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Research article

EFFECT OF CLIMATE CHANGE ON THE STATUS AND PRESENCE OF VEGETATION IN SAUDI ARABIA

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ABSTRACT: A succession of environmental events over the last few years has led to a dramatically increased awareness of the issue of global climate change. Global climate change is affecting the distribution of marine species and is thought to represent a threat to biodiversity. The global climate changes are new and unique in that they will have been generated by human activity and could result in disruptions in ecosystems. The goals of both conservation biology and agriculture of feeding an increasing world population and preserving species diversity may be seriously challenged when linked to climate change. This study applies all species distribution in relation to climate projection to explore the potential impacts of climate change on species by 2050. A set of species in the KSA, including different threatened species were used as a case study. Changes in habitat suitability in selected candidate protected areas around the KSA under future climatic scenarios were assessed for these species. Using collected readings from main meteorological stations, changes in climate of Saudi Arabia were recorded and incorporated to endemic and rare or endangered plants. Outputs of these data had an average climate change trend around KSA from 2000 to 2011, with high inter annual variability. The pattern is expected given that it is relatively shallow (average depth ≈90 m). Also, average increases between 1985 and 2050 are 0.77°C and 1.27°C. Atmospheric changes in precipitation patterns, temperature, and greenhouse gases had extreme effects on species distribution and ecosystems characteristics. Vegetation profoundly affected, with local, regional, and global changes. Species distribution is likely to be altered as a consequence of global climate change. The ensemble projections indicated that northward shifts in species at an average rate of 27 km per decade, resulting in small average changes in range overlap between threatened exploited species. Furthermore, the adverse consequences of climate change on the habitat suitability of protected areas were projected to be small. Although the models show large variation in the predicted consequences of climate change, the multi-model approach helps identify the potential risk of increased exposure to human stressors of critically endangered species.
Key Words: climate change, Saudi Arabia, vegetation, meteorological stations.

INTRODUCTION

The last 100 years have seen significant changes in the global climate that are very likely to be attributed to anthropogenic greenhouse gas emissions [1]. Mean global surface temperature has increased by approximately 0.1°C per decade since the late 1950s and is projected to be 1.4–2.1°C above pre-industrial levels by 2050 [1], with temperatures increasing in the Arctic at almost twice the global rate in the last century. Furthermore, the ocean is becoming more acidic and less oxygenated [1], [2]. Climate change has been observed to be having a profound effect on both marine and terrestrial biodiversity [3]–[5], and this trend is expected to continue, with associated changes in species compositions [6], distributions [4] and phenological patterns [7]. Concern over the impact of climate change in the marine environment is also increasing, with longer-term shifts in mean environmental conditions and climatic variability moving outside the bounds within which adaptations in marine communities have previously been associated [8]. The changes in abundances and distributions that result from these ocean-atmospheric changes may severely impact the biological and environmental functioning of ecosystems or food webs [9], the goods and services derived from them and conservation and resource management [10], [11].

The effects of climate change on threatened or endemic species (those unique to a defined geographic area) are of particular concern. These species are frequently restricted to relatively small areas and population sizes and may have highly specific habitat requirements, likely reducing their adaptive capacity to climatic change [12]. In addition, lack of knowledge or data concerning the abundance, dispersal and life history characteristics of threatened species is common.

Recent years have thus seen an increase in studies attempting to assess how climate change might impact threatened and endemic species in terrestrial environments [13]–[15] and how conservation goals and actions should adapt in a changing climate [16]–[18]. There are far fewer studies attempt to assess the impacts of environmental and climate change on threatened marine vertebrate species. [14]This is likely due to the issue of scarce and unreliable data available for the marine environment [19]. Furthermore, there has been little attempt to assess the interactions between climate change and other anthropogenic stressors, such as planting, on threatened marine species.

Climate and sea water changes may also affect threatened species by influencing the efficacy of measures designed to protect them. Specifically, marine protected areas are a major tool to conserve marine biodiversity [20] and have been shown to enhance population resilience to climate-driven disturbance [21]. However, their effectiveness may itself be influenced by climate change. For example, future climate change has been predicted to reduce the amount of suitable habitat for particular species that falls within current protected areas [22], thereby reducing its future conservation value. There is a need to increase the robustness and enhance resilience of protected areas to climate change [23], [24]. By assessing the degree of future environmental change within proposed protected areas, conservation planning may thus be used to protect against biodiversity loss [25], [26].

Species Distribution has been widely used to predict the potential impacts of climate change on both terrestrial [27]–[29] and marine species [30]–[32]. The bioclimatic envelope is defined here as a set of physical and biological conditions suitable for a given species [33] and is frequently obtained by using statistically or theoretically derived methods to associate current climatic variables with species occurrences.[31] By predicting a species' current range as the manifestation of habitat characteristics that limit or support its existence at a particular location, a shift in that range may be elucidated by assessing shifts of the bioclimatic envelope under climate change scenarios. Species Distribution Models (SDMs) are able to predict species' distributions with presence only data and also perform well under small sample sizes (see [34]–[36] for an overview of methods). [35]Applications of SDMs have been criticized [37] and it is acknowledged that some SDMs over-simplify the mechanisms determining species' distributions. However, recently developed modelling approaches have increasingly addressed these criticisms [38], [39]. SDMs also remain useful in exploring the possible magnitude and direction of species' distribution shift under climatic change. Furthermore, key uncertainties in using SDMs to assess climate change impacts on marine biota, which stem from the differences in the structure of the SDMs and the underlying climate forcing, can be explored by comparing outputs from multiple SDMs and climate models. Using multiple SDMs with a range of complexity, data requirement and statistical mechanisms is therefore a more robust way to assess species' distributions [40].

Climate scenarios developed from multiple models are also considered to be more robust than using a single model as climate models vary in complexity and reliability, with uncertainty being introduced by data input as well as interpolation method. [41]There is therefore a need to compare future species' distribution predictions made using alternative SDM algorithms, Global Climate Models (GCMs) and species' occurrence/environmental tolerance data. The uncertainties in outputs resulting from these variations help us understand the range of potential predictions, the extent of agreement between them as well as possible extremes.[42]

This study aims to assess the potential impact of climate change on a set of threatened species (under the International Union for Conservation of Nature (IUCN) Red List of Threatened species) predominantly inhabiting the KSA.

SAUDI STUDY AREA

Saudi Arabia is located in the Middle East and borders the Persian Gulf, the Red Sea, Yemen, the United Arab Emirates, Iraq, Qatar, Oman, Jordan, and Kuwait (Figure 1). Riyadh is its capital city, with a population of 4,193,000. Saudi Arabia is a monarchy led by King Abdullah, who has been head of state since 2005, and an appointed 150-member consultative council. Saudi Arabia is the historical home of Islam, its official religion, and Arabic is its official language.

Like most of its Gulf State neighbors, Saudi Arabia is a founding member of the Organization of Petroleum Exporting Countries (OPEC) and is the world's largest producer and exporter of total petroleum liquids. It was the world's largest producer of crude oil in 2008, producing 3.9 million barrels per day. As of 2009, Saudi Arabia held the world's greatest proven oil reserves264.2 billion barrel and the fourth greatest proven natural gas reserves7,306 cubic kilometers. With approximately one fifth of the global proven oil reserves and minimal production costs, Saudi Arabia is expected to remain the world's largest oil exporter over the short and long term. As a result of its role in energy production, Saudi Arabia, with 0.4 percent of the world's population, accounts for 1.1 percent of global greenhouse gas (GHG) emissions, the highest level of GHGs on average among the oil-producing Gulf States. Since World War II, Saudi Arabia has been closely aligned with the United States as a major trading partner. It is the second-largest exporter of oil to the United States after Canada.

Fig. 1: Location of Saudi Arabia.

On January 31, 2005, Saudi Arabia ratified the Kyoto Protocol and was classified as a developing, non- Annex I nation, meaning that it was not required by the protocol to reduce its GHG emissions. Because of its relatively high GHG emissions, however, Saudi Arabia expressed interest in the protocol's clean development mechanism (CDM), which allows industrialized, Annex I countries to satisfy their Kyoto commitments in part by funding environmentally friendly development projects in non-Annex I countries. In 2006, Saudi Oil Minister Ali al-Nuaimi hosted an international CDM conference in Riyadh, where attendees reviewed investment opportunities in Saudi Arabia and other oil-rich Gulf States for new CDM projects, including some that employed high-technology carbon capture-and-storage technology.

In such technology, carbon dioxide (CO_2) is removed from petroleum processing plants and sequestered in mature oil fields. CDM programs have assumed greater significance for the Gulf States that fear their oil exports might be restricted should the United Nations raise environmental standards in 2012, when the Kyoto Protocol is to be replaced. Industrial diversification is an alternative to CDM programs.

The World Trade Organization (WTO) has encouraged Saudi Arabia to lessen its economic dependence on its oil and petroleum industries by diversifying its industrial sector so as to include more environmentally friendly endeavors. Paradoxically, since 2000, the wealth garnered from the GHG emitting energy industry has driven such diversification, enabling Saudi Arabia and other Gulf States to achieve significant economic development both with their own domestic capital and through some 750 American business ventures. This activity has resulted in a diverse range of new business opportunities for the Saudi government and employment opportunities for the country's workforce. As part of an effort to attract foreign investment and diversify the economy, Saudi Arabia has substantially increased spending on job training and education, infrastructure development, and salaries for government employees. Saudi Arabia acceded to the wishes of the WTO in 2005 and announced plans to establish six "economic cities" in different regions of the country to promote development and diversification.

