13th Conservation Workshop for the Biodiversity of Arabia

ورشة الحفاظ على التنوع الحيوي في شبه الجزيرة العربية

Engaging Local Communities and Protected Area Zonation

6-9 February 2012

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1. Introduction

The Thirteenth Annual Conservation Workshop for the Biodiversity of Arabia was held at the Breeding Centre for Endangered Arabian Wildlife (BCEAW) in Sharjah, UAE, from the 7th to the 9th of February 2012. The Protected Areas component of this workshop continued the theme of protected area management, first introduced in 2007, by considering two aspects raised during management effectiveness evaluations in previous years: engagement of local communities, and the related issue of protected area zonation. Delegates were invited to share their own regionally relevant experience and approaches, and working groups explored guidelines for co-management, and zonation Plans for protected areas in the region. Key topics included:

- Legal status and relevant national legislation
- Current land use in the area (tourism, harvest) and the surrounding area
- Historical, biological, cultural and physical information (key features, importance, basis for protection, but also changes, threats, and built structures such as roads and buildings)
- Details of engagement and/or conflict with local stakeholders
- Rationale and methodology for PA zoning and effectiveness of its implementation

The inclusion in 2012 of a camera-trapping workshop marked the start of a complementary technical theme. This followed on naturally from recommendations of earlier species-focussed workshop components that called for regional standardisation of data collection methods. Camera trapping is a widely applied method to passively collect data on cryptic and shy animal species. Commonly, camera trapping is used to confirm the presence of a species, to document animal diversity at focal sites, or as an index of relative abundance. However, camera trapping can derive data suitable for quantifying occupancy or deriving estimates of abundance. The two-day hands-on workshop covered the practical aspects of equipment selection, preparation, placement, and survey design, and reviewed data analysis options, including mark-recapture population-size estimation, and newer approaches used to derive estimates of animal density using camera trapping grid arrays.

2. Engaging Local Communities in Protected Areas Management

2.1. Introduction

Past Sharjah Workshops have considered a number of aspects of protected area (PA) management, including: assessing management effectiveness; production of management plans and work programmes; protected area tourism, and Transboundary Conservation Areas (EPAA 2009). One aspect that has arisen a number of times has been the issue of engaging stakeholders in PA management. During the 9th Conservation Workshop for the Fauna of Arabia a review of PA management effectiveness found a significant lack of meaningful participation by local communities in protected area decision that affect them (d in the graph below) (EPAA 2008). In the 10th Conservation Workshop 72% of protected areas surveyed in the region were considered to lack adequate social research and monitoring (Seddon *et al*. 2009).

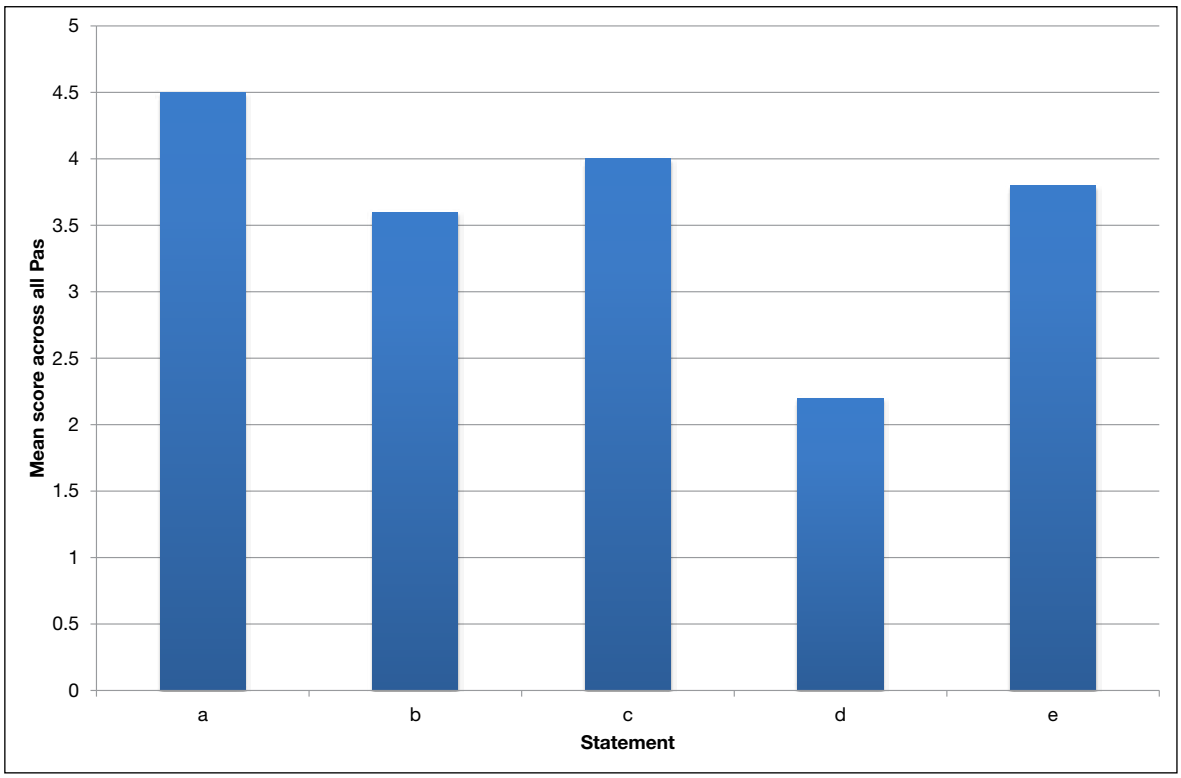

Figure 1. Summary of protected area management processes in the Arabian Peninsula: mean scores across all protected areas reviewed. Higher mean scores indicate more positive performance. The five categories relate to: (a) clear internal organization; (b) transparent decision making; (c) effective collaboration; (d) meaningful participation by local communities; (e) effective communication (Seddon *et al*. 2009).

Engaging local communities is one of the most challenging aspects of protected area management, but one that is increasingly recognised as critically important to the development and sustainability of protected areas. The need for stakeholder engagement is not very new, but nevertheless progress has been slow throughout the world. There are no simple prescriptions or solutions, what works in one region may not be applicable in another. It is important to understand the regionally specific obstacles to local community engagement in the management of areas close to them, and from this to identify regionally relevant approaches to achieve equitable participation.

2.2. Aims

The aim of this component of the 13th Conservation Workshop was to evaluate how well protected areas in the Arabian Peninsula are engaging with local communities

Through sharing of experiences of what works and what does not work in the region it was hoped to identify challenges and fruitful approaches for ensuring equitable participation by this key stakeholder group.

2.3. Outline and Process

The workshop session began with a review of the history of Protected Area management and an outline of the "new paradigm". The range of possible levels of participation in protected area management were set out in a Spectrum of Participation that allowed participants to position their own organisation.

The different types of protected area governance structures were summarised, placed in a classification system, and then applied to protected areas in the Arabian Peninsula

As always, these workshops succeed through the engagement of participants and their willingness to share both the good and the bad experiences. For this reason a key element of the workshop was the presentation of international and regional case studies, addressing the questions of: what is being tried, what works, and what doesn't work in engaging local stakeholder for protected areas in the region? From the case studies, working groups considered: (How) does your region/PA/ organisation engage local stakeholders in PA management? Workshop participants then sought to identify the fruitful approaches for engaging communities in PA management in the region.

2.4. A History of PA Management

There have been three broad stages of protected area management change.

These do not necessarily represent discrete phases, i.e. one didn't completely replace the other, but rather are indicative of more general trends. The three stages are: Local management of resources; "Fortress conservation" - the Yellowstone model; "The New Paradigm".

Local management of resources may be considered the default mode for the most of human history, whereby local communities have traditionally been stewards of the natural resources in their area and have developed traditional ecological knowledge (TEK) for the management of their own resources over many generations. The primary motivation was survival, but not to the exclusion of cultural, religious, aesthetic and even commercial values for natural resources. It would be a mistake however, to consider this history to be some lost utopia of perfect harmony of humans and nature as there are many documented instances where the outcomes have been less than ideal, e.g. Rapa Nui Easter Island (Diamond 2005). Nevertheless, a sense of stewardship and ownership, and a mutual dependence on resources, reinforced an understanding that humans are part of, not apart from, nature.

"Fortress conservation", also referred to as the Yellowstone model because the early management of Yellowstone National Park in the United States typified an approach to protected management that was top-down, authoritarian and exclusive. The US Congress created Yellowstone in 1872 as a: "*pleasuring ground for the benefit and enjoyment of the people*". The land had no mineral resources and was not suitable for grazing, and the Union Pacific Railroad owned adjoining land and supported development of the region as a tourism attraction. However, the area was heavily used by First Nations tribes, including Nez Perce, Crow, Blackfeet, but native peoples were excluded from the Park on grounds that Indian hunting methods were:"*wasteful and barbaric*", and that Indian

land management involving burning was:"*the single greatest threat to forests in the American West*". Indian migration patterns that saw seasonal use of important natural resources in the area were disregarded as: "*random wanderings*". The Yellowstone example established National Parks as wilderness preserves in which human occupation and resource use would be prohibited, and became the dominant approach to protected area management over the next 150 years.

In the increasingly industrialised and urbanised society, people and nature became considered to be separate, and human concerns seen as incompatible with conservation. Hence there was an attempt to exclude people and prohibit use of natural resources in protected areas, with the greatest prestige being accorded to strict and wilderness areas.

The New Protected Area Paradigm proceeded from three lines of thinking:

- Protected Areas are not isolated from the surrounding landscape and are just one component of conservation;
- Ecological management depends on biological history, and human disturbance such as grazing and fire can be part of conservation
- There is a need to work with, not against, local communities, NGOs and the private sector, with biodiversity conservation inseparable from its sustainable use.

The overarching philosophy is that **conservation should do no harm to human societies**.

The UN Conference on Environment & Development (Rio Summit) formalised the link between conservation and development, stating that:
"*International and national conservation should seek to harmonise with social needs and development agendas*".

The protected area definition by the Convention on Biological Diversity refers to a:
"*Geographically defined area, which is designated or regulated and managed to achieve specific conservation objectives*".

The IUCN marries the two by defining a protected area as an:
"*Area of land and or sea dedicated to the protection and maintenance of biological diversity, and of natural <u>and associated cultural resources</u>, and managed through legal or other effective means*" (emphasis added).

In summary, the old thinking meant that protected areas were established as separate units and managed as "islands" to protect existing assets, not for restoration. Almost exclusively protected areas were set up and run only for conservation and managed by scientists and natural resource experts to control the activities of local people, without their involvement. Virtually all protected areas were run by central government, paid for by central government, and managed to benefit primarily tourists. National Parks were viewed as national assets with priority over local considerations.

Under the new thinking protected areas are now planned as part of systems and managed as elements of networks. They continue to be about protection, but also restoration and rehabilitation, and have scientific, ecosystem services, and cultural objectives. They are frequently managed by multi-skilled (including social skills) individuals, and established and run with (or even by) local people sensitive to the needs of local communities, with the participation of many partners. Funding may come from many sources, not just central government. Their management aims to provide benefits to local communities, and thus they can be viewed both as national asset and community heritage.

Equity

The approach to protected area management under the New Paradigm is guided by the principle of Equity, i.e. the state, quality, or ideal of being just, impartial, and fair. There are three dimensions to this (Fig. 2):

- Just and impartial participation
- Good Governance
- Justice and fairness in outcomes

In the context of local community engagement in protected area management we can define '"local community" as any human group sharing a territory and involved in different but related aspects of livelihoods.

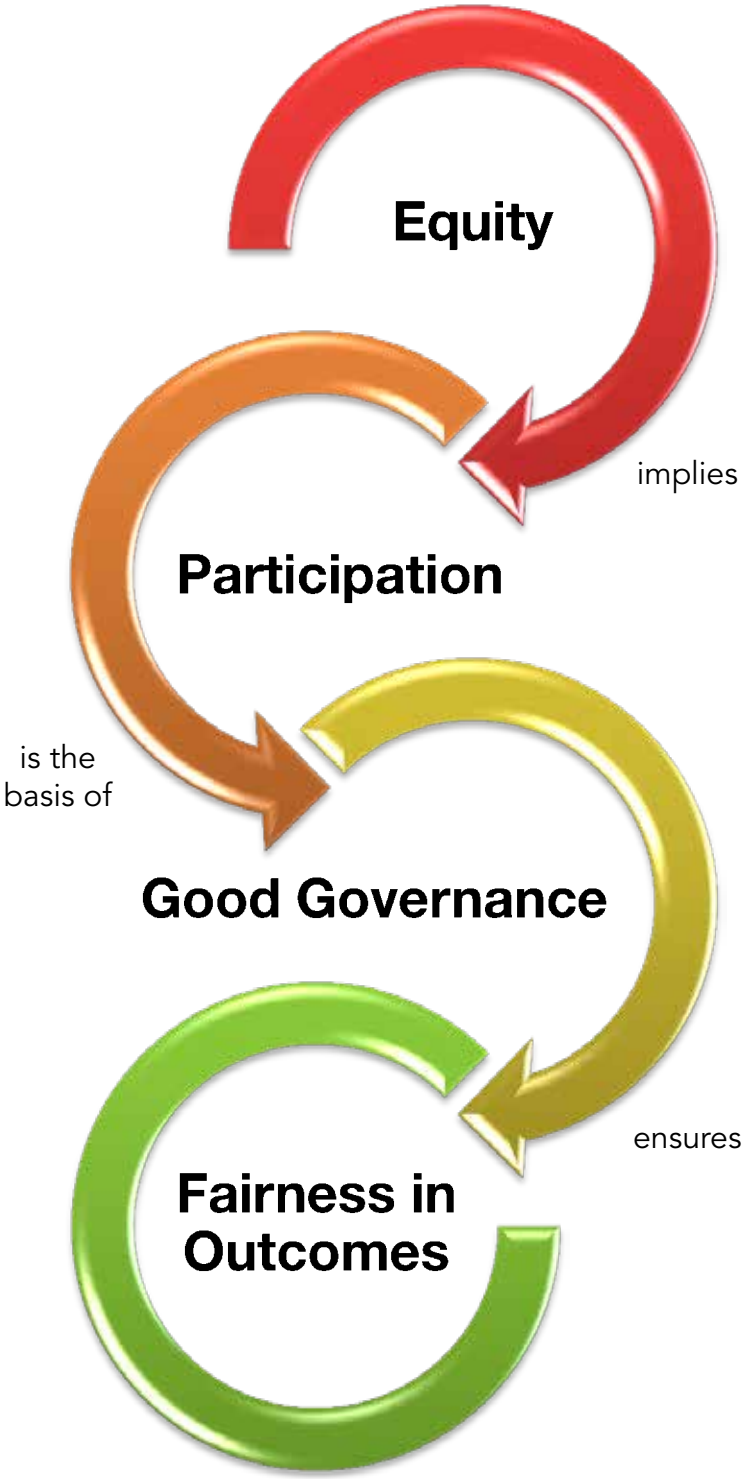

Figure 2. A roadmap to Fairness in Outcomes, whereby Equity requires Participation, which in turn is the basis of Good Governance.

