Effects of Climate Change on Protected Areas

Protected areas are the most common and most important strategy for biodiversity conservation. However, global climate change will lead to a changing relationship between the shifting ranges of plant and animal species, and the fixed boundaries of protected areas (Hannah 2008). The majority of protected areas are designed to represent and protect specific natural features, species, and communities. However, as temperature, precipitation, fire, and carbon dioxide (CO_2) regimes change, species are moving, plant and animal communities are being reassembled, and iconic landscapes are changing or disappearing.

Protected areas may be some of the most sensitive regions of the planet to changes in climate. They are often small isolated fragments in the midst of degraded or developed landscapes, and they often contain rare or unique species and communities with narrow environmental tolerances. Alpine regions are also a prominent feature of many protected areas, and these are some of the most sensitive to warming temperatures, with many cold-adapted species that depend on glaciers and snowpack (Bunn 2009) At the same time, protected areas, and especially wilderness, may have fewer available options for adaptation, since the ability to manipulate or intervene in these landscapes may be limited by law and policy. The unavailability of particular adaptation strategies may in large part determine the magnitude of ecosystem change and management objectives. However, hands-off approaches may lead to less-effective and more expensive last-minute emergency adaptation and increased vulnerability to rapid change (Scott & Lemieux 2005).

This summary identifies the major effects that climate change is likely to have for protected areas, and then discusses the implications of climate change for the future of protected area design and management.

Effects on species

A primary concern for protected area managers is that some species may be moving out of the reserves, parks, and wildernesses designated to protect them. There is good evidence that recent and ongoing climate change is leading to rapid changes in the distributions of species. These can be movements of species into areas where they were not previously found, the disappearance of species from a region where they once were, or a shift in the abundance and distribution of individuals within a species range (Parmesan 2006). Many of these range shifts are in the direction of the poles, especially in highly mobile species. Other species are moving steadily upward in elevation, which may lead to a shrinking of the species range, as species are limited in their ability to move upwards, or an extension of ranges as low-elevation species expand upwards (Moritz 2008, Wilson 2011). Changes in species distribution depend on the ability of a species to move into new territory and a species' poor dispersal abilities, or fragmented or degraded habitat surrounding current ranges and protected areas may lead to shrinking species ranges, rather than range shifts (Thomas et al 2004, Root and Schneider 2006). Even species that are not directly affected by climate may be strongly affected by predators, prey, pollinators, and competitors whose ranges do experience climate-induced shifts (Thomas 2010). Change in predator-prey, plant-herbivore, and pollinator relationships can lead to the partial or complete transformation of the species in an area (Wang 2002, Frelich 2009). National parks in the U.S. may lose up to 20% of the mammal species currently within their boundaries if atmospheric levels of carbon dioxide were to double (Burns 2003).

If species' future ranges move outside protected areas, and species cannot migrate to new regions due to fragmented or degraded landscapes, or suitable habitat becomes too scarce, populations and species may face extinction. A 2004 model of the associations between climate and species distributions worldwide found that, under many climate change scenarios, 21-52% of species would completely lose their habitat (Thomas 2004). Especially at risk are species with small, localized ranges or specific habitat requirements, populations on the edges of species ranges, species in fragmented landscapes, and poor dispersers (Griffith 2009). Researchers have already seen the disappearance of local populations or severe population reduction in a number of charismatic or endangered species, including white-tailed ptarmigans in Rocky Mountain National Park and bighorn sheep in parks and preserves in California and the southwestern US (Saunders 2007).

Effects on ecosystems

Shifting species ranges, in concert with direct changes to the physical environment such as increasing fire regimes and melting glaciers, may lead to protected areas that look very different from current and historical landscapes. In many cases, these changes may lead to the emergence of new ecosystems. In the southwestern US, regions of former grassland have become shrubland as a result of changing precipitation patterns, and shortgrass steppe in Colorado is in the process of making this change, as higher temperatures are leading to decreasing productivity of dominant native grasses (McCarty 2001). Models of the interaction between climate and ecosystems have shown that more than 40% of all protected areas in Canada are expected to experience a major change in vegetation (Lemieux and Scott 2005). In US National Parks, models predict that boreal forests could be replaced by temperate evergreen forests, shrub steppes, and savanna woodlands in Grand Teton, Rocky Mountain, and Yellowstone National Parks, and shrub steppes could largely be replaced by savanna woodlands and grasslands across the Colorado Plateau, including Arches and Bryce Canyon National Parks (Saunders 2007).

