The endangerment and conservation of cheetahs (*Acinonyx jubatus*), leopards (*Panthera pardus*), lions (*Panthera leo*), and tigers (*Panthera tigris*) in Africa and Asia

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Abstract

Increasing habitat depletion, habitat degradation, and overhunting in Africa and Asia have resulted in the designation of the four largest species of felid (cheetah, leopard, lion, tiger) as vulnerable or endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. Scientists interested in understanding and potentially slowing the disappearance of these species need access to causal factors, the past and current range of each species, the life history, and importance of conservation. This article presents one such resource with all of this information compiled in a place that Is easy for people to get to. The primary target of this article is educators but will be useful to anyone interested in these species, their current state, and their future peril.

Keywords: cheetah, leopard, lion, tiger, endangered species, conservation, Old World, big cats, habitat

Introduction

Conservationism is a common term heard in many settings in the modern world, implying that an effort to conserve species needs to be made and enforced. However, talking about conservation is not enough. There have been few to no changes made to improve the state of some ecosystems, while there have been a few successes, most habitats continue to be depleted. Rainforests are still being depleted and illegal poaching is still a major issue in many parts of the world. It is necessary how these smaller conservation efforts can be part of a global effort to conserve the planet.

To begin, this article will be different from other articles. This is an intensive literature review and compilation effort. This article will not follow the typical structure of a scientific paper because there is no experiment being tested or a true question being answered. This work is meant to be informative and full of information that can be used in many settings ranging from wildlife education to advocating for climate change interventions. The basis of the endangerment of these species is part of a global problem. This article can be used by other researchers as an example of problems that need to be addressed to benefit the planet as a whole. I hope that this article will serve as an education tool and a research tool for other conservationists in the future.

Generally speaking, there are several stages to species restoration that are utilized in some parts of the world with some species programs. These steps are used to analyze whether or not a species is in danger and are then used to halt the decline and reverse it. The first is population decline; this is the obvious decline in a population that incites a need for a change to be made. This can be seen over time through observation and monitoring of populations. Crisis management is the next step, in which obvious actions are taken to halt the decline rather than allow it to continue. This is the planning stage, when a strategy is formed to halt the decline. The next step is stabilization which is imperative if a species to be able to recover. In this stage, numbers do not continue to fall, but rather become stable. Precarious recovery, the next step, is the gradual increase in population and survival of offspring. This step can be small, or large, as long as there is some form of recovery observed. This is followed by sustained recovery which is when the species begins to grow at a faster rate and grows exponentially. The final step is also very important because it entails managing the growing population in relation to the environment and making sure they do not exceed the carrying capacity of the area (Meena et al. 2011). However, species restoration, no matter how effective and beneficial, is counterproductive if the is not sufficient habitat.

For each species, I have amassed information pertaining to the classification, habitat, past and current ranges, hunting methods utilized, preferred prey, and the effects of humans. This article can be used as a tool

to educate the public about the problems associated with species decline as well as habitat degradation and depletion. All of these factors together contribute to a unique situation for each species, and therefore a slightly different approach is necessary to ensure conservation success for each species. There are conservation efforts being made for each species, but in some cases, such as the cheetah, the need is far greater. Some efforts will affect the entire ecosystem, like the lion, because they are a keystone species. A keystone species is the species that the entire ecosystem relies upon for regulation and if the species were to disappear the system would suffer drastic consequences.

Cheetahs

Classification, Habitat, and Range

Cheetahs may be identified by their simple spot fur pattern, which is unique among cats (Figure 1, Animal Club 2017). They have lighter ventral sides and their tail is tipped with stripes. There are also stripes on their faces. This pattern makes them unique and easy to distinguish from other big cats. They are typically a meter tall at the shoulder and can reach up to around 70 kilograms (Kelly 2001).

Cheetahs occupy a habitat that is composed of grassland and woodland (Caro 1994). Some of their typical home ranges fall on land preserves, and these populations are therefore protected. However, other parts of their ranges are not located in these protected areas. Figure 2 shows that there has been a significant decrease in the home range of the cheetah, specifically in Asia and Northern Africa (Cheetah Conservation Fund 2017). The IUCN calculated this exact range to be approximately 10% of the historical range (IUCN Red List 2017). Of the species examined in this study, cheetahs suffer the most from kleptoparasitism, in which another animal steals their kill. Cheetahs are most afflicted by lions, hyenas, and wild dogs. The individuals that live in denser habitats encounter these threats less often (Hayward and Henschel et al. 2006).

