CARNIVORE CONSERVATION: EVIDENCE FOR THE EFFECTS OF HABITAT-BASED INTERVENTIONS

by

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Abstract

Terrestrial carnivores (Order Carnivora) are experiencing rapidly declining populations around the world. They face a myriad of threats, not least of which are threats to their habitat. Human population growth and development have destroyed, fragmented or degraded much of the land these charismatic species require to survive. Large carnivores in particular are affected by such threats due to their life history traits, such as low population density, solitary social structure and low fecundity. Many of these large mammalian carnivores are in urgent need of effective interventions to prevent their extinctions. However, the conservationists who are trying to save these species do not currently have access to an adequate evidence-base to inform their practices.

Limited time, funds and experience in academic jargon can make it difficult for conservation practitioners to access and assess the scientific literature. This often forces conservationists to rely on common sense and expert opinion to choose strategies, making their decisions vulnerable to bias and lack of information. Conservation Evidence is a project started at Cambridge University to compile scientific evidence for conservation interventions into a concise and approachable package made freely available to the public. This study constitutes a portion of their upcoming synopsis of the evidence surrounding conservation strategies for terrestrial carnivores, focusing on habitat-based threats. While it is increasingly known that the conservation field requires a more evidence-based approach, this project shows there is a very limited amount of empirical evidence to support carnivore conservation efforts with respect to land use.

Introduction

Arguably, carnivores are the most charismatic animal species in the world. Animals such as tigers (*Panthera tigris*), wolves (*Canis lupus*), and giant pandas (*Ailuropoda melanoleuca*) inspire in us awe and admiration. We are both fascinated by and fearful of these creatures. We love them as pets and we hate and persecute them as man-eaters. Our complex relationship with carnivores has been shaped by millennia of evolutionary history in which we have consistently inhabited similar ecological niches. Across human history, we have competed with them for food and space and we have come into direct and deadly conflict with them. Yet, we also value them for their meat and pelts as well as for their beauty and companionship as domesticated pets. As we continue to compete with carnivores over habitat, space and prey our increased population

and technological capacity has given us the decided advantage. If we do not take steps to mitigate the impacts we have on carnivores, we could lose many of these species forever. Of all terrestrial mammals, many of the most threatened are carnivores (Karanth and Chellam 2009).

Order Carnivora

Carnivora is a diverse order that ranges in size from the least weasel (*Mustela nivalis*) at 35 g to the southern elephant seal (*Mirounga leonine*) at over 3,600 kg (EOL 2012). Members of the Order Carnivora can be found on every major land mass and in every ocean. That they are adapted to such a wide range of habitats means they exhibit a wide diversity of characteristics and life history traits. Due to this diversity, as a group they are faced with a variety of threats that require a variety of conservation strategies to mitigate them.

From habitat loss to disease to poaching to highways to overhunting of their prey, species carnivores are experiencing a wide number of threats that are causing their populations to decline. Many interventions to address these threats are currently being put into practice around the world that range from paying ranchers not to kill carnivores that predate their livestock to killing problematic individuals to protect the population as a whole. These different types of interventions address specific threats that arise from specific contexts and thus when putting these interventions into practice they need to be tailored to the needs of the target carnivore in its particular context.

Evidence-Based Conservation

For conservationists, however, it is not always clear which intervention may be most effective and appropriate in a particular situation. They have three primary methods to access the information to make this decision (Dicks 2010). They can read the scientific literature, ask a scientist, or read reviews of the literature. The first method is difficult for many conservation practitioners, as they may not have institutional access to scientific journals or the funds to pay for access (Pullin, Knight et al. 2009). If they do have access to academic journals, it is a time-consuming process to sort through the literature and the process can be hindered by scientific jargon. The second option is only possible if the practitioner knows a scientist in their field and these experts' opinions can often be swayed by their own personal experiences and biases. The last option is the most practical and unbiased, but as of yet there are few systematic reviews available on the issues that carnivore conservationists are interested in. The intent of this work is to provide practitioners with such a review.

A study of UK conservation practitioners (Sutherland, Pullin et al. 2004) found that most conservationists use common sense over other sources of information. In fact, only 2.4% of the

study sample actually consulted the scientific literature. Another study of over 1000 protected areas in Australia (Cook, Hockings et al. 2010) found that in 25% of cases reserve managers lacked sufficient data to complete management effectiveness assessments. Furthermore, when these assessments could be completed, 60% of them relied entirely on experience, not empirical data, to support the efficacy of their management actions.

There are several barriers that prevent pure research from reaching the hands of those in positions to implement management actions (Sutherland, Goulson et al. 2011). There is often a long time lag between scientific discoveries and their implementation, the application of scientific findings can be hindered by factors outside science such as politics and marketing, and results can be forgotten if scientists do not try to actively disseminate them to the public. What this leads to is a divide between science and practice, decisions made independently of the available research, few lessons learned from successes and failures, and management conducted on common sense, personal experience, myths and anecdotes rather than the best available evidence.

Due to these issues, many are now realizing the need for evidence-based conservation. The evidence-base movement has two goals: 1) to systematically review, collate, assess and disseminate the research on the effectiveness of interventions, and 2) to identify knowledge gaps and prioritize future research (Stewart, Coles et al. 2005). These goals are important as reviews in ecology and conservation are not often conducted systematically, but rather follow the narrative review format (Roberts, Stewart et al. 2006). This allows for only qualitative assessment of the data, with the subjective views and experiences of the authors having a large impact on the stated conclusions. Ecological reviews also do not commonly report their methods for search and synthesis of papers, making their results less reliable.

Reviews should be conducted more systematically as they are valuable sources of information that identify the connections between large bodies of research that can be conflicting and controversial. Reviews have revolutionized the field of medicine by allowing researchers to bring together large amounts of data that collectively reveal more robust finings (Pullin and Knight 2009). Using systematic review methodology, medical researchers synthesize the results of many different studies, reducing the amount of variability due to bias and random errors. This has played an important role in making medical interventions safer and more effective. The same thing can and should be done for conservation. Without this evidence-base, we cannot know if our actions are doing more harm than good and we cannot defend these actions to donors and critics. Conservation interventions cost society money and we need to be able to justify this cost.

As a part of the growing evidence-base movement, the Conservation Evidence (CE) project, conceived by Professor William Sutherland at the University of Cambridge, strives to compile and disseminate the quantitative evidence on how to conserve biodiversity. There are three components to CE: an online journal that publishes original studies that quantitatively assess conservation interventions, a searchable online database of concise summaries of existing studies (found at http://www.conservationevidence.com), and a series of synopses of available evidence for particular taxa or ecosystem types.

Terrestrial Carnivore Synopsis

This project is a contribution towards the upcoming CE synopsis on terrestrial carnivores. Two synopses, for birds (Williams, Pople et al. 2013) and bees (Dicks, Showler et al. 2010), have so far been published. They compile concise summaries of all available evidence on the interventions in use to conserve those specific taxa. These synopses have been published in print form and are freely available online as PDFs (http://www.conservationevidence.com/synopsis/index). It is CE's goal that these synopses will aid conservationists interested in conserving a particular taxon or type of habitat to decide which type of intervention is best suited to their situation. The synopses are intended to be as concise as possible while providing a thorough review of the literature. They do not give recommendations on which interventions to choose. They merely state the evidence objectively and allow the reader to weigh the merits of each intervention type.

The terrestrial carnivore synopsis will cover all the reasonably applied interventions currently proposed for members of the Order Carnivora that occupy terrestrial habitats. This particular project contributes toward the sections of the synopsis that address habitat-based threats. These threats are of particular importance to large carnivores, most of who require large areas of habitat to survive. Threats to carnivore habitat include the loss and/or fragmentation of habitat from human development, including urban development, highways, and resource extraction activities; habitat degradation caused by pollution and climate change; and declining prey availability due to overhunting by humans.

