Linking Conservation Behavior, Management and Human Societal Context: An Examination of Canids in the Brazilian Cerrado.

A Professional Paper
by
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Abstract:

There is currently a disconnect between animal sciences, human social sciences and conservation though there has been a call for interdisciplinary research in recent years. In order to bridge this gap, I adapted a conservation behavior framework, expanding it to include anthropogenic alterations, management strategies/tools, animal behavior and societal context. This framework was then applied to three species of South American canids found within the Brazillian Cerrado: *Chrysocyon brachyurus* (Maned wolf), *Cerdocyon thous* (Crab-eating fox), and *Speothos venaticus* (Bush dog). Though these species are all found within this topographically and biologically diverse region, they exhibit different social structures, ranges and hunting strategies which have varying influences on their management. The implications of species-specific behavior, diet and habitat use as well as protected areas, the Forest Code, habitat loss and potential predation are discussed in relation to conservation and regional human societal concerns. These societal concerns include economic disparities, eco-tourism, and agricultural/livelihood loss with most of the research originating in Africa and India. Region and species-specific information was obtained as part of a literature review with preference given to articles published after 2004. Data was also obtained from the IUCN. This interdisciplinary approach elucidates gaps in our current knowledge and indicates the necessity of such research in the future.

Keywords: Animal Behavior, Anthropogenic, Brazil, Bush Dog, Canid, Cerrado, Conservation, Crab-eating fox, Eco-tourism, Human Dimensions, Interdisciplinary, Maned Wolf, Protected Area, Wildlife Management.

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1. Introduction

Singular approaches to wildlife management and conservation limit the efficacy of management plans; therefore, knowledge of wildlife behavior and human components must be considered when developing management and conservation strategies (Baruch-Mordo et al. 2009). Animal behavioral research can provide valuable behavioral predictors for effects of anthropogenic changes, indicators of management plan success, and as alarms for unforeseen ecological changes (some which may be anthropogenic in origin) (Berger-Tal et al. 2011, Moore et al. 2008). Changes in animal behavior may be seen before population declines are recognized as statistically significant, thus allowing managers, scientists and other stakeholders to respond before such alterations become intractable (Berger-Tal et al. 2011). These features of animal behavior make such research crucial to management and conservation efforts.

There currently exists a disconnect between animal behavioral research (particularly behavioral ecology and animal behavior) and conservation biology, though collaboration between the two has been called for in many papers within the last ten years (Angeloni et al. 2008, Linklater 2004). From 1965 to 2002, there was substantial growth in the proportion of conservation literature and references to wildlife behavior within the sphere of wildlife literature (Linklater 2004). From 1996 to 2005, however, the proportion of behavior-focused conservation papers remained steady (Angelino et al. 2008). Citation of behavior-based conservation literature has also declined since 1984 (Angeloni et al. 2008), indicating a lower impact of papers with this emphasis than papers without a behavior focus. This lack of growth may be due to the historical segregation of the two areas (Angeloni et al. 2008), the scale or focus of research (Angeloni et al.

2008, Linklater 2004), or the bias of journals or editors (Angeloni et al. 2008). Linklater (2004) noted that "conservation biologists appear to be much more interested in behavioral processes and phylogenies" and have much broader areas of study, whereas behavioral ecologists are more interested in the adaptive value of a behavior making collaboration more difficult.

In New Zealand, however, collaboration between animal behavioral scientists and conservation biologists has seen considerable success, much of which has been attributed to the nation's small size, limited bureaucracy, lack of "conflicting interest groups" and open communication between researchers and managers (Moore et al. 2008). Numerous aspects of animal behavior, including learning, causation, adaptive value, phenotypic plasticity, dispersal and mating systems have been incorporated into management plans. Research efforts include effects of song repertoire on the mating success of translocated North Island kokako bird (*Callaeas cinerea wilsoni*) (Rowe & Bell 2007) and dispersal/settling of the endangered Maud Island frog (*Leiopelma pakek*) (Trewenack et al 2007). Many of these aspects of behavior have predictive value and allow researchers and managers to increase success of reintroductions/translocation and evaluate impacts of ecotourism and other anthropogenic changes (Moore et al. 2008).

Though the implications of animal behavior on conservation and management are extensive, human social, economic and political aspects also dramatically influence management strategies. This is especially true for wide-ranging species which require ecosystem-level management strategies. Such plans may cross social and political boundaries, adding to the complexity of management and necessitating a more malleable and socially empathetic strategy. One strategy includes the creation of protected areas (PA) which can have varied effects on the local economy

(Sekhar 2003, Richardson et al. 2012, Mackenzie 2012). How PAs are created can also have long-term effects on local attitudes towards the PA itself and management efforts (Bizerril et al. 2011). Social institutions may also play a vital role in management of protected areas and compliance with regulations (De Merode et al. 2007). One approach to increase community involvement in management is the practice of community-based PA management (CPAM) (Thuy et al. 2011) or community-based natural resource management (CBNRM) (Richardson et al. 2012). Community-based management plans involve the delegation of management responsibilities for a portion of a PA or other resource area to a locally-based institution (either a village or a group of individuals from areas nearby) (Thuy et al. 2011). Incentives are given for participation in conservation programs (Thuy et al. 2011). These incentives then contribute to the area's economy and, hopefully, towards positive attitudes concerning the PA and conservations efforts. Given the potential impact of social institutions on conservation strategies, a new framework should be developed which accounts for the effect of human societal context on the development of successful conservation and management strategies.

As a practical application of this amalgamation of management, animal behavior, and societal context, I examine the various factors effecting conservation of canids in the Cerrado region of Brazil. To do this, I adapted the "conservation behavior framework" described by Berger-Tal et al. (2011) which utilizes the idea of "conservation behavior". I alter and expand upon the three themes presented by Berger-Tal et al. (2011) and add a fourth theme "Societal Context" which allows for the incorporation of human social, economic and political variables. Once the adapted framework has been established, a discussion of the Brazilian Cerrado and its current perceived status is presented, as well as an evaluation of three ecologically similar yet behavioral varied

species of South American canid who utilize the Cerrado: *Chrysocyon brachyurus* (Maned wolf), *Cerdocyon thous* (Crab-eating fox), and *Speothos venaticus* (Bush dog). These species exhibit a spectrum of differing social structure (asocial to social), hunting strategies (individual to pack) and spatial variations (habit usage).

In order to address the impacts of each theme, a literature review was conducted to apply the adapted framework to the discussed canid species in the Cerrado. Each theme is elaborated on in relation to the region and species. Studies from Africa and India concerning wildlife conservation, protected areas and the effect of various management strategies are reviewed. Information on the ecology and behavior of all three canid species, anthropogenic alterations currently affecting their conservation, management strategies which are currently or could potentially be utilized, and the societal forces acting in the region are then integrated and the implications discussed. Connections are considered to better understand the dynamics between all four themes.

