12-6-2012

The Effects of Climate Change and Overexploitation on Birds and Mammals: Phenological shifts, range shifts, and population changes

Rachel Denny
Western Michigan University, rachel.m.denny@wmich.edu

Follow this and additional works at: http://scholarworks.wmich.edu/honors_theses
Part of the Biology Commons

Recommended Citation
THE EFFECTS OF CLIMATE CHANGE
ON BIRDS AND MAMMALS:
PHENOLOGICAL SHIFTS, RANGE
SHIFTS, AND POPULATION CHANGES

RACHEL DENNY
LEE HONORS COLLEGE
BIOLOGICAL SCIENCES

THESIS MENTOR: DR. DAVID KAROWE
BIOLOGICAL SCIENCES
Abstract

Our world is changing more than many individuals could imagine. Climate change is not a hoax. Comprehensive empirical records of changes since 1900 in local, regional, and global temperature clearly indicate that Earth is warming more rapidly than ever in recorded history. In response, some bird species are already shifting, both phenologically (timing) and geographically. However, the majority of birds are not shifting or not shifting fast enough, and this is resulting in population declines. A much smaller number of studies suggest that mammals are also shifting phenologically and geographically.

If we do not alter our current behaviors soon, Earth will warm in excess of 4.5°C by 2100. Such warming is likely to result in the extinction of many species of birds and mammals, and substantial population declines for many more. The most vulnerable species will be those that live at high latitudes, high altitudes, and on islands.

Overexploitation, the overuse of wildlife and plant species by people for food, medicinal and personal use, also affects a wide range of birds and mammals. 345 species of birds and 250 species of mammals threatened due to overexploitation. 14% of the world's birds and 22% of the world's mammals are exploited for either consumption or medicinal uses; of these, 23% of bird species are threatened and 36% of mammal species are threatened.

Although climate change and overexploitation are formidable threats, there are solutions for both. If we act quickly to replace fossil fuels with carbon-free energy sources, several of which are already viable alternatives, we can avoid many adverse
effects on birds and mammals. Overexploitation can be minimized by strengthening existing international regulations. The first step for all solutions is to generate the desire to implement them.
I. Introduction

Our world is changing and probably much more than many individuals could ever imagine. Foremost among these changes is the drastic global warming our planet is experiencing due to harmful anthropogenic actions that are completely preventable and even possibly reversible. Global warming is not a hoax, it is not based on false data, and it is not a subject of meaningful debate among scientists. Our comprehensive empirical record of changes since 1900 in local, regional, and global temperature clearly indicate that Earth is warming more rapidly than ever in recorded history, and very likely faster than at any time during the past 55 million years.

A wide variety of extremely complex climate models are able to replicate observed climate change with high accuracy but only if they include both anthropogenic-forcing agents, such as greenhouse gasses, aerosols, and land use changes. Therefore, is it reasonable to have confidence in predictions of future climate change made using these same models. Several general predictions are remarkably consistent across virtually all climate models running virtually any realistic emissions scenario. First and most notably, all model/scenario combinations predict that Earth is predicted to warm on average 2-4°C by 2100. Areas at higher latitude, in particular the poles, will experience dramatically greater warming than the rest of the globe, anywhere from 4-8°C is this the absolute amount of warming predicted at the poles. Second, precipitation is consistently predicted to increase at higher latitudes. However, in the subtropics and everywhere else, precipitation is predicted to decrease. Drought is predicted to
increase as well, with a very similar pattern. Third, many types of extreme weather events are predicted to increase. Increases in severe rainfall events and droughts, both of which have already been detected in several regions including the U.S., are predicted to accelerate. These nearly unanimous predictions lead to the inevitable conclusion that Earth’s future climate will be more challenging for most or all groups of species.

The purpose of this thesis is to review the literature addressing the effects of climate change on the two taxa of terrestrial animals that have most captured the attention of humans: birds and mammals. Because both birds and mammals will experience multiple stressors simultaneously, this review also addresses the effects of a second formidable challenge: overexploitation. Since the fate of these taxa, and indeed of the planet, depends on choices we make today and in the coming decades, this review concludes with a discussion of possible solutions.

II. Effects of Global Climate Change on Earth’s Birds and Mammals

A. Observed Climate Change

The IPCC is the Intergovernmental Panel on Climate Change; the data they collect is vital for analyzing the effects of climate change. The IPCC is a scientific intergovernmental body established by the United Nations in 1988. Their goal is to provide periodic comprehensive scientific, technical, and socioeconomic reports on the effects and risks of climate change due to anthropogenic factors. IPCC reports are authored and reviewed by thousands of scientists from hundreds of countries, and are widely viewed as representing the highest level of climate expertise. Data
from the fourth and most recent IPCC report (AR4, 2007) will be used extensively throughout this thesis.

In order to make any confident predictions about the future, the past must first be extensively analyzed in order to determine whether birds and mammals have already been affected by climate change. Temperature trends from 1979 to 2005 have shown that warming is occurring in the majority of the world. In just these 26 years, some areas, such as parts of the United States and Canada in the winter time period, warmed as much as 1°C (IPCC AR4 WG1 Chapter 3; Smith and Reynolds, 2005; Figure 1). In this figure, white crosses, which indicate where statistically significant warming has occurred, cover a little over half of the globe. This figure is particularly valuable because it evaluates differential warming among the seasons. These geographic patterns are important when interpreting biological changes with birds and mammals. For example, the northern areas of North America have actually been cooling during early spring. Yet, on the other hand, during the winter months this area has warmed as much as 1°C. This can help with interpreting biological results, especially changes in the migration timing of many birds. Temporal patterns of warming and cooling in the Northern Hemisphere illustrate why it is so important to analyze warming separately for all seasons. Also it is vital to note that certain seasons are more noteworthy than others. The migratory seasons, fall and spring, are particularly important, due to their implications with birds sensing when to travel. However, this does not mean to totally discount the winter and summer temperature changes because these could have some secondary effects, especially dealing with effects on the animals' life cycle.
Precipitation is inherently more variable than temperature both within and between years. Therefore, it is not surprising that, unlike temperature, there has not yet been an overall global trend for precipitation (IPCC AR4 WG1 Chapter 3; Figure 2). Some areas, such as parts of Africa and Australia, have experienced increases in precipitation whereas others, such as parts of the Western United States and parts of South America, have experienced decreases. For many individuals, the lack of statistically significant regional trends is surprising. Since there are no consistent trends for past precipitation patterns, it can be rare for scientific papers to use this for their observations or predictions dealing with birds and mammals. However, when scientific papers use climate envelopes models for their predictions precipitation can be part of these models, thus considered when making predictions about the future.

On a similar note, droughts over the past 50 years have been variable as well. There is no specific latitudinal pattern or really any spatial pattern at all, however they have been changing, increasing in the majority of areas of the globe (Dai et al. 2004; Figure 3) but, like precipitation, it will be a very important determinant of biological changes.

B. Observed Responses of Birds and Mammals to Climate Change

Although observed climate change, such as the 0.8°C increase in global temperature since 1900, may seem small, it is clear that they have already had a measurable effect on birds and mammals. In the past decade, several comprehensive reviews have been published summarizing two of the primary ways in which plants and animals are responding to climate change (Root et al., 2003 and
Parmesan and Yohe, 2003). The first way, commonly called “range shifts”, involves expansion and/or contraction of a species’ historical geographic range. The second, commonly called “phenological shifts”, involves changes or shifts in the timing of growth and breeding events in the lift of a bird or mammal.

Many species of both birds and mammals have already displayed range shifts, the majority of which are in a direction consistent with climate change (i.e. poleward and/or to higher altitude). As of 2003, 100% of three species of birds that showed a significant range shift and 100% of two species of mammals that showed a significant range shift had shifted their ranges poleward or to higher altitude (Parmesan and Yohe, 2003). It was unfortunate how small these sample sizes were but these results were essentially corroborated by a second review (Root et al., 2003), which reported that 126 bird species had a phenological shift, 118 bird species had shifts in their living ranges and seven bird species had changes in population densities, whereas four mammal species had changes in their living ranges and one species of mammal had a phenological shift. A subsequent comprehensive study of 329 British species of all sorts of animals over the past 25 years, 84% of all species showed a northward (poleward) shift (Hickling et al., 2006; Figure 4). 66 species of birds, and 22 species of mammals were part of this 84% that showed the poleward shift. This paper had some surprising results. The fact that mammals have shifted, on average, farther than birds is a very interesting result. Of the two types of animals, birds have the ability to adjust and move according to climate change more efficiently, which is why birds were predicted to have the greatest extent of northward shift, this had been noted in a great deal of
scientific papers. The possible reason for the birds not having a greater shift compared to mammals is because of all taxa, the distribution data for birds were gathered during the shortest time period (22 years), and datum was only collected in seven years compared to an average of eleven years for all other taxa. It is also important to note that each taxon analyzed had a different degree of northward shift. Differences in range shifts could be important for many reasons. Since all species depend on others, unequal range shifts may disturb ecological interactions. For instance, if the prey are shifting more, the predator population may suffer due to its inability to keep up with its food source. Variability in observed range shifts also indicates that certain taxa are already tracking climate change better, which could be very valuable information for future predictions.

1. Birds
   
a. Range Shifts

   Although there are fewer long-term records than in Europe, range shifts have also been documented in North America, particularly for birds. For example, La Sorte & Thompson (2007) noted a latitudinal shift among North American birds: the winter range boundary has expanded northward. Hitch and Leberg (2006) also did a study of the breeding distributions of North American bird species. This study analyzed 56 bird species categorized as northern or southern species. For both northern and southern species, 48% had a northern shift of their northernmost border. Only two species (~4%) had a range shift in the southern direction.
Southern species showed the most significant shifts northward and their average northward shift was 2.35 km/year or 1.46 miles/year.

