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EFFECTIVENESS OF PROTECTED AREAS IN MAINTAINING BIODIVERSITY AND REDUCING HABITAT LOSS

Systematic Review Protocol

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1. Background

Protected areas cover around 10.1-15.5% of the planet's land surface (Soutullo 2010) and are perhaps the most important tool available to conservationists and other stakeholders to maintain habitat integrity and species diversity in a rapidly changing world (Andam et al. 2008; Brooks et al. 2004; Bruner et al. 2001a; Butchart et al. 2010; Coad et al. 2008; Jenkins and Joppa 2009; Rodrigues et al. 2004b; Rodrigues 2006). Besides protecting biodiversity and habitats, protected areas are also increasingly recognised for their role in protecting ecosystem services such as carbon, pollination, water, climate and soil stabilisation, and various timber and non-timber products (Armsworth et al. 2007; Hockings 2009; Kearns et al. 1998; Klein et al. 2007; Naidoo et al. 2008; Raudsepp-Hearne et al. 2010; Ricketts 2004; Schroter et al. 2005).

However there is considerable debate on the extent to which protected areas deliver conservation outcomes in terms of species and habitat protection (Andam et al. 2008; Brooks et al. 2006; Ferraro 2001; Ferraro & Simpson 2002; Meir et al. 2004; O'Dea et al. 2006; Rodrigues et al. 2004b; Whittaker et al. 2005). It has been suggested that many of the worlds protected areas are present only 'on paper', having no effective management on the ground (Chape et al. 2005; Joppa et al. 2008) . Measuring the effectiveness of protected areas is hindered by a lack of quantitative data. Information on protected areas management is sparse; of the worlds 113,000 protected areas management data has been systematically collected for only 8,500 sites (Butchart et al. 2010), and few protected areas have collected long-term datasets for species populations. There has therefore been little quantitative research on the outcomes of protected area management in relation to the protection of biodiversity and habitats (Dudley et al. 2004; Ervin 2003; Ewers & Rodrigues 2008; Quayle & Ramsay 2005), and there is also a lack of consensus on how these outcomes might best be measured (Bleher et al. 2006; Fazey et al. 2006; Parr et al. 2009; Roman-Cuesta and Martinez-Vilalta 2006). A better understanding of the ability of protected areas to deliver conservation outcomes in terms of species protection and habitat preservation is essential to ensure that protected area and conservation funds are being spent in an optimal way (Brashares and Sam 2005; Brooks et al. 2004; DeFries et al. 2007; Kapos et al. 2008; Kapos et al. 2009; Kleiman et al. 2000; Margules and Pressey 2000; Myers et al. 2000; Rodrigues 2006), and the impacts of protected area management practices and governance can be fully understood, allowing for adaptive management.

Protected area effectiveness in preserving species:
Most studies of species protection to date have focused on the measurement of the representativeness of protected area networks in terms of their coverage of species diversity, endemic species or threatened species (Catullo et al. 2008; Maiorano et al. 2006; Rodrigues et al. 2004a; Rodrigues and Gaston 2001). There are examples of protected area gap analyses at global (Rodrigues et al. 2004a), regional (Rouget et al. 2007), national (Larsen et al. 2008) and sub-national levels (Gallo et al. 2009). Gap analyses can be used to inform the design of protected area networks and increase the ecological representativeness of global, regional and national reserves networks. However, they do not provide information on the ability of these reserves to effectively protect and preserve species. Few studies have looked at whether protected areas have been able to maintain species diversity and populations better than if the areas has not been protected in the first place. For instance, several authors have

shown greater species richness in parks compared to surrounding areas (Brashares et al. 2001; Caro et al. 2009; Growcock et al. 2009; Larsen et al. 2008; Lund 2002; Newmark 1995; Rodrigues et al. 2004a) and Gardner et al. (2007) have shown higher species abundance in Protected Areas compared to surroundings; but without information on the temporal trends these studies do not allow an assessment of Protected Areas as a viable conservation strategy. A few studies have gathered data on species changes to assess if trends of increase or decline are higher or lower within protected areas in comparison with surrounding non-protected areas (Evans et al. 2006; Newmark 1987; Stoner et al. 2007a; Stoner et al. 2007b; Western et al. 2009). However none have looked across studies to evaluate whether any general patterns emerge in PA's ability to preserve and protect biodiversity or attempted to link biodiversity changes with the effects of management.

