THE GLOBAL WARMING WILDLIFE SURVIVAL ACT
(S. 2204)

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Executive Summary

Climate change is an impending reality that will adversely affect wildlife. According to the Intergovernmental Panel on Climate Change (IPCC), ambient temperatures will increase by at least 1.5-2.5° C by the end of the century. This rapid rise in temperature will have extensive impacts on ecosystems throughout the United States. Climate change will contribute to habitat fragmentation, alter the composition of habitats, change the spatial ranges of species, and disrupt phenological events. Moreover, sea level rise and ocean acidification will threaten organisms in marine systems and coastal regions. In addition to these direct effects, climate change will also increase the range of pests and pathogens, which will further jeopardize the health of imperiled species. All together, climate change will threaten biodiversity and crucial ecosystem services, making it an imminent concern for wildlife management policy. Without human intervention, many species will go extinct due to the effects of climate change.

The Global Warming Wildlife Survival Act seeks to address the negative impacts of climate change on wildlife. Title I of the Act requires the Secretary of the Interior to establish a national strategy for addressing these impacts. An Advisory Board of scientists from relevant fields will be created to advise the Secretary and inform the national strategy. Under this title, the Secretary will also create a National Global Warming and Wildlife Science Center as well as grant programs for further research on the effects of climate change on wildlife. Title II covers ocean programs, which address sea level rise and ocean acidification. Under this title, the Secretary must develop a national strategy for addressing the impacts of climate change on oceans and marine life. Title III of the Global Warming Wildlife Survival Act provides special consideration for imperiled species, and it instructs the Secretary to hold national symposia to determine the impact of global warming on imperiled species.

The solutions addressed by the legislation focus on entire ecosystems by seeking to mitigate the impacts of climate change not only on species, but also on their habitats. Proposed solutions will focus on increasing biodiversity and ecosystem resilience in affected areas. The legislation addresses the importance of establishing effective monitoring programs and proposes a number of traditional conservation techniques for implementation, such as wildlife refuges, assisted migration programs, and wildlife corridors. New strategies will also be devised under the research provisions of the act to address controversies and deficiencies of these traditional methods in the face of uncertain climate change.

The ultimate goal of the Act is survival of species, which encompasses both protection and recovery against the negative impacts of climate change. Recovery of a species is defined as one that exhibits stable or growing populations, decreases in threats, and a low risk of extinction. When measuring the success of the Act, mere survival of a species is an unsuitable measure because a species could be deemed surviving even if only a few individuals remain. Thus, other demographic factors must be taken into account.

Through creation of an institutional framework and consideration of specific species recovery schemes, this Act creates a foundation for improving species survival in the face of global warming. While the legislation is by no means a comprehensive solution, it lays crucial groundwork for mitigating the effects of climate change on wildlife.

Introduction

The Intergovernmental Panel on Climate Change's (IPCC) 4th report in 2007 confirmed that anthropogenic activity is causing large-scale climate changes. The most apparent changes are steep rises in ambient and sea surface temperatures. These climate changes are likely to have negative impacts on wildlife. Based on mid-range climate estimates for 2050, 15-37% of species will be "committed to extinction"(Thomas, 2004). A species' biological traits, community interactions, and habitat are strongly influenced by climate. Therefore, changes in climate will force wildlife to change as well. The accelerated rate at which these changes are occurring will preclude most evolutionary adaptation to changing circumstances. Anthropogenic destruction of habitat has exacerbated the problem. The purpose of the Global Warming Wildlife Survival Act (Act) is to establish a national strategy for the United States to aid wildlife in adapting to climate change. This national strategy will inform all federal land and wildlife management decisions in the hopes of preserving biodiversity (S. 2204, 2007).

The Environmental Problem

Global warming is the change in the annual mean surface temperature and related aspects of climate over a considerable period of time that are attributed directly or indirectly to human activity. Anthropogenic activity affects climate by increasing the amount of greenhouse gases, namely carbon dioxide (CO2), nitrous oxide (N_2O), methane (CH_4), hydroflourocarbons (HFCs), perflourocarbons (PFCs), and sulfur hexafluoride (SF_6), present in the atmosphere (IPCC, Working Group II, 2007). These gases act as a blanket to absorb infrared radiation, or heat emitted from the Earth's surface, which warms the Earth's surface. During the last century, Earth's temperature has risen by 1.5°C and scientists predict that the global temperatures will continue to increase another 3-15°C by the end of this century (Houghton, 1997).

