A thesis submitted to the Department of Environmental Sciences and Policy of Central European University in part fulfillment of the Degree of Master of Science

Assessing biodiversity threat mitigation efficacy: A case study of Kakum Conservation Area (2004 to 2012)

Brittny Dawn ANDERSON

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Budapest

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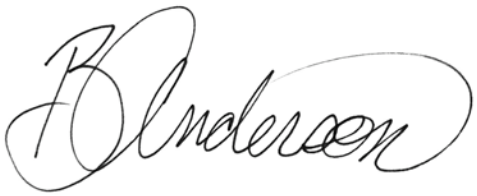

Brittny Dawn ANDERSON

CENTRAL EUROPEAN UNIVERSITY

ABSTRACT OF THESIS

Submitted by:
Brittny Dawn ANDERSON for the degree of Master of Science and entitled: Assessing biodiversity threat mitigation efficacy: A case study of Kakum Conservation Area (2004 to 2012)

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Protected Areas (PAs) are a vital component of conservation strategies intended to preserve the natural environment from the current environmental crisis. The establishment of a PA does not guarantee preservation; effective management strategies are necessary to ensure conservation objectives are fulfilled. An evaluation of management strategies is important to determine effectiveness, reveal successes and highlight areas where further effort and improvement is necessary. The objective of this research is to assess the effectiveness of threat mitigation in KCA by management staff from 2004 to 2012. A Threat Reduction Assessment (TRA) uses threats as a proxy measurement of biodiversity and is a useful tool where a paucity of data exists. The modified TRA used in this research revealed nine threats to biodiversity in Kakum Conservation Area, Ghana and determined an overall 44% reduction of threats to biodiversity from 2004 to 2012. The geospatial component introduced here, illustrated the spatial changes of each threat over the temporal period. The most critical threats to biodiversity in KCA are community-based. Management strategies employed to mitigate community-based threats have caused a reduction of these threats since 2004. However, threats driven by globalization and development have emerged and increased over the temporal period and have not been effectively mitigated by KCA management. KCA has been effective in allocating their limited resources to mitigate threats that are most harmful to biodiversity in KCA.

Keywords: Modified Threat Reduction Assessment (TRA), threats to biodiversity, Kakum Conservation Area, Kakum National Park, Ghana, protected area, geospatial representation of threats, monitoring

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LIST OF ABBREVIATIONS

AARR	Assin Attandanso Resource Reserve
CBD	Convention on Biological Diversity
CEPA	Conservation Education and Public Awareness
CITES	Convention on the International Trade in Endangered Species of Wild Flora and Fauna
DPSIR	Driving forces, Pressure, State, Impact, Response
FC	Forestry Commission
GHCT	Ghana Heritage Conservation Trust
IUCN	International Union for the Conservation of Nature
KCA	Kakum Conservation Area
KNP	Kakum National Park
PA	Protected Area
PAMAB	Protected Area Management Advisory Board
RAPPAM	Rapid Assessment and Prioritization of Protected Areas Management
TRA	Threat Reduction Assessment
WCPA	World Commission on Protected Areas
WD	Wildlife Division
WPA	Wildlife Protected Area
WWF	World Wide Fund for Nature

CHAPTER 1 - INTRODUCTION

1.1. Background

Conservation initiatives have been expanding globally to address the current environmental crisis. Protected areas (PAs) are created as part of conservation strategies to protect the environment and reduce the loss of biodiversity, which provides many ecosystem services locally and globally (Lockwood *et al*. 2006). The establishment of a PA does not ensure the protection of the ecosystem within the boundaries of the PA. The employment of effective management strategies is necessary to ensure that a PA fulfils its written objectives. The development and deployment of management strategies are necessary to effectively supress biodiversity threats within a PA (Lockwood *et al.* 2006; Chape *et al*. 2005; IUCN-WCPA 2009). The evaluation of management effectiveness is crucial to enable PA management teams to target and refine their efforts, making the best use of limited financial and human resources.

The depletion of biodiversity is severe in West Africa. Ghana was a regional leader in conservation during the 1960s, but now faces the same conservation challenges that are present globally (Terborgh 2004). Kakum Conservation Area (KCA) has one of the highest levels of biodiversity richness of all the protected areas in Ghana (UICN/PACO 2010). KCA, like many other PAs in West Africa, is an island of biodiversity in a sea of cultivated land. KCA was originally established as a timber reserve with the additional objective of ensuring watershed protection for many communities including the regional capitol, Cape Coast (WD 1996). Once it was gazetted as a wildlife reserve, the management team at KCA has become endowed with the responsibility of protecting biodiversity. KCA management have actively been working to protect the PA from threats (Jachman 2008). However, the effectiveness of

their efforts has not been systematically evaluated in a thorough manner. The IUCN conducted an evaluation of management effectiveness in eight Wildlife Protected Areas (WPAs) in Ghana. The Rapid Assessment and Prioritization of Protected Area Management (RAPPAM) determined that poaching is the primary threat to wildlife in KCA and concluded that management effectiveness in Ghana needs to be improved (UICN/PACO 2010).

1.2. Justification and objective

The superficial assessment of KCA through the RAPPAM did not determine if threats were increasing or decreasing, leaving the opportunity for a further, more in-depth assessment. A more thorough assessment of biodiversity threat mitigation in KCA is a valuable contribution to academia. Additionally, the results could enable management staff to determine where further efforts and resources should be focused. The objective of this research is to assess the effectiveness of management to mitigate biodiversity threats in KCA from 2004 to 2012.

1.3. Organizational structure

First, the importance of biodiversity, the challenges of protecting biodiversity and initiatives employed to conserve biodiversity from human impacts will be discussed through a review of the literature, followed by a contextualization of the situation at Kakum Conservation Area in Ghana. To achieve the objective of this research, a modified Threat Reduction Assessment (TRA) will be employed and a geospatial component will be introduced and utilized, providing the theoretical framework. The TRA methodology is a simple yet effective tool that has been employed around the globe to measure the effectiveness of PA conservation efforts through the measurement of threats as a proxy to biodiversity (Salafsky and Margoluis 1999; Margoluis and Salafsky 2001; Mugisha and Jacobson 2004; Anthony 2008; Matar and Anthony 2010). The methodology will reveal, rank and map out the threats to biodiversity, determine their respective changes within KCA from June 2004 to June 2012. A review of

KCA documents and interviews with staff and community members will further explore the challenges of conserving biodiversity in KCA.

The research presented in this document is structured into 6 chapters. The second chapter is a literature review, which examines the necessity of conservation strategies in a global context, the challenges presented while striving to conserve biodiversity in PAs and finally discuss the importance of assessing management effectiveness. The third chapter discusses the methods used to collect the necessary data and empirical research. It also details the limitations of the research. The fourth chapter reveals the results of the research. The fifth chapter discusses the underlying causes of the threats, and its relevance, details the inconsistencies of the results compared to previous research, presents the contributions to research and makes future recommendations for application and research. The final chapter concludes the study.

CHAPTER 2 - LITERATURE REVIEW

The purpose of this chapter is to provide justification for the topic chosen for this study and the methodology employed to achieve the objectives of the research. This chapter will discuss the importance of biodiversity, the challenges of protecting biodiversity and initiatives employed to protect biodiversity from anthropogenic impacts. This will be followed by paragraphs intended to contextualize the situation of Kakum Conservation Area in Ghana and address the importance of management evaluation.

2.1. Biological diversity

The Earth's resources, on which all human and non-human life is dependent, are finite. Biodiversity, as a natural resource, provides basic materials such as food, medicine and fuel; and form the complex web of organisms that are essential for ecosystem services (World Conservation Monitoring Centre 1992). Biodiversity is defined by the United Nations in Article 2 of the Convention of Biological Diversity as: "variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (Lockwood *et al.* 2006, 12). The tropics are the most biologically wealthy regions but they are also regions with the highest levels of poverty and exploding populations, which increases stress on biological resources (Terborgh 2004).

Deterministic and stochastic processes cause biodiversity loss (World Conservation Monitoring Centre 1992). Stochastic processes are not within the scope of this research and thus biodiversity conservation will only focus upon deterministic processes directly caused by anthropogenic intervention. Anthropogenic modifications of the natural environment and the

repercussion caused because of it are potentially irreversible. There is ample evidence and documentation of ecosystem and biodiversity decline. Human modification, extraction and pollution of the environment have dramatically increased since the industrial revolution. However, in regards to environmental degradation, the past 50 years are a period of time incomparable to any other in human history (Lockwood *et al.* 2006).

There exists many forms of biodiversity loss however; the most acute is the extinction of species, due to its irreversibility (World Conservation Monitoring Centre 1992). Therefore, conserving biodiversity requires the facilitation of conditions that ultimately prevent extinctions from occurring (Terborgh 2004). Secondary extinctions occur because of habitat fragmentation and the disruption of ecological processes (Terborgh 2004).

2.2. Anthropogenic pressures on biodiversity

The European Environment Agency uses the Driving forces, Pressure, State, Impact, Response (DPSIR) framework to articulate environmental indicators in a comprehensible manner (Smeet and Weterings 1999). The DPSIR framework is a systems analysis portraying the relationship between environmental system and the human system depicting the origins and consequences of environmental problems (Smeet and Weterings 1999). The relationships are portrayed as:

- "**Driving forces** and
- the resulting environmental **pressures**, on
- the **state** of the environment and
- **impacts** resulting from changes in environmental quality and
- the societal **responses** to these changes in the environment"

Driving forces are anthropogenic circumstances related to economic, social and demographic phenomenon that shape consumption and production patterns. Consumption and production places pressure on the environment and modify its state. A lexicon of anthropogenic threats to

biodiversity is outlined by the International Union for the Conservation of Nature (IUCN) and illustrated in table 1.

State indicators are descriptive of the quantity and quality of physical, biological and chemical phenomena in a particular location. Environmental pressures, which affect the state of the environment, have subsequent impacts on environmental functions. Once the severity of the impacts is recognized a response by society is triggered (Smeet and Weterings 1999). This framework is useful to understand the relationships and linkages that influence the current environmental state and subsequently create social desire to preserve it. Due to these socio-economic factors "the greatest challenges of conservation involve non-scientific issues: overpopulation, inequities of power and wealth, exhaustion of natural resources, corruption, lawlessness, poverty, social unrest" (Terborgh, 2004, 17). If patterns of rapid land use change, population growth and consumption continue to deteriorate natural landscapes soon the only remnants of natural ecosystems will be found in protected areas; this is especially true in the tropics (Terborgh 2004). Because of the acute and widespread nature of this issue there has been a global movement focused on environmental protection.

2.3. The role of international institutions

International institutions have guided the international discourse on global environmental protection. Briefly speaking, through their work they have increased international environmental awareness, created best practice standards and conservation strategies, facilitated collaboration,

Direct Threats (level 1) o ***Subcategories (level 2)***	**Definition**
1. Residential and commercial development o *1.1 housing and urban areas* o *1.2 commercial and industrial areas* o *1.3 tourism and recreation areas*	Human settlements or other nonagricultural land uses with a substantial footprint
2. Agriculture and aquaculture o *2.1 annual and perennial nontimber crops* o *2.2 wood and pulp plantations* o *2.3 livestock farming and ranching* o *2.4 marine and freshwater aquaculture*	Threats from farming and ranching as a result of agricultural expansion and intensification, including silviculture, mariculture, and aquaculture
3. Energy production and mining o *3.1 oil and gas drilling* o *3.2 mining and quarrying* o *3.3 renewable energy*	Threats from production of non-biological resources.
4. Transportation and service corridors o *4.1 roads and railroads* o *4.2 utility and service lines* o *4.3 shipping lanes* o *4.4 flight paths*	Threats from long, narrow transport corridors and the vehicles that use them including associated wildlife mortality.
5. Biological resource use o *5.1 hunting and collecting terrestrial animals* o *5.2 gathering terrestrial plants* o *5.3 logging and wood harvesting* o *5.4 fishing and harvesting aquatic resources*	Threats from consumptive use of "wild" biological resources including deliberate and unintentional harvesting effects; also persecution or control of specific species.
6. Human intrusions and disturbance o *6.1 recreational activities* o *6.2 war, civil unrest and military exercises* o *6.3 work and other activities*	Threats from human activities that alter, destroy and disturb habitats and species associated with non-consumptive uses of biological resources.
7. Natural system modifications o *7.1 fire and fire suppression* o *7.2 dams and water management/use* o *7.3 other ecosystem modifications*	Threats from actions that convert or degrade habitat in service of "managing" natural or semi-natural systems, often to improve human welfare.
8. Invasive and other problematic species and genes o *8.1 invasive non-native/alien species* o *8.2 problematic native species* o *8.3 introduced genetic material*	Threats from non-native and native plants, animals, pathogens/microbes, or genetic materials that have or are predicted to have harmful effects on biodiversity following their introduction, spread and/or increase in abundance.
9. Pollution o *9.1 household sewage and urban waste water* o *9.2 industrial and military effluents* o *9.3 agricultural and forestry effluents* o *9.4 garbage and solid waste* o *9.5 air-borne pollutants* o *9.6 excess energy*	Threats from introduction of exotic and/or excess materials or energy from point and nonpoint sources.
10. Geological events o *10.1 volcanoes* o *10.2 earthquakes/tsunamis* o *10.3 avalanches/landslides*	Threats from catastrophic geological events.
11. Climate change and severe weather o *11.1 habitat shifting and alteration* o *11.2 droughts* o *11.3 temperature extremes* o *11.4 storms and flooding*	Long-term climatic changes that may be linked to global warming and other severe climatic or weather events outside the natural range of variation that could wipe out a vulnerable species or habitat.

Table 1. Lexicon of anthropogenic threats to biodiversity
Source: table adapted from Salafsky *et al.* 2008, 4-7

established communication networks and provided support for local conservation initiatives (Lockwood *et al*. 2006). The major international environmental institutions are the United Nations through the United Nations Environment Programme (UNEP) and the United Nations Development Programme (UNDP), International Union for Conservation of Nature (IUCN), World Wide Fund for Nature (WWF), World Commission on Protected Areas (WCPA), Nature Conservancy and Conservation International (CI), among others.

The IUCN and the WCPA have been the principle international bodies contributing to the basis of conservation science and management. That base continues to be built upon by academia and conservation organizations (Chape *et al.* 2005). Protected areas are defined by the IUCN since 2008 as: "A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley 2008, 60).

There are over 1000 different terms for 'protected area' globally. The IUCN has created a categorization system for protected areas to provide a global framework that attempts to ensure consistency, improve communication, enhance data collection and dissemination of protected areas (Chape *et al.* 2003). The categorization is described as a non-hieratical in nature but rather an expressed gradient of human intervention permitted. Biodiversity conservation is a key goal in all protected areas categories (Lockwood *et al.* 2006).

2.4. The role of international conventions

International conventions provide a framework for interaction among nations and document mutually agreed upon obligations, which at times are binding (Lockwood *et al.* 2006). The major international environmental conventions relating specifically to biological diversity and protected areas are the Ramsar Convention, the Convention on the International Trade in

Endangered Species of Wild Flora and Fauna (CITES), the Convention Concerning the Protection of the World Cultural and Natural Heritage Convention and the Convention on Biological Diversity (CBD) (Dudley 2008; Lockwood *et al.* 2006).

The CBD has gained widespread acceptance and as of May 2012 had 193 parties and 168 signatories, including Ghana (Convention on Biological Diversity n.d.). Members are required under Article 8 of the CBD to develop *In situ* conservation management strategies to "establish a system of protected areas or areas where special measures need to be taken to conserve biological diversity" (Lockwood *et al.* 2006). A conservation target of "at least 10% of each of the world's ecological regions" was set by the seventh Conference of the Parties of the CBD (Chape *et al.* 2005).

Despite the increasing number of protected areas the biological diversity crisis continues (Buck *et al.* 2001). Although the area covered and number of protected areas is increasing globally, the quality of many protected areas are threatened or degrading. Thus, assessing the effective management of biological conservation in protected areas is a priority (Lockwood *et al.* 2006; Chape *et al*. 2005; IUCN-WCPA 2009). Effective management is necessary to ensure the goal of biodiversity conservation is achieved in protected areas. The decision-making authority is accountable to ensure management objectives are being achieved effectively, benefits of the park are shared equitably and that its exterior support ensures sustainability (Lockwood *et al.* 2006, Chape *et al*. 2005).

2.5. Protected areas and their role in biodiversity conservation

A large portion of the earth's surface encompasses land that humans have appropriated (Terborgh 2004). This land is most frequently modified and exploited. Thus it is vitally important that land is appropriated for nature, biological diversity and ecological processes.

PAs are the cornerstones of biological diversity conservation strategies (Chape *et al.* 2005). *In situ* conservation maintains the preservation of biological diversity in its natural state. Protected areas function as a refuge for species and ecosystem functions that are not adapt to anthropogenically-modified landscapes. PAs perform a vital role in the conservation of natural ecosystems and the habitats they contain. They also provide an environment for natural evolution to occur.

Although the term 'protected area' is relatively recent in the conservation lexicon, setting aside a spatial area for conservation is not a new phenomenon in human history (Chape *et al.* 2005). Over two millennia ago Mauryan Emperor Ashoka of India created sites to preserve wildlife out of ethical concern (Chape *et al*. 2005; Lockwood *et al.* 2006)

McNeely acknowledged that the establishment of protected areas to be "cultural response to perceived threats to nature" (Chape *et al.* 2005). Thus, the dramatic increase in the area and number of protected areas globally over the past few decades (Chape *et al*. 2005; Lockwood *et al.* 2006) should not be surprising as levels of pollution, areas of land modification and exploitation are increasing placing extreme pressure on the natural environment, causing biodiversity to vanish (Chape *et al.* 2005; Lockwood *et al.* 2006).

Nature must not be reduced to being valued only as a natural resource, existing for the material satisfaction of humans. Its value is beyond that of a resource; across time and space nature has been understood as having value, a value far beyond the value placed upon it by humans (Lockwood 2006; Terborgh 2004). Intrinsic value includes the value of biodiversity conservation separate from anthropogenic utility. Recognition of intrinsic value for PA

managers is important but in many cases must also be balanced with anthropogenic values because of management objectives and funding requirements. Protected areas have worth beyond intrinsic value as outlined in table 2.

Value of Protected Areas

o On-site goods and services
  o Flora and Fauna products
  o Recreation and tourism
  o Scientific knowledge and research
  o Education
o Off-site goods and services
  o Human and non-human life support
  o Water and air quality and quantity
  o Fisheries, Agriculture and human settlement protection
o Community value (non-material)
  o Culture
  o Identity
  o Spiritual meaning
  o Social well-being
  o Legacy for future generations
o Individual value
  o Satisfaction (experiential and existence)
  o Physical and mental health
  o Spiritual well-being

Table 2. Value of protected areas
Source: adopted from Lockwood *et al* 2006, 103.

2.6. Management of protected areas

The World Conservation Monitoring Centre (1992) named three broad categories of management objectives of Tropical Humid Forests:

- The supply of products such as timber;
- Protection of critical soils and water catchment;
- Biodiversity conservation.

