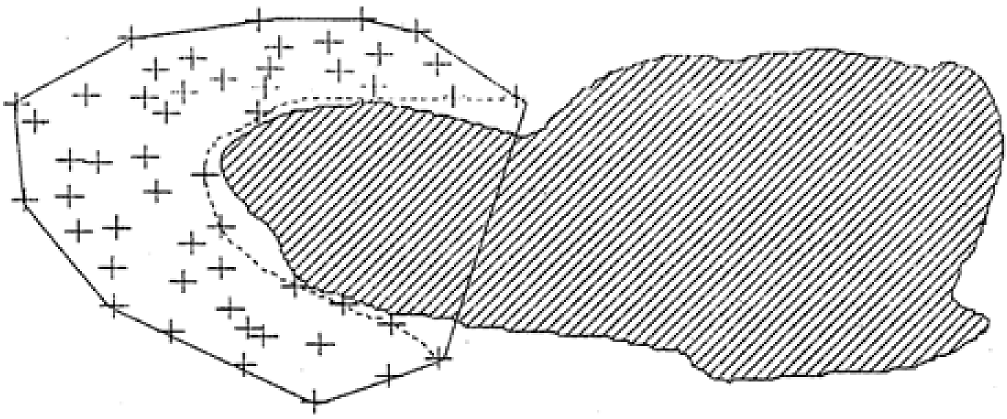


Figure 18. The minimum convex polygon includes party of a lake not accessed by the terrestrial target animal (from White & Garrott 1990)

An approach to correcting defects of convex polygons is the construction of a minimum concave polygon, but this requires some objective rule to be made regarding which of the points are on the boundary.

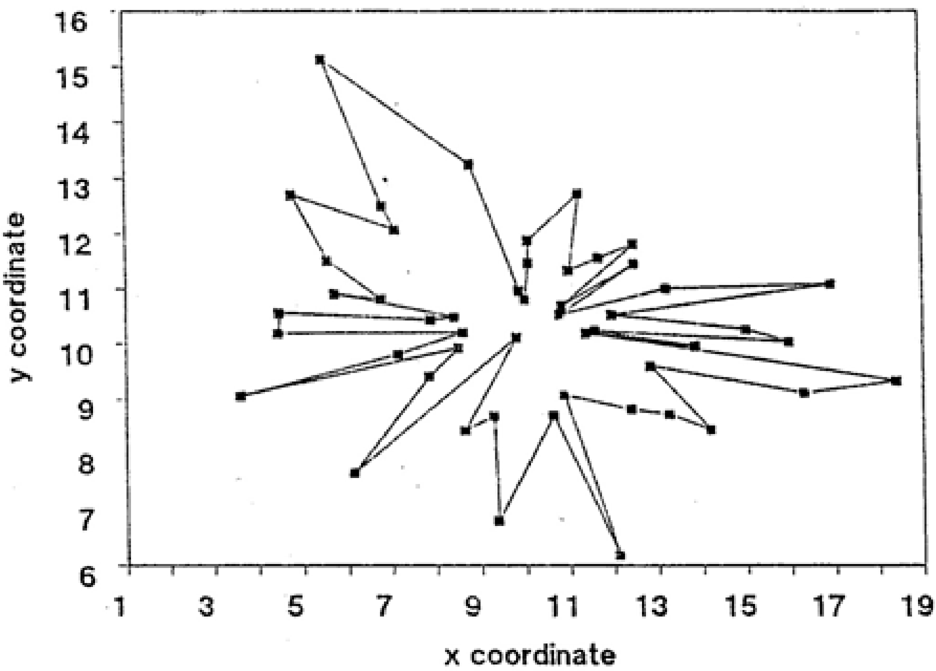


Figure 19. A concave polygon that connects all of the locations obtained for an animal (from White & Garrott 1990)

Probabilistic methods of calculating animal home range consider the density and distribution of location points. A number of different analytical approaches have been developed, including bivariate normal ellipse, kernels, grid cell counts, harmonic means, and Local Convex Hulls (LoCoH).

Bivariate normal ellipse assumes that an animal's use of space is normally distributed around a single centre of activity. It is a parametric method that requires large sample sizes and is sensitive to outliers.

