CONCEPTUAL OVERVIEW

Terrestrial Biodiversity & Climate Change

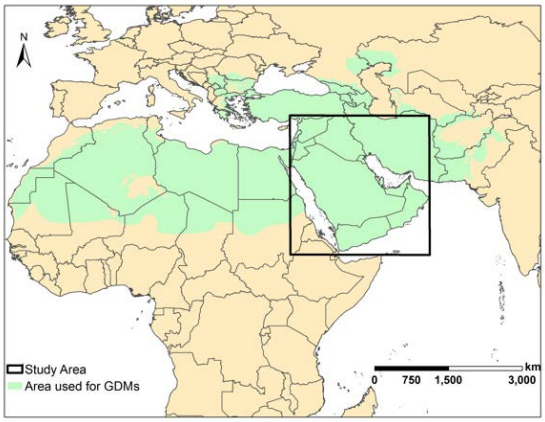
Dr. Matthew Fitzpatrick (Principle Invesigator)
Appalachian Laboratory at the University of Maryland Center for Environmental Science.
Kavya Pradhan, Matthew Lisk (co-authors)

There is compelling evidence that climate change may impose widespread adverse impacts on terrestrial biodiversity, including dramatic increases in extinction rates and changes to ecosystem structure and function. At regional scales, the primary impacts of climatic change are expected to be rapid geographic shifts in climatically suitable habitats. As temperatures increase and precipitation patterns change, species will be forced to either adapt to new conditions, migrate to areas that become suitable, or potentially face extinction. The increasing isolation and fragmentation of natural habits and the rapid rates of projected climatic change are expected to make migration unfeasible for all but the most agile and widespread species.

The Arabian Peninsula region's substantial range and level of biodiversity is the heart of this study. Regarding vegetation, there are estimated to be approximately 7,000 native species of plants in the Arabian Peninsula, with up to about 20% being endemic. Regarding birds, the Arabian Peninsula lies on important bird migration routes as a bridge between Africa, Asia and Europe, and contains numerous stopover habitats for both migrating and overwintering birds. Regarding mammals, approximately 100 species of native mammals have been recorded in the Arabian Peninsula, from small rodents and bats to large herbivores and carnivores. Regarding reptiles, both species richness and the proportion of endemic species are relatively high, with 172 species currently recognized and 89 species (52%) considered endemic. Of this range of biodiversity, the focus was on a set of 111 priority species, as identified by regional stakeholders and informed by data availability.

The overall aim of this study was to provide a comprehensive assessment of the potential vulnerability of terrestrial biodiversity in the Arabian Peninsula to climatic change. There were three main objectives: (1) Describe how a group of priority species and taxonomic communities are likely to respond to changes in climate as realized across a wide range of future climate scenarios; (2) quantify the magnitude of uncertainty associated with the modeled responses; and (3) provide a set of visualizations pinpointing areas of species loss which can be used for future conservation planning in the

Figure 1: Map of study region (black rectangle) and general extent of areas used to fit models used



region. The approach allows for an identification of species and sub-regions that are most vulnerable to climate change, while documenting the degree of uncertainty in forecasts, and offering maps depicting changes in species distributions and patterns of biodiversity. The study region is shown in Figure 1.

The fundamental concept underlying the vulnerability assessment is that climate-driven changes in habitat suitability will place species at risk by reducing the area that can support populations and/or by forcing individuals to shift their geographic ranges to track suitable climate regimes. These changes in the distributions of individuals will lead to the disassembly of existing communities and the formation of new ones, which in turn will alter ecosystem structure and function. A key requirement for quantifying any shift in geographic range is a suitable amount and quality of species occurrence data. For the majority of species, there is limited information available in the format needed to develop robust quantitative predictions regarding all possible types and magnitude of changes expected. Hence, the results should be viewed as a first cut assessment of climate change impacts that should be updated as additional data become available.

The focus of the effort was on a set of priority species, as identified by stakeholders and informed by data availability. This involved developing a list of species for which to seek data records for subsequent modeling. A consultative approach was used whereby 1) feedback from local specialists was obtained regarding priority species; 2) existing literature and published assessments of those species were examined; and 3) the availability of all other local and internationally available occurrence records were investigated. As a result of this process, a total of 111 priority species were selected, encompassing birds, mammals, plants, reptiles, and amphibians. Table 1 provides a list of priority species considered. While all of the species in Table 1 were explored, some had to be discarded due to lack of adequate data at the resolutions needed.

Modeling of the impact of climate change on terrestrial biodiversity was conducted at the species level using Maxent, a species distribution model, and at the community level using the Generalized Dissimilarity Modeling (GDM) system. Both modeling frameworks incorporated information of current and future climate in the region. An ensemble approach to climate change was applied to account for the range of potential future conditions. To describe current climatology (1950-2000), a database of globally-contiguous gridded representations of climate at were used. For future climate, 62 future climate simulations at 2.5 arc-minute spatial resolution and global extent for decades 2030, 2050, 2070, and 2080 were downscaled to the Arabian Peninsula, together with output from the high-resolution climate change modeling simulations developed as part of the Regional Atmospheric Modeling sub-project. Representative Concentration Pathways (RCP) 4.5 and 8.5 were considered. Hundreds of maps have been developed and are accessible at the Terrestrial Biodiversity Inspector

Ensemble projections from MaxEnt and GDM to numerous climate scenarios provide a comprehensive overview of the potential future of terrestrial biodiversity in the Arabian Gulf countries from the perspective of both individual species and from biodiversity as a whole. Findings from this study suggest climate change has the potential to cause widespread changes in species distributions and patterns of biodiversity across the Arabian Peninsula and that the magnitude and spatial extent of impacts will increase through time. For individual priority

species, loss of suitable habitat is expected to be most pronounced in the southern half of the region. This includes Qatar, the UAE, Yemen (including the island of Socotra), and Oman, and along the western coast of Saudi Arabia. For biodiversity as a whole, both northern and southern areas may undergo substantial changes in species composition (high climatic stress). Only a fraction of the southern portion of the region – and the southwestern corner in particular – was projected to experience low climatic stresses and therefore comparatively little changes in species composition.