Just over twenty-three per cent of the world's remaining tropical humid forests were protected in 2003, demonstrating a significant increase from nearly nine per cent in 1982 (Chape *et al*.

2003). There is a perception that nature is safe in parks, however this is not the case. Many protected areas do not have effective protection or management plans (Terborgh 2004). Some protected areas only exist as paper parks, and the protection they grant biodiversity within their boarders is nonexistent. “West Africa is one of conservation’s worst case scenarios” (Terborgh 2004, 76). Terborgh (2004) adamantly states that nature can only be ‘saved’ with the employment of good science and strong institutions.

Many protected areas in the tropics are in devastating state, existing in a state of neglect. In some cases loggers, poachers, miners or farmers have overtaken the land and the protection they wield only exists on paper (Terborgh 2004). Protected Areas located in the tropics are under the most extreme threat due primarily to extraction and impoverishment of flora and fauna and proximate land conversion (Chape *et al.* 2005; Terborgh 2004). As environmental degradation occurs and natural resources are depleted outside of PAs the biodiversity contained within PAs also becomes increasingly threatened (Lockwood *et al.* 2006). The primary threats to biodiversity in Ghana are land use, conversion, habitat degradation, over-exploitation, pollution, invasive species and climate change effects (CBD 2007?). Factors that lead to habitat destruction include but are not limited to: shifting cultivation (accounting for 70% of deforestation in Africa), transmigration, population pressure, logging, roads, large-scale commercial clearance, fuel collection and resource extraction (World Conservation Monitoring Centre 1992, CBD 2007?).

To protect PAs from outside threats many PA’s employ rangers or guards. PA rangers/guards in the tropics are almost ubiquitously underpaid and often put their lives in danger to protect the biological diversity existing in the park from the ominous outside world. In some cases

neither guards, nor their superiors have the authority to make arrests in an attempt to maintain the areas integrity (Terborgh 2004; Bakarr 2001).

The management of biological diversity in protected areas involves not only natural science components, but also is a social and political practice. Management must balance the desires of diverse stakeholders including but not limited to governments, funding agencies and community members who may have divergent opinions regarding value, need, strategy and implementation. Inability to accurately measure links between project activities and outcomes or measuring incidental outcomes can lead to inefficient or ineffective program design, implementation, monitoring and the subsequent use of valuable resources (Salafsky and Margoluis 1999). Traditionally, biologically indicators through complex monitoring techniques are frequently used to assess the effectiveness of protected area management strategies (Bleher *et al.* 2006).

2.7. Monitoring

The Earth is neither homogeneous nor static. The general theory of ecology identifies heterogeneity, contingency and evolution as part of their fundamental principals (Scheiner and Willig 2008). Begon *et al.* (1996) describe ecological community structures as "non-uniform, continually altering and subject to statistical events of random change." Thus, organisms are in a constant and frequently unpredictable state of change and flux, across time and space and are part of a web of interactions that supports the ecological system. Conservation strategies must ensure the web of interactions remains intact (Terborg 2004).

Monitoring helps to make sense of those changes and inform managers of patterns and trends. However, the understanding of complex natural systems will always be incomplete (Lee 1993). Therefore, management is always required to make decisions without having complete

knowledge. Ideally management strategies understanding this complexity are sensitive to changes in the environment and society to enhance the practice and techniques of biodiversity conservation.

There are challenges presented regarding monitoring the state of biodiversity and the effectiveness of protected area management (Anthony 2008). Most methods that measure conservation project success rely primarily on biological indicators using a combination of varying parameters (Salafsky and Margoluis 1999). Using biological indicators to monitor biodiversity requires baseline data (Salafsky and Margoluis 1999; 2010 Biodiversity Indicators Partnership, 2010). There is often a paucity of data required for a baseline.

Most monitoring methods are complex in nature and are not practical for measuring short term, periodic project outcomes (Salafsky and Margoluis 1999). Biological indicators exhibit relatively slow changes over time and require a long-term time investment to demonstrate true patterns. Short-term assessments of biological indicators may indicate results that are skewed by natural cyclical fluctuations, which frequently occur. Consistent monitoring of biological indicators is often a difficult task to implement, as they demand extensive effort (Salafsky and Margoluis 1999).

Without a mechanism to measure the short-term success of management strategies park managers cannot conclude which interventions have been successful and should be continued, which are failing and require modification or where interventions have been absent and demand establishment (Salafsky and Margoluis 1999). Protected area managers are thus unable to effectively articulate success or failures with supporting evidence to personnel outside of their institution. Failure to do so may negatively impact policy creation, funding

opportunities, community awareness or other support that would be of benefit to the protected area and the conservation of biodiversity as a whole (Salafsky and Margoluis 1999).

Biological approaches often require complex data sets as well as collection and analysis by experts. Most biological assessment methods require special technical equipment and trained specialists such as computer-based geographical information systems, regular censuses, careful sampling, sophisticated mathematical and statistical analysis. Results are difficult for untrained personnel to accurately interpret and inform decisions related to project interventions (Salafsky and Margoluis 1999, 2010 Biodiversity Indicators Partnership, 2010). Biological monitoring methods do not lend them self to easy comparison among vastly different sites (Salafsky and Margoluis 1999).

Availability of human and financial resources limits managers from implementing an ideal program evaluation (Salafsky and Margoluis 1999). A need exists to use low-cost, efficient and simple program evaluation methods (Salafsky and Margoluis 1999). Few methods are practical due to economic and technological limitations in economically constrained projects (Salafsky and Margoluis 1999). Due to the above mentioned constrains protected area managers may find difficulty in collecting and accurately analysing the data to measure conservation success or failure.

2.8. Management monitoring methods

Several methodologies exist to evaluate the management effectiveness of PAs without the explicit use of biological indicators. To evaluate program interventions program goals and objectives must be clearly defined, casual connections between intervention activities and hypothesized outcomes must be predicted so that actual results can be compared with predicted assumptions (Salafsky and Margoluis 1999; Salafsky *et al.* 2001). This allows

managers to then reflect upon initial program strategies and determine their effectiveness (Salafsky and Margoluis 1999). Outlined by Lockwood *et al.* (2006) the ideal assessment tools for monitoring protected area management strategies are:

- Cost effective (low cost)
- Replicable
- Simple
- Statistically valid
- Documented for review
- Creditable, honest and non-corrupt
- Compatible with management and community expectations
- Timely

A pressure-state-response model, which demonstrates the state of the system, the pressures that impact the state, and the responses that can be used to counter the pressures, is useful in designing program strategies (Salafsky and Margoluis 1999). The identification and mitigation of threats is an essential element of the effective management of protected areas (Hockings *et al.* 2006). Failure to accurately understand the casual relationships reduces the likelihood that projects could be successfully modified based upon previous mistakes (Salafsky and Margoluis 1999).

Various methodologies exist to evaluate the management effectiveness of PAs. The RAPPAM methodology is a tool developed by the WWF to rapidly assess management effectiveness on a national scale (Lockwood *et al.* 2006). The WCPA has developed a tool to assess management effectiveness through six elements (context, planning, inputs, process, outputs and outcomes). The tool focuses upon the management effectiveness in regards to the biological, social, economic and cultural values of the site (Lockwood *et al.* 2006). The

Nature Conservancy has developed a computerized tool to help protected area managers assess the effectiveness of conservation through the 5-S Framework (systems, stresses, sources, strategies, success measures) (Lockwood *et al.* 2006). The Threat Reduction Assessment (TRA) is a simple yet effective tool developed by Nick Salafsky and Richard Margoluis to measure protected area conservation project outcomes through the measurement of threats as a proxy to biodiversity (Salafsky and Margoluis 1999).

2.9. Threat Reduction Assessment

TRA is used to monitor threats as a proxy measurement of biodiversity. It has been used globally as a tool to measures conservation project outcomes and determines whether management strategies are effective (Salafsky and Margoluis 1999; Margoluis and Salafsky 2001; Mugisha and Jacobson 2004; Anthony 2008; Matar and Anthony 2010). It informs decisions regarding which specific interventions should be focused upon (Salafsky and Margoluis 1999). As a tool the TRA is useful because of the following attributes:

1. It has the capacity to influence project design and monitor project design,
2. Can be useful in creating a standardized index that compares vastly different project sites because it is "unitless" and is calculated based upon the percentage of threat change at each site,
3. Data expressed in the TRA index can be easily understood and used by project managers, staff, community members, policy makers and funding providers.

The TRA provides a key tool for the methodology created by the WCPA to facilitate reporting of management effectiveness on a broad scope. The first step required as determined by the WCPA is to "[i]dentify the strengths and weaknesses of a protected area system (Chape *et al.* 2005, 452). The TRA method will be utilized to examine the effectiveness of management strategies to mitigate the threats to biodiversity in KCA.

2.10. Ghana

The following paragraphs will contextualize the research. Ghana, located in Western Africa is 238533 km^2 and has an estimated population of approximately 24 million people. Population density is 100 people/km^2 and is only slightly lower outside forested areas than the national average (Jachman *et al.* 2011; UN 2012). Population growth from 2010 to 2015 is projected to be 2.0% per year on average and 51.5% of the population is under 14 years old (UN 2012).

2.10.1. Economics and the environment

Ghana was ranked 135 out of 187 countries in the UNDP 2011 Human Development Index and is ranked above the regional, Sub-Saharan average (UNDP 2011). Its gross domestic product is approximately 14 billion US dollars (UN 2012). Poverty is disproportionally higher in rural areas than urban areas (UN 2002). Marginalized people are disproportionally impacted by environmental degradation because they tend to be more dependent on proximate natural resources for their productive activities. Fifty eight per cent of people identified as living under the national poverty line were from households participating primarily in farming activities (UN 2002). The environmental Kuznets curve theory would support targeted economic development in Ghana to reduce poverty, which would subsequently lead to improved environmental conditions (Stern 2003). Social, economic and political factors are increasing pressure on the environment and due to these pressures Ghana is reporting difficulties reaching CBD targets (CBD 2007?).

2.10.2. Bushmeat

Wildlife populations have decreased in density outside of PAs in Ghana due to habitat fragmentation, and bushmeat hunting (Jachman *et al.* 2011). Numbers, density, dispersion and distribution of some species show evidence of declining trends in forested areas in Ghana

(CBD 2007?). There are 215 threatened species in Ghana, 49 of which are forest dwelling species (IUCN 2011).

Hunting for bushmeat is a traditional practice and an integral part of human livelihood activities in rural Ghana. Increased human population, and lack of alternatives (economic and protein) is a factor in the decline of species caused by bushmeat utilization. Traditional practices of subsistence hunting have transformed into commercial bushmeat trade, which is now estimated at around US$350 million annually (Bakarr 2001). Population growth and urbanization are the principle causes of the transformation of the bushmeat trade. Improved infrastructure development has enabled bushmeat from rural areas to reach urban centres. Many farmers rely on bushmeat hunting as supplementary source of income (Bakarr 2001). Due to depleted populations many remaining forest fragments in Western Africa exhibit the "Empty Forest Syndrome" (Bakarr 2001). In 2001 Conservation International launched a three-phase programme including public sensitization, research and cultural-based conservation initiatives to reduce threats posed by the bushmeat trade (Bakarr 2001). A recent study examined the relationship between incidents of hunting and the abundance of forest duikers (*Cephalophus spp*) in KCA. It concluded that hunting is strongly suspected to impact the duiker population and a long-term study examining the relationship between duiker populations and hunting activities was recommended (Wiafe and Amfo-Otu 2012). There is a deficiency of research and data to determine how particular activities impact biodiversity in KCA.

2.10.3. Agriculture

The farming activities in Ghana include subsistence farming, cultivation of food crops and cash crops (WD 1996). Small, family operated farms using rudimentary technology produce approximately 80% of total agricultural production (UN 2002). Cassava, maize, plantain,

cocoyam and vegetables are cultivated for primarily subsistence or local trade (Kyei-Agyare 1994). Cocoa is the primary cash crop; one of Ghana's primary exports and its cultivation is the primary livelihood for 70,000 farmers (Kolavalli and Vigneri 2011).

Ghana has had one of the highest rates of deforestation on Africa. It is primarily due to shifting cultivation, conversion to agriculture lands, fuel wood collection and commercial logging. Seventy percent of deforestation in Ghana has been caused by shifting agriculture (Palo and Yirdaw 1996). Fallow periods have been shortened due to population pressure making the agricultural practice destructive and unsustainable. Since 1920 Ghana's closed forest areas has decreased from nearly 10 million hectares to less than 2 million hectares in 1990. Officially demarked forest reserves contain over 80% of the natural closed forests (Palo and Yirdaw 1996).

2.10.4. Tourism

International tourism has increased in Ghana by 22% per year since 2005 (Jachman *et al.* 2011). The tourism sector contributes 6.7% to the gross domestic product and is the fourth largest foreign exchange earner in Ghana (Jachman *et al.* 2011). KCA attracts the highest number of visitors of all PA's in Ghana due to the canopy walk (Jachman *et al.* 2011). As an ecotourism destination KCA generates income for the government of Ghana while allowing visitors to experience and learn about the value of nature and the importance of conservation. Tourism in KCA has the potential to attract income for adjacent communities but most villages have not realized the expected benefits of ecotourism. One village, Mesomagor, has created a local ecotourism strategy and undertaken entrepreneurial endeavours to benefit from the increase in tourism at KNP (Appiah-Opoku 2011).

2.10.5. Protected Areas

Ghana was an exemplary model of conservation in West Africa half a century ago. While other countries in the West African region were traumatized by civil wars, which led to illegal extraction of natural resources devastating wildlife populations; Ghana was able to establish six national parks shortly after obtaining independence in 1960. The parks were created as representations of the country's diverse ecosystems. There were forty-one species of charismatic mega fauna inhabiting the six parks at the time of establishment. Devastatingly, eleven species had disappeared from the national parks, and perhaps the entire country, by 1998. An additional eleven species were only confirmed inhabiting one park. The baboon, which adapts well to human presence, was the only species encountered in all six parks. Illegal hunting was determined to be the primary threat to those species (Terborgh 2004). The biodiversity of all PAs in Ghana is threatened by illegal hunting, which is supported by the bushmeat trade and the trade of other wildlife products such as ivory (WDa 2009).

Protected Areas in Ghana have been the most effective areas for the implementation of the CBD on a national level (CBD 2007?). Currently in Ghana there are twenty-one Wildlife Protected Areas (WPAs) covering a total of 13476000 ha. Seven National Parks, six Resource Reserves, two Wildlife Sanctuaries, one Strict Nature Reserve and five coastal wetlands form Ghana's protected area network. This network protects a total 5.6% of Ghana (UICN/PACO 2010).

2.11. Kakum Conservation Area

KCA was previously Kakum Forest Reserve established in 1952. Traditionally KCA land belongs to the Assin Attandanso, Twifo Heman, Denkyera and Abura states. Traditional leaders from these states had the right to lease the land and allowed portions of the forest to be logged by timber companies. People living near the reserve had access to its natural resources

to supplement their household economic activities (Kyei-Agyare 1994). The Central Regional Administration created KCA as part of an integrated tourism and development program in July of 1989. The management of the area became the responsibility of the Ghana Wildlife Division and community leaders who were the traditional authorities relinquished their right over the land and resources (Appiah-Opoku 2011; Kyei-Agyare 1994). It was officially opened to tourists in March 1994 (Kyei-Agyare 1994).

Prior to the establishment of the park residents living in close proximity to the area used the natural resources such as thatched roofing, meat, basket weaving, medicinal plants, mushrooms, sponges, and fuel wood (Appiah-Opoku 2011). With the establishment of the KNP, villagers were prevented from accessing its natural resources. Currently the products that were previously provided by the area where the park is presently located must be acquired from elsewhere or illegally from the KNP (Appiah-Opoku 2011). People expressed discontent that their access to the resources contained within KCA were no longer available to them however the community was found to be supportive of the idea of the PA (Kyei-Agyare 1994).

Kakum Conservation Area's ecosystem is classified as a tropical humid forest (World Conservation Monitoring Centre 1992) Additional geographical and meteorological data is displayed in table 3. Its vegetation in 1996 was determined to be a representative sample of tropical evergreen forest (WD 1996a). The park provides an isolated remnant of virgin forest surrounded by anthropogenically-modified land. It is estimated that between 65,000 and 70,000 people reside adjacent to KCA. There are four forest reserves managed for timber extraction by the Forest Department in close proximity to KCA but the majority of land surrounding KCA has been transformed into agricultural land. A buffer zone between the

boundaries of Kakum Conservation Area and cultivated fields is non-existent (Boafo and Oduro 2009).

Kakum Conservation Area (KCA) is comprised of Kakum National Park (KNP) and Assin Attandaso Resource Reserve (AARR) as depicted in fig. 1. Kakum National Park is a state managed IUCN category II protected area (Appiah-Opoku 2011). KCA has one of the highest concentrations of biodiversity of all protected areas in Ghana (UICN/PACO 2010). Because of KNP's status, hunting activities and the extraction of species are prohibited. Due to its status, AARR could allow for more human intervention than KNP. However, KNP and AARR are not managed as separate entities but as one entity. This decision constricts AARR's allowable human intervention to the same level as KNP (Wiafe 2012).

Kakum Conservation Area Geographical and Meteorological Data Summary	
Location	Central Region, Ghana
Biome	Tropical Humid Forest [a]
Central coordinates	1° 19.00' West 5° 26.00' North [b]
Area	36,600 ha [b]
Altitude	135 - 250m [b]
Annual Rainfall	1500 – 1750 mm [c]
Rainfall Pattern	Bi-modial [c]
Months of Highest Rainfall	May – June and September – October [c]
Average Monthly Temperature	20.2°C - 31.6°C. [c]
Average Relative Humidity	85% [c]

Table 3. Kakum Conservation Area geographical and meteorological data summary
[a] World Conservation Monitoring Centre 1992
[b] BirdLife International 2012
[c] Kyei-Agyare 1994

The Ghana Wildlife Division (WD) of the Forestry Commission (FC) is responsible for park management (Appiah-Opoku 2011). Their most recent park management plan was implemented in 1996 (WD 1996). Prior to the 1996 KCA management plan, no management or development strategy was in place. Since 1996, the park is to reassesses their management strategy annually and relevant revisions are to be made (WD 1996). An adaptive management strategy was implemented in 2004 and a review is conducted on a quarterly basis (Jachman 2008).

The objectives of KCA as set out in the management plan are (WD 1996):

Kakum National Park

I. To actively protect and conserve all natural resources and aesthetic features in Kakum National Park and maintain them as an example of a tropical rainforest ecosystem.
II. To exploit the Park's potential for tourism and sustainably develop it based on recreational, educational and aesthetic appeal.
III. To integrate the National Park into the district and regional development process, especially into that of the surrounding communities, to ensure their cooperation and support for the conservation of the Park's resources.
IV. To improve WD field staff welfare, discipline, motivation and capabilities.
V. To increase the number of visitors to the Park and its revenue generation potential.

Assin Attandanso Resource Reserve

I. To ensure the conditions necessary for the conservation of the unique biological features within the reserve and the sustainable utilization of selected exploitable resources.
II. To exploit the tourism potential of the reserve based on game viewing, recreational, inspirational and cultural interest.
III. To integrate the development of the reserve with that of the local communities.
IV. To improve the WD staff welfare and increase their capabilities.