Saudi Arabia's non-CO_2 emissions grew by 50 percent from 1990-2000, the highest percentage among the top-twenty-five GHG emitters. Population growth in Saudi Arabia was 46 percent from 1990-2002, the highest percentage of the top twenty- five GHG emitters, three times greater than that of China, and almost twice that of Iran. Energy intensity (energy consumption per unit of GDP) increased in Saudi Arabia by 52 percent from 1990-2002, the highest percentage among the top twenty- five GHG emitters.

As regards per capita ranking, while the OPEC Gulf States have high per capita GHG emissions, data show that of the top-twenty GHG emitters, generally, the highest emitters per capita were the Annex I countries (Australia, the United States, and Canada, ranked fifth, seventh, and eighth, respectively, with per capita GHG emissions of 25.6 metric tons, 24.3 metric tons, and 22.2 metric tons, respectively). Annex I countries' per capita emissions are approximately double those of the highest- ranked developing country in the top twenty (South Korea, at 11.0 metric tons per capita), and they are six times that of China (3.9 metric tons per capita) [18]. Saudi Arabia was ranked fifteenth in per capita GHG emissions, producing 16.5 metric tons per person.

The population density of Saudi Arabia in 2007 was 11.3 persons per square kilometer, in a country a little more than one-fifth the size of the United States. Economic growth in the top GHG emitters is sometimes measured in terms of GDP per capita, and this measurement has been shown to bear a significant relationship to a country's GHG emissions. Usually, significant GDP growth per capita results from energy-intensive activities, which significantly increase GHG emissions. In 2008, the Saudi GDP was ranked twenty-third in the world by the International Monetary Fund (IMF); the Saudi petroleum sector accounted for roughly 45 percent of the nation's GDP, 80 percent of its budget revenues, and 90 percent of its export earnings. Some 40 percent of the GDP came from the private sector.

High oil prices through mid-2008 enhanced economic growth, government revenues, and Saudi ownership of foreign assets, enabling Saudi Arabia to pay down its domestic debt. In March, 2009, Saudi Arabia, along with other OPEC member nations, cut production of oil to support falling oil prices on the world market, and crude oil futures rose to $51.55 per barrel in New York. OPEC lowered Saudi Arabia's production quota for oil, although it was reported that the Saudi government privately promised to satisfy the energy needs of their export partners. However, liquid fuel demands in the United States are expected to increase by only one million barrels per day from 2007 to 2030, as domestic biofuels and other renewable energy sources, along with increasing domestic oil production, reduce U.S. dependence on the foreign oil market. As a result, the United States is projected to import less than 40 percent of liquid fuels it consumes in 2025. This decrease will likely decrease Saudi oil revenues, either directly by lowering volume of sales or indirectly by lowering prices.

MATERIALS AND METHODS

Saudi Arabia is divided to 6 regions as presented in Figure 2. The regions are chosen in order to produce localized climate details. In addition, thirty seven separate locations (Figure 3) were chosen to present the spread effects of climate change and to determine the more sensitive areas to changes in climate. There are 28 stations that have continuous records of hourly and daily observations. The need arise to adopt other locations to have a better representation of the area. Reanalysis data is used as a historical data for those stations as well as each of the six regions. These data is used as historical data for available stations.

Using collected readings from 37 main meteorological stations to 6 main regions of KSA, changes in climate were recorded. Using excel program, data (days, months) changed to years data. Using the program, data changed to diagrams for ten years (2000-2011) to each locality. Recording all degrees of endangered, extinct, endemic and rare plants in response of climate change of KSA. Determination the red list of plants exposed to extinction and rate of distribution.

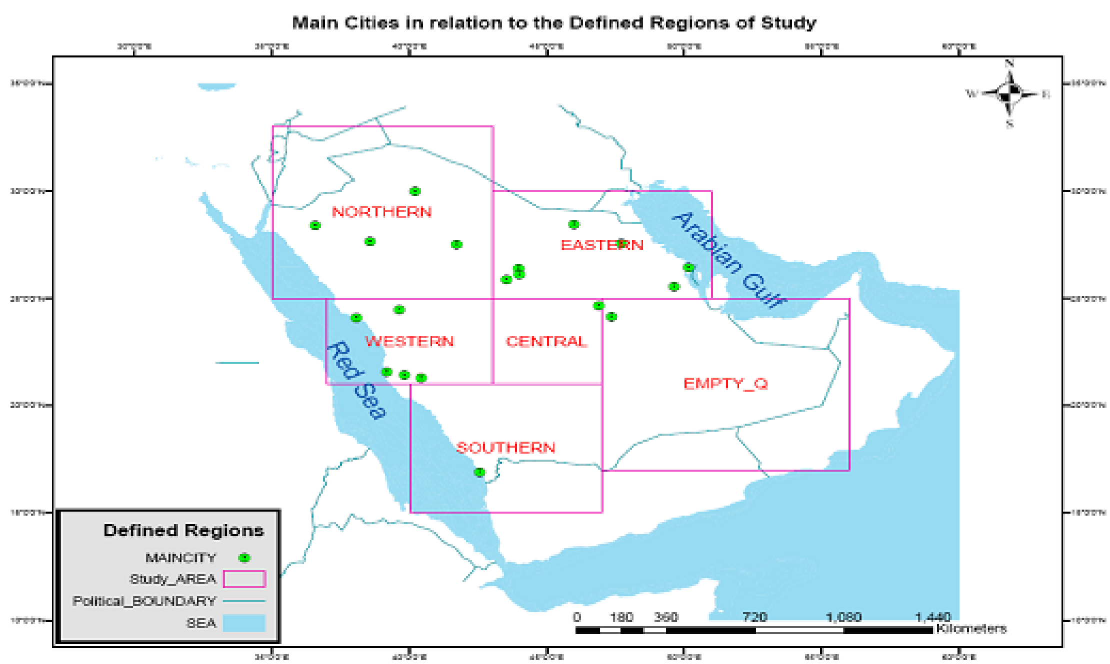

Fig. 2: Shows the regions representing Saudi Arabia.

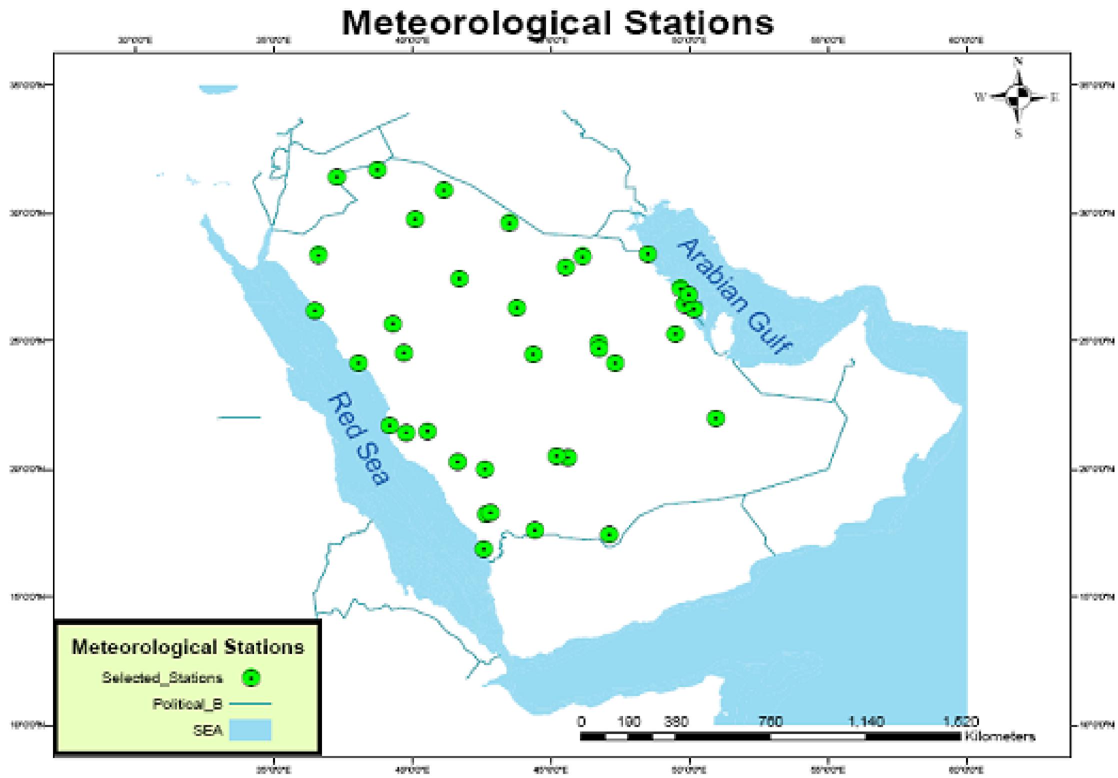

Figure 3. Shows the 37 locations studied over Saudi Arabia.

RESULTS AND DISCUSSION

Saudi Arabia has a tropical climate with variable rainy and dry seasons, depending on the location. In the southeast of Saudi Arabia it is hot and wet most of the year, but it is dry in the southwest and farther inland. In the north and west, a savannah climate with marked wet and dry seasons prevails, while a steppe climate with little precipitation is found in the far north. Generally speaking the length of the rainy season decreases from south to north. In the south (lie rainy season lasts from March to November, compared lo the far north, where it lasts from mid-May to September. In the south and the southeast especially, precipitation is heavier with over 3,000 mm of rain a year (compared with about 1,800 mm in the southwest). Rainfall decreases progressively away from the coast and the far north receives no more than 500mm a year.

Desert Climate is generally dry and hot, with low humidity. Temperatures can drop quite low at night because heat that arrives during the day, with no clouds to hold it in, escapes into the atmosphere at night. In some deserts in Saudi Arabia temperature can drop below freezing as late as April. In the hottest deserts in the winter, temperatures can rise to the 90o F (30oC) in the day and drop to the 30oF (single digits C) at night.

