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Impact of Climate Change on Biodiversity in Desert

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ABSTRACT: Global warming is increasing the incidence of drought, which dries up water holes. Higher temperatures may produce an increasing number of wildfires that alter desert landscapes by eliminating slow-growing trees and shrubs and replacing them with fast-growing grasses. Deserts have been predicted to be one of the most responsive ecosystems to global climate change. Climate change is one of the strongest threats for ecosystems worldwide. Variations in the density of species, range changes, and extinction events have been documented at local and global level . Furthermore, changes in species diversity, ecosystem functioning, and service provision are expected for the future as a consequence of climatic pressures on natural populations .Deep impacts by climate change have been forecasted for animals , plants ,and biodiversity in general .

KEYWORDS: global warming, climate change, ecosystems, biodiversity, variation, desert

I.INTRODUCTION

Desert plants go wild during wet years when treated to excess carbon dioxide, researchers say. The finding backs up climate change models, which predict that rising levels of atmospheric CO_2 will disrupt the ecology of sensitive desert ecosystems. Experts fear that the change will favor invasive plants given to triggering wildfires.[1]Plentiful CO_2 helps plants use water more efficiently, and atmospheric levels of CO_2 are expected to double, relative to preindustrial times, by future.. Global-warming researchers predict that such massive increases will eventually transform desert ecosystems. The boom in plant growth is expected to upset delicately balanced desert ecosystems--changing the nutrient cycle, fire cycle, and distribution of water. The rising temperatures that drive climate change are most keenly felt in the world's deserts. Scientists predict that "super and ultra-extreme" heat events with temperatures above 56°C will become frequent in the Middle East and North Africa in the second half of this century. Plants and animals that live in deserts depend on the landscape's surface protective layer, known as biocrust, because it is rich in microorganisms. Fungi, lichens, mosses, blue-green algae and other microbes play a vital role in deserts' natural ecosystems by retaining water and producing nutrients used by other organisms, from plants to small mammals. If the biocrust dies, so will the plants and the animals that depend on them.[2] This will lead to deserts eventually spreading and engulfing productive agricultural land. The United Nations estimates that 12 million hectares of productive land are already lost each year, much of it to encroaching deserts. There have been numerous studies showing how climate change is impacting a variety of environments—from the Arctic to coral reefs to alpine—but how could a warmer world damage deserts, already the world's warmest and driest environments? New research shows that the key is nitrogren.A new study in Science found that as deserts become hotter their soil releases nitrogen, a gas vital for life. Losses of nitrogen in these arid environments, scientists believe, will result in a loss of plant life, since nitrogen is second only to water in determining the amount of life in a desert[3]."We're on a trajectory where plant life in arid ecosystems could cease to do well," says lead author Carmody McCalley, a graduate student at Cornell University. If plant life diminishes then animals and insects dependent on them for survival will also be negtaively impacted.Using instruments sensitive enough to measure level of nitrogen in parts per trillion, the researchers discovered that abiotic (non-biological) factors played a bigger role in nitrogen loss than biological—where past researchers have placed their focus[4]."At 40 to 50 degrees Celsius [about 100-120 F], we found rapid increases in gases coming out of the soil" regardless of the light, McCalley said. Midday ground temperatures average about 150 Farenheit and can reach almost 200 Farenheir in the Mojave Desert."This is a way that nitrogen is lost from an ecosystem that people have never accounted for before," said Jed Sparks, associate professor of ecology and evolutionary biology at Cornell and co-author of the study. "It allows us to finally understand the dynamics of nitrogen in arid systems"[5].The discovery that hotter temperatures lead to nitrogen loss requires changes in climate models, according to the researchers. Nitrogen in the lower atmosphere adds to air pollution and the greenhouse effect. While the term may bring to mind the windswept sand dunes of the Sahara or the vast salt pans of the Kalahari, it's an issue that reaches far beyond those living in and around the world's deserts, threatening the food security and livelihoods of more than two billion people.The combined impact of climate change, land mismanagement and unsustainable freshwater use has seen the world's water-scarce regions increasingly degraded.[6] This leaves their soils less able to support crops, livestock and wildlife. The southwestern United States is historically the hottest and driest part of the country—and is expected to become still hotter and drier due to climate change. Plants and animals in the Sonoran Desert are adapted to endure the region's harsh climate but many live on the edge of physiological limits for water and temperature stress. Thus, slight changes to climate can have outsized impacts on desert species.[7]