Participation

Participation is the process in which individuals or groups work together with a common purpose to actively pursue a common goal. Arnstein (1969) expressed this as a participation ladder to illustrate the different degrees of participation with regard to any form of management (Figure 3), describing this typology as: "The bottom rungs of the ladder are (1) Manipulation and (2) Therapy. These two rungs describe levels of "non-participation" that have been contrived by some to substitute for genuine participation. Their real objective is not to enable people to participate in planning, but to enable powerholders to "educate" or "cure" the participants.

Rungs 3 and 4 progress to levels of "tokenism" that allow the have-nots to hear and to have a voice: (3) Informing and (4) Consultation. When they are proffered by powerholders as the total extent of participation, citizens may indeed hear and be heard, but under these conditions they lack the power to insure that their views will be heeded by the powerful. When participation is restricted to these levels, there is no assurance of changing the status quo.

Rung (5) Placation is a higher level tokenism because the ground rules allow have-nots to advise, but retain for the powerholders the continued right to decide.

Further up the ladder are levels of citizen power with increasing degrees of decision-making clout. Citizens can enter into a (6) Partnership that enables them to negotiate and engage in trade-offs with traditional power holders. At the topmost rungs, (7) Delegated Power and (8) Citizen Control, have-not citizens obtain the majority of decision-making seats, or full managerial power."

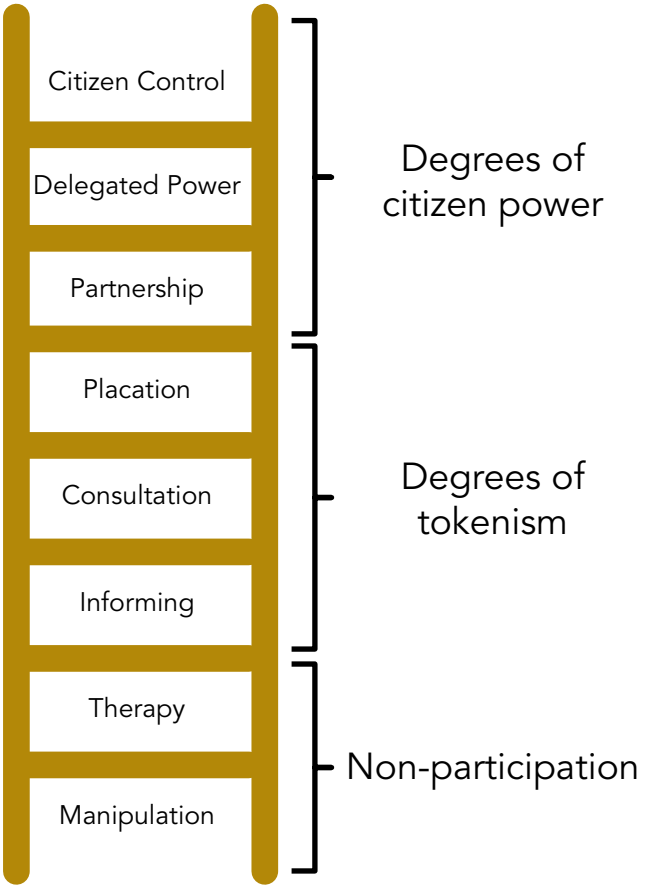

Figure 3. Sherry R. Arnstein's Ladder of Citizen Participation (from: http//lithgow-schmidt.dk/sherry-arnstein/ladder-of-citizen-participation.html).

We can translate this ladder into a spectrum of participation for protected area management, from least to most, allowing a protected area manager to place their organization along the spectrum according to the degree to which local communities are formally able to participant in decisions that can affect their surroundings.

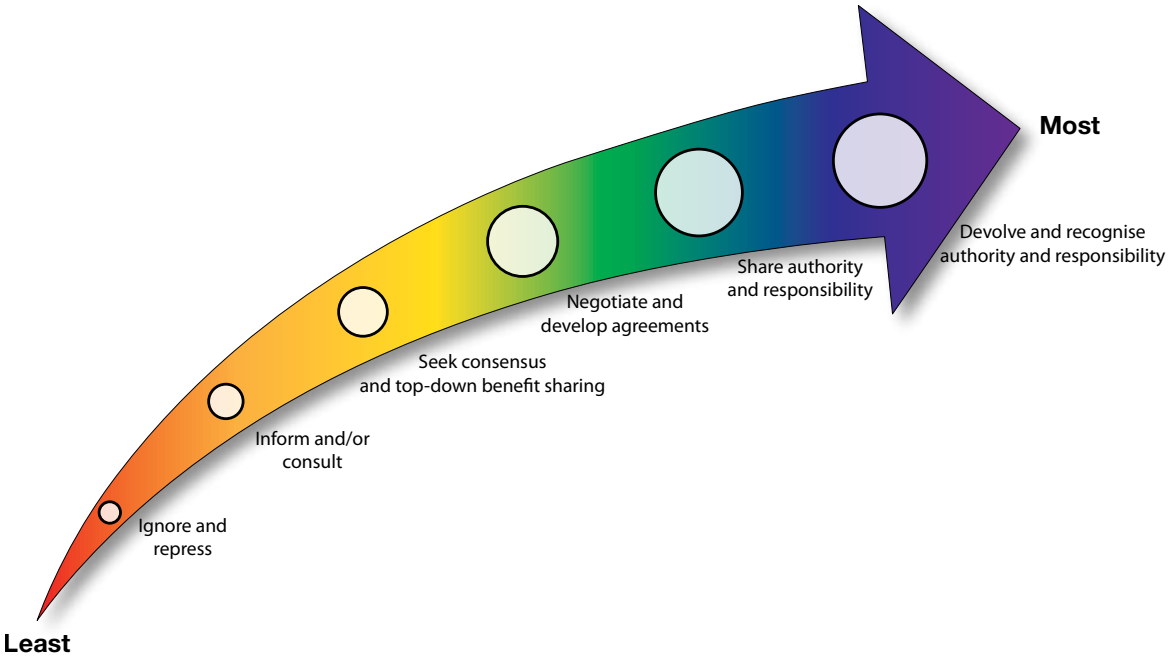

Figure 4. The Participation Spectrum.

Good Governance

Good Governance can be defined as: "*The interactions among structures, processes and traditions that determine how power is exercised, how decisions are take on issues of public concern, and how stakeholders have their say*".

Good governance principles for protected areas include:

- Ensuring that stakeholders can influence decisions
- Sharing the costs and the benefits of conservation
- Meeting the needs and concerns of all stakeholders
- Attributing management authority and responsibility to institutions closest to the resources at stake

There are four general types of Protected Area Governance: government management; co-management; private management, and community conservation.

Government Management

A Government body, such as a Ministry, holds the authority, responsibility and accountability for managing the protected area, it determines the objectives, and often also owns the land. Sub-national and municipal government bodies may also be protected area managers. In some case the state retains full land ownership, but devolves management to a para-statal organisation, NGO, or even a private operator

Co-Management

A number of complex processes can be employed to share management authority among a range of groups, including national or local government authorities, local community groups, private entrepreneurs, and landowners. We can think of a range of co-management structures, from more to less centralized government control:

> *Trans-boundary Management* is a form of Co-Management that involves the coordination of management by different agencies across borders.

Collaborative Management generally has the formal authority sit with one (often national government agency) but that agency must collaborate with stakeholders. This may entail only weak collaboration, involving consulting and informing only, or strong collaboration, necessitating approval by consensus

Joint Management is a form of Co-Management that requires that all groups are represented on a management body with decision-making authority, responsibility and accountability

Private Management this is most commonly applied to private reserves and includes areas under individual, cooperative, corporate for profit and not-for profit ownership. Conservation NGOs may buy land and dedicate it to conservation, or individual landowners pursue conservation objectives out of respect for the land. In any case the authority rests solely with the landowner and consequently accountability to wider society is limited.

Community Conservation this is possibly the oldest form of protected area governance, encompassing both natural and modified ecosystems. Authority rests with the community group concerned via a variety of locally agreed organizations and rules. Accountability to larger society varies, and a broad range of partners, including governmental organisations, is possible.

2.5. International Case Study

Community & Civil Society Participation in Conservation Management in Zambia: the case of Kasanka National Park and Kafinda Game Management Area

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Zambia has a wealth of natural resources and a large rural community dependent on these. For over 25 years the country has experimented with various methods to encourage the participatory management of protected areas. Zambia's first Community Based Natural Resources Program - the Lupande Development Project - was initiated in 1983 to test the feasibility of community co-management of wildlife resources. In 1988 the country's first Private Public Partnership arrangement for the management of a national park was signed between Kasanka Trust and the Zambian Government. This paper provides a review of Zambia's legislation and its protected area co-management policies, as well as a case study of a partnership between the Zambian government, an NGO and a community- based organisation.

Policy environment

Zambia recognizes eight categories of Protected Areas (PAs): National Parks (NP), Game Management Areas (GMA), Wildlife Sanctuaries, National Forests, Local Forests, Fisheries Areas, Ramsar sites and Heritage Sites. The management of these PAs is delegated to four national agencies:

1. The Zambian Wildlife Authority (ZAWA) regulated by the Zambian Wildlife Act of 1998. ZAWA is responsible for 19 national parks, 2 wildlife sanctuaries, 36 GMAs and 119 private game ranches.
2. The Forestry Department (FD) regulated by the Forest Act of 1973 (amended 1999), responsible for 184 national forests, 306 local forests and 56 botanical reserves.
3. The Fisheries Department (FoD) regulated by the Fisheries Act of 1974 (amended 1999), responsible for 2 sites with 5 new areas proposed.
4. The National Heritage Conservation Commission (NHCC) regulated by the National Heritage Conservation Commission Act 1994, responsible for 3687 heritage sites.

The Zambian Government encourages community and private sector involvement in the management of natural resources by sharing responsibilities and benefits. This is most explicit in the Wildlife Act

which makes provision for Community Resources Boards (CRBs) and community participation in wildlife management. A CRB is mandated to promote and develop an integrated approach to the management of human and natural resources in a GMA or an open area. In conjunction with ZAWA, it has the right to manage the wildlife under its jurisdiction. This includes the negotiation of co-management agreements with hunting and photographic tour operators, plus the appointment of community scouts to perform the duties of a wildlife police officer.

The draft Forestry Act (1999) introduces the concept of Joint Forestry Management (JFM) which allows NGOs and the private sector to form partnerships with local communities to manage forest resources. It includes a mechanism for sharing income from licence fees. Equally, the new Fisheries Act (2007) provides for the establishment of Fishery Management Areas and Fishery Management Committees (FMC), with a fund set up from licence fees to enhance the social and economic well being of the community.

In addition to the protected area and environment legislation, it is important to mention the Decentralization Policy of 2000 which provides for the devolution of responsibilities from Central Government to provincial, district and sub-district levels. The policy recommends the establishment of Area Development Committees (ADCs) at village level.

To date, very little of the new legislation (Forestry and Fisheries) has been tested or fully implemented. Uncertainty remains about how well groups such as the CRBs, JFMs, FMCs and ADCs can work together. Moreover, such groups appear to have overlapping functions, which begs the question, as yet unanswered, as to whether an integration of functions would be more efficient in encouraging truly collaborative relationships.

Notwithstanding the difficulties, the consensus among Zambian conservationists is that these policies represent a positive way forward, and are generally acknowledged as a sound basis for an adaptive learning approach towards implementing improvements.

Status of protected areas in Zambia

Zambia's – until recently abundant - natural resources are in a rapid state of decline (National Policy on Environment 2005). Zambia ranks number 5 on the world's list of highest deforestation rates (FAO 2010). Fishing was and is a major source of income for many rural Zambians but drastic declines in fish catches per unit indicate that the national stocks are either fully or overexploited (FAO 2012).

GMA habitats are much impacted upon and constantly under threat, whereas those within the national parks are mostly intact. GMAs were created to act as buffer zones between national parks and farming areas. Human settlements, regulated hunting, compatible farming and photographic tourism are allowed. Quantitative evidence suggests that over the past decade more than half of Zambia's animal populations in GMAs have declined, mainly due to poaching (Simasiku et al 2008). Equally the natural habitats available to support wildlife in GMAs have been shrinking due to increased settlements, cultivation, and traditional land claims and uncoordinated planning by government departments (Simasiku 2008). Community members generally consider agriculture as a more profitable form of land use as compared to wildlife management. Land use planning was not practiced until very recently whilst law enforcement for illegal practices in GMAs is mostly insufficient. Thus, habitats for wildlife and especially corridors between core protected areas are degenerating at a fast pace.

An additional problem is the continued ambiguity over ownership and authority of the wildlife hunting areas. Land within GMAs is traditionally allocated by the local Chief. However, the local government has the responsibility for general planning and administration of the area and ZAWA has the responsibility for the administration of wildlife-related matters in GMAs.

Co-management & participation

In recent years the Zambian government has recognized that it does not have sufficient human and financial resources to manage its many protected areas in an adequate manner. Alternatives are therefore being investigated. The existing Private Public Partnership (PPP) initiatives in the country were reviewed in 2008 and based on the results, a PPP policy has now been drafted.

The study (Johnstone 2008) made a distinction between partnerships that are comprised of public and private partnerships only (PPP1); and partnerships where the community and civil society are also included (PPP2). Currently 10 conservation partnerships are active in Zambia. The status of these partnerships vary as some of them existed for a long time and others were only recently initiated.

The use of PPPs for managing and financing PAs in developing countries has been motivated by the fact that PAs receive less than 30% of the funding estimated to be needed for their basic conservation management (Johnstone 2008).