Fig. 1 Cheetah (Animal Club 2017)

Fig 2. Cheetah Distribution Map (Cheetah Conservation Fund 2017) The gold color represents the approximate current range of the cheetah, while the tan represents the approximate historical range of the cheetah.

Prey and Hunting Methods

The main prey species of cheetahs include but are not limited to impala, blesbok, kudu, steenbok, duiker, Thomson's gazelle, springbok, and hartebeest. They are opportunistic hunters, hunting whichever of the preferred species they come across, but prefer prey of similar body size or smaller to reduce the chances of kleptoparasitism. The decline of preferred prey in a certain area can lead to the decline of the cheetah in that area (Howard et al. 2006). The diet of the cheetah overlaps with most large predators with which they share habitat. Cheetahs and wild dogs overlap the most due to similar body size (Owen-Smith and Mills 2008). Within their dietary niche, the lion, leopard, and hyena outcompete the cheetah. Cheetahs outcompete the wild dogs, but only marginally because wild dogs hunt in packs (Hayward and Kerley 2008).

Cheetahs have five different hunting strategies. The first is waiting for prey to come closer, during which the cheetah would lay camouflaged for the prey to come within striking distance. Another tactic is the slow approach and then sprint during which the cheetah would stalk up on the prey and then hopefully kill it with a sudden burst of speed. Another less common method was the dead charge in which a cheetah would put on an immediate burst of speed into a large group of prey and potentially catch them by surprise. The most famous method is the stalk and chase, when the cheetah characteristically stalks closer to the prey and then a chase ensues. The last method is to flush out prey which is also rarely used because it takes a lot of useful energy to flush out the prey before the chase happens. Cheetah coalitions are also not as successful as individual hunting (Caro 1994). They can lose up to 12% of kills

to kleptoparasites but still have high success rates which are influenced by high energy input. Cheetahs can also experience morphological limitations, low energetic benefit, and high energetic costs throughout hunting (Howard et al. 2006). In general, cheetahs rely on speed for hunting, for which they are most famous. Throughout the year, their hunting range can fluctuate because they are forced near water sources during the dry season, but can use open land to their advantage during the rainy season (Hilborn et al. 2012).

Endangerment Factors

One major factor leading to cheetah population decline is poaching. Cheetah populations were once hunted down to approximately 100 individuals. This led to a small gene pool during reproduction, which is resulting in several health issues becoming increasingly common in the species. The cheetah coat is often sought out for clothing items and similar items. Also, due to the kleptoparasitism that cheetahs endure from other top carnivore species, cheetahs are often forced to go after easy prey that may include farmer's livestock. The farmers will then often shoot the invading predators to save their own livelihood. The close quarters between people and cheetahs are intensified by the increasing size of the Sahara Desert (Caro 1994).

Habitats are shrinking for one major reason: human development, which is also leading to the growth of the Sahara Desert by desertification. Tourism is a major threat because these solitary creatures avoid human populations. This effect has been recorded in the greatest amount in the Serengeti. This tourism and human borders expanding is creating an incredible amount of habitat destruction, which is the number one threat to cheetah populations (Caro 1994). Cheetahs also depend on their habitat for camouflage while hunting; without these habitats their coat is useless to use as an advantage (Kelly 2001).

All of these factors support the same conclusion: habitat loss is a major contributor to the decline of cheetah populations. Conservation efforts are being made by increasing populations on nature reserves and through captive breeding programs the health of the species in captivity in recovering. Conservationists hope to release some of the captive population to interbreed with wild populations to benefit the health of the species as a whole.