Kernels are contour analyses, which estimate density indices for locations at intersections of a matrix set across an animal's range, and then interpolate contours between the values of the matrix. The contours estimate the probability of including a particular proportion of locations i.e., the outermost contour is estimated to include 99% of the location distribution. They can be used to calculate multiple cores of activity, yield a utilization distribution and are not sensitive to outliers, but minor changes to the smoothing parameter have a large effect on the home range size.

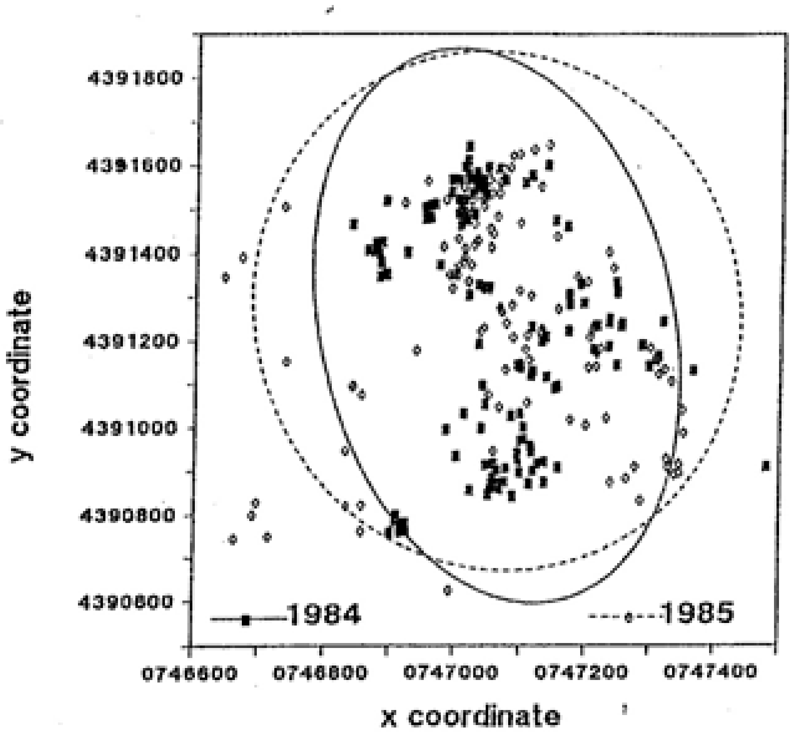


Figure 20. Bivariuate normal ellipse for the summer home range of a female mule deer In western Colorado that was radio-tracked for two consecutive summers (from White & Garrott 1990).

The smoothing parameter or bandwidth is the critical component in kernel density estimation and determines the amount of smoothing applied to the data. With small bandwidths the estimated kernel density function partially breaks into its constituent kernels. With large band widths the local peaks and valleys are smoothed over into a single surface. In the fixed kernel method the same band width is used over the entire evaluation area. Bandwidth may be chosen by LSCV (least squares cross validation) or other methods to minimize the error between the estimated and the true density. An adaptive kernel uses a local bandwidth selected for each observation and is larger in areas with fewer observations. Therefore the tails of the distribution are smoothed more than the peaks. This may be appropriate where estimation errors of the locations are greater at the edge of the home range.