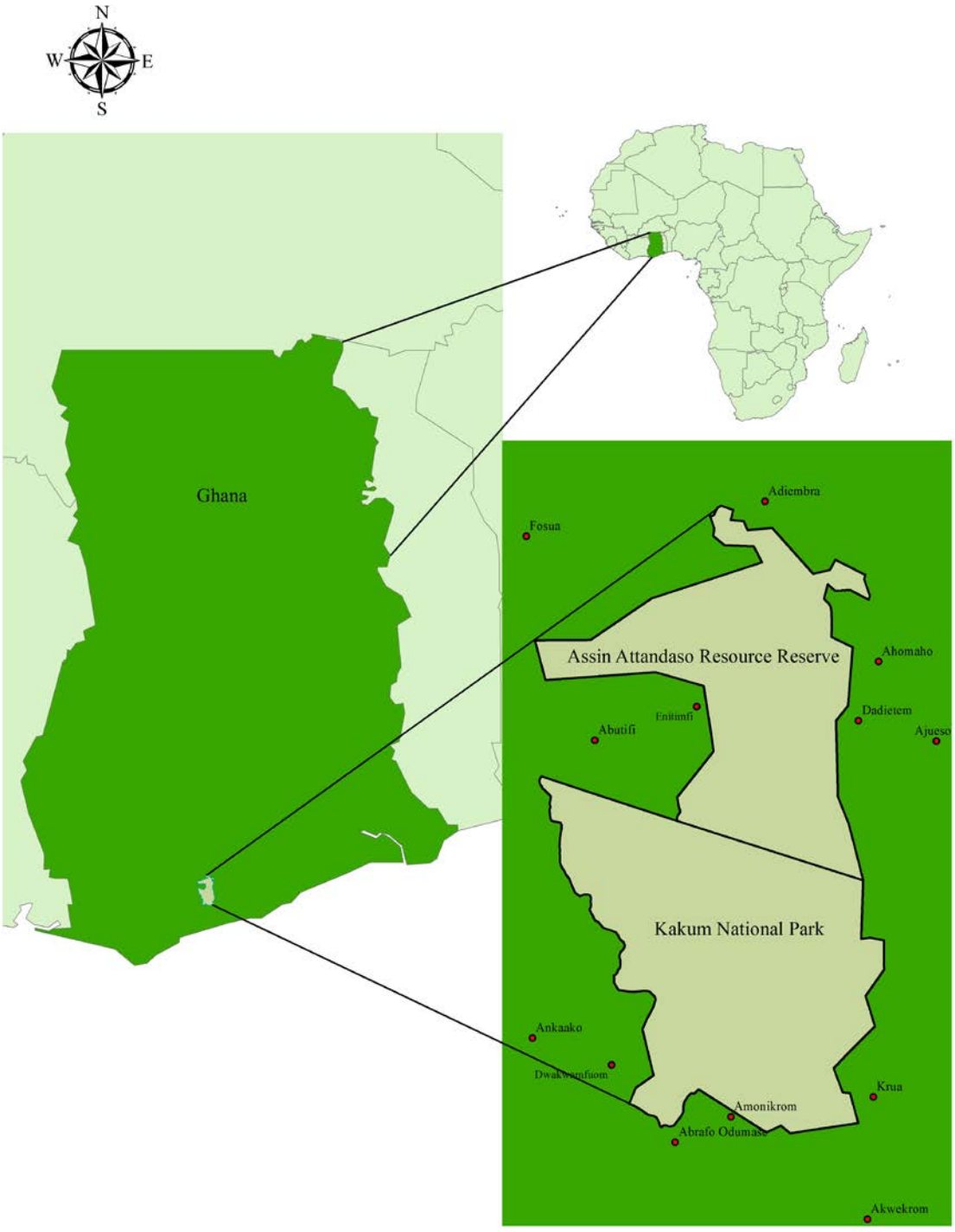

Fig. 1. Kakum Conservation Area
Source: GADM 2012, Wiafe and Amfo-Out 2012

To achieve their objectives KCA received a 3.4 million dollar grant from the United Nations Development Program for technical assistance, which was matched with 2.4 million dollars from the Government of Ghana. In addition KCA received funding from Conservation International, the US International Development Agency, the U.S. Committee on International Council of Monuments and Sites and the Smithsonian Institution (Appiah-Opoku 2011). Large amounts of external funding have ceased and currently KCA receives the vast majority of its budget from the FC. The FC allocates funding to KCA is based upon the budget drawn up by the KCA management team however. It continues to receive both technical support and funding from the Ghana Heritage Conservation Trust (GHCT) (Appiah-Opoku 2011).

2.11.1. Wildlife and Habitat Monitoring in KCA

PA patrol staff conducts wildlife and habitat monitoring. Patrol staff records and reports wildlife species seen, distribution, the state of habitat and any incidents of illegal activities (WD 2009a). The species recorded by PA patrol staff as part of their regular duties is displayed in table 4. The data collected by the patrol staff is the only long-term data collected on species or incidents in the PA. Prior to 2004 monitoring at KCA as to was *ad hoc* and lacked a systematic approach necessary for long-term effectiveness (Wiafe 2012). This data is complied and included in the PA's quarterly report. The reports are sent to the head office in Accra and distributed among the PAs. External parties conduct additional *ad hoc* research and data collection.

Species sightings recorded on patrols	
Elephant (*Loxodonta cyclotis*)	Palm Civet (*Nandinia binotata*)
Bush Baby (*Galago senegalensis*)	Leopard (*Panthera pardus)*
Lowe's (mona) Monkey (*Cercopithecus campbelli lowei*)	Red River Hog (*Potamochoerus porcus*)
Spot-nose Monkey (*Cercopithecus petaurista petaurista*)	Giant Forest Hog (*Hylochoerus meinertzhageni)*
Olive Colobus (*Procolobus verus*)	Porcupine (*Atherurus africanus africanus*)
Potto (*Perodicticus potto*)	Cusimanse (*Crossarchus obscurus*)
Royal Antelope (*Neotragus pygmaeus*)	Mongoose (*Mungos gambianus*)
Maxwell Duiker (*Cephallophus maxwellii*)	Giant Forest Squirrel (*Protoxerus stangeri*)
Yellowback Duiker (*Cephalophus silvicultor*)	Pel's Flying Squirrel (*Anomalurus peli*)
Bay Duiker (*Cephalophus dorsalis*)	Horn Bill (*Tockus fascitus*)
Black Duiker (*Cephalophus niger)*	Crowned Eagle (*Stephanoaetus coronatus*)
Bush Buck (*Tragelaphus scriptus)*	Pangolin (*Manis gigantea*)
Bongo (*Boocercus enryceros*)	African Python (*Python sebae)*
Nile Monitor (*Varanus niloticus*)	Cusimanse (*Crossarchus obscurus*)

Table 4. Species sightings recorded on patrols
Source: WD. Quarterly Reports 2004 to 2012, Kingdon 1997, Borrow and Demey

2.11.2. Relevance of application of TRA in KCA

The IUCN conducted an evaluation of management effectiveness of eight WPAs in Ghana. The RAPPAM concluded that management effectiveness must be improved in Ghana (UICN/PACO 2010). The assessment determined that poaching is the main threat to wildlife in KCA. Invasive species were the only other threat to biodiversity revealed in their report (UICN/PACO 2010). A more through assessment of the threats to biodiversity in KCA is valuable to determine how management staff have been successful at mitigating particular threats and where further efforts and resources must be extended. As Bakarr (2011) states "as conservation efforts become more targeted to addressing underlying causes of the threat facing wildlife, opportunities to mobilize public support must be quickly harnessed to ensure full involvement of all major actors." An adaptive management approach enables

management to review their progress and learn from mistakes to ensure future efforts are more targeted.

TRA is well suited to be part of an adaptive management approach. A cornerstone of adaptive management is the assumption that resource management is inherently uncertain and therefore unanticipated results become ‘opportunities to learn’ and change rather than ‘failure to predict’ (Lee 1993). Adaptive management provides a framework for managers to systematically assess the successes of their project and seek opportunities for improvement. From the results of the assessments conservation managers are able to learn from and adapt their own conservation strategies to increase the likelihood of future successes (Lee 1993, Salafsky *et al.* 2001). The modified TRA with the additional geospatial threat component will reveal, rank and map out the threats to biodiversity, determine their respective changes within KCA from June 2004 to June 2012. Interviews and a review of support material and data will expose the challenges of its conservation. This will enable a review of management effectiveness and determine to what degree threats have decreased or increased within KCA and reveal where threats have expanded or contracted spatially.

CHAPTER 3 - METHODOLOGY

This chapter will address the various methods utilized to conduct research, data collection, processing and analysis. Fig. 2 provides a brief overview of the methodological steps taken to fulfill the objectives of the research. A through explanation and justification of the methodology is described in the subsequent paragraphs of this chapter. The final component of the methodology section discusses the limitations of the research.

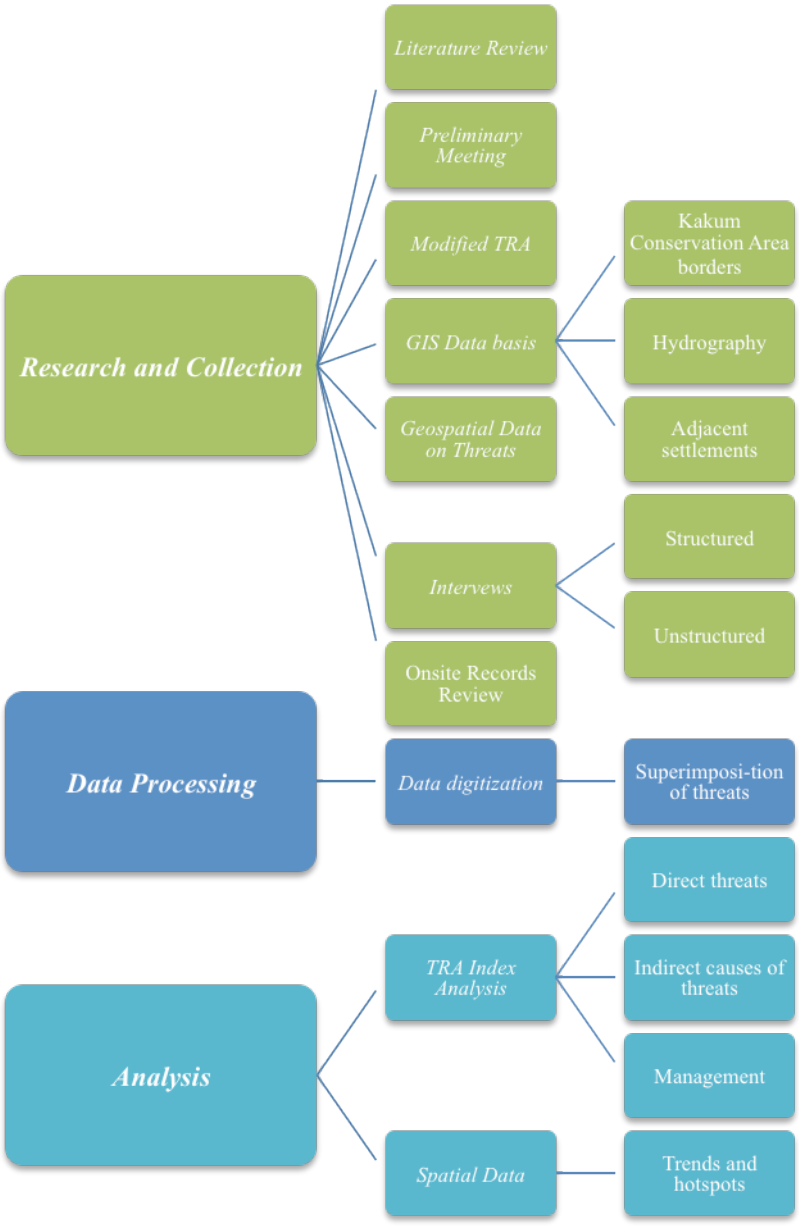

Fig. 2. Methodological approach

3.1. Research Design

The systematic approach harnessed qualitative and quantitative research methods within the research design. Qualitative data was collected through the literature review, a preliminary meeting, interviews and a review of WD produced documents. Quantitative data was collected through the modified TRA workshop, WD documents, from GIS databases, and additional geospatial data was acquired from consultation with experts during the workshop.

3.2. Site Selection

Kakum Conservation Area was selected for this study because it represents a remnant of West Africa's vanishing rain forest. It is situated in Ghana, a politically stable and reasonably safe country to conduct research in. KCA contains the one of the highest levels of biodiversity in Ghana (UICN/PACO 2010) and encompasses a fully protected wildlife reserve (KNP) and a resource reserve (AARR) that are managed as one entity. In addition the WD of the FC, the body that manages the site, was willing to participate in the TRA and geospatial data collection workshop as well as participate in interviews and allow the researcher to collect additional data through a review of the available onsite files. Willingness of WD staff to participate made the research methodology possible.

3.3. Qualitative Research

3.3.1. Literature Review

The initial phase of research included data collection through a comprehensive review of relevant scientific literature. Literature concerning biodiversity conservation, environmental indicators, protected areas, international policies and institutions provided the foundation. Sources that provided the foundation for this research included academic books, journal articles and online sources provided by internationally recognized institutions. To focus the research literature regarding the management of protected areas, monitoring mechanisms

including an in depth review of the modified TRA approach was collected through a review of academic journals articles and institutional reports. To contextualize research background, information on Ghana and the Kakum Conservation Area was gathered. This information was collected primarily through a review of locally sourced documentation from the Wildlife Division (WD) and the Forestry Commission (FC) of Ghana, in addition to the above-mentioned sources. The information was then synthesised to compose a literature review of appropriate breadth and depth.

3.3.2. Preliminary Meeting and Workshop Preparation

A preliminary meeting was held with two local experts. During the meeting the experts helped to identify a suitable time period for the modified TRA. The meeting also allowed for the identification appropriate participants for the TRA workshop. It was also helpful in the collection information regarding local cultural norms to support the execution of the TRA workshop. Following the preliminary meeting, the TRA workshop was set up with KCA staff after a mandatory research permit was obtained from the Wildlife Division of Ghana.

3.3.3. Interviews

Multiple interview methods were employed to collect additional data. A structured interview with select management staff utilizing the questionnaire included in the World Bank/WWF document titled “Reporting progress at protected area sites” (Stolton *et al*. 2005) was conducted to acquire thorough information on KCA not readily available through an overview of official documents accessible to the public. Nineteen formal, semi-structured interviews were conducted with WD staff and an additional dozen unstructured, informal interviews were conducted with WD staff and local stakeholders. The format of each interview was determined by the appropriateness of the situation (hiking through the protected area versus sitting in an office). Some interviews were arranged before hand while others were conducted

spontaneously. Each person interviewed was informed about the nature of the interview and gave verbal consent. Interviews were conducted to supplement information obtained during the TRA workshop and collected from academic literature. Interviews provided a deeper illustration of the local context and the implementation of management strategies.

3.4. Quantitative Research

3.4.1. Modified Threat Reduction Assessment Workshop

The modified TRA method (Anthony 2008) was utilized to determine the effectiveness of management strategies to mitigated threats to biodiversity in Kakum Conservation Area since the adoption of an adaptive management approach in 2004 until the date of the TRA workshop in June 2012. The standard lexicon for biodiversity conservation unified classifications of threats and actions (Salafsky *et al.* 2008) provided the conceptual framework and was applied with the TRA tool (Matar and Anthony 2010). The modification of the TRA tool developed by Anthony (2008) allows for the inclusion of negative values into the '% threat reduced' category. The modification enables the index to calculate reductions and increases of threats enhancing the accuracy of the tool. This is an important adjustment as the modification now facilitates the prioritization of emerging or mounting threats. The standard lexicon for biodiversity conservation unified classifications of threats and actions developed by the IUCN allows for systematic identification of threats and improve information sharing between conservation practitioners (Salafsky *et al.* 2008).

The TRA tool is an appropriate method for measuring conservation project success in KCA. The tool was chosen because of the following attributes:

- Practical and cost effective,
    - Based on data collected through simple techniques,
    - Does not require externally created baseline data

- Identifies threats and assesses changes in threats,
- It is sensitive to changes over short periods of time,
- Reflects changes in biodiversity throughout the site,
- Has the potential to overcome the challenges frequently preventing project managers from conducting any monitoring of the success or failure of a project.

Previous studies have indicated that the TRA is most effective when conducted in a workshop setting (Matar and Anthony 2010). The retrospective TRA workshop was conducted on site at Kakum Conservation area on 1 June 2012. Participants were contacted prior to the assessment and asked to have any relevant support documents at hand to be utilized and referenced during the workshop.

3.4.1.1. Participant Selection

Six experts participated in the modified TRA workshop. They were selected based upon the following criteria:

- Expert knowledge of the site,
- Intimate involvement in management and monitoring processes,
- History with the KCA.

To begin the TRA a short, interactive presentation was given by the facilitator to ensure all participants understood the purpose and method of the TRA. Participants were recorded on an attendance sheet and a workshop booklet was given to each participant. It contained the following:

- An *information sheet* that contained detailed methodological steps and explanations of the modified TRA process and key assumptions (Appendix I),
- A *TRA Index calculation sheet* (Appendix II),
- A *description of threats and definition of 100% reduction sheet* (Appendix III),

- The *IUCN classification of direct threats sheet* including level 1 and 2 category descriptions and level 1 definitions (table 1),
- A detailed *site map (Appendix VI).*

3.4.1.2. Key assumptions of the TRA method

Fundamental assumptions of the modified TRA method are (Salafasky and Margoluis 1999):

1. *All destruction of biodiversity is human-induced*. Losses of biodiversity due to natural phenomena are not considered as threats. However, threats that have increased in magnitude or frequency due to human activity are considered as anthropogenic threats.
2. *All threats to biodiversity at a given site can be identified*. At any given point in time, experts of KCA have the ability to identify, distinguish and rank all the direct threats to biodiversity in terms of area impacted, intensity, and urgency.
3. *Changes in all threats can be measured or estimated*. Experts have the ability to systematically, either qualitatively or quantitatively, assess the percentage of change of all threats at any given time.

3.4.1.3. Calculation of TRA Index

First, the assessment was defined both spatially and temporally by facilitator and confirmed to be appropriate by the participants. Spatially the workshop assessed Kakum Conservation Area, consisting of Kakum National Park (KNP) and Assin Attandaso Resource Reserve (AARR). Although the two protected areas have separate classifications they are managed as one entity. At present, AARR is under the same restrictions as KCA (Wiafe 2012) although its classification legally allows for more human intervention. June 2004 to the present date, June 2012, was selected to be the appropriate timeframe for the assessment. June 2004 was selected because that is when the adaptive management approach was adopted by KCA management staff. The target condition was defined as the biodiversity in KCA. Biodiversity

includes species present, habitat condition and area and ecosystem functions (Salafsky and Margoluis 1999).