Leopards

Classification, Habitat, and Range

Leopards are one of several cats that have a rosette fur pattern as seen in Figure 3 (Animal Club Leopard 2017). They can reach head to tail lengths of up to 2 meters, and males can weight up to 90 kilograms. This species is often mistaken for the jaguar of South America, but is distinguishable by the size of its skull. Leopards occupy a wide range of habitats that span from semi desert to rainforest while avoiding grasslands (Bertram 1978, Balme et al. 2007). They are one of several cats that are common in both Africa and Asia, so the fact that they occupy a large variety of habitats is not surprising. Figure 4 shows that their range has also shrunk back to corners of Africa and Asia (Broad 2012). The IUCN calculated they have experienced a 61% loss of historical habitat (IUCN Red List 2017). Leopards are at a slight advantage because of their large variety of habitat (Balme et al. 2007). They prefer habitats with good prey, which still allows them a large variety of habitats (Stein and Hayssen 2013).

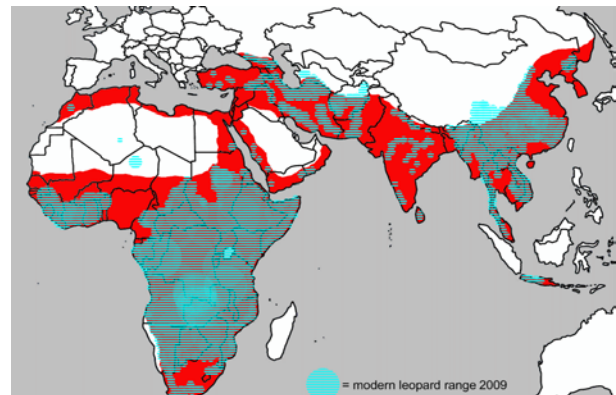Fig 3. Leopard (Animal Club Leopard 2017)

Fig 4. Leopard Distribution Map (Broad 2012) The blue color represents the approximate current range of the leopard, while the red and blue area represents the approximate historical range of the leopard.

Prey and Hunting Methods

The preferred prey of the leopard includes impala, kudu, giraffe, warthog, zebra, steenbok, grey duiker, and blue wildebeest (Bailey 1993). Within their dietary niche, leopards are only outcompeted by lions (Hayward and Kerley 2008). However, they do not compete with lions very much because each species focuses on a certain size prey; lions hunt larger individuals and leopards hunt smaller individuals

(Owen-Smith and Mills 2008). Leopards must hunt prey that is closer to their own body size or even smaller because they utilize trees when they are hunting to keep other large predators from stealing their kills. Because leopards have a variety of habitats, they experience a lower level of competition than other species (Bailey 1993).

Leopards use catchability as a factor in determining prey, and then typically use the stalk and kill method (Balme et al. 2007). This method utilizes their camouflage of the rosette pattern amongst filtered light (Allen et at. 2011).

They require dense concealment to be successful during hunting, but may still have issues because they are solitary hunters (Hayward and Henschel et al. 2006). Most of their hunting is done in areas of semi-vegetation as compared to open land or heavy vegetation (Balme et al. 2007). The leopard has also been known to drop out of trees or scavenge on rare occasion, but they consistently carry prey similar to their body size up into the trees, while they consume small kills immediately on the ground (Bertram 1978).

Endangerment Factors

One threat is human populations, which they avoid at all costs (Toni and Lodé 2013). The other threat is the fact that they share habitat with tigers, but they are restricted by the presence of the larger cat (Stein and Hayssen 2013). Another threat would be that their prey is often depleted by human hunting and habitat loss (Bailey 1993).

Leopards are afraid of human presence and remain as solitary as possible throughout their lifetime. Tigers also frighten them, while simultaneously competing with them. Furthermore, as in the case of the cheetah, the number one threat to this species is loss of habitat (Bailey 1993). Leopards rely on their habitat and coat pattern as a form of camouflage and advantage during hunting (Allen et al. 2011). Unfortunately, leopards are another species that suffer from poaching.

Lions

Classification, Habitat, and Range

Lions reside mostly in grasslands but can be found in woodlands as well (Bertram 1978). They choose a territory based on its capability to support the size of the pride. Lions have the simplest coat of the cats that are in this study, possessing fur that is simply a sandy color with a white belly. The males also have a unique black tuft of hair on their tail (Bertram 1978). The mane is also a distinctive feature of this species, but not all subspecies have manes, so it is not the most reliable form of identification as can be seen in Figure 5 (Howard 2015). Lions can be up to 3 meters long from head to the tip of the tail, and males can weigh up to 250