The summer is so hot that shoes fall apart because the glue melts, thermometers don't have high enough readings to record the high temperatures, and the hot sands can reach 180°F. The air is so dry that pages fall out of books because the bindings fail. At night the temperature drops only to 85°or 90°F (30°C) and people sleep on their roof to escape the heat.

In the middle of the country (Fig. 4-5), summer temperatures are very hot, approaching 50°C occasionally. The average high temperature in July is 45.5°C. It is said to be the hottest capital city in the world. Winters are mild with cold, windy nights. The overall climate is arid, receiving very little rainfall, but the city receives a fair amount of rain in March and April. It is also known to have many dust storms. The dust is often so thick that visibility is under 10 meters.

In the north of the country (Fig. 6-9), desirous continental weather with mild summers and cold winters. Temperature in the summers are between 26-46°C while in winter they're between 4-18°C, with wide spread frosts. Freezes are common with temperatures reaching low -6°C in some winters. Rainfall falls in the winter months from November to March and precipitation ranges between 50 – 150 mm with some not uncommon snow every 3–4 years.

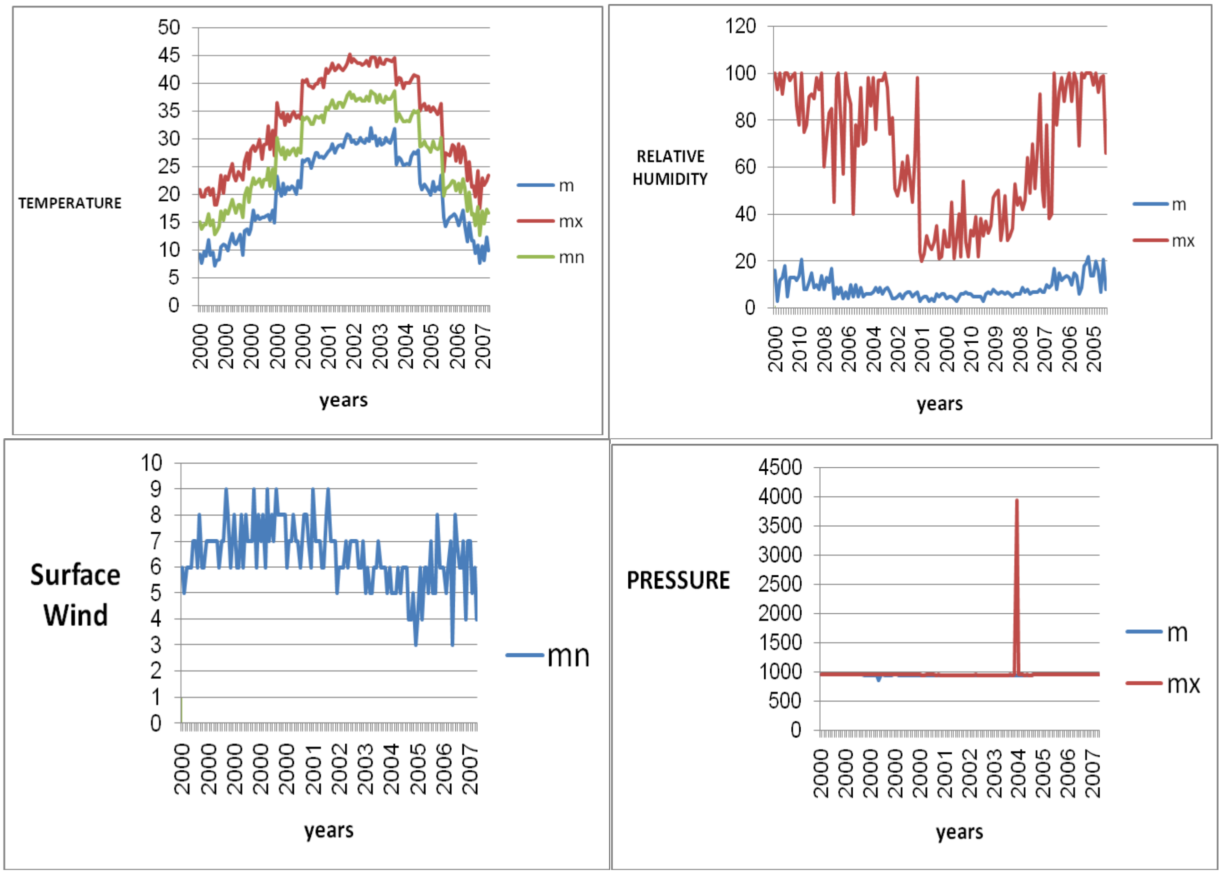

Fig. 4: Periodical climate changes in Riyadh region – Airbase.

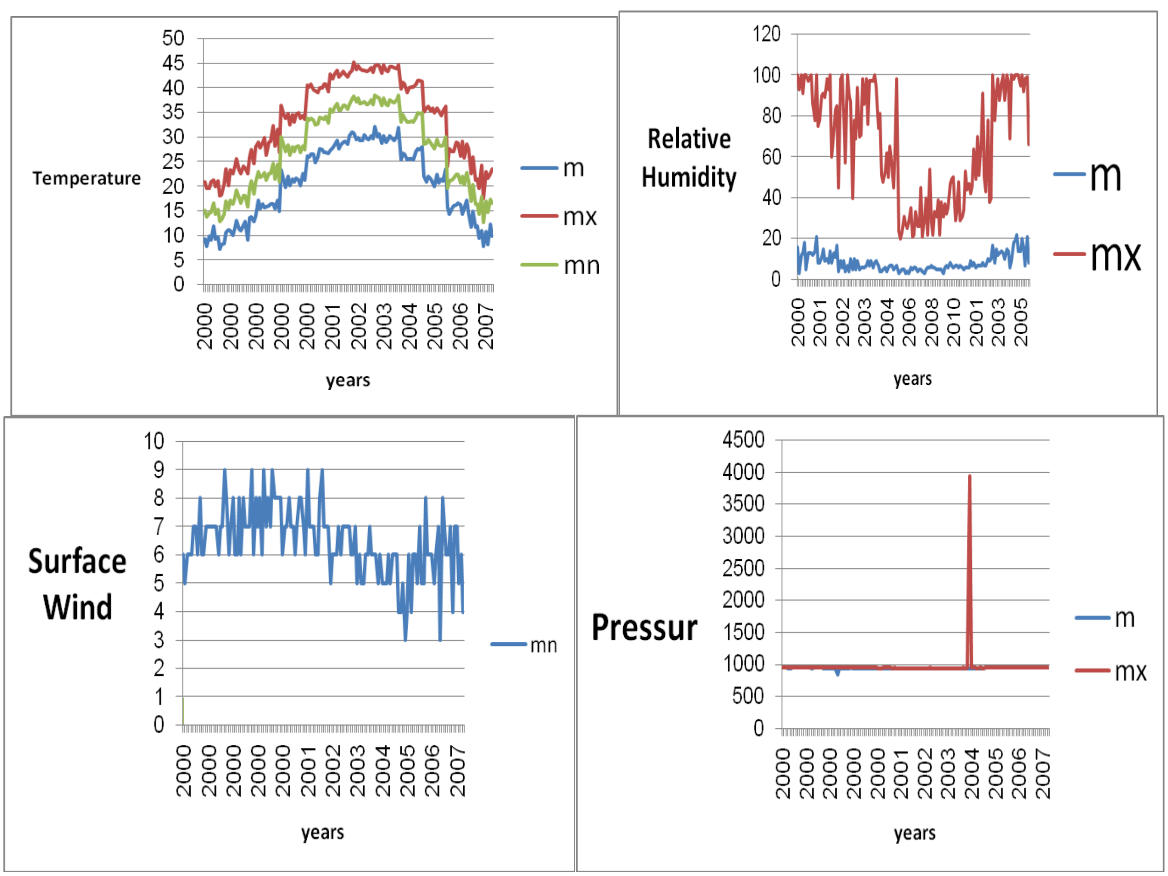

Fig. 5: Periodical climate changes in Riyadh region – Airport.