Finally, a study focused in New York State once again confirmed this pattern. It was found by using the New York State Breeding Bird Atlas that 129 species included in the analysis showed an average northward range shift in their mean latitude of 3.58 km, or 2.22 miles (Zuckerberg et al., 2009). Of the 129 species, 57% showed a movement northward in their mean latitude and 43% demonstrated a movement southward. Yet as stated before the mean shift was northward. Interestingly, the greatest northward shifts occurred in the southern range boundaries.

b. Elevation Shifts

In response to warming, species could in principle expand their range to higher elevations as well as higher latitudes. In fact, several species of birds appear to be shifting to higher elevations. For instance, elevational shifts were found when analyzing the living boundaries, or the edges of ideal living environment, for montane tropical birds in Southeast Asia (Peh, 2007). This study was based over a 28-year period; the sample size was 485 local bird species. It was found that 27% of bird species had an increase in elevational range, 17% had a decrease in elevational range, only 2% had an upward shift of both upper and lower boundaries, and 54% were stable in their elevational range. This paper addressed another common question: which shifts are first, upper or lower boundaries? It was found that 84 species extended their upper elevational limit while the lower boundary remained
stable. In contrast, seven species showed only an upward shift in their lower
elevational limit and only three species shifted both their upper and lower
boundaries upward. Thus, it appears that the upper elevational limit moves first
and it is rare for upper and lower elevational shifts to occur at the same time and to
the same degree. This paper was multifaceted because it also analyzed if the birds
were tracking climate change or change in habitat due to other anthropogenic
factors such as habitat destruction, which is very common in Southeast Asia. This
study concluded that these birds were not tracking habitat specificity, species
restricted to only one habitat type, such as broad-leaved evergreen forest, but rather
the combination of climate change and anthropogenic habitat loss. Although it will
be discussed in more detail later, it is important to point out here that, for species
that already live at high elevation, there will be limited opportunity for future
elevational shifts; there is a limited amount of potentially suitable habitat at higher
elevations. This constraint is less imminent for low elevation, mid-latitude species
that can disperse pole ward.

A study done in the Sierra Nevada Mountains in California did an analysis on 53
species of birds (Tingley et al., 2009). This study focused on an approximate set of
climatic conditions in which species can occur, also known as the Grinnellian niche,
and if these birds were tracking this niche as the climate changed. This niche was
broken down into three factors that the birds were tracking; these were
temperature, precipitation and the combination of the two. Of 53 focal bird species,
91% tracked either temperature or precipitation over time, and 26% of species
tracked both temperature and precipitation. Species tracked precipitation toward
wetter conditions, but tracked temperature toward cooler or warmer conditions, depending on the species. These findings are extremely helpful, and show the importance of precipitation.

Probably the biggest issue that will also be brought up later is that montane birds are a particularly susceptible species to global warming because there is only so much available habitat for the birds to inhabit. Especially since once the birds reach the top of the mountain (if they can even inhabit this area) there is nowhere else for them to go. North American birds still have some room to move northward, they do not have a limited optimal living environment compared to island or montane birds. A meta-analysis that compiled a great deal of papers dealing with birds phenological and range shifts (La Sorte & Jetz, 2010) showed that the general trend that was found was birds are responding to recent climate change in a variety of ways including shifting their geographic ranges to cooler climates. There is evidence that northern-temperate birds have shifted their breeding and non-breeding ranges to higher latitudes, and tropical birds have shifted their breeding ranges to higher altitudes. Determining how the distributions of tropical species in lowland and montane regions are currently being affected by climate change is an important area of further research.

c. Phenological Shifts

In addition to geographic and altitudinal shifts, birds are responding to climate change by altering the timing of important events in their life cycles. These changes in timing are known as phenological shifts. Phenological shifts can be identified in a
variety of categories. Migration timing is vitally important when analyzing how quickly and how well birds are tracking climate change. Several studies of spring arrival of birds have shown that many species are arriving earlier (Both et al., 2009; Van Buskirk et al., 2009; Vegvari et al., 2010; Walther et al., 2002; Parmesan and Yohe, 2003; and Crick, 2004) and it is important to address arrival times and whether they are changing or not. Most of these studies have been conducted on European species. For instance, in the Netherlands from 1984 to 2004, spring arrival date for six species of long distance forest migrants shifted earlier by 50 days (Both et al., 2009; Figure 5). The long distance migrants that were arriving earlier did not have a decrease in population. Conversely, birds that were arriving about 20 days later than the first birds that arrived were shown to have population declines. Long-distance migrants can be relatively inflexible to respond to advances in spring phenology of their breeding habitat thus decline in population is a possible cause and effect. Their mismatch is not so surprising in avian long-distance migrants could be because of their complex annual cycle of migration and possibly due to missing their environment’s seasonal food peak. Yet, short-distance migrants have been tracking climate better and local birds have not experienced population declines because it is easier for these birds to predict the spring starts in their breeding grounds. Similarly, in North American over a 46-year period, 78 species of songbirds’ species were analyzed for their spring arrival and fall arrival dates (Van Buskirk et al., 2009; Figure 6). This study is particularly convincing because of the large sample size and the long period of time over which arrival times were recorded. The study found that, while a majority of species arrived much earlier in
the spring, there was no significant delay in fall departure date. This study did a very important analysis of short-term migrants verses long-term migrants. This comparison shows clearly (especially in the figure) that short distances migrants are tracking climate change much better than long distance migrants. Short distance migrants come back earlier relative to long-distance migrants in the spring and stay later in the fall, whereas the long-term migrants arrive later and leave earlier. The short-term migrants have a longer summer season due to this, and this could cause serious issues for the long-term migrants especially if there is any direct competition between the two species for resources. Northern migrants spring timing is advancing slightly, but local breeders are advancing their timing slightly more. This is surprising, because the northern areas of the globe are warming more than the southern. So it was expected that the northern migrants would be arriving earlier as in arriving earlier and even possibly shifting their arrival times more compared to the local breeders, yet this was not observed. This could be very problematic because the northern migrants aren’t tracking their warming climate and are arguably more threatened than local breeders.

The climate change can possibly cause a chain reaction in all phenological aspects of the birds’ life cycle. For instance, over 10 years, egg-laying date has advanced 10 days earlier in Italian black kite populations, possibly due to higher spring temperatures. Yet there is some uncertainty with this study, both because correlation does not prove causation and because the correlation between temperature and laying date is relatively weak. Therefore, there laying date is likely responding to other factors as well (Sergio, 2003; Figure 7).
**d. Possible Responses to Changing Food Sources**

Although many bird species are already exhibiting phenological shifts, many are not and the magnitude of climate tracking differs among species that are shifting their timing. Therefore, if accurate tracking of a changing climate is beneficial, we would expect that species that fail to track effectively would be experiencing adverse consequences. Several studies address this expectation. For instance 100 European bird species were monitored over 40 years (Moller *et al.*, 2008). The birds that were having a negative change in migration date, which means arriving earlier, had an increase in population. However, when birds were arriving later in relation to mean spring migration date they experienced population declines.

The same pattern has been observed among populations of a single species. Nine populations of pied flycatchers in The Netherlands were analyzed on how well they were tracking their food source based on the population trends over sixteen years (Both *et al.*, 2006; Figure 8). The most likely explanation for the association between lack of phenological shifts and decreasing population size is because their food source had an early food peak date. The populations had at least a population decline of 10% and bird populations had declined almost as much 90% because the caterpillar peak date advanced too quickly for the birds to track. It was shown that the peak date of these caterpillars advanced 16 days over this 16-year sample period. This study could have been improved by further analyzing why this caterpillar peak date increase occurred, or even how the caterpillars were tracking this climate change (their food source etc.).
As mentioned before, there have not been any noticeable patterns for precipitation in the past while climate change has been occurring. However, a study was done to show how precipitation could affect the fitness and population of San Clemente sage sparrows (Hudgens et al., 2011; Figure 9). This particular figure shows how precipitation can possibly affect the juvenile mortality rate of these sparrows. The paper does not go into great detail about why there is such a high juvenile mortality rate when the annual rainfall is low. However, it can be seen in the next year because the population of sage sparrows goes down after a year of little rainfall. It is unsure exactly why precipitation could effect the juveniles of the sage sparrow, food availability possibly being one of them, this paper would benefit by trying to identify any possible causes of the juvenile sparrow mortality rate. However, as stated many times in the past there is not 100% correlation for juvenile mortality rate to amount of precipitation of the past year, thus these results can be considered inconclusive, but this study has the strongest evidence compared to most studies.

2. Mammals

2.a. Geographic Shifts/Range Shifts

Unfortunately there are fewer studies done on the range shifts and past effects of climate change on mammals. Documenting responses to climate change requires that data were gathered in the past for other motivations; long-term data sets exist because people were interested in charismatic animals (e.g. birds and butterflies). In each of the two review papers published in 2003 mentioned earlier, bird species
vastly outnumbered mammal species. However, although there is a paucity of long-term data sets for mammals, some do exist. Small mammals such as chipmunks, squirrels, opossums, rats, mice, and marmots have been monitored more extensively than large mammals. From 1883 to 2006, the communities of small mammals in the Northern Great Lakes Region expanded their range on average about 200 km northwards (Myers et al., 2009). The paper addressed the question of whether south populations are replacing northern communities or adding to the communities that were already there, this question could only be applied to one area and what was found was that southern species could have possibly resulted in the decline in populations of resident northern species and no specific reason was given for this decline but a variety of factors could be responsible. The causes of range change were broken down into three categories, first the slow renewal of forests from logging and fires in the 1800s, second is the recent changes in human population and third climatic warming; the combination of these three trends has caused this northward shift of the small Great Lakes mammals.

b. Elevational Shifts

In Yosemite National Park, the data of ranges of 28 small mammals were affected by a 3°C temperature increase over 100 years (Moritz et al., 2008; Figure 10). The overview showed how the low elevation species expanded their ranges to higher elevations, whereas the higher elevation species ended up contacting their lower limit of their ranges as the temperature warmed. Twelve species did not follow this trend, but the majority (sixteen) of mammals displayed this shift.
c. Phenological Shifts

A species-specific study was done on marmots at the Rocky Mountain Biological Laboratory for twenty-three years (Inouye et al., 2000; Figure 11). This study was fairly simple but very helpful. The yellow-bellied marmots are emerging 38 days earlier than 23 years ago. As stated before this study could have been better if it delved more into how exactly the marmots are tracking the climate change (food source, plant changes, temperature alone etc.), but this datum implies that they are moving due to the changing climate.