In North America, the annual mean warming is likely to exceed global mean warming in most areas. This warming is likely to be the greatest in Northern areas in the winter and in the Southwest in the summer. Precipitation is very likely to increase in the Northeast United States and decrease in the Southwest. The lengths of the snow season and snow depth are very likely to decrease over the entire United States (Christensen, 2007). Changes in climate will also result in increased frequency and intensity of extreme weather events such as tornadoes, droughts, or floods. Elevated concentrations of greenhouse gases have also contributed to the acidification of the world's oceans. When carbon dioxide comes into contact with the oceans it produces carbonic acid. Increased concentrations of carbon dioxide, increases the amount of carbonic acid produced, reducing the overall pH of the oceans, thus rendering the oceans more acidic (Caldeira, 2003).

The changes in climate observed over the last century are already affecting wildlife worldwide. Anthropogenic climate change is occurring on a much more rapid time scale than natural variation. As such, ecosystems have a reduced capacity to adapt to these changes (Harley, 1999; Houghton, 1997). Because the rate at which climate change will occur is still uncertain, it is difficult to predict whether species will be able to adjust their ranges fast enough to account for these changes (IPCC, Working Group II, 2007). Over the past century, scientists have observed changes in species distribution or phenotypic variation in as much as 59% of the 1,598 observed species. The majority of observed changes were in the direction dictated by climate change, strongly suggesting that these changes are connected to climate (Parmesan, 2006). In its latest report, the IPCC Working Group II stated that 20-30% of plant and animal species assessed so far are likely to be at risk of extinction if global average temperatures increase by more than 1.5-2.5°C (IPCC, Working Group II, 2007).

In North America, scientists expect terrestrial species ranges to continue to shift northward and upward in altitude as temperatures continue to rise (IPCC, 2002). On average, range boundaries moved 6.1 kilometers per decade northward or 6.1 meters per decade upward. If northern range boundaries are restricted the loss of suitable habitat at southern boundaries causes absolute range size to be reduced, increasing species' risk of extinction (Parmesan, 2006). Polar species and species occupying tops of mountain habitats are especially at risk because there is no additional habitat to which then can migrate. Fragmentation of suitable habitat and lack of migration corridors will also be an issue as species attempt to move to remain within favorable conditions (IPCC, 2002). In Alaska, tundra will likely disappear from the mainland, leading to a loss of crucial habitats for migratory waterfowl and mammal breeding. The loss of this habitat will also lead to loss of animal and plant species used by indigenous peoples. Other unique ecosystems such as prairie wetlands, coastal salt marshes, and arid landscapes are especially vulnerable to climate change.

Effective adaptation is unlikely for species adapted to specific narrow habitats (IPCC, 2002). The timing of phenological events, such as migration, is also expected to change. Earlier spring arrivals of both bird and insect species have already been observed, with an average spring advancement of 2.3 days per decade (Parmesan, 2006). Phenological changes can lead to mismatches in seasonal events, such as the arrival of species and the availability of their food sources (IPCC, 2002).

Marine habitats will be affected by rising temperatures, resultant sea level rise and changes in precipitation (IPCC, 2002). Waters off the coast of California have warmed 2°C over the last century causing a significant increase in southern-range ocean species and a decrease in northern-range ocean species (Parmesan, 2006). In Louisiana, Florida, and on the Atlantic coast of the U.S., sea level rise and increased storm surges will lead to increased coastal erosion, coastal flooding and saltwater intrusion. The IPCC predicts that 50% of North American coastal wetlands could be inundated. Stream fish habitats are expected to decline by 47% for cold-water species, 50% for cool-water, and 14% for warm-water species. The Great Plains region is already experiencing summer water temperatures near lethal limits for stream fish. In western North America, snowmelt dominated watersheds will experience earlier than normal spring flows and reductions in overall flows, affecting freshwater aquatic species (IPCC, 2002).