This evaluation is based on a literature review from a variety of journals and spatial data from the International Union for the Conservation of Nature (IUCN) (IUCN 2008a, IUCN 2008b, IUCN & DeMatteo 2011) and World Database on Protected Areas (WDPA)(IUCN and UNEP-WCMC 2013). Google Scholar, Web of Science and the Texas A&M University Library Online Search engine. The majority of articles chosen for review were published after 2000, with preference given to articles after 2004. Species-specific information was gathered using both the scientific and common names as keywords; other keywords and search phrases included

Cerrado, Brazil, conservation, protected area, land use, ecotourism, wildlife, anthropogenic, and animal behavior.

2. Conservation Behavior Framework

Berger-Tal et al. (2011) developed a conceptual framework structured around "conservation behavior," the linking of conservation biology and animal behavior. This growing interdisciplinary field seeks to utilize recognized animal behavior in conservation planning (Berger-Tal et al. 2011). Centered around three "behavioral domains," the conceptual framework is divided into three "themes", each of which is subdivided into two "focal pathways" (Berger-Tal et al. 2011). These themes are intertwined with one attributing to changes in another. For example: a "behavior-sensitive management" strategy may be examined via behavioral indicators. The results may signal a need to alter the management strategy. The themes and pathways are described below.

Theme 1: "Anthropogenic impacts on animal behavior"

- Pathway: Inflexible behavioral strategies or adaptation at a rate slower than environmental change which leads to population decline.
- Pathway: Flexible behavioral strategies which may result in increased short-term success but have long-term effects on the species or ecosystem. These adaptations may also necessitate intervention through management.

Theme 2: "Behavior-based Management"

- Pathway: Utilizing the current behavior of a species to develop management strategies.

- Pathway: Management plans are devised in order to alter or protect a particular behavior.

Theme 3: "Behavioral Indicators"

- Pathway: "Early warning" to reveal habitat or population-level changes before statistical analysis indicates a problem.

- Pathway: Using animal behavior to monitor the success of management strategies.

The Berger-Tal et al. (2011) conceptual framework provides a valuable cornerstone on which to build more comprehensive and practical models for use within conservation behavior. In this paper, I expand on the previous framework, modifying the previous three themes and including Theme 4, "Societal Context," which assesses the political, economic and social aspects of human society that impact conservation and management strategies (Figure 1). Theme 1 has been altered to examine the anthropogenic alterations themselves rather than the changes in animal behavior resulting from them. Theme 2 has been broadened to encompass all of the available management tools instead of differentiating the strategies based on animal behavior. Theme 3 has been rename "Animal Behavior" but remains very similar in the use of behavioral indicators and behavioral alarms.

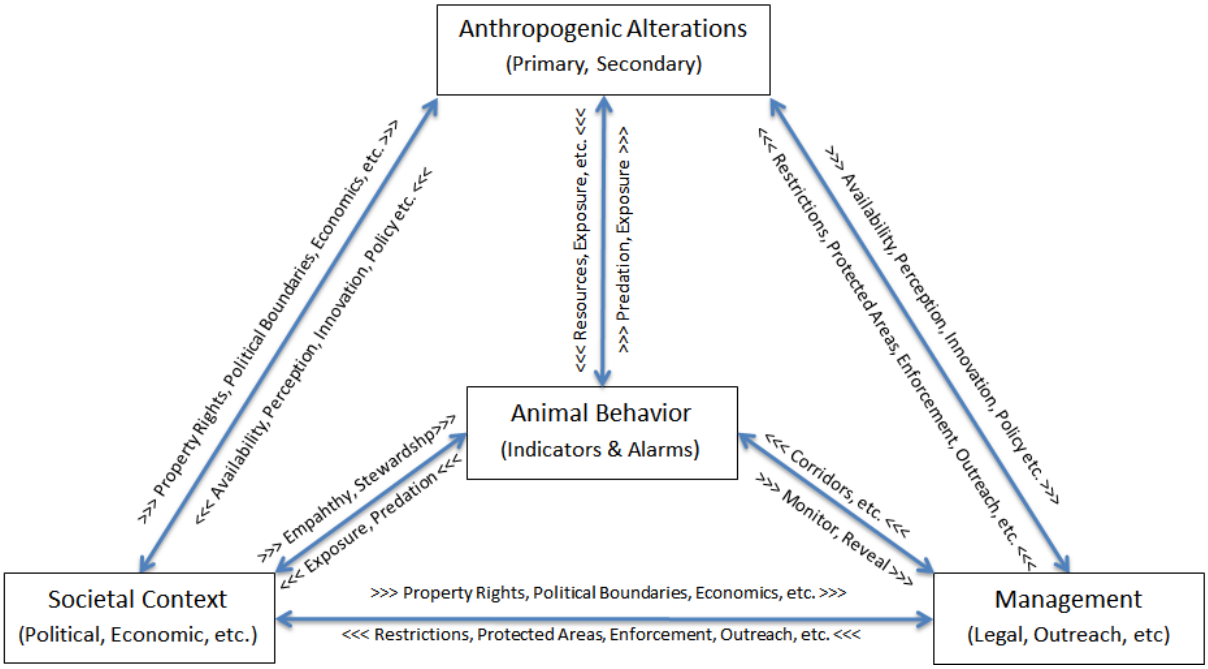

Figure 1. Conceptual framework adapted from Berger-Tal et al. (2011).

2.1. Theme 1- Anthropogenic Alterations

Anthropogenic alterations are all of the human caused changes that impact the ecosystem. Primary factors are those changes which initially alter the habitat. Secondary factors occur as a result of primary factors and would not have occurred alone. For example: deforestation is a primary factor, whereas soil erosion in a deforested area would be a secondary factor. The previous framework evaluated the impact of these alterations on animal behavior as either flexible or inflexible; however, I found that when evaluating individual behaviors based on this delineation questions arose. The measurement of positive/negative fitness resulting from flexible changes, and the combined flexibility and inflexibility of certain behaviors, such as the foraging in human habitats seen by *C. thous*, make segregating some behaviors difficult and potentially deleterious to the overall understanding of the anthropogenic impacts. Behaviors exist within a

flexible to inflexible continuum, with some behaviors being more towards one end than another. For example: an individual whose diet includes rodents may continue to hunt rodents following human disturbance, but does so within areas of dense human habitation. The static diet would make the behavior inflexible, however, the utilization of human areas would make it flexible. How should these behaviors be categorized? By instead looking at the factors themselves instead of trying to succinctly categorize their impacts, a new characterization scheme emerges which allows us to examine both the seemingly obvious and the more discrete factors which attribute to all of the other themes.