Collectively participants were asked to list all threats to biodiversity, concentrating on the assessment period, in KCA in their own words. Threats were defined as direct anthropogenic activities that adversely affect biodiversity (Margoluis and Salafsky 2001) in Kakum Conservation Area. Each threat was then categorized according to the IUCN standard lexicon of threats. To utilize a more detailed description of threats, each was identified at 2 sub categories (Margoluis and Salafsky 2001). Participants were also asked to produce a site-specific explanation of each threat, which was recorded. This was done to enable comparisons of threats across sites to occur without loosing valuable detail caused by standardization.

Participants then order threats according to relative importance. Discussion and the use of relevant materials were encouraged. The use of material allowed for further evidence to be incorporated into the assessment. This helped to reduce the subjectivity of the assessment and increase validity. For the defined start date of the assessment period, each threat was ranked in order for (Salafsky and Margoluis 1999):

a. *Area:* percentage of habitat(s) in the site that the threat will affect
b. *Intensity:* the impact of the threat on a small scale within the overall area
c. *Urgency:* the immediacy of the threat

For each threat '100% threat reduction' was defined. The TRA facilitator defined '100% threat reduction' as the absolute abolishment of a threat to decrease ambiguity and standardize scoring as recommended by Anthony (2008). If participants felt that they strongly disagreed with '100% reduction' defined as total elimination of the threat it was indicated on the worksheet and the distinct 100% threat reduction' was defined.

Participants were then instructed to individually assign a percentage of change reflecting the degree to which the each threat had decreased or increased since the implementation of the adaptive management approach in 2004. Immediately following participants were asked to collectively discuss and agree upon percentages (Anthony 2008). Again, hard evidence was relied upon to assign a percentage of change for each threat, decreasing subjectivity and increasing validity.

The raw scores for each threat were then calculated by multiplying the total ranking by percentage. Then the final TRA index score was calculated by adding up the raw scores for all threats, dividing it by the sum of the total rankings and then multiplied by 100 (Salafasky and Margoluis 1999).

$$\textbf{TRA index} = \sum \textbf{raw scores} / \textbf{total rankings} * 100$$

3.4.2. Geospatial Threat Modelling

Geospatial data was utilized in this research to display changes in threats to biodiversity in KCA during the same time period assessed during the TRA. Geographical information system (GIS) is a method of using computer technology to digitally illustrate and model geospatial phenomena. GIS enhances understanding of present and future occurrence in geographical space. This is beneficial in prescribing action. Geographical management techniques are well-suited to protected areas. To harness the power of GIS, ArcGIS version 10, a state of the art software tool, was used to digitize, analyze, manage and display the geographical data (Ormsby *et al.* 2008).

To commence the geospatial component of this research digital data sets were collected and used to create a base map. The base map included the following features:

- GIS data sets on administrative borders of Ghana (Hijmans *et al.* 2007);
- GIS data sets on the boundaries of Kakum National Park and Assin Attandanso Resource Reserve (Wiafe and Amfo-Out 2012);
- GIS data sets on hydrography (Lehner 2008);
- GIS data sets on elevation (METI and NASA 2011);
- GIS data sets on settlements (Wiafe and Amfo-Out 2012).

The author digitized settlement locations using Google earth and the KML file was converted with KML2SHP Online software (Zonum Solutions 2010)

3.4.2.1. Key assumptions of geospatial threat modeling

The fundamental assumptions of the geospatial threat modeling component are:

1. *The location of all threats to biodiversity at a given site can be identified*. At any given point in time, experts of KCA have the ability to identify the location of all the direct threats to biodiversity,
2. *All threats to biodiversity at a given site can be ranked*. Experts have the ability to systematically rank the intensity and urgency of each threat at any given time.

3.4.2.2. Geospatial threat data collection

Modeling threats to biodiversity using a spatiotemporal method was used to illustrate threats, and identify hotspots. This addition to the modified TRA is useful to illustrate the spatial changes of threats. It can help management focus resources and produces a useful visual representation that can be used to educate staff and a variety of stakeholders. It is particularly useful where there is a paucity of spatial data and limited resources.

A short, interactive presentation was given by the facilitator to ensure all participants understood the purpose and method of the geospatial threat data collection component. A workshop booklet was given to each participant. It contained the following:

- An *information sheet* that contained detailed methodological steps and explanations of the geospatial threat data collection process and key assumptions (Appendix I),
- A detailed *site map* (Appendix VI).

To begin the geospatial threat collection process, the approximate location(s) of each threat identified during the TRA was drawn on the detailed map provided. The approximate location(s) of each threat during the two periods of study, June 2004 and June 2012, were drawn on separate maps.

For each threat and time period, participants ranked both the intensity and urgency on a scale from 1 to 3 (1=low, 2=medium, 3=high). In the case where a threat required different assigned values in specific locations it was noted on the map. This was necessary to determine where each threat was most severe within the PA and useful to determine the changes of intensity and urgency of specific threats over the temporal period.

The geospatial data collection was done as a collaborative process. Dialogue and the use of support materials were encouraged. The use of the additional material allowed for complimentary evidence to be integrated into the assessment. This reduced the subjectivity of the spatial data collected and increased validity.

3.5. Data Processing and Analysis

The hand drawn geospatial threat maps acquired during the workshop were then digitised and imported into ArcGIS 10 platform. After digitization of these threats each was assigned a specific map layer in ArcGIS 10. Any differentiation in assigned values was indicated.

A map displaying the superimposition of all threats for each time period was produced. The numerical value of each layer was used to show a spatial gradient of the intensity and urgency of each threat. As a final result derived from the GIS analysis, two maps representing threats to biodiversity at two specific temporal periods were created.

3.6. Reflection of workshop

Following the TRA and geospatial data collection process, an informal discussion was ignited to reflect upon the workshop. Threat mitigation and indirect threats were the principle themes of this discussion. The discussion was useful for guiding interview questions after the workshop process. Participants were then asked to reflect upon the workshop and give feedback to the facilitator (Appendix V).

3.7. Limitations

There are limitations to all scientific methodologies employed. Biological methods used to measure project success have the theoretical advantage of directness as it is designed to produce a quantitative measurement of biodiversity health and are more consistent and explicit (Salafsky and Margoluis 1999). However, where a paucity of data exists they are unable to be utilized.

The TRA method uses threats as a proxy to biological diversity and is subjective. Allowing local experts to draw and pinpoint threats is also subjective however, it is a simplified yet effective approach where there is a paucity of data. The reliability is dependent on the accuracy and explicitness of the underlying assumptions. If the workshop participants do not accurately identify, rank, assess the progress of the threats or locate them on the map the results maybe misleading (Salafsky and Margoluis 1999). TRA and geospatial data collection which relied on the expertise of workshop participants is subject to bias (Salafsky and

Margoluis 1999) however the personnel that participated in the workshop were believed to have had the best knowledge of threats to biodiversity in the area of study over the time period examined and understood the objectives of the study.

CHAPTER 4 - RESULTS

This chapter will present the qualitative and quantitative research findings from the Modified TRA workshop, geospatial threat modelling and data collected during a review of locally sourced documents and interviews.

The following paragraphs will give a brief introduction of the results; define each threat identified during the TRA process, detail the definition of 100% reduction and describe the state of each threat in June 2004 and June 2012. The geospatial illustration of threats will be discussed and presented within the discussions of the individual threats. The challenges management and WD staff face eliminating each threat will then be presented and discussed. Finally, a brief overview of additional management challenges and barriers that do not fit within the above framework will be presented. These provide valuable information and insight on additional factors that prevent the most effective PA management in KCA from existing.

4.1. Context

The modified TRA workshop was conducted on 1 June 2012 at the WD office in Abrafo Odumase adjacent to the protected area. There were five participants present at the workshop. All of the participants currently held KCA management positions with the exception of one participant whom was no longer a WD employee but had worked for the WD at KCA holding a management position for 7 years. The employees ranged from having two to seven years of experience with the WD at KCA. The assessment was defined spatially as KCA comprised of KNP and AARR. It was defined temporally from June 2004, when the Adaptive Management Strategy was adopted by the PA management (Jachman 2008), to June 2012. The target

condition was defined as the biodiversity in KCA including species present, habitat condition and area and ecosystem functions (Salafsky and Margoluis 1999).

The expert TRA participants identified nine principal threats to biodiversity in KCA as displayed in table 5. Other threats such as 'mining and quarrying' were mentioned during the preliminary discussion however the experts determined that because only prospecting around the site had occurred it was not a current threat nor a historical threat to biodiversity but must remain considered a future threat and thus not appropriate for the TRA.

As described in the methodology chapter, each threat was ranked on the relative area that it affects, its urgency and intensity for June of 2004 and "100% reduction" was defined for each threat by the experts presented in table 6. This awarded each threat with a relative score. The percentage of change for each threat was then calculated from the June 2004 date to June 2012.

The approximate location(s) of each threat during the two periods of study, June 2004 and June 2012, were drawn on maps and later digitized. The location of threats to biodiversity in 2004 is displayed in fig. 3 and the threats to biodiversity in 2012 are displayed by fig. 4. For each threat and time period, participants ranked both the intensity and urgency on a scale from 1 to 3 (1=low, 2=medium, 3=high). In the case where a threat required different assigned values in specific locations it was noted on the map. This was necessary to illustrate spatially the intensity and urgency of each threat on a gradient over the temporal period.

The TRA Index showed a positive reduction of 44% from June 2004 to June 2012. One threat, 'fishing and harvest aquatic resources', was completely eliminated while telecommunication lines were erected within park boundaries, marking the appearance of a new threat to

biodiversity, ‘utility and service lines’. The increased traffic on existing roads that transect KCA exhibited a negative increase on the index. Interestingly, management also considered the work of park staff, specifically alterations caused during patrols to be an important threat to biodiversity. KCA is a high profile tourist destination and conservation education centre in Ghana, however increasing tourism has had adverse impacts on biodiversity in KCA. ‘Annual and perennial crops’ which are legally permitted and only on a small section of land, showed no change. The top three threats ‘logging and wood harvesting’ ‘gathering terrestrial plants,’ and ‘hunting and collecting terrestrial animals,’ all showed a significant positive reduction of 66% or more. Effective law enforcement and patrols were attributed to reducing these top threats. The threats will be presented by relative importance from the highest to the lowest TRA Total Ranking Score.

No.	Threat	IUCN threat code[a]	Criteria Rankings (relative)			Total Ranking	% Threat Reduced[b]	Raw Score
			Area	Intensity	Urgency			
1	Hunting and collecting terrestrial animals	5.1	9	9	9	27	70	18.9
2	Logging and wood harvesting	5.3	7	8	8	23	90	20.7
3	Gathering terrestrial plants	5.2	6	7	7	20	66	13.2
4	Tourism and recreation areas	1.3	5	6	3	14	-40	-5.6
5	Work and other activities	6.3	8	3	2	13	-3	-0.39
6	Annual and perennial nontimber crops	2.1	3	4	6	13	0	0
7	Fishing and harvesting aquatic resources	5.4	4	5	4	13	100	13
8	Roads and railroads	4.1	2	2	5	9	-30	-2.7
9	Utility and service lines	4.2	1	1	1	3	-100	-3
		TOTAL	**45**	**45**	**45**	**123**		**54.11**

[a] see http://www.iucnredlist.org/technical-documents/classification-schemes/threats-classification-scheme-ver3

[b] see table below

TRA Index Formula	Total Raw Score		Total Ranking		Convert to %		**TRA Index (%)**
TRA Index Calculation	**54.11**	**÷**	**123**	**=**	**0.440 x 100**	**=**	**44.0**

Table 5. Threat Reduction Assessment Index

No.	Threat	Total Ranking	% Threat Reduced	Description of threat	Explanation of 100% Reduction
1	Hunting and collecting terrestrial animals	27	70	Poaching (bushmeat, ivory), removal of live animals by tourists (very rare).	Total elimination of all hunting within KCA boundary.
2	Logging and wood harvesting	23	90	Fuel wood collection 1 km into PA. (No commercial logging occurring currently).	Total elimination of wood harvesting within KCA boundary.
3	Gathering terrestrial plants	20	66	Gathering terrestrial plants from within boundaries of KCA.	Total elimination of plant collection within KCA boundary.
4	Tourism and recreation areas	14	-40	All tourism activities within KCA.	Carrying capacity of facilities not exceeded on a daily basis. Zero littering.
5	Work and other activities	13	-3	Work of WD staff and other permitted people in the boundaries of KCA that negatively impacts biodiversity	Total elimination of all non-essential disruption.
6	Annual and perennial nontimber crops	13	0	All crops (permitted and illegal) within boundary of PA.	Total elimination of crops in protected area boundary.
7	Fishing and harvesting aquatic resources	13	100	Fishing and collection of aquatic species from PA.	Total elimination of fish harvesting within KCA boundary.
8	Roads and railroads	9	-30	Roads that transect park.	Tarring of the road and creation of wildlife bridges. Zero expansion of road. Elimination of speed above 20 km/hour
9	Utility and service lines	3	-100	Service lines telecommunications and electricity (All lines follow current roads)	Zero expansion of utility and service lines.

Table 6. Description of threats and definition of 100% reduction

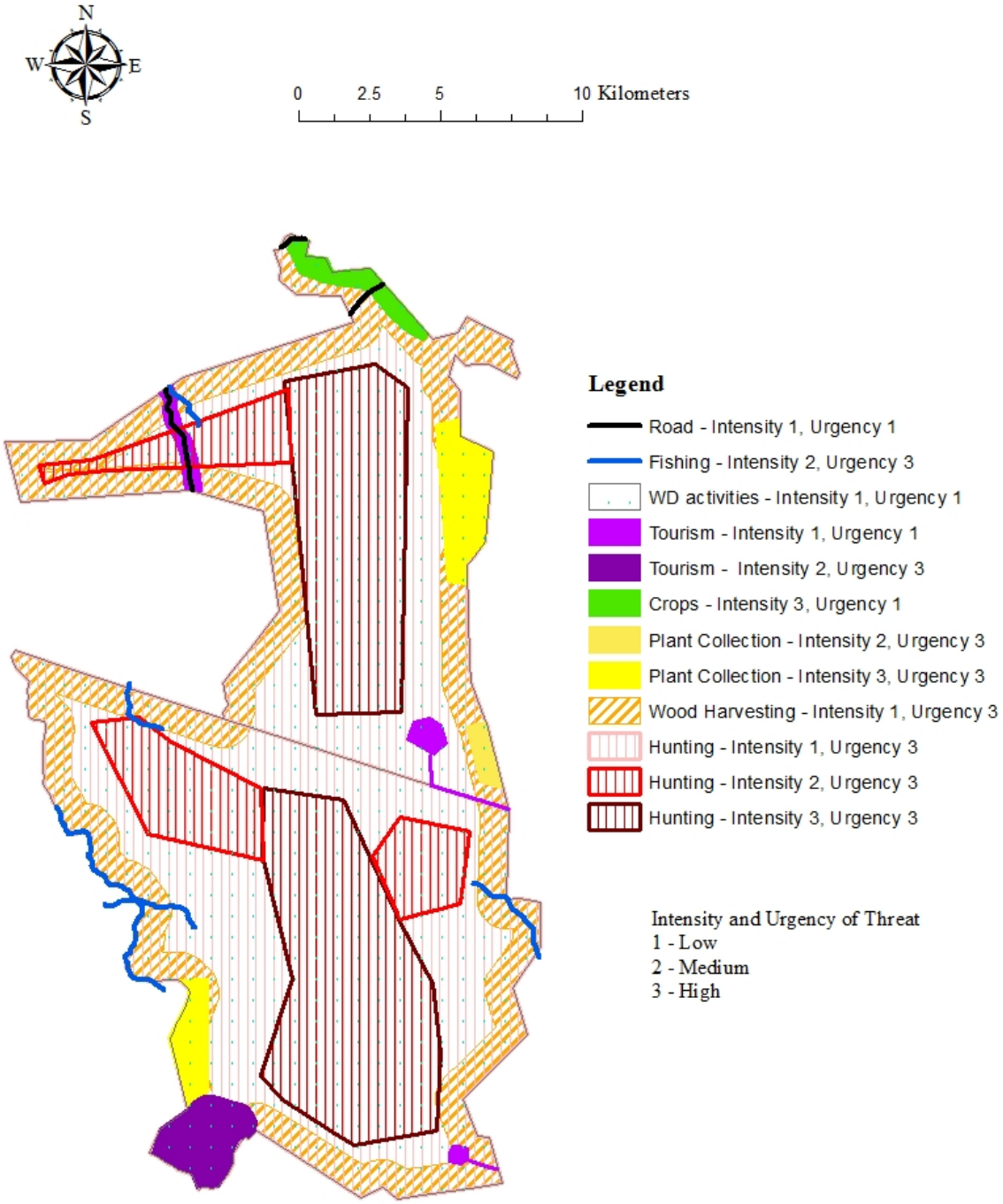

Fig. 3. Threats to Kakum Conservation Area's biodiversity in 2004
Sources: KCA boundary (Wiafe and Amfo-Out 2012), hydrography (Lehner 2008)

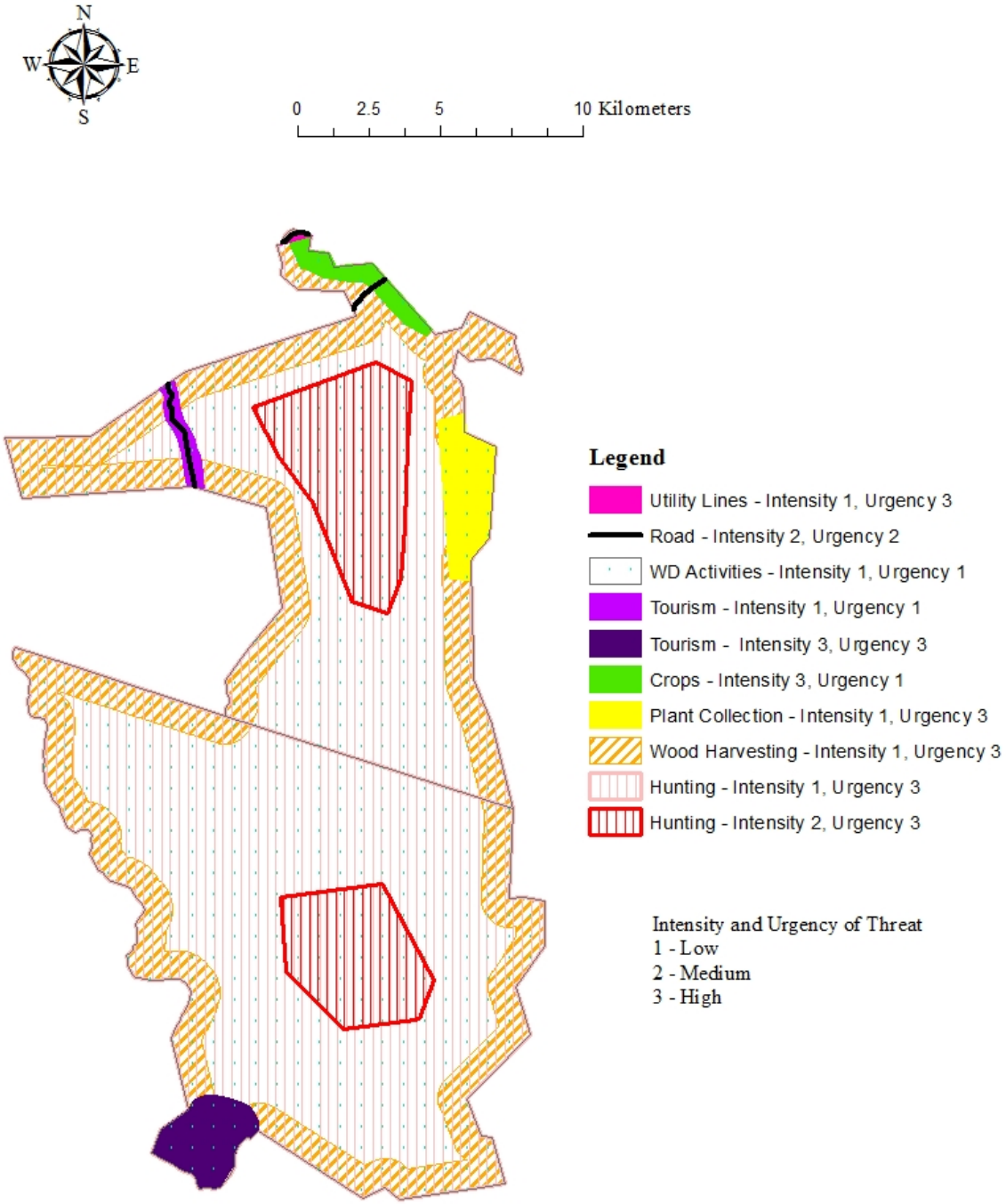

Fig. 4. Threats to Kakum Conservation Area's biodiversity in 2012
Source: KCA boundary (Wiafe and Amfo-Out 2012)

4.2. Community-based threats

The three most critical threats to biodiversity in KCA fall under the 'biological resource use' category (Salafsky *et al.* 2008). These threats are directly attributed to the actions of members from communities adjacent to KCA, and in descending order are:

- Hunting and collecting terrestrial animals.
- Logging and wood harvesting;
- Gathering terrestrial plants;

Prior to discussing each threat separately, the role and relationship of communities adjacent to KCA will be discussed. The role and approach of the law enforcement staff, the body endowed with the responsibility of protecting the PA from illegal activities, will be outlined. This will help to reveal how the community is engaged with the KCA and how KCA is protected from members of the community who do not abide by the laws of conservation.