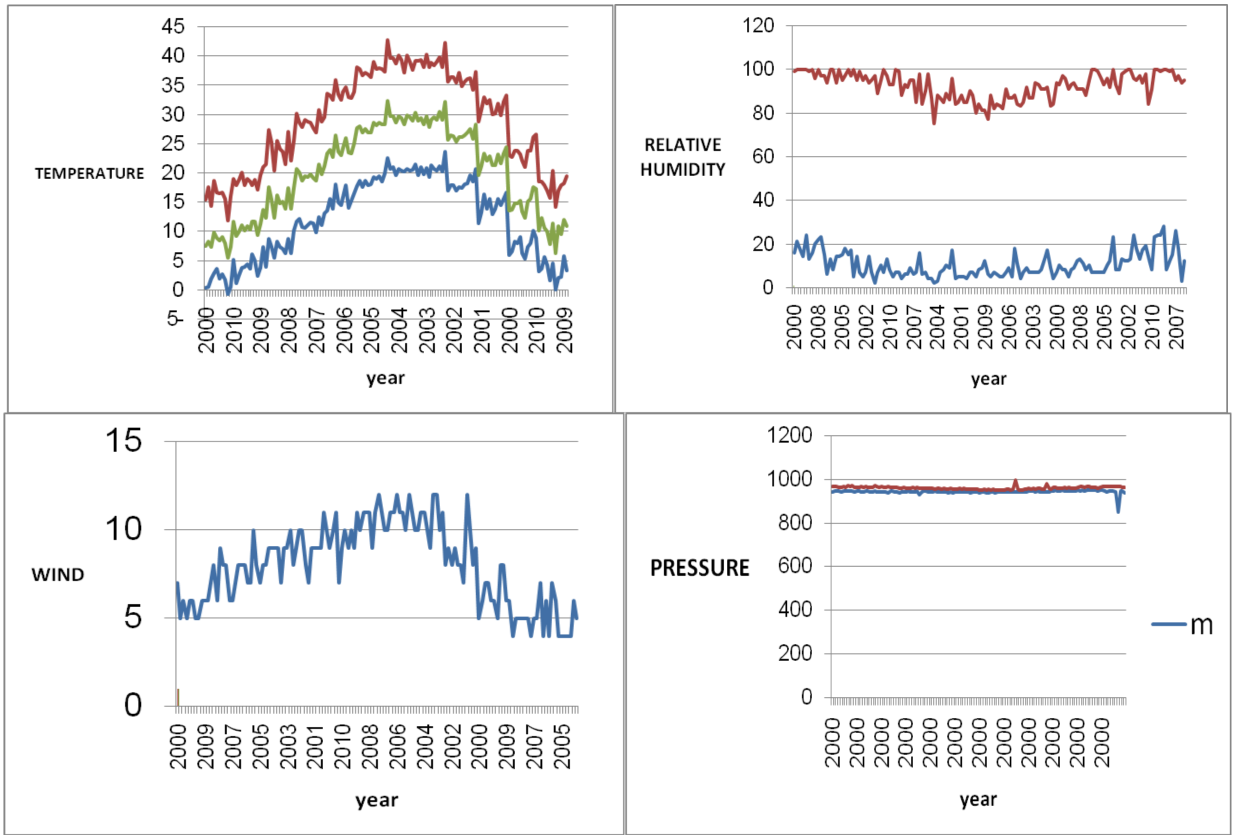

Fig. 6: Periodical climate changes in Gurayat city.

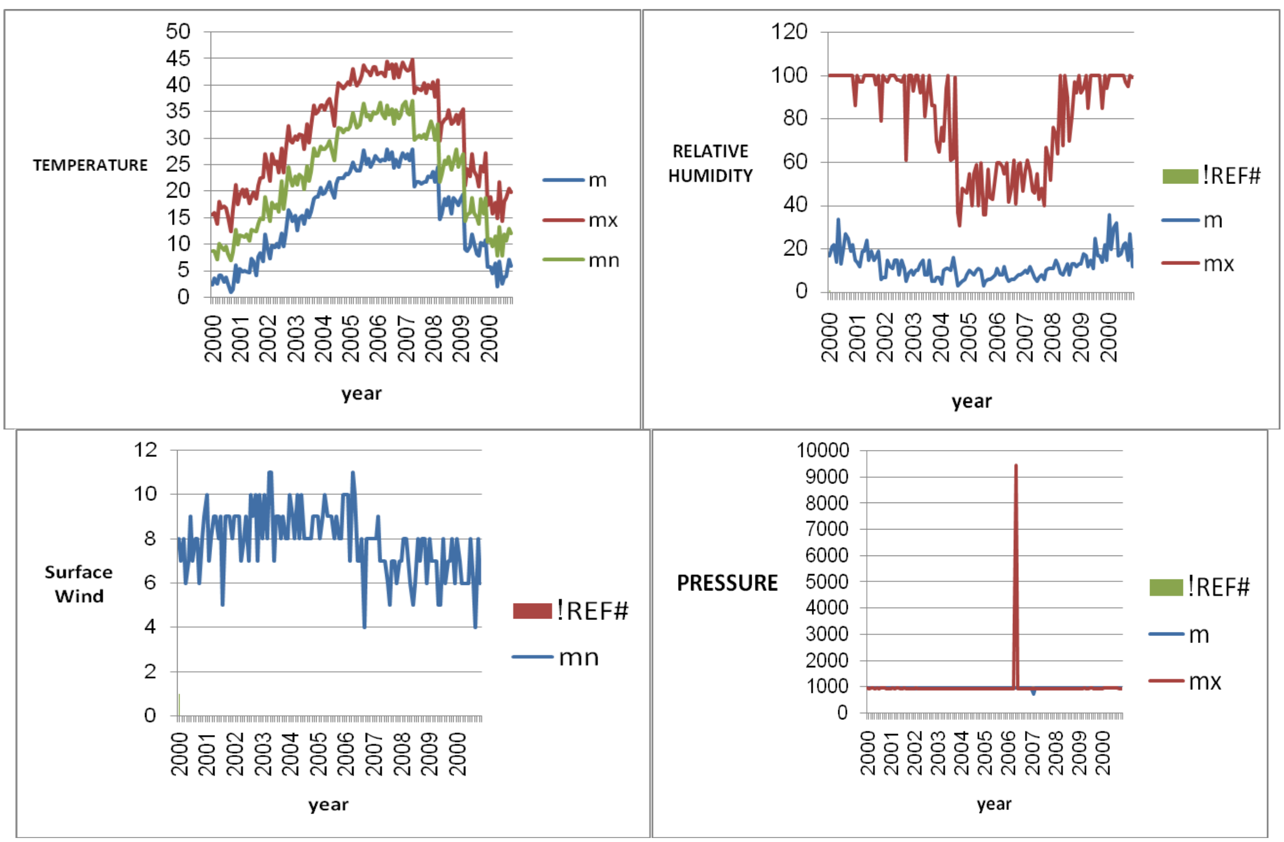

Fig. 7: Periodical climate changes in Arar city.

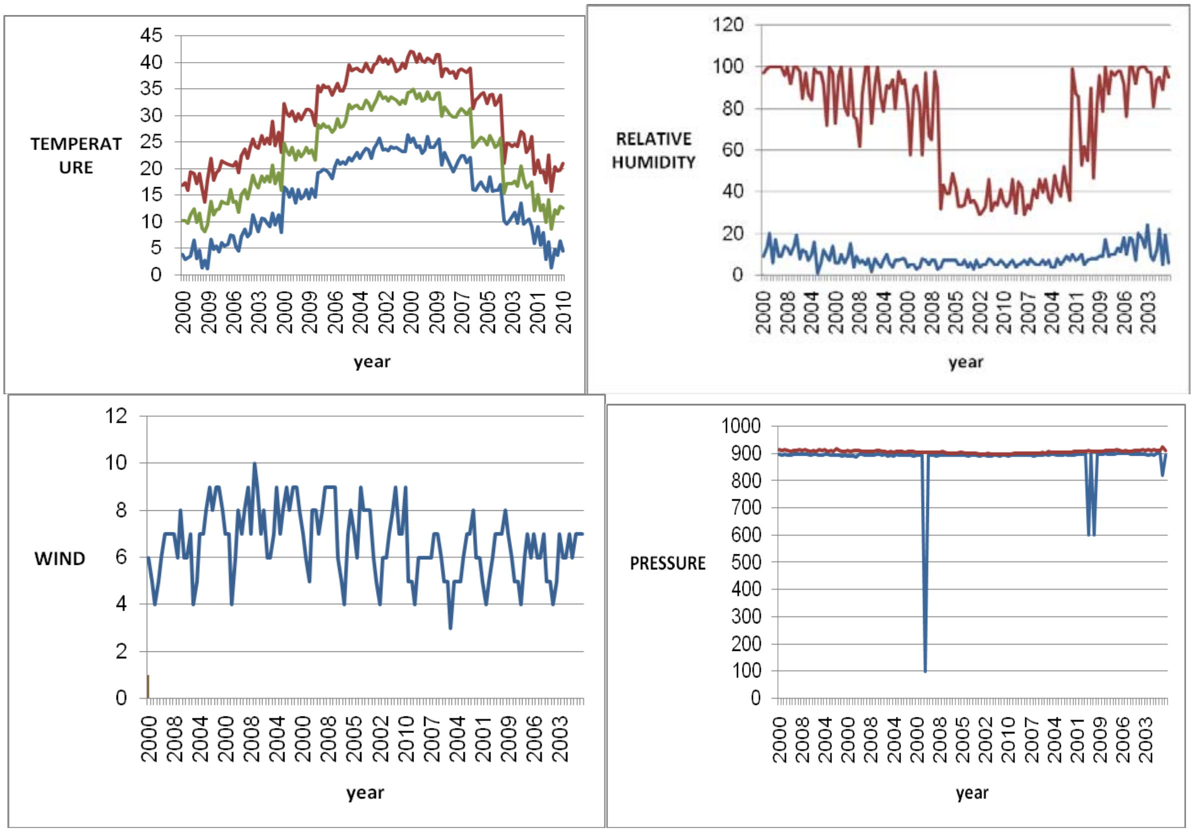

Fig. 8: Periodical climate changes in Gurayat city.