As a result of climate change, the southwest is already experiencing hotter maximum summer temperatures and warmer fall days. Temperatures currently considered unusually high will soon become commonplace. While total annual rainfall is declining, storms have become larger and more intense. These longer periods of drought interspersed with high intensity rainstorms will paradoxically increase both droughts and floods. Streamflow and groundwater recharge are expected to decline because of reduced snowfall and increased evaporation due to hotter temperatures.[8]

If these climate changes continue, the abundance and biodiversity of desert species will also change. Woody plants common to the Sonoran Desert, like mesquite and palo verde, are expected to decline. The iconic saguaro will likely become less abundant under drier conditions and regeneration will decline without woody "nurse plants." The decline of native vegetation can provide drought-tolerant invasive grasses the opportunity to establish and spread. The range of invasive grasses, such as buffelgrass, is limited by freezing temperatures. As temperatures warm these species may spread to higher latitudes and elevations. As vegetation changes, so must the animals that rely upon it. When native woody vegetation is replaced by invasive grasses, animals reliant on shrubby landscapes are supplanted by animals partial to grassland habitat. Riparian habitat is particularly vulnerable and will degrade as water availability declines and drought intolerant vegetation (like cottonwood and willow) diminishes. Desert fish, many of which are already endangered, may not survive in warmer water.[9]

Ectotherms, such as reptiles, rely on moving among habitats to manage their body heat and will have to alter their behavior to survive higher temperatures. Eggs and pupae will be even more susceptible to heat stress because they are unable to move themselves into a cooler spot. The sex of some desert reptiles, such as the threatened desert tortoise, is determined by egg incubation temperature. Eggs incubated at higher temperatures produce more female young and population sex ratios may become unbalanced. However, populations should persist as long as some male turtles continue to hatch. Birds and mammals are susceptible to heat stress and dehydration at high temperatures, particularly animals with limited water storage capability (such as small or young birds). Entire populations of a species may not survive when multiple risk factors exist. For example, pronghorn populations will likely be lost from vulnerable areas due to climate impacts on their food sources, gestation timing, and lactation success.[10]

Phenological changes, or "timing mismatches" can impact many parts of the food chain by changing plant growth, flower bloom timing, insect activity, animal hibernation, and animal migration. Events that historically occurred simultaneously may no longer be "in sync" as species react differently to changing climatic conditions. Forty years of data collected at the Desert Museum and Saguaro National Park, among other studies, show that desert shrubs and flowers are blooming earlier, which could impact food sources for migratory hummingbirds. As climate changes, the boundaries of the entire Sonoran Desert ecosystem may expand north and east as the southwest becomes warmer and more arid. Desert inhabitants will shift, as some species persist, and others leave or arrive. In a changed climate, familiar elements of the desert landscape will combine with new components to create a novel desert ecosystem unlike anything we observe today.[11]

What can we do to preserve the desert's diversity and resiliency in the face of change? We can help to slow the pace of change by supporting community- and individual-scale efforts to shift to greener energy, food, goods and infrastructure. This will give us, and the ecosystems in which we live, more time to adapt. Conservationists and ecologists are also experimenting with techniques to help plants and animals adapt, for example, by selecting for resilient varieties, assisting their migration to more suitable climates, or conditioning them to the stresses of future climate. [12]