2.2. Theme 2- Management

Management strategies can take many forms and exploit many tools, including: laws, surveys, management areas, captive-breeding and reintroduction programs, translocations, population models and community outreach. The framework provided by Berger-Tal et al. (2011), divided management based on its use of animal behavior. Though useful, it does not take into consideration the societal implications of actions nor does it discuss any of the tools that may be used. I propose a "Management" theme which incorporates all of the available management and conservation tools, a few of which I will discuss in more detail. Protected areas, hunting and trade laws, and land-use regulations are some of the most obvious and widely used tools in conservation and wildlife management. These, like all tools, have their limits and the acceptance and enforcement of them is built upon complex human social structures and constraints. Locally, community-based programs can provide valuable support for various management actions. Involving a variety of stakeholders, many with very different opinions, gives legitimacy, allows for concerns to be addressed before they become problematic, elucidates previously omitted

options, and advocates for more inclusive plans (Barrow 2010). Education and outreach programs designed not only to inform the public but also to include them in development, incorporate current science with local culture and understanding, allowing for the growth of both. This approach may also help communities feel more involved with and emotionally connected to the area or species in question, thereby increasing compliance. Other tools such as captive-breeding, reintroduction, and corridor building are very species and/or sight-specific and usually require much collaboration and planning over a long period of time. Success of management plans can sometimes be hard to measure, however the addition of animal behavioral indicators may provide us with valuable information, particularly concerning what is inadequate.

2.3 Theme 3 –Animal Behavior

Animal behavior can provide researchers and managers important information concerning the status of the ecosystem, the species and the individual. The "Behavior Indicators" theme proposed by Berger-Tal (2011) remains largely intact though it is now termed "Animal Behavior," as indicators are only one half of the theme, with behavioral alarms comprising the second half. Animal behavioral indicators can be used to evaluate the effectiveness of active management strategies. Whereas behavioral alarms reveal changes in an ecosystem before they are considered statistically significant. As an example, *C. brachyurus* have been documented to forage in areas of previous human disturbance (Massara et al. 2012). An individual foraging in an area previously not utilized may signify a change in food availability, which could indicate previously unrecognized environmental changes and would thus be considered an alarm. Causation could be complicated but may include destruction of habitat, loss of plant life due to pollution, competition with domestic dogs and so on. Alternatively, if the species in question

was currently being managed to increase breeding success and the number of offspring was increased over last season, this indicator could signify a successful management plan.

2.4. Theme 4 – Societal Context

Societal contexts are a sometimes overlooked aspect of conservation and environmental management. Within this theme are the economic, political, social and religious facets of everyday life which effect and are affected by wildlife and wildlife management plans. Though this category is broad, its importance cannot be stressed enough as the opinions of local communities can be a determining factor in the success of many management plans (Getz et al. 1999, De Merode et al. 2007). Management strategies, particularly those related to the creation of protected areas and the regulation of land-use and other resources, brings with it a confluence of positive and negative aspects. In many places, wildlife are regarded as pests, responsible for economic losses through crop raiding/destruction, predation on livestock and personal injury (Getz et al. 1999, Mackenzie 2012, Richardson et al. 2012). These economic losses can sometimes be mitigated through the creation of jobs, income through resource access agreements (RAAs), compensation for crop damage by wildlife and community development through schools, hospitals, roadways and other infrastructure services (Mackenzie 2012, Richardson et al. 2012, De Merode et al. 2007, Sekhar 2003). Wildlife also do not adhere to political boundaries, thus necessitating management plans that encompass multiple counties, states or countries.

3. Location and Species

3.1. Cerrado

The Cerrado is a unique mosaic of woodland and savanna which comprises approximately twenty-one percent of Brazil (Conservation International 2005). This biome is known for its dramatic range of topography and plant life, varying from grassy savanna to gallery (riparian) forest (Jepson 2005). While savanna biomes are present globally, the Cerrado is located in South America with the bulk of that being in Brazil (Silva & Bates, 2002). Conservation International (2005) has designated the Cerrado as a "biodiversity hotspot," due to the high level of endemism (native species) and large percentage of original habit lost. The area is very ecologically diverse with nearly two hundred mammalian species and ten thousand documented plant species (Conservation International 2005). Twenty eight percent of its amphibians and forty-four percent of its plants are endemic (Klink & Machado 2005). Even though it is one of the richest and most diverse regions in the world, only 2.2% of the Cerrado is currently preserved within protected areas and reserves (Klink & Machado 2005). Due to its poor, acidic soil (Klink & Machado 2005), the Cerrado was historically considered an agriculturally impractical and economically insignificant portion of Brazil, however, recent agricultural trends have led to the conversion of much of the Cerrado into highly profitable agricultural land (Brazilian Agriculture 2010). This trend was encouraged by some agencies and scientists as a means to reduce anthropogenic alterations in Amazonia regions (Silva & Bates, 2002), and while well-meaning in theory, the effects on Brazilian biodiversity are just now being explored.

3.2. Maned Wolf

Chrysocyon brachyurus are tall, slender omnivores weighing between 20 and 30 kg (Dietz 1984, Jacomo et al. 2004, Sillero-Zubiri et al. 2004, Nowak 2005). They are the largest canids in South America and are frequently referred to as "foxes on stilts" because of their long-limbed, foxlike appearance (Dietz 1984). Their diet is comprised of approximately 50% plant material, particularly the "maned wolf fruit" lobeira (*Solanum lyocarpum*), and slightly less than 30% small mammals (< 20 kg) (Figure 5) (Dietz 1984, Jacomo et al. 2004). They are classified as Near-Threatened by the IUCN Red List (Rodden et al. 2004). Though they are monogamous, *C. brachyurus* are solitary (asocial) and generally den and hunt alone (Kleiman 2011, Sillero-Zubiri et al. 2004, Nowak 2005 pg). Territories are either defended by a single individual or shared by a breeding pair, though breeding pairs rarely hunt or rest together, usually only coming together to mate (Kleiman 2011, Dietz 1984). Within their territories, they show agonistic and defensive behaviors (Kleiman 2011), with limited paternal care. Males provide mainly indirect care (care that requires no direct interaction) of young through acquisition and defense of territory and provisioning of food for the female (Kleiman

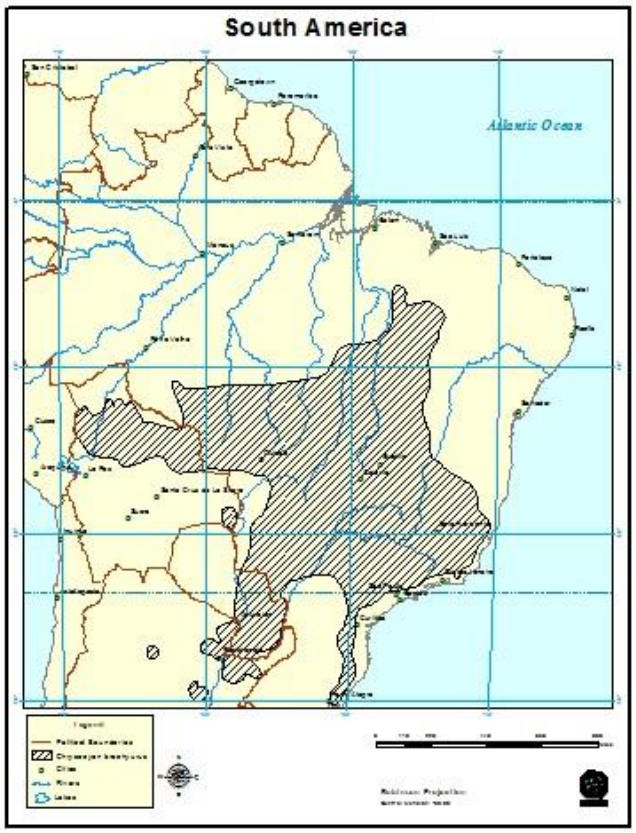

Figure 2. Range map of *C. brachyurus* in South America. (Map created in ArcMap 10 using ArcGIS basemap and species spatial data from IUCN (2008b)).

