Climate change impacts on plants

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Introduction

Climate change is one of the greatest environmental, social and economic threats that the planet faces at the moment. Scientists from different fields have acknowledged the rise of earth's average surface temperature by 0.76° C since 1850 when reliable records began. Eleven of the 12 warmest years worldwide since 1850 occurred between 1995 and 2006. While climate change has global repercussions, the most vulnerable organisms will experience the greatest impacts from climate and disaster risk. Climate change is threatening the lives and livelihoods of plants and animals, including human beings, reducing natural resources making it impossible for sustainable utilization of limiting resources. Generally, climate change threatens biodiversity, ecosystem services and natural processes by increasing hazards, vulnerabilities and anthropogenic disturbances.

What is climate change?

According to the Intergovernmental Panel on Climate Change (IPCC), climate change is any long-term significant change in the "average weather" that a given region experiences (IPCC 2001a). Average weather may include average temperature, precipitation and wind patterns. It involves changes in the variability or average state of the atmosphere over durations ranging from decades to millions of years. These changes can be caused by dynamic processes on Earth, external forces like variations in sunlight intensity, and more recently by human activities (IPCC 2001a).

It is predicted that the continuation of these activities will result in a 1.8 - 4°C average temperature increase over the next century (IPCC 2001a), causing changes in weather patterns (NEAA). Changes in climate patterns may cause extreme weather events such as heat waves, floods, storms, droughts and bushfires (IPCC 2001a). Climate change and its impacts has been reported in different parts of the world including the United States (Smith and Tirpak 1989, Adams et al. 1990, NAST 2000), Australia (Hughes 2003, Braasch 2008), UK (Harry et al. 2001, Berry et al. 2002), Europe (Arnell 1999, Thuiller et al. 2005, Pompe et al. 2008) and Africa (Desanker and Justice 2001, Midgley et al. 2002, Turpie et al. 2002, Lukman 2003, McClean et al. 2005).

What causes climate change?

Basic climate change science explains that climate change may occur naturally as a result of a change in the sun's energy or Earth's orbital cycle, or it could occur as a result of persistent anthropogenic forces. The Earth is warmed by solar radiation, and in turn, the Earth radiates energy back to the outer space. The atmosphere (thick layer that keeps the surface warm and protects it from small-to-medium sized meteorites) acts as a greenhouse and traps some energy that would not be radiated to space (Wikipedia 2008a). The result of this greenhouse effect is a warm Earth, which is habitable and conducive to support different life forms (Philander 2000). The main human influence on global climate is emissions of the key greenhouse gases (GHG) - carbon dioxide (CO_2), methane (CH_4), chlorofluorocarbons (CFC) and nitrous oxide (N_2O) (DEAT 2004).

Increase of these GHG in the atmosphere is a result of human activities such human activities includes, burning of fossil fuels, farming and clearing land for industrial development. Concentrations of CO_2 has risen from about 270 parts per million (ppm) to 370 ppm, concentration of CH_4 have also risen due to cattle production, cultivation of rice fields and release from landfills and most of the N_2O emissions are a result of industrial processes and automobile emissions (AG:DCC, IPCC 2001b). When ecosystems are altered and vegetation is either burned or removed, the carbon stored in them is released to the atmosphere as CO_2. The main reasons for defor-

estation are agriculture and urban development, and harvesting timber for fuel, construction and paper. Part of the CO_2 emissions to the atmosphere can be attributed to land-use change (IPCC 2001b). The oceans are a major component of a climate system. Oceans absorb much of the sun's radiation thereby acting as carbon sinks and storage for abundant CO_2 gas (Philander 2000). The Oceans cools down the Earth's temperature through mixing and circulating warm and cold waters. Water vapour contributes to the formation of clouds which shade the surface and have a cooling effect (IPCC 2001b).

What are the effects of climate change?

Climate change is a result of increased temperatures, resulting in altered rainfall patterns across the country (IPCC 2001a). These changes threaten water availability, agricultural production, health, and biodiversity. The effects of climate change are being felt in different parts of the world, depending on the rate of changes and the ability to adapt to changes by the ecosystems. In 2001, the IPCC released the report on climate change revealing that in the last 100 years the earth has warmed by 0.74°C. The last 12 years (1995-2006) rank among warmest years since 1850, and by the end of 21st century temperatures could rise by between 1.1 °C and 6.4 °C (IPCC 2001a).

Climate models tend to show that the greatest warming will occur over inland areas, less warming over oceans and coastal zones, and the least warming will occur over the southern Oceans because of its large capacity to transport surface heat into deeper waters. Changes in the oceans have important implications for South Africa. In the recent past, variation in ocean currents has caused major changes in several fish resources, both as a source of food and biodiversity (Braasch 2008). Changes in temperatures will also lead to more frequent extreme climatic events. It is anticipated that the number of hot days will increase with fewer colder and frosty days. In addition, intense summer heat could result in more violent storms and tropical cyclones as the oceans warm and more energy is stored in our warming atmosphere. This could cause greater flooding, mud/land slides and damage to buildings, roads and bridges.