kilograms (Bertram 1978). Another distinctive feature of the lion is that they are the only cat in this study that live in prides. Figure 6 shows that their range has dramatically decreased and only spans a small fraction of Africa and a very small area of Asia (Panthera 2015). The IUCN calculated this to be 17% of the historical range (IUCN Red List 2017).
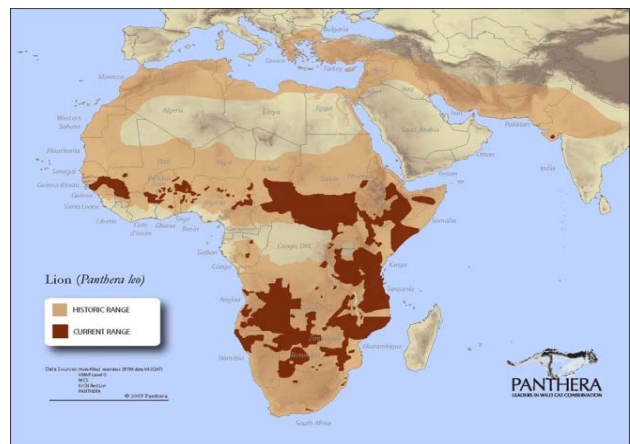

Fig 5. Lion (Howard 2015)

Fig 6. Lion Distribution Map (Panthera 2015) The dark brown color represents the approximate current range of the lion, while the tan color represents the approximate historical range of the lion.

Prey and Hunting Methods

The preferred prey of lions includes zebra, wildebeest, hartebeest, topi, eland, waterbuck, impala, gazelle, and warthog (Bertram 1978). Lions outcompete all of the other predators in both their preferred niche and their overall dietary niche. The only other species they may compete with would be hyena, but due to overall body size, the lion is still the top predator (Hayward and Kerley 2008). Because lions use the pack hunting strategy, they are typically more successful that other species or individual predators. This strategy

ensures that they can successfully hunt prey twice their body mass to feed the entire pride (Owen-Smith and Mills 2008).

Endangerment Factors

It is often a topic of news of how threatened lions are in the modern day. A lot of this can be attributed to the fact that lions prefer a habitat that is better to hunt in rather than a habitat where prey is more abundant (Balme et al. 2007). This is an advantage and a disadvantage. It is an advantage because the cover does make their hunting more successful. It is a disadvantage because they are being forced to follow food sources because they no longer exist in beneficial habitats.

Human populations moving too close have forced the herds to move on. Lions have no choice but to follow or starve. When they follow, they are less successful hunters because they are working in a less than optimal habitat. Therefore, as with the other species focused on in this study, habitat depletion is the number one factor for their endangerment as well. Humans are also responsible for the poaching of lions, which is another big feature factoring into their endangerment.

Tigers

Classification, Habitat, and Range

Tigers inhabit a variety of habitats, overlapping with leopards. The two species do not compete though because the tigers are so much larger (Stein and Hassen 2013). This species tries to avoid human populations as well as they can, though there are many areas where they live closely together.

Tigers have one of the most recognizable coats, the unique strips that each individual possesses as seen in Figure 7 (Smithsonian's National Zoo and Conservation Biology Institute 2017). Tigers can reach nose to tail tip lengths of up to 3.5 meters and can weigh up to 300 kilograms (Stein and Hassen 2013). Figure 8 shows that their range has shrunk back to the edges of Asia as compared to their historical range which also included much of the interior of the continent (McGonagle 2012)

Fig 7. Tiger (Smithsonian's National Zoo and Conservation Biology Institute 2017)
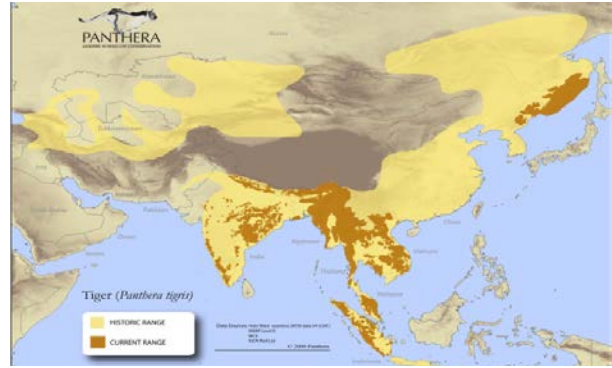