Habitat-Based Threats

Habitat fragmentation can have a wide variety of effects on species, including increased mortality, reduced abundance, changes in movement and dispersal patterns, disruption of social structure, reduced population viability, and decreased genetic variation that leads to reduced adaptation ability, inbreeding depression, reduced survival and reproduction, and increased likelihood of extinction (Dixon, Oli et al. 2007). These effects vary with species. While each terrestrial member of the Order Carnivora occupies a similar ecological guild, they differ greatly in

life history traits, body size, diet, niche breadth, and social structure. Some species will even benefit from certain types of habitat fragmentation, such as domestic cats (*Felis catus*), gray foxes (*Urocyon cinereoargenteus*) and opossums (*Didelphis virginiana*) (Oehler and Litvaitis 1996; Crooks 2002). Such mesopredators are more human-tolerant and able to reside in urban areas, making them less negatively affected by development, which also releases them from competition with other predators that cannot survive in the urban matrix.

A species' sensitivity to fragmentation depends on a number of variables that interact with each other in different ways. Two or three of these factors must be considered together to determine how sensitive a species will be to fragmentation. In general, the species that are most sensitive are those with low population density/high individual area requirement, high fluctuation in population, low fecundity, little storage of resources, little dispersal power, and specialist resource requirements (Henle, Davies et al. 2004). Any number of these traits in combination with each other can suggest that a species is highly vulnerable to habitat fragmentation. Furthermore, it appears that niche breadth is particularly important in determining whether a species will be tolerant to fragmentation as a generalist species will be better able to adapt to changes in habitat and resource availability (Swihart, Gehring et al. 2003).

Large carnivores are typically described by many of these highly vulnerable traits, as they tend to require large home ranges to find adequate numbers of prey, which results in low population densities. Reduction of these ranges by human encroachment can lead to increased intra-species aggression over food sources and mates and increased aggression towards humans. Human-carnivore conflict is a serious problem that endangers the safety of people living in proximity of carnivores and increases retaliation against carnivores.

Large carnivores are also much more likely to be susceptible to the effects of reduced genetic variability, as they tend to display low fecundity and long generation times. Species such as the Florida panther (*Puma concolor coryii*), Florida black bear (*Ursus americanus floridanus*) and giant panda (*Ailuropoda melanoleuca*) have been shown to lose genetic diversity when their habitats are fragmented (Dixon, Oli et al. 2007). This loss of genetic diversity occurs when habitat fragmentation prevents male dispersal (Banks, Lindenmayer et al. 2005). That many large mammalian carnivores experience such negative consequences from habitat fragmentation makes it a significant threat to Carnivora, despite those members of the order that are benefitted by it.

Due to the diversity in how mammalian carnivores respond to habitat disturbance, protecting them from this disturbance is particularly difficult. Successful management of carnivore habitats requires specific knowledge of the ecological processes at play in those habitats and the

complex interactions between them. This is complicated by the fact that habitat fragmentation has a lasting impact beyond the initial increase in extinction rate (Henle, Lindenmayer et al. 2004). Species continue to go extinct after the habitat loss is halted from stochastic forces within the remaining habitat fragments. Currently there remains a dearth of data on the stochastic forces resulting from fragmentation, on the conversion of research into practical tools for habitat management, and on the outcomes of management options when they are implemented. Lack of data on how fragmentation affects species, on the efficacy of management actions, and conflicts between conservation goals and those of other actors all contribute to making land management for species conservation a very challenging process.

Habitat fragmentation is a particularly difficult threat to manage due to how closely-linked it is to positive human values such as economic development. Attempts to mitigate habitat loss have typically involved the establishment of protected areas (PAs) (Margules and Pressey 2000). It has only been very recently that decision-makers have begun to design and site these reserves using systematic and scientifically defensible methods. Many existing PAs were designed with political objectives in mind, resulting in inappropriately located reserves that do not adequately represent the biodiversity in need of conserving. As conservation goals generally require the protection of PAs from resource extraction, these areas become less economically viable to the local population. When an area of high conservation potential also has high economic potential from resource extraction, development usually wins over conservation. Furthermore, established reserves that are not robustly and politically protected can be degraded and dismantled when new economic opportunities are discovered within their boundaries.

Ecological Importance of Carnivores

Despite these challenges, protecting terrestrial carnivores within their habitats is not only crucially important for the survival of the carnivores themselves, but for the ecosystems they inhabit as well. When top predators are lost from an area the whole system can experience the drastic consequences of the resulting trophic cascade (Estes and Terborgh 2010). A trophic cascade occurs when changes in one trophic level have cascading implications for the rest of the trophic web. When a top predator is removed from an ecosystem, its prey species are released from predation allowing their populations to explode to untenable numbers. These herbivore species then have the potential to decimate the vegetation that they rely on, ultimately leading to reduction in overall biodiversity.

In this way, top predators perform a very important function in their ecosystems by regulating herbivore populations to prevent them from overharvesting the vegetation that is the base of all higher trophic levels. An example comes from the 1986 recolonization of wolves into

Banff National Park, Canada, which saw a full re-establishment of a wolf population in most of the park while one area remained at low wolf density due to high human activity (Hebblewhite, White et al. 2005). The area with low wolf densities had greater than 60% less wolf predation on elk and experienced much higher density and survival of elk which led to lower aspen and willow recruitment, fewer active beaver lodges and lower abundance and diversity of riparian songbirds.

A trophic cascade can have a different type of consequence when there exists an intermediate trophic level of mesopredators between the top predator and the herbivores. In this case, when the top predator is removed from the system its prey, the mesopredator, is released leading to increased predation on their prey resulting in lower biodiversity (Crooks and Soulé 1999). For example, eliminating coyotes from an urban habitat releases domestic cats from predation leading to extinctions of bird populations. Different ecosystem structures, therefore, have different responses to removal of top predators, but the consequence is still usually negative.

Trophic cascades have also been shown to transcend ecosystem boundaries, even crossing between terrestrial and aquatic systems, particularly when the trophic web contains species with complex life histories (Knight, McCoy et al. 2005). Species that live parts of their life cycle on land and other parts in water can carry the effects of a trophic cascade between these different ecosystem types, causing the cascade to reach regions beyond the specific ecosystem where the original predator was removed. Therefore, the loss of a top predator species can have wide-reaching impacts both within the specific area they inhabited and in neighboring ecosystems.

Status of Carnivore Habitat Conservation

While the impacts of habitat loss and fragmentation on terrestrial carnivores and the subsequent loss of overall biodiversity have become widely established in recent years, the methods to address this issue have not been as rigorously studied. Reserves have long been the preferred method for conserving species, ecosystems, and/or biodiversity but simply putting land into a reserve and protecting it from threats is not always effective (Margules and Pressey 2000). There are two variables that must be met for a reserve to be successful; it must be representative of the full suite of biodiversity at different levels of organization, and it must be persistent through time to maintain the protection of biodiversity from threats. To accomplish this reserves must be systematically planned using an empirically based decision-making process. This takes more time and resources than are typically devoted to land conservation efforts.

Systematic conservation planning has six primary requirements (Margules and Pressey 2000). It must:

- use clearly-defined surrogates for overall biodiversity in the planning process;

- translate its goals into explicitly-stated, quantitative targets;
- analyze how effective existing reserves have been in meeting conservation goals;
- design and locate new reserves to meet those goals existing reserves have failed to achieve using simple and explicit methods;
- determine and implement specific criteria for the on-the-ground protection of the reserve, particularly in scheduling protection when it is not possible in all areas of the reserve; and
- explicitly state objectives and methods for maintaining management and monitoring its effectiveness.

These criteria must be met to ensure that the reserves are able to efficiently allocate limited resources to successfully achieve their goals. The reserves must also be flexible and defensible against competing land uses as well as accountable by allowing critical review of their management decisions. These factors make systematic conservation planning more robust and effective than simply putting land indiscriminately into reserves without justification.