The northward and upward movement of pest species and diseases will also affect wildlife (Parmesan, 2006). As temperatures increase, pests are able to expand their ranges, exposing organisms which have never come into contact with these threats before. Humans are also at risk from this change, as pests such as mosquitoes expand their range, carrying diseases such as West Nile virus. The concern of tropical pests migrating to new climes increases as the temperature ranges shift and warmer weather becomes more prevalent in northern regions (Parmesan, 2006). Vectors for emerging pathogens are already expanding in range. The emergence of West Nile Virus is an example how the expanding ranges of pathogen vectors will impact public and animal health. Aedes spp. and Culex spp. are common mosquito vectors capable of transmitting West Nile Virus in the United States. In just nine years West Nile Virus has spread across the United States from New York City to Washington State. Cervids such as deer are primarily affected, but raptors and multiple other bird species are susceptible to the virus as well. While livestock, pets and people are all susceptible to West Nile virus currently there is only a vaccine available for horses (CDC, 2008).

Why is Action Needed?

Wildlife is critical to the overall functioning of the planet, as well as significant contributors to the economic value of the planet. In a seminal paper on the value of ecosystem services, Costanza and colleagues identified many areas in which wildlife contribute to ecosystem services. Ecosystem services are undervalued because they are not included in traditional economic market systems, nor are they normally thought of in quantifiable economic terms (Costanza, 1997).

Wildlife contribute to ecosystem services in a variety of ways. Insects such as bees and butterflies pollinate crops. Fish and game also contribute direct value to the human food supply. Furthermore, many species of wildlife provide biological controls for other species such as keystone predator controls of prey species and herbivore control of plant species. Wildlife also contribute to the genetic resources available for researchers studying new medicines and materials for the advancement of human health. Recreational activities are often dependent on the presence of wildlife, including eco-tourism and sport fishing. In some cultures, wildlife also contribute to the spiritual health of the human population (Costanza, 1997).

Because the impacts of global climate change are so widespread, many species of wildlife will not be able to adapt to these changes without human intervention. No policy to date is suited to preventing the impacts of climate change from adversely affecting wildlife (Rohlf, 2005). In the U.S., natural resource managers lack the information needed to make informed policy decisions about wildlife management. Without this baseline information, all decisions about wildlife management become reactionary. Comprehensive monitoring systems and models to predict future changes are needed for effective management (GAO, 2007). A new policy is needed that builds on the groundwork laid by past wildlife management legislation. For instance, the Endangered Species Act of 1973 (ESA) protects species and their habitat only after it has been demonstrated that their numbers are dwindling. Even for species currently protected under the ESA, there is no explicit consideration of how climate change may affect them (Rohlf, 2005).

A Solution: The Global Warming Wildlife Survival Act

The Global Warming Wildlife Survival Act (Act) addresses the effects of climate change on wildlife by requiring the Secretary of the Interior to "establish a national strategy for assisting wildlife populations and habitats in adapting to the impact of global warming (S. 2204, 2007)." Under the Act, wildlife is defined as "any species of wild, free-ranging fauna including fish and other aquatic species and any fauna in a captive breeding program." Title I of the Act requires that the national strategy should be based on the best available science, provided to the Secretary by an Advisory Board (Board). The Board will be composed of ten to twenty members with expertise in a variety of disciplines, including wildlife biology, ecology, and climate change and the Director of the National Global Warming and Wildlife Science Center, also established under the Act. The Secretary should consult with state and local agencies, and provide an opportunity for public comment when establishing the national strategy. The strategy should include goals and plans for implementation, including relevant timeframes. The national strategy should then be incorporated into all subsequent federal land management policies and plans. Since the federal government manages approximately 30% of U.S. land area, this provision will result in substantial application of the research and implementation conservation and recovery programs (S. 2204, 2007). After five years, and every ten years thereafter, the national strategy should be revised to reflect the most up to date information.

The Secretary must also establish the National Global Warming and Wildlife Survival Center, which will coordinate scientific research on national issues relating to the impact of global warming on wildlife, wildlife habitat and mechanisms for adaptation, and the mitigation of negative impacts. The Act will also establish a grant program for federal and state agencies, territories, regional partnerships, Indian tribes, universities and conservation organizations. Successful grants will seek to improve the conditions of the species considered, be broad in geographic scope, and be cost effective (S. 2204, 2007).

Allocation of funding for Title I is divided into three categories. Federal agencies will receive 45% of the budget to develop and implement the national strategy. Twenty-five percent of funds will be available to federal agencies to carry out the national strategy through the implementation of fish and wildlife programs. The remaining 30% will be made available in the form of grants to States and Indian tribes for carrying out adaptation programs or revising current wildlife assistance plans (S. 2204, 2007).