Fig 8. Tiger Range Map (McGonagle 2012) The brown color represents the approximate current range of the tiger, while the light yellow and brown represent the approximate historical range of the tiger

The IUCN has calculated that tigers occupy only 6% of their historical range (IUCN Red List 2017)

Prey and Hunting Methods

Tigers shared prey preferences with the leopard, including impala, kudu, warthog, and zebra, but it is their disparate sizes that keep these two species from directly competing for prey. Tigers prefer prey their size or smaller, but due to the significant body size difference between tigers and leopards, tigers still go for larger prey than leopards (Hayward et al. 2012, Kumaraguru et al. 2011). Tigers also eat as much as they can in one sitting so they do not rely on their prey being small enough to drag up into trees. Their leftovers feed many other scavenger species in their habitats. Tigers rely on their fur pattern as camouflage during hunting, using low light environments as well as similar colored backgrounds such as long grass.

Endangerment Factors

The areas that tigers inhabit are some of the most populated parts of the planet, bringing the boundary between tiger habitats and human villages closer together. These thinning boundaries sometimes lead the predators too close to a human population for comfort and are killed out of fear or protection. The tiger is a highly revered species in many rituals and religions, in which parts of the tiger are used in the worship. Oftentimes, only small parts of the animal are taken such as the paws or the tail, leading to a large loss for a small sacrifice. Due to their coat, they are often the victim in trophy hunting as well.

Conservation

Cheetahs are considered to be in a vulnerable state, with a known population of 6,700 individuals in 2015, according to the IUCN. The number of countries where

this species is regionally extinct exceeds those where they are native. In an attempt to preserve the species, there is a breeding program in place in Africa in which individuals from captive populations are exchanged throughout the program to try and keep the gene pool as large as possible despite their still decreasing population. The USA has a similar program in which the population is used for educational purposes because the species is not native in this hemisphere (IUCN Red List 2017). The poor genetic condition of the cheetah is marked by a high level of juvenile death as well as the inability to combat infectious disease (Caro 1994). In some countries, the species is protected by law against poaching and trading. However, these laws have been put in place too late in some cases because the cheetah is already extinct in these places or they are consistently broken by those supporting the black market.

Leopards are also considered to be vulnerable according to the IUCN in 2016, with an estimated population of fewer than 2,500 individuals. This species has seen a majority of regional extinction in the southeast corner of Asia, but they still thrive in heavily forested parts of Africa and Asia. Most countries of North and West Africa have listed the lands where leopards exist to be protected, but the areas are not large enough to support a large wild population. Each subspecies, the Amur Leopard (*Panthera pardus orientalis*), the Arabian Leopard (*Panthera pardus nimr*), the Javan Leopard (*Panthera pardus melas*), the Sri Lankan Leopard (*Panthera pardus kotiya*), and the Persian Leopard (*Panthera pardus saxicolor*) has their own captive breeding program for conservation (IUCN Red List 2017). Luckily, there are many subspecies of leopard so they will not experience the same poor genetic condition as the cheetah because they have enough sufficiently large populations to cross breed and maintain a large gene pool.

Lions are considered vulnerable as well with a known population of 7,455 individuals as of 2014. Lions are considered to be regionally extinct in 52% of their historical range, with most of this area in the Middle East. This species is commonly found in protected areas, but there are no known laws in place specifically protected them. Instead, many countries of Africa have put their own conservation plans in place that also include conservation of habitats and ecosystems (IUCN Red List 2017). This is one of the species in this study in which conservation efforts include habitat preservation. This is because the lion is a keystone species, meaning that it is the most important species in the ecosystem, and it helps to keep the entire system stable. If lions were to go extinct, there are no other large competing predators in Africa that could fill their niche. Cheetahs and leopards both hunt smaller prey and because they are solitary animals do not feed as much. The large ungulate populations of Africa would eventually grow to out-of-control levels, consuming any and all vegetation as well as human crops. This could in turn lead to the complete desertification of the continent, which would drive out human populations because the land would be uninhabitable, and the remaining animal populations would also die. A similar example of this was the extinction of the wolf in Yellowstone National Park. As the landscape began to suffer from increasing populations of elk, deer, and bison, people reintroduced wolf packs and the park has returned to its former state. However, if the lion population continues to decrease as it has been in the past years, there would no longer be a wild population with which to replenish the regionally extinct population. Captive populations would not be ideal candidates due to their lack of hunting knowledge, and that could lead to the only known populations of lions being in captivity.