2011). Male guarding behavior increases during and following birth (Kleiman 2011). Once the pups leave the den, direct care (involving interaction) by males increases, including regurgitation of food and playing with young (Kleiman 2011). Play behavior is complex and it is speculated that the wide variety of objects manipulated by *C. brachyurus* during play, provides practice for foraging and hunting as they age (Kleiman 2011). In *C. brachyurus*, dispersal occurs at approximately one year of age with limited to no interactions between parents and offspring after dispersal (Kleiman 2011, Dietz 1984, Rodden et al. 2004). They are currently found in central Brazil, Paraguay, Eastern Bolivia and Northeast Argentina, though their range was historically much larger and included Uruguay (Queirolo et al. 2011). They forage and hunt predominantly in the grasslands of the Cerrado (Dietz 1984, Nowak 2005). Local folklore considers *C. brachyurus* to have a "supernatural identification with man" and infers that they have powers of healing and protection (Dietz 1984). The right eye, canine teeth, hide, heart and feces are all ingredients in local folk remedies and talismans for healing and protection, though these are only to be collected from already deceased individuals (Dietz 1984).

3.3 Crab-eating Fox

Cerdocyon thous are medium-sized canids, weighing between 4.5 and 8.5 kg (Sillero-Zubiri et al. 2004, Nowak 2005). Opportunistic omnivores, their diet, which includes human refuse, is location and availability dependent (Sillero-Zubiri et al. 2004), consisting mainly of plants and birds (including chickens) in Brazil (Figure 5) (Jacomo et al. 2004). They are classified as Least Concern by the IUCN Red List (Courtenay & Maffei 2004) and are considered pests in many regions in South America. While pairs and family groups may hunt within an area at the same

time, they generally hunt individually (Sillero-Zubiri et al 2004, Nowak 2005). Monogamous and moderately social (pre-social), packs are usually composed of parents and offspring, with vocalizations used to maintain contact during separation (Sillero-Zubiri et al. 2004). Affiliative and defensive behaviors are seen within the pack (Kleiman 2011). Males provide predominantly indirect care prior to and immediately following birth but may enter the den when the female is gone (Kleiman 2011). Provisions for the female and pups are left outside the den and the males usually sleep next to the den (Kleiman 2011). Once the pups have left the den, parental care of the young becomes equally divided (Kleiman 2011). Play is advanced, similar to that seen in *C. brachyurus* and may be indicative of the varied diet and hunting and foraging methods utilized with maturity (Kleiman 2011). In *C. thous*, dispersal occurs within the first six months of age (Kleiman 2011); however, offspring keep home ranges bordering or overlapping their natal range and amicable visits/interactions are seen between parents and offspring, with some offspring returning to their natal range after a life-event (Macdonald & Courtenay 1996). They are found throughout much of northern and eastern South America (Figure 3).

Figure 3. Range map of *C. thous* in South America. (Map created in ArcMap 10 using ArcGIS basemap and species spatial data from IUCN (2008a)).

3.4. Bush Dog

Speothos venaticus are short, stocky canids, weighing between 6 and 8 kilograms (Kleiman 2011, Zuercher et al. 2004, Nowak 2005). They are carnivorous pack hunters, preying predominantly on small mammals (Zuercher et al. 2005, Zuercher et al. 2004, Nowak 2005), though most data concerning their diet is based on observations of hunting groups. Data specifically concerning Brazil is largely absent, however, scat analysis by Zuercher et al. (2005) in the Mbaracayú Forest Nature Reserve in Paraguay indicates a diet of over 50% small mammals (Figure 5). They are classified as Near Threatened by the IUCN Red List (DeMatteo et al. 2011). Considered one of the most social small canids, bush dogs are monogamous and live in packs of up to twelve individuals (Zuercher et al. 2004). Once bonded, breeding pairs remain in close proximity to one another and will hunt and den together (Kleiman 2011). Vocalizations are designed for short distances as individuals are rarely apart (Kleiman 2011). Bush dogs show affiliative and submissive behaviors towards one another within the pack (Kleiman 2011). Males are present during the birth of offspring and have been known to remove young from the birth canal and clean the newborn pups (Kleiman

Figure 4. Range map of *S. venaticus* in South America. (Map created in ArcMap 10 using ArcGIS basemap and species spatial data from IUCN and DeMatteo (2011)).

2011). Males participate in all aspects of rearing, apart from lactating (Kleiman 2011). Play behavior is very simplistic but cooperative and may be indicative of the very basic hunting strategies and limited prey utilized by bush dogs (Kleiman 2011). Their range map covers much of North and Central South America (Figure 4), however, they are rarely seen and quantitative estimates of density are rare (Zuercher et al. 2004, de Oliveira 2009). They are known to utilize a variety of habitats, however, they are generally found in forested regions near streams or rivers (Zuercher et al. 2005, Zuercher et al. 2004, de Oliveira 2009, DeMatteo & Loiselle 2008, Nowak 2005). Their webbed feet allow *S. venaticus* to swim fairly well (Nowak 2005), even permitting them to carry items in their mouths while swimming (Crystal Arkenberg *personal observation* 2013).