The systematic conservation planning process provides a guideline to follow when making habitat conservation decisions. Following these steps allows one to identify appropriate actions depending on the specific location. Over the last decade, it has been increasingly accepted and implemented but studies of the efficacy of the process and the actions it inspires have not been made widely available. The process would be greatly improved if conservation managers had access to results of such studies. This project as an attempt to address this need and make available the information that will allow conservation planners to follow the systematic planning process with as much robustness and reliability as possible.

Objectives

The objectives of this project are:

1. To provide the most comprehensive list possible of the habitat conservation interventions that can be applied to conserve carnivores.
2. To collate, assess and summarize the literature that quantifies the effects of these interventions following the guidelines of CE.
3. To contribute this product to CE as a portion of the upcoming carnivore synopsis so that it can be disseminated and made widely accessible to any interested parties.
4. To prioritize where future research into habitat-based carnivore conservation should focus.

Methods

This project was conducted in two phases:

Phase 1

In fall 2011, the Big Cats Initiative (BCI) intern group at Duke University decided to compile a document assessing the effectiveness of strategies to conserve big cats. BCI is an effort by National Geographic to slow big cat decline through research, conservation action, and education. The intern group at Duke works on the research arm of this mission by conducting inquiry into the causes of big cat decline and ways to mitigate it. For this particular project, we began by drawing on our own experience and knowledge to compile a list of all interventions that are being implemented to conserve big cats (appendix I).

We then conducted key word searches on Google Scholar for the individual interventions, compiling a database of articles studying them. We defined our own criteria for inclusion into this database with three levels of evidence: 1) data shows intervention strategy has reduced cat mortality/or increased the cat population, 2) data shows strategy has reduced the amount of human/felid conflict, or 3) data shows there is a perception that mortality and/or conflict decreased due to strategy. These levels represent a hierarchy of evidence that we preferred to find in our search, but any article that fit one of these categories was included in our database. As these studies were identified, we began to summarize the studies found in a format that we created.

We encountered several issues when following this method. The first was that the intervention list was the result of our one group's collective knowledge and experience. This list was not reviewed by outside experts and therefore was likely biased towards interventions with which we are more familiar. This is evident in the fact that the number of interventions was weighted heavily towards those mitigating human/felid conflict. Secondly, our search for articles did not follow a systematic approach. We kept track of keywords used to search Google Scholar but we did not determine a set point for when to stop the search with a particular keyword. This likely resulted in many articles being overlooked. A third limitation involved the criteria for which articles to include in the database. Our inclusion criteria were not specific enough to determine which types of evidence were robust enough to be concluded. We also in this stage discovered the fact that quantitative studies are lacking on big cats. Since interventions to conserve other carnivores will likely be relevant to big cat conservation as well, we decided to include these in our search but we never explicitly stated which species could be included in the database. The

final limitation of this method was that we had a very loosely defined structure for writing the summaries. This meant that the resulting summaries were not directly comparable to each other.

After following this method and encountering the problems inherent in our approach, we contacted the CE project team and discovered that they were interested in creating a terrestrial carnivore synopsis. We decided to reformulate our project to contribute to this synopsis, realizing that it addressed all of the difficulties jut outlined. This restructuring led to phase two of the project.

Phase 2

To properly contribute to CE's carnivore synopsis we began the process again following CE's own methodology. The CE method is inspired by the methodology of systematic reviews. A systematic review can be summarized into eight main steps (Pullin and Stewart 2006; Pullin and Knight 2009):

1. Formulate a question for the review to focus on.
2. Generate a protocol that explicitly and clearly defines the review's methodology.
3. Systematically search for studies.
4. Select relevant studies following the criteria stated in the protocol.
5. Critically assess the quality of the methodology, acknowledging limitations and biases.
6. Extract data from the studies into a standardized and transparent format.
7. Synthesize the data using quantitative and qualitative analyses.
8. Peer review and disseminate the report.

The systematic review method was inspired by the medical field, which differs from conservation in important ways. However, the validity of this methodology in the conservation field has been assessed (Stewart, Coles et al. 2005) and was found to be effective as long as three issues are addressed: 1) the definition of what an effective intervention outcome is clearly stated and accepted by all stakeholders, 2) the intervention in question has enough good quality data to be synthesized into a review, and 3) the question is specific enough to be manageable but broad enough to cover key variables in what is invariably a complex system. In the field of ecology, these issues are not always easy to meet and we attempt to address them as best we can.

CE has generated a protocol for the synopsis teams to follow (appendix II). My colleague from the BCI group, Sarah Lockhart, and I took lead of the project and have been working in conjunction to complete the synopsis. She has completed the first five steps of the CE protocol. The draft list of interventions that she has assembled in conjunction with the Advisory Board can be found in appendix III. I have completed steps 6-10 and will be completing the rest of steps 11-20 for the habitat-based sections by the fall of 2013.

Steps 6-10 of the CE protocol involve trawling specialist journals for articles that satisfy CE criteria. These criteria are that "1) there has to be an intervention that conservationists would be likely to do, and 2) its effects on biodiversity or ecosystem services must have been monitored quantitatively" (CE 2012b). We identified the Journal of Mammalogy and Wildlife Society Bulletin as the specialist journals most likely to contain terrestrial carnivore relevant articles. I trawled the archives of both of these journals from January 1970 to December 2012. This process involves reading the abstracts for every article in the archive and extracting the citations for each one that meets CE criteria. These citations are all pulled into an EndNote library, including the studies that do not address terrestrial carnivores. The resulting EndNote library is shared with CE for future synopsis writers to access.

After this step I collected the articles from this trawl as well as journal trawls previously conducted by CE that address habitat-based interventions for terrestrial carnivores. Each article is summarized following the CE format (appendix IV). The first step in the summarizing process is to complete a form on the CE website (www.conservationevidence.com) with the most important information from the study. This information goes into CE's online searchable database. The second step is to summarize the study in a single paragraph that will go into the final synopsis.

The synopsis is finally compiled in the standard synopsis format (appendix V). The synopsis is divided into sections based on the broad intervention categories. Background information is provided for the category and a key message for each intervention type is written, based on the collection of evidence found for that category. Key messages are one or two sentences that contain only the most important information about that intervention type. These are followed by descriptions of the particular intervention types and a collection of the summary paragraphs for each study found in each type. The final synopsis is published in print and made freely available as a downloadable PDF on the CE website. This makes it simple for anyone interested in conserving carnivores to access the synopsis in whichever format is most convenient for them.

Results

This project is focused on creating the sections of the synopsis that address habitat and land-use based interventions. This began with determining a thorough list of these interventions. The inclusive list of all reasonably applied interventions for terrestrial carnivores that Sarah Lockhart and the Advisory Board devised includes 52 possible interventions (appendix III). From this list, I have identified three intervention categories as being relevant to habitat and land use (Table 1).

Table 1. List of habitat-based interventions for terrestrial carnivores. (PA = Protected Area).

ROADS AND RAILROADS
3. Reduce collisions
Install infrastructure (e.g. underpasses, speed bumps, exclusion fences)
Change traffic laws (e.g. speed limits, access points)
Increase driver awareness (e.g. highway lighting, signs)
INCIDENTAL OR ACCIDENTAL MORTALITY
8. Conserve prey bases
Reintroduce prey species
Manage habitats for prey species
Limit takes of prey base (e.g. legal and illegal hunting)
Restore vegetation-prey-predator balance
9. Food and water shortage
Provide supplemental food and watering holes
10. Use medical interventions for injured/snared animals
11. Mitigate potential infrastructure risks (e.g. wells, electrocution)
HABITAT PROTECTION/MANAGEMENT
42. Protect core populations and habitats
Create new protected areas
Increase effectiveness of existing PAs (e.g. buffers)
Increase support and protection of PAs (e.g. funding, guards, fencing)
43. Improve or restore habitat
Introduce fire management
Increase water access and availability
Convert ranchlands to conservation or tourism areas
44. Reduce fragmentation with corridors
Incorporate corridors between PAs
Incorporate private and public reserves
Maintain or recreate corridors of natural migration
45. Use graded management zones or metapopulation management

The trawls of the archives from January 1970 to December 2012 of the Journal of Mammalogy and the Wildlife Society Bulletin reveal 356 articles meeting the CE criteria. Of these, 38 study terrestrial carnivores and of these, 6 concern the preceding intervention types related to habitat and land use (Fig. 1 & Fig. 2).