As discussed in the literature review KCA was established in 1989 and prior to its establishment it was a managed forest reserve and members of the communities adjacent to the PA used it as their source of natural resources. Upon its establishment as a wildlife reserve people were prohibited from entering the PA without permission granted from the WD and their right to extract resources from KCA was revoked. Although some community members supported the establishment of KCA, others vehemently opposed it. Local support of a PA is exceedingly critical as the local community can be the strongest force protecting the PA or pose as its biggest threat (Infield 2001; Pimbert and Pretty 1997). KCA has attracted local support however people from the adjacent communities are the primary threat to biodiversity in KCA due their involvement in illegal activities as described in the above-mentioned categories. During an interview WD staff revealed that it is very infrequent that people caught involved in illegal activates inside the KCA are not from a surrounding community. The

exception to this is when people enter the PA seeking ivory, however community members are usually involved in this process, helping to locate the elephants. WD staff members are confident that community members from the adjacent villages are well aware of the PA boundary line and restrictions pertaining to KCA. The law states that: “No person is allowed to enter a PA without an appropriate and valid entry permit or equivalent” (WD 2009a, p 34). The boundary of KCA is continuously cleaned to ensure it is well defined and recognizable. However, each month people are arrested within the boundaries of KCA for engaging in illegal activities.

The WD message of conservation reaches community members through WD community outreach initiatives. KCA is committed to educate peripheral communities about the importance of the WD, KCA and the impacts they can have on the PA. The Conservation Education and Public Awareness (CEPA) campaign involves educational visits to schools, community conservation and education workshops and conflict resolution meetings with community leaders, primarily traditional chiefs and elders. During school visits students are educated on the importance of wildlife, wildlife laws and elephant crop raiding. Many students are also members of wildlife clubs that are supported by KCA. Educational posters are also distributed to schools and communities (WD 2012). Community workshops have dealt with the following issues: closed hunting season, laws governing bushmeat and trade, hunting licences and pepper fencing training to deter crop raiding (WD 2010d).

CEPA has struggled to reach hunters and people involved in the bushmeat trade. Two of the quarterly reports in 2005 highlighted the difficulty WD staff were having reaching hunters in order to educate them on hunting laws, protected species, licences and the bushmeat trade. Bushmeat vendors refused to cooperate with WD staff and identify the hunters in 2005 (WD

2005b, 2005c). However, in 2010 bushmeat traders partook in a workshop, which educated them on the regulations governing bushmeat trade (WD 2010b). Although no established widespread hunting association exists for communities adjacent to KCA such associations are being established elsewhere in Ghana. In 2011 hunters from 27 fringe communities surrounding Gebele Resource Reserve established their own hunting association after taking a Community Collaborative Management and Conservation Education workshop which educated them on basic wildlife laws, hunting laws and weapons issues (WD 2011a). This provides an excellent example of an effective method that could be employed to reach hunters near KCA.

KCA staff has a network of community informants that gather intelligence of illegal activities and relay that information to staff members. In the third quarter of 2006 the Community Wildlife and Crop Protection Volunteers was formed to assist the Community Wildlife Volunteers programme, which was initiated in 2003. The broad network of community volunteers help support projects such as the pepper fencing initiative, disseminate information and report illegal activities (WD 2006c). This involvement demonstrates community support and concern for the PA, support that is critical for KCA's ultimate success as a conservation scheme.

Annual meetings involving the Community Management Advisory Board ensures that there is direct participation of community members in KCA management decisions. It is also a platform for communities to raise issues and concerns regarding the PA. In 2005 two major workshops bringing together major stakeholders were held to support the establishment of a Protected Area Management Advisory Board (PAMAB) (WD 2005b). Separate advisory boards were established for KNP and AARR due to geographical position however they are

intended to function as an apex unit which oversees both KNP and AAR as a single unit (WD 2005b). PAMAB works closely with and is funded by the GHCT. By involving community members the WD hopes to ensure the communities adjacent to the PA support KCA.

PAs in Ghana are considered 'environmental security zones' and thus are ensured effective protection. The integrity of KCA is safeguarded through regular patrols by the WD law-enforcement staff. From its inception, the WD has been paramilitary and WD law enforcement staff is required to carry firearms and ammunition to protect themselves from wild animals and poachers (WD 2009a). Although their duties expand beyond anti-poaching activities, the WD refers to law enforcement staff as the anti-poaching team. All members of the anti-poaching team at KCA have had military training and are considered on duty call 24/7. Staff members are not permitted to refuse the call of duty when the need arises (WD 2009a). Anti-poaching duties are carried out 356 days a year and are coordinated by the law enforcement head officer stationed at the WD office in Abrafo Odumase. In July 2004 a law enforcement monitoring system, developed by Dr. Hugo Jachman was adopted and operationalized (WD 2004b, Jachman *et al.* 2011). The Rules of Engagement for dealing with PA trespassers is as follows (WD 2009a, p 38).

1. Command presence
2. Verbal control
3. Impact weapons
4. Warning shot
5. Lethal force

All WD staff members interviewed demonstrated a genuine sense of duty to protect the PA. The law-enforcement frequently put their lives in danger while protecting the biodiversity in KCA. They must be careful not to be caught in traps set out by poachers, can find themselves

under fire from poachers and have to be continuously mindful of the lethal insects, reptiles and mammals that inhabit the PA. Conflicts between community members and law enforcement staff have also been documented.

The patrols are conducted to ensure PA law is abided by, to deter community members from engaging in poaching and other illegal activities and to gather data for monitoring purposes. Official policy states "[a]nyone who is suspected to have contravened the wildlife laws and regulations must be arrested, investigated and if found wanting, prosecuted." (WD 2009a, p 26). The patrol staff at KCA has the power to arrest people suspected to illegal activities. This is important as it gives authority to KCA patrol staff, whose job it is to protect KCA from illegal activities. The patrol staff ensures law enforcement and monitoring is conducted throughout the entire area by conducting cross-country patrols on a regular basis. Most anti-poaching staff members participate in several short and two long patrols, which can last up to 5 nights per month. Patrol teams are usually made up of three to five staff to maintain safety standards and integrity. They do not use tents during their overnight patrols, to reduce the possibility of detection and thus are never fully protected from the elements. The lack of proper equipment, including rain jackets, is a concern of KCA management staff.

The majority of anti-poaching team members live in camps at the perimeter of the PA. The presence of WD law enforcement staff in communities surrounding the PA is strategic for enforcement as they help to deter people from illegally entering the PA. Illegal activities are also more easily reported by community members to KCA staff because of their presence in the communities. Poachers also are able to use the presence of law-enforcement in the villages to their advantage. Poachers are able to gather intelligence on WD staff and use their whereabouts to their advantage. For example if it is known that the law enforcement team

recently returned from a long-patrol and are exhausted at camp, poachers may take advantage of the situation and slip into the PA while they recuperate. Although enforcement staff is instructed to not divulge information on anti-poaching activities, in a small village context it is exceedingly difficult to keep all information and activities secret. For example, during a law-enforcement training session away from KCA, poachers seized the opportunity of absent officials and two elephants were killed in AARR. Although there is community support for KCA, some members from communities adjacent to KCA are involved in activities that directly impact the biodiversity in KCA.

4.3. Threats to biodiversity in Kakum Conservation Area

4.3.1. Hunting and collecting terrestrial animals

Hunting and collecting terrestrial animals is the primary threat to biodiversity in KCA. The hunting of animals presents an acute problem because it is lethal and the effects are irreversible. This is particularly significant when the targeted animals are threatened species. WD staff confirmed that bushmeat is the primary target for most poachers. Hunting within the boundaries of KCA is part of the widespread illegal hunting culture in the Central Region that impacts biodiversity in KCA. The animals that inhabit KCA are not restricted to the boundaries of the PA, therefore hunting activities that are not regulated by the WD also impact biodiversity within the PA. For the purpose of discussion and because an evaluation of the specific WD hunting regulations is beyond the scope of this research, it will be assumed that the established hunting regulations, if followed correctly, ensure species populations are not compromised.

Hunting within the boundaries of a wildlife reserve is strictly prohibited and is an offense punishable by law. Hunting species that are not fully protected is permitted outside the boundaries of wildlife reserves with the accompaniment of an appropriate permit (Act 43

Wild Animals Preservation Act 1961). Hunting in a regulated manner that does not compromise species populations is an important aspect of conservation. Unregulated hunting can have devastating consequences. The WD is the body responsible for issuing hunting permits and ensuring the hunting laws are abided. Many people interviewed confirmed that hunting incidents outside of KCA without a permit is a frequent occurrence, also having a direct impact on the biodiversity of KCA. Despite efforts to suppress hunting activities through the presence of law enforcement, patrols and community education initiatives, illegal hunting still continues to occur outside and within the boundaries of KCA.

Since 2004, a 70% positive reduction of threats emanating from hunting activities within KCA boundaries has occurred according to expert participants in the TRA workshop. This is attributed to an increase and enhancement of patrols, harsher sentencing for perpetrators and community education. Available documentation showed an increase in the hours and distance patrolled on a monthly basis. During the TRA it was determined that a 100% reduction of 'hunting and collecting terrestrial animals' is the total elimination of poaching in KCA. However, illegal poaching outside the boundaries also poses a great risk to the forest dwelling wildlife that migrate in and out of the PA. Therefore, a total elimination of the threat should be the elimination of all illegal hunting in the entire Central Region.

Animals are hunted as a source of protein, which is either consumed within the household or the bushmeat is sold to chopbars[1] or directly to buyers. Animals are also hunted for other commodities such as fur, bone and ivory (Ministry of Environment and Science 2002, Odonkor *et al.* 2007; Jachman 2008). Ivory, banned under CITES, is a highly lucrative commodity traded globally in the black market. The bushmeat trade and the illegal trade of

[1] A chopbar is a restaurant that butchers, cooks and serves bushmeat to customers.

animal products are major threats to wildlife in KCA and Ghana (Ministry of Environment and Science 2002; Odonkor *et al.* 2007; Jachman 2008).

Throughout the quarterly reports the number of poachers arrested is given however often the final sentence is not described and the report only states 'pending (bail)' not indicating the punishment, or lack of, the person has received for their crimes. This makes it difficult to determine if the penalties have decreased or increased in harshness. However, when reported it appears that the sentences given to poachers are increasingly harsher. This was also corroborated by WD staff, which partially attribute the decrease in poaching activities to the harsher sentences handed down by judges. Law-enforcement also stated that judges are harshest with people who have been previously convicted of a similar crime. The support from the judicial system is crucial. Harsher sentences reduce the number of casual poachers.

A significant portion of the KCA's limited resources is devoted to primarily protecting the PA from poaching activities. Although the law-enforcement team also works to protect KCA from the previously discussed threats, due to the urgency and intensity of poaching activities, poaching is their primary focus. Evidence of poaching within KCA is recorded monthly. Fig. 5 illustrates the poaching activities recorded from April 2004 to March 2012.

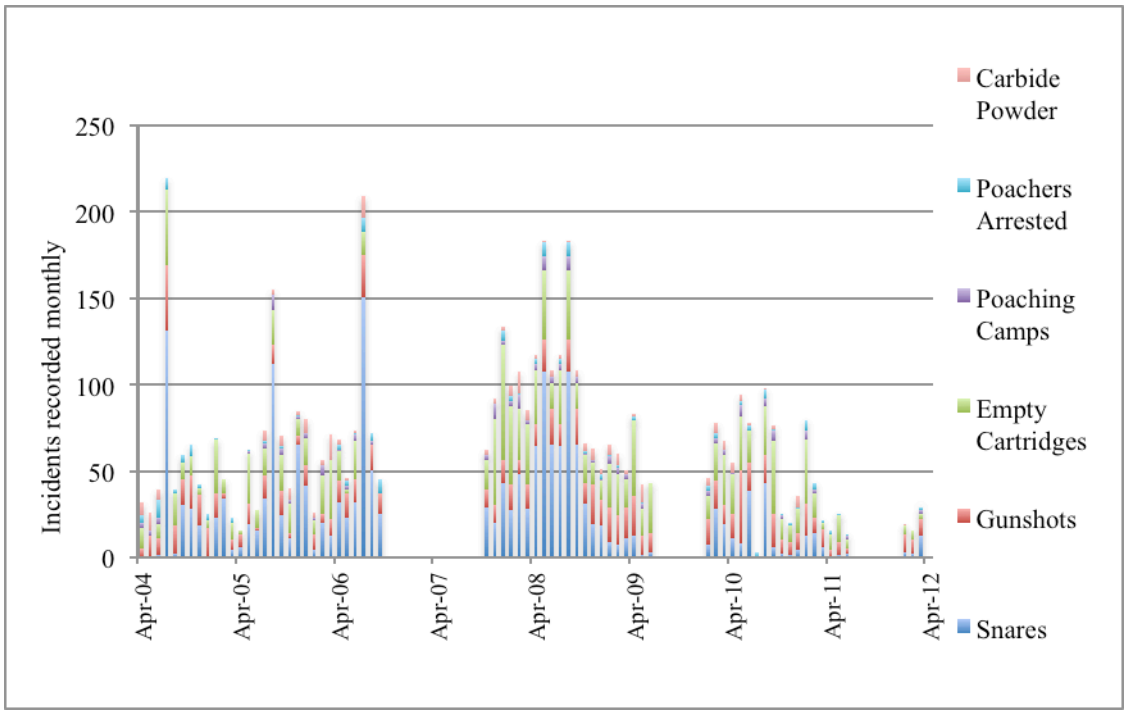

Fig. 5. Monthly evidence of poaching incidents recorded in KCA
Source: Wildlife Division. Kakum Conservation Area's Quarterly Reports 2004 to 2012

The numbers were obtained from the available quarterly patrol reports at the WD office in Abrafo Odumase. The gaps in data occur because reports or monthly statistics were unavailable. The area covered by patrols and the hours on patrol vary each month, however, an increase in both has occurred since 2004. Only the most recent reports indicate if the poachers had actually obtained an animal and, if so, which species. This information is useful to determine and track which species (threatened or abundant) are being targeted and killed. Species, such as forest elephants (*Loxodonta cyclotis*) are at times specifically targeted. Other animals are killed because they simply cross the path of an indiscriminate hunter seeking extra food or income for his or her family.

Although hunting remains a widespread problem throughout the PA, the geospatial model illustrates how the areas of greatest intensity are shrinking. The areas of greatest intensity are located in the centre of the PA, furthest from all other human disturbances including noise pollution. Although more challenging for poachers to access, it is likely that they target these

areas due to the abundance of species and distance from law enforcement camps. One might also wonder if there is a relationship between the reduction of hunting within the PA, the decrease in areas with the highest intensity and the population sizes of particular species. There was no available data regarding population sizes or trends of particular species during the time of the research therefore it is impossible to accurately determine if poaching has decreased in KCA partially due to the lack of species present making illegal entry and hunting within the PA unprofitable.

Beyond the illegal hunting activities within KCA, poaching is prevalent in the Central Region. Law enforcement staff estimate that the number of people that hunt greatly exceeds the number of permits issued. Many opportunistic hunters are farmers. WD staff described how farmers frequently lay traps or bring a gun along with them during their daily tasks and seize the opportunity if it presents itself. Animals may also be killed as a form of pest control. This activity is extremely difficult to monitor or estimate as the hunting and consumption occurs within a very small spatial and temporal space. With farmers abundant through the Central Region this type of unregulated hunting is extremely dangerous for species that may also dwell within KCA. As farming families continue to earn 50 to 60 GHS (approximately 20 - 25EUR) per month, hunting licenses continue to be inconvenient to obtain and animals continue to dwell on cropland, poaching will continue to occur on cropland as it gives families a source of protein and income unless a specific strategy is implemented to target this type of behaviour. The grasscutter (*Thryonomys swinderianus*) breeding project established in communities provides a continuous source of income and protein (WD 1996). The project has been successful according to WD staff and has the potential to be expanded.

Although Kakum is supposed to provide a haven for wildlife, poaching within and illegal hunting outside the boundaries make these animals highly vulnerable. Although the reduction in hunting is a positive sign it continues to be the most critical threat to biodiversity in KCA.

4.2.2. Logging and wood harvesting

KCA prior to its establishment in 1989, was Kakum Forest Reserve and managed for timber extraction (Appiah-Opoku 2011). Since its establishment all extraction of biotic and abiotic resources is strictly prohibited. However, wood harvesting remains one of the primary threats to biodiversity in KCA. Commercial logging no longer exists within the PA boundary and does not pose a threat to its biodiversity. Community members seeking firewood for cooking fuel within the boundaries of KCA are the primary contributor to this threat.