II.DISCUSSION

Aside from regional variations in temperature and precipitation, Earth's surface will be a few degrees warmer in future than the temperatures we experience today. In effect, that means that today's climatic zones will generally shift upslope in mountainous areas and towards the poles on lowlands, plains, and plateaus. To survive, climate-sensitive plants and animals will need to track these shifts so that they remain within their suitable climatic envelopes of temperature and precipitation.[13] Species that live on mountains are at particular risk from climate change. Because temperatures decrease by roughly 0.65°C for every 100 m in elevation rise (known as temperature lapse rates), a 1°C increase suggests that climate-sensitive species living on a mountain would be displaced by at least 150 m (1.5 m/year) upslope between the years 2000 and 2100. Species that live on the lower slopes of mountains and are mobile enough to make such an adjustment may have opportunities to move to higher ground. However, species that live on or near peaks may have nowhere else to go as the world heats up, resulting in what biologists call mountain-top extinctions. [14]While a mountain-top extinction has yet to be recorded in Africa, we have ample evidence to suggest that the region's wildlife is vulnerable to it. For example, due to climate change, populations of some bird species endemic to the Cape Floristic region's mountains have shrunk by 30% over the past two decades .Species inhabiting Tanzania's Eastern Arc Mountains,Albertine Rift ,and the Guinean Forests of West Africa , appear to have experienced similar declines. Given these observations, it is only a matter of time before one of Africa's mountain specialists follows the example of Costa Rica's once-abundant Monteverde golden toad ,the first known amphibian extinction attributed to climate change .The response of species living in lowlands and on plains tend be more variable and complex than those living on mountains. While some species may only need to make minor range adjustments, researchers estimate that some tropical taxa may need to move 500 km ,maybe even 1,000 km to keep up with climate shifts. For species, such as Tanzania's savannah birds that have already shifted their distributions by 200–300 km ,adapting seems relatively easy thanks to their mobility and largely intact ecosystems[15]. Unfortunately, the rate of climate change will likely outpace the ability for most species to adapt , For example, nearly 62% of Sub-Saharan Africa's species are predicted to undergo range contractions , and 37% species are facing extinction if climate forecasts hold true . Species living in Southern Africa's Miombo Woodlands are even more vulnerable, where as many as 90% of amphibians, 86% of birds, and 80% of mammals face extirpation, or localized extinctions [16].

Species of tropical lowland forests and deserts are also highly vulnerable to shifting climates. Many tropical species have narrow tolerances for temperature and rainfall variation, while desert specialists may be at the limits of their physiological heat and desiccation tolerances Consequently, even small changes in the climate of these two ecosystems may have major effects on reproduction, species distributions, and hence ecosystem composition .One species already impacted is the nocturnal aardvark (*Orycteropus afer*, LC): a study in Southern Africa's Kalahari Desert found over 80% mortality rates in this species during recent summers .The high levels of mortality in this species was attributed to above average temperatures, which subjected the animals to heat stress, leading to behavioral disruptions, declining body conditions, and eventually starvation. The impact of climate change on the aardvark is of concern because it is an ecosystem engineer: their burrows provide denning and refuge sites for multiple other species . Deserts, with their extreme temperatures and scarce and unpredictable rainfall, are among the most inhospitable environments on the planet. To survive and breed in arid regions, organisms must minimize their energy and water requirements, and avoid exposure to potentially lethal temperatures. Birds are generally small and diurnal, and are therefore among the groups of animals most vulnerable to even small increases in air temperatures associated with climate change. Studies of the effects of temperature on arid-zone birds can thus be highly informative in terms of identifying new conservation challenges posed by global warming, developing mitigation measures, and understanding the management interventions that may become necessary during the 21st Century.[17]

Daytime temperatures in many deserts regularly exceed avian body temperature, creating conditions under which birds can avoid lethal heat stroke only by dissipating heat via evaporation. But rapid rates of evaporation increase the risk of birds becoming lethally dehydrated. Desert birds thus face life-or-death decisions between avoiding hyperthermia by evaporative cooling versus avoiding lethal dehydration by minimizing water losses. Mass mortality events occasionally take place during extreme heat waves when air temperatures exceed birds' physiological tolerance limits.[18] In Australia, for example, there are both historic and contemporary accounts of die-offs sometimes involving millions of birds. As Earth heats up under climate change, the risk of such die-offs in desert birds is expected to increase dramatically for the deserts of Australia and North America during the 21st Century .