The Community Resource Board (CRB) is the most established structure for local natural resource management in Zambia. Experience with CRBs has been built up since 1998. Communities that lie within existing chiefdom boundaries inside a GMA, or within an open area of specific wildlife interest, may apply to ZAWA to form a CRB. This Board may have between 7 to 10 members, including representatives from the area chiefdom and the local authority with the area chief as its patron. The community representatives are elected by Village Action Groups (VAGs) which form the representation at village level. Democratic elections at board and VAG level should take place every 2-3 years.

A CRB can only be registered, or re-registered, if ZAWA is satisfied that the right democratic procedures have been followed. Once this procedure is completed the CRB becomes the single co-manager of wildlife resources at community level in that particular GMA and is entitled to 50% of all income from organised hunting in the GMA, plus 20% of concession fees. Currently 63 CRBs are active in Zambia and are annually audited by ZAWA. In some areas CRBs are also active in fisheries or forestry related activities.

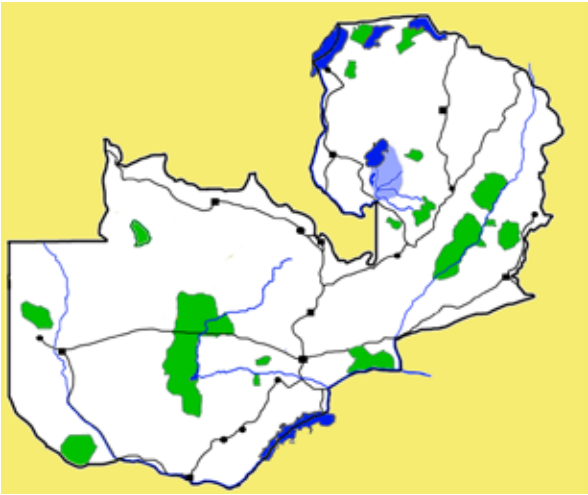


Figure 5. National Parks in Zambia

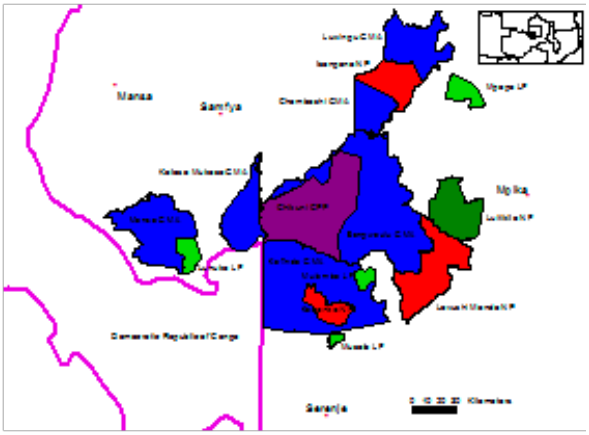


Figure 6. Location of Kasanka NP and Kafinda GMA

<u>Case study: Kasanka National Park and Kafinda Game Management Area</u>

Kasanka National Park

Kasanka National Park (KNP, 360km²) was declared a National Park in 1972. It has been managed by Kasanka Trust Limited (KTL, a Zambian NGO) in cooperation with the Zambian Wildlife Authority (ZAWA) since 1988. The park is made up from an exceptional variety of habitats, including miombo woodland, riverine floodplains, seasonally wet grasslands, papyrus swamps and gallery forest. These habitats sustain a rich diversity of wildlife being home to the world's densest populations of the sitatunga and puku antelope, as well as hosting a migratory colony of eight million straw-coloured fruit bats, one of the largest mammal concentrations in the world. An astonishing 460 bird species have been recorded in the park to date and the park has the status of Important Bird Area.

Kasanka NP is the first and longest running Private Public Partnership Park in Zambia. A unique Memorandum of Understanding with ZAWA allows Kasanka Trust to take on the day to day

management of the park, recruit and deploy wildlife scouts, develop tourism and community outreach programmes. As the Trust is a charity, all tourism revenues are invested back into conservation after deduction of 10% for ZAWA and 5% for the Community Resources Board. A multi-stakeholder forum with representatives from the community, the local authority and ZAWA acts as the governance board. It therefore classifies as a PPP2 partnership.

Achievements

Kasanka NP was at the verge of being de-gazetted in 1986. However after 25 years of PPP management the park has seen a remarkable increase in wildlife, especially in sitatunga, puku and common duiker populations. Other species which have benefitted include elephant, buffalo, warthog, hippopotamus, jackal, baboon, vervet and blue monkeys. However, poaching pressure remains high, inhibiting the increase of the more vulnerable species such as zebra, hartebeest, waterbuck, roan, sable and leopard.

KTL employs 80 permanent staff from the local community and provides training on the spot, thus becoming a major force in capacity building and significantly contributing to the local economy. Assuming each staff member supports 8 household members and employs a minimum of 1 person annually, the direct employment benefits 720 people. Additionally, Kasanka Trust runs an extensive community program reaching out to the full Kafinda GMA community of 80,000 people. The program focuses on environmental education, alternative sources of income, sustainable use of natural resources and capacity building.

A review of PA management effectiveness in Zambia (Mwima 2007) indicates that only 8 out of 19 national parks in Zambia meet the minimum management effectiveness criteria as defined in the Management Effectiveness Tracking Tool (METT) for Protected Areas Managed by the Zambia Wildlife Authority. Kasanka is amongst these 8 most effective parks, with its success attributed to key factors such as significant donor support; regular income from tourism, underpinned by a business approach to management and administration including exemplary cost control and cost sharing amongst different sectors of the organisation. Furthermore, the Trust implements a hands on law enforcement program; long term ecological monitoring and research; a strong tradition of professional volunteers, plus a professional board of directors providing their services for free.

In recognition of the partnership's strength, ZAWA granted KTL an extension to include the management and the development of the neighbouring Lavushi Manda National Park in 2011. The extension is financially supported by the Global Environment Fund through the World Bank.

Kafinda GMA and Chitambo CRB

Kafinda GMA comprises an area of 3860km² around Kasanka National Park. It was declared a GMA in 1972, but is officially depleted, thus no hunting is allowed. The GMA consists mainly of miombo woodland, flanked by floodplains and wetlands. Wild mammals are rarely found due mainly to poaching and the impact of shifting cultivation. Timber and charcoal production is also common, resulting in further depletion of wildlife habitat. Kafinda GMA is a remote and poor area with little development and little support from the government. The Lala tribe inhabitants are originally hunter gatherers but are now in transition to subsistence agriculture. Education and employment opportunities in the area are very limited, with little or no access to electricity, phone, television or newspapers.

The Chitambo Community Resources Board (CCRB) was initiated in 1999. His Royal Highness Chief Chitambo IV is the Patron and the board is officially recognised by Serenje District Council and ZAWA. The Board is subdivided into 10 Village Action Groups (VAGs) who together represent the 80,000 inhabitants of the Kafinda GMA. The objective of the CCRB is to promote and develop an integrated approach for the management of human and natural resources in the Kafinda Game Management Area.

The CCRB educates the wider community in the benefits of conservation through public awareness campaigns. The board also promotes sustainable agriculture such as bee keeping, fish farming and chilli production. Community groups are encouraged to register with the board and apply for a

loan or technical support. In return, recipients sign a contract whereby they pledge not to take part or support illegal activities such as poaching and fish poisoning. The Board is actively involved in participatory resources inventories and community consultations for the development of land use plans. The board employs 6 village scouts whom are seconded to ZAWA to protect the GMA.

The Chitambo Community Resources Board receives a 5% quarterly share of Kasanka National Park's tourism income. This is a unique arrangement in Zambia as no other CRB receives tourism income from a national park. The gesture was initiated by KT as compensation for the lack of hunting revenue due to the depleted status of Kafinda GMA.

Figure 3. Chief of the Lala tribe signing Kafinda LUP.

Achievements

At the start of CCRB there was no experience within the local community in participatory resources management. Capacity in participatory planning, finance and conservation management had to be built from scratch with the support of Kasanka Trust. Considering the low education level of the community, it has taken many years of concerted effort to build this up. Considerable progress in awareness, alternative livelihoods and conservation management has since been made, as indicated by the milestones in Table 1.

Table 1. Milestones CCRB in conjunction with KTL:

Conservation
Development of a fisheries by-law
Agreement and implementation of fish levy collection with Serenje District Council
Destroyed fish weirs in main breeding areas
Good fire and fishing awareness campaigns jointly with relevant government departments.
Kafinda GMA General Management Plan signed by Minister of Tourism, ZAWA board and Chief Chitambo

Education/awareness/ capacity building
Sponsorship of 4 community teachers
Renovation of 5 community schools and 3 government schools
Construction of meeting room, public library and CRB office at Kapepa Community Centre
Training of > 150 VAG and technical committee members after each CCRB general election
Livelihood
Training and support in conservation farming, agroforestry, bee keeping, fish farming, chilli production, food processing, marketing skills, hammer mill maintenance
Community based 'Problem Animal Control' campaign including chilli fencing
Set up self-help fund, developed implementation plan and monitored 101 self help projects

Observations in the GMA indicate a trend towards ecological recovery due to a reduction in tree cutting & fish poisoning; regeneration of trees and an increase in fish migration.

In 2008 the CCRB was reported to be amongst possibly only four CRBs that managed to produce a draft management plan for their GMA (Simasiku 2008). The Kafinda plan was drafted after elaborate consultations, discussions and feedback at the village, chiefdom and district level. The agreement includes a human settlement plan, a fish breeding zone, a 2 km buffer zone around the park and an animal corridor connecting Kasanka National Park with the Greater Bangweulu Ecosystem; all under CRB management. The buffer zone has the potential for future hunting opportunities as species numbers recover and grow significantly. The plan was formally approved by the Minister of Tourism and the ZAWA board in 2011.

Discussion

The SWOT analysis below makes it clear that the ten year partnership between CCRB and KTL has resulted in considerable progress in the capacity of the CCRB. However, the identified weaknesses and threats need to be addressed where feasible and opportunities should be fully utilized to increase the CCRB performance.

The CCRB is currently still very dependent on KTL for its income as well as technical support, however, steps towards financial independence have been made. For example, linking the CCRB to buyers of agricultural commodities has resulted in an agreement in 2011 to bulk-buy groundnuts against a guaranteed price. The CCRB also partnered in the grant application process to IUCN Netherlands, DED and the Finnish embassy thereby building up expertise in planning, implementation, monitoring and evaluation. The CCRB has experienced loss of knowledge and skills due to trained members moving out of the area in pursuit of employment. The obligation to organise regular elections also results in loss of knowledge as new, inexperienced members are introduced. A first step to avoid competition and loss of skills was already taken by the integration of the functions of ADC and CRB in Kafinda GMA.

Zambia's GMAs are in a spiral of degradation and the Kafinda GMA is no exception to this situation. The management of wildlife and habitats in GMAs is only enforceable with a management plan prepared by the CRB and approved by the ZAWA board. The approval of the Kafinda GMA Management Plan is therefore a major milestone towards conservation and sustainable use of the remaining natural resources whilst empowering the local community to plan their own future.

KTL and CCRB are fully committed to address the identified weaknesses, threats and opportunities on the long term. Funding towards this goal has already been secured through a 2-year grant from the Finnish Embassy for community outreach and through various smaller donors for education. The community outreach plan focuses on implementation of the Kafinda GMA management plan, democratic CRB elections, broadening the CCRB income base, promotion of sustainable livelihoods and consolidation of achievements so far.

Conclusion

As Simasiku *et al*. (2008) suggested, '*Experience in Zambia so far suggests that there is a high potential for community & civil society partnerships to succeed as a deliberate strategy to promote sustainable rural livelihoods whilst at the same time reversing the threats to biodiversity conservation. However there is currently a discrepancy between stated intentions and actual practice*'.

The situation is complicated by the fact that natural resources management is scattered across several government institutions and different acts. At the same time these institutions experience limited capacity to implement legislation whilst communities are not adequately empowered to fully participate.

The introduction of a single community structure would enable an integrated and more efficient approach to the management of natural resources. The CRBs are the most logical candidate as they are already a well established structure for local natural resource management in Zambia. The authority of CRB village scouts, whom currently function as Wildlife Police Officers under the Wildlife Act, can for example be extended to include the Fisheries and the Forestry Act.

There is a need for a dedicated national NGO with a direct interest to lead the CRB's towards institutional sustainability. Its task would include the development of a long term vision, lobby and technical support.

Capacity building in community structures and improving performance should be seen as a long term process. Specialized NGOs and the private sector – in close partnership with the relevant government departments or parastatals - can play an important role in this process as illustrated in the case study.

In addition, PPP partnerships in conservation should be encouraged as they assist the government in improving efficiency and saving costs whilst bringing much needed economic, social and ecological benefits to the local community.

2.6. Regional Case Studies

Note: Thank you to the following people for presenting case studies for their region: Othman Lewellyn, Nashat Hamdan, Abdul Karim Nasher, Maral Khaled Shuriqi, Abdulqadar Khamis, Hadi Al Hikmani. It is understood that these summaries do not express official policy and that any errors of omission or commission are the responsibility of the editors of this proceedings alone.

Kingdom of Saudi Arabia

In Saudi Arabia there persists a recognised traditional system of community-managed resource use that long anticipated and effectively enshrines all the principles of the new PA paradigm. The *hema* is a traditional Saudi Community Conserved Area existing under Sharia law and intended for forest conservation or as no-grazing zones within with fodder for livestock may be cut. *Hema* were founded under four criteria: (1) they were to be established and ratified by a legitimate governing authority; (2) they are for public benefit; (3) benefits must outweigh harm, and (4) they must not deprive local communities. Even by the 1950s in southwestern areas of Saudi Arabia there were ~3,000 *hema*; today only ~50 are still managed by local communities in the absence of official recognition or policy.

Jordan

Protected areas in Jordan are managed by the Royal Society for the Conservation of Nature, (RSCN) an NGO created in 1966 under the mandate of the Ministry of Environment and with its own Board of Trustees. Throughout the history of protected areas in Jordan virtually all levels of participation have been used, from the now unacceptable "Yellowstone model" entailing the creation of isolated sites taken from tribal lands, to informing and consulting with the potential for rifts between different stakeholder groups, and through to the development of agreements with a focus on meeting the basic needs of local communities. All Jordanian protected areas are run by local community members in their role as NGO staff, and all protected areas currently generate revenue. The RSCN is currently introducing the concept of Special Conservation Areas – these are sites with unique biodiversity values, almost equivalent to hema, to be run by local communities with appropriate technical input, capacity building and funding.