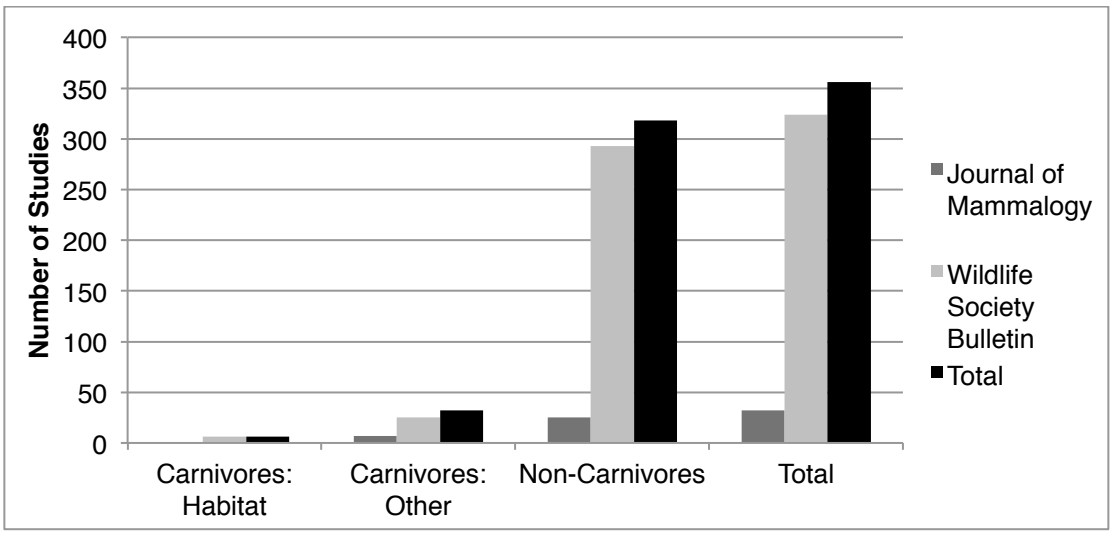

Fig. 1. The number of articles found from the trawl of the Journal of Mammalogy and Wildlife Society Bulletin archives, January 1970 to December 2012.

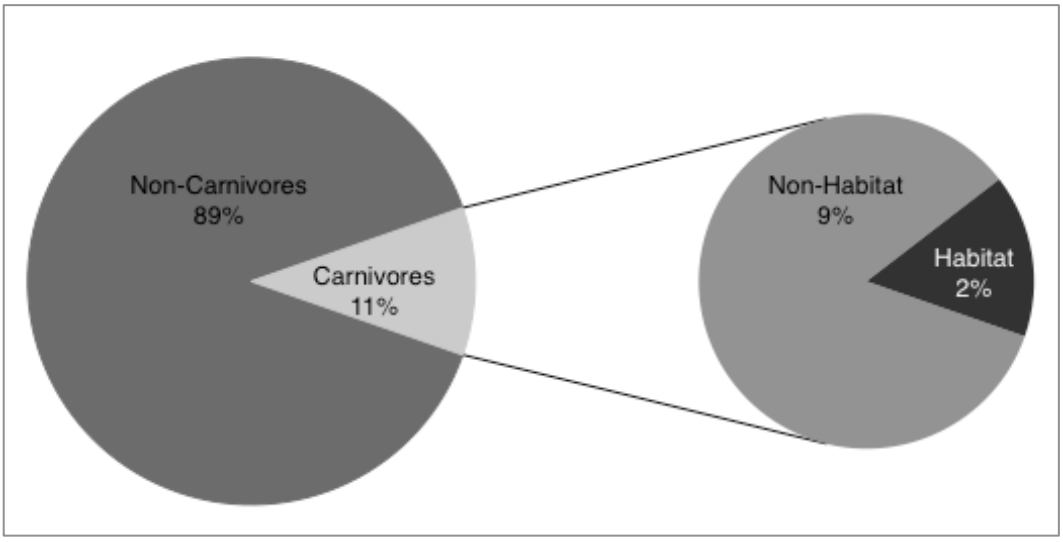

Fig. 2. The distribution of subject matter of the CE-relevant studies from the Journal of Mammalogy and Wildlife Society Bulletin archives, January 1970 to December 2012.

An additional 6 habitat studies are available from the trawls previously conducted by CE. Combining these with the results from my trawl results in 42 carnivore related studies, 12 of which study habitat-based threats (Table 2).

Table 2. Terrestrial carnivore intervention types studied by the articles discovered in trawl.

Intervention Type	Number of Studies	Percentage of Total
Non-Habitat		
Prevent livestock killings	4	10%
Change legal hunting laws and practices	3	7%
Reintroduction	10	24%

Translocation	3	7%
Deterrents and adverse conditioning	6	14%
Fencing	1	2%
Ex-Situ Conservation	1	2%
Decrease Illegal Taking	1	2%
Trap and Remove Individuals	1	2%
Sub-Total	30	71%
Habitat		
Increase effectiveness of existing PAs	2	5%
Increase support and protection of PAs	1	2%
Maintain or recreate corridors of natural migration	1	2%
Improve or restore habitat	3	7%
Install infrastructure	5	12%
Sub-Total	12	29%
Total	42	

The 12 habitat studies will be summarized and published in the terrestrial carnivore synopsis. The analysis of their data (Table 3) reveals where gaps exist in the available research.

Table 3. Basic data extracted from the 12 studies revealed in journal trawling. (Martinka 1974; Foster and Humphrey 1995; Rodriguez, Crema et al. 1996; Caro 1999; Clevenger and Waltho 2000; Clevenger, Chruszcz et al. 2001; Main and Richardson 2002; Cunningham, Ballard et al. 2003; Ng, Dole et al. 2004; Davies and Pullin 2007; Paviolo, Blanco et al. 2009; Barrett, Kalies et al. 2012)

Study	Action	Threat	Research Design	Effective?
Barrett et al. 2012	Improve or restore habitat	Fire/suppression	Site comparison	Inconclusive
Caro 1999	Increase effectiveness of existing PAs	Hunting/trapping terrestrial animals, logging/wood harvesting	Site comparison	Yes
Clevenger & Waltho 2000	Install infrastructure	Roads and Railroads	Replicated	Yes
Clevenger et al. 2001	Install infrastructure	Roads and Railroads	Site comparison	Yes
Cunningham et al. 2003	Improve or restore habitat	Fire/suppression	Site comparison	Yes
Davies & Pullin 2007	Maintain or recreate corridors of natural migration	Residential and Commercial Development	Systematic review	Inconclusive

Foster & Humphrey 1995	Install infrastructure	Roads and Railroads	Replicated	Yes
Main & Richardson 2002	Improve or restore habitat	Fire/suppression	Before-and after trial	Yes
Martinka 1974	Increase effectiveness of existing PAs	Recreational activities	Before-and after trial	Yes
Ng et al. 2004	Install infrastructure	Roads and Railroads	Site comparison	Yes
Paviolo et al. 2009	Increase support and protection of PAs	Hunting/trapping terrestrial animals, logging/wood harvesting	Site comparison	Yes
Rodriguez et al. 1996	Install infrastructure	Roads and Railroads	Site comparison	Yes

These studies focus on a diverse array of locations and species, however most (58%) of the studied threats and actions address the "habitat protection/management" category of interventions (Table 4). 42% address threats in the "roads and railroads" category and of these all implemented "install infrastructure" as the action type. None of the studies addresses the "incidental or accidental mortality" category.