It is currently estimated that 10% increase in rainfall coupled with an increase in CO_2 would lead to a 10-20% increase in wheat and maize production, while a 10% decrease in rainfall would be approximately balanced by the rising CO_2 content of the atmosphere. Slightly warmer temperatures may lead to a small reduction in wheat yields, but would have little effect on maize. These predictions are not very certain (Turpie et al. 2002) but give an indication of what might lie ahead. Higher CO_2 concentration will lead to less protein in the grass, which will reduce any benefit resulting from increased plant growth. An increase in rainfall or a reduction in plant water use (due to a higher atmospheric concentration of CO_2) could ease the problem slightly (Braasch 2008).

Ecosystems throughout the world are already experiencing high pressures from human activities making them vulnerable and less capable of adapting to ongoing changes. These conditions reduce biodiversity and influence ecosystem functioning. Climate change affect human health, safety and living standards by causing increasing environmental health hazards and reducing natural resources (WHO 2003, Braasch 2008). A small increase in temperature would allow, for instance, malaria to spread into areas which are currently malaria-free, and would increase its severity in areas where it already occurs and could lead to increased drug resistance illness (Lindsay and Martens 1998, Turpie et al. 2002, WHO 2003).

Plants, in particular, have trouble keeping up with rapid climate change. Small, isolated populations could go extinct as a result. South Africa has about 10% of all the plant species in the world, of which about half occur nowhere else on Earth. Warming and a change in the seasonal rainfall within the Cape floral kingdom, is a cause for concern to conservationists (Midgley et al. 2001). Climate change might significantly impact the distribution and species composition in different of habitats in different ways (Midgley et al. 2001, Berry et al. 2002, Pompe et al. 2008), and could possibly drive many species to extinction (Thomas et al. 2004).

Temperature effects, rainfall and soil properties are important factors determining the distribution

of plants, determinants of the tree-grass ratio, bush encroachment and vegetation boundaries. Climate change prediction models show the possibility of an increase in aridity in the western regions of South Africa, particularly the Northern Cape (SoER 2004). This aridity may result in changes in vegetation and crop production, amongst other things (Leuci and Ramsay 1999) and the weather conditions being more extreme, with cold and frost and extreme heat in summer (Burger 2002).

Plant diversity is concentrated in several unique native environments known as biodiversity hotspots. These areas are unusually rich in species but are highly threatened by human activities. Hotspots boost a large number of rare, endemic and protected species. The Cape Floral Kingdom (fynbos) has 7,300 plant species of which 68 % are endemic to that area and occur nowhere else in the world (Gibbs 1987). The Succulent Karoo biome contains over 6,000 species of which 2,500 are endemic (Cowling et al. 1998). The plants in Fynbos and Succulent Karoo live on the edge of survival, completely dependent on low but fairly reliable winter rainfall. If the climate of this region becomes any drier, the effects on the entire biome will be devastating. These two floral biodiversity hot spots occur in winter rainfall regions and would be threatened by a shift in rainfall seasonality (Midgley et al. 2001).

A study conducted by South African National Biodiversity Institute (SANBI) strongly suggests that the range of the *Aloe dichotoma* (Quiver tree) has begun to respond to climate-induced stress. Observations from over 50 sites in the trees range noted two trends. Firstly, where populations were found on slopes, mortality was much higher at lower elevations than at higher ones (at higher altitude it is cooler). Secondly, there were higher mortality rates in the north of the tree's range (towards the equator), than those found in the south towards the tropics suggesting that cooler climate were more efficient for the species survival. This strongly suggests that a combination of water and heat stress is the cause of mortality in declining Quiver tree populations (Midgley et al. 2005, Foden et al. 2007)

Rutherford et al. (1999a, b) and Midgley et al. (2001) reported that climate change has been suspected of affecting the biota of conserved nature areas in different and significant ways. Midgley and Thuiller (2007) and Foden et al. (2007) explored why Namaqualand plant diversity might be particularly vulnerable to anthropogenic climate changes despite presumed species resilience. Using simple modelling approaches, their results show strong reduction in spatial extent of bio climates typical of Namaqualand within the next five decades and that both generalist species with large geographic ranges and narrow-range endemics may be susceptible to climate change induced loss of potential range.

Scientists have shown that increased CO_2 levels will increase and improve plant growth (Eamus and Palmer 2007). Tews & Jeltsch (2004) concluded that possible increase in precipitation will strongly facilitate shrub encroachment threatening savanna rangeland conditions and regional biodiversity and that shifts in precipitation patterns will potentially have severe consequences for woody plant population dynamics. Climate change is expected to promote woody plant establishment accelerating bush encroachment, suppressing the grass layer dominance.

Conclusion

The timing and extent of global climate change are uncertain, and as a result our actions need to be pragmatic. Plans to conserve South Africa's rich plant biodiversity must take account of future climate change scenarios. More ecosystems are becoming vulnerable due to their narrow distribution. Eventually many plant species may be lost and this may alter the ecosystem structure, functioning and distribution. Regional and national actions need to be taken to conserve and preserve our plants.

Climate change is a threat to plants distribution and natural habitats due to extreme weather conditions and anthropogenic disturbances. Plants have adapted to these changes for many decades, however it is not predictable if plants will adapt to this rapid changes that has been recorded in the last 100 years. Failure to adapt and shift distribution might lead to extinction from its natural habitats.

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