Polar mammals may have experienced the most adverse effects of climate change thus far. Warming in the Arctic could have some of the most devastating effects on mammals (Post et al., 2009). Phenological shifts have already occurred in the Arctic for both polar bears and arctic foxes. Polar bears have received a lot of attention when it comes to global warming, and rightfully so. Polar bears are experiencing rapid declines in their populations and birth rates due to the loss of sea ice. On the other hand the arctic foxes are declining because red foxes are invading their environment. This overlap of ranges causes competition between the species, a competition that the arctic foxes are losing (Post et al., 2009).

C. Future/Predicted Climate Change

Unfortunately past warming events cannot be used to predict future consequences, since no past warming event matches the rate of current warming. By looking into past trends of climate history, scientist may hope for some implications of the future warming yet to occur on this planet. Ice core data from the past
800,000 years does not match the speed of the degree of warming that is occurring on Earth now. This is not to be confused with the maximum past temperatures of Earth. During the Paleocene-Eocene Thermal Maximum (PETM), about 55 million years ago, Earth was warmer than at present and was warmer than any other in Earth’s recorded temperature history. Yet there is one glaring different between this past and current warming. The PETM was a sudden global warming up about 8°C over a time period of 1,000 to 10,000 years and it lasted for about 100,000 years. This was caused by huge release of carbon into the atmosphere from the ocean. The ocean then subsequently absorbed carbon and that slowed warming rather than causing it. Something that makes the current warming very unique compared to the PETM is that this 8°C warming was gradual and occurred over a very long time frame. The warming we are experiencing now has occurred over a much shorter time frame and differs from the most analogous past event. Thus future predictions cannot be based on what we have observed in the past, they must be created in order to forecast what is in store for the planet in the next 100 years.

The IPCC Fourth Assessment Report (AR4, 2007) is truly vital to this literature review. Predictions about future biological effects depend on at least reasonably confident predictions about future climate change. The IPCC AR4 contains recent consensus predictions about many important components of climate change, including changes in surface temperature and precipitation. However, future climate change will depend largely on future greenhouse gas emissions, which will be the result of choices we make now and in the future. This leads to two important points: 1) No future prediction about the effect of climate change on birds or
mammals can be made with certainty, and 2) Any prediction about the fate of birds or mammals depends on the emissions scenario used to model future climate.

All predictions of effects of climate change on birds and mammals (and all other species) depend on the greenhouse gas emissions scenario used to predict future climate change. Most predictions discussed in the remainder of this thesis are based on one or more of the six emissions scenarios detailed in the 2001 IPCC Special Reports on Emissions Scenarios (SRES). These six scenarios predict future greenhouse gas emissions, and therefore future climate change, based on three primary variables; population projections (billion of people), total energy use (exajoules per year), and percent of energy from carbon-free sources. There are four main scenarios with one scenario having three different subcategories. A1 is the first scenario with three different possible subcategories (IPCC 2000; based on Durand, 1967; Demeny, 1990; UN, 1998; and Lutz, 1996; Figure 12). A1 is defined by rapid economic and global population growth, a predicted peak of 8.7 billion people mid-century then a decline afterwards with a total global population of around 7 billion by 2100. The three subcategories of A1 all vary based on energy sources, A1FI is a fossil intensive scenario, A1T is non-fossil energy sources and A1B is a balance across all sources. A2 is a scenario where the global population will increase to 15 billion by 2100, and more importantly that no real development in economic change or technological change will exist. This implies that there will be a large increase in energy use along with a low percentage of carbon-free energy. The B1 scenario is similar to A1 in terms of population trends yet it differs in that there will be rapid changes toward a service and information economy along with an
introduction of clean technologies. The last scenario B2 states that the global population will reach around 10 billion and intermediate levels of technological and economic development will occur. These six scenarios all predict some degree of warming. A1FI is the worst-case scenario with an average of 4.5°C of warming by 2100, and B1 is the best-case scenario with an average of only 2°C of warming by 2100.

Before discussing the details of predicted future climate change, several very important points are worth emphasizing. First, if we continue on our current trajectories of increased emissions and population growth, by 2100 the average global warming will exceed the worst case SRES scenario of 4.5°C. Second, even the most optimistic scenario (B1) results in an average global temperature by 2100 that is higher than Earth has experienced in 55 million years (since the PETM). Third, the rate of warming under all SRES scenarios is greater than Earth has experienced in 55 million years. Together, these comparisons suggest that anthropogenic climate change is likely to create unprecedented, and very challenging, conditions for birds and mammals.

The IPCC constructed global maps; each map is broken down into 20-year intervals. The scale of warming varies throughout the globe, but warming trends can be noted (Kunkel and Liang, 2005; Xu et al., 2005; IPCC AR4 WG1 Chapter 10; Figure 13). This figure shows the A2 scenario, where an average of 4°C is predicted by 2100. Warming will be most drastic at high northern latitudes and over large landmasses. The Antarctic will experience warming but not near the degree of the North Pole, which could warm as much as 7°C by 2100. It is important to keep in
mind that this is not the most extreme of the six SRES scenarios (A1FI is).
Precipitation follows a somewhat similar pattern to past observed precipitation patterns of the globe. Precipitation is predicted to increase globally on average with some seasonal variation for winter and summer. Figure 14 shows precipitation in the A1B scenario (average warming of 3.1° C). Both winter and summer have a similar trend with a decrease of precipitation in the subtropics and increase at high latitudes and the subtropics variation is the most important trend to note. The subtropics are an area of the globe that depends greatly on the amount of rain for the health of their ecosystems. The reduced precipitation could be devastating to a variety of environments and animals (Wang, 2005; Emori and Brown, 2005; Rowell and Jones, 2006; Neelin et al., 2006; and IPCC AR4 WG1 Chapter 10). For drought the predicted pattern is extremely widespread and more severe over the entire globe except the high northern latitudes, and India (Dai, 2011; Figure 15).

D. Predicted Responses of Birds and Mammals to Climate Change

1. Birds

a. Overall

Similar to observed responses to climate change, far more information exists for bird than mammal species when it comes to the possible effects of future climate change. For 87% of all land birds, in the worst-case scenario (6.4° C of warming), and the worst-case scenario for land use change, there is a projected 30% extinction (2498 species) of all land birds by 2100 (Sekercioglu et al., 2007; Figure 16). Under the 4° C of warming, with the worst-case scenario for land use change, there is a
projected 15% extinction of 8459 species of land birds. This paper focuses on the extinction risks for all of these land birds encompassing a variety of habitat loss scenarios along with climate change. These habitat loss scenarios are taken from a similar study like the IPCC. The Millennium Assessment habitat-loss scenarios (socio-economic) are used and similar to warming estimates they have varying degrees of habitat loss, from Adaptive Mosaic to Order from Strength (best to worst). The data on Figure 13 the low-end climate change (1.1°C) it can be seen that habitat loss has little to no effect on the amount of birds that become extinct or at risk. It isn’t until the moderate warming (2.8°C) that there is a notable difference between the habitat-loss scenarios. By analyzing the high warming scenario and worst-case habitat-loss scenario, about 20% of all land bird extinctions will be attributed to global warming, while the other 10% of extinctions will be due to habitat loss. It is important to note that even when habitat loss is considered that climate change could attribute to more land bird extinctions. The data for 87% of land bird was a collaboration of previous data from a variety of sources. This study is well done because it combines climate change and a variety of habitat loss scenarios, so I feel that this study can be valued based on the two very realistic factors that will affect land birds. Unfortunately this study does not identify which groups suffer the most. Not all are bird species are equally vulnerable; there are habitat characteristic that make subgroups of birds more sensitive to climate change.

b. Particularly Vulnerable
i. Ice Obligate Species

Disappearing ice is likely to have devastating effects on the birds that depend on ice. The immediate bird that comes to mind involving ice is the penguin. Not all penguin species will suffer regardless of global warming. Some penguin species will be climate ‘winners’ or climate ‘losers’. Climate winners are species of penguins that benefit from global warming, whereas climate losers suffer detrimental effects from climate change. The emperor penguin is an ice obligate species, meaning it requires sea ice in order to survive. Because of this the emperor penguin is a climate loser. The emperor penguin populations have already decreased drastically, especially in the western Antarctic Peninsula where breeding pairs have decreased from 300 to 9 in 30 years. The adeleie penguin is another climate loser that has already experienced anywhere from 50 to 70% reductions in abundance (Barbraud & Welmerskirch, 2001; Crick, 2004; and Parmesan, 2006). The probability of extinction of the emperor penguin under the A1B scenario (average warming of 3.1°C), a decline of 95% or more is at least 36% likely by 2100. The median population size of the emperor penguin is projected to decline from 6,000 to 400 breeding pairs. Evolution and migration seem unlikely for such long lived species at the remote southern end of the Earth, especially considering their inability to fly, specific environmental needs, and long generation times (Barbraud et al., 2009). On the other hand, ice-intolerant species, such as the chinstrap and gentoo penguins, are likely to be climate winners. These two species already appear to have benefitted from warming by invading new southward regions due to the lack of ice.
Chinstrap and gentoo penguins benefit from less ice because it extends their feeding areas (Parmesan, 2006).