Energy is a necessary commodity and wood is the main source of cooking fuel for many people living in close proximity to KCA. The TRA workshop participants determined that the collection of firewood is widespread and occurred around the entire perimeter of KCA and up to one kilometer into the PA. Felling trees for firewood within KCA is rare therefore the primacy concern is the collection of dead wood. The persistent presence of humans in KCA alone impacts biodiversity.

The collection of firewood from forests can cause widespread damage. The collection of deadwood alters the habitat of KCA and impacts natural processes, such as the behaviour of forest dwelling species and decomposition, which transforms deadwood into nutrients. Since 2004 the threat posed by the collection of firewood has been reduced by 90%. Staff that were interviewed, but did not participate in the TRA, corroborated this decrease of firewood collection. The area of firewood collection has not diminished but the intensity has.

Community members are often seen collecting firewood from forested areas adjacent to the road and in forested areas where the collection is permitted. Securing renewable sources of fuel is necessary to ensure community members do not resort to collecting fuel within the PA once other sources have been exploited. The WD donates tree saplings to be planted, maintained, harvested and sold as firewood to local schools. This initiative increases the availability to firewood to communities from a renewable source and is used as a fundraising scheme for local schools. This and other community wide initiatives need to be further developed to secure renewable fuel sources and prevent the further destruction of habitat.

4.2.3. Gathering terrestrial plants

Terrestrial plants found within the humid tropical forest have a plethora of uses including dental care products, building materials, food, fibers, and medicine (WD 1996; Ramcilovic-Suominen *et al.* 2012). Non-timber forest products have great socio-economic value for rural Ghanaians. Logging and the expansion of cropland have lead to widespread deforestation in the Central Region of Ghana. This has decreased the availability of traditional materials (World Conservation Monitoring Centre 1992).

Forest reserves and wildlife reserves are nearly the only places left where these materials are widely available. Wildlife reserves, including KCA, prohibit the extraction of resources including terrestrial plants. However, extraction continues to occur within the boundaries of KCA and is considered to be the third most critical threat to biodiversity. The extraction of terrestrial plants occurs primarily in AARR on the eastern border. TRA participants believed that it may be due to its strategic position furthest away from the WD office in Abrafo Odumase, a high number of access points to the PA because of proximity to roads and paths from the concentration of admitted farms and a denser distribution of desired species in that area.

Extraction of these resources is permitted outside wildlife reserves once a permit is obtained from the FC (FC 2008). WD staff acknowledged that the majority of local community members do not obtain a permit to extract these resources. WD staff interviewed stated that sometimes people feel that they should be able to take products from the reserve because it is in close proximity to their farm and they are able to see the products from their farm. In other cases products are required immediately and a permit, which is issued within 7 days (FC 2008), is simply not obtained due to the time constraints. For example a man from a local community stated that anti-venom for snakebites can be created from products found within the tropical humid forests but they must be extracted immediately to be effective. He told the story of his mother collecting the appropriate plants for anti-venom on three occasions, over the span of years, after a poisonous snake had bitten him. She did not have a permit to collect these plants nor the time to get a permit or to find someone from the community that both had a permit and knew the species and location of the specific plants required. In some cases communities surrounding the PA also have access to an adjacent forest reserve and with a permit the resources required can be collected from these reserves. In other cases KCA provides the only habitat in which these products are found near the community.

In other cases there is a blatant disregard for the law. The following observation illustrates how community members, fully aware of the laws continue to extract non-timber resources from forested areas illegally. While walking on a road bordering KCA to the South West, I met a local man carrying a bag of locally sourced forest products. After a friendly exchange of words he showed me the products, cane and chewing sticks, that he had collected from the forest. The man never revealed the exact location where these products were extracted. He did reveal that he was part of an organization that worked closely with the WD in KCA. The man gave his name to me and allowed his picture to be taken with the products he had

collected, understanding the focus of my research. Through a later discussion with one of the WD management staff members it was revealed that this man did not hold a permit to collect non-timber products and because of where the man had been encountered it was highly likely that the products had been collected from KCA.

The modified TRA revealed a 66% positive reduction of the extraction of non-timber products from KCA. The success was attributed to the work of the law enforcement team, which has increased its presence and improved its strategy in the PA since 2004. A 100% reduction of the threat was determined to be a total elimination of gathering terrestrial plants from KCA. Although this may be achieved through law enforcement patrols in the future it does not address the issue of community access.

KCA resources will continue to be under pressure until communities have secured access to desired resources outside of the PA to fulfill their needs. This pressure will also grow with the rapidly rising population in Ghana. The WD is currently involved in community campaigns that provide trees to local schools. Although these trees are intended for fuel wood the model could be developed to include other forest products desired by community members. The expansion and development of these community initiatives could improve access to the products desired by the community. Further establishment of strategic forest plantations could help to reduce the pressure on the existing forest resources although they are not a substitute for natural forests.

4.3.4. Annual and perennial non-timber crops

KCA is surrounded by cropland and exists as an island of biodiversity and natural habitat among a sea of plantations and cropland. If the land currently encompassing KCA had not been established as a forest reserve and later a national PA it would have almost certainly

have been turned into cropland. There exists an area of cultivated land within the boundaries of KCA that existed prior to its establishment as a protected area. The area of cultivation has decreased since the PA's establishment in 1989 however it has remained the same since 2004, neither expanding nor contracting. Regular patrols have not recorded any encroachment since 2004. The cultivated land is a part of larger farms that extend into the park. There are no settlers living within the park boundaries. At the deepest point the cultivated land extends 1.5 km into the park, and is concentrated in AARR, on the eastern border. A buffer zone does not exist between the PA boundary and cropland that surrounds it. Crops are planted right up next to the boundary to take advantage of the microclimate created from the humid tropical forest. The cropland within the boundaries and on the periphery of KCA both present threats to biodiversity within KCA.

A 100% reduction of the threat would be total elimination of all cropland existing within the boundaries of KCA. Eliminating cropland from existing in the park is a complicated political task; if done properly it would require proper compensation for people that farm the land. As the population expands (Ghana Statistical Service 2012) arable land in Ghana will become more valuable, making compensation increasingly more costly. Although people do not live within the boundaries of the PA their homes are in close proximity to the land farmed. Therefore, it cannot be overlooked the connection these people may feel to that land as part of their home containing their historic roots and having cultural significance beyond farm land. Simply relocating these people to land of similar value may not be considered a fair relocation to the people although it would be beneficial to the biodiversity in KCA. Allowing the cropland to be swallowed up by KCA would increase the habitat of the area-constrained PA but may cause repercussions by the community that are unfavourable for the PA if not conducted properly.

Cropland is not a natural habitat for forest dwelling species; those that find it suitable habitat are frequently considered pests to crops and are not desired by farmers. KCA is relatively small and the habitat is constrained. Because no buffer zone exists and only two adjacent forested areas exist, once species migrate outside the PA boundaries they most often enter cropland. Crops, especially when they are nearing harvest, provide an excellent source of food for many forest dwelling species. Farmers, who already earn a meagre profit from their crops, cannot afford to be raided by these animals. Once animals leave the PA, they have a higher chance of being killed, legally or illegally, by farmers and other community members. Techniques such as pepper fencing have proven to be an effective, low cost deterrent to crop raiding species such as elephants and reducing human wildlife conflict (Addo-Boadu 2010). However, these animals still live within a constrained habitat and even if species numbers were to increase they have no room for range expansion. The lack of natural forest habitat and wilderness corridors between these habitats in Ghana constricts species growth.

Animals are not the only species that are impacted by cropland. As widespread deforestation has occurred to increase cropland native plant species are cleared indiscriminately. Species that are used by villagers for various products, including fuel wood, are no longer widely available in close proximity to the village except in forest and wildlife reserves such as KCA. Therefore the expansion of cropland has placed increased pressure on existing forested areas and their resources. So although croplands existing within the boundaries of KCA are not expanding the decreased availability of forest products outside KCA increases those within KCA increasingly more valuable.

4.3.5. Tourism and recreation areas

KCA is an ecotourism destination that generates income for the Ghanaian Government while giving visitors the opportunity to experience a remnant of remaining tropic humid forest and

learn about the value of nature and importance of conservation. Tourism, although part of KCA goals (Appiah-Opoku 2011), impacts biodiversity in KCA. Tourism as a threat to biodiversity has experienced an increase from 2004 to 2012. The number of visitors has grown since 2004 as depicted in fig. 6.

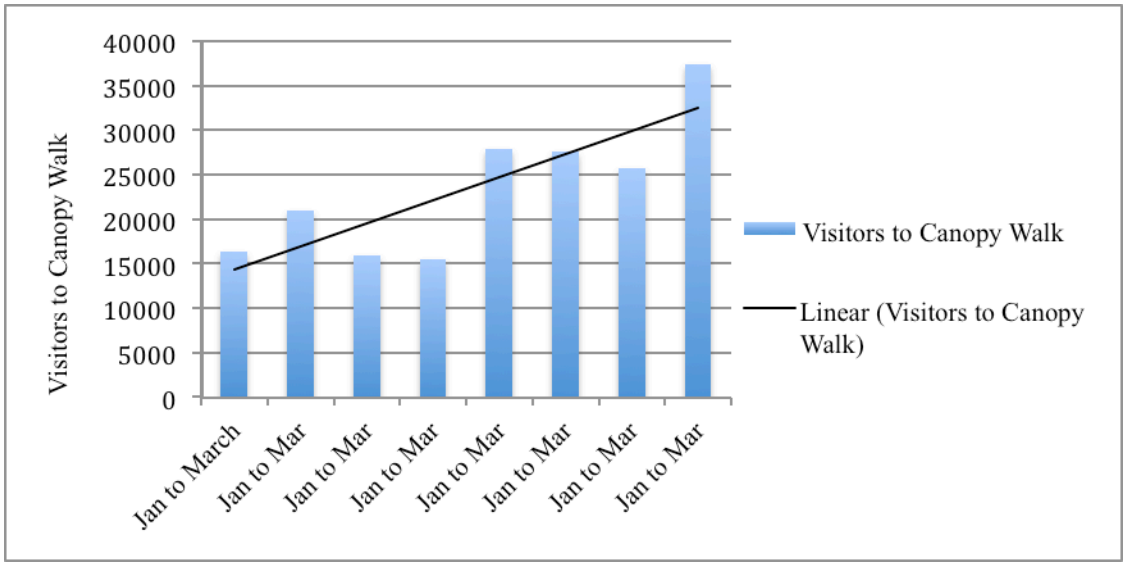

Fig. 6. Visitors to KCA Canopy Walk for the first Quarter of each year
Source: Wildlife Division. Kakum Conservation Area's First Quarterly Reports of the year 2005 to 2012.

The statistics on number of visitors to KCA was obtained from quarterly reports. January to March were selected due to a paucity of data for other quarters. Gaps exist because records were unobtainable in the WD office in Abrafo Odumase.

On an average day the number of tourists does not exceed the carrying capacity of KCA however a few times a year the number of visitors spikes. Two of the busiest days of the year are Ghanian national holidays: Independence Day on March 6th and Republic Day on July 1st. From January to March 2012, the canopy walk was visited by 37,458 people, with the majority (20,369) visiting in March alone. Most visitors to KCA visit only the canopy walk. The canopy walk is advertised as a one-of-a-kind experience in West Africa. A significantly lower number of people go on a nature walk or bird watching.

The majority of visitors, regardless of the month, are Ghanaian students as depicted in fig. 7. The number of Ghanaian students visiting the PA is considered to be positive, as it is vital they learn about the value of conservation and are introduced to environmental issues afflicting their country. However, tourism, above and beyond the carrying capacity of KCA, has the potential to be harmful and erode its ecological, cultural and aesthetic value. "[E]cotourism should be promoted and regulated in accordance with the carrying capacity and management objectives" (WD 2009a).

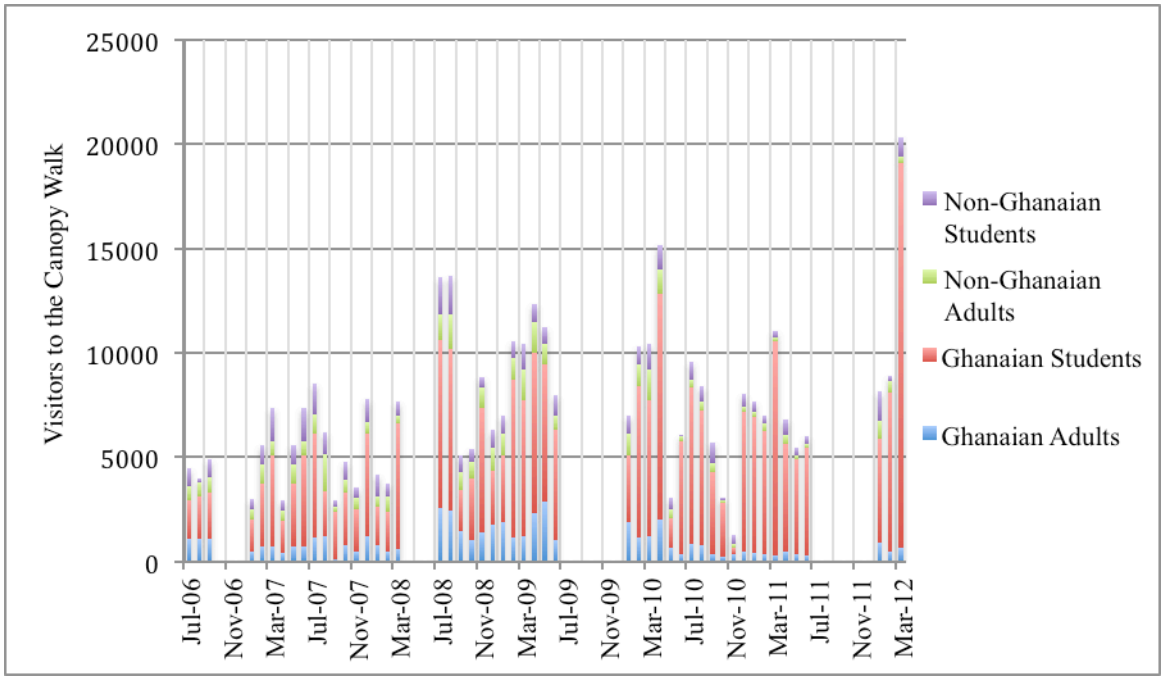

Fig. 7. Monthly visitors to KCA's Canopy Walk by demographic
Source: Wildlife Division. Kakum Conservation Area's Quarterly Reports April 2006 to March 2012

Visitors' impact should be environmentally benign however; human presence always has an impact. Particularly after busy days, areas beyond the paths and trails are trampled and litter, particularly plastic from drinking containers and food wrappers, are found throughout the visitor's area. Guides help to monitor and minimize the impacts of the visitors, however, when the ratio of visitors to guides is too high guides are simply unable to monitor and control the activity of each visitor effectively. The litter, although momentarily unsightly, is cleaned up promptly by WD staff. What the litter reflects is the message and experience

people have during the busiest days when the number of visitors is beyond the capacity of the infrastructure and staff.

KCA experts defined 100% threat reduction for tourism and recreation as 'carrying capacity not exceeded on a daily basis and a 100% elimination of littering. This follows recommendations outlined in the Operations Manual (WD 2009a) however no current KCA policy exists to limit traffic on the busiest days. WD management staff is considering raising the rates on those days. However, the majority of visitors on those days are student groups organized through schools. Only permitting a limited number of student groups and requiring reservations on those days could suppress the influx of visitors to fall within the carrying capacity. WD staff believes that the influx of student groups on Ghanaian National Holidays is attributed to the fact that schools want to treat students to a national treasure on national holidays. Although noble in nature, the objective of teaching students about KCA is lost when the number of visitors is simply unmanageable. It would also send a strong message to schools, staff, students and all other visitors that conservation and education are priorities of KCA and therefore the quality of the experience is valued.

The majority of visits to the PA are contained within a relatively small area in the south-western corner of the PA. Two tree-house which was used for overnight visits and birding in 2004 has since been closed to visitors. Bird watchers also visit the north-east corner of the PA. The closure of the tree house has reduced the overall area impacted by tourism. During the TRA the possibility of expanding tourism infrastructure was discussed as a way to alleviate the pressure caused by high numbers of visitors on particular days. This is a step in the wrong direction, as it would introduce human presence in the park where it does not currently exist. The habitat of species in KCA is already severely constrained and increasing infrastructure to

accommodate tourists will only increase the impact of tourism. Additional infrastructure or activities of interest to visitors could be developed outside the boundaries of KCA. This would increase revenue for communities and move visitors away from disturbing wildlife and flora within KCA.

The presence of tourists within the boundaries of the PA also contributes to noise disturbance. Because of noise and the presence of people on the canopy walk, animals have since migrated from that area. The canopy walk which is supposed to help showcase the diversity of canopy species is unable to fulfil its role as human presence is too disruptive for many species that would normally find this habitat to be suitable. The canopy walk excites many tourists and their shouts of enjoyment or fear can be heard as groups pass over the habitat. Although the WD guides explain to each visitor the importance of remaining quiet this is simply not abided by and thus animals have been driven from this area. The WD staff members are well aware that animals simply do not live near the canopy walk or other parts of the visitors area due to human presence. Thus management needs to ensure that silence is strictly abided by and anyone who raises his or her voice for any reason should be escorted from the area immediately. This needs to come from management, otherwise guides have no incentive to enforce this rule. A guide who prevents their group members from raising their voices while another guide leads a group of gleefully vocal students will create tension among the guides, between guides and visitors and possibly between visitors and other visitors. If reduced noise levels persist animals may return to this area and provide a real spectacle for visitors. Currently pamphlets of KCA display charismatic mammals and birds however few visitors to KCA are fortunate to see any of the animals displayed on the promotional posters. The animals simply avoid the visitors' area because of the visitors but effective management strategies have the potential to reverse this.

Revenue that is generated from tourism at KCA does not go directly back into the PA. Therefore there is little reason from a conservation standpoint to increase tourism as it adversely impacts biodiversity without providing a positive trade-off such as increased funding for monitoring or habitat rehabilitation. A portion of the proceeds should be directly input into conservation strategies at KCA as a trade off for the negative impact visitors have on the PA. The Galapagos Islands in Ecuador, National Parks in Botswana, PAs in Nepal and some National Parks in the United States are allowed to retain revenue collected from visitor fees to reinvest into maintaining the PA. In the Turks and Caicos, and Belize money generated through taxation of tourists' is used to finance PA conservation trust funds. All of the revenue generated is required to be used in conservation projects. The 'user pay' principle is recognized as a fair way to acquire funding for environmental protection (Spergel 2004).

4.3.6. Work and other activities

Work and other activities was perhaps the most surprising threat revealed by KCA experts. Acknowledging the work of WD staff as a threat demonstrates great awareness on behalf of PA management. Prior to the workshop WD staff had never seriously considered their own presence and activities as a threat that negatively impacted the biodiversity they work diligently to protect. Regular patrols covering the entire area of KCA are necessary to protect and monitor biodiversity, however, human presence ultimately has consequences on biodiversity. Patrols directly impact biodiversity when plants are cut, animals are trampled and habitat is disturbed. This impact may be considered minimal when comparing the trade-offs that these patrols provide. The patrols are currently necessary to protect wildlife against poaching activities, and to prevent community members from collecting timber and non-timber products from the PA.