Protected area effectiveness in preserving habitat:
Most studies of the effectiveness of protected areas in preserving habitat have focused on protected area effectiveness in preserving tropical forest in developing counties. This is largely because remote sensing methods struggle to accurately resolve subtle changes in non-forested habitats where seasonality can be a bigger influence on the remote sensing image than the actual changes in habitat (Nagendra and Rocchini 2008). The most common method of measuring effectiveness has been the use of a buffer-analysis, comparing deforestation rates inside protected areas with the immediate surrounding area (Achard et al. 2002; Gaveau et al. 2007). More complex analyses aim to compare deforestation rates within protected areas with comparable habitat outside, using a landscape modelling approach (Andam et al. 2008; Bruner et al. 2001b; Nelson and Chomitz 2009).

Although there is debate in the literature and we have not yet conducted a comprehensive review, it does appear that the bulk of evidence indicates that protected areas, in general, do help reduce the rate of deforestation (Achard et al. 2002; Cropper et al. 2001; Gaveau et al. 2007; Kinnaird et al. 2003; Pelkey et al. 2000). Very recently Joppa and Pfaff (2010) conducted a review of methods used to evaluate effectiveness of Protected Areas in reducing forest loss. The review, though not disputing Protected Areas have a role in protecting forests, states that effects are often overestimated. Hence, whilst protected areas may reduce the rate of deforestation inside the protected area compared to outside, forests may still be cleared at high rates both in- and outside of the protected area (Clark et al. 2008; Sommerville 2005).

Therefore the existence of a protected area does not necessarily result in reduced deforestation. Protected area funding, staffing, planning, infrastructure and community involvement, among other protected area characteristics, may influence the ability of a protected area to reduce deforestation rates within its boundaries (Leverington et al. 2010). Although there are a number of studies which have measured the effectiveness of individual reserves or reserves networks e.g. (Gaveau et al. 2007; Songer et al. 2009), none have been able to rigorously analyse which protected area characteristics appear to be influencing their effectiveness in combating deforestation and degradation, often due to sample size limitations. There is therefore potential for this systematic review to include a meta-analysis of individual studies, investigating whether there are any key protected area characteristics which influence effectiveness.

In conclusion, even though a synthesis, highlighting the challenges of Protected Area function, has been published (Gaston et al. 2008), no systematic collection of case studies or available knowledge has been produced on the impact of protected areas on delivering conservation outcomes in terms of species diversity, species abundance and populations trends, or habitat changes over time. This systematic review will bring together and review the state of knowledge from peer reviewed papers, and the critical grey literature derived from practical conservation work in the field. It will use meta-analysis techniques to address the question of how protected areas perform in the conservation of biodiversity.

2. Objective of the Review

2.1 Primary question

What evidence is there that terrestrial protected areas have maintained biodiversity.

Population: Temporal biodiversity or habitat trend measures
Input data: Any type of management as defined in the individual study.
Comparator 1: Inside/outside protected area comparison*
Comparator 2: Attributes of protected area**
Comparator 3: Management effectiveness of protected area***
Outcome: Positive effects on species or habitat measurements

* Within reserve and outside reserve comparison of reserves matched by habitat types and social attributes

** Protected area characteristics (e.g. ownership, IUCN category, age, spatial characteristics (e.g. proximity to roads and urban areas, altitude, slope, habitat, nation/region and background rate of deforestation and degradation), and human activities) influence protected area effectiveness in conserving biodiversity

*** Elements of management effectiveness such as staffing, budgets, management plan, community outreach programme, and as defined in studies identified by the systematic review search.

3. Methods

3.1 Search strategy

We will search for papers written in English, French, and Danish. If possible we will extend this to the Spanish literature.

A number of relevant terms and descriptive words have been compiled from the referenced literature and derived directly from the questions addressed in the review. Boolean nomenclatures '*'= all letters will be allowed after the *, will be used on the root of words where several different endings will apply and Boolean'$' where only one letter changes

are relevant. Compilation of different terms and words has then been grouped into search criteria using Boolean separators where terms are either exclusive or inclusive:

TERMS:

English: Conserv*, Biodiversity, Monitoring, Management, Deforestation, Forest*, Degradation, Effectiveness, Outcome$, Effect$, Success*, Species, threatened species, threaten*, Trend$, Endemic$, Composition, Red$list, threaten*, endanger*, decline*, bird$, mammal$, amphibian$, reptile$, plant$, Habitat*, Destruction, Output, Governance, Protected, Area$, National*, Park$, National$park$ Reserve*, Communit*, Conserved*, Indigenous$People, community$conserv*$area$.