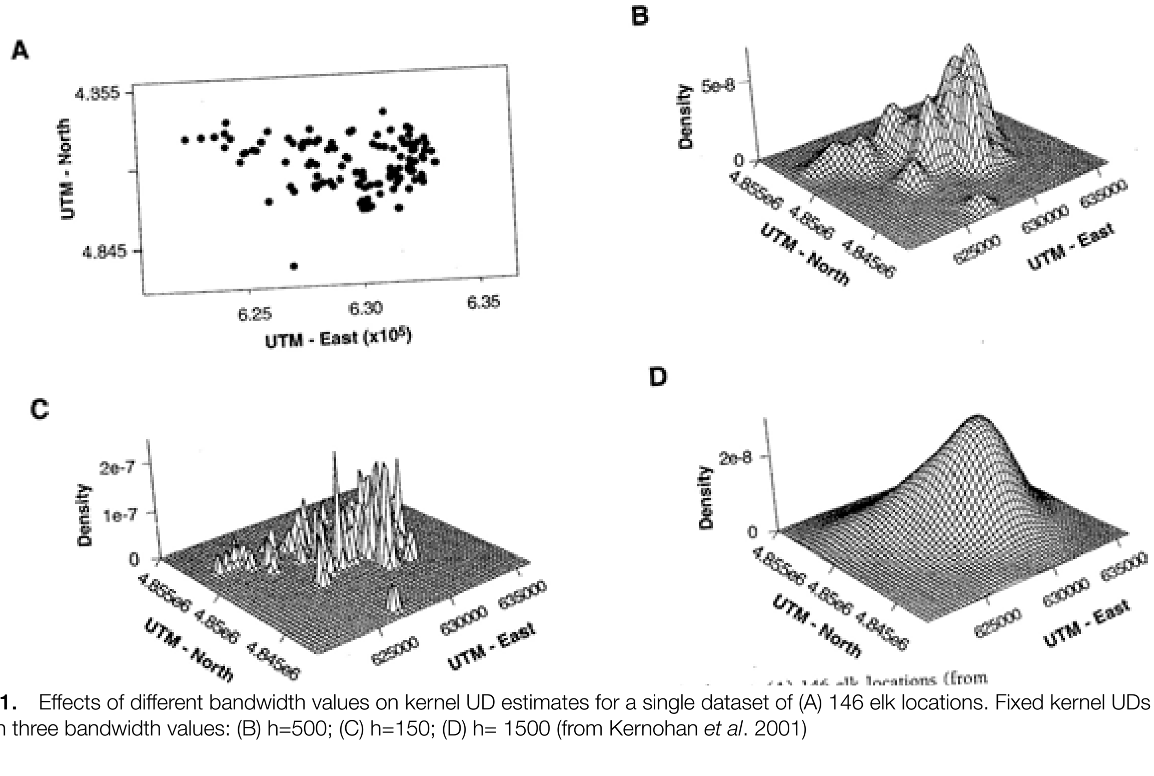


Figure 21. Effects of different bandwidth values on kernel UD estimates for a single dataset of (A) 146 elk locations. Fixed kernel UDs are based on three bandwidth values: (B) h=500; (C) h=150; (D) h= 1500 (from Kernohan *et al*. 2001)

Grid cell counts are a non-parametric method in which an animal's locations are tabulated for each grid cell and the sum of the areas of the cells is taken as the estimate of the home range size. There is a need to sample very intensively and the choice of grid cell size is an arbitrary decision

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
15				1												
14																
13				1				1								
12					1	2			1		2					
11			1		1	1			3	3	2	1				1
10			1			1	2	2	1	1	1	1	1	1	1	
9			1				1	1		2	1	1			1	
8					1			1					1			
7								1								
6											1					
5																

Figure 22. Grid cell counts make no assumptions about the shape of the area used, and it is possible to detect centres of activity. However the selection of a coarse grid will over estimate home range size, and vice versa.

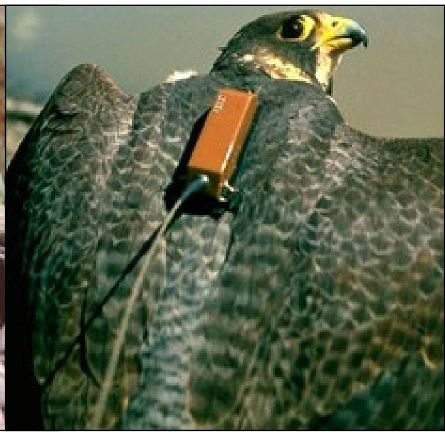
Selection of the appropriate home range estimator will consider the required sample sizes, the ability to calculate multiple cores of activity, the sensitivity to outliers, and the robustness with respect to autocorrelated data. Autocorrelation is the dependence of successive locations, thus there is a need to determine a time interval between successive locations that is large enough to be confident of independence. If data are autocorrelated then home range models will tend to underestimate the true home range size. Autocorrelation effects will be greatest with discontinuous radio-tracking, however, with the continuous data that can be obtained using GPS tracking, the autocorrelation of locations can contain information about animal movement pathways.