Changes in fire and precipitation regimes may drive or accelerate shifts from one ecosystem state to another. There is a projected global increase in fire potential on many continents around the world, through different combinations of increases in temperature and changes in precipitation patterns (Liu 2010). Area burned in the Western US and in boreal forests is predicted to double by the end of the century, even in mild climate-change scenarios (McKenzie 2004, Flannigan 2009). Increased temperatures will also likely extend fire seasons by up to several weeks in many areas of the US, and some fire-prone landscapes may experience fire year-round (Liu 2010).

Changes in fire regimes will lead to changes in the abundance and distribution of dominant plant species in many protected areas. Increased fire frequency will favor fire-dependent or fire-tolerant species, leading toward changes in species composition (Noss 2001). For example, models predict the conversion of shubland and chapparal to annual grasslands due to increased fire re-occurrence (McKenzie 2004). In some ecosystems, changing frequency and severity of fires may alter age and stand structure of vegetation. For example, increasing fire frequency in Yellowstone could replace old and mixed stands with more uniform younger stands, with effects on habitat connectivity and plant and wildlife conservation (Romme 1991). In other ecosystems, changing fire regimes may trigger a shift between existing ecosystems. For example, Wind Cave National Park lies at the border of ponderosa forest and mixed grass prairie, and the two communities coexist due to the current fire regime. Climatic warming would increase fire frequency, and could shift the system away from forest toward more open grasslands and woodlands (Bachelet 2000).

Climate change will also likely disrupt patterns of precipitation and water availability, as well as the condition of water resources. Warming temperatures and changes in the timing and intensity of precipitation will affect the way in which snowpack and glaciers regulate streamflow and runoff, especially in mountainous ecosystems. In the mountains, a warming climate will cause more precipitation to fall as rain rather than snow, leading to earlier, and potentially larger, spring run-off events. In addition to changes in water availability and flooding, changes in timing and magnitude of spring runoff affect the success and timing of the spawning of fish and emergence of insects (Williams 2011). In addition, decreased snowpack and earlier, higher pulses of runoff in the spring mean less water in the summer and fall, especially in dry western ecosystems. Models in the Rocky Mountains predict significant declines in summer stream flow (Shepherd 2010), with effects on both the survival of aquatic species and water availability for surrounding vegetation and associated animal species, compounding the effects of warmer air temperatures on plant and animal species, and increasing fire frequency and intensity.

Effects on recreation

As climate, water, and fire regimes, as well as plant and animal species change in protected areas, so will the character of the landscape and the experience of visitors. Climate strongly affects the suitability of locations for recreation, and drives the amount and seasonality of activity (WTO-UNEP).

In the short term, the direct effects of temperature on the comfort and experience of visitors will likely affect recreation decisions. Studies indicate that a shift of attractive climatic conditions for tourism towards higher latitudes and altitudes is very likely (WTO-UNEP). Southern parks and wildernesses may see a decrease in visitor use as temperatures creep upward. However, studies show that northern, mountainous parks in the US and Canada will likely see a greater number of visitors over the next fifty years. One study predicts an increase in park visits of 10-13% in Rocky Mountain National Park due to a lengthening of the peak summer season (Richardson), while another predicts a similar increase in parks through the 2050s in the Canadian Rocky Mountains (Scott 2007).

An increase in seasonal length and number of annual visitors may increase visitor impact on some protected areas, requiring additional management, infrastructure, or regulation (Scott 2007). Alpine regions in particular may be vulnerable to the effects of increased visitor use. Climate change may also have subtle yet potentially far-reaching adverse effects on recreation experiences and visitor perceptions about protected areas and wilderness. Declines in charismatic wildlife populations may lead nature-watchers, photographers, and hunters to seek other habitats that offer more substantial populations (Sasidharan 2000). Radically altered ecosystems – due to species loss, increasing fire frequency, vanishing glaciers, or other changes – may negatively affect the attachment of people to the landscape, as their identification with an historical aesthetic decreases (Lemieux 2011). These changes to the characteristics of protected areas may reduce the perceived attractiveness of these landscapes. A study of projected visitation to parks in the Canadian Rockies indicates that, under scenarios of species loss and glacier melt predicted for the 2080s, nearly one-fifth of visitors would no longer utilize these parks, and many others would visit less frequently (Scott 2007).

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