Danish: naturforvaltning, biodiversitet, monitering, forvaltning, afskovning, skov, forvaltningseffektivitet, succes, arter, truede$arter, trend*, truede*, endemisk*, rødliste*, sammensætning, fugl$, pattedyr$, padde$, krybdyr, plante$ habitat, ødelæggelse, beskyttede$område*, beskyttede*, nationalpark, reservat*

Spanish: Conservación, Biodiversidad, Seguimiento, Gestión, La deforestación, Bosque$, Selva$, Silvestre, Forestales, La degradación, Eficacia, La eficacia, Resultado$, Resulta$, Efect*, Éxito, Éxito, Un Éxito, *Especi*, specia, Las especies en amenaza, Tendencia$, Endémica$, composición, Lista$rojo, Amenaza*, En$ amenaza, Poner en peligro*, *Disminución, Ave$, Mamífero$, Anfibio$, Reptil*, Planta$, Hábitat*, Destrucción, *Salida*, Gobernabilidad, Protegida$, Área$, Zona$, Nacional*, Parque$, Parqu$$naci$nal*, Reserva$, Comunid*,*Conserv*, *Preserv*, PersonaIndgena*, área de conservation de la comunidade, áreas de conservation de las comunidades

French: Conservation, Biodiversité, Surveillance, Gérance, Déboisement, Forêt*, Boisé, Dégradation, Efficacité, Résultat$, Effet$, Succès, Réussi, Espèce$, Espèce$menacé$, Tendance$, Endemie$, Composition, Liste$rouge, Menac*, En voie de disparition, En voie d'extinction, Déclin*, Oiseau$, Mammifère$, Amphibie$, Reptile$, Plante$, Habitat*, Destruction, Production, Gouvernance, Protégé, Région$, Zone$, Nation*, Parc$, Parc$nation*, Réserve*, Communaut*, Préserv*, Gens$Indigènes, Zone$préservé$d'une$communauté, Zonedeconservation$d'une$communauté

GROUPING OF RELATED SEARCH-TERMS:

1. Biodiversity OR species OR trend$ OR Threaten* OR Threatened$species OR Endemic* OR Species$Composition OR Red$list* OR Red$listed$Species OR Monitoring OR decline OR bird$ OR mammal$ OR amphibian$ OR reptile$ OR plant$
2. Habitat$destruction OR Habitat$degradation OR Deforestation OR Forest$degradation OR
3. Conservation outcome OR Conservation success OR Conservation effect OR Conservation output
4. Management OR Management effectiveness OR Governance

5. Protected$Area* OR National$Park* OR Park* OR Reserve* OR community$conserved$area OR indigenous$area* OR Forest$reserve*

COMBINING GROUPINGS

Biodiversity focused search: 1 AND 3 AND 4 AND 5
Forest change focused search: 2 AND 3 AND 4 AND 5

SEARCH ENGINES USED IN THE REVIEW:

General sources:

- ISI Web of Knowledge
- BIOSIS citation index
- Zoological records
- ASFA
- SCRIS
- Science Direct
- Directory of Open Access Journals
- Index to Theses Online
- CAB abstracts
- COPAC
- University of Oxford Libraries
- SCOPUS
- ProQuest Dissertations and Theses http://www.il.proquest.com/

Specialist sources:

- World Environment Library http://www.nzdl.org/fast-cgi-bin/library?a=p&p=about&c=envl
- Forestscience.info http://www.forestscience.info/
- Tropical forest conservation and development database http://forestry.lib.umn.edu/bib/trps.html
- Conservationevidence.org
- UN-REDD Web Platform http://unfccc.int/methods_science/redd/items/4531.php
- FAO online catalogue: http://www4.fao.org/faobib/

Websites:

- Google/Yahoo/chrome
- Google scholar
- IUCN website
- WWF website
- FAO website
- UNEP website
- CIFOR website
- Woods Hole research centre
- Conservation International
- WCS
- World Bank
- UNDP
- WCPA

3.2 Study inclusion criteria

All studies including temporal biodiversity or habitat changes accruing inside protected areas will be included. Studies describing changes inside and outside protected areas will also be included in the review. Since the total literature base for this review is expected to be fairly limited strict a priori exclusion criteria is not appropriate.
Temporal biodiversity and habitat change: only studies with trends specifically relating to the protected area, and not the species or habitat type will be included.
Management: the review will primarily include studies which measures management interventions, which will be any action or premise by area managers, NGO's or governmental officials that has the potential to change the conditions after the establishment of the protected area.
Protected Area: will not be a priori defined, but related to the individual studies and the management practices within its boundaries.
The protocol will be checked for consistency using a Kappa analysis (Edwards et al. 2002).