Yemen

While the idea of a protected area is widely interpreted by local communities in Yemen as a top-down government-run structure that may entail loss of land access, in the Socotra archipelago the main approach has been the negotiation and development of agreements that allow most of the regions protected areas to be managed by local communities. These structures are supported by access to GEF (Global Environment Fund) small grants funding and have been recognised by a UNDP (United Nations Development Programme) award, enabling traditional livelihoods to be sustained. Nevertheless, Socotra's protected areas remain vulnerable to changing tourism numbers.

Fujairah, UAE

The Wadi Wurayah National Park (WWNP) in Fujairah was conceived in 2005, surveyed in 2006-08, and officially declared in 2009. In 2010 WWNP was declared a Ramsar wetland site, only the second for the United Arab Emirates. As part of the management of the area a stakeholder map has been created, identifying a wide range of local interests and therefore the need to differentiate levels of participation. The WWNP Management Board includes tribal representatives who have input into the future implementation of the management plan for the area.

Bahrain

Bahrain currently has two protected areas, Arad Bay and the Pearling Pathway. In Arad Bay a local community initiative promoted a project by the Municipal Council, which sought to foster a sense of community ownership. The Pearling Pathway comprises a marine region, an island, and a coastal zone, and is built around the idea of recognising and preserving a traditional system of resource use.

The establishment of The Pearling Pathway has involved direct interaction with local communities and detailed socio-economic surveys.

Oman

Oman has 14 protected areas, but to date little community involvement. However, conservation efforts directed towards important regional populations of the Arabian leopard, by necessity, work closely with local communities to ensure that measures for leopard protection also meet the needs of local communities. One challenge is to help local communities to understand what it is they need.

2.7. Regional Lessons

In working groups delegates discussed and addressed the following:

1. Consider the range of governance types and add or modify these for your region;
2. Classify all or selected Protected Areas based on your experience;
3. Identify the obstacles or challenges to some types of Protected Area governance in your experience;
4. Suggest the most fruitful approaches to community engagement in your experience.

Table 2 summarises the distribution of protected area governance types by IUCN category for protected areas in the Arabian Peninsula; individual protected areas or countries are not identified. It is clear that government managed protected areas are dominant in the region, especially those under the control of a Federal and National Ministry. Co-management structures do exists, with both Transboundary and Collaborative management arrangements, though centralised authority is still a feature. The region is virtually devoid of private protected areas, with the exception of official recognition of traditional resource management arrangements (*hema*) that have preserved community conservation areas for managed resource use.

2.8. Obstacles/Challenges

Workshop participants identified the following issues as being of particular concern in the Arabian Peninsula countries:

Legislative issues, including concerns over international obligations, clarity of land tenure arrangements, and the legal recognition or acceptability of some devolved governance options.

Ensuring ***adequate and appropriate representation of communities***, recognising the problems faced by marginalised groups, or arising due to infighting, competing interests, conflict, and inequalities in the capacity to participate.

One of greatest challenges to protected areas in the region is that of ***conflicting priorities***, specifically a clash between the conservation objectives for a site versus other uses, many of which, e.g. mining, are incompatible with conservation or restoration aims.

2.9. Principles/Points

The following conclusions were reached for the Arabian Peninsula region:

1. Government Management and Co-Management may be the best structures for Protected Area management in the region since government management allows for some level of public engagement but retains a centralised authority, while co-management arrangements allow shared responsibility.

Table 2. Governance types by IUCN category for protected areas in the Arabian Peninsula

Governance Types / PA Category	A. Government Managed Protected Areas			B. Co-managed Protected Areas		C. Private Protected Areas			D. Community Conserved Areas
	Federal or national Ministry in Charge	Local Ministry or agency in charge	Government delegated management e.g. to NGO	Transboundary management	Collaborative and joint management	Declared and run by individual landowner	... by non-profit organisation, e.g. NGOs, universities	... by for-profit organisations e.g. corporate landowners	Declared and run by local communities
1a Strict Nature Reserve									
1b Wilderness Area									
II National Park									
III Natural Monument									
IV Habitat/Species Management									
V Protected Landscape/ Seascape									
VI Managed Resource Area									

Key to relative number of PAs in each category for each governance type

0	
1-<5	
5-<10	
10+	

2. It is vital to engage local communities early in the protected area establishment process and to include local communities in the planning process. Sustained engagement will foster a sense of ownership over an area and its resources, facilitating the meeting of local needs.
3. It is important not to raise false expectations, but rather to promise less, yet deliver more, and quickly to show tangible benefits to local communities.
4. It is also essential to plan for change; change in local community circumstances, structures and representatives, and changes in regional and national political, social and economic factors.

3. Protected Area Zonation

3.1. Introduction

Zonation of protected areas and in turn their integration into the surrounding matrix remains an important component of protected area and bioregional planning and management. It arises primarily from the conflict over how to protect and use the areas within protected areas. Traditionally zonation was designed to offer some degree of greater protection to important biodiversity, cultural, historical or geological features within protected areas. Secondarily, they have been expanded to regulate human enjoyment and appreciation, utilization, or even extractive use in a regulated manner in the limited space available.

Zoning of protected areas remains one of the most important mechanisms to help identify, record and potentially mitigate for conflict. It thus requires extensive and transparent negotiation and collaboration between all stakeholders involved in an attempt to agree on some shared rationality for the area in question and how it should be used in a meaningful and least impacting way. Zoning could be used for (Middleton 2003):

- providing protection for critical or representative habitats, ecosystems and ecological processes;
- separating conflicting human activities;
- protecting the natural and/or cultural qualities while allowing a spectrum of reasonable human uses; and
- enable damaged areas to be set aside to recover or be restored.

Young and Young (1993) stated that:
"*Zoning defines what can and cannot occur in different areas of the park in terms of natural resources management; cultural resources management; human use and benefit; visitor use and experience; access; facilities and park development; maintenance and operations. Through management zoning the limits of acceptable use and development in the park are established*".

Since 2007 the conservation workshops held annually in Sharjah, UAE, have considered different aspects of protected area creation and management in the Arabian Peninsula. As with many of the subjects discussed over the years a great deal has been learnt about the extent, diversity of approaches, failures and successes. The degree to which a protected area delivers on its mandate is often guided via its accepted zoning system. It was apparent from previous work shops that the subject of zonation required dedicated discussion.

Therefore the aim of this component of the 2012 workshop was to consider his range of issues:

- Provide an overview of the occurrence, use & types of zoning used in protected areas across the region;
- The principles upon which zones have been established, their purpose & whether they are effectively used;
- The process by which zones have been developed;
- Whether zones are integrated into regional plans;
- What lessons have been learnt.

3.2. The zonation process

Zonation plans should ideally flow as a logical output from the protected area management planning process that has collectively identified the desired state for the area, its objectives, identified activities, and the monitoring and evaluation feedback route. A zonation plan translates the management plan into a visually and spatially explicit representation of the area, defined in

terms of control or limitations on development, use of resources, and or access, designed ideally to achieve the protection and enjoyment of the areas natural assets.

Such plans can be developed through the collation of spatial information via simple mapping procedures or more sophisticated systematic computer-based GIS methods, drawing upon a myriad of information inputs (Figure 7). Information can be lumped into biological, aesthetic and cultural heritage themes, that can be collectively summarized into a sensitivity map (Figure 8). The systematic route provides the opportunity to provide repeatable and defendable products from which to make informed inputs into a zonation plan. The latter is supported by a decision framework of assessing collective biological, aesthetic cultural values against perceived sensitivity to disturbance (Figure 9). This ranges from areas of low perceived value and sensitivity (ideal for development) to those of high value and sensitivity that require greater protection via stricter zones such as wilderness or primitive designations.

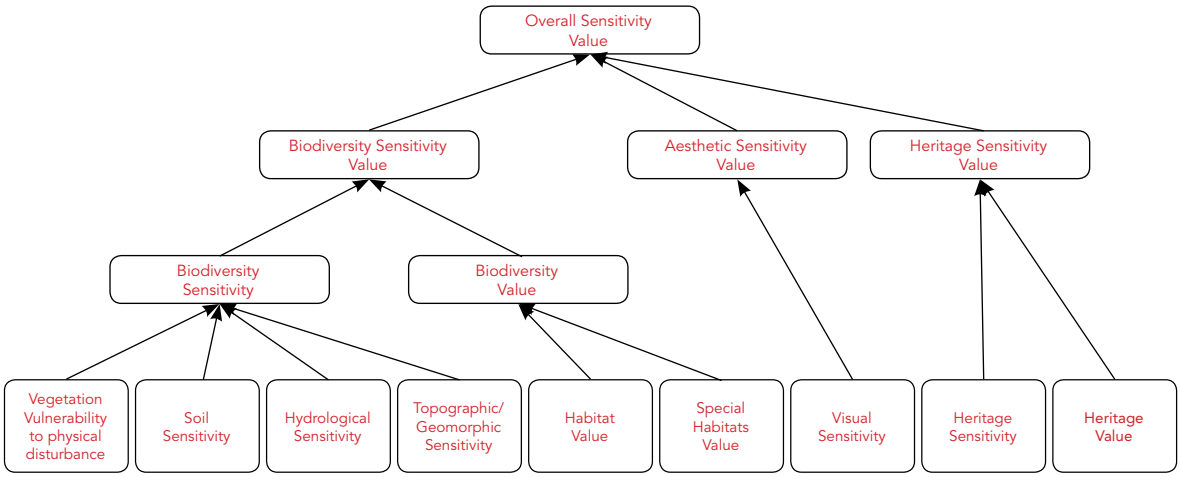


Figure 7. The hierarchal structure of the information input layers into developing a zonation map.

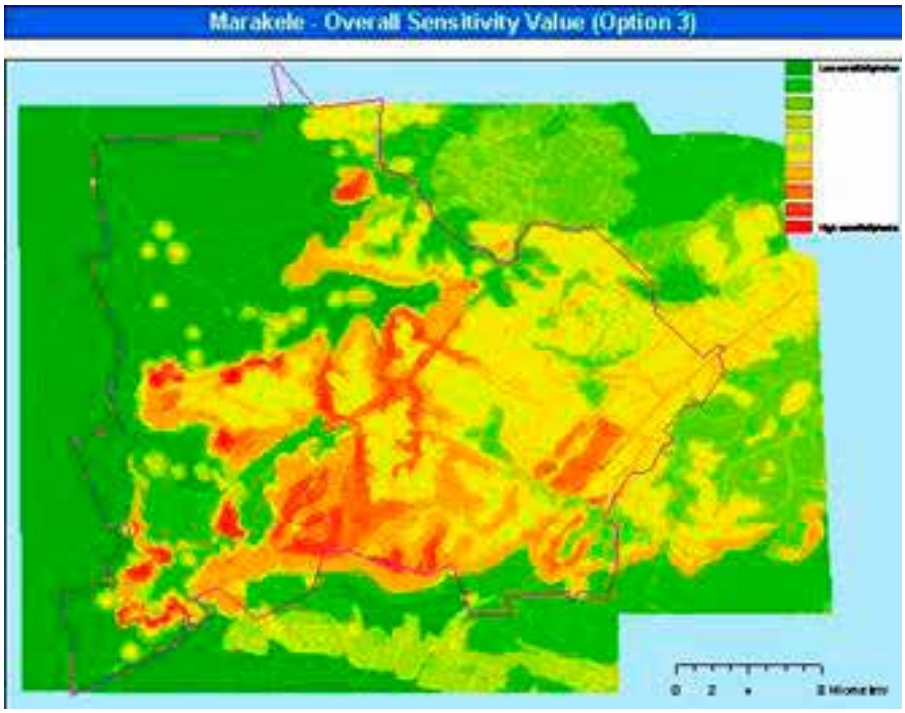


Figure 8. This map is an example of a sensitivity map for a protected area (red most sensitive, green least sensitive).

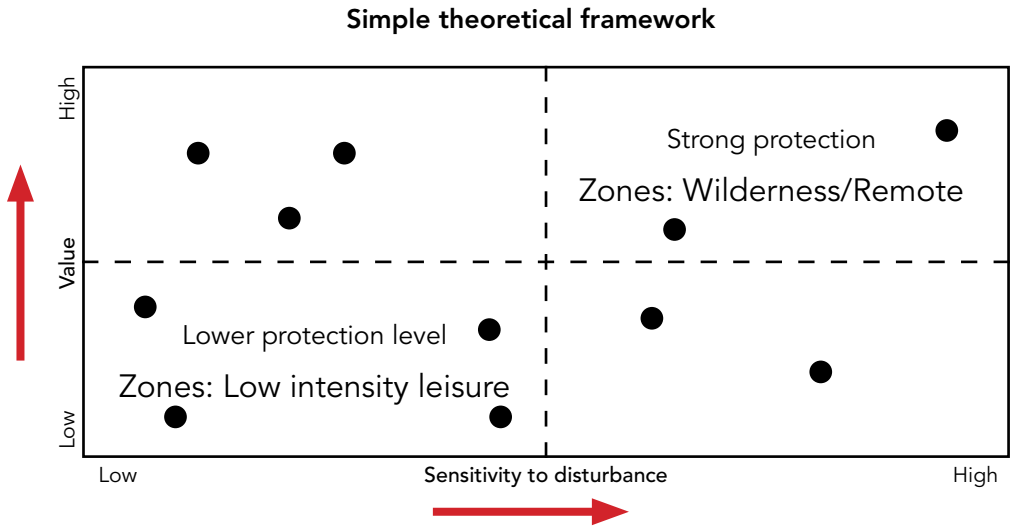


Figure 9. A framework to translate the sensitivity layer into different use zones with those ranging from low value and low sensitivity to those with high value and high sensitivity.

This information is then used to generate a zonation map (Figure 10) that in this case has four zones listed that range from wilderness (highest protection), through remote, primitive, to low intensity leisure. Although the above process appears simple, it is developed through an initial interactive workshop, followed by numerous iterations (Figure 11). The public are brought in once the technical sensitivity map has been generated and requires its translation into use or experiential zones is required.