**ii. Montane Birds**

Montane bird species are particularly vulnerable to adverse effects of climate change because their habitat is so specific and limited; as warming occurs, the birds’ suitable habitat will eventually run out at the peak of the mountain, or possibly at lower elevations. Observations over 19 years encompassed 1009 montane bird species. The projections are for 2080 to 2099 under a moderate global warming (A2 scenario, warming of 4°C) (La Sorte & Jetz, 2010; Figure 17). This paper analyzed the species richness change, the number of species and median change in range size. All of these aspects are predicted to have some varying degree of decrease. In particular, the median size of the range for montane birds is predicted to decrease in all montane areas by at least 13% and at most by 100% (which results in extinction). Montane birds located in North American, Africa, the Arctic, Indonesia and Northern Continental Europe have the greatest reductions in median size of the range, but there is another important factor, that being species richness. The Neotropics (South America) has the greatest number of species of montane birds and these species are predicted to lose 50% or more of their range. A total of 327 species fall into this category, of which 54 are projected to lose 100% of their range. Of the 327 species, 73 are currently listed as threatened. This study gives a complete analysis of how a particularly vulnerable group to global warming could be affected.
drastically. However, it does not identify specific species that are more vulnerable than others.

**iii. Island Dwelling Species**

Hawaiian honeycreepers are bird species endemic to the Hawaiian Islands. Eight honeycreeper species are already endangered due to the spread of the avian malaria, human habitat destruction and the introduction of new predators. Now honeycreepers are faced with the threat of climate change as well. A B1 scenario (2°C of warming) was used to analyze the movement of suitable habitat for the Hawaiian honeycreepers; of the three areas analyzed all three show various reductions in forest habitat by 2100. However, the worst area analyzed, the Alakai region is expected to lose 85% of suitable habitat for the honeycreeper along with an increase in the prevalence of *Plasmodium* (malaria causing protist) in mosquitoes due to sporadic warming events (Benning *et al.*, 2002).

2. **Mammals**

   *a. Range Shifts and Population Reductions*

   Despite a relative lack published work on the observed responses of mammal species to climate change, many studies predict effects of future climate change on mammals.

   Mammal species in the Great Basin mountain ranges (United States) were analyzed and a 3°C warming by 2100 would cause a loss from 9% to 62% of the species that inhabit these mountain ranges (McDonald & Brown, 1992; Figure 18).
The warming scenario used for this paper was based on a general climate model and used the lower end of this scenario (Schneider, 1990). Three of the 14 species are predicted to go extinct due to this climate change, these animals being the Western Jumping Mouse, Belding’s ground squirrel and the white-tailed jackrabbit. These three species are unique because they only inhabit two to five of the 19 mountain ranges in the Great Basin. Other animals such as the Bushy-tailed Woodrat and the chipmunk inhabit 17 of the isolated mountain ranges and thus had a greater chance of survival, and after the climate change has no population reductions. All other species in this study are predicted to have extinctions in various mountain ranges. It is very probable that the more mountain ranges a mammal inhabits the better chance they have for survival during global warming. It also could illustrate a general principle that more widespread species are less likely to go extinct due to climate change. It is important to note the date of this study. The fact that was published in 1992 was very impressive. This may be one of the first studies dealing with the possible responses of mammals to climate change.

* b. Particularly Vulnerable

Mammals, like birds, can be divided into different vulnerable groups. These groups are polar mammals and large mammals. Mammals are also likely to be particularly vulnerable if there are geographic barriers to their ability to move to future suitable habitat (bodies of water, mountains, etc.).

* i. Polar Mammals
Like penguins, polar mammals will potentially be affected by continued ice melting. Polar bears are another ice obligate species; they cannot survive or prosper without it, so the decrease in sea ice is likely to result in a decrease in their populations. The walrus, bearded seal and ringed seal are also ice obligate species. Unfortunately, all ice obligate species are likely to decrease in numbers in a warming climate (Derocher et al., 2004; Lewis et al., 2010; and Ford et al., 2006). Under the A1B scenario (average warming of 3.1°C) by mid-century, almost all sea ice is predicted to melt to less than 1 meter in thickness (Overland and Wang, 2009). For polar bears this means that under the A1B scenario they could lose up to 68% of their habitat in the summer months and 17% in the winter months by 2100 (O’Neill et al., 2008).

On the other hand, seasonally migrant species, ice intolerant species, and a variety of whale species are likely to benefit from the loss of sea ice (Moore & Huntington, 2008; Figure 19). For example, reductions in sea ice may actually enhance feeding opportunities for bowhead whales (Moore and Laidre, 2006). Recent loss of sea ice may explain the observed 3.4% increase in their population over the past 20 years.

**ii. Large Mammals**

Large mammals are especially threatened by climate change due to their need for large habitat area and inability to travel due to anthropogenic and natural barriers (cities, mountains and bodies of water). For 277 large African mammals, (Thuiller et al., 2006; Figure 20) in Southern Africa with moderate warming (A2
scenario, warming of 4° C) 80 to 100% of the species are predicted to become extinct. In Central Africa anywhere from 60 to 75% of these large mammal species are predicted to be lost. Both predictions are based on the assumption that the mammals cannot disperse, or moving according to their appropriate climate conditions. Papers have taking this into consideration and applied it in their studies.

**iii. Geographic barriers**

Dispersal limitations may constitute a formidable challenge for other mammals as well. For instance, in the Great Lakes region, 20 mammal migratory pathways were analyzed using two different climate-warming scenarios, anything from skunks to squirrels to weasels (Francl et al., 2009; Figure 21). It was predicted how far these mammals must travel in order to keep up with the changing climate. To keep pace with climate change predicted to occur these mammals will need to move about 2 km a year. By 2070, the mammals will run into the Strait of Mackinac and will not be able to travel any further even if they are tracking climate to begin with.

In an area encompassing all of the British Isles and continental Europe 120 native terrestrial mammals are predicted to be a risk of extinction or become extinction (Levinsky et al., 2007; Figure 22). When the two different future climate scenarios (A2 scenario, a warming of 4° C and B1 a 2° C of warming) were used it was shown that almost 9% of European mammal risk extinction where as many as 78% could be severely threatened. There is an overall trend of a movement of mammal species northward and to higher elevations in order to follow the cooler
and optimum climate. However, mountain ranges and large bodies of water could pose as a geographic barrier for mammals trying to move to their ideal climate.

III. Effects of Overexploitation on Birds and Mammals

A. Introduction

Many of the species on our planet are threatened by not just one but a multitude of anthropogenic factors. This thesis explicitly addresses only one other anthropogenic factor that poses a great threat to both birds and mammals: overexploitation. Overexploitation is the overuse of wildlife and plant species by people for food, clothing, medicine, sport and many other purposes (www.wikipedia.com). It is very common for humans to take more than what the natural world can supply, that is, to harvest at unsustainable levels. Many species have been hunted to extinction, from the dodo bird to the passenger pigeon (National Wildlife Federation). Other species, including the American Bison and a variety of whale species, have been pushed to the brink of extinction. The International Union for Conservation of Nature (IUCN) is the world’s oldest and largest global environmental organization. The IUCN generates a list of threatened species and their population declines called the Red List. The definition of threatened animals is broken into three categories by the IUCN: an animal that is threatened can be Vulnerable (the lowest ranking), Endangered, or Critically Endangered. Overexploitation of birds and mammals occurs for three major reasons: food, personal use (medicine, clothing etc.), and pet trade. Many mammals and birds are exploited for more than one use. The IUCN identifies 345 species of
birds and 250 species of mammals threatened due to overexploitation. This section will describe patterns of overexploitation of birds and mammals, and will conclude with various legislative and personal solutions.

B. Past & Present

1. Food

The first category of overexploitation of birds and mammals for food is bushmeat. The African forest is commonly referred to as “the bush”, thus bushmeat is any animal caught in the bush. Bushmeat can be any and all wildlife species (including threatened and endangered species) that are eaten for their meat. Bushmeat includes elephants, gorillas, primates, crocodiles, rats, antelope, lizards, and a variety of other creatures. In Ghana, Africa, the demand of bushmeat fluctuates with the availability of fish. When regional fish supplies are low, local bushmeat hunting intensifies (Rowcliffe et al., 2005; Figure 23). This data was gathered by monitoring the hunting intensity in local forest reserves and the per capita fish supply. Thus, as the per capita fish supply decreases, the decline in wildlife abundance in nature reserves accelerates. Not surprisingly, the number of hunters in wildlife reserves is inversely correlated with the per capita fish supply. When the per capita fish supply was 40 kilograms, there were only about 60 hunters in the reserve but, when the per capita fish supply was only 22 kilograms, there were about 160 hunters in the reserve. On average, there was an annual consumption of 800 million pounds of bushmeat and 1 billion pounds of fish (Rowcliffe et al., 2005).
The Congo Basin is another area of Africa that relies heavily on bushmeat (Wilkie & Carpenter, 1999; Figure 24). Bushmeat is an integral part of household economics; because it is both a source of revenue and a good source of protein, there is a substantial demand and market for bushmeat. On average, about 2.6 billion pounds of bushmeat are eaten each year in the Congo Basin. The most frequently consumed is ungulates; these are hoofed animals, commonly small to medium sized antelope and wild pigs. Primates are consumed second most commonly, then rodents, then other animals. The issues are brought to attention are that the forests of the Congo Basin are and will be progressively stripped of certain wildlife species, risking their extinction and the possible decline of the local economies. Due to their low reproductive rates, large mammals, especially primates, are even more susceptible to extinction via overexploitation (Wilkie & Carpenter, 1999).