- **Relevant subject(s):**
  - Protected areas globally, regionally, nationally, locally
  - Habitat change (loss and gain)
  - Forest habitats (for deforestation and degradation studies).
  - Terrestrial species trends and diversity changes (mammal, bird, reptile, amphibian, plant)
- **Types of intervention:**
  - Protected area.
- **Types of comparator:**
  - Unprotected comparable habitat in similar landscape surrounding protected areas
  - Characteristics of protected area in terms of age, location, size, IUCN category, habitat type, etc
  - Management effectiveness of protected areas (using various tools including RAPPAM, METT, ProArca etc).
- **Temporal biodiversity change (outcomes):**
  - Differences in species diversity inside and outside protected areas
  - Changes in species numbers and abundance over time
  - Changes in species compositions and number of threatened species.
  - Changes in rate of deforestation or forest degradation
  - Time series analyses of before and after protected area creation
- **Types of study:**
  - All studies that deals with evaluating the effects of protected areas on habitat loss and biodiversity indicators.
  - Studies that deal with evaluating conservations efforts either global or site specific studies.

3.3 Potential effect modifiers and reasons for heterogeneity:

Protected area characteristics:

- Shape, size, location, area to perimeter ratio
- Date of establishment
- Management (can be measured using IUCN management category system)
- Governance (can be measured using IUCN governance category system)
- Capacity (funding, staffing)
- Biodiversity data

Landscape characteristics:

- Base deforestation rate
- Proximity to urban areas/roads
- Habitat type
- Diversity of habitats within protected areas

National and regional scale:
Country, region, WB development index

3.4 Study quality assessment

All studies, reports and papers assessed in the systematic review will first be screened by one reviewer for 1) Subject comparability; 2) Types of questions being proposed; 3) Data, review or essay driven analyses, and 4) quality of the methodology and type of data.

To ensure that studies of good quality are included in the systematic review, an analysis of experimental deigns methods will be carried out. Each study will be scored in terms of methodological rigour, following the methods outlined in Pullin and Knight (2003). We are keen to include studies that have used a well-defined method for assessing impact, by defining baseline figures for their metrics, such as measurement of deforestation rates/biomass/carbon over time, or comparison of rates with a control area of similar characteristics. Where a number of high-quality analyses are available, others with less rigorous methods may be rejected from the review. However, for topics where literature is scare, this may not be possible.

3.5 Data extraction strategy

Data will be extracted to spreadsheets designed as part of the review, including information on:

1. Location
2. Study site characteristics (e.g. forest, grassland etc)
3. Intervention (e.g. protected area)
4. Measures (e.g. deforestation, species populations and diversity),

5. Methodology (e.g. temporal and spatial comparisons - buffer analyses, time-series),
6. Sources of bias
7. Outcomes (e.g. deforestation rate, changes in species population over time/space),
8. Notes and references.

Methods for data extraction and synthesis will be refined during the early phases of the review. The protocol will be amended as this process is undertaken.

3.6 Data synthesis and presentation

Information from each selected study will be synthesised in a spreadsheet, as outlined in section 3.5. This spreadsheet will be made available in the final review as an online appendix.

Where possible, meta-analyses will be carried out to further understand the predictors of protected area effectiveness in reducing deforestation and conserving species.

The review will present the methodologies currently in use to assess protected area effectiveness, followed by a review of the findings of the studies; this may be divided into geographic region, or by predictor (IUCN category, management, governance etc), depending on data availability. Common predictors of protected area effectiveness will be illustrated using figures and tables.

A discussion section will focus on 'lessons learned' in terms of methodologies used to measure protected area effectiveness, and conservation actions which appear to be increasing protected area effectiveness. The review will also highlight information gaps which call for further research and monitoring programs

4. Potential Conflicts of Interest and Sources of Support

None known. People involved are supported by their home institutions.

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