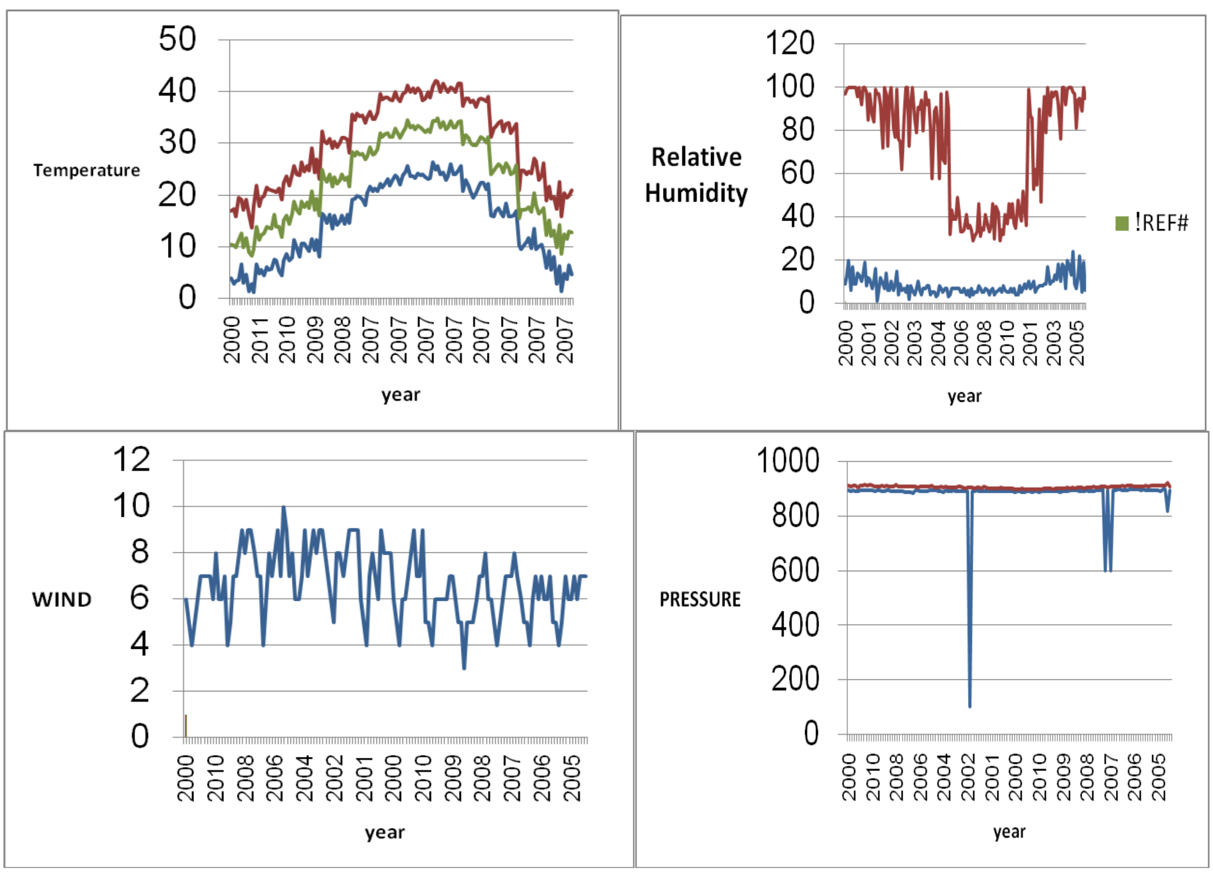

Fig. 9: Periodical climate changes in Hail city.

Data recorded of Saudi Arabia have shown that Asia like others has been climate change throughout the 20th century at a rate of about 0.05°C per decade, amounting to an increase of approximately 0.5°C. The climate change has been more significant in the period June-November each year. The most significant change to Asia's climate has been a long-term reduction in rainfall in the semi-arid regions of West Asia. In the Saudi Arabian Sahel region, there has been a 25% decrease in precipitation on average in the last 30 years[6]. However, the reduction in precipitation has been more moderate in other parts of Asia.

In the past 10 years, both droughts and floods have increased in frequency and severity on the continent. The regularity of drought periods has been a notable aspect of Saudi Arabian climate in recent years, especially in the drier regions. Well shown droughts in the l970s and 1980s significantly affected West Asia in the 20 century and they severely affected large areas of northern Saudi Arabia and the Sahel region [7]. These drought periods are indication of the large variability in climate tropical Asia, the most serious effects of which are usually felt at the drier margins of biological zones or in the regions occupied primarily by pastoral groups [8].

In recent years, Asia has seen more frequent flood and cyclone episodes. The Saudi Arabian delta has in particular seen a marked increase in flooding in the last few decades [9]. Dust storms (which are partly due to changes in land use such as grazing and deforestation) in the some parts of the Sahel have also increased, particularly between the 1950s and 1980s The Intergovernmental Panel on Global Climate change (1PCC) Fourth Assessment Report explains that during 1961 to 2003, the average sea level rose by I .8 + 0.5 mm per year. While sea level rise varies between regions, Saudi Arabia's entire coastline has been affected by this observed rise [3]. Such a rise will have already led to an increase in coastal erosion and exacerbated flooding damages,

A global rise in Red Sea level or Arabian Gulf is expected to significantly affect Saudi Arabia's coastline. The current IPGW predictions are a rise in sea level of between 18 and 59 cm by 2100 relative to 1980-1999, depending on the scenario [3]. As such, this study assumes there to be an increase of potentially 40cm by 2050 for the best estimate. The general consensus in the scientific community is that extreme events will continue to increase and become more severe across the continent. However, the IPGW has stated that there is insufficient information on which to assess possible changes in the spatial distribution and frequency of tropical cyclones affecting Asia. However, it is thought that a further 1°C rise in surface sea temperature in the Atlantic will create the conditions required to create hurricanes off the coast of Saudi Arabia.

A general increase in high-rainfall events is expected, coupled with the expected increase in atmospheric water vapor. The probability of extremely warm seasons is 100% for West Asia, with a 22% probability of extremely wet seasons [4]. In terms of more recent study predictions highlighting positive feedback climate change and stronger climate change, signals from observations have not been focused on Saudi Arabia in particular. Thus a direct translation and downs calling of the recent findings oil temperatures and sea level rise to Saudi Arabia in terms of changes to precipitation, the frequency of extreme events etc on a local level, is not possible.

For validation of the same domain covering the area of Saudi Arabia, a period of 30 years, 1961 to 1990, was downscaled in two separate experiments. Date was obtained from the Hadley Center global atmospheric model for the 1st experiment, and for the second experiment the reanalysis observation data was obtained from the European Center for Medium Range Weather Forecast. Also, weighted domain values were compared for means and standard deviation and visual differences.

A comparison between simulated and the observed mean and standard deviation values of average daily temperature, precipitation, evaporation, wind speeds, and runoff of Saudi Arabia are indicated that it has a cold bias of approximately 2 ^{o}C, but visual comparison indicates a wide deviation north and outside the concerned area. The fact tended to worsen near the edges of the domain was expected and taken care of when the experiment was designed by choosing margins wide enough to get much better values for the region of interest in Saudi Arabia.

The two basic categories of causes of climatic change are external and internal. External causes mean that the climate change arises outside of the system and it is not influenced much by the system, although external processes do not have to be physically external to the Earth (such as the sun). If our focus is on atmospheric change on a 1-week time scale (that is, the weather), the oceans, land surfaces, biota, and human activities that produce CO_2 are all external (that is, they are not influenced much by the atmosphere in such a short time). If our focus is on 100,000-year ice age interglacial cycles, however, the oceans, ice sheets, and biota are part of the internal climatic system and vary as an integral part of the Earth's environmental systems. On this longer scale we must also include as part of our internal system the "solid" Earth, which really is not solid but viscous and elastic. Therefore, stating which components are external or internal to the climatic system depends on the time period and spatial scale being examined, as well as on the phenomena being considered.

Fluctuations in heat radiated by the sun--perhaps related to varying sun spots--are external to the climate system. Influences of the gravitational tugs of other planets on the Earth's orbit are also external. Many researchers think that such tugs gave rise to the 40,000-year ice cycle in the past 2.5 million years and possibly contributed to the 100,000-year ice age and interglacial cycles as well. Human-caused changes in the Earth's climate could not perceptibly alter either one of these cycles.

Changes in volcanic dust or CO_2 in the atmosphere also influence climate; volcanic dust can cool the climate by scattering some sunlight back to space, and CO_2 can warm the climate through the greenhouse effect. On short time scales, these factors are largely external because the state of the climatic system presumably does not have much influence on them. This may not be true, though, in the long term. For example, the tendency for volcanoes to erupt might change when the Earth's crust is distorted by the weight of ice sheets. Likewise, if the climate changes in such a way that an area previously covered with plants becomes drier, dust can be raised more easily. Thus, on the long-term scale, dust generation falls into the internal category.

Carbon dioxide and methane levels rise and fall with ice age cycles (Fig. 1), which are clearly internal on a 10,000-year time scale. But on a 20-year scale these greenhouse gases become largely an external cause of climatic change, because small changes in climate have little feedback effect on, for example, humans burning fossil fuel.

Changes in the character of the land surface, if caused by human activities, are largely external. If vegetation cover changes because of climatic change, however, land surface change then becomes internal because changes in plant cover can influence the climate by changing albedo (reflectivity to sunlight), evapotranspiration, surface roughness, and relative humidity. Snow and ice are important factors in climatic change because they have higher albedo (reflectivity) than warmer surfaces and, in the instance of sea ice, can inhibit transfer of heat and moisture between air and wet surfaces. Salinity, which affects changes in sea ice and in the density of seawater (which helps control where ocean waters sink), may also be an internal cause of climatic variation. The sinking and upwelling of ocean waters are biologically significant because the upwelling waters are often nutrient-rich.

Saudi Arabia's plant diversity is under threat from multiple stresses (Table 1). Climate change is one of the several pressures. Although climate changes will have consequences all over Saudi Arabia, not all regions will be affected equally, nor all regions equally vulnerable to those impacts. Saudi Arabia, being located in the arid part of the world is expected to experience faster warming due to climate change than countries located in the tropical or temperate regions. However, significant variation can be anticipated due to the large size of the country, its diverse landscapes and also due to its Red Sea coast on the western side and the Arabian Gulf on the eastern side.