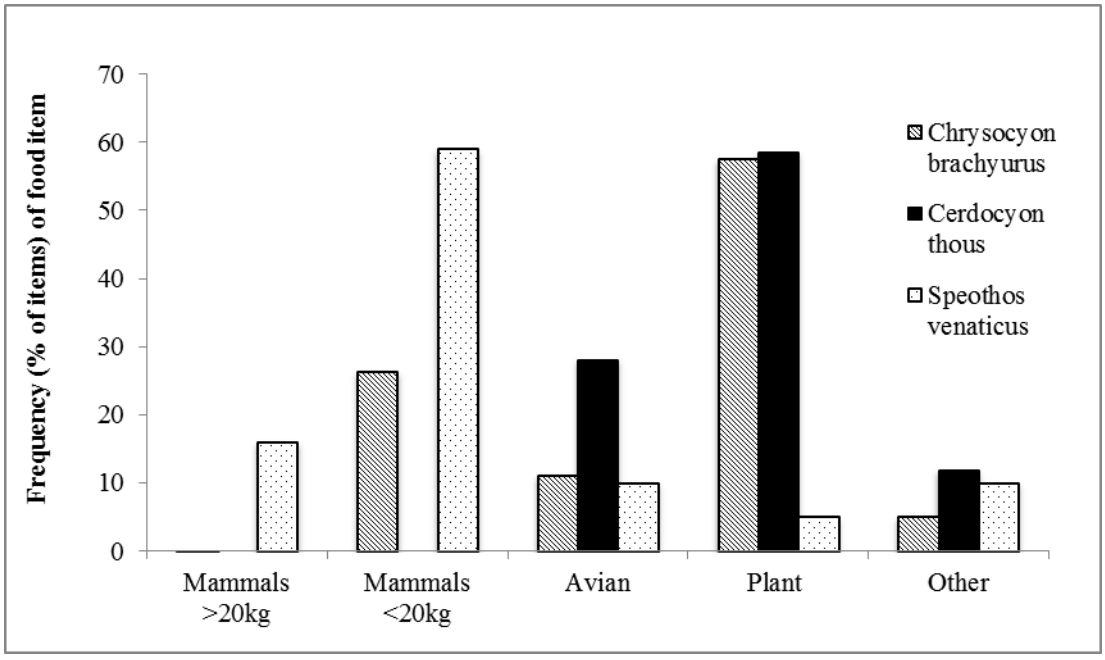

Figure 5. Percentage of food item present in scat of *C. brachyurus*[1], *C. thous*[1] and *S. venaticas*[2]. [1]Jacomo et al. 2004 (a small percentage of food items were not identifiable at the species level, has resulted in an underestimation of food items) [2]Zuercher et al. 2005.

4. Applying the Framework

4.1. Anthropogenic Alterations

Within the last few decades, development has dramatically changed the face of Brazil with agricultural production increasing by over three hundred and sixty percent in only ten years (from 1996 to 2006) (Brazilian Agriculture 2010). According to a 2010 article in the Economist, (Brazilian Agriculture 2010) one third of the world's soybeans are now being grown on only six percent of Brazil's arable land. Much of this growth is now occurring in the Cerrado. This surge of cultivated land and subsequent increase in agriculture was initially the result of an intense, multi-dimensional approach to land management and research instituted by the governmental agricultural research agency EMBRAPA, or Empresa Brasileira de Pesquisa Agropecuária (translated as the Brazilian Agricultural Research Corporation) (Brazilian Agriculture 2010) and academic institutions (Conservation International 2005). African *Brachiaria* grass was crossbred with indigenous species creating a resilient hybrid, *braquiarinha*, which when used on pastureland in conjuncture with Nelore cattle revolutionized the ranching industry (Brazilian Agriculture 2010). Soybeans were crossbred and are now being genetically modified to maximize productivity and increase tolerance to various soil and climatic conditions. EMBRAPA also advocated alternating livestock and crop production between fields, as well as the planting of trees between fields which may contribute to the mosaic nature of the landscape, providing forage and cover for both livestock and wildlife (Brazilian Agriculture 2010).

Cerrado vegetation is generally fire-adapted and some species are dependent on regular fires for propagation. However, some of the introduced grass species, such as molasses (*Melinis*

minutiflora), create much hotter fires with taller flames that may be capable of damaging the canopy at the edge of forested regions (Klink & Machado 2005, Hoffman et al 2004). This causes atypical damage to the Cerrado and modifies succession patterns (Klink & Machado 2005). Estimates for the loss of Cerrado due to agriculture and development are varied, however, most studies indicate at least a 50% loss of native Cerrado due to anthropogenic alterations (Klink & Machado 2005, Malhado et al 2010, Conservation International 2004). This loss represents more than three times the loss seen in the Brazilian Amazon (Klink & Machado 2005). Some researchers feel such a large estimate does not adequately consider all relevant factors and may be too high. Jepson (2005) utilized high-resolution satellite images of Cerrado in Eastern Mato Grosso, Brazil to evaluate changes in land cover between September 1986, August 1992 and August 1999. Areas were designated as either as Cerrado, Forests or Agro-pastoral. While a gross reduction of Cerrado land cover was seen in Eastern Mato Grosso, there was also a regeneration of Cerrado vegetation that caused the net reduction to be 50% less than the gross reduction. Though Cerrado is being lost, the loss may not be as intensive as previous studies have indicated due to regrowth. Jepson noted that contrary to popular opinion, vegetation loss is not "unidirectional," and that secondary growth is possible once agricultural uses have stopped. She also indicates that this regeneration may help account for the widely differing estimates of Cerrado vegetation loss (Jepson 2005). The conclusions drawn by Jepson (2005) concerning the over-estimation of vegetation loss in the Cerrado is something that needs to be further analyzed, however, the study area must be considered before assuming this conclusion correct. Settled in the early 1970's, Eastern Mato Grosso was bought as a "colonization cooperative" by over 800 families (Jepson 2005). Within 4 years of the first satellite image used for this study, 460 040 ha had already been sold for "private colonization initiatives" (Jepson

2005). The area of interest is only a small portion of the Eastern Mato Grosso, surrounding the Municipio seat of Canarana and encompassing various tributaries (Jepson 2005). This brings into question how representative a sample this may be and how it can be applied to other areas of the Cerrado. However, the study does elucidate a key point lacking in some other research, the regeneration of habitat. Other questions that need to be asked are at what rate the Cerrado is regenerating in relation to its loss and whether or not agro-pastoral lands will be left to "regenerate" in the future. This is especially concerning given the infrastructure necessary for continued growth in Brazilian agriculture.

Paralleling the agricultural development is infrastructure development in rural areas; roadways, housing and other support systems must be built to sustain and expand agricultural areas. These structures cause changes in the natural landscape and increase the exposure of wildlife to machinery, roadway accidents, domesticated animals and various man-made chemicals. Primary factors such as replacement of natural habitat with housing developments or shopping structures are fairly obvious anthropogenic impacts. Secondary factors, however, are more subtle and may be overlooked at first glance. Changes that are the result of a primary anthropogenic factor, but which could not have occurred individually, are secondary factors. As an example: increased exposure to domesticated animals, particularly domestic dogs, is a secondary anthropogenic factor because they are associated with human habitation. Domesticated dogs are generally considered to have a negative impact on local wildlife and are carriers for numerous zoonotic diseases, including rabies virus, canine distemper virus (CDV), and Parvo virus (Young et al. 2011). A review done by Hughes & Macdonald (2013) examined sixty-nine papers evaluating interactions between wildlife and "free-roaming domestic dog" ("dogs reliant on human

communities for food and shelter"). Predation by domestic dogs on wildlife and disease transmission from domestic dogs to wildlife, were the prevailing topics within the papers. A few studies also concluded that domestic dogs may have been responsible for localized extinctions (Hughes & Macdonald 2013). Rabies was the predominant transmittable disease, with most studies occurring in Africa. Rabies is usually transmitted through saliva in bite wounds; however, cases have also been seen due to transplantation of infected organs and exposure of open wounds to infected body material (saliva or brain material) (CDC 2004). Canine distemper virus and leishmaniasis were also diseases of note within the Hughes & Macdonald (2013) study. While complete eradication of such risks may not be possible, management of them can be.