Title II of the Act covers ocean programs, which addresses the issues related to sea level rise and ocean acidification. The act recognizes that healthy ecosystems are more resilient than degraded ecosystems and that the natural resources found in coastal, ocean, and Great Lakes ecosystems will be jeopardized by the impacts of global warming. The Secretary is required to establish a national strategy to "protect, maintain, and restore coastal and marine ecosystems" (S. 2204, 2007). The strategy should include measures to "avoid, alleviate, or mitigate" the impacts of global warming, including sea level rise and ocean acidification. Title II also includes provisions for the development of offshore alternative energy programs as well as carbon capture and sequestration activities (S. 2204, 2007).

Title II also adds an amendment to the already existing Coastal Zone Management Act of 1972. Termed "Section 320: Climate Change Resiliency Planning," the amendment establishes the conditions of eligibility of coastal states for federal assistance. Federal help is proposed in the form of financial grants, technical assistance, and/or general help in the development and implementation of plans to mitigate changes in coastal species' resiliency in response to climate change (S. 2204, 2007).

Title III of the Act provides for a Special Imperiled Species Program. Imperiled species are defined as species listed under the ESA, species proposed for listing under the ESA, candidate species under the ESA, species listed as endangered under any state law, or species whose populations are declining at a significant rate. The Secretary must convene scientific symposia to examine the ecological impact of global warming on each imperiled species. The reports produced from these symposia should include an assessment of the impact of global warming on each imperiled species, recommendations for federal, state, and local agencies in assisting imperiled species in adapting to global warming, and other relevant ecological information (S. 2204, 2007).

Overall, the central focus of the Act is research. The Secretary is required to develop the national strategy in cooperation with scientists from a variety of disciplines as well as state, local, and tribal governments. This cooperative structure enforces an overarching management framework, coordinating all existing institutions and legislation. This system will provide a centralized source of information through the Science Center, reduce research costs, clearly define stakeholders, and maximize the impact of government funding by working with existing entities. While the solution is essentially administrative, it is somewhat vague which may lead to difficulties in implementation. Communication and coordination between entities may also prove to be costly and time consuming. However, vague policy allows for adaptive strategies, which will be necessary in dealing with climate change. (S. 2204, 2007).

Science of the Proposed Solutions

The focus of these solutions is preserving biodiversity, which is linked to ecosystem resilience. Ecosystem resilience is defined as an ecosystem's capacity to recover from disturbances and to retain ecosystem functions despite environmental stresses, such as ocean acidification or fluctuating ambient temperatures. Additionally, the stability of ecosystems can be disturbed through the loss of a single keystone species (Hughes T. P., 2005). Increased biodiversity can boost ecosystem resilience (Levin S.A., 2008). Initial monitoring efforts should focus on indicator species that can serve as a gauge of ecosystem health. Collecting demographic information will allow analysts to predict future population trends and extinction risks. The assessment of the current "on the ground" situation of species and their habitats will enable scientists to effectively prioritize management actions in order to maximize biodiversity conservation (Campbell, 2002).

In addition to monitoring, proposed programs for the mitigation of climate change effects on terrestrial wildlife include the creation of wildlife refuges, assisted migration, and the establishment of migration corridors. The overarching concern with solutions is a lack of certainty. The most volatile arguments surround modeling of regional climate variability. Developing precise regional models is extremely difficult as there is a significant margin of error, and this complicates the development of policies and requires adaptive actions. Challenges in estimating the timing of climate change events also complicates the establishment of timetables for program implementation. It will also be difficult to convince the public that the benefits of these programs will exceed the costs because the economic burden is immediate, while the benefits are delayed (Smith, 1997).

Proposed techniques to assist wildlife also have inherent risks that must be considered before any conservation activities are initiated. Pathogens and invasive plant and animal species may accidentally be introduced or moved across boundaries that were previously impenetrable due to altitude, distance or other natural barriers. If a particular species is near the brink of extinction, introducing a pathogen may be enough to push the dwindling population into extinction (Parmesan, 2006).