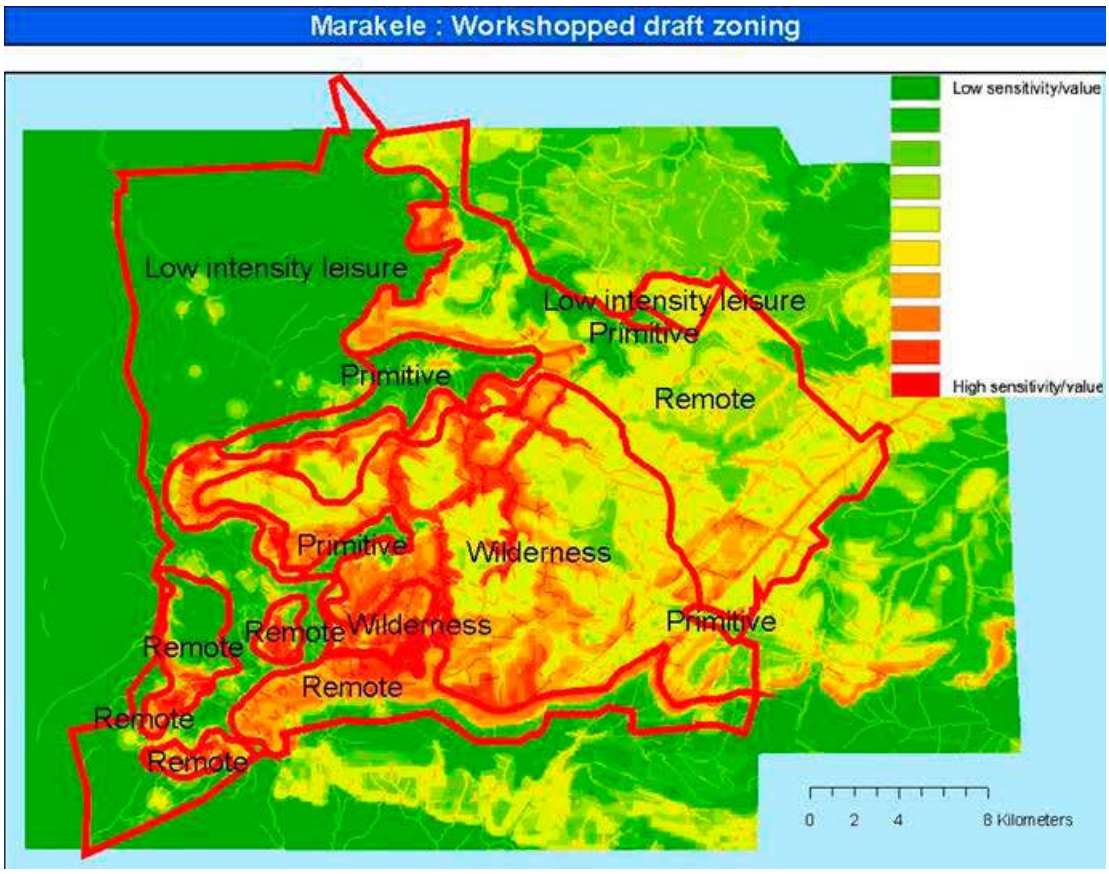


Figure 10. Translation of the sensitivity map in Figure 8 to use zones that range from low intensity leisure to wilderness.

Figure 11. The interactive consultative zonation development process as part of a conservation development process.

Numerous different types of zones are used. They are largely influenced by the category of protected area, and the unique qualities of the area in question. To follow on the theme illustrated in Figures 7 to 9, the list of zones, that differ slightly from the basic set advocated by the IUCN (Thomas & Middleton 2003). These are expanded below:

1. **Remote:** Retains an intrinsically wild appearance and character, or capable of being restored to such. Access is strictly controlled, with entry allowed only on foot, no vehicles, no roads, nor infrastructure.
2. **Primitive:** Generally retains wilderness qualities, but with basic self-catering facilities. Access is controlled, with 4x4 vehicles and trails allowed, with basic self catering tented camps. Provides access to the Remote Zone, and can serve as a buffer and is sometimes referred to as such.
3. **Quiet:** This zone allows non-motorised access to areas which generally retain a natural appearance and character. Access is not specifically controlled.
4. **Low intensity leisure:** The underlying characteristics of this zone is motorised self-drive access with basic self-catering facilities. The numbers of visitors are higher than in the Remote and Primitive Zones. Camps are without modern facilities such as shops and restaurants.
5. **High intensity leisure:** The main characteristic is that of a high density tourist development node, with modern amenities, where more concentrated human activities are allowed.

Each of these zones are defined in terms of: experiential qualities; degree of interaction between users; types of activities allowed; types of facilities permitted; limits of acceptable change with regard to the biophysical, aesthetic and recreational environment/activities.

Zonation systems can also include those of a temporal nature to address cultural activities, fish spawning activities, bird breeding and the like. It is important that a zonation system should strive to be as simple as possible, with as few and distinct number as possible of zones, that are easy to identify on the ground.

Development of marine zoning systems are often more complicated, given common access to marine resources. As such they are often faced with considerable resistance by users. Marine zones are often framed around the regulation of use of resources (eg. fishing, bait collection) and experiential (water activities/sports, motorised access) uses. The zones applied in the Great Barrier Reef in Australia offers a good example (Day 2002).

3.3. Zonation around protected areas – the role of buffer zones

The concept of buffer zones have their origins in the UNESCO's Man and the Biosphere programme (UNESCO 2000). The goals of buffers zones can be divided into two broad antagonistic camps, with one proposing that they form an extension of protected areas, and the other that they attempt to integrate protected areas, people and development in a manner that protects the central protected area from encroachment and destructive activities (Martino 2001) and also offer greater resilience to protected areas in the face of global climate change. Our interpretation here leans more to the latter concept.

Here again depending upon the situation there are numerous different examples of buffer zones. As an example, the South African National Parks defines three different zones within the surrounding buffer area, namely:

- **Priority Natural Areas (PNAs)** that are important natural areas outside of PAs, mostly intact or untransformed, & are important for the ecological function of the park, that immediately abuts the protected area.
- **Catchment Protection zones** areas connected to the surrounding landscape, where negative impacts in upstream catchments should be minimized, such as in riverbeds.
- **Viewshed Protection areas** identify where developments could potentially impact on the aesthetic quality of a visitors experience in a protected area. This area is concerned with the visual impacts (both day and night), and sound pollution on the core protected area.

An important point about buffer zones is that they ideally have greater value if they have legal support and are integrated into regional planning initiatives, otherwise they have limited impact. Without any legal support, it would be difficult for the PA authority to be regulating activities in the surrounding buffer area.

3.4. Case studies, summary & recommendations

A total of eight case studies were discussed. These include: Wadi Wurayah (UAE); Subkhat Al-Jabboul (Syria); Dubai Desert Conservation Reserve (UAE); Dahna Protected Area (Jordan); Jibal Aja (Saudi Arabia); Socotra (Yemen); Jebel Ali Wildlife Sanctuary (UAE) and Kalba (UAE) (see Table 3). They provide a diverse mix of terrestrial protected areas and those with terrestrial and marine areas, as well as areas with a range of focuses from pure biodiversity conservation to those with a heavy emphasis on development. These areas are described in terms of their overall objectives, how the zones were developed, whether it involved some stakeholder consultation, types of zones, whether used and accepted by management and the lessons learnt.

Unfortunately, no systematic assessment of what proportion of protected areas from the region have zonation plans was determined.

The following key points can be gleaned from an assessment of the case study exercises (Table 3) and the associated discussions:

1. Zonation should flow from the vision and objectives as defined and described in the PAs management plan. This was not the case in those with urgent developmental pressure. What is planned to be achieved by the zoning plan need be well articulated.
2. The identification of zones need be based upon best available biological, socio-economic and cultural/historical information available.
3. Zonation is an essential tool to mitigate and appease conflicts around how and where to undertake certain activities within PAs. It visually & spatially reconciles competing interests and resolves conflicts. Only about 50% of the cases studies indicated consultation with stakeholders. It should be based upon a broad based, transparent, consultative process involving the responsible authority, local government, local stakeholders and others.

4. About 50% of the plans appeared not to be respected by PA authorities and local/federal government. This could arise from poor legislative support and possible poor law enforcement in the PAs.
5. Zonation systems are adapted to the category of PA and the unique context of the areas in question – i.e. no single prescribed system as illustrated by the suite of zones used.
6. It needs to be adaptive and dynamic to meet the specific challenges and objectives of an area. The use of a seasonal zonation system was quite intriguing. However, any zonation plan needs to be simple, with well defined zones, and easily identifiable on the ground (visual maps, signage) to facilitate interpretation by staff and visitors alike.
7. There appeared to be limited extension of zonation systems into the surrounding matrix around the PAs, with the exception of one example that wanted to.

Key issues and challenges across the region include:

- Need for zonation plans to flow from the management plans;
- Mechanisms for greater public consultation are required and essential;
- Acceptance that zonation plans are dynamic documents needing regular review.
- Like the management plans, they need a supportive legal framework, which seemed to be poor or missing in most cases.
- Need to be supported by effective law enforcement and regulations;
- Should ideally be integrated into regional planning/zoning initiatives, again supported by appropriate legal frameworks.
- Requirement of buy-in by PA authorities and adjacent local governments.

Table 3. Regional case studies of zonation systems. PA=protected area.

Protected area	Objectives	How developed & stakeholder engagement	Type of zones	Accepted & respected management authority & government	Challenges & lessons learnt
Wadi Wurayah, Fujarah	Focused on regulating ecotourism use of the small PA. Protecting water resources was a key environmental objective, as were other biodiversity & cultural sites	Developed out of management plan objectives. Participatory process with stakeholders was critical	Two zones. Central core protecting key biodiversity, archaeological sites and water resources. Surrounded by buffer zone to outer border of protected area, in which limited livestock farming was allowed.	Actively used & accepted by management authority	Must be adaptive to changing circumstances and information. Zonation was a key aspect in the negotiation process. Based upon good baseline surveys & information. Ecotourism plan with accepted activities
Sabkhat Al-Jabboul, Syria	To protect key seasonal bird area - only Ramsar site in Syria. Separated out human use areas.	Used GIS extensively in developing zones & maps. No indication of degree of consultation in the process.	Has seasonal (winter) conservation zones to protect main bird feeding areas. This zone varies from year to year depending upon where the birds are breeding. Use zones for fishing, hunting & other activities identified.	Yes.	Dynamic ecosystem requiring dynamic zoning system
Dahna Protected area, Jordan	Zonation based upon natural, social and cultural values and identified threats as listed in PA management plan	Collaborative process with all stakeholders.	Three zones: Wilderness: minimal impact, research allowed, & low impact tourism. Conservation: Tourism focused zone. Intensive use: Infrastructure heavy zone such as information centres etc.	Accepted by management & local authorities	Zonation planning must be inclusive of all stakeholders to reduce conflict. GIS is a useful tool in developing & illustrating zonation. Problem of being adaptive in the face of environmental/ climate change. Need update information on a regular basis & be prepared to change zoning in line with new findings
Dubai Desert Conservation Reserve, Dubai, UAE	To mitigate for identified critical threats. Primarily focused on controlling tourism operators. Attempting to restore natural processes.	Developed in consultation with selected tourism providers only – no broad local stakeholder engagement in the process.	Three zones that include: no human interference zone (no infrastructure, feeding sites) – research allowed; low impact development zone (camel rides) – surround high intensity zone with main resort/s and infrastructure.	Fully accepted by management & users.	Initial zonation system not based upon biodiversity which is highly variable in this ephemeral system.

Protected area	Objectives	How developed & stakeholder engagement	Type of zones	Accepted & respected management authority & government	Challenges & lessons learnt
Jibal Aja (proposed PA), Saudi Arabia	Proposed biosphere/Hema reserve. Biodiversity & cultural focused objectives that were based upon ecological & social surveys.	Internal government process with no stakeholder involvement. There are plans to include public involvement in the review of the plan.	Three zones: Core; high use and buffer zones (within reserve); Transit (outside PA). There are subzones within some of these zones such as the 'water harem zone'	Not yet fully accepted by management nor local stakeholders	Need for public involvement would facilitate the process. Also need explore unique-government, public-private sector involvement in this planned biosphere reserve, especially since current Saudi law excludes private property from being included into PAs.
Socotra, Yemen	Focused on biodiversity protection but informed by local user needs. Runs across the terrestrial- marine environments.	Prepared by multidisciplinary group, with involvement of local stakeholders.	Five zones: nature sanctuaries (strict protection); national park (regulated recreation);resource use areas (fishing), general use (infrastructure focused areas); Special botanical reserves (Terrestrial areas only) ;	Has government and local support.	Problem that most people are illiterate which makes for difficult information sharing. Current plan under review and plans to increase sanctuaries.
Jebal Ali Wildlife Sanctuary, Dubai, UAE.	Biodiversity focused objectives, resource use (fishing) and spans terrestrial-marine interface.	No consultative process undertaken.	Two zones: No take fishing area; fishing & pearling zones.	Has limited federal & local government support.	Zoning failed to stop the Palm Jabal Ali development taking over terrestrial section – but luckily suspended given recession. No wider stakeholder engagement. Zones not enforced except possible marine section that's protected by Coast Guard. Need firmer regulations in place to protect the management plans and law enforcement of the zoning plan.

Protected area	Objectives	How developed & stakeholder engagement	Type of zones	Accepted & respected management authority & government	Challenges & lessons learnt
Kalba, Sharjah, UAE.	Objectives have not been clarified nor agreed upon yet. Mangroves are important birding area.	In planning phase. Vision and objectives for reserve have not been agreed upon, yet development proposal on table.	Four zones are suggested & reflect habitat types (mangrove, mountain, central plains, marine) .	No acceptance yet given lack of clarity of vision, objectives and players in the project.	Need conclude a management plan from which the zoning plan & opportunities/activities will flow. Needs detailed background information to inform planning. Pressure to develop may usurp the required detailed planning process. Lack of communication (within government departments) & consultation with local stakeholders over fishing, grazing of livestock and current recreational (although uncontrolled) use will lead to conflict & lack of support for the PA. Need negotiate, integrate, plan & adapt.