Africa's arid regions are also experiencing significant temperature increases which are predicted to continue over the next several decades .Under these conditions, the impact of air temperature on avian physiology can be mediated by behavior. Birds employ a trio of behavioral adjustments to manage heat load and keep their body temperatures within safe limits. These include shade-seeking, reducing activity to minimize metabolic heat production, and gaping the beak (panting, sometimes accompanied by gular flutter) to facilitate respiratory evaporative cooling .[19]Although these behaviors can buffer birds against physiological costs of high temperature, they carry subtle but important costs of their own, notably via their impact on birds' ability to forage. For desert birds, foraging is critically important for maintaining both energy and water balance, as most species obtain all their water from food. Reduced activity almost inevitably means reduced food intake via impacts on time available for foraging. Seeking shade also carries costs: for some species, returns on foraging effort in shaded locations are significantly lower than in the sun . Finally, respiratory evaporative cooling can severely restrict the ability of actively-foraging birds to acquire food due to mechanical constraints on simultaneously gaping the bill and using it for prey capture and handling[20] .

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Under climate change, the implications of these behavioral trade-offs between foraging and thermoregulation are non-trivial. Inability to balance water and energy budgets means birds progressively lose body condition during heat waves .Compromised foraging also affects birds' capacity to provision offspring, resulting in reduced nest success and/or smaller, lighter fledglings which may struggle to survive and recruit into the breeding population .

Successfully balancing the trade-offs between foraging and thermoregulation, and between hyperthermia and dehydration, is the secret to success for birds in hot places. As the climate warms, achieving this balance will become ever more challenging. Sublethal behavioral costs of keeping cool kick in at temperatures cooler than those promoting mass mortalities. In some parts of the world, such as Southern Africa, the loss of birds from desert ecosystems may therefore occur through the insidious whittling away of fitness and weakening of populations before we even witness the dramatic die-off events for which Australia is already infamous.[21] An additional concern for lowland ecosystems is that climate change will likely lead to the creation of novel (i.e. hotter) ecosystems unlike any others currently on Earth .These changes will lead to biotic attrition. The gradual impoverishment of biological communities of lowland ecosystems as species either go extinct or move away while tracking their climatic envelopes. What is not clear is how the niches left open by the net loss of species, and newly created niches in the novel ecosystems, will be filled. The most likely scenario is that more tolerant, generalist species will fill the empty niches[22]. However, with the inevitable loss of some species, combined with the decoupling of important biological interactions some functions and services associated with lowland ecosystems are likely to eventually collapse. It is important to note that tropical lowland forests and deserts are by no means the only ecosystems vulnerable to biotic attrition. For example, researchers have found that even mild warming would expose the Ethiopian Highlands to biotic attrition .