Protein from fish, crustaceans and mollusks accounts for 14-17% of the animal protein intake of the human population (Ichiro, 2000). Clearly, fishing is a vital part of life for many individuals. Something that many people do not realize is that unsafe fishing practices and over fishing have consequences for many birds and mammals. Unsafe fishing practices have the unfortunate effect of incidental by-catch, which occurs when various birds and mammals are caught unintentionally in nets and various other traps for fish. One study focused on a marine mammal, the dolphin, and the effects of incidental by-catch of this mammal and how it can be prevented. In northwest Spain, many short-beak common dolphins were caught by pair-trawlers, which are nets dragged behind fishing boats (Fernandez-Contreras et
Dolphins were only caught in water shallower than 250 meters (Fernandez-Contreras et al., 2010; Figure 25), thus possible legislation could require that trawling nets must be in water less than 250 meters. If this protocol were enacted, 78% of the short-beak common dolphins would not have been caught. However, this study is a very small sample of dolphins and does not encompass other species of dolphins in other parts of the world. A meta-analysis or larger study would be very helpful in order to see the true global magnitude of incidental by-catch of dolphins.

Dolphins are not the only animals that fall prey to entanglement in fishing nets. Many seabirds have been caught on fishing lines while trying to scavenge bait. This causes both a decline in seabird populations and a reduction in efficiency for fishermen (Lokkeborg, 2000). The estimated average annual mortality along the Patagonian shelf is at least 1,160 birds over an area of about 2.7 million square kilometers (Favero et al., 2003). Despite large spatial variation, estimates indicate that the annual by-catch may be on the order of thousands, with around 10,000 seabirds killed by longliners between 1999 and 2001 (Favero et al., 2003). The longline fleet operating in Brazil by itself causes the death of more than 7,000 seabirds per year (Olmos et al., 2000), including a variety of albatrosses, petrels and other seabirds. Longline fishing has also proven to be a threat for 22 IUCN threatened species, 17 albatrosses, four petrels and one giant petrel, the majority of which (16) reside in New Zealand (Nel & Taylor, 2003). Several mitigation measures have been tested in order to reduce the number of sea birds caught in these fishing lines. By hiding the bait from the sea birds and making it very hard to
access, a bird scaring line reduced by-catch by 98-100% (Lokkeborg, 2000; Figures 26 and 27).

2. Personal Use

While many birds and mammals are overexploited based on necessity, the majorities are harvested for human wants more than needs, that is, for personal use. Many birds and mammals have been overexploited purely based on old world traditional or religious beliefs. Interestingly, the most common medicinal aliment that is treated using mammals is erectile dysfunction (ED). Traditional Chinese Medicine (TCM) relies heavily on animal products for treatment of ED (Von Hippel & Von Hippel, 2002; Figure 28). The four mammals that are most commonly used for ED treatment are deer, pinnipeds, rhinoceroses, and tigers. Figure 28 also identifies what animal part is used, if ED treatment is a primary use of the animal, whether the animal product is more expensive than Viagra and, finally, whether Viagra has the potential to replace this TCM. Viagra is cheaper than 75% of the mammals and has the potential to replace 75% of the various animal products. As shown in the table, three of the four mammals are threatened whereas tigers are endangered. Therefore, Viagra not only addresses the main problem of TCM but also poses a realistic modern solution.

A fairly recent study of three free markets in the Central West region of Brazil recorded 30 different animals in the market that were sold for therapeutic use (Costa-Neto & Motta, 2010; Figure 29). Four of these animals were birds, specifically helmeted guinea fowl, chicken, rhea (a large, flightless bird) and a vulture. Many
parts, including the fat, oil, feathers, gizzard, and liver bile were used to treat maladies from influenza to bronchitis to alcoholism. The chicken was the most common bird sold in the market for obvious reasons. However, the vulture had the highest value for medicinal use, and the rhea ranked fourth of all animals traded in these markets. This study shows how a wide variety of animals, including birds, can be used for traditional medicine and that their value and usage is widely variable.

Tusk trade is a familiar component of overexploitation; elephants have been poached and overexploited for their tusks for hundreds of years, since ivory is a very highly valued commodity. The tusk trade can influence elephant poaching (Wasser et al., 2010). African elephants are particularly vulnerable to poaching and this study focuses on the evident link between the rise in elephant poaching and the rise in ivory trade. The countries of Zambia and Tanzania have shown the greatest increase in ivory trade and, consequently, in elephant mortality. In Tanzania, a population of elephants mortality rate rose from 22% due to ivory poaching in 2003 to 63% in 2009, the ivory exports of Tanzania also increased and was equal to about 90 tons or 14 million dollars. In Zambia, a population of elephants mortality rate hit a record of 88% in 2008 and ivory trade exports increased to around 22 tons or 3.5 million dollars. This relationship shows how the demand for ivory is detrimental for elephants and causes them to become even more vulnerable to overexploitation.

Due to their traditions and beliefs, China is the largest worldwide consumer of ivory, and Asia is the largest regional purchaser on the globe (Mullen & Zhang, 2005).

Skin trade is a very important cause of overexploitation. High demand for tiger skins has caused a devastating effect on global tiger populations (Verheij et al.,
Tigers are killed and sold purely for aesthetics, traditional medical use, and greed. Wild tigers have plummeted by around 95% over the past 100 years; Figure 30 shows how the present range has shrunk radically compared to the historic range. TRAFFIC, which is the wildlife trade-monitoring network, did a mass seizure of skins (480), bones and skeletons (1253 kg), dead individuals (197) and claws (1313) from 2000-2010. This seizure was probably only a small portion of the tiger items on the black market. The extinction of this animal is imminent if no actions are taken.

3. Pet Trade

Pet stores are very common, and most of them have some exotic birds and mammals. Many individuals don’t think about the efforts put forth in order to get these exotic pets to the store. Exotic birds and small mammals (gerbils, rats, chinchillas, etc.) are imported to the United States from Southeast Asia. Unfortunately, there is not a lot of information about mammals and the pet trade. However, a survey done by CITES (Convention on International Trade in Endangered Species of Wild Flora and Fauna) found that 400,000 mammals were exported during 1998-2007 from Southeast Asia alone. Birds, on the other hand, are studied and monitored extensively when it comes to the pet trade; 1 million species of birds were exported from Southeast Asia during this same time (Nijman, 2010).

Indonesian birds are very common in the pet trade (Shepherd, 2006). In Indonesia it is also very popular to keep wild caught birds as pets and the markets for this trade are vast and spread throughout the country. Surveys of three bird
markets in Indonesia from 1997-2001 counted a total of 3,500 birds representing 300 species. Since a law in Indonesia protected 56 of these species, these birds were being exploited illegally. Unfortunately, preservation can backfire. For instance, the Javan hawk eagle is endangered and on the IUCN Red List. This bird was declared Indonesia’s National Rare/Precious Animal in 1993 and, probably as a consequence, the illegal trade of the Javan hawk eagle increased by 85% by 2005 (Nijman et al., 2009; Figure 31). This is an example of how a well-intentioned conservation action can put a species at even greater risk.

4. Overall

As mentioned before, CITES, like the IUCN, is a very helpful organization. CITES has also evaluated the trade status of many animals, and lists them in their three appendixes. Appendix I includes species threatened with extinction. Trade in these species is permitted only in exceptional circumstances. Appendix II includes species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid future endangerment. Appendix III includes species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling the trade. In a local market in Amman, Jordan in 2009, 17,000 birds were for sale, representing 54 species (Eid et al., 2011; Figure 32). Of these, 43% (23 species) were listed on the CITES II and III appendices. Interestingly, there were very few mammals traded in the market and none were in the CITES appendices.

Meta-analyses exist for overexploitation in various parts of the globe. For instance, in the Mediterranean, which is a biodiversity hotspot, 10% of all bird
species and 20% of all mammal species are primarily threatened by overexploitation (Vie et al., 2008; Figure 33). This study was based off the IUCN Red List and is very helpful meta-analysis for this area of the globe. A global analysis concluded that 14% of the world’s bird and 22% of the world’s mammals are exploited for either consumption or medicinal uses; of these, 23% of bird species are threatened and 36% of mammal species are threatened (Vie et al., 2008; Figure 34).

Unfortunately, there apparently are no predictions about the effects of overexploitation on birds and mammals because it is so hard to predict and create models to replicate possible predictions. Based on data available now, many future predictions would probably show mass extinctions of birds and mammals if no proactive approaches were implemented.

**IV. How Overexploitation and Global Warming Will Likely Interact and Potential Ways to Minimize These Adverse Effects**

Global warming and overexploitation are very likely to interact with each in the near future, as warming accelerates and human populations continue to grow. It is hard to know to what degree these two factors will influence each other. Many birds and mammals are threatened by global warming and, if a bird or mammal was also overexploited, this could cause devastating effects on its population. The interaction between overexploitation and global warming was modeled using rotifers, which are microscopic aquatic organisms. The rotifers were kept in 300 separate populations, each of which was exposed to one of three warming treatments (0° C,
0.3°C and 0.6°C) and one of five harvesting treatments (0%, 12.5%, 25%, 37.5%, or 50% of the initial population removed per generation). The warming was increased every 2006 days, which was a full generation time (interval of time between the birth of parents and the birth of their offspring). The greatest population declines (up to 51.3% per generation) were observed when populations experienced high levels of harvesting and rapid warming (Metzger et al., 2007). These declines were 36 times faster compared to populations that were not experiencing overexploitation or warming nice point. Although this experiment used rotifers, its results are likely extendable to birds and mammals, since they are experiencing a similar combination of these harmful factors. Future studies that address the combined effects of and these two anthropogenic factors on birds and mammals would be very useful.