Before anthropogenic global warming, species were subjected mainly to regional pressures, such as overhunting and habitat destruction. With the acceleration of anthropogenic global warming since the industrial revolution, climate change has begun to influence species safety. Nigel Stork, in the article "Re-assessing Extinction Rate" explains, "the key cause of extinction being climate change, and in particular rising temperatures, rather than deforestation alone." Stork believes climate change is the major issue as to why species are becoming endangered. Stork claims rising temperature on a local and global level are making it harder for species to reproduce. As global warming continues, species are no longer able to survive and their kind starts to deteriorate. This is a repeating cycle that is starting to increase at a rapid rate because of climate change therefore landing many species on the endangered species list.

The overall median change in threatened species (expressed as a percentage of the 1985 overlap value), across models and thresholds, is relatively small (+/−4%) with the distribution of differences for threatened species. However, selected large changes in overlap (exceeding +/−50%). All species are predicted to decrease in overlap for at least one threatened species and modeling scenario. In contrast, all but two commercial species are, on average, projected to overlap more in predicted range with threatened species by 2050 (Table 1).

Consistencies in patterns of the relative habitat suitability change between models for scientific people suggest that these inter-variations stem from characteristics of each modeling procedure, their mechanisms and algorithms. These differences might, for example, result in the majority of cells in a predicted distribution being given characteristically higher, or lower, values, explaining why predictions made using different climate forcing frequently show greater similarity than those made using the same climate forcing.

As the relative response of species to change in one or other of the environmental variables and the possible interactions between them is highly uncertain, both projected responses should be considered. Thus, a multi-model or ensemble model approach helps quantify the variability in projections. In addition, the skill of a model in predicting changes in distribution could be assessed using model hindcasts and historical distribution data, rather than relying on the assumption that the models perform equally well in making future as current species distribution predictions. For example, comparison of historical projection of rate of range shift of exploited species in the Bering Sea and North Sea by DBEM showed a significant agreement between model outputs and observed rate of range shift [38]. Such model assessments could be applied to compare model preferences in future studies.

There are three possible methods in which plants may respond to climate change such as 1) persistence in the modified climate, 2) migrating into better adaptable climate and 3) extinction. Changes can take place in the first category in which three types of persistence are possible, phenotypic plasticity, gradual genetic adaptation of population or ecological changes. However evidences show that during adverse climatic conditions, species are tend to migrate to a more suitable place rather than adapt genetically. Overall, species having a great potential for adaptive responses through genetic diversity, phenotypic plasticity, high abundance or significant dispersal capabilities are least at risk of extinction. Extra arid desert, mountain ranges or shore lines, sometimes, block the easy migration of several species. Climate change will have drastic impact on such species.

Table 1: Status and presence of vegetation in Saudi Arabia.

Families	Scientific Names	Status	Presence
ACANTHACEAE	*Barleria proxima*	#	R
	Crossandra wissmannii	-	O
AIZOACEAE	*Delosperma harazianum*	#	LC
ALLIACEAE	*Allium asirense*	*	O
ALOEACEAE	*Aloe armatissima*	*	L
	Aloe brunneodentata	*	R
	Aloe castellorum	-	FW
	Aloe cephalophora	*	R
	Aloe fleurentinorum	#	LC
	Aloe parvicapsula	*	L
	Aloe parvicoma	*	R
	Aloe porphyrostachys	*	LC
	Aloe pseudorubroviolacea	+	FW
	Aloe rivierei	#	R
	Aloe sabaea	-	FW
	Aloe shadensis	*	O
	Aloe sheilae	*	LC
	Aloe vera var.*officinalis*	-	W
	Aloe vulcanica	*	R
	Aloe x abhaica	*	R
	Aloe x qaharensis	*	R
	Aloe yemenica	#	LC
AMARANTHACEAE	*Nothosaerva brachiata*	#	R
AMARYLLIDACEAE	*Crinum album*	-	W
	Pancratium maximum	-	O
	Pancratium tortuosum	-	FW
	Scadoxus multiflorus	-	O
ANACARDIACEAE	*Pistacia* cf.*khinjuk*	*	LC
	Rhus abyssinica	#	R
ANNONACEAE	Annona squamosa	#	O
ARACEAE	*Arisaema flavum*	#	R
ASCLEPIADACEAE	*Angolluma commulata* ssp.*sheilae*	*	FW
	Angolluma deflersiana	#	LC
	Angolluma eremastrum	#	LC
	Caudanthera sinaica	#	O
	Caudanthera sinaica ssp.*baradi*	#	O
	Ceropegia arabica	#	L
	Ceropegia arabica ssp.*abbreviata*	*	LC
	Ceropegia aristolochioides ssp.*deflersiana*	+	W
	Ceropegia botrys	#	O
	Ceropegia bulbosa	#	R
	Ceropegia rupicola	#	R
	Ceropegia somalensis	#	R
	Ceropegia superba	#	L
	Ceropegia tihamana	*	R
	Ceropegia variegata var.*adelaidae*	#	FW
	Ceropegia variegata var.*variegata*	#	FW
	Ceropegia vignaldiana	#	R
	Crenulluma petraea	#	FW
	Cylindrilluma solenophora	#	R
	Cynanchum acutum ssp.*sibiricum*	#	LC
	Diplostigma canescens	#	R
	Duvalia sulcata	#	R
	Duvalia velutina	*	FW
	Glossonema sp.aff. *boveanum*	*	LC

Table-1 cont….

	Gymnema sylvestre	#	LC
	Huernia arabica	X	
	Huernia laevis	#	R
	Huernia saudi-arabica	*	FW
	Huernia sp.aff. *lodarensis*	*	R
	Huernia sp.nov.aff. *boleana*	+	LC
	Periploca visciformis	#	W
	Rhytidocaulon macrolobum	#	O
	Rhytidocaulon macrolobum ssp. minimum	@	
	Rhytidocaulon sheilae	*	L
	Sarcostemma arabica	+	FW
	Sarcostemma forskaolianum	+	W
	Sarcostemma vanlessenii	#	R
	Sarcostemma viminale ssp.*stipitaceum*	+	FW
	Sulcolluma shadhbana	+	O
	Sulcolluma shadhbana var.*barhana*	+	O
BURSERACEAE	*Commiphora erythraea*	#	LC
CAPPARACEAE	*Boscia angustifolia*	#	O
	Cleome hanburyana	#	O
	Capparis spinosa (blue-leaved)	–	LC
	Capparis tomentosa	#	
	Maerua triphylla	#	L
CARYOPHYLLACEAE	*Dianthus deserti*	*	FW
	Dianthus judaicus	#	O
	Gypsophila umbricola	*	O
	Petrorhagia cretica	#	L
	Silene asirensis	*	LC
	Silene corylina	*	LC
	Sphaerocoma aucheri	#	LC
CELASTRACEAE	*Maytenus heterophylla*	#	R
	Maytenus undata	#	R
CHENOPODIACEAE	*Cornulaca arabica*	*	LC
COMPOSITAE	*Anthemis sheilae*	*	LC
	Anthemis zoharyana ssp.*brachyota*	*	O
	Centaurothamnus maximus	*	L
	Crepis sancta ssp.*sancta*	*	O
	Dicoma tomentosa	#	R
	Kleinia pendula	#	LC
CONVOLVULACEAE	*Astripomea malvaceae*	X	
	Convolvulus excelsus	*	R
	Convolvulus infantispinosus	*	LC
	Convolvulus siculus	#	LC
	Cuscuta hyalina	X	
	Xerostegia tridentata	X	
CRUCIFERAE	*Dolichorhyncus arabicus*	*	R
	Erysimum hedgianum	*	R
CYPERACEAE	*Cyperus alternifolius* ssp.*flabelliformis*	–	O
DIPSACACEAE	*Pterocephalus* sp.aff.*sanctus*	*	R
	Pterocephalus brevis	#	R
DRACAENACEAE	*Dracaena ombet*	–	O
	Sansevieria ehrenbergii	–	FW
EBENACEAE	*Diosporus mespiliformis*	#	LC
ERICACEAE	*Erica arborea*	–	O
EUPHORBIACEAE	*Euphorbia agowensis*	X	
	Euphorbia ammak	–	LC

Table-1 cont..

	Euphorbia sp.aff.*cactus*	–	LC
	Euphorbia sp.aff.*fruticosa*	*	R
	Euphorbia pirottae	X	
	Euphorbia sp.aff.*parciramulosa*	+	O
FLACOURTIACEAE	*Oncoba spinosa*	X	
GLOBULARIACEAE	*Globularia arabica*	#	LC
GRAMINAE	*Sporobolus pellucidas*	–	LC
	Trisetaria chaudharyana	*	LC
HYACINTHACEAE	*Albuca pendula*	*	LC
	Leopoldia tenuiflorum	#	O
HYDNORACEAE	*Hydnora johannis*	#	R
HYPERICACEAE	*Hypericum collenettiae*	@	
IRIDACEAE	*Gladiolus dalenii*	–	O
	Iris albicans	#	R
	Iris postii	#	R
LABIATAE	*Ajuga arabica*	*	LC
	Lallemantis royleana	#	O
	Nepeta sheilae	*	LC
	Phlomis brachyodon	#	LC
	Plectranthus arabicus	X	
	Teucrium popovii	*	R
	Thuspeinanta persica	X	
	Thymus decussatus	#	R
LEGUMINOSAE	*Abrus precatorius*	#	LC
	Acacia seyal	–	L
	Acacia seyal var.*fistula*	–	L
	Argyrolobium confertum	#	LC
	Argyrolobium crotalarioides	*	LC
	Astragalus collenettiae	*	O
	Astragalus echinus ssp.*arabica*	*	L
	Cicer cuneata	X	
	Crotolaria persica	#	LC
	Cyamopsis senegalensis	#	LC
	Desmodium gangeticum	X	
	Faidherbia albida	#	R
	Glycyrrhiza glabra	#	R
	Indigofera linifolia	#	LC
	Indigofera volkensii	#	LC
	Tephrosia pumila	#	OL
	Tephrosia subtriflora	#	OL
	Vigna ambacensis	#	R
LILIACEAE	*Tulipa biflora*	#	R
MALVACEAE	*Alcea striata*	#	W
	Pavonia hildebrandtii	#	R
MORACEAE	*Dorstenia foetida*	–	FW
MORINGACEAE	*Moringa peregrina*	–	FW
MYRTACEAE	*Myrtus communis*	#	R
NYCTAGINACEAE	*Boerhavia elegans* ssp.*elegans*	*	R
OCHNACEAE	*Ochna inermis*	#	R
ORCHIDACEAE	*Bonatea steudneri*	#	R
	Epipactis veratrifolia	#	R
	Eulophia guineensis	#	O
	Eulophia petersii	–	FW
	Eulophia speciosa	#	
	Holothrix arachnoidea	–	O