III.RESULTS

Across many diverse ecosystems, a great number of species are threatened by climate change because of their poor dispersal abilities. Because they lack appropriate dispersal mechanisms, species, such as slow-maturing plants ,mosses, and flightless insects may simply not be able to keep up with changing climatic conditions[23]. The impacts of climate change on tropical dispersal-limited species can already be seen. For example, the once abundant Aldabra banded snail is today so rare that this Lazarus species was once believed to be extinct due to climate change .Next might be the cave katydid (*Cedarbergeniana imperfecta, CR)* and Marais' lace-winged katydid (*Pseudosaga maraisi*, CR); these highly threatened insects count among very few cave specialists, and yet, by living in highly restricted and restrictive ecosystems, they face major challenges in adapting to climate change .Dispersal limitations will also greatly affect terrestrial species living on oceanic islands, which will find it near impossible to track their climatic niches as it moves over the ocean[24]. One such species is Cabo Verde's Raso lark ,with a population size that fluctuates in response to rainfall, climate change-induced drought conditions have pushed this bird to the brink of extinction in recent years .Species that are highly mobile are not entirely spared from the negative impacts of climate change. Consider migratory species for a moment. The same way the musicians of an orchestra rely on a conductor to remain synchronised, migratory species rely on environmental cues, such as day length and temperature,[25] to decide when they need to start moving from one area to the next. But because different species rely on different environmental cues to time their life cycles (e.g. breeding), not all species will adjust to climate change at the same rate. There is consequently a high likelihood that climate change will disrupt these synchronous movements that the animal kingdom has developed over thousands of years .This disruption of timed aspects of a species' life cycle, such as migration and breeding, is called phenological mismatch or trophic asynchrony. Researchers have already seen signs of phenological mismatch: some migratory birds that overwinter in the tropics have started to migrate to their European breeding grounds at earlier dates than before .If these trends hold, they may soon start breeding before peak food availability, which could lead to lower fitness of offspring.[26]We can already see evidence of how climate change is disrupting migrations and mutualistic relationships that were developed over thousands of years.[27]Resident species are also vulnerable to phenological mismatch. While these species might not be known for large-scale movements around the globe, they may still have to adjust their ranges to keep track of their climatic niches. Considering the improbability of different species will adapt at the same pace, there is thus a danger that important mutualistic relationships might be pulled apart these during range adaptations. [28]This is of concern for species with specialized feeding niches, as seen in some pollinators. For example, studies from South Africa have shown how necessary range adjustments under climate change threaten both sunbirds—which show low adaptability and their host plants, if specialized pollinator niches are left vacant.Extinctions arising from this decoupling of mutualistic relationships are referred to as coextinction ,while a series of linked coextinctions is called an extinction cascade. One may think that reptiles—often seen basking on sun-drenched rocks to obtain active body temperatures—may benefit from climate change. Yet, as a group, they are also expected to suffer under climate change. One reason is because many reptiles will also have to adapt their ranges to shifting climates .Even more important, climate change will increase reptiles' vulnerability to demographic stochasticity .[29] Many reptiles—and some fish—have their sex determined by temperature during embryonic development, with warmer temperatures often leading to more females .In general, females regulate their offspring's sex ratios by fine-scale breeding site selection. Under climate change, however, it might be harder for the females to find breeding sites with suitable microclimates. This situation is of concern for Nile crocodiles (*Crocodylus niloticus*, LC) that already struggling to find suitable breeding sites due to microclimate changes caused by invasive plant encroachment. [30]Those species unable to adopt new mechanisms to control for offspring sex ratio bias may eventually go extinct, even under relatively small temperature shifts .The Thar Desert is located in north-west India. It is one of the major hot deserts of the world with the highest population density. Many people living in this desert are subsistence farmers, but with increasing development opportunities, the human population is also growing. Due to population pressures this environment is increasingly under threat. One of the biggest concerns in this region is the process of desertification. Climate change **-** the global climate is getting warmer. In desert regions, conditions are not only getting warmer but drier too. On average there is less rain now in desert regions than there was 50 years ago.[31]

IV.CONCLUSIONS

Prevention is much more cost-effective than rehabilitation. Desertification can be reduced and biodiversity can be increased by adopting the following strategies.

- Planting more trees – the roots of trees hold the soil together and help to reduce soil erosion from wind and rain.
- Improving the quality of the soil – this can be managed by encouraging people to reduce the number of grazing animals they have and grow crops instead. The animal manure can be used to fertilise the crops grown. Growing crops in this way can improve the quality of the soil as it is held together by the roots of plants and protected from erosion. This type of farming is more sustainable.
- Water management – water can be stored in earth dams in the wet season and used to irrigate crops during the dry season. This is an example of using appropriate technology to manage water supplies in the desert environment.
- Magic stones (or bunds) are circles of stones placed on the ground to hold water on the soil rather than letting it run quickly over the surface.[32]

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