Research activities, especially transects that are cut and maintained, also impacts biodiversity. Transects clear lines of vegetation and provide poachers with easy access to the interior of the PA, where wildlife is least accessible. Poachers are known to use these transects, particularly when attempting to rapidly exit the PA with game. The boundary of KCA is continuously cleared to ensure it is obvious. Although this is done to prevent accidental trespassing it is potentially harmful to forest dwelling species living on the periphery of the PA boundary.

The percentage of change, -3%, in the impact of work as a threat appears insignificant however the rationale behind this change is not. It was determined that an increase in patrol staff and number of patrols from 2004 to 2012 would naturally increase the impact but the adoption of better practices would in turn decrease it. An examination of the quarterly reports shows the increase of workers to be minimal but both effective patrol days and effective distance patrolled has increased. In November 2011, 622 effective patrol days and 657.96 km patrolled were recorded (WD 2011c). In June 2005 the cumulative number of effective patrol days for April, May and June was 522 and the cumulative distance covered was 469.77 km (WD 2005a). The improved patrol strategies can be attributed to the law enforcement monitoring system, developed by Hugo Jackman that was adopted and operationalized by the WD in July 2004 (WD 2004b).

A 100% reduction of the threat was elected to be the elimination of all non-essential disruption of biodiversity. This can be included within the current training curriculum of law enforcement staff and relayed to researchers. Law enforcement currently moves through the forest in a manner that minimizes the disruption of wildlife and vegetation. For example rather than cutting through dense vegetation law enforcement weaves through the dense undergrowth. Prohibiting the development of new transects for research would reduce the impact on biodiversity while allowing research to occur by utilizing transects that currently

exist. The WD management team can easily enforce this as they approve research methodology within the boundaries of KCA.

Reducing the impact on biodiversity by improving work and research techniques is less challenging to implement than strategies related to reducing other threats. The people impacting biodiversity in this case are under the direct supervision of management staff and are already committed to protecting biodiversity within the PA. If effective strategies to eliminate all non-essential disruption to biodiversity are implemented this threat could see a 100% reduction in the near future.

4.3.7. Roads and railroads

Threats posed by roads and railroads experienced a 30% increase from 2004 to 2012. In 2004 a railway boarding a northern section of KCA was functioning, operations have since ceased. Three roads, all within the AARR section of KCA existed in 2004 but have since experienced a marked increase in traffic. The increase in traffic has lead to an increase in dust pollution and noise pollution. It also increases the likelihood of collisions and puts species desiring to migrate across the roads in increased danger. KCA experts unanimously agreed that closing the sections of roads within the boundaries of the park or re-routing the roads was not politically realistic. Although "the park manager has the discretion to close any type of road to any type of traffic either temporarily or permanently" (WD 2009a, p60).

Instead a 100% reduction of the threat would incorporate the following:

- Tarring of the road,
- Creation of fencing and wildlife bridges,
- Zero expansion of the road network.
- Elimination of vehicle speeds above 20 km/hour.

Paving the roads would reduce dust and prevent potholes from being filled with sand excavated from KCA. Although fencing and wildlife bridges may be expensive it would eliminate wildlife-vehicle collisions while allowing animals to freely and safely access their habitat within the park. These mechanisms to protect wildlife may not be viewed favourably by the local community members who do not receive fencing from the government to protect their crops from wildlife raids and have the dust generated by dirt roads as part of their daily life in rural Ghana. Human-wildlife conflict, particularly crop, raiding has been a major concern for WD staff and community members. Thus development to protect the wildlife in KCA would be most beneficial as part of a larger development initiative in the region including paving of the main roads between communities, and community education. Zero expansion of the road network would eliminate any further habitat fragmentation, which can impact species migration and destroy critical habitat. The Field Operations Manual published by the WD in 2009 states: "All roads in PAs must be designed, constructed and maintained to ensure that they do not interfere with the natural functioning of the ecosystem and other ecological processes. To keep existing roads in good and prompt maintenance schedule must be adhered to in all PAs" (WD 2009a, p 41). It is essential that the management team ensure this policy is abided by.

4.3.8. Fishing and harvest aquatic resources

'Fishing and harvesting aquatic resources' is a sub category of the 'biological resource use' category from the *Standard lexicon for biodiversity conservation unified classifications of threats and actions* (Salafsky *et al.* 2008). The extraction of resources including fish and all aquatic resources in KCA is strictly prohibited. The area, urgency and intensity rankings from June 2004 tied 'fishing and harvesting aquatic resources' with two other threats as the fifth most critical. Incidents and evidence of traditional fishing techniques along with the exceedingly destructive method of cyanide fishing had been observed along four rivers in

KCA. A decline in fishing has occurred within the boundaries of KCA. Since the beginning of 2011 until the assessment workshop in June 2012, no incidents of illegal fishing were recorded. Thus, experts determined a positive 100% reduction in fishing. Fishing and harvesting aquatic resources is the only threat that has witnessed a 100% reduction by WD staff over the assessment period.

Park staff did not attribute a single cause to the elimination of fishing activities in the PA, but it was suggested that increased public awareness and patrols may be responsible for its decrease. Staff that were interviewed, but did not participate in the TRA, corroborated this decrease of fishing incidents.

Fishing activities are still observed outside the PA boundaries. Therefore it is important to acknowledge that a reduction of fishing within the park boundaries cannot be attributed to a regional phenomenon. Fishing within the boundaries of KCA, as opposed to hunting, is limited to the comparatively narrow areas of habitat and thus easier to patrol. The number of some species that are of interest to hunters is comparatively higher in KCA than in the surrounding areas thus, although illegal, hunting in KCA may give hunters an advantage. It is possible that a similar discrepancy in population do not exists in portions of rivers within KCA boundaries and for those same rivers once they flow out of the PAs boundary. If this is the case there is no comparative advantage for people to illegally fish within the boundaries of KCA. Because law enforcement has a strong presence within the PA and the judicial system enables the arrest and prosecution of people caught disobeying PA laws, fishing within park boundaries has a comparative disadvantage and perpetrators can face steep fines. The reduction of fishing within the boundaries of KCA through adequate law enforcement is an

example of how political and economic disincentives can protect biodiversity within the boundaries of protected areas.

4.3.9. Utility and service lines

Although service lines did not exist within KCA in 2004, electrical and telecommunications lines have since been constructed with government permission. The newly constructed lines are located in AARR along the road furthest north. The construction of the utility lines alters habitat in an area that is already severely constrained. Although the utility lines ranked as the least critical of all threats in KCA in 2012, its emergence is symbolically important. The government allowed habitat to be altered within the PA boundaries without any compensation. The utility lines construction was approved within the park because the cost of construction would be greater if the PA was bypassed, as this design would mean that compensation would have to be paid to land owners and more materials would be required. Although the area impacted by the service lines is relatively small, as indicated on the 'utility and service lines' map the impact to biodiversity may prove to be more critical.

The construction of utility lines within the boundaries of KCA sets a negative precedence for additional infrastructure to be constructed within PA boundaries in the future. It also sends the wrong message to developers who may advocate using portions of the park, further fragmenting it. Workshop participants agreed that removal of all current lines was not a reasonable solution. It was agreed that a 100% threat reduction would mean no further expansion. This could be effectively achieved if all infrastructure development that is not congruent with KCA's objectives is legally forbidden. Total elimination of the utility lines was suggested as the definition for 100% reduction during the TRA workshop but participants agreed that due to political and economic factors elimination of the utility lines was not possible and thus could not be considered.

4.4. Additional Challenges

Beyond the threats discussed previously there are additional dynamics that pose challenges and barriers to conserving biodiversity in KCA. These additional factors provide insight into operational obstacles that prevent KCA management from achieving its objectives.

4.4.1. Funding

Funding for KCA is primarily obtained from the FC. The GHCT also provides a small amount funding to KCA but the majority of funding is obtained from the FC. KCA funding is based upon the budget drawn up by the KCA management team. The FC is frequently either unable or unwilling to allocate the full monetary amount requested. This forces KCA management staff to continuously reduce programmes, prevents them from establishing new initiatives or forces them to simply go without equipment. Cumulatively it prevents them from effectively and efficiently operating. The inadequate operational funds were one of the most commonly cited challenges in the quarterly reports. Other challenges referring to the general operation of KCA include:

- Lack of adequate equipment,
    - Field staff equipment (protective clothing, vehicles, GPS units),
    - Office/technical equipment (printers, software, internet at WD Abrafo Odumase office)
- Lack of reliable communications networks,
- Inadequate training of employees,
    - Computer skills,
    - Communication skills,
    - Research skills.

Adequate funding would enable all of the above to be addressed and is necessary to establish or enhance initiatives that reduce the impacts on biodiversity in KCA. It would be beneficial

for KCA to secure resources from additional sources such as revenue from tourism, which currently goes directly into the national government revenue. However, this would require a national policy change or amendment, which the PA is simply not equipped to lobby for. The current financial crisis makes acquiring funding for conservation increasingly more difficult but as population's rise and biodiversity is lost it couldn't be more critical. The KCA management team should explore additional funding mechanisms as various foundations and agencies allocate millions of dollars annually to support biodiversity conservation.

The Yachana Foundation attracts funding to preserves rainforest in the Ecuadorian Amazon through various campaigns and initiatives that could be replicated at KCA. For example their EcoTribe campaign sells online memberships at a low cost of US$30.00 per month and the funding is used to "organize a burgeoning community of environmentalists that can be mobilized behind ecological and cultural preservation" (Yachana EcoTribe Membership 2011). It provides the Yachana Foundation with a steady flow of income to maintain and implement various conservation projects. Yachana has also purchased more than 43000 acres of rainforest through their Adopt an Acre of Rainforest Program marketed through 'Traveller's Philanthropy' (Yachana Get Involved 2011). The Adopt an Acre of Rainforest initiative EcoTribe and memberships can be purchased through their website by credit card and memberships are renewed automatically. Each page on the Yachana Foundation's website has links to explore conservation initiatives and donation opportunities. KCA does not have its own website and its official online presence is through the WD. There is no obvious link on the WD or GHCT webpages allowing for interested philanthropists to get involved or donate to KCA conservation initiatives. The fundraising initiatives employed by the Yachana Foundation are within the capacity of KCA and GHCT and could be adopted, increasing KCA's revenue for conservation.

4.4.2. Organization

There is a general lack of organization at the WD office in Abrafo Odumase, i.e. many resources, records and materials are inaccessible to staff, researchers and other stakeholders. It also raises questions of if analysis of data collected during monitoring is actually occurring, other than *ad hoc* monitoring by external parties.

The KCA records are poorly kept by WD staff. During an overview of the quarterly reports from 2004 until the end of 2011 many full reports were missing or available reports were incomplete. Only hard copies of the quarterly reports could be produced by WD staff at the office in Abrafo Odumase. Data on species population trends, were unavailable and only sparse data was available on species recorded through hard copies of the quarterly reports. The paucity of data makes it impossible to assess how populations may be decreasing or increasing based on trends. It was expressed that the data contained in the quarterly reports had been 'ineffectively managed' and thus sufficient long-term electronic data was unavailable.

Support material was also widely unavailable at the WD office in Abrafo Odumase. For example, WD management staff members were unable to produce a hard or electronic copy of the Adaptive Management Strategy, which was adopted in 2004 and was selected by experts as the base date for the TRA. Only a former manager whom has since taken a position outside of the WD was in the possession of a hard copy of the Adaptive Management Strategy. The copy was hundreds of kilometres away from Abrafo Odumase and thus unavailable for staff or stakeholder reference. The law enforcement monitoring system, developed by Hugo Jackman and adopted by the WD in July 2004 to enhance the anti poaching initiative was also absent at the local WD office.

Academic resources on KCA were unavailable at the WD Abrafo Odumase office. The research permit, which must be obtained prior to conducting research in the PA, requires one copy of the research and three copies of any published work to be provided to the PA's Executive Director. It is possible that the documents were delivered to the office however a lack of any effective organization in the library or of the files made it exceedingly difficult to find useful or relevant information.

Many of the KCA staff members were exceedingly accommodating and presented me with all the material and information they had available. However, due to the lack of a centralized networking system electronic copies that should be available at all times to all upper management staff, such as the quarterly reports, were not. It is also possible that this data does exist in an organized fashion but the person who has the data was unwilling to share it.

The lack of resources, support material data, and organization is a great disadvantage to the PA. Although data is being collected monthly by the law enforcement staff, inability to access the data means that trends are not being tracked and effective monitoring cannot occur. Although the concepts in materials such as the adaptive management strategy are abided by as part of the operational strategy of the PA, without being able to actually access and reference this material many of the ideas and concepts may be lost or skewed over time. A revision of these materials is also important so employees can remain consistent in their methods and understand the deeper purpose of these methods. A lack of organization makes resources simply unavailable or too inconvenient to access when necessary, which impedes the ability of the staff to fulfil their potential. Ensuring data and resources are available enhances the ability for staff and researchers to do good work.

Students that receive a degree from a government-funded university in Ghana are required to serve the government for one year after graduation. At the time of research KCA had two recent graduates and one student partaking in an internship. The recent graduates do not have specific positions but rather 'float' through the different departments to acquire skills and support staff. Part of the responsibility of these students could be to collect, organize and maintain the necessary materials and documentation. It would give students the opportunity to learn more about the PA and conservation while providing a necessary service.

4.5. Conclusion

The research methodology was sufficient in addressing the objective of this research. Nine principle threats to biodiversity in KCA were identified and the challenges of conserving biodiversity within KCA were exposed. The TRA Index revealed a positive reduction of 44% from June 2004 to June 2012. Biological resource use in the form of poaching, firewood collection and terrestrial plant collection, by members from communities adjacent to KCA, are the most critical threats to biodiversity. These threats have all shown a decrease from June 2004 to June 2012; largely attributed to the increased law enforcement presence, improved patrol methods employed by KCA staff, harsher punishments, and community education. The geospatial threat representations demonstrated areas of intense poaching decreasing over the study period. The geospatial component was useful in illustrating the location of threats in KCA for the two time periods. Interviews and observation revealed funding inadequacies and a lack of data and document organization posed additional challenges to conserving biodiversity in KCA. Further effort on behalf of the WD, community compliance and the creation or enhancement of initiatives is required to continue reducing threats to biodiversity in KCA. The following chapter will discuss the relevance of this research in a broader context.

CHAPTER 5 - DISCUSSION

The results revealed nine principle threats to biodiversity in KCA. Table 7 portrays a summary of the threats in descending order, and includes the IUCN threat code for further reference. For a more extensive overview of the TRA Index please see table 5 in chapter 4. The TRA index revealed a 44% reduction of threats to biodiversity from June 2004 to June 2012, which demonstrates that management strategies and operations are somewhat effective but improvements could be made. The geospatial component effectively illustrated the spatial changes of the threats over the temporal period. These maps can be found in chapter 4 as fig. 3 and fig. 4. This chapter will discuss the underlying causes of threats, and its relevance, describe inconsistencies, present contributions to research, make future recommendations for similar application and research opportunities.

No.	Threat	IUCN threat code [a]
1	Hunting and collecting terrestrial animals	5.1
2	Logging and wood harvesting	5.3
3	Gathering terrestrial plants	5.2
4	Tourism and recreation areas	1.3
5	Work and other activities	6.3
6	Annual and perennial nontimber crops	2.1
7	Fishing and harvesting aquatic resources	5.4
8	Roads and railroads	4.1
9	Utility and service lines	4.2

Table 7. Primary threats to biodiversity in KCA from 2004 to 2012
[a] IUCN threat code source: Salafsky *et al*. 2008

5.1. Relevance

As revealed through the TRA workshop and the interviews conducted over the research period, the top threats to biodiversity in KCA are all threats directly attributed to adjacent communities. All of the threats directly attributed to community activities have been significantly reduced; fishing and harvesting aquatic resources was totally eliminated, wood

harvesting was reduced by 90%, hunting and collection of terrestrial animals, the primary threat to biodiversity, was reduced by 70% and gathering terrestrial plants was reduced by 66%. Management has been effective at mitigating community-based threats to biodiversity in KCA but further effort is required to eliminate these threats.

The focus of KCA management has been community-based threats mitigation; this demonstrates that management has appropriately focused their human and financial resources on the most critical threats to biodiversity in KCA. Community education and awareness initiatives were revealed in the previous chapter and are believed to have partially attributed to the decrease. This is relevant because it supports the research of Infield (2001) and Pimbert and Pretty (1997) which conclude that community support of a PA is critical, as local communities can be the greatest threat to a PA or the most prevalent force protecting it. As community-based actions continue to pose the greatest threat to biodiversity in KCA, it is essential that WD efforts continue to foster deep, widespread community support.

The management team at KCA has been unsuccessful at mitigating threats to biodiversity that are not community-based. Although these threats are currently not the most critical threats, the increase, emergence and the inability for TRA staff to mitigate them is significant. Emerging and worsening threats require strategies and stronger governmental policy to be formed to protect the biodiversity in KCA. To mitigate these threats KCA management staff must enforce the powers endowed to them to prevent development from occurring within KCA that does not comply with their objectives (WD 2009a). The threat posed by the work of WD staff and the impacts posed by tourism can be mitigated through direct policy enforcement by KCA management. The threats posed by roads and utility lines stem from

external forces and the mitigation of these threats requires external support of the PA beyond that of the community.

The emergence of utility lines and the increased threat posed by roads, are driven by economic and political factors beyond the activities of communities adjacent to KCA. These threats can be attributed to development and globalization that is occurring in Ghana. For example, utility lines are constructed as part of development projects to bring modernity and services to rural Ghanaians (AEO 2012); increased traffic on roads to transport cocoa, and other goods to global markets also occurs because of development and globalization (Kolavalli and Vigneri 2011, AEO 2012). Although the community-based threats may also be influenced by globalization and development, they are different in nature because they are directly attributed to community members.

KCA management defined 100% reduction of each community-based threat as the total elimination of these threats within the boundaries of the PA. The definition of 100% reduction was proposed by Anthony (2008) to be the total elimination of a threat. However, the removal of utility lines and roads was not considered politically or economically possible by KAC management staff and thus 100% reduction of the threat was not defined as the elimination of all roads and utility lines rather it was defined as zero expansion of each of these threats and the improvements of road infrastructure coupled with decreased speed. KCA staff was confidant that community-based threats were possible to mitigate but threats driven by globalization and development were more problematic for management staff to address. This may be due to the fact that development is desired by the communities, supported by the government and driven by global economic forces. Understanding the root causes of threats and the obstacles of management to mitigate threats is important to understand why

management may have been previously unsuccessful and where opportunities for improvement exist.