Table 4. Distribution of studies in habitat-based intervention categories.

Intervention Category	Number of Studies	Percentage of Total
ROADS AND RAILROADS		
3. Reduce collisions	5	42%
Subtotal	5	42%
INCIDENTAL OR ACCIDENTAL MORTALITY		
8. Conserve prey bases	0	0%
9. Food and water shortage	0	0%
10. Use medical interventions for injured/snared animals	0	0%
11. Mitigate potential infrastructure risks	0	0%
Subtotal	0	0%
HABITAT PROTECTION/MANAGEMENT		
42. Protect core populations and habitats	3	25%
43. Improve or restore habitat	3	25%
44. Reduce fragmentation with corridors	1	8%
45. Use graded management zones or metapopulation management	0	0%
Subtotal	7	58%
Total	12	

Of the 8 types of research design that CE recognizes, the majority of the studies (58%) use one type of design, "site comparison" (Fig. 3). CE defines this research design as "a study that considers the effects of interventions by comparing sites that have historically had different interventions or levels of intervention" (CE 2012b). The remaining studies use either "replicated", "before-and-after trial" or "systematic review" design. 4 types of methodology ("controlled", "paired sites", "randomized", and "review") were not used by any of the examined studies.

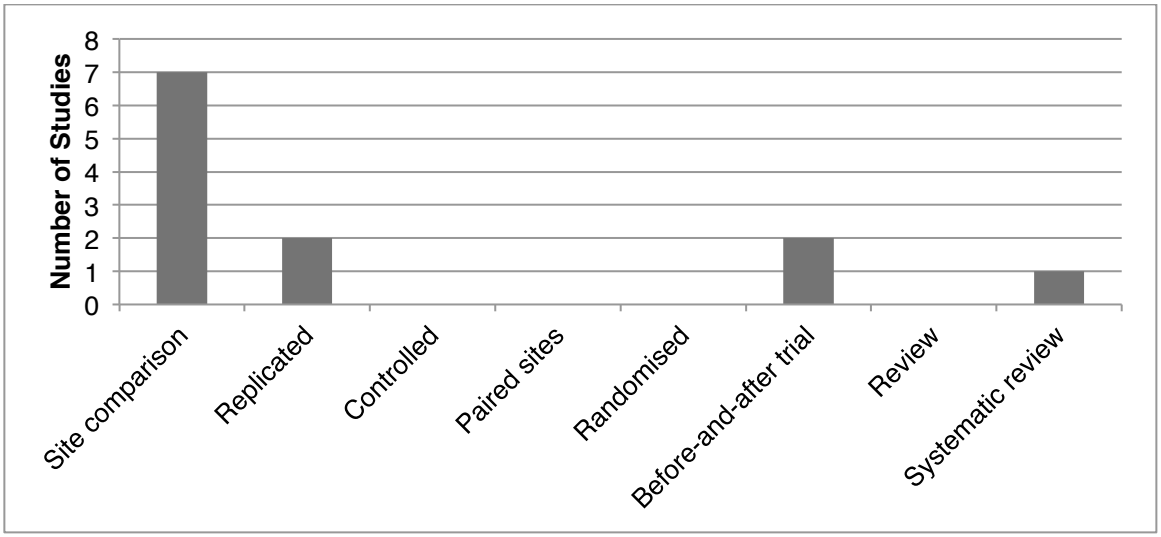

Fig. 3. Frequency of research design used.

The large majority of the studies (83%) found their action to be effective (Fig. 4). The other 17% had inconclusive data and none found an action to be conclusively ineffective. Of the actions studied, only "maintaining or recreating corridors of natural migration" and "improving or restoring habitat" had studies that were inconclusive.

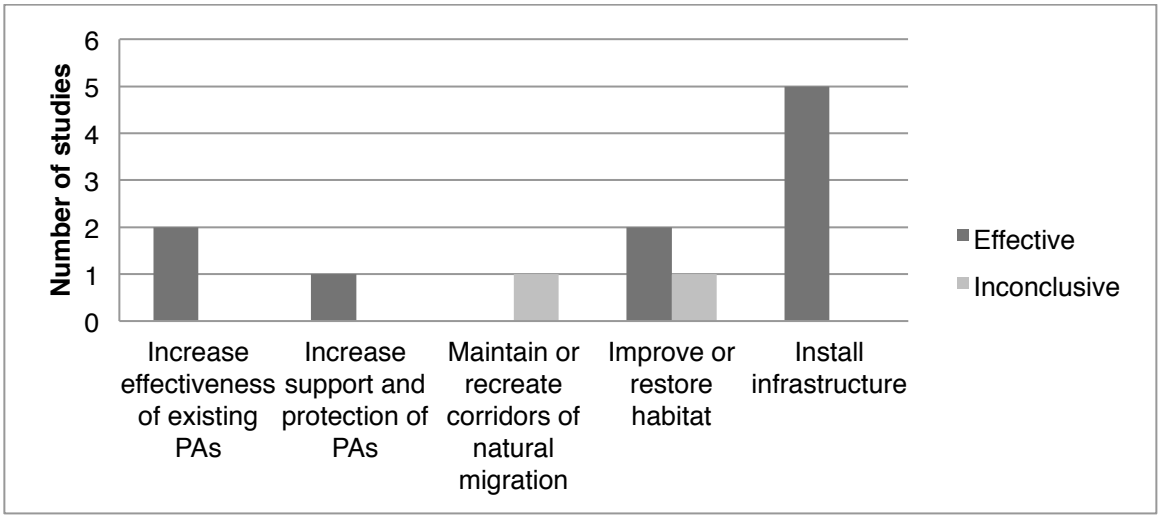

Fig. 4. Frequency of action being found effective.

The summaries of these 12 interventions will comprise three sections out of the final synopsis, following the CE template (appendix V). Each study will be summarized in one paragraph that contains the most important information (Fig. 5).

A site comparison study in 2003-7 in 3 sites of subtropical dry forest in Argentina and Brazil(1) found that pumas (*Puma concolor*) had higher densities in the areas with lower poaching pressure and amount of logging. Puma densities were 1.55-2.89 individuals/100km^2 in the site with the lowest poaching pressure and 0.3-0.74 individuals/100km^2 in the site with the highest poaching pressure. Sites with intermediate amounts of poaching pressure had densities in between these numbers. Pumas also increased their nocturnal activity in the least-protected sites. Surveys of poaching signs were used to estimate poaching pressure. Camera traps were used to estimate puma density.

(1)Paviolo, A., Y. E. D. Blanco, et al. (2009). "Protection Affects the Abundance and Activity Patterns of Pumas in the Atlantic Forest." Journal of Mammalogy **90**(4): 926-934.

Fig. 5. Example summary paragraph for one of the studies that will be included in the terrestrial carnivore synopsis.

Discussion

From over forty years of articles in two major academic publications, there were a large number of articles that met the CE criteria of being actionable and quantitative. However, only a small number of these (11%) studied terrestrial carnivores and a miniscule proportion (16%) of these addressed threats relating to habitat and land use. This is likely due to the challenges involved both in studying carnivores in implementing landscape-scale studies.

Carnivores are difficult to study as they tend to be elusive, nocturnal and can occasionally become dangerous to researchers (Karanth and Chellam 2009). For these reasons we lack basic knowledge on many large mammalian carnivores. The most commonly studied intervention found during this process for terrestrial carnivores was reintroduction. This is disappointing since reintroduction is only needed after a species has been extirpated from an area. This expensive and difficult process could be avoided if preventative interventions are taken instead.

Habitat-based interventions in general are not often empirically tested as they pose several challenges, including:

- the large amount of effort and cost needed to implement landscape-scale studies,
- the long time-scale required to see results of these studies,
- the difficulty of isolating the effects of habitat interventions from other factors affecting the area,

- the difficulty of addressing both the needs of people and conservation over large spatial scales, and
- that conserving land primarily for species conservation is still a relatively new idea.