4. Camera Trapping Workshop

4.1. Introduction

This topic marked the first time the workshop series has included a technical component; the selection of camera trapping as a focus was due to the widespread use of camera traps to conduct biodiversity surveys and to assess the presence and distribution of threatened species in the Arabian Peninsula. Consequently, the main objective of the camera-trapping workshop was to share regional experience in the use of camera traps for conservation. The key resource for the use of camera traps in wildlife research is O'Connell, Nichols and Karanth (2011); readers are directed to this valuable resource.

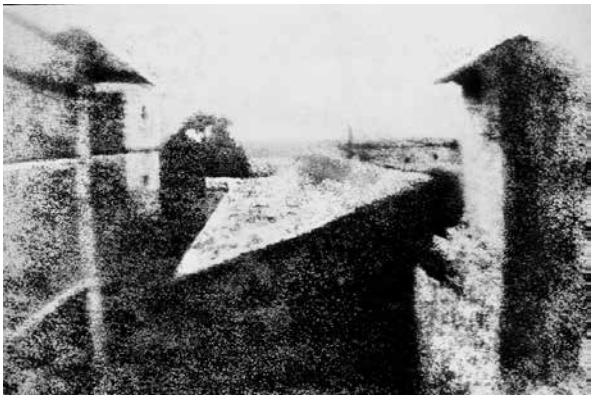
Outline:

- A brief history of remote wildlife photography
- Case studies
- Lessons learned
- Regional coordination

4.2. A brief history of remote wildlife photography

The timeline given below is based on the overview provided by Kucera and Barrett (2011)

- 1826 First ever permanent photograph – by Joseph Nicephore Niepce

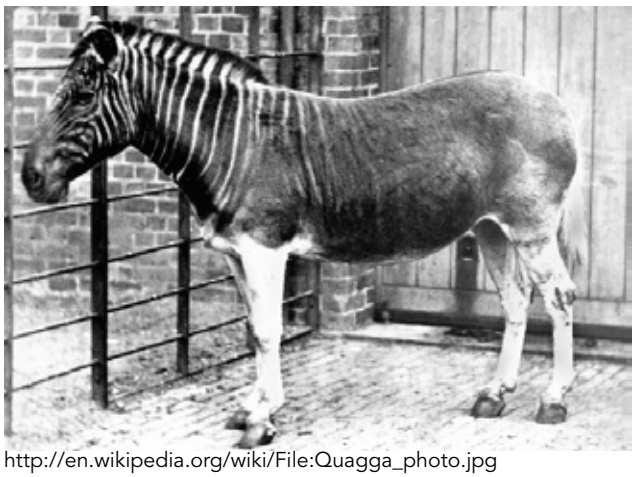


http://en.wikipedia.org/wiki/File:View_from_the_Window_at_Le_Gras,_Joseph_Nicéphore_Niépce.jpg

- 1838 First ever photo of a human (10 minute exposure) – by L. Daguerre

http://en.wikipedia.org/wiki/File:Boulevard_du_Temple_by_Daguerre.jpg

- 1870 First photo of endangered species – captive Quagga, London Zoo

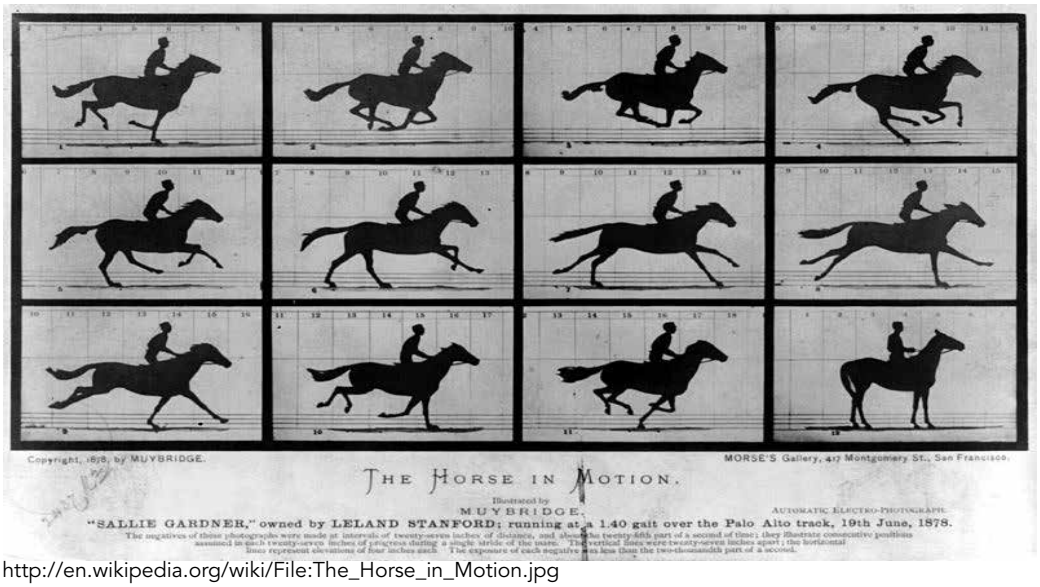


http://en.wikipedia.org/wiki/File:Quagga_photo.jpg

- 1872-1876 First scientific use of photography – C. Newbold, a Corporal in the Royal Engineers was part of the HMS Challenger expedition to Antarctic waters and used photography to document Rockhopper penguin colonies on Kerguelen Island.

http://www.aucklandcity.govt.nz/dbtw-wpd/virt-exhib/hochstetter/photography/rotorua.html

- 1878 First cameras triggered by animal movement – E. J. Muybridge photographed a galloping horse, the first animal movement studies.

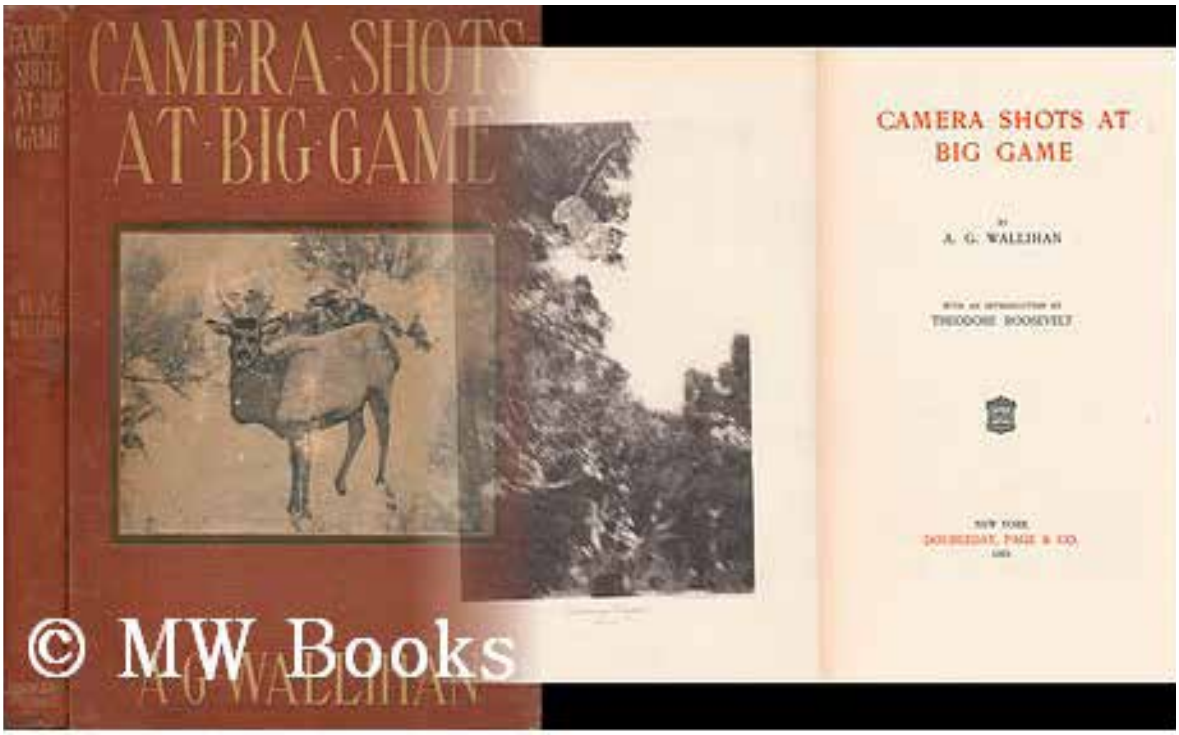


http://en.wikipedia.org/wiki/File:The_Horse_in_Motion.jpg

- 1890 First remote wildlife photos – George Shiras developed a baited trip wire trigger and flash unit to take photos of deer that won a gold medal at the 1900 Paris World Exhibition; his photos of wildlife have featured in National Geographic magazine.

http://cameratrapcodger.blogspot.com/2010/01/camera-trap-pioneers-george-shiras-3d.html

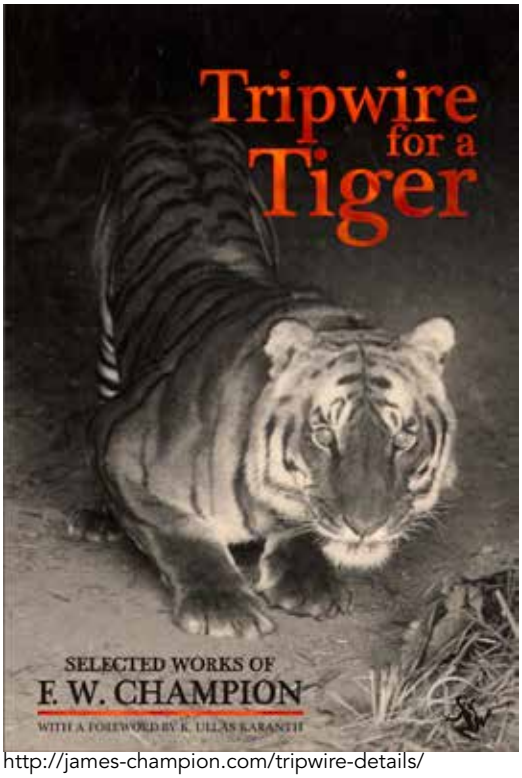
- 1899 Zoological Photographic Club founded
- 1900 4 million camera owners in the United Kingdom
  - Oliver Pike develops a "Bird-land camera", "specially designed for Natural History Photography"
- 1901 A. G. Wallihan publishes "Camera Shots at Big Game" featuring photos of wildlife in the Rocky Mountains, USA.



http://www.mwbooks.ie/amazoneu/152138.main.jpg

- 1903 – 1927 Increasing attempts to have animals take their own photos
- 1903 Carl Shillings publishes photographs wildlife in East Africa
- 1926 First guide to outdoor photography

- 1927 Frederick Walter Champion develops cameras triggered by trip wires to photograph tigers in India



http://james-champion.com/tripwire-details/

- 2nd half of 20th Century - Development of smaller, more portable systems
- 1956 Gysel and Davis published plans for a remote camera for wildlife
- 1959 Pearson developed trigger system using a light beam
- 1960 Dodge and Snyder produced plans for a lighter system using a car battery (22kg!)
- 1964 Coombs proposed a system with 420 exposures, instead of just 36, to extend field deployment time
- 1965 Cowardin and Ashe made a timer system to take a photograph every 15 minutes to count waterfowl
- Stanley Temple used time lapse photography to record Peregrine falcon nesting behaviour
- 1981 Goetz refined flash and power systems and experimented with Polaroid film
- 1984 Seydak conducted a survey of rainforest mammals with 6 cameras with sequential placements in a 100 ha blocks for one month; he detected 14 species and estimated to population of bushbuck, and was able to identify individual leopards and honey badgers. He concluded that there is "*… a great potential for the photographic recording census technique as a versatile tool of qualitative research and general wildlife censusing.*"
- 1991 Cathew and Slater developed a pulsed infrared beam as a trigger for a survey of animal pollinators of flowering plants in Australia
- 1994 Mace used microwave motion detectors and passive infrared sensors to survey grizzly bears in Montana
- 1995 Karanth identified individual Indian tigers using natural marking in order to estimate numbers by means of formal Capture-recapture (CR) methods
- 1999 Cutler and Swan reviewed the camera trap literature and determined that the most common studies were of nest predation, feeding ecology, nest behaviour, and equipment evaluation, whereas the least common were those estimating population parameters.
- 2000s Despite high initial costs, camera trapping starts to become preferred over track surveys and direct counts, especially for rapid faunal surveys and for cryptic species. A wide range of topics start to be addressed across a wide range of species; topics such as

abundance and survival estimation, niche relations, habitat selection and the documentation of the presence of presumed extinct species.

- Developments have been driven by:
  - Electronic flash units
  - Smaller batteries
  - Digital photos
  - More durable units

    e.g. The Reconyx system is able to be deployed in the field for 4 months, taking 20,000 images in all weather conditions.

The future will see the development of smaller, longer-life units, including possibly web-based image processing whereby an online remote video streams images from a digital camera through a server to a desk-top computer, and data are used in more powerful analytical tools.

Animal-borne systems are one area of rapid development allowing direct observation of behaviour and the remote monitoring of conspecifics and other species. Such units may be linked to GPS (Global Positioning System) tags and to a wide range of sensors, providing geographically references behavioural and physiological information.

A Crittercam-wearing emperor penguin plunges into a dive hole at the Penguin Ranch research station in Antarctica. Crittercam video has revealed how some emperors hunt beneath the ice: They swim down deep, look up to see fish silhouetted against the glowing ice, then shoot up to snatch their prey.© Greg Marshall, http://www.nationalgeographic.com/crittercam/pcpenguin.html

4.3. Camera Trapping Case Studies

Workshop participants were invited to share their accounts of applying camera trapping for wildlife research. This section presents a brief summary of the case study presentations.

Snow Leopards in Mongolia

Based on the presentation by David Mallon and the information available in Janecka *et al*. (2011).

The endangered snow leopard (*Panthera uncia*) is a cryptic species persisting at low densities in relatively inaccessible terrain, factors that make it challenging to obtain robust estimates of abundance necessary to track population trends. Camera trapping has been used on a wide variety of wild, felids to derive estimates of density and population size. During 2007 a camera trapping survey of snow leopards was conducted in the Gobi Desert region of Mongolia. Eighteen camera stations were established in areas and run for 65 consecutive nights yielded a total of 1,114 camera trap nights. Forty-seven capture events provided a total of 120 photos, with 34/47 providing photos of individually identifiable leopards, equivalent to 0.63 individuals detected per 100 trap nights. Capture-mark-recapture analysis was performed using program CAPTURE under an assumption of population closure (see Appendix 1 Abundance Estimation for a definition of population closure). The population estimate for snow leopards is 4 adults (95% Confidence Interval 4-4), the precision of this estimate indicating that all the adult snow leopards present in the area were identified. Using the mean maximum distance moved by snow leopards between photographic captures, a one-half MMDM of 3.38 km was derived, giving an effective study area size of 264 km², and resulting in an estimated density of 1.5 adult snow leopards per 100 km².