5.1.1. Further research opportunities

Globalization and development are frequently sold as a positive step for all of humanity however; these forces can also have severe local and global, socio-economic and environmental, implications (Najam *et al.* 2007). Further research to is required to provide a more in depth understanding of the implications of globalization and development on specific PAs. An overview of effective threat mitigation strategies specifically focused on direct threats to biodiversity driven by globalization and development would be a useful starting point; enabling further policy to be tailored to specific geographical, environmental and socio-economic settings. This research is specifically necessary in regions where development is rapidly occurring and biodiversity is in decline; as development may be given prioritization over conservation and because of this, effective policy is critical to prevent total environmental degradation and biodiversity loss. Development is not going to cease so it is increasingly critical that biodiversity is properly protected.

5.2. Inconsistencies

Invasive species were the only other threat to biodiversity, besides poaching, revealed in the RAPPAM report conducted by the IUCN (UICN/PACO 2010). The siam weed (*Chromolaena odorata*), an invasive species known to be harmful to agriculture and the environment across Australia, Africa and Oceania (McFadyen and Skarratt 1996), was mentioned as a threat to biodiversity in KCA during the TRA workshop. However, participants agreed that it did not pose a primary threat to biodiversity in KCA because it is not adapt to grow under the shaded canopy covering KCA. This is supported by McFadyen

and Skarratt (1996), which state ‘open or partial shade’ as the optimal environment for *Chromolaena odorata*. The *Chromolaena odorata* may pose a threat to species on the periphery of the PA however; the nine threats revealed during the TRA are considered the most critical to KCA. This inconsistency may have occurred due to the variations in the methodological approach.

5.3. Applicability

5.3.1. Threat Reduction Assessment

The TRA method is scientifically replicable and has been utilized across the globe (Salafsky and Margoluis 1999; Margoluis and Salafsky 2001; Mugisha and Jacobson 2004; Anthony 2008; Matar and Anthony 2010). The TRA workshop was logistically simple to facilitate as it required only a few experts, was timely, low cost, enabled baseline data to be created during the workshop itself and did not require elaborate technology. These unique attributes make it logistically practical for PAs with limited resources, which is frequently the case for PAs located in the tropics (Terborgh 2004). It also makes this methodology attractive for academics with limited funding.

The modified TRA method was an appropriate tool to assess the management effectiveness to mitigate threats to biodiversity in KCA over the temporal period assessed. Managers effectively mitigated some threats such as fishing and harvesting aquatic resources, which has been completely eliminated from KCA. Other threats such as the construction of government approved utility lines have been introduced as an emergent threat to the PA, unsuccessfully mitigated by management. The advantage of measuring the change of threats over the temporal period specifically enables deeper analysis of individual threats to occur, which can lead to more targeted management approaches.

The use of the IUCN standard lexicon of threats allows for comparative analysis across sites. However, the compartmentalization of threats restricts protected area experts from including necessary descriptive data to define each particular threat. The allowance of subcategories was a potential solution proposed (Anthony 2008) and utilized during the TRA. To enable threats to be compared across sites without loosing detail caused by standardization participants were: asked to identify threats to biodiversity using their own words; then categorized each threat according to the standard lexicon (Salafsky *et al.* 2008, Matar and Anthony 2010); and, finally, produced a site specific explanation detailing each threat (table 6). The methodology allows for comparative analysis and the use of detailed data to be recorded during the workshop.

5.3.2. Geospatial Component

The TRA method has been applied to PAs across the globe and is a proven appropriate method of measuring effectiveness of PA management staff. The geospatial component, a method introduced in this research as a supplement to the TRA method, effectively illustrated the spatial changes of threats to biodiversity over the designated temporal period. The geospatial component was a beneficial addition to the research methodology. The expert participants gave the geospatial component positive feedback during the feedback portion of the workshop and once the maps were sent back to them for their records. The methodology employed, enabled the creation of baseline data during the workshop thus data collection was not hindered by the paucity of available digital geospatial data. If geospatial data of threats over a specific time period was available it could be incorporated into the analysis. However, one of the attributes of this technique is that it can be completed without digital data.

In addition to the value of this methodological approach for research purposes, the geospatial component was useful for participants because of the dialogue it generated regarding the location of threats and how they are changing spatially over the temporal period. This may be

particularly useful for larger PAs where managers may oversee specific areas and the location of threats over the entire PA is not effectively communicated or shared.

If the management team of a PA were interested in using the geospatial component in conjunction to the TRA method as aspect of their adaptive management strategy but did not have the access to technology, such as ArcGIS, the exercise of drawing the threats on a map for the designated temporal periods is in itself a valuable exercise. The digitization of the data through software is beneficial to illustrate the data clearly but is not absolutely necessary for analysis to occur. It is important to be flexible and not insist that digitization of data occurs because the technology may be simply unavailable or out of the financial reach of PAs. This is particularly relevant when considering its usefulness in the tropics where PAs are notoriously underfunded and resources may be more effectively allocated elsewhere.

5.3.2.1. Further methodological development opportunities

It is important for methodologies to be reviewed and refined. The geospatial component could be further developed to ensure the gradient scale more accurately represents the changes of intensity and urgency of each specific threat over temporal periods.

CHAPTER 6 - CONCLUSION

This chapter will provide a brief conclusion of the overall research findings and discuss how the objective of this research was fulfilled through the employment of the methodology.

6.1. Fulfillment of research objective

The objective of this research was to assess the effectiveness of management to mitigate threats to biodiversity in KCA from 2004 to 2012. The modified TRA identified nine principal threats to biodiversity in KCA, provided a relative ranking based on intensity, urgency and area, and revealed the percentage of change of each threat over the temporal period. This was computed to disclose the TRA Index, which provided an overall representation of threat mitigation over the temporal period. The geospatial component revealed the spatial distribution and change of each threat over the temporal period assessed. A 40% decrease in threats to biodiversity from 2004 to 2012 in KCA demonstrates that management strategies and operations are somewhat effective. Further investigation through interviews and analysis of WD documents revealed the underlying causes of each threat and exposed where mitigation had been successful and where future improvements can be made.

The most critical threats to biodiversity in KCA are community-based threats KCA management has been effective at reducing these threats. The focus of KCA management staff has been community-based threat mitigation through patrols, which ensure compliance, educational programmes and community outreach initiatives. Although only one of the community-based threats has been eliminated all of the community-based threats have experienced a reduction. The impacts of work by WD employees and the presence and actions of tourist were also revealed as threats to biodiversity; the mitigation of these threats relies on

the capacity of KCA management to ensure policy compliance of staff and tourists. Threats driven by development and globalization have not been successfully mitigated; utility lines have emerged as a threat and the impact of roads is increasing. KCA has yet to effectively mitigate these solutions although the have the right to restrict development within the boundaries of KCA, as stated in the Field Operations Manual (WD 2009a).

In conclusion, KCA management have been able to reduce the threats to biodiversity that are currently most critical. They have been effective in identifying the most serious threats to biodiversity and have focused their limited resources to address these threats.

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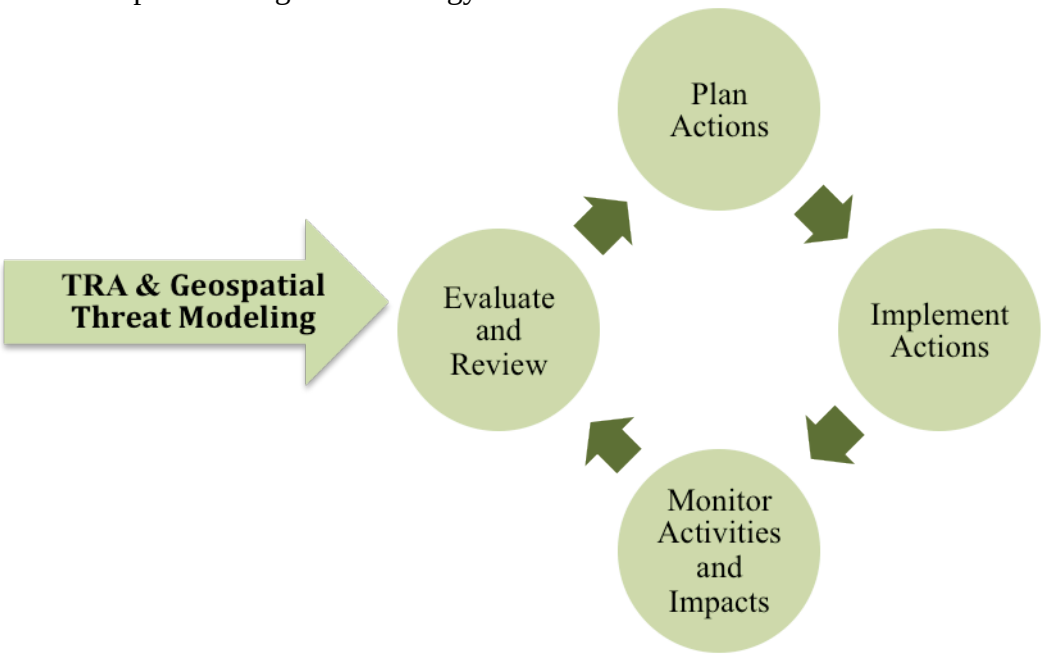
APPENDIX I –TRA WORKSHOP INFORMATION SHEET

Threats to biodiversity are monitored through the modified Threat Reduction Assessment (TRA) tool as a proxy measurement of conservation success.[2] Threats will be modelled geospatially. The modified TRA method and modelling tool can be a useful as part of an adaptive management strategy.



Adaptive Management and Monitoring Cycle[3]

Content

1. An information sheet that contained detailed methodological steps and explanations of the modified TRA process and key assumptions,
2. A TRA index calculation sheet,
3. A threat definition and 100% reduction sheet,
4. The IUCN classification of direct threats sheet including level 1 and 2 category descriptions and level 1 definitions,
5. A geospatial threat data collection sheets,
6. A detailed site map.

Key assumptions of the TRA method[4]

4. *All destruction of biodiversity is human-induced*. Losses of biodiversity due to natural phenomena are not considered as threats. However, threats that have increased in magnitude or frequency due to human activity are considered as threats.
5. *All threats to biodiversity at a given site can be identified*. At any given point in time, experts of Kakum Conservation Area (KCA) have the ability to identify, distinguish and rank in terms of area they impact, intensity, and urgency all the direct threats to biodiversity.
6. *Changes in all threats can be measured or estimated*. Experts have the ability to systematically, either qualitatively or quantitatively, assess the percentage of change of all threats at any given time.

[2] Salafsky and Margoluis 1999
[3] Adapted from Tucker 2005, 13
[4] Salafsky and Margoluis 1999

Steps to produce the modified TRA Index[5]

2. Define the *study period* spatially and temporally.
3. Define the *target condition*
    a. The target condition is the state of the site on which the management authority is ultimately responsible for. For this assessment it is assumed to be the biodiversity of KCA. The target condition has three main attributes:
        i. Species present,
        ii. Habitat condition and area,
        iii. Ecosystem functions.

4. List historical and present *direct threats* to biodiversity on site.
    a. *Threats* are defined as direct anthropogenic activities that adversely affect biodiversity[i] in KCA. Threats can be subdivided as:
        i. *Internal Direct Threats*: caused by the stakeholders living on site,
        ii. *External Direct Threats*: caused by outsiders,
        iii. *Indirect Threats*: Social, political, and economic influences that provoke direct threats. Indirect threats are not to be included specifically as part of the assessment worksheet but help to distinguish the origin and influential actors of direct threats.

5. Collectively discuss threats and define each threat within the IUCN lexicon of threats categories. *See hand-out*

6. Define *100% threat reduction* of each threat.
    a. *100% threat reduction* will be defined as the absolute abolishment of a threat unless otherwise determined by protected area experts and noted on the worksheet.

7. For the defined start date of the assessment period, rank each threat in order of:
    a. *Area:* percentage of habitat(s) in the site that the threat will affect,
    b. *Intensity:* the impact of the threat on a small scale within the overall area,
    c. *Urgency:* the immediacy of the threat.

8. Determine the degree to which each threat has been mitigated based upon the definition of 100% reduction (step 4) by the end of the assessment period.

9. Rank each current threat in order of area, intensity and urgency.

10. Calculate the final threat reduction index score.

TRA index= $\sum$ raw scores/ total rankings*100

[5] Salafsky and Margoluis 1999, Margoluis and Salafsky 2001, Anthony 2008 and Matar 2009.

Geospatial Threat Modeling

Modeling threats to biodiversity using a spatiotemporal method will help to illustrate present knowledge of threats.

Key assumptions of geospatial threat modeling

The fundamental assumptions of geospatial threat modeling is:

1. *The location of all threats to biodiversity at a given site can be identified*. At any given point in time, experts of KCA have the ability to identify the location of all the direct threats to biodiversity,
2. *All threats to biodiversity at a given site can be ranked*. Experts have the ability to systematically rank the intensity and urgency of each threat at any given time.

Steps to collect data for the geospatial threat model

1. For each threat identified during the TRA rank the intensity and urgency for the two time periods (June 2004 and June 2012).
    a. The scale is from 1 to 3 (1=low, 2=medium, 3=high). The total score of each threat range is between 2 and 6.
    b. In the case where a threat requires a different assigned value in specific locations note it on the worksheet, in the next step it will be indicated on the map.

2. Draw the approximate location of each threat for the defined start and end date of the assessment period on a separate map. The specific urgency and intensity rankings of each threat, for each location, must be indicated on each map.

Implications and follow up

A group discussion regarding the value of the TRA assessment and geospatial threat modeling tool and the origin of indirect threats will be initiated. The purpose of the group discussion will be to:

1. Discuss specific actions that have been successful at mitigating threats to biodiversity.

2. Discuss strategies that need to be revised to decrease threats to biodiversity.

3. What are the prevalent indirect threats?

APPENDIX II - TRA INDEX CACULATION SHEET

Workshop Facilitator: Brittny Anderson
PA Name:
Assessment Period:

			Criteria Rankings (relative)					
No.	**Threat**	**IUCN threat code[a]**	**Area**	**Intensity**	**Urgency**	**Total Ranking**	**% Threat Reduced[b]**	**Raw Score**
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
		TOTAL						

[a] see http://www.iucnredlist.org/technical-documents/classification-schemes/threats-classification-scheme-ver3

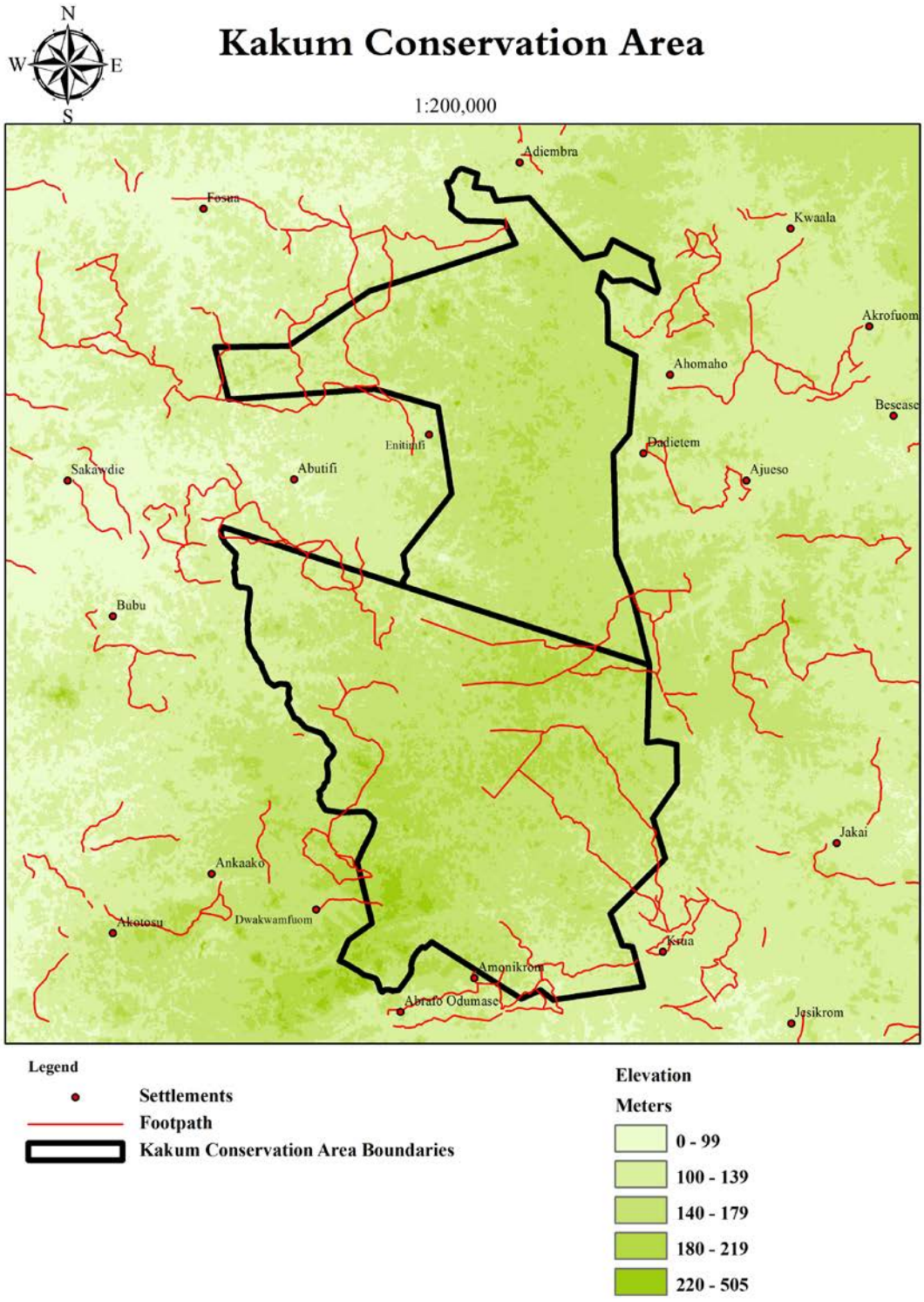
[b] see table below

TRA Index Formula	Total Raw Score		Total Ranking		Convert to %		**TRA Index (%)**
TRA Index Calculation		÷		=	**x 100**	=	

APPENDIX III –DESCRIPTION OF THREATS AND DEFINITION OF 100% REDUCTION

No.	Threat	Total Ranking	% Threat Reduced	Description of threat	Explanation of 100% Reduction
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

APPENDIX IV –TRA WORKSHOP SITE MAP



Source: KCA boundary and settlements (Wiafe and Amfo-Out 2012) GIS elevation (METI and NASA 2011)

ABSTRACT V – TRA FEEDBACK FORM

TRA Workshop Site:
Date:

Thank you for your participation. Please take 5 minutes to fill in this feedback sheet.

1. Did you find the TRA tool and mapping component beneficial?
   (Please circle) **Yes / No**

   a. Please indicate any positive aspects of TRA:

   b. Please indicate any negative aspects of TRA:

2. Do you think it is helpful and/or appropriate to use the TRA method and mapping component regularly as part of your management performance monitoring system?
   (Please circle) **Yes / No**

   a. *If YES, please indicate* How is TRA and mapping component are helpful? *If NO, please indicate* Why is TRA and mapping component are not helpful?

Thank you, your feedback is highly appreciated!
Brittny Anderson
Master of Environmental Science and Policy student
Central European University
Anderson_Brittny@student.ceu.hu

Source: adapted from Matar 2009