Creation of Wildlife Refuges

Global warming is expected to modify the ranges of certain animals, which will tend to migrate towards northern latitudes or upward in altitude to remain within their suitable temperature niches. However, it is unlikely that the location of these new habitats will coincide with currently protected lands. Research programs should be established to determine the climatic conditions in which species have thrived historically and to model a projection of geographic locations where these conditions will occur in the future. Such projections can then be used to establish appropriate refuges for an altered climate. In addition, habitat buffer zones should be created around areas that are particularly impacted by anthropogenic activities linked to climate change. For example, human-caused wildfires are likely to increase in regions where climate change reduces precipitation (Intergovernmental Panel on Climate Change, 2007). The creation of habitat buffers directly protects ecosystems and habitats from anthropogenic activities. Additionally, buffer zones around existing habitats will be necessary for populations to be able to move on their own as a response to habitat shifts (Hilbert, 2007).

Refuges may be unable to effectively mitigate the effects of climate change because of their static nature. Climate change causes variations in the range of wildlife, so refuges with static boundaries could be costly and ineffective. Given the extent of human development in the U.S., it would be virtually impossible to create mobile or flexible refuge boundaries. Theoretically, the expansion of current refuges would be a possibility, but only if we could accurately determine a refuge size that is large enough to provide alternate habitat range. This solution may be the most cost effective, in that it would primarily use existing range areas and infrastructure (Zimmer, 2007).

Assisted Migration

In cases where wildlife is particularly imperiled, assisted migration could be used to move individuals from one area to another. This can be accomplished through two processes. Reintroduction is a process by which individuals or populations are returned to a historical habitat from which they were displaced. Relocation is the movement of populations to new areas with increased likelihood of survival under altered climate conditions. Reintroduction and relocation contribute to increasing intra- and inter-species diversity by increasing diversity both within a population and the diversity of species in a habitat or ecosystem. Increasing the number of individuals within a population or managing gene flow through assisted migration can reduce inbreeding and promote genetic diversity, which also contributes to healthier population dynamics and increased resilience. Conserving interaction networks between species is a key factor in maintaining community dynamics, which may increase overall ecosystem resilience (Dodd, 1991; McFadden, 2008).

Reintroduction and relocation can become problematic when trying to decide which species to relocate. Not all at risk species can be moved because of ecological concerns, cost concerns, and the issue of cost allocation. In recent years, individual groups have been responsible for a particular species relocation. In order to promote more homogeneous management approaches, actions actions should be planned in accordance with the national strategy. There is also a risk in simply moving one species because that species is part of an interconnected ecological environment. The Act must also examine the viability of moving entire networks of interconnected species. Unfortunately, there is little practical knowledge or experience in the scientific community with regard to the movement of an entire species (Hunter, 2007).

Wildlife Corridors

In areas affected by anthropogenic fragmentation, such as road construction, a specific type of assisted migration, which consists of the creation of corridors and linkages, should be implemented. These are designed to connect populations that live in patchy or fragmented habitats (Bond, 2003). The creation of corridors between patches promotes the movement of individuals and populations from one area to another. This movement allows genetic mixing, thus promoting genetic diversity. Higher mobility of individuals throughout suitable habitats reduces wildlife vulnerability to localized disturbance of certain patches. Species are able to migrate through corridors and other areas to avoid predation or look for food sources (Young, 2006; McFadden, 2008). Corridors may be constructed in previously developed areas. This helps avoid biodiversity loss, but poses the dilemma of retrofitting developments as well as repurchasing roads and structures to build corridors, which can be very expensive. Another option is to set aside undeveloped land for migration corridors. This option is much less costly since it is a preventative measure, but it may not be sufficient if barriers to migration have already negatively impacted species or ecosystems and thus may not be worth the investment (Smith, 1997).

Marine Systems

The main problems associated with marine habitats are ocean acidification and sea level rise. Mitigation of these effects is especially difficult because of our limited understanding of marine ecosystems. Traditional wildlife management tools such as relocation and refuges are relatively ineffective in marine environments. Because there are no natural barriers in oceans, marine organisms cannot be sequestered in one area. For sessile species such as corals, relocation may be a viable alternative for some faster growing species (Mayor). The adverse effects of ocean acidification and sea level rise are challenging in part because they are global issues. Ocean acidification is accepted as a consequence of global warming; drastic measures would need to be taken by the majority of polluting countries to reduce CO_2 emissions in order to mitigate these effects.