4.2. Management

Of all of the wildlife management and conservation tools previously mentioned, resource-use restrictions (including land, wildlife, and other natural resources such as water or minerals) and protected areas are two of the most prominent. Previously, the Brazilian Forest Code required specific percentages of land holdings be set aside as a "legal reserve." Holdings within the Cerrado region were to maintain 20% of the land as natural reserves whereas holdings in the Amazonian region were to maintain 80%, (Klink & Machado 2005) (The Economist 2012). Along riverbanks, a protected buffer zone from 30 to 500 meters (depending on the width of the river) was to be preserved (The Economist 2012). The law was revised in May of 2012, requiring reserves in the Amazon to remain at 80% of the land holding, and increasing preservation of Cerrado holdings to 35%, though they can remain at 20% if the farmer is able to prove the holding was established "when the limit was 20%" (Stewart 2013). Unlike the

previous legislation, "spatially protected areas" may now be included in the compulsory nature reserve allotments (The Economist 2012). Riverbanks are now only protected from between 5 to 100 meters from the bank, depending on river width (The Economist 2012, Stewart 2013). All farmers also now have five years to enter their holdings into the Environmental Registry and comply with all regulations or "face fines and denial of bank loans" (The Economist 2012). Reparations must be made for areas cleared illegally under the previous Code; however, small farmers must only replant 20% of the illegally deforested area (The Economist 2012).

The increase in Cerrado preservation areas seems like a step forward in conservation efforts, however, the decline in riverbank buffer zones is a definitive step back. There are over 1,700 terrestrial protected areas in Brazil recognized by the World Database on Protected Areas (WDPA) (IUCN and UNEP-WCMC 2013) (Figure 6). These areas vary dramatically in size and are divided into 7 categories based on their purpose. This significant number of protected areas begs the question, what do protected areas accomplish? Researchers in Kenya found that wildlife numbers are declining both within and outside of PAs at a similar rate (Western et al. 2009). This is attributed to a lack of migratory areas included in the

Figure 6. Map of protected areas in Brazil. Map created in ArcMap 10 using ArcGIS basemap and spatial data from IUCN and WDPA (2013).

PA, range loss and fragmentation. The researcers suggest a need for larger, more connected areas and more extensive management practices, especially community-based outreach (Western et al. 2009). De Merode et al. (2007) examined how effective the protected areas in the Democratic Republic of Congo are, particularly before, during and after conflict. In the governmentally managed Garamba National Park armed guards (rangers) patrol the area illegal hunting (poaching) within the park. A recording system is used to note "hotspots" for illegal activity. Adjacent to the park is the Azande Hunting Reserve which is "under the jurisdiction of local traditional leaders" in which the hunting of unprotected species is legal. The researchers found that illegal removal of bushmeat was significantly higher when there was armed conflict in the region. During the conflict, however, one village retained a steady legal trade in bushmeat due to the actions of its chief. These findings led the researchers to suggest that "social institutions" may be instrumental in the management of protected areas.

In some instances, it may be more advantageous to alter human behavior rather than attempt to alter that of local wildlife (Baruch-Mordo et al. 2009). A three-pronged approached was used by Bizerril et al (2011) to increase community awareness and communication concerning *C. brachyurus* conservation in the Serra da Canastra National Park area. This project was an innovative mix of public participation, education and community building. Firstly, a group of community members of varying ages and occupations worked together to create a book which discussed the region's environmental importance, history, culture and economy. Well received, the book was intensely used in schools immediately following its dissemination and is still used by some teachers today. The second prong utilized "screenings" of short, locally produced films concerning the local environment, the *C. brachyurus* project underway in the area and the use of

chicken coops to decrease predation. Each "screening" was followed by a discussion session. The third aspect was aimed at facilitating better communication within and beyond the community in the future and consisted of local workshops concerning communication and media creation. This helped to equip community leaders with the necessary tools to actively participate in future discussions and attempted to give their community a greater sphere of influence and stronger voice. This type of approach could be altered and used in many different scenarios for multiple species. By combining this type of approach with research done at the local level on both ecology and sociology, a collaborative understanding and more robust management plan may be developed.

In some areas, these collaborations are already underway. In 2004, the Brazilian chapter of Conservation International was collaborating with numerous NGOs, the University of Brasilia, the Secretaria do Meio Ambiente e dos Recursos Hídricos - Goiás (SEMARH)(governmental entity responsible for "the environmental and hydrological resources of Goiás"), and the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) (governmental entity responsible for national environmental policy) to implement six biodiversity corridors throughout the Cerrado (Conservation International 2004). Corridors are areas of land which connect fragmented areas within a landscape. These corridors are crucial for the dispersal of wildlife between otherwise disconnected populations, thus maintaining genetic diversity and attributing to overall species fitness. The creation of these corridors combines management practices with known animal behaviors particularly dispersal and migration. Utilization of these corridors by wildlife will allow managers and conservation biologist to evaluate their success.

4.3. Animal Behavior

The previous delineation between flexible and inflexible responses to anthropogenic changes described by Berger-Tal et al. (2011) is of great importance when developing management strategies. Rarely can animal behaviors be so easily categorized as they exist within a continuum with inflexible behaviors at one end and flexible behaviors at another. Wright et al (2010) hypothesized that not only is the flexibility of a behavior varied within a population, the expression of this variability may change depending on circumstances. This hypothesis was applied to invasion of new areas by a population; however, its application to anthropogenically altered areas should be evaluated as species are beginning to utilize these altered landscapes (Massara et al. 2012).

Studies in animal behavior are generally divided into three categories or "domains;" 1) land use, 2) foraging/hunting, and 3) reproduction and social behaviors. Though our understanding of how human disturbance influences these domains is growing, there is still much we do not appreciate. Changes in vocalizations, dispersal patterns, land use and foraging/hunting styles are just some of the behavioral changes which can be used to develop and evaluate management strategies and to inform managers of environmental changes. Other changes, such as an increase in minimum home range size for "self-sustaining" populations of *S. venaticus* may indicate the level of fragmentation within the landscape (as estimated by ecological niche modeling) (DeMatteo &Loiselle 2008). Given their large estimated home range and similar diet to local large fields, competition and prey availability may be a determining factor in the persistence of *S. venaticus* (DeOliveira 2009).