Tigers are classified as endangered as of 2014, with a population of 3,194 individuals as of 2014. Tigers are in a unique position because the mortality of breeding females has risen above 15%, which is a highly dangerous situation. If the adult population of females drops to a low enough point, there will be no chance at recovering the species. This species is regionally extinct in much of the Middle East. However, there are worldwide efforts being made for the conservation of tigers. In 2010, 13 Tiger Range Countries drafted and adopted a Global Tiger Recovery Program, headed by Russia. The goal of this program is to double the population of wild tigers by 2022 through preservation of habitats, decreasing poaching and trade, and restoring tigers to their historical range (IUCN Red List 2017). Tigers also play an important role in ecosystems as a keystone species (Zhang et at. 2013). They play a part in population control which in turn leads to preservation of habitats. Breeding populations are prevalent in many countries around the world, with conscious efforts of maintaining a large gene pool for future population increases.

Conservation is important on many levels, starting at the species level and then working all the way up to global systems. There are already many species that have been lost, such as the western black rhinoceros, and many species that are on the cusp of extinction, such as the northern white rhinoceros. For future generations, these species will only exist in images or videos. For now, the four big cat species in this study still exist in the wild, but in lower and lower numbers every year. The key to preserving habitats is preserving species, which will benefit the globe as a whole.

Conclusion

To conclude, there are many factors leading to the loss of these big cat species around the world. The

amount of habitat that had been impeded upon by human populations has greatly impacted these populations in several ways. First, it has been proven that manipulating habitat structure can also affect how well or poorly a predator can hunt (Quinn and Cresswell 2004). It has also been proven that habitat is the key to the predator prey relationship because it is so beneficial to the predator (Hilborn et al., 2012). This goes hand in hand with prey abundancy, which is the other factor that predators rely on (Balme et al. 2007). Prey preference is key factor in conservation as well (Meena et al. 2011). A smaller range of preferred prey with increased overlap between these species and other predatory species such as the wild dog or hyena can increase the impact of loss (Hayward and Kerley 2008). Within hunting strategy, each predator has their own unique way of being successful (Hayward and Hofmeyr et al. 2006). It is also known that groups may be more successful that solitary hunters, especially in the case of the lion and the cheetah (Owen-Smith and Mills 2008).

A more recent fear in scientific community is that humans are the leading factor in what could potentially become another mass extinction event. Past estimates were that approximately four species went extinct per year, but now the estimates range into the thousands, implying that many occur every day. Most of these may be an insect or a remote species of frog and therefore have a small impact on the environment if any. However, if these top predators are lost, a much larger impact will be observed in lack of population control of other species. If we are to prevent this Anthropocene Extinction and the presumed long term effects on the worldwide ecosystem, we must work hard to conserve the species we have left and the habitats they rely on.

References

Allen, W. , I. Cuthill, N. Scott-Samuel, and R. Baddeley. 2011. Why the leopard got its spots: Relating pattern development to ecology in felids. Proceedings: Biological Sciences 278:1373-1380.

Animal Club. 2017. Cheetah [Internet]. [Cited 25 September 2017]. Available from http://elelur.com/mammals/cheetah.html

Animal Club. 2017. Leopard [Internet]. [Cited 25 September 2017]. Available from http://elelur.com/data_images/mammals/leopard/leopard-05.jpg

Bailey, T.N. 1993. The African Leopard: Ecology and Behavior of a Solitary Felid. New York: Columbia University Press.

Balme, G. , L. Hunter, and R. Slotow. 2007. Feeding habitat selection by hunting leopards Panthera pardus in a woodland savanna: Prey catchability versus abundance. Animal Behaviour 74:589-598.

Bertram, B. 1978. Pride of Lions. New York: Charles Scribner's Sons.

Broad, M. 2012. Leopard Habitat [Internet]. [cited 10 May 2016]. Available from http://pictures-of-cats.org/Leopard-Habitat.html

Caro, T. M. 1994. Cheetahs of the Serengeti Plains: Group Living in an Asocial Species. Chicago: The University of Chicago.