Still, habitat loss is one of the major causes of the decline in the tiger (*Panthera tigris*) which now occupy only 7% of their historic range (Dinerstein, Loucks et al. 2007). Interventions to address this type of threat are therefore vital. This project shows that there is an especially severe lack of research on interventions to address prey depletion. Prey availability is an essential component of carnivore habitat and has been directly linked to tiger survival (Chapron, Miquelle et al. 2008). Conserving large areas of carnivore habitat and protecting it is not enough if poachers have depleted the reserve of prey.

Another issue raised is the preponderance of "site comparison" research designs used by the habitat intervention studies. This is because researchers do not usually have the ability to enact large-scale interventions such as setting aside large reserves of land or building wildlife overpasses. When dealing with landscape-scale issues, they must analyze the effects of interventions that have already been done. This is a valid method of inquiry but it does not allow the researcher as much control over external variables that can influence the experiment. Research designs such as "replicated", "paired sites", and "controlled" are much more scientifically rigorous but are not easily conducted for these types of interventions.

An encouraging outcome of this analysis is that the vast majority of studies did conclude that their interventions were effective. The only studies that could not claim effectiveness were hindered by lack of data. This suggests that the types of interventions that are currently being conducted and studied are based on correct assumptions and beliefs, although this cannot be verified until more evidence is collected.

This analysis shows that there is a deficit of data on the effectiveness of interventions to conserve terrestrial carnivores. Assessing the current literature will form the foundation of an evidence-base but more research needs to be done before robust conclusions can be drawn from it. Research has indicated for some time that protecting large-scale, well-connected areas of habitat from human use is necessary for worldwide biodiversity conservation (Soulé and Terborgh 1999). This is believed to be true for most regions and taxa but is of particular importance for large carnivores. In many cases it is simply not possible for humans and carnivores to live peacefully together, leading some to claim that large reserves well-protected from human uses is absolutely necessary to conserve carnivores (Karanth and Chellam 2009). While this most likely is the case, there is not currently a sufficient body of evidence to absolutely support these initiatives.

For conservation research to be effective it needs to have an impact on the policy-makers, practitioners and funders who need to know that the actions they are supporting will have substantial positive impacts. CE is striving to provide a strong evidence-base for conservation to rely on and to disseminate it as widely as possible but for it to be truly effective there need to be mechanisms in place to link this information with policy institutions (Segan, Bottrill et al. 2011). There exists a substantial and persistent gap between the science that has identified and studied important issues and the knowledge that informs policy institutions (Pullin, Knight et al. 2009; Sutherland, Fleishman et al. 2011). We are only just beginning the evidence-base movement and by identifying and addressing these concerns, conservation, as a whole, will be more effective.

Conclusion

That carnivores will thrive when given habitat that is large, continuous, and protected from poaching and logging seems like common sense. But we cannot rely on common sense alone to save carnivores. Carnivores are severely threatened by a wide variety of threats; in particular, threats to the habitat that they need to exist. Large carnivores especially are harmed by habitat loss and degradation due to their life history traits. Without large-scale interventions, some of the most charismatic and emblematic species on Earth could disappear. Yet, while serious efforts are being made to save these animals, those implementing them often do not have access to research to support their actions. Such important interventions come at a great cost, which cannot be justified without a body of evidence showing them to be effective. This evidence-base does not currently exist for terrestrial carnivores, which is the problem this work and CE as a whole are trying to address.

In working to contribute to this synopsis, it is clear that there is simply not a sufficient amount of literature available on the conservation of terrestrial carnivores. These species are enigmatic, elusive, and sometimes dangerous. Their study needs to be pursued more fully before we will be able to understand the most effective means of protecting them. In particular, studies into the protection of their habitat are severely lacking. It is our hope that the carnivore synopsis will inspire more people to study these interventions so that carnivore conservationists will have a strong body of evidence on which to rely.

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Appendix I: Big Cats Interventions List

Interventions for Decreasing Causes of Cat Mortality

1. Preventing Conflict

a. Preventing livestock predation

- Buffer zones around PAs
- Carnivore proof fencing
- Guarding (herder dogs and donkeys)
- Vigilance
- Improved livestock husbandry practices
  - Technology (movement-activated guards, electric training collars)
  - Livestock herd management (controlling breeding times)
  - Waste management systems (i.e. disposing of animal carcasses)
- Conditioned taste aversion (CTA)
- Supplemental feeding of cats
- Deterrents, lion herding
  - Fires
  - Pepper dung
  - Noisemakers
  - Pepper spray
  - Chilies
  - Beehives placed at edge of fields
  - Traditional methods, urine solutions

b. Preventing human deaths

- Preventing crop raiders such that humans do not sleep in fields unprotected
- Changing habits
  - Increasing herder age
  - Moving bathrooms indoors
  - Restrictions on activity at night

2. Preventing Retaliatory Killing

a. Market-based incentives

- Compensation program
- Insurance program

b. Punishing Retaliatory Killings

- Enforcement of existing laws and/or strengthening laws
- Collars (people think they will be caught and punished)

c. Problem Animal Control

- Lethal (killing problem animal)
- Relocation of problem animal
- Trophy hunting of problem animal specifically

d. Education

- Lion Guardians and conflict managers
- Decreasing desire to retaliate
  - Specialness of lions
  - Increasing social/political/religious value of lions

e. Vaccinating livestock (to reduce herd mortality and induce herders to accept loss to predation)

3. Cultural Killing

- **a. Education (continuation of education in 2)**
- **b. Religious Conversion**
  - Changing beliefs in spirit lions and other magic
  - Changing rites of passage, e.g. alamoyio (maasai)

4. Poaching, trade of live animals, incidental hunting

- **a. Enforcement**
  - Threat of death penalty (shoot on site)
  - Increasing anti-poaching and anti-snaring teams
  - Better enforcement of existing laws
- **b. Economic incentives not to poach/trade live animals**
  - Incentive programs (i.e. "pay not to poach") / Decreasing economic attractiveness of poaching
  - Alternative livelihoods / Increasing economic options

5. Legal Hunting

- **a. Stopping or reducing trophy-hunting numbers**
  - Changing laws
  - Upgrade to CITES appendix I
- **b. Changing trophy hunting practices**
  - Restrictions on age of trophy
  - Restrictions on number of animals shot
  - Limiting locations where hunting is allowed
  - Increasing cost of trophy hunting

6. Increasing Value of Cats to (Local) People

- **a. Tourism**
- **b. Incentive programs**
  - Payments for presence of cats on property

7. Habitat Loss / degradation, road kills

- **a. Land tenure reform to maximize land use**
  - Increasing agricultural productivity
  - Densification of people and livestock
  - Consolidation of human settlement patterns
  - Relocation of activities
  - Securing separate water points for wildlife
- **b. Establishing new protected areas**
  - Voluntary displacement
  - Involuntary displacement
  - Fencing
  - Including corridors
- **c. Increasing effectiveness of existing PAs**
  - Repositioning protected area boundaries
  - Better enforcement
  - Increase funding
  - Increase socio-political priority
  - Buffers
  - Limiting encroachment of human settlements

8. Loss of prey base

a. Conservation of prey

- Reserve areas for ungulates

b. Reduce Competition with Livestock

- Incentives to reduce number of livestock
- Alternative livelihoods/food sources

9. Disease

a. Control of disease vectors

- Culling local dogs
- Vaccinating local dogs

b. Control of disease in cat population

- Vaccination
- Culling/management

c. Inbreeding

- Increasing connectivity
- Translocation

10. Interspecific Competition

a. Management/culling of interspecific competitors

11. Alteration to Improve Habitat

a. Example - CCF's bush removal to improve habitat for cheetah (BushBlok).

b. Theoretically there could be alterations to improve habitat for the cat itself or its prey (e.g. fire management, addition of year-round water holes etc.)