Whatever the home range estimator used it is important to report what was done, including details of the method used, the type of software used and the version, the number of animals tracked, the number of locations obtained per animal, whether the area reached an asymptote.

Transmitter effects on animals

In any wildlife tracking study it is assumed that the animal tagged are a representative sample of the entire population of interest, and that the transmitters attached do not make their responses different from that of untagged animals. However, there is most likely to be some impact as a result of the capture, handling and tagging, and these impacts may range from subtle temporary changes in behaviours, through to long-term changes that affect reproduction and survival. Researchers ideally need to design experiments to detect effects of tags on animals, but it can be difficult to compare uninstrumented animals with a control group, when radio-tracking is being used to collect data that can't be collected in other ways. Other ways to assess tag impacts include: monitoring body mass changes with different weight of tag; quantifying changes in behaviour such as disruption of incubation or feeding, and signs of skin/feather wear or entanglement. There are no single guidelines for maximum tag weight as a proportion of body mass, though figures of 5% and 3% are used as a rule of thumb, but have no basis in empirical evidence.

Different taxa will be more or less tolerant of tags depending on the attachment method (see below) and the habitat in which they live. For example ducks and geese are very sensitive to external transmitters, especially for diving sucks with backpack harnesses. Backpacks, ponchos and breast harnesses are used extensively on upland game birds and long-term effects on reproduction and survival have been noted.



Raptors tend to be quite tolerant of backpack-mounted devices, depending on resource availability, and for shorebirds and seabirds adhesives, tail mounts and suture methods are preferred.

There have been few studies of impact of tagging of small mammals, but neck collars are known to reduce activity, whereas for medium to large terrestrial mammals neck collars rarely affect survivorship, reproduction or behaviour. For aquatic seabirds such as penguins, and marine mammals, the shape and placement of the device may be more important than the weight. For bats adhesive methods seem suitable.

In general it is sensible to use small inconspicuous devices, to test attachment first in captivity if possible, to anticipate growth and seasonal changes in mass, to anticipate how and when a tag may be shed, to allow a period of acclimation, to not assume there will be no effects, and to fully report both positive and negative results.

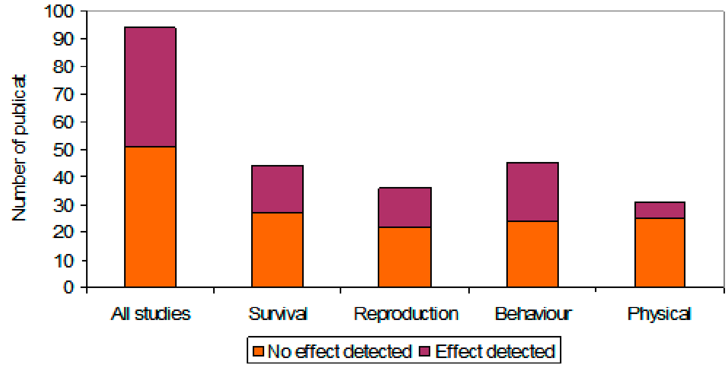


Figure 23. Withey et al. (2001) reviewed 96 articles from J. Wildlife Management, Wildlife Society Bulletin, J. Field Ornithology and J. Mammalogy