Cheetah Conservation Fund. 2017. About the Cheetah [Internet]. [cited 25 September 2017]. Available from https://cheetah.org/about-the-cheetah/race-for-survival/

Coss, R. , U. Ramakrishnan, and J. Schank. 2005. Recognition of partially concealed leopards by wild bonnet macaques (Macaca radiata). Behavioural Processes 68:145-163.

Hayward, M., P. Henschel, J. O'Brien, M. Hofmeyr, and G. Balme. 2006. Prey preferences of the leopard (Panthera pardus). Journal of Zoology 270:298-313.

Hayward, M. , M. Hofmeyr, J. O'Brien, and G. Kerley. 2006. Prey preferences of the cheetah (Acinonyx jubatus) (Felidae: Carnivora): Corphological limitations or the need to capture rapidly consumable prey before kleptoparasites arrive?. Journal of Zoology 270:615-627.

Hayward. M., W. Jedrzejewski, and B. Jedrzewska. 2012. Prey preferences of the tiger Panthera tigris. Journal of Zoology 286:221-231.

Hayward, M., and G. Kerley. 2008. Prey preferences and dietary overlap amongst Africa's large predators. South Africa Journal of Wildlife Research 38:93-108.

Hilborn, A. , N. Pettorelli, C. Orme, and S. Durant. 2012. Stalk and chase: How hunt stages affect hunting success in Serengeti cheetah. Animal Behaviour, 84:701-706.

Howard, B. C. 2015. The killing of Cecil the lion sparks debate over trophy hunts [Internet]. [Cited 25 September 2017]. Available from http://news.nationalgeographic.com/2015/07/150728-cecil-lion-killing-trophy-hunting-conservation-animals/

Howard, M., M. Hofmeyer, J. O'Brien, and G. Kerley. 2006. Prey preferences of the cheetah (Acinonyx jubatus) (Felidae carvivora): morphological limitations or the need to capture rapidly consumable prey before kleptoparasities arrive? Journal of Zoology 270:615-627.

IUCN Red List. 2017. IUCN Red List of Threatened Species [Internet]. [Cited 25 September 2017]. Available from http://www.iucnredlist.org

Kays, R.W. , and B. D. Patterson. 2002. Mane variation in African lions and its social correlates. Canadian Journal of Zoology 80:471.

Kelly, M. 2001. Computer-Aided Photograph Matching in Studies Using Individual Identification: An Example From Serengeti Cheetahs. Journal of Mammalogy 82:440-449.

Kumaraguru, A., R. Saravanamuthu, K. Brinda, and S. Asokan. 2011. Prey preferences of large carnivores in Anamalai Tiger Reserve, India. European Journal of Wildlife Research 57:627-637.

McGonagle, J. 2012. Panthera Tiger Range Map [Internet]. [Cited 25 September 2017]. Available from http://conservationcubclub.com/2012/01/tigers-on-top-of-the-world/panthera-tiger-range-map/

Meena, V. , Y. Jhala, R. Chellam, and B. Pathak. 2011. Implications of diet composition of Asiatic lions for their conservation. Journal of Zoology, 284:60-67.

Owen-Smith, N., and M. Mills. 2008. Predator: prey size relationships in an African large-mammal food web. Journal of Animal Ecology 77:173-183

Panthera. 2015. Range Maps [Internet]. [cited 10 May 2016]. Available from http://www.panthera.org/sites/default/themes/panthera/images/rangemaps/lion.jpg

Quinn, J. , and W. Cresswell. 2004. Predator hunting behaviour and prey vulnerability. Journal of Animal Ecology 73:143-154.

Smithsonian's National Zoo and Conservative Biology Institute. 2017. Sumatran Tiger [Internet]. [Cited 25 September 2017]. Available from https://nationalzoo.si.edu/animals/sumatran-tiger

Stein, A. , and V. Hayssen. 2013. Panthera pardus (Carnivora: Felidae). Mammalian Species Volume 900:30-48.

Toni, P. , and T. Lodé. 2013. Fragmented populations of leopards in West-Central Africa: Facing an uncertain future. African Zoology, 48:374-387.

Zhang, C., M. Zhang, and P. Stott. 2013. Does prey density limit amur tigers Panthera tigris altaica recovery in northeastern China? Wildlife Biology 19:452-461.