Arabian Leopards in Oman

Based on the presentation by Hadi Musalam al Hikmani, and the information available in Spalton *et al*. (2006)

During 1997 to 2000 the first camera trapping survey for Arabian leopards (*Panthera pardus nimr*) was conducted in the remote 4,500 km² Jabal Samhan Nature Resrve in southern Oman. Twelve Trailmaster TM1500 camera traps were established, comprising eight permanent sites and four temporary placements, yielding a total 1,036 photo records and including 251 images of leopards – an average of one photo record of a leopard every 29 days. Seventeen individual leopards could be recognised: 16 adults (9 female, 5 male and 2 unsexed) and one cub. Long-term camera trapping at fixed sites enabled tracking of movements by individual leopards within and between wadi systems, enabled documentation of activities patterns indicating peak activity between 0200 and 0700 hours and a lull between 0800-1600 hours. Images recorded social behaviour such as scent marking, and importantly provided evidence of breeding with the detection of a cub. Camera trapping was essential to confirm the importance of the Nature Reserve for Arabian leopards. Ongoing camera trapping work in Oman includes the placement of camera traps near livestock carcasses to confirm scavenge and possible kills by Arabian leopards.

Camera Trapping in Saudi Arabia

Based on the presentations by Ahmed Boug and Torsten Wronski.

Camera trapping has been used in Saudi Arabia for general distributional surveys for Arabian leopard, and for specific studies of the behaviour of gazelles. To total of 65 camera traps were established for intensive survey work for Arabian leopards at two sites, An Namas and Bani Saad, in the Asir Mountains of south-western Saudi Arabia. Images confirmed the presence of ibex, striped hyaena, wolf, baboon, porcupine, caracal, ratel, hyrax, white-tailed mongoose, sand partridge, small-spotted genet, and feral donkeys in the area – but no images of Arabian leopards were obtained. However, during the survey period two Arabian leopards were killed by livestock herders in the region, suggesting the continued presence of leopards in the area, but are very low densities.

The communicatory significance of localized defecation sites of Farasan gazelle (*Gazella gazella*) was investigated using camera trapping. Gazelle on Farasan Island, in the southern Red Sea, have extensive dung middens and it was thought possible to use these middens to estimate the gazelle population size. Camera traps were placed at selected midden sites; a total of 599 midden sites were identified and camera traps located at 15 of these and monitored for 285 days yield a total of 6,840 camera trap hours. The photo records enabled the quantification of frequency of use, an the relative use by makes versus females, and provided evidence of inter-sex and territory holder communication, confirming the value of camera trapping for behavioural ecology research.

Camera Trapping in the United Arab Emirates

Based on the presentations by Amy Cockayne and by Greg Simpkins

Camera trapping has been used to monitor striped hyaena released in 2009 into the 41km² wildlife park at Sir Bani Yas, Abu Dhabi. All released animals have been monitored with VHF and GPS tracking systems, with camera trapping being used to monitor den sites and to record social behaviours. Reconyx PC800 Hyperfire Pro cameras have been deployed, using 12 AA batteries to give a field life of up to one year and a capacity to shoot up to two frames per second. Analyses are ongoing.

A total of nine camera traps have been established within five habitats in the Dubai Desert Conservation Reserve to assess wildlife diversity including feral cats, and to attempt to estimate the abundance of some key species within the reserve. A Reconyx camera has recorded some 6,000 images to date. Utilising the Buckview Image Management system, it has been possible to categorise images for viewing, then to create spreadsheets to group monthly data summarised by species, and to compile this data across the camera trap network.

Camera Trapping in Jordan

Based on the presentation by Ehab Eid

Staff of the Research and Survey Section of the Royal Society for the Conservation of Nature in Jordan have been using camera-trapping techniques in the Dana Biosphere Reserve since 2008, with a focus on investigating the use of waterholes by wildlife, and the assessment of tourism impacts. Camera trapping in Dana has proven useful to confirm the presence of rare species, to provide images for public awareness and education programmes, and to confirm the importance of artificial waterholes in supporting local biodiversity.

Camera Trapping in Sinai

Based on the presentation by Husan El Algamy

Camera trapping has been used by the Egyptian Environmental Affairs Agency for mammal surveys in Sinai. A total of six Trailmaster cameras have been placed for 12 months at a time within three grid systems providing different spatial scales. Data from 2,400 camera-days yielded 1,000 photographic captures of seven species: wolf, red fox, Blanford's fox, wildcat, hyaena, ibex and dorcas gazelle. This allowed the calculation of species-specific average probabilities of detection and provided presence records to enable habitat distribution modelling for the most common species, ibex, using the program MAXENT, in turn leading to the identification of movement corridors in the region.

4.4. Lessons Learned

In a hands-on session using a range of makes of cameras, groups of participants practiced setting up camera traps in wildlife enclosure areas around the workshop venue. Cameras were set up in the afternoon, left overnight, and collected the following morning. Any images captured were downloaded and, in an informal feedback session, group members displayed images and discussed any issues and key points that were raised by the practical exercise. Utilising the collective experience of the group, and with reference to the case study examples, a general discussion drew out some

key points. These are summarised below.

1. Camera trapping is a relatively inexpensive, efficient, and reliable method to obtain information about cryptic and/or rare species in relatively inaccessible areas over extended periods of time.
2. While photo captures can provide confirmation of the presence of species, and associated images for use in public awareness programmes, the technique has the capacity to derive detailed information on population parameters, distribution and behaviour.
3. Population parameters that can be derived from camera trapping include indices of relative abundance, robust estimates of density and population size using individual identification and mark-resight techniques (see also appendix on Abundance Estimation), confirmation of breeding and recruitment, survival rate estimation, and data on population structure.
4. Distribution data can be used in formal resource selection studies, applying either presence-only models, or use versus availability or presence/absence analyses to derive predictive maps of species distributions.
5. Behavioural data includes activity patterns, use of key sites such as dens or latrines, social behaviour, predator/prey and scavenging behaviours, and inter-specific (including human impact) interactions.
6. To maximise the value of camera trapping it is necessary to:
    a. Define the biological question to be answered first in order to see if camera trapping will be appropriate, and if so,
    b. Determine the appropriate methodology in terms of :
        i. Camera make and specifications (IR capacity, durability…)
        ii. Camera trap number and layout (e.g. grid, transect, etc)
        iii. Camera trap positioning (location, height, hazing, lures…)
        iv. Camera settings (e.g. inter-shot intervals, trigger sensitivity…)
        v. Duration of trapping and desired number of captures
        vi. Image collection and processing
    c. Understand in advance the appropriate type of analyses to be applied once the images have been captured so as to be sure the data is collected in the correct way for the chosen analysis to address the pre-defined question. Given that some camera trapping deployments may take place over several months, there is considerable incentive to ensure this is done correctly the first time.

4.5. Regional Co-ordination

The technical component of the workshop concluded with a discussion on how best to build on the camera trapping session in order to best utilise the regional expertise.

The following recommendations were made:

1. **Create a central database of images** (possibly with limited access)
    a. To assist in the identification of regional species
    b. To facilitate meta-analyses
    c. To complement bioregional planning initiatives
    d. To support public awareness programmes
2. **Regional coordination of survey design**
    a. To increase inter-project collaboration
    b. To facilitate inter-area comparisons
    c. To feed into bioregional planning
    d. To enable meta-analyses and evaluation of regional population trends for key taxa

3. **Develop a regional camera trapping website**
    a. To maintain a register of regional expertise and contact details
    b. To provide links to equipment reviews, equipment manufacturers, analytical software
    c. To host or link to a regional data base of images to facilitate online identification of regional species
    d. To provide or give links to new or existing technical manuals in English and in Arabic
    e. To provide links to camera trapping project outputs, such as peer-reviewed papers, published reports, conference abstracts and internal reports
    f. To advertise national workshops that may be open to wider participation
4. **A Regional Camera Trapping Contact Group** could be formed
    a. To implement the recommendations listed above
    b. To develop new initiatives

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APPENDIX 1. Abundance Estimation

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Why estimate population size?

Size and spatial distribution are fundamentals of ecology: how many and where?

Wildlife management objectives are often stated in terms of population size or trends.

However, an emphasis on population size is often misleading, since a single population estimate may be of limited value and often a series of estimates is required to track trends or measure responses.

Therefore the following questions must be asked:

- Do you need any indication of absolute abundance or density, or will some index of abundance suffice to address your objectives?
- What is the most appropriate method biologically and statistically?
- How much will it cost? Would the money be better spent addressing another question?

Conceptual framework

Two challenges: Observability and Sampling

$$\hat{N} = c / \hat{\alpha}\hat{\beta}$$

Where: $\hat{N}$ = general population size estimator

c = numbers actually counted

$\hat{\alpha}$ = estimate of the fraction of the total area sampled

$\hat{\beta}$ = estimate of the proportion counted

Density = number of animals per unit area

$$D = N/A$$

Where: D = density estimate
N = population estimate
A = total area of interest

Challenge is to define A

Observability (or detectability)

Concerns the estimate of β = *the probability of seeing an animal*

If $\beta < 1$, then not all animals are seen or counted, therefore partial detectability (most common situation)

$E(c) = \beta N$ *(expected value of a count = the proportion of the total population detected)*

Thus: $N = c/\beta$ or $\hat{N} = c/\hat{\beta}$ "hat" denotes an estimate

The majority of the effort in the development of population estimation methods involves

ways to estimate β. There are two general approaches:

1. β estimated on a subset of sample units, e.g. double sampling

   e.g. *aerial survey and ground count(breeding ducks) on a subsample of sampling units to correct for incomplete detection by establishing a linear relationship between the ground and aerial counts to adjust the aerial counts on units sampled only by air; assumes ground count β =1*
2. β estimated on all sample units, e.g. multiple observers; distance sampling; marked sub-populations

Sampling

Concerns α = the fraction of the total area that is sampled

Not often able to apply survey methods to the entire area of interest,

therefore the sample area chosen = α = the fraction of the total area

If β = 1 (all individuals detected – unusual case)

$E(c) = \alpha N$ *(expected value of a count = the proportion of the total population counted)*

Thus: $N = c/\alpha$ or $\hat{N} = c/\hat{\alpha}$

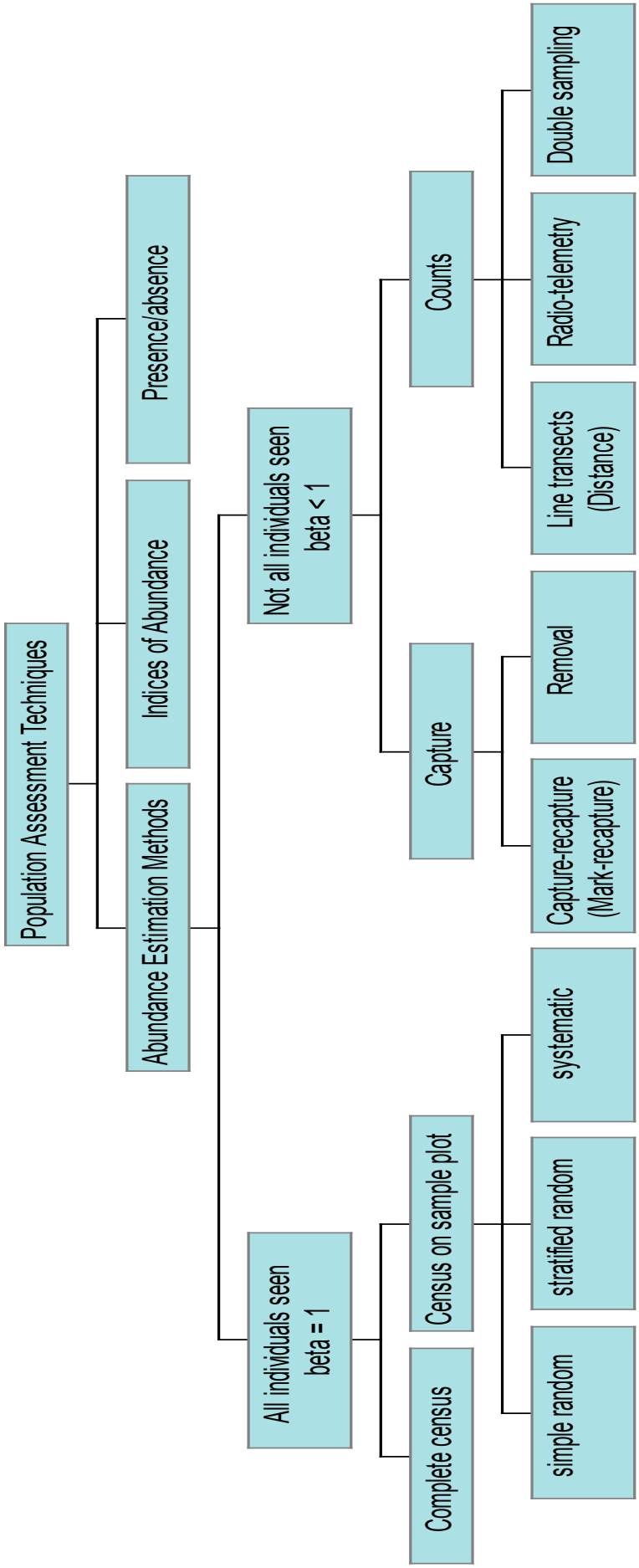
Population Estimation Methods (see figure following page for complete overview)

- Indices = any measurable correlative of density
- Sampling Concern, i.e. all individuals are seen, i.e. β = 1,
  - Complete census = Total count

    $N = c;\ \alpha \& \beta = 1$
  - Sample census (total count on sample plots)

    $N = c/\alpha$
- Observability Concern, i.e. not all individuals are seen, i.e. β < 1
  - Capture-recapture methods
    - Lincoln-Petersen
    - Jolly Seber
  - Counting methods
    - Line transects

Framework for abundance assessment



Population Abundance Indices

- Not an estimate of animal abundance, rather a correlative of abundance
- Use to compare between populations at the same location at different times, or between different populations at the same time

$$E(I) = \beta N, \text{ i.e. expected value of the index = observability of N (=detectability)}$$

- Therefore, constant proportion index; observability not vary over time or space.