A. Possible Solutions

1. Global warming

The future may seem bleak for birds and mammals in terms of global warming and overexploitation. However, there are solutions that can be implemented in the near future to reduce or even eliminate the predicted effects on birds and mammals. Global warming is due to anthropogenic change thus it will take anthropogenic actions, both technological and political, to reduce warming. On the other hand for overexploitation only political changes can be put in place in order to remedy the current situations.
Technological advances have been numerous in the past century, and many will help reduce our carbon footprint. Alternative energy sources are very important when it comes to reducing carbon emissions and global warming. Two technologies that I feel are most important to be informed about are wind turbines and solar power. Both have the potential to lower the consumption of fossil fuels by humans while producing enough electricity to power the entire globe. Solar and wind power can provide a substitute for coal and gas used to generate electricity, however they’re not a replacement for liquid fuels. Some replacements for liquid fuels could be fuel cells and bio-fuels such as ethanol, bio-diesel and methane.

a. Wind Turbines

Wind turbines have a very basic design. The flow of wind turns the blades, which are connected to the rotor. The rotor is attached to a shaft with magnets, which rotate around a coiled wire, creating an electrical current (Figure 35). As of right now China is the largest user of wind power, and the United States is currently second (www.investing.curiouscatblog.net). However, wind power is not nearly utilized to its capacity. Potential electricity production from wind power is vast. If all possible land areas other than forests, urban regions, and ice covered regions) were utilized along with costal areas, wind turbines could produce over 40 times the current worldwide electricity use (Lu et al., 2009). The United States could produce almost 28 times its current electricity use. Wind energy is not only carbon-free and pollution-free; it is also less expensive than coal and gasoline. When cost comparisons are done, it is important to know the two different types of costs, the
economic cost of the product and the “external costs” of the product. “External costs” include all costs of the product and the costs created by the product, such as the health costs or environmental costs of burning coal for energy. The cost of electricity from wind turbines per kilowatt-hour is 2.6 cents for offshore wind turbines and 5.6 cents for onshore wind turbines. Coal on the other hand costs 7.2 cents. When “external costs” are considered, wind costs 3 cents (offshore) and 6 cents (onshore) where coal costs 26.3 cents. Wind turbines are a viable, clean and economical way to obtain electricity.

b. Solar Power

Solar power uses another one of Mother Nature’s powerful energy sources, the sun. Unlike wind power, there is more than one type of technology to harness energy from the sun. The first is concentrated solar power (CSP), which can be produced using three different technologies. The first is solar thermal power; this is where the sunlight is focused on a substance that can be heated up by many mirrors. This heat creates steam the bottom of the tower, which drives a turbine that creates electricity. This is important because it solves the common misconception that solar power is intermittent and is only viable when the sun is out. The second type of CSP is a parabolic trough; this is where sunlight is focused by parabolic reflectors onto an oil-containing tube. The oil then transfers heat to a steam turbine that creates electricity. Something that is unique about these kinds of solar power is that the excess heat that is generated during the day can be stored and used at night. The final type of concentrated solar power is the parabolic dish. Unlike the first two
types of concentrated solar power, this kind of solar power does not use any water. Instead, sunlight is focused onto a Stirling engine that generates electricity directly. Unlike other types of CSP, parabolic dishes can be employed on a small scale, even for someone’s household. Photovoltaic (PV) panels are unlike any concentrated solar power technologies. PV panels are made of high-grade silicon; they generate electricity directly, use little or no water, and do not generate heat for night electricity production (Patel, 1999). As of 2008, in the entire world, solar power only accounted for a small fraction of all alternative energy sources (USEIA 2011a). The United States ranks fifth in solar power use compared to other countries (Earth Policy Institute 2011). We used about 103 exajoules of energy in 2010 and only 1% came from solar power (USEIA 2011b). Like wind turbines, the potential electricity production from solar power is immense. Yet unlike wind turbines, solar panels, especial PV panels, can be placed just about anywhere. The global potential for solar power is 3-100 times the current electricity use (IPCC). If solar panels were placed in a small section of the Sahara desert; they could power the entire globe (May 2005, TRANS-CSP 2006). Locally, the entire United States could be supplied with electricity by placing solar panels in an area measuring 100x100 miles in the Southwest (Caplowe, 2008).

c. Possible Political Solutions

Political solutions to global warming have not met the current success of technological solutions. In the United States, there has been one national attempt at climate change legislation. The American Clean Energy and Security Act (ACES), co-
sponsored by Henry Waxman (California) and Edward Markey (Massachusetts), was passed by the House of Representatives in 2009 but in 2010 it was never voted on by the Senate (Environment Northeast, 2009). ACES would have required the U.S. to reduce carbon emissions 17% by 2020 and 80% by 2050 under 2005 levels. Therefore, by mid-century, our economy would have been fueled primarily by renewable energy instead of fossil fuels. The plan was based on a “cap and trade” system, where a carbon market is created by assigning allowances (carbon credits) for the amount of greenhouse gases emitted by certain entities (refineries, natural gas companies, and electric companies). Household emissions were not included directly; so individuals would not have received allowances. Allowances would have been cut back as time progresses (Figure 36). Entities would also have been allowed to sell their unused allowances, giving companies incentive to reduce their carbon output. Each year, a proportion of allowances would have been auctioned by the federal government to generate funds for many uses, including relieving economic hardship experienced by low-income citizens and a project protecting forests and other areas that serve as carbon sinks. By creating a carbon market, ACES would have greatly promoted the use of clean energy sources. Unfortunately there are currently no nationwide efforts regarding climate change in the United States.

In Europe, climate change legislation has been implemented. In 2005 the European Union Emissions Trading Scheme (EU-ETS) was launched. This plan includes all countries in the European Union (27 countries). Like ACES, EU-ETS created a carbon market by providing allowances for greenhouse gas emissions. This agreement is broken down into three different phases. The first phase was
from 2005-2008 where the carbon market was established, yet countries increased their emissions by 2%. The second phase was from 2008-2012. Three countries that were not apart of the European Union joined, Norway, Iceland and Lichtenstein. Since 2005 there was a decrease in greenhouse gas levels by 7%. The final phase, phase three will go from 2013 to 2020 and this is where the carbon allowance will change to carbon auctioning (Ellerman and Buchner, 2007). Overall EU-ETS is a great example of how climate change legislation can work, it is a viable model for a worldwide effort.

There has been one international treaty to regulate greenhouse gas emissions. The United Nations Framework Convention of Climate Change was a treaty yet it was not binding, and it only created protocols for actions and targets for greenhouse gas emissions. A total of 195 countries are members in this convention. The Kyoto Protocol was the first initiative of the convention. It became operational in 2005 and had a goal of reducing emissions by 5% compared to 1990 levels. 192 countries have ratified this protocol but the United States has not. Like the climate change legislation mentioned above, the Kyoto Protocol aimed to turn carbon into a commodity and to create a carbon market (Kyoto Protocol Reference Manual). As stated before the United States signed this agreement yet never ratified it. The United States is in desperate need of climate change legislation; greenhouse gas emissions have increased by 17% since 1990 (U.S. Climate Action Report, 2010; Figure 37). The average rate of increase was about 0.9% per year from 1990 to 2007. In December of 2012 in Doha, Qatar the Kyoto Protocol met and decided that rich nations need to start compensating poor nations for their losses because of
climate change (Harrabin, 2012). This decision pushes rich nations to raise at least 10 billion dollars a year up to 2020. It is a step in the right direction, but with any change there will be some resistance. The United States did not state one-way or the other if they would support the 10 billion dollar compensation.

Another potential legislative action that can be implemented in order to combat global warming is a carbon tax. A carbon tax would tax certain entities based on how much carbon dioxide they emit into the atmosphere. The government sets a price per ton on carbon, and then it translates into a tax on fossil fuels. The tax encourages utilities, businesses and individuals to reduce consumption and increase energy efficiency. A carbon tax also makes alternative energy more cost-competitive with cheaper, polluting fuels like coal, natural gas and oil (even if external costs are ignored, as is the common practice). There are a variety of arguments for and against a carbon tax. The carbon tax is viewed as a different legislative action compared to the cap and trade method, because the carbon tax is simply a tax and doesn’t set up a carbon market. The carbon tax makes businesses pay for negative externalities, the costs that are not paid for by the production of goods and services, such as the effects of pollution. A carbon tax would generate about 50 million dollars a year in the United States, but the cap and trade system would generate this kind of revenue easily especially if allowances were auctioned. However, being titled a carbon tax it could be less accepted by the general public. Another con to the carbon tax is there is no real guarantee that some entities will reduce their emission of greenhouse gases. Finally advocates for the cap and trade system argue that it could be easier for industries to become exempt from the tax by finding loopholes (Avi-
Yonah & Uhlmann, 2009). There have even been suggestions of making an international cap and trade system where the cap differs between developed or developing countries (Dornbusch & Poterba, 1999). This idea for this cap and trade scheme could also be used to solve the problem that arises for low-income households under the cap and trade scheme and the carbon tax. Low-income households could be shielded from increased poverty and hardships by giving them extra allowances due to the socioeconomic status (Greenstein et al., 2007).

2. Overexploitation

Unfortunately, currently there are only some minor legislative solutions for overexploitation. Birds and mammals do not receive a great deal of attention when it comes to overexploitation; in many cases the main focus is fish, amphibians and reptiles. The Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) purposed two possible legislative solutions. These proposals were discussed during the CITES resolution conference meetings. The first was dealing with bushmeat, which affects a variety of mammals and birds. The goals of this proposal were to prohibit exploitation of Appendix-I species for consumption as food, to have sustainable levels of exploitation for species in Appendix II and III, to make individuals aware of alternative sources of protein, to take other measures to reduce the demand for bushmeat particularly Appendix-I species and, finally, to define administrative responsibilities of the government agencies that control the domestic regulation of trade in bushmeat (CITES, 2004). The other conference covered the issue of traditional medicines and the effect they have on birds and
mammals, particularly large mammals. This resolution conference offered possible solutions to this problem such as developing public education and awareness programs, using forensic science for identifying parts and derivatives used in traditional medicines, having traditional medicines use alternative ingredients instead of specimens of threatened wild species and, finally, possibly using captive breeding as an alternative (CITES, 1997). In Indonesia, having birds as pets is a very common pastime and currently many individuals are trying to implement a non-state, market based solution. This solution is to make captive bred birds more valuable than wild caught birds. Captive bred birds would attain a higher quality by coming from certified breeding facilities that can guarantee a pedigree similar to how dogs are bred in the United States (Jepson and Ladle, 2009). This solution is different because it does not have any governmental involvement; rather it attempts to change individuals’ thinking about where they get their birds and to put more value on birds bred in captivity. Like global warming, the success of these solutions depends a great deal on the awareness of individuals and their willingness to act to prevent the worst-case scenario due to anthropogenic changes.