Studies evaluating changes in behavior between rural and urban areas, such as the study of birdsongs, are numerous (Montague et al. 2013, Ditchkoff et al. 2006, Rowe & Bell 2007), however studies concerning agricultural areas are more limited. In one such study, Massara et al (2012) evaluated the scat of *C. brachyurus* in the "buffer zone" bordering the Tola Moca Ridge State Park and the Fechos Ecological Station protected areas. It was determined that *C. brachyurus* were actively hunting within the buffer zone, including areas previously disturbed by fire and cattle grazing. The authors speculated that this is due to the increase in small mammal density following these types of disturbances. Generally, the diet of *C. brachyurus* is comprised of large quantities of fruit and moderate quantities of small rodents (Vynne et al. 2011); however, individuals utilizing croplands for foraging consumed mostly rodents and seeds, though they were not known to eat the crops themselves (Vynne et al. 2011). This type of change would be considered an alarm or early-warning behavior, which indicates a change in the ecosystem. The utilization of human exploited areas by wildlife carries with it increased risks of zoonotic diseases, mechanical injury, and ingestion of chemicals. All of these factors, among others, may negatively impact an individual's physical fitness and/or reproductive success (Vynne et al. 2011).

4.4. Societal Context

Management and conservation strategies should be diverse and based on specific knowledge of animal behavior and societal context. A "one-size-fits-all" strategy which excludes the local community, particularly cultural, economic and political factors, may find local attitudes hostile

and compliance low. In Brazil, land was confiscated during the military regime and some areas were designated as protected without any community involvement (Bizerril et al. 2011). This loss of land is not something that can be easily forgotten, especially when living near a protected area has so many associated caveats and may be economically detrimental to local townspeople (Richardson et al. 2012, Sekhar 2003, and Mackenzie 2012).

Though there are many protected areas in Brazil, studies concerning their socioeconomic impacts are limited. Studies from Africa and India are useful case studies concerning the effects of protected areas on local people. However, difference in local wildlife, current levels of ecotourism and legality of hunting vary between Brazil, Africa and India and should be remembered when evaluating this research. A study done by Mackenzie (2012) in the areas surrounding Kibale National Park (KNP) in Uganda examined the economic benefits and losses of living near a protected area. Through the use of focus groups, interviews, surveys and an evaluation of crop raiding, she found that villages within 0.5km of the park suffered the greatest economic losses, though benefits "extended up to 15km from the park." Crop raiding, arrests/fines for illegal use of the park, livestock predation and wild animal attacks were all noted losses associated with living near the park. Revenue sharing, park-based employment, resource access agreements and NGO funding were all indicated as benefits of living near the park. Crop raiding was overwhelmingly attributed to baboons and elephants, whereas predation was predominantly by mongoose (*Herpestidae* spp.), serval cats (*Felis serval*) and baboons (*Papio cynocephalus*). Perceived economic losses generally outweighed perceived benefits, though loss/benefit calculations showed a net annual gain for eight villages and a net annual loss for the

remaining seventeen. Those with a net gain were generally near park-based employment areas or utilizing a resource access agreement (predominantly beekeeping).

Another study by Richardson et al. (2012) showed similar results for game management areas (GMA) surrounding national parks in Zambi, Africa. These buffer zones include human structures and were designed for safari (trophy) hunting. Within the parks themselves, hunting and human habitation are not permitted. Economic gains, through revenue sharing, employment, small business ownership and other industries, were correlated with areas of high persistence, diversity of wildlife and tourism areas, though these gains were unequally distributed to the already higher-income residents. Crop raiding was also higher when wildlife numbers where higher (Richardson et al. 2012), thus decreasing net gains in the area. Locals have cited lack of compensation for wildlife-induced crop loss (particularly by elephants), and the current ineffectiveness of damage mitigation efforts, as a primary obstacle to "socioeconomic development in GMAs."

The utilization of protected areas for ecotourism is a growing trend that may provide substantial economic benefit to surrounding villages. In India, wildlife tourism within protected areas was seeing dramatic growth while still in its infancy and lacking in infrastructure (Sekhar 2003). In the Sariska Tiger Reserve (Rajasthan, India), tourists come to see the tiger (*Panthera tigris*), Leopard (*Panthera pardus*), various ungulate and avian species, and numerous monuments and ruins (Sekhar 2003). Tourists are usually limited to short day trips due to the lack of a substantial infrastructure and associated services, however, numbers are increasing annually. Sekhar (2003) found that gains were seen predominantly by villages within 2km of a tourist zone

though even these were limited. Gains were in the form of sales from agricultural or hand-crafted products, employment or guide services. Villages near the reserve had a lower mean household income than those farther away. This was attributed to limited access of grazing and agricultural lands, as well as restricted use of the reserve for other resources. This coincides with the results seen by Richardson et al. (2012) and Mackenzie (2012) concerning the disproportionate distribution of economic benefits associated with PAs.

A study done by Gussett et al (2008) which examined the attitudes of local people and tourists towards the African wild dog (*Lycaon pictus*), particular reintroduction in Hluhluwe-iMfolozi Park (HiP), may help bridge the gap between the human societal contexts in Brazil, Africa and India. The study found that tourists held positive attitudes towards *L. pictus* and considered them an attraction which could contribute to ecotourism. Local people, however, held predominantly negative associations with *L. pictus*, mostly attributed to the threat of livestock predation. This threat of predation by *L. pictus* is more applicable to the conservation and management of Brazilian canids than the crop-loss associated with large mammals seen in Africa and India (Richardson et al. 2012, Mackenzie 2012). Documented cases of predation on livestock by *C. brachyurus, C. thous* and *S. venaticus* in Brazil have been low thus far (Jacoma et al. 2004, Zuercher et al. 2005), however, changes in land use and diet have been seen (Masarra et al. 2012) and should be monitored.

5. Implications

Consumer demand for beef, soybeans, and other agricultural goods is now a driving force behind Brazil's economy (Brazilian Agriculture 2010). With demand expected to rise as both Brazil and

the world's population grows, the need for agricultural land also grows. Given the recent changes lead by EMBRAPA, one of the world's most biologically diverse areas is now accessible for development, both agricultural and residential, as towns and roadways are constructed alongside large ranches and farms.

Historically, the agricultural methods used by subsistence farmers seem to have had a limited impact on *C. brachyurus* populations (Dietz 1984). However, the expanding large-scale operations can cause pervasive changes to the landscape. While some species, like *C. thous* seem to be highly flexible, others may struggle to adapt quickly enough to persist. *C. thous*, for example, will hunt and forage within human cities, even utilizing human refuse (Jacomo et al. 2004). Alternatively, *S. venaticus* have very specific habitat and prey requirements and their reclusive nature causes them to generally avoid human encroachment areas (Kleiman 2011) though they have been found in modified and fragmented habitats (DeMatteo & Louiselle 2008). The utilization of previously grazed agricultural land by *C. brachyurus* (Massara et al. 2012) indicates that their adaptability falls somewhere between *C. thous* and *S. venaticus*. The use of fragmented and anthropogenically altered landscapes by wildlife may lead to numerous issues such as crop-raiding, predation of livestock and exposure to infectious diseases which need to be evaluated. Crop-raiding by the *C. brachyurus*, *C. thous* and *S. venaticus* is thus far very rare with all three species occasionally preying on chickens (Jacomo et al. 2004, Zuercher et al. 2004). The use of protective structures, such as chicken coops, reduces this risk (Massara et al. 2012). In India and Africa, crop-raiding is generally associated with large, very destructive animals such as the elephant (Richardson et al. 2012, Mackenzie 2012), which can cause immense damage in a short period of time. Brazil is lacking in exceptionally large mammals,

making the potential economic losses from crop raiding even more limited. Another issue is an increase in home range size due to lower prey availability in areas of human disturbance (DeMatteo & Loiselle 2008). Conflictingly, it has been suggested that potential prey populations will increase in agricultural areas (Massara et al. 2012). Currently, agriculture in certain parts of South America is undergoing a transformation from soybean (low-lying) to sugar cane (dense cover) (Vynne et al. 2011). The dense nature of sugar cane may restrict movement of wildlife through fields, thus limiting its ecological utility so alternative studies may also need to be done and management strategies may need to be adjusted.