Table-1 cont…

PASSIFLORACEAE	*Adenia venenata*	–	O
PITTOSPORACEAE	*Pittosporum viridiflorum* ssp.*arabicum*	#	R
POLYGONACEAE	*Atraphaxis spinosa*	#	O
	Calligonum comosum	–	W
	Calligonum crinitum ssp.*arabicum*	+	O
	Persicaria amphibia	X	
	Rheum palaestinum	X	
PRIMULACEAE	*Androsace maxima*	#	R
PSILOTACEAE	*Acrostichum aureum*	#	R
	Psilotum nudum	#	R
RANUNCULACEAE	*Delphinium sheilae*	*	FW
RESEDACEAE	*Ochradenus arabicus*	+	O
	Reseda pentagyna	*	LC
RHAMNACEAE	*Ziziphus mucronata*	#	L
RHIZOPHORACEAE	*Rhizophora mucronata*	–	O
ROSACEAE	*Crataegus sinaica*	#	R
	Potentilla dentata	#	R
	Prunus korshinskyi	#	OL
RUBIACEAE	*Breonadia salicina*	#	
	Crucianella ciliata ssp.*arabica*	*	R
	Tarenna graveolens	*	R
SALICACEAE	*Popolus euphratica*	#	R
SAPINDACEAE	*Cardiospermum halicacabum*	#	R
SAPOTACEAE	*Mimusops laurifolia*	–	O
SCROPHULARIACEAE	*Chaenorhinum rubrifolium*	*	
	Halleria lucida	#	R
	Harveya obtusifolia	X	
	Kickxia collenettiana	@	
	Kickxia elatina ssp.*crinata*	X	
	Verbascum decaisneanum	#	LC
SOLANACEAE	*Physalis minima*	#	R
	Solanum cordatum	*	LW
STERCULIACEAE	*Glossostemon bruguieri*	#	O
TAMARICACEAE	*Tamarix tetragyna*	X	
THYMELACEAE	*Daphne linearifolia*	#	O
	Thymelaea mesopotamica	#	O
UMBELLIFERAE	*Oreoschimperella arabiae - felicis* var.*laevis*	*	O
	Peucedanum inaccessum	*	R
URTICACEAE	*Parietaria umbricola*	*	R
VALERIANACEAE	*Valerianella cf.sclerocarpa*	*	LC
	Valerianella muricata	#	LC
VELLOZIACEAE	*Xerophyta arabica*	#	R

Status- *: Endangered Endemic, @: Extinct-Endemic, # : Endangered non-endemic, X : 'extinct' non-endemic, + : not endangered endemic, - : not endangered or endemic.
Presence- R : rare, O: occasional, L: local, C: locally common, FW: fairly widespread, W: widespread, WX: widespread/overexploited

Some categories of plants would appear to be more vulnerable. Fragmentation of population is of particular importance for endemics. Due to climatic variations, if they cannot persist or adapt, species showing a fragmented distribution may see their range become even more fragmented, with local disappearances. Locally or regionally, climatic change may even weaken dominant species such as *Acacia* spp., *Lyciumshawii*, etc through defoliation.

The effects of temperature on plants are often difficult to assess because they are closely dependent on the available water supply. There are various adaptations to overcome very high temperature, such as vertically arranged narrow leaves or drooping leaves (e.g. *Ficussalicifolia*), or thick white dense hairs (e.g. *Teucriumpolium*).

According to scientists, an increase in nitrogen deposition and atmospheric CO_2 concentration will favour groups of species that share certain physiological or life history traits that are common among invasive species (*Argemonemexicana, Tridaxprocumbens, Nicotianaglaucum, Opuntia* spp.) that allow them to dominate in a locality. As far as the distribution of plants is concerned, there are ups and downs in the response towards climate change. Studies show that dispersal would not be a significant problem for most species in the changing climate, provided the platform of suitable habitats was not altered. Unfortunately this privilege cannot be taken as granted as far as the situation in Saudi Arabia is concerned. Most of the habitats in Saudi Arabia and elsewhere in the Arabian Peninsula are highly fragmented due to human activities and therefore the opportunities for migration and establishments will be limited and restricted to less than 50% of the floristic elements present in Saudi Arabia.

In areas in and around Jabal Tallan, Jabal Warjan, etc, there are signs of significant microclimate change. In these mountains, the lower slopes are covered with immense stands of totally dead *Juniperus* trees along with many dead Dragon trees (*Dracaena ombet*). Now most of the vegetation in these mountains is present only in sheltered gullies and ravines where water is lingering after rain. According to Collenette "in 1977, among the many endemic plants which grow on this mountain (Jabal Dibbagh) there were some twenty-five plants of a *Phlomis* species new to science, about the same number of shrubs of *Daphne linearifolia*, and a number of gravel pans in a limited areas were carpeted with *Tulips*. In 1985, nearly all the large *Junipers* had been removed, the number of *Phlomis* plants had been reduced to five, most of the *Daphne* bushes were dead or dying and the number of tulip plants had been reduced by over half. People living in the area, especially near Sawawin camp, commented on how seldom the mountain was wreathed in cloud compared to previous years". The wood lands of *Juniperu sprocera* was in a healthy condition for many centuries. Unfortunately extensive decline has been reported in the last two decades or so. The decline is characterized by die back at the lower altitudinal ranges of the woodlands. However, the woodlands in high altitude are generally in a healthy condition.

Distributions, population sizes and population density have been affected directly by the changes in vegetation in most parts of Saudi Arabia. Many communities are expected to be placed at greater risk because of unsuitable habitats and various obstacles in species migration due to change in land uses and thereby the fragmentation of habitats. Due to improper management, these obstacles or pressures will cause some species currently placed as "critically endangered" to become extinct and a majority of those labelled as "endangered or vulnerable' to become rarer and thereby closer to extinction in the next few decades.

A central criticism of species distribution and bioclimatic envelope modeling lies in the assumption that a species is in pseudo-equilibrium with its environment [35]. To ensure that this assumption was upheld here, all available valid occurrence data on each species was included to obtain as near as possible the species' absolute environmental tolerance limits. However, each of the species investigated here are thought to have been recently restricted to areas which do not adequately reflect their historic distribution for reasons other than change in environmental suitability, such as planting and other human disturbances. Predictions made using these data are therefore unlikely to represent the actual current distribution of each species, potentially biasing estimates of a species' environmental tolerance limits and environmental envelopes.

Adverse effects of climate on communities would definitely have serious ramifications for the security and integrity of our natural resources. The overall climatic change in Saudi Arabia or in the Middle East in general will have drastic effect on the impoverished biodiversity of the region. In such situations, most of the vulnerable species will no longer be able to grow in their present habitats and therefore they will either migrate to the nearest suitable places or their population shrink and later extinct locally. Occasionally species that cannot migrate to new areas change their physiological behavior by further reducing their overall stature of the plant or do not produce any flowers.

Distributions, population sizes, population density, etc. have been affected directly by the changes in vegetation in most parts of Saudi Arabia. Many communities are expected to be placed at greater risk because of unsuitable habitats and various obstacles in species migration due to change in land uses and thereby the fragmentation of habitats. Due to improper management, these obstacles or pressures will cause some species currently placed as "critically endangered" to become extinct and a majority of those labeled as "endangered or vulnerable' to become rarer and thereby closer to extinction in the next few decades.

SUMMARY

No clear physical objection or direct empirical evidence has contradicted the consensus of scientists that the world is not climate change, nor has evidence emerged to contradict the substantial probability that temperatures will rise because of increases in greenhouse gases. The evidence for current global climate change forecasts is circumstantial, but is sufficient enough that many researchers believe that recently observed climatic variations and human activities are probably connected. The consensus remains widespread that a global temperature increase of anywhere from 1°C to 5°C is reasonably probable in the next century.

The scientists gave global average temperature changes (from CO_2 doubling) ranging from 1.5°C to 4.5°C three stars, equivalent presumably to a 60% subjective chance. As mentioned previously, though, the ecologically important forecasts of time-evolving regional climatic changes are much less credible and require that ecologists use many alternative scenarios of possible climatic changes.

This study suggests that a change in climate of south KSA will not result in an overall, unidirectional change in the relative habitat suitability of marine protected areas. This is generally because of the large variation in the predicted changes in relative habitat suitability between model combinations.

REFERENCES

[1] Albouy C, Guilhaumon F, Araújo MB, Mouillot D, Leprieur F 2012. Combining projected changes in species richness and composition reveals climate change impacts on coastal Mediterranean plant assemblages. Global Change Biology 18: 2995–3003 doi:10.1111/j.1365-2486.2012.02772.x.

[2] Araújo MB, New M 2007. Ensemble forecasting of species distributions. Trends in ecology & evolution 22: 42–47 doi:10.1016/j.tree.2006.09.010.