V. Conclusion

This review of the effects of past and current climate change and overexploitation, and the likely effects of future global warming, on birds and mammals leads to the inevitable conclusion that our planet is changing in ways that have dramatic adverse effects on these charismatic animals. Although the information contained in this thesis may cause individuals to view the future as
bleak and full of hardship, it is crucial to recognize that there is a brighter future if proactive actions are taken. Our harmful behaviors can be altered, but it will take a combination of legislative and technological changes to accomplish this. Knowing particularly vulnerable groups of birds of mammals along with parts of the globe that will be most drastically affected by global warming can serve as motivation to make personal changes and spread the word. Because the effects of global warming and overexploitation on birds and mammals are preventable, their fate depends on the choice we make in our own lives. The range solutions offered for both global warming and overexploitation should be vigorously pursued, since these solutions could drastically brighten the currently unwelcoming future in store for our planet.
Literature Cited


CITES. http://www.cites.org/eng/res/index.php


IUCN. http://www.iucnredlist.org/


Péter K. Molnár, Andrew E. Derocher, Gregory W. Thiemann, Mark A. Lewis, Biological Conservation, 2010. Predicting survival, reproduction and abundance of polar bears under climate change. 143 (7), 1612 – 1622


Sergio, F. (2003). Relationship between laying dates of black kites Milvus migrans and spring temperatures in Italy: rapid response to climate change? Journal of Avian Biology, 34, 144-149


Appendix

Figure 1. Global seasonal temperature trends since 1979. White crosses indicate areas of statistically significant warming. (IPCC AR4 WG1 Chapter 3; Smith and Reynolds 2005)

Figure 2. Trend of annual land precipitation amounts (% per century) for 1901-2005. The percentage is based on the means for the 1961-1990 period. (Grey areas: insufficient data; black + marks: trends significant at p<0.05.) (IPCC AR4 WG1 Chapter 3)

Figure 3. Linear trends of Palmer Drought Severity Index from 1950-2002. Red areas indicate drying, blue areas indicate wetting. (Dai et al. 2004)

Figure 4
Figure 4: Latitudinal shifts in northern range margins for 16 taxonomic groups during recent climate warming. Results are given for three levels of subsampling of data (recorded, blue; well-recorded, yellow; heavily recorded, red). Only species occupying more than twenty 10 km grid squares across the two time periods are included in analyses; for several of the species-poor groups, these criteria excluded all species from the analysis of ‘heavily recorded’ squares. Asterisk indicated significant range shifts (Hickling et al., 2006).

Figure 5: Population trends of migratory passerines in forests and their spring arrival date between 1984 and 2004. Later arriving species decline most. Population trends are expressed as the ratio of densities present in 2004 relative to 1984, which is based on the annual population growth rates. (1=stable, 0.1 is a 90% decline, 10 is a 10-fold increase). Arrival data are based on the first three males arriving in a study site in Drenthe (northern Netherlands). (Both et al., 2009)

Figure 6: Long-term changes in the timing of spring migration (a) for species that breed locally or to the north of Powdermill Nature Reserve, and autumn migration (b) for species that winter primarily in North America (short-distance migrants) or in the neotropics (long-distance migrants). Shown are averages (1 Standard error) of slopes from separate regressions against year for the dates on which 10%, 25%, 50%, 75%, and 90% of individuals were captured. (Van Buskirk, et al., 2009)
Figure 7: Mean laying date plotted against mean spring temperature. (Sergio, 2003)

Figure 8: Trends in response to the local date of caterpillar peak and the slope of annual median laying date in 2003. Population of pied flycatchers with an early food peak and a weak response declined most strongly in 2003 (Both et al., 2006)

Figure 9: Annual rainfall (bars) and San Clemente sage sparrow population estimates (lines), from San Clemente Island, California, 2000-2007. (Hudgens et al., 2011)

Figure 10: Summary of elevational range changes across all species in relation to life zones. Significant shifts are colored green for range expansion and red for contraction. Species were classified as “No Change” if range shifts were biologically trivial (<10% of previous elevation range) or of small magnitude (<100m). (Moritz et al., 2008)
Figure 11: Date of the first sighting of a marmot at Rocky Mountain Biological Laboratory each year from 1976 to 1999. (Inouye, Barr, Armitage & Inouye, 2000)

Figure 12: Population projections, total energy use, and percent of energy from carbon-free sources (IPCC 2000; based on Durand 1967, Demeny 1990, UN 1998, and Lutz 1996).

Figure 13: Multi-model mean of annual mean surface warming for the scenario A2 at three time periods. Anomalies are relative to the average of the period 1980 to 1999 (Kunkel and Liang 2005; Xu et al. 2005; IPCC AR4 WG1 Chapter 10).
Figure 14: Multi-model mean changes in precipitation for winter (above) and summer (below) using the A1B scenario, for the period 2080 to 2099 relative to 1980 to 1999. Stippling denotes areas where predictions are more consistent (Wang 2005; Emori and Brown 2005; Rowell and Jones 2006; Neelin et al. 2006; IPCC AR4 WG1 Chapter 10).

Figure 15: Figure 13. Mean annual Palmer Drought Severity Index (PDSI) for 1975-1984 (left) and 2060-2069 (right) calculated using a 22-model ensemble running the A1B scenario. Red to pink areas are extremely dry (severe drought) conditions while blue colors indicate wet areas relative to the 1950-1979 mean. (Dai 2011).

Figure 16: Number of Western Hemisphere bird species projected to be at risk of extinction or to be extinct by 2100. Estimates are based on the projected reductions in their current global ranges as a consequence of surface warming (IPCC 2007) and habitat change (MA 2005). Black = extinct, grey = at risk (Sekercioglu et al., 2007).
Figure 17: Maps summarizing current and projected geographical and ecological patterns within montane regions globally. (C) Species richness of montane birds (F) the number of montane birds projected to lose 50% or more of their range resulting in range sizes less than 20,000 km$^2$ under the no-dispersal (ND) scenario. (E) Median percent change in range size for montane birds. (La Sorte & Jetz, 2010)

Figure 18: Effects of assumed scenario of 3°C warming on the area of boreal habitat and the number of small mammals species on nineteen isolated mountain ranges in the Great Basin. (McDonald & Brown, 1992)
Figure 19: A conceptual model of sea ice impacts on ice-obligate, ice-associated, and seasonally migrant marine mammal species: positive impacts are indicated by circled plus signs; negative impacts by circled minus signs. Dashed lines indicate uncertainty regarding potential impact of sea ice gain or loss for ice-associated species. (Moore & Huntington, 2008)

Figure 20: Relative number of predicted species lost by pixel for the two time slices (2050 and 2080) and the two storylines (A2 and B2). Current species richness is displayed at the centre of the figure. (Thuiller et al., 2006)

Figure 21: Average distance (km) mammal species captured from 30 sites in St. Joseph and Porter counties. (Great Lakes Region) Distance based on northeastward movements according to model simulations for the contemporary reference period 1961-1990 and two future climate change scenarios (A1FI and B1) as simulated by two climate models, HadCM3 and PCM. "*" Indicates that northeastward pathways reached dead-end at Strait of Mackinac and hence the distance is underestimated. (Francl et al., 2009)
Figure 22: Modeled changes in mammalian species richness in percentage, under the mild climate scenario, B1 (A) and A2 (B) in a 50km x 50km area mapping units. Red - loss of species richness. Blue - gain in species richness (Levinsky et al., 2007)

Figure 23: Relationships between survey results from five reserves and annual per capita national fish supply in Ghana (a) Annual counts of hunters from 1976 to 1992 (b) Annual change in the biomass of mammals, derived from transect counts and body weights of all species from 1971 to 1998, a value of 1 indicates no change. (Rowcliffe et al., 2005)
**Figure 24**

<table>
<thead>
<tr>
<th>Location</th>
<th>Ungulatesa</th>
<th>Primates</th>
<th>Rodents</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ituri forest, DRC¹</td>
<td>60–95%</td>
<td>5–40%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Makokou, Gabon²</td>
<td>58%</td>
<td>19%</td>
<td>14%</td>
<td>9%</td>
</tr>
<tr>
<td>Dibou, Congo³</td>
<td>70%</td>
<td>17%</td>
<td>9%</td>
<td>4%</td>
</tr>
<tr>
<td>Ekong, Cameroon⁴</td>
<td>85%</td>
<td>4%</td>
<td>6%</td>
<td>5%</td>
</tr>
<tr>
<td>Brazzaville, Congo¹³</td>
<td>76%</td>
<td>8%</td>
<td>6%</td>
<td>10%</td>
</tr>
<tr>
<td>Ouesso, Congo⁵</td>
<td>57%</td>
<td>34%</td>
<td>5%</td>
<td>4%</td>
</tr>
<tr>
<td>Ndoki and Ngatongo, Congo⁶</td>
<td>81–87%</td>
<td>11–16%</td>
<td>2–3%</td>
<td></td>
</tr>
<tr>
<td>Libreville, Port Gentil, Oyem, and Makokou, Gabon⁸</td>
<td>34–61%</td>
<td>20–45%</td>
<td>5–27%</td>
<td>3–12%</td>
</tr>
<tr>
<td>Bioko and Rio Muni, Equatorial Guinea⁹</td>
<td>36–43%</td>
<td>23–25%</td>
<td>31–37%</td>
<td>2–4%</td>
</tr>
<tr>
<td>Dja, Cameroon¹²</td>
<td>88%</td>
<td>3%</td>
<td>5%</td>
<td>4%</td>
</tr>
<tr>
<td>Ekong, Cameroon¹⁰</td>
<td>87%</td>
<td>1%</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td>Olerne, Congo¹¹</td>
<td>62%</td>
<td>38%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 24: Composition of Bushmeat Captured in the Congo Basin (Wilkie & Carpenter, 1999)*