Appendix II: CE Protocol (from CE 2012a)

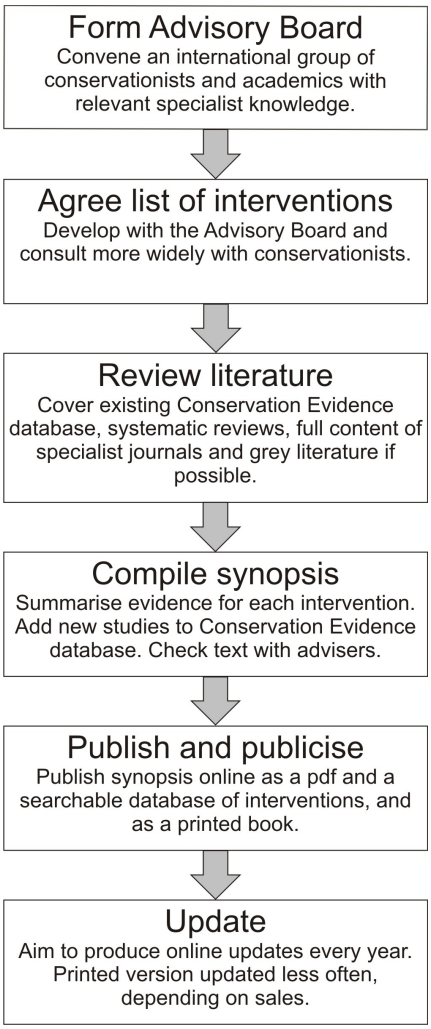
ConservationEvidence.com

Protocol for production of Conservation Evidence synopses

1. Set up Advisory Board – include academics and conservationists from all continents (if possible).
2. Decide on initial list of interventions and agree with Advisory Board (can be done by email). See notes below on combined interventions.
3. Plan synopsis, using IUCN threat categories as far as possible, and action categories where needed (http://www.iucnredlist.org/technical-documents/classification-schemes).
4. Search the web-based databases and journals provided at www.conservationevidence.com and www.environmentalevidence.com.
5. Contact the Conservation Evidence Cambridge team to collect relevant references that have been pulled out (and labelled by synopsis) by the ongoing review process (and are separate from those on the website).
6. Systematically trawl relevant specialist journals (agreed with Advisory Board). Use the 'Guide to Writing for Conservation Evidence' to select appropriate references. See *Defining the boundaries of Conservation Evidence* on page 2.
7. Please pull out papers that test **any** intervention and monitor **any aspect of biodiversity conservation and ecosystem services**. Those that test interventions but are not relevant to your synopsis should be collected separately. These references do not need to be classified by subject/synopsis, but please collect them in a reference manager and submit the RIS file to the Conservation Evidence Cambridge team. We hope that this trawl for additional papers will be thorough enough that the journal does not need revisiting for other synopses.
8. Add new references to an Endnote database (or other reference manager) and save pdfs to a folder for the synopsis, files named by author and year.
9. Upload Endnote database to Conservation Evidence website, labelled by broad taxon or habitat type, depending on synopsis subject.
10. It is useful to create a synopsis skeleton. This could be a matrix in Excel, or a database in Access. In it, each reference has a unique reference number and is linked to the interventions it covers. If working in a team, save this in a shared file area (such as Dropbox if working remotely). This eases the process of dealing with studies that appear in several interventions, and allows team members to mark off studies when they have read and summarised them.
11. When all literature is gathered, write synopsis paragraphs (and summaries if necessary – see *When to write summaries as well as synopsis paragraphs* below) intervention by intervention, following steps 14-20 below. See notes below on interventions with a large associated literature.
12. Before summarising a reference, use the search facility on www.conservationevidence.com to check whether it has already been written.
13. For references that appear in more than one intervention, write all relevant synopsis paragraphs at once, rather than returning repeatedly (this is where the matrix from number 10 is useful). If working in a team, write all the synopsis paragraphs in a single document. Name the file according to the author, date and if possible unique reference number, and store these in a dedicated folder in the shared file area.

For each intervention

14. Create a Word document for each intervention, to be merged for full synopsis pdf.
15. Create a Word document for each reference, with the synopsis paragraph(s), relevant tags (and summary if necessary). The file name should contain author and year and unique reference number).
16. Number references, to allow citation in key messages (not done for Bee Synopsis).
17. On completing each section, proof read carefully. Then write 'key messages', with numbered citations where appropriate.
18. Circulate the draft intervention text to relevant experts in your Advisory Board and ask what is missing. If necessary, add any new references they suggest.
19. Upload intervention to Conservation Evidence website
20. Upload synopsis paragraphs to Conservation Evidence website attached to appropriate reference (and summary if you have written one) and intervention. As you do this, tag each reference with appropriate search terms.



Appendix III: List of Terrestrial Carnivore Interventions

CARNIVORE CONSERVATION: A SYNOPSIS OF THE EVIDENCE

-Draft list of interventions
-Threats used in list correspond to the IUCN Threat Classification Scheme (3.1) and the IUCN Conservation Actions Classification Scheme (2.0) as appropriate.
-Interventions relate to terrestrial carnivores (order carnivora, class mammalia)
-Numbers are to facilitate comments

THREAT: AGRICULTURE
LIVESTOCK FARMING AND RANCHING

1. Maximize land use/zoning
- Increase agricultural productivity
- Consolidate people and livestock
- Relocate activities
- Secure separate water points for wildlife

2. Increase economic options to farmers
- Incentivize smaller herds
- Facilitate alternative livelihoods
- Encourage alternative food sources
- Domesticate indigenous livestock 'alternatives'

THREAT: TRANSPORTATION & SERVICE CORRIDORS
ROADS and RAILROADS

3. Reduce collisions
- Install infrastructure (e.g. underpasses, speed bumps, exclusion fences)
- Change traffic laws (e.g. speed limits, access points)
- Increase driver awareness (e.g. highway lighting, signs)

THREAT: BIOLOGICAL RESOURCE USE
INTENTIONAL MORTALITY (HUMAN USE)

4. Change legal hunting laws and practices
- Stop trophy hunting
- Upgrade species protection under CITES (i.e. Appendix 1)
- Increase hunting restrictions (e.g. limitations on age, season, locations)
- Reduce hunting quotas and permits
- Ban imports and exports of trophies
- Encourage hunting alternatives (e.g. "Green hunts")

5. Decrease illegal taking (i.e. poaching, trade of live animals)
- Improve enforcement (e.g. anti-poaching teams, ranger patrols)
- Strengthen anti-poaching laws
- Increase effectiveness of anti-poaching (e.g. support/finance of patrol teams)
- Increase enforcement presence
- Increase tourism

6. Reduce incentives to poach
- "Pay not to poach"

Decrease economic attractiveness of poaching
Facilitate alternative employment (e.g. 'poacher turned gamekeeper')
Introduce alternative food sources (e.g. reduce bushmeat consumption)

7. Reduce demand for carnivores and their products

Criminalize trade in wildlife (e.g. restaurants, sale)
Use educational and public awareness campaigns
Decrease medicinal trade and demand

INCIDENTAL OR ACCIDENTAL MORTALITY

8. Conserve prey bases

Reintroduce prey species
Manage habitats for prey species
Limit takes of prey base (e.g. legal and illegal hunting)
Restore vegetation-prey-predator balance

9. Food and water shortage

Provide supplemental food and watering holes

10. Use medical interventions for injured/snared animals

11. Mitigate potential infrastructure risks (e.g. wells, electrocution)

PERSECUTION & CONTROL

12. Punish retaliatory killings

Enforce existing laws (at all levels)
Strengthen existing laws (e.g. larger fines, increased prison lengths)

13. Control specific problem animals

Kill (e.g. selective removal, trophy hunting)
Relocate
Identify problem animals (e.g. salivary DNA testing)