Zoonotic diseases may play a pivotal role in human-wildlife interactions due to the high number of mammalian species found in the region, all of whom are potential vectors for rabies and other diseases. Domesticated animals also pose a risk to wildlife through predation, competition, and disease transmission (Hughes & Macdonald 2013). Though articles concerning zoonotic diseases are prevelant in the literature (Hughes & Macdonald 2013), the effects of general displacement and harassment, such as the effects of domestic dogs chasing gazelle (Young et al. 2011), are more difficult to quantify than instances of rabies, distemper or parvo virus (Hughes & Macdonald 2013). Efforts to decrease the population of free-roaming domesticated dogs may be met with resistance by dog owners and current financial limitations; however preemptively addressing the situation may incur a lower cost than reacting to issues (Young et al. 2011).

Though there are currently land conservation measures in place in Brazil, they tend to preserve forested areas and woodlands over savannas and grasslands as these are of the least use in agriculture (Vynne et al. 2011) and may be more costly than savannah regions to convert for

agricultural. Given their foraging strategies, this preservation may provide some benefit for *C. thous* and *S. venaticus* who utilize forested regions for hunting and denning; however, *C. brachyurus* hunt predominantly in the savannah (Vynne et al. 2011). Current studies indicate that *C. brachyurus* may be utilizing croplands for foraging (Vynne et al. 2011, Massara et al. 2012) thus mitigating some of the loss of savannah to agricultural land. How beneficial this may be to their overall fitness is still in question given their exposure to machinery, chemicals, domesticated animals and other risks within human disturbed areas. Given their asocial nature and large home ranges, the use of converted lands by *C. brachyurus* may indicate more pressure on them than previously thought. If their presence within these areas were to continue to rise, an increase in foraging pressure may be inferred, though more research would be needed to determine if there was a preference for specific forage types (seeds, fruit, rodents, etc.) in this changing landscape. *C. brachyurus* and *C. thous* have varied diets that currently change based on availability. This flexibility in diet may prove advantageous as ecosystems are altered, however, the long-term effects may be difficult to determine. The overall change in fitness related to dietary changes will also need to be evaluated.

Recent changes in the Brazilian Forest Code increased Cerrado protection from 20% to 35% but decreased river protection dramatically (The Economist 2012, Stewart 2013). This may be deleterious to *S. venaticus* who hunt and den in the gallery forests along riverbanks (Zuercher et al. 2005, Zuercher et al. 2004, de Oliveira 2009, DeMatteo & Loiselle 2008, Nowak 2005). *S. venaticus* has been known to utilize other habitats, however, the loss of approximately 80% of their previously protected habitat may prove too much for population persistence, especially when both hunting and denning behaviors are considered. While their social nature allows for

larger numbers of individuals per area of home range than *C. brachyurus*, their carnivorous diet and fairly static prey preference make all changes in available hunting habitat significant. Evaluation of wildlife use of "buffer zones," previously burned areas and agricultural land needs to be done to determine if these provide viable habit and/or dispersal corridors for wildlife.

The affiliative behaviors and shared/overlapping home ranges of *C. thous* may allow for more flexibility of home range and number of individuals within the home range. The highly social behavior of *S. venaticus* is evident in their affiliative and submissive behaviors as well as their pack hunting method (Kleiman 2011). The predisposition for multiple individuals to live in close proximity and their developed hierarchical system indicate a high ability for co-habitation of a home range, making *S. venaticus* the most easily adapted to limited dispersal ability. Whether or not there are the resources available to sustain such a population would need further examination. As ideal habitat becomes more limited, dispersal patterns and home range sizes may be altered. I hypothesize that if resources are limited, dispersal of offspring may occur earlier; however, it could be extended if the ability to disperse is limited. Corridors aim to aid in dispersal and allow for migration between fragmented areas. The use of corridors will be instrumental in wildlife management efforts as currently fragmented areas are re-connected allowing for increased gene flow.

6. Conclusion

The implementation, monitoring and maintenance of wildlife management plans has many consequences socially, politically and economically that must be evaluated along with the

environmental and behavioral implications. This is especially true of protected areas which have been widely used as a means to safeguard specific species and habitats. With the growing economic importance of agriculture in the Cerrado region of Brazil, the loss of potential agricultural land to provide protected areas is a major concern at all levels, from large-scale corporate farms and ranches to subsistence farmers. The ever growing demand for agricultural goods and the increasing population of the country (and the world) requires a growing agricultural industry which is dependent on usable land. The fear of losing land and therefore profits and food supplies is a very real issue, one which local communities have previously experienced under the military regime (Bizzeril et al. 2011). Ecotourism, particularly in and around protected areas, may help to offset the losses or costs of conservation efforts for local communities, if it is approached from both an environmental and societal standpoint. Such programs could be used to help fund management of protected areas as well as contribute to the economy of local communities, thus increasing support for conservation initiatives in the area (Sekhar 2003). However, the trends seen in Africa and India related to distribution of income surrounding PAs (Sekhar 2003, Richardson et al. 2012, Mackenzie 2012) indicates a prevalent need for community involvement in planning and management. While programs should help increase infrastructure (such as schools, roadways and hospitals) in rural areas as seen in the previous studies, they should also aim to decrease poverty levels and benefit local communities through resource access agreements, job creation and training, and contracts for locally produced goods.

Along with societal context, animal behaviors need to be included in the development of management and conservation plans. This can be done through the utilization of behavioral

indicators in the evaluation of management plans and the recognition of behavioral alarms as signals necessitating research or intervention. The location of a behavior on the flexibility continuum will allow for the development of management and conservation strategies which aim to protect, utilize or attempt to alter animal behaviors. The incorporation of anthropogenic alterations, societal context, and animal behavior can form the basis of comprehensive management strategies which aim to protect both animal and human populations. Management efforts should always be flexible and open to new ideas and information, allowing them to mature as societal concerns change and our understanding of wildlife behavior and ecology advances.

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