[3] Araujo MB, Thuiller W, Pearson RG 2006. Climate climate change and the decline of amphibians and reptiles in Europe. Journal of Biogeography 33: 1712–1728. doi:10.1111/j.1365-2699.2006.01482.x.

[4] Barange M, Cheung WWL, Merino G, Perry RI 2010. Modelling the potential impacts of climate change and human activities on the sustainability of marine resources. Current Opinion in Environmental Sustainability 2: 326–333 doi:10.1016/j.cosust.2010.10.002. . doi: 10.1016/j.cosust.2010.10.002.

[5] Beaugrand G 2004. The North Sea regime shift: Evidence, causes, mechanisms and consequences. Progress In Oceanography 60: 245–262 doi:10.1016/j.pocean.2004.02.018.

[6] Blanchard JL, Jennings S, Holmes R, Harle J, Merino G, 2012. Potential consequences of climate change for primary production and plant production in large marine ecosystems. Philosophical transactions of the Royal Society of London Series B, Biological sciences 367: 2979–2989 doi:10.1098/rstb.2012.0231.

[7] Botkin DB, Saxe H, Araújo MB, Betts R, Bradshaw RHW, 2007. Forecasting the Effects of Global Climate change on Biodiversity. BioScience 57: 227–236. doi: 10.1641/B570306.

[8] BRIG 2007. Report on the Species and Habitat Review; Report by the Biodiversity Reporting and Information Group (BRIG) to the UK Standing Committee. Joint Nature Conservation Committee (JNCC website). http://jncc.defra.gov.uk/page-5705. Accessed 2012 Dec 23.

[9] Burrows MT, Schoeman DS, Buckley LB, Moore P, Poloczanska ES, 2011. The pace of shifting climate in marine and terrestrial ecosystems. Science 334: 652–655 doi:10.1126/science.1210288.

[10] Cheung W, Pitcher T, Pauly D 2005. A fuzzy logic expert system to estimate intrinsic extinction vulnerabilities of marine plants to planting. Biological Conservation 124: 97–111 doi:10.1016/j.biocon.2005.01.017.

[11] Cheung WWL, Dunne J, Sarmiento JL, Pauly D 2011. Integrating ecophysiology and plankton dynamics into projected maximum fisheries catch potential under climate change in the Northeast Atlantic. ICES Journal of Marine Science 68: 1008–1018 doi:10.1093/icesjms/fsr012.

[12] Cheung WWL, Lam VWY, Pauly D 2008. Modelling present and climate-shifted distributions of marine plants and invertebrates. Fisheries Centre Research Report 16.

[13] Cheung WWL, Lam VWY, Sarmiento JL, Kearney K, Watson R, 2010. Large-scale redistribution of maximum fisheries catch potential in the global ocean under climate change. Global Change Biology 16: 24–35 doi:10.1111/j.1365-2486.2009.01995.x.

[14] Cheung WWL, Lam VWY, Sarmiento JL, Kearney K, Watson R, 2009. Projecting global marine biodiversity impacts under climate change scenarios. Plant and Fisheries 10: 235–251 doi:10.1111/j.1467-2979.2008.00315.x.

[15] Cheung WWL, Sarmiento JL, Dunne J, Frölicher TL, Lam VWY, 2012. Shrinking of plants exacerbates impacts of global ocean changes on marine ecosystems. Nature Climate Change 2: 1–5 doi:10.1038/nclimate1691. doi: 10.1038/nclimate1691.

[16] Cianfrani C, Lay GL, Maiorano L, Satizábal HF, Loy A, 2011. Adapting global conservation strategies to climate change at the European scale: The otter as a flagship species. Biological Conservation 144: 2068–2080 doi:10.1016/j.biocon.2011.03.027.

[17] Close C, Cheung W, Hodgson S, Lam V, Watson R, 2006. Distribution ranges of commercial plants and invertebrates. Fisheries Centre Research Report 14: 27–37.

[18] Coetzee BWT, Robertson MP, Erasmus BFN, van Rensburg BJ, Thuiller W 2009. Ensemble models predict Important Bird Areas in southern Africa will become less effective for conserving endemic birds under climate change. Global Ecology and Biogeography 18: 701–710 doi:10.1111/j.1466-8238.2009.00485.x.

[19] Conroy MJ, Runge MC, Nichols JD, Stodola KW, Cooper RJ 2011. Conservation in the face of climate change: The roles of alternative models, monitoring, and adaptation in confronting and reducing uncertainty. Biological Conservation 144: 1204–1213 doi:10.1016/j.biocon.2010.10.019.

[20] Deutsch C, Brix H, Ito T, Frenzel H, Thompson L 2011. Climate-forced variability of ocean hypoxia. Science (New York, NY) 333: 336–339 doi:10.1126/science.1202422.

[21] Dockerty T, Lovett A, Watkinson A 2003. Climate change and nature reserves: examining the potential impacts, with examples from Great Britain. Global Environmental Change 13: 125–135 doi:10.1016/S0959-3780(03)00010-4.

[22] Dulvy N, Notobartolo di Sciara G, Serena F, Tinti F, Ungaro N, 2006. Dipturusbatis. IUCN 2001 IUCN Red List of Threatened Species Version 20112. Available: www.iucnredlist.org. Accessed 2011 Dec 2.

[23] Dulvy NK, Rogers SI, Jennings S, Stelzenmller V, Dye SR, 2008. Climate change and deepening of the North Sea plant assemblage: a biotic indicator of climate change seas. Journal of Applied Ecology 45: 1029–1039 doi:10.1111/j.1365-2664.2008.01488.x.

[24] Dulvy NK, Sadovy Y, Reynolds JD 2003. Extinction vulnerability in marine populations. Plant and Fisheries 4: 25–64. doi: 10.1046/j.1467-2979.2003.00105.x.

[25] Dunne JP, Gnanadesikan A, Sarmiento JL, Slater RD 2010. Technical description of the prototype version (v0) of tracers of phytoplankton with allometric zooplankton (TOPAZ) ocean biogeochemical model as used in the Princeton IFMIP model. Biogeosciences 3593.

[26] Edwards M, Richardson AJ 2004. Impact of climate change on marine pelagic phenology and trophic mismatch. Nature 430: 881–884 doi:10.1038/nature02808.

[27] Elith J, Ferrier S, Guisan A, Graham CH, Anderson RP, 2006. Novel methods improve prediction of species' distributions from occurrence data. Ecography 29: 129–151. doi: 10.1111/j.2006.0906-7590.04596.x.

[28] Elith J, Kearney M, Phillips S 2010. The art of modeling range-shifting species. Methods in Ecology and Evolution 1: 330–342 doi:10.1111/j.2041-210X.2010.00036.x.

[29] Ellis J 2005. Raja clavata. IUCN 2001 IUCN Red List of Threatened Species Version 2012. Available: www.iucnredlist.org. Accessed 2011 Dec 2.

[30] Ellis J, Serena F, Mancusi C, Haka F, Morey G, 2009. Scyliorhinusstellaris. IUCN 2001 IUCN Red List of Threatened Species Version 20112. Available: www.iucnredlist.org. Accessed 2011 Dec 2.

[31] Fielding AH, Bell JF 1997. A review of methods for the assessment of prediction errors in conservation presence/absence models. Environmental Conservation 24: 38–49. doi: 10.1017/S0376892997000088.

[32] Fitter AH, Fitter RSR 2002. Rapid changes in flowering time in British plants. Science (New York, NY) 296: 1689–1691 doi:10.1126/science.1071617.

[33] Froese R, Pauly D 2011. Plantbase. World Wide Web electronic publication. Available: www.plantbase.org, version (02/2011). Accessed 2012 Feb 2.

[34] Fuller T, Morton D, Sarkar S 2008. Incorporating uncertainty about species' potential distributions under climate change into the selection of conservation areas with a case study from the Arctic Coastal Plain of Alaska. Biological Conservation 141: 1547–1559 doi:10.1016/j.biocon.2008.03.021.

[35] Guisan A, Thuiller W 2005. Predicting species distribution: offering more than simple habitat models. Ecology Letters 8: 993–1009 doi:10.1111/j.1461-0248.2005.00792.x.

[36] Guisan A, Zimmermann NE 2000. Predictive habitat distribution models in ecology. Ecological Modelling 135: 147–186. doi: 10.1016/S0304-3800(00)00354-9.

[37] Hagerman S, Dowlatabadi H, Satterfield T, McDaniels T 2010. Expert views on biodiversity conservation in an era of climate change. Global Environmental Change 20: 192–207 doi:10.1016/j.gloenvcha.2009.10.005.

[38] Harborne AR, Mumby PJ 2011. Novel ecosystems: altering plant assemblages in climate change waters. Current Biology 21: R822–R824 doi:10.1016/j.cub.2011.08.043.

[39] Henderson P 2007. Discrete and continuous change in the plant community of the Bristol Channel in response to climate change. Journal of the Marine Biological Association of the UK 87: 589–598 doi:10.1017/S0025315407052447.

[40] Hijmans RJ, Graham CH 2006. The ability of climate envelope models to predict the effect of climate change on species distributions. Global Change Biology 12: 2272–2281 doi:10.1111/j.1365-2486.2006.01256.x.

[41] Hobday AJ, Okey TA, Poloczanska ES, Kunz TJ, Richardson AJ 2006. Impacts of climate change on Australian marine life: Part B. Technical Report. Report to the Australian Geenhouse Office, Canberra, Australia, September 2006.

[42] Hu J, Jiang Z 2011. Climate Change Hastens the Conservation Urgency of an Endangered Ungulate. PLoS ONE 6: e22873 doi:10.1371/journal.pone.0022873.

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