14. Prevent livestock killings

Install or improve fencing (e.g. electric fences, bomas)
Install technology (e.g. movement-activated alerts, radio collars, GSM/GPS)
Increase vigilance (e.g. watchmen, geo-fencing, horseback guardsmen)
Increase guarding (e.g. guard dogs, donkeys)

15. Improve livestock husbandry/management

Reduce uncertainty surrounding livestock loss (e.g. document and identify causes, predators involved, and extent of depredation)
Reduce other threats to livestock (e.g. starvation, disease, lost animals)
Educate on proper husbandry
Select secure pastures (e.g. avoid areas with stalking cover)
Change livestock breeds (e.g. flocking behavior, anti-predator instincts, size)
Change breeding patterns (e.g. controlled breeding times, seasonal patterns)

16. Improve waste management

Dispose of animal carcasses

17. Use deterrents and adverse conditioning

Install light and sound devices (e.g. firecrackers, alarms, ultrasonic devices)
Use biological deterrents (e.g. lion dung, pepper products)
Induce pain (e.g. electric shock collars, rubber bullets)

Use conditioned taste aversion methods

18. Prevent human death

Prevent crop raiders (to reduce humans sleeping in fields)
Change behavior to avoid attacks (e.g. Sundarbans masks)
Change herder habits (e.g. increase age, restrict nighttime activity)

19. Educate with respect to cultural killing (e.g. rites of passage)

20. Educate with respect to problems of persecution (carnivore's ecological role)

21. Design species-specific education initiatives (when appropriate)

22. Target key groups in education (e.g. tourists, community leaders)

23. Use market-based incentives to reduce retaliation

Use compensation programs (e.g. monetary, access to resources)
Use insurance programs (e.g. insure property or livestock)
Use assistance incentives (e.g. co-fund adoption of good husbandry practices)
Provide payments or subsidies for carnivore presence on private land
Transfer user fees from recreation to land owners

25. Offer employment opportunities

Employ local conflict managers and officers
Hire local teachers and community members for outreach
Support alternative employment (e.g. handicraft markets)

26. Increase value of carnivores to local people (e.g. ecotourism)

27. Decrease access to poisons (e.g. Furadan)

28. Decrease desire to retaliate (e.g. complaint forums, increased acceptance)

29. Enhance local pride and participation

Use cooperative wildlife management processes
Incorporate local knowledge (e.g. tracking, trapping)
Build community-relevant monitoring processes (e.g. Lion Guardians)

THREAT: HUMAN INTRUSIONS & DISTURBANCE

30. Limit motorized access

31. War?

32. Oil development?

THREAT: INVASIVES & OTHER PROBLEMATIC SPECIES CONTROL

INVASIVE NON-NATIVE SPECIES

33. Eradicate invasive species

Reduce competition (e.g. American mink outcompeting European mink)
Reduce predation (e.g. stoats in New Zealand)
Reduce hybridization (e.g. coyotes and red wolves)
Perform blanket reductions

PROBLEMATIC NATIVE SPECIES

34. Pest control

Kill (e.g. poison, kill traps, recreational harvest, host specific disease)
Control fertility (e.g. control reproductive rate, reversible contraception)
Perform permanent sterilizations (i.e. surgical and chemical)
Establish sterile barriers (e.g. fencing)

Trap and remove individuals (e.g. translocations)

Disease

35. Control disease vectors

Cull or vaccinate putative domestic reservoirs (e.g. feral dogs)
Offer livestock disease control methods
Increase human self-interest in disease control (e.g. rabies contraction)
Increase pet owner responsibility (e.g. change owner behavior, encourage vaccination for critical pathogens, enforce mandatory immunizations)

36. Remove causal factors (e.g. toxic agents, heavy metals)

37. Control disease within populations

Deworm (e.g. mass distribution of medicines via food baits)
Vaccinate (e.g. trap-vaccinate-release, baits)
Cull (e.g. individuals, to reduce density, or to create pathogen barriers)
Treat individual or focal animals (direct intervention when susceptible)

38. Address disease by specific species

Identify and mitigate potential for disease spread and severity
Identify and mitigate epizootic threats and potential diseases
Perform disease detection with scat analysis

39. Perform veterinary conservation checks

Quarantine translocated animals before release

THREAT: POLLUTION

40?

THREAT: CLIMATE CHANGE

41? (Polar bears, tigers- e.g. rising sea level in the Sundarbans, changes in vegetation and resultant changes in herbivore numbers)?

OTHER THREAT TYPES:

HABITAT PROTECTION/MANAGEMENT

42. Protect core populations and habitats

Create new protected areas
Increase effectiveness of existing PAs (e.g. buffers, reduced edge effects)
Increase support and protection of PAs (e.g. funding, guards, fencing)

43. Improve or restore habitat

Introduce fire management
Increase water access and availability
Convert ranchlands to conservation or tourism areas

44. Reduce fragmentation with corridors

Incorporate corridors between PAs
Incorporate private and public reserves
Maintain or recreate corridors of natural migration

45. Use graded management zones or metapopulation management

SMALL/DECLINING POPULATIONS

46. Increase species number
- Enhance reproductive success or output
- Provide breeding sites and refuges
- Artificially augment groups (e.g. release captive bred animals)

47. Maintain genetic viability
- Identify and control heritable diseases
- Cross-foster captive born individuals to wild parents
- Increase connectivity (e.g. corridors)
- Decrease hybridization (e.g. polecats and ferrets)
- Translocate individuals (e.g. into isolated subpopulations)
- Preserve "back-up" populations

48. Perform ex-situ conservation
- Breed captive animals
- Create genome resource banks

49. Assist reproduction (e.g. in-vitro fertilization, embryo transfer)

50. Perform reintroductions

51. Increase effectiveness of reintroductions (e.g. health risks, habituation)

INTERSPECIFIC COMPETITION/INTRAGUILD COMPETITION

52?

Appendix IV: Summary Template (CE 2012b)

Online summary Form

TITLE: The title should **sum up the main finding**, and include information about the species, habitat and the study site, region and country.

PUBLISHED SOURCE: RIS File

LOCATION (include country, region, site name, latitude, longitude or grid reference if known)	
ACTION *	Uses IUCN categories. Can be more than one.
THREAT*	Uses IUCN categories. Can be more than one.
HABITAT*	Uses IUCN categories. Can be more than one.
TAXON	Binomial Latin name and common name of any species that are the focus or target of the intervention.
BROAD TAXON*	Mammals, e.g.
RESEARCH DESIGN*	Site comparison, Replicated, Controlled, Paired sites, Randomized, Before-and-after trial, Review, or Systematic review.
COST, FUNDER	

Summary paragraph template

A [TYPE OF STUDY] in [YEAR and SEASON] in [HOW MANY SITES] of [HABITAT] in [REGION and COUNTRY] [REFERENCE] found that [SPECIES] subject to [INTERVENTION] were [MAIN RESULT]. In addition, [EXTRA RESULTS and CONFLICTING RESULTS]. The [DETAILS OF TECHNIQUES or SAMPLING METHODS].

Appendix V: Skeleton of Habitat Management/Protection Section of Terrestrial Carnivore Synopsis

1. Habitat Protection/Management

Background

Some background information on the broad intervention type.

'Bibliography' for background references

Key messages

Protect core populations and habitats

Key message for this specific intervention type.

Increase effectiveness of existing protected areas

Key message for this specific intervention type.

Increase support and protection of protected areas

Key message for this specific intervention type.

1.1 Protect core populations and habitats

- Bullet point for each type of result found.

'Summary paragraph' for each study of this intervention.

1.2 Increase effectiveness of existing protected areas

- Bullet point for each type of result found.

'Summary paragraph' for each study of this intervention.

1.3 Increase support and protection of protected areas

- Bullet point for each type of result found.

'Summary paragraph' for each study of this intervention.