The regional effects of ocean acidification are tied to changes in the direction and intensity of water currents, pH perturbations, and atmospheric CO_2 concentrations. A rise in sea surface temperatures is thought to lead to coral reef bleaching; however there is no conclusive data on what levels of CO_2 will lead to temperature increases that cause bleaching. This makes it difficult for policy makers to effectively plan and implement mitigation efforts.

The most important direct physical effects of a significant rise in mean sea level include coastal erosion, shoreline inundation, and saltwater intrusion, primarily into estuaries and aquifers. Methods used to mitigate these phenomena vary according to the physical and socio-economic features of an area. For example, approaches taken in an open coastline with a high-cliff beach would differ from those taken in a long, narrow estuary used as a commercial port. Mitigation efforts range from development of tidal barriers, to rehabilitation of natural features such as barrier islands. The U.S. has approximately 12,383 miles of coastline and the implementation of these methods would be complicated and costly (Sorenson, 1984).

Measuring the Success of the Global Warming Wildlife Survival Act

Mere implementation of these wildlife plans will not ensure that efforts to improve adaptation will be successful. The Act establishes a framework of research tools and policy initiatives to protect wildlife and their habitats against the negative impacts of climate change. In order to evaluate the efficacy of this framework, it is necessary to define success and delineate several parameters to measure the outcomes. The goal of the Act is defined as recovery of a species compromised by climate change or protection of a species against the impacts of climate change. The Act should seek to avoid the pitfalls inherent in the ESA's definition of full recovery as the only measure of success. A recovered species exhibits an increase in the number of stable or growing populations, a decrease in threats against the population, and low risks of extinction. However, survival alone is an unsuitable measure of success. Benchmark goals for both species and habitat preservation should be established as well. Demographic considerations such as the size of the population, age structure, and sex ratios must also be evaluated. Habitat integrity and other threats such as an increase in the number of predators must also be taken into account (Campbell, 2002). A cumulative assessment of all of these factors will allow for a more complete picture of a population's status (Primack, 2004).

Effective monitoring techniques are needed in order to assess the parameters for a population. A variety of techniques can be employed for this purpose. The capture-mark-recapture (CMR) method involves tagging animals, releasing them, and then capturing the same animals again (Pradel, 1996). DNA-based CMR is a similar process, but researchers use DNA from hair or other samples to identify animals. This method has the benefit of being non-invasive and does not require physical capture (Schwartz, 2007). Another DNA-based method of monitoring involves studying mitochondrial DNA and variable genes to analyze the scope of a species' distribution (Hedrick, 1992). Lastly, since it is impossible to monitor all species in an ecosystem, an indicator species can be monitored in order to assess the condition of an ecosystem and other associated species. This is accomplished through monitoring the species' interactions within the ecosystem or with other species (Lindenmayer, 1999).

The ESA serves as a model for the measurement of success of the Act, since many of the same metrics of success will be employed. The ESA seeks to measure recovery of a species in response to Endangered Species listing and subsequent protective policies. Likewise, the Act will gauge recovery or protection of a species in response to the negative effects of climate change. The success of the ESA is challenged by its requirement to be measured on a long time scale and by its methods of data collection (Suckling, 2006). The Act will encounter the same data collection and interpretation difficulties as the ESA.

Case Study: American pika

American pikas are small terrestrial mammals that live on the rock-strewn talus slopes of mountains. Rocks on these slopes provide shade for relief from high temperatures and protection from predators. The home range of the pika is especially small, usually only 800 meters in radius. Pikas have dense fur, which prevents them from dissipating heat easily (Grayson, 2005). All of these factors make American pikas vulnerable to the effects of global warming. Found as low as 7,800 feet in 1910, pikas now cannot be found below 9,500 feet in Yosemite National Park (Niijhuis, 2005). While scientists expected mountain species would simply move up mountain slopes as temperatures warmed, the pika is not making the move successfully due to its limited dispersal ability and lack of suitable habitat. In the mountains of the Great Basin, a warming of 3°C is predicted to cause the loss of 9-62% of all mountain species and the extinction of three out of fourteen pika populations throughout the region. Seven of the twenty-five documented pika populations in the Great Basin were extinct by the end of the 20^{th} century (Beever, 2003).