**Figure 25**

![Figure 25: Depth of the tows that captured or did not capture short-beaked common dolphins. (Fernandez-Contreras et al., 2010)](image)

**Figure 26**

<table>
<thead>
<tr>
<th>Mitigation measure</th>
<th>Cruise no. 2</th>
<th>Cruise no. 3</th>
<th>Cruise no. 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>No measure</td>
<td>99 (1.75)</td>
<td>74 (1.06)</td>
<td>32 (0.55)</td>
</tr>
<tr>
<td>Bird-scaring line</td>
<td>2 (0.04)</td>
<td>0 (0.00)</td>
<td>0 (0.00)</td>
</tr>
<tr>
<td>Setting funnel</td>
<td>28 (0.49)</td>
<td>6 (0.08)</td>
<td>*</td>
</tr>
<tr>
<td>Line shooter</td>
<td>*</td>
<td>*</td>
<td>13 (0.22)</td>
</tr>
</tbody>
</table>

*Not tested.

*Figure 26: Numbers and catch rates (number per 1000 hooks in parentheses) of seabirds caught by longlines set with no mitigation measure, bird-scaring line, setting funnel and line shooter. (Lokkeborg, 2000)*

**Figure 27**

![Figure 27: The bird-scaring line. (Lokkeborg, 2000)](image)

**Figure 28**
<table>
<thead>
<tr>
<th>Taxon</th>
<th>Conservation status</th>
<th>Part used</th>
<th>ED treatment a primary use?</th>
<th>More expensive than Viagra?</th>
<th>Viagra has potential?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea cucumbers</td>
<td>10–20 species vulnerable to overexploitation</td>
<td>body</td>
<td>yes</td>
<td>some species</td>
<td>yes</td>
</tr>
<tr>
<td>Pipefishes</td>
<td>1 species critically endangered, 5 vulnerable</td>
<td>body</td>
<td>yes</td>
<td>some species</td>
<td>yes</td>
</tr>
<tr>
<td>Sea horses</td>
<td>1 species endangered, 30 vulnerable</td>
<td>body</td>
<td>yes</td>
<td>some species</td>
<td>yes</td>
</tr>
<tr>
<td>Geckos</td>
<td>many species threatened&lt;sup&gt;1&lt;/sup&gt;</td>
<td>body</td>
<td>yes</td>
<td>some species</td>
<td>yes</td>
</tr>
<tr>
<td>Green turtles, <em>Chelonia mydas</em></td>
<td>endangered&lt;sup&gt;2&lt;/sup&gt;</td>
<td>eggs&lt;sup&gt;3&lt;/sup&gt;</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Deer</td>
<td>many species threatened&lt;sup&gt;4&lt;/sup&gt;</td>
<td>male sex organs, antler velvet</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Pinnipeds</td>
<td>many species threatened&lt;sup&gt;2&lt;/sup&gt;</td>
<td>male sex organs</td>
<td>yes (prior to Viagra)</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Rhinoceroses</td>
<td>many species threatened&lt;sup&gt;6&lt;/sup&gt;</td>
<td>male sex organs, horn&lt;sup&gt;7&lt;/sup&gt;</td>
<td>no</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Tigers</td>
<td>endangered&lt;sup&gt;8&lt;/sup&gt;</td>
<td>male sex organs&lt;sup&gt;9&lt;/sup&gt;</td>
<td>no</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>

Figure 28: Animal taxa of conservation concern that are collected for traditional Chinese medicine treatments for ED. (Von Hippel & Von Hippel, 2002)
### Figure 29: Zootherapeutic Resources
Traded in Three Free Markets of the Federal District, Brazil.

<table>
<thead>
<tr>
<th>Common name/ English name</th>
<th>Probable scientific name</th>
<th>Raw material</th>
<th>Therapeutic use</th>
<th>NC</th>
<th>UV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estrela-do-mar Starfish</td>
<td>Asteroida</td>
<td>Whole</td>
<td>Asthma</td>
<td>1</td>
<td>0.16</td>
</tr>
<tr>
<td>Minhocu-pretta Black earthworm</td>
<td>Oligochaeta</td>
<td>Whole</td>
<td>Schistosomosis, lumps</td>
<td>1</td>
<td>0.16</td>
</tr>
<tr>
<td>Cupim-pretta Black termite</td>
<td>Isoptera</td>
<td>Whole</td>
<td>Tuberculosis</td>
<td>1</td>
<td>0.16</td>
</tr>
<tr>
<td>Oncinha Velvet ant</td>
<td>Multilidae</td>
<td>Whole</td>
<td>Bronchitis</td>
<td>1</td>
<td>0.16</td>
</tr>
<tr>
<td>Besouro-do-amendoim Peanut beetle</td>
<td>Psilobus dermestoides</td>
<td>Whole</td>
<td>Aphrodisiac, energetic reposition</td>
<td>2</td>
<td>0.33</td>
</tr>
<tr>
<td>Jia Frog</td>
<td>Anura</td>
<td>Fat</td>
<td>Rheumatism, depurative</td>
<td>1</td>
<td>0.33</td>
</tr>
<tr>
<td>Arraiá Ray</td>
<td>Condrichthys</td>
<td>Oil</td>
<td>Rheumatism</td>
<td>1</td>
<td>0.16</td>
</tr>
<tr>
<td>Tubaño Shark</td>
<td>Carcharinidae</td>
<td>Cartilage</td>
<td>...</td>
<td>1</td>
<td>0.16</td>
</tr>
<tr>
<td>Cavalo-marinho Seahorse</td>
<td>Hippocampus sp.</td>
<td>Whole</td>
<td>Asthma</td>
<td>1</td>
<td>0.16</td>
</tr>
<tr>
<td>Peixe-elétrico Electric fish</td>
<td>Electrophorus electricus</td>
<td>Fat</td>
<td>Rheumatism</td>
<td>1</td>
<td>0.16</td>
</tr>
<tr>
<td>Sucuri Anaconda</td>
<td>Eincthes sp.</td>
<td>Oil</td>
<td>Rheumatism</td>
<td>2</td>
<td>0.33</td>
</tr>
<tr>
<td>Cascavel Rattlesnake</td>
<td>Croalio durissus</td>
<td>Oil</td>
<td>Bronchitis, arthritis, joint problems, cancer, back-aches</td>
<td>5</td>
<td>0.83</td>
</tr>
<tr>
<td>Jibóia Boa</td>
<td>Boa constrictor</td>
<td>Oil</td>
<td>Rheumatism</td>
<td>1</td>
<td>0.16</td>
</tr>
<tr>
<td>Tiu Tegu lizard</td>
<td>Tupinambis sp.</td>
<td>Oil</td>
<td>Earache, deafness</td>
<td>2</td>
<td>0.33</td>
</tr>
<tr>
<td>Tartaruga Turtle</td>
<td>Chelidae</td>
<td>Oil</td>
<td>Rheumatism</td>
<td>1</td>
<td>0.16</td>
</tr>
<tr>
<td>Jacaré Alligator</td>
<td>Crocodilidae</td>
<td>Dried skin, oil</td>
<td>Rheumatism</td>
<td>3</td>
<td>1.0</td>
</tr>
<tr>
<td>Galinha-d’angola Helmeted guinea fowl</td>
<td>Numida meleagris</td>
<td>Fat</td>
<td>Influenza, bronchitis</td>
<td>1</td>
<td>0.16</td>
</tr>
<tr>
<td>Galinha-caipira Chicken</td>
<td>Gallus gallus</td>
<td>Oil</td>
<td>Influenza, asthma, bronchitis, expectorant</td>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>Urubu Vulture</td>
<td>Catharidae</td>
<td>Feather liver (bile), oil,izzard</td>
<td>Alcohologism</td>
<td>2</td>
<td>1.33</td>
</tr>
</tbody>
</table>

Figure 30: Map depicting the historic and present range of Tigers in Asia (Verheij, Foley & Engel, 2010)
Figure 31: Cumulative number of Javan hawk eagles in trade from 1975 to 2006, suggesting an increase in numbers after the species was declared National Rare/Precious Animal in 1993. (Nijman et al., 2009)

Figure 32: Number of species according to their CITES status (Eid et al., 2011)

Figure 33: Breakdown of the major threats to amphibians, birds, cartilaginous fishes, crabs and crayfish, dragonflies, endemic freshwater fishes, mammals (including marine mammals) and reptiles in the Mediterranean. (Vie et al., 2008)
Figure 34: Proportion of all known birds, mammals and amphibians by threat status (i.e., threatened (CR), not threatened (NT) and Data Deficient (DD)) and used for food and medicine (a); and a comparison of threat status of species used for food and medicine against threat status for those species not used in this way (b). (Vie et al., 2008)

Figure 35: Basic design of wind turbine. www.windpowerturbines.info/wp-content/uploads
Figure 36: Allowances distribution by sector from 2012 through 2035 (Environment Northeast 2009).

Figure 37: Growth in U.S. Greenhouse Gas Emissions by Gas: 1990–2007. In 2007, total U.S. greenhouse gas emissions rose to 7,150.1 Tg CO₂ Eq., which was 17 percent above 1990 emissions, and 0.6 percent above 2005 emissions (U.S. Climate Action Report 2010).