First consider the objectives of the study: Will an index of abundance suffice?

Population Abundance Indices involved less effort and expense, but permit only weaker inference about population status and trends.

Relationship of I (Index value) to N (Population size)

- Typically +ve, i.e. an increase in N or D produces an increase in I
- Should be monotonic over reasonable values of N
- Non-monotonic index virtually useless, e.g. bird call rates may be suppressed at high D; similarly bobcat scent marking rates decline at high D
- Linear index is usually assumed, but non-linear is possible, although the form of the relationship must be understood
- Non-zero intercept is possible, i.e. a lower threshold of detectability
- I must be precise, i.e. value of I shows little variation at given D or N
- Non-homogeneous slope possible, e.g. habitat specificity; different detectability
- Many indices based on actual counts of animals seen, caught or heard, but for others I may not represent numbers of animals

Calibration and testing assumptions

All indices assume constant β, but few studies test this assumption explicitly (many studies seem unaware that this is a key assumption)

- In most cases variation in β due to exogenous variables, therefore need to collect index data under standard conditions, e.g. weather, time, observer
- Assumption of constant β is required for use of indices to compare population sizes, but data required to test assumption seldom collected.

Usual to assume that I is +ve, linear, and monotonic, but this is seldom confirmed. Therefore it is necessary independently to estimate population for several time periods/locations and examine regression of estimates on index values

- If constant proportion index, then linear relationship; intercept zero, and slope of the regression will estimate β

Total Population Census

$$N = c, \text{ i.e. population estimate = the no. actually counted}$$

(Note misuse of the term in the literature)

since

$$\beta = 1; \alpha = 1$$

seldom, if ever, achieved

Examples include:

- Drive counts
- Aerial photography of nesting seabirds
- Total territory mapping
- Thermal scanning during aerial surveys

Total Counts on Sample Plots

β = 1, *i.e. assume can count all individuals within each sample plot*

thus

$N = c/\alpha$

i.e. *pop estimator = no. actually counted, divided by the proportion of the area surveyed*

therefore concerned with plot-to-plot variation an extrapolate to make inferences about the larger area

$N = x\,S$;

where

x = *mean number of animals counted per sample plot*

$S = A$*(total area)/a (plot area) = total number of potential sample plots in* A

or

N = total number counted/α (proportion of the total area sampled)

and

$D = N/A$

Presence/Absence surveys (also misused as being apparently simpler/easier)
At simplest assumes β = 1, i.e. if animal present then it will be seen (is this reasonable?
Note: PRESENCE = method to calculate detectibility and % area occupied using repeat presence/ absence surveys at replicate sites (see later for software details).

Capture-recapture methods

Estimating abundance when not all animals can be counted.

Observability

Concerns the estimate of β If $\beta < 1$, then not all animals are counted

Thus 3 possibilities:

i. assume β varies randomly across time and space
ii. identify variables causing variation in β and model these
iii. estimate β directly

$$\hat{N} = c/\hat{\beta}$$

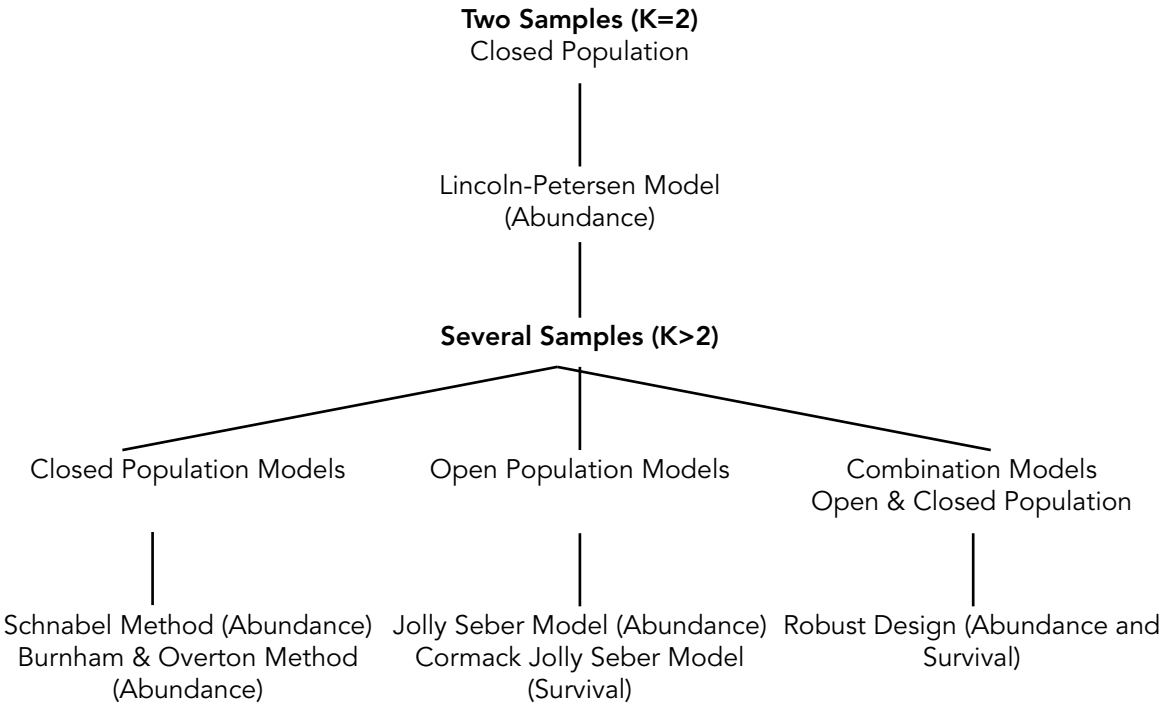
Therefore two approaches to the estimation of β:

- Capture-recapture (CR) methods
- Line transect methods (Distance Sampling) (see Part C)

Capture-Recapture (CR) Methods

Basic concept involves some number K>1 of discrete sampling occasions involving the capture and marking and release of a sample of animals; this sample is some unknown proportion of the wider (study) population. These animals then mix with the study population, and another sample of animals is caught or observed.

This results in a capture history for each animal, a vector of K ones or zeros, where 1=animal seen, and 0=animal not seen. Estimates of abundance and survival may be derived from capture histories. Different models are applied depending on the number of sampling periods; on whether populations are open or closed; whether marks identify individuals or are batch specific only, and whether an estimate of abundance, or survival, or both are required.



1. **Lincoln-Petersen Method (Petersen Method; Lincoln Index)**
   - LP estimator is basis for understanding virtually all capture-recapture estimators
   - Requires one capture and marking session and one recapture session: K = 2
   - Assumes closed population
   - Differences in catching effort between the two sessions has no effect on estimates
   - First used by Laplace in 1786 to estimate the population of France
   - Used by Lincoln in 1930 to estimate the abundance of waterfowl in North America; also associated with the work of C. J. G. Petersen, a Norwegian fish biologist, although he did not actually use CR data to estimate abundance

It is assumed that the proportion of marked animals in the second sample is the same as that in the study population, thus:

$$\frac{n_1}{N} = \frac{m_2}{n_2}$$

rearrange equality to give:

$$N = \frac{n_1 n_2}{m_2}$$

Where: n_1 = the number of animals first marked and released
n_2 = the number of animals caught in the second sample
m_2 = the number of marked animals in the second sample

Assumptions:

- Closed Population
  Critical assumption: No gains (births or immigration); No losses (deaths or emigration)
- Marks are not lost nor overlooked
  Marking loss or misidentification will positively bias the estimator
- Marking does not affect mortality or behaviour
  If identifying animals from photos using natural markings then this assumption is upheld, and it is likely that artificial marking , such as ear tags, will not affect the likelihood of an animal being photographed.
- All animals are equally trappable (homogeneity of capture)
  Capture probabilities do not need to be the same for the two samples, but within each sample all animals are assumed to have the same probability of being caught. Two possible violations:
  - Members of sampled population heterogenous with capture probability
  - Trap response (shy/happy)

Chapman's equation: refinement of LP index (equation above) to eliminate statistical bias:

Variance is calculated using Seber's method:

$$\hat{N} = \frac{(n_1+1)(n_2+1)}{m_2+1} - 1$$

Therefore, 95% confidence intervals will be:

$$\hat{\text{var}}(\tilde{N}) = \frac{(n_1+1)(n_2+1)(n_1-m_2)(n_2-m_2)}{(m_2+1)^2(m_2+2)}$$

(1.965 is an acceptable approximation for most purposes; exact values are derived from

$$95\%CI = \pm 1.96\sqrt{\hat{\text{var}}(\tilde{N})}$$

critical values of the t-distribution and will vary with sample size)

Example: Red foxes,

Caught and tagged (or identified in photos) on first occasion: 6 (n_1)

Total photographed subsequently: 10 (n_2), of which 5 (m_2) were identifiable

Therefore:

LP Index	N = 6 x 10/5 = **12**;
Chapman's	$\hat{N}$ = ((7x 11)/6) – 1 = **11.8**;
Variance	$\hat{var}$ = 1.5
95% CI	= + 2.4
Estimate	$\hat{N}$ = **12 (10 - 14)**

Multiple resighting sessions allows examination of variation in estimates and derivation of a combined estimate of greater precision, thus you could calculate the arithmetic mean of the Chapman's estimates. The 95% confidence intervals are calculated using the standard error of the mean to look at variation across the estimates, thus:

95% CI + 2.447 (SEM = SD/sq. rt. n resight estimates) = ±

A more robust approach when there are multiple resighting sessions applies a hypergeometric estimator (there's a program that can do this for you: NOREMARK).

Other CR Methods in brief:

2. **Schnabel Method**
   - Same assumptions as for LP index, but appropriate for several capture sessions, i.e., where unmarked animals in each capture sessions are marked before release.
   - Estimate based on the increasing proportion of marked animals caught as the total number animals marked increases, therefore when proportion = 1.0, the total number of marked animals = the total population.

3. **Burnham & Overton Method**
   - Allows animals to differ in capture probability
   - Information used to estimate population size is number of animals caught exactly 1, 2, 3, and 4 times over entire study (study must comprise 4+ sample periods).
   - Assumes capture probability does not change over time (trap shyness)
   - Makes 4 different estimates of population size and tests successive errors to choose the best.
   - Requires high capture rates to achieve precise estimates

4. **Removal Method**
   - Only methods that can be used in closed populations where there is a trap response, i.e. trap-shy/trap happy
   - Not strictly a mark-recapture method as does not use recaptures.
   - Used where trapped animals are removed from the population, therefore based on the rate of decline in numbers trapped.

5. **Jolly-Seber Method**
   - Method of choice for open populations
   - Requires 3+ samples taken and marks that are at least batch specific to derive capture histories

6. **Cormack Jolly-Seber Metho**
   - Used to estimate the survival of tagged individuals
   - Assumes that there is the same probability of survival within a given time period.

7. **Robust Design**
   - Used to calculate both population size and survival but minimises the sample correlation between density estimation and survival estimation
   - Uses primary period for capture and marking, with primary period spaced widely (a month) apart, to estimate survival
   - Uses secondary periods for recaptures spaced more closely together (e.g. daily for a week) to estimate density

8. **DENSITY**

- As indicated above, variety of methods to estimate N from capture-recapture and removal studies. N often treated as surrogate for D (density), or converted to D by an estimate of the effective trapping area (A), but A difficult to define or to measure accurately, thus estimates of D based on A are distrusted.
- New method (see software) uses mean distance between successive capture on a trapping grid to derive a detection function (see Distance Sampling next section), assuming a declining probability of capture the further a trap is from the centre of an animal's stable home range.

Free Software for Abundance Estimation

CAPTURE http://warnercnr.colostate.edu/~gwhite/mark/markhelp/programcapture.htm

This software, which may be run from program MARK, computes estimates of capture probability and population size for "closed" population capture-recapture data.

White, G.C., K.P. Burnham, D.L. Otis, and D.R. Anderson. 1978. User's Manual for Program CAPTURE, Utah State Univ. Press, Logan, Utah.

Rexstad, E., and K.P. Burnham. 1991. User's Guide for Interactive Program CAPTURE. Colorado Cooperative Fish & Wildlife Research Unit, Colorado State University, Fort Collins, Colorado.

PRESENCE www.proteus.co.nz/home.html

This software estimates the probability a site is occupied by a species (and related parameters), given that the species will not always be detected with certainty, even when present. The method is detailed in MacKenzie et al. (2002).

MacKenzie, D.I., J.D. Nichols, J.E. Hines, M.G. Knutson and A.D. Franklin. 2003. Estimating site occupancy, colonization and local extinction when a species is detected imperfectly. Ecology 84: 2200-2207.

Jennelle, C.S., M.C. Runge and D.I. MacKenzie. 2002. The use of photographic rates to estimate densities of tigers and other cryptic animals: A comment on misleading conclusions. Animal Conservation 5: 119-120.

MacKenzie, D.I., J.D. Nichols, G.B. Lachman, S. Droege, J.A. Royle and C.A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83: 2248-2255.

DENSITY www.otago.ac.nz/density/index.html

Program DENSITY is a Windows application for mark-recapture estimation of animal population density and related parameters. DENSITY implements the method of Efford (2004) for estimating absolute population density from closed-population samples. DENSITY also provides: a graphical interface for calculating closed-population estimates; a simulator for spatial mark-recapture sampling; a tool for developing new trap layouts; conventional estimation of density by the boundary-strip method; simple open-population analyses.

Efford, M. G. 2004. Density estimation in live-trapping studies. Oikos 106, 598–610.

NOREMARK http://welcome.warnercnr.colostate.edu/~gwhite/software.html

NOREMARK computes estimates of population size for a population with a known number of marked animals and 1 or more resighting occasions. Four different estimators are provided: joint hypergeometric maximum likelihood, immigration/emigration joint maximum likelihood, Minta-Mangel bootstrap procedure, and Bowden's estimator. Simulation procedures for determining estimator performance and necessary sample sizes are also provided.

White, G. C. 1996. NOREMARK: population estimation from mark-resighting surveys. Wildlife Society Bulletin. 24:50-52.

APPENDIX 2. Participant List

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