Pikas are highly active throughout the year so they must gather and store vegetation throughout the summer for over-winter survival. However, warm temperatures force pikas to retreat into cool, shady areas, reducing the amount of time spent collecting food. If they remain active in warmer temperatures this can lead to direct thermal stress. Pikas are unable to survive even six hours in temperatures of 25°C when they cannot behaviorally thermoregulate by retreating to the shade. This also affects their ability to migrate to better habitats because they cannot migrate through lower elevation valleys to access other suitable habitat. Early maturation of vegetation associated with increased temperatures can also affect food availability (Grayson, 2005; Beever, 2003).

Scientists are especially concerned about the loss of the pika because it has been likened to the "canary in the coal mine" of climate change's effect on wildlife. Scientists had assumed that alpine and sub-alpine systems were not at risk from human activities because of their extreme isolation. As the pikas were locally abundant, the response of these populations is a direct signal of changes in these ecosystems. Thus, alterations of distribution of the pika population are directly driven by anthropogenic climate change and attendant impacts on vegetation. The extinction of pika could also have a cascading effect on its predators such as the ermine, eagles, foxes, and bears (Beever, 2003).

One suggested solution for the American pika is to relocate entire populations to more northern regions, such as Canada. Pika populations are appropriate for relocation because warming has rendered their habitats unsuitable, and they are unable to relocate without human intervention (Bertrand, 2008). The proposal is controversial because of the considerable risks associated with the introduction of a new species. Pikas may carry pests and pathogens, or they may become an invasive species in their new habitat. The significant cost of relocation is also a concern, especially because such efforts have variable results. While the relocation of the American pika may be risky, the costs should be weighed against possible extinction (Hoegh-Guldberg, 2008).

Case Study: Hawaiian Coral Reefs

Coral reefs are among the most productive and diverse ecosystems on Earth. Reefs are large structures made of calcium carbonate, deposited over thousands of years. They serve as important habitat for many marine species, providing food, shelter, and breeding grounds (Hickman, 1998). Coral reefs also contribute $6,057 per hectare per year in ecosystem services, mainly through disturbance regulation, recreation, and food production (Costanza, 1997). In 2002, coral reefs contributed $360 million to the GDP of Hawaii (NOAA, 2008). Reefs are subject to a number of climate change threats including elevated sea surface temperature and ocean acidification. Coral bleaching events have been increasing across the globe since the 1980s, occurring more often and becoming more widespread. These bleaching events are a direct result of increased sea surface temperatures caused by anthropogenic climate change (Jokiel, 2004).

In the summers of 1996 and 2002, coral reefs off the coast of Hawaii suffered major bleaching events due to an average sea surface temperature increase of 11°C (Jokiel, 2004). Mutualistic algae called zooxanthellae live in the coral tissue, where they produce sugars and nutrients from solar energy, providing 95% of the metabolic requirements of the host. When temperatures exceed summer maxima by 1 to 2°C for 3-4 weeks, the zooxanthellae may die or be expelled (Hickman, 1998). The loss of these algae is termed coral bleaching. There is high mortality among bleached corals. Some coral may survive and recover the zooxanthellae but the system will still show reduced growth, calcification, and fecundity. Increasing acidification can also lead to decreased coral calcification. Under acidified conditions, the reef will either continue to reproduce, with reduced skeletal density, making it more susceptible to breakage, or use more energy for calcification and less for reproduction. In either case, the result is a loss of productivity in the reef system. The losses of corals themselves also harm the other species that use the reefs as a habitat and nurseries (Jokiel, 2004).

As explained above, traditional conservation techniques such as assisted migration are not practical for assisting coral in adaptation to climate change, except in very limited circumstances (Mayor). There is no current solution for assisting coral reefs in adapting to climate change. The research component of the Act is so important because of the need to address these types of issues.

Conclusions

Anthropogenic climate change is already affecting wildlife in the United States. Movements of habitat range both northward, and upward in altitude as well as the advancements of seasonal events such as migrations are just the beginning. Without some form of intervention, 15-37% of species will be committed to extinction. The Global Warming Wildlife Survival Act seeks to aid wildlife in adapting to the effects of climate change. The Act seeks to devise a national strategy for dealing with this issue, and provides funding for increased research. While traditional methods of wildlife conservation will be used in these efforts the Act provides funding for increased research to develop better adaptive strategies. Wildlife and their habitats provide critical ecosystem services for humans. The Act will help to preserve these systems in the face of the ever-growing threat to biodiversity from climate change.

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