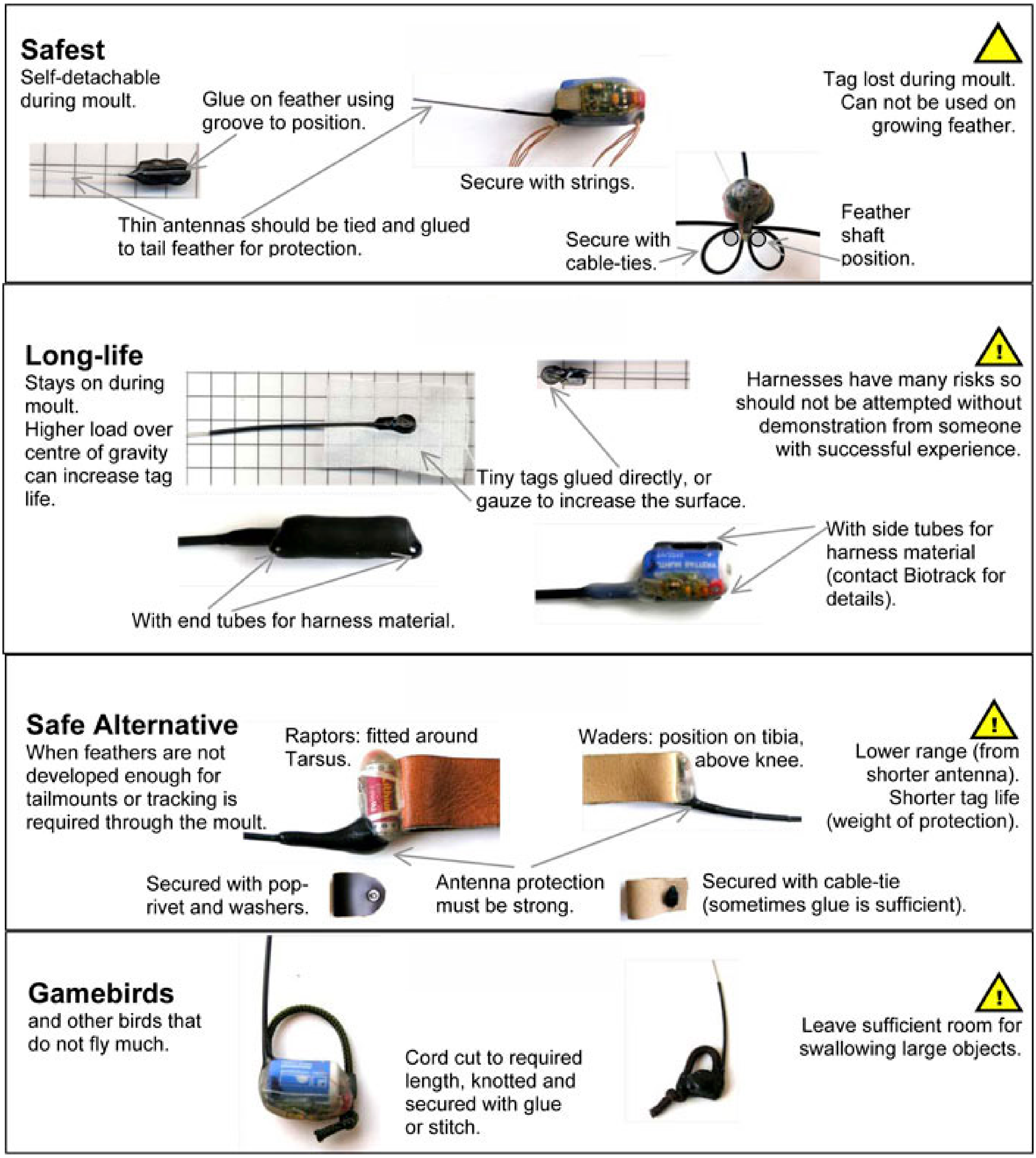


Figure 24. Attachment methods. Top: tail mounts; upper middle: backpacks and glue mounts; lower middle: leg mounts; bottom: necklaces (from the Lotek web site http://www.lotek.com/bird-bat-beeper-transmitters.htm)

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Telemetry Equipment Suppliers

Biotrack (UK)
http://www.biotrack.co.uk/

Lotek (Canada)
http://www.lotek.com/

Sirtrack (New Zealand)
http://www.sirtrack.com/

Televeit (Sweden)

Holohil (Canada)
http://www.holohil.com/

Africa Wildlife Tracking (South Africa)
http://www.awt.co.za/

Telonics (USA)
http://www.telonics.com/

Advanced Telemetry Systems (USA)
http://www.atstrack.com/

Wildlife Materials (USA)
http://wildlifematerials.com/

Other resources

A Critique of Wildlife Radio tracking and its Use in National Parks, United States Geological Survey
www.npwrc.usgs.gov/resource/wildlife/radiotrk/radiotrk.pdf

Ground-based radio tracking. SOP No. 13.4, Department of Environment and Conservation, Western Australia
www.dec.wa.gov.au/.../4017-sop-13-4-ground-based-radio-tracking.htm

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