An integrative approach for studying the effects of global climate change on natural ecosystems along an aridity gradient

Marcelo Sternberg & Claus Holzapfel: Tel Aviv University, Israel
Katja Tielbörger, Florian Jeltsch, & Martin Köchy: University of Potsdam, Germany
Hanoch Lavee & Sarah Pariente: Bar-Ilan University, Israel
Aliza Fleischer & Jaime Kigel: The Hebrew University of Jerusalem, Israel

(1) Overall Goals *or* Why do we do this?

Current global climate change models predict drastic changes in precipitation in semiarid and arid areas of the Middle East. Changes in these areas are likely to affect natural communities to a much larger extent than in more mesic areas, leading to important changes in land-use patterns. Even though some theoretical models allow predictions of these changes, information based on experimental approaches is still very scarce.

The **aims** of our project are to gain detailed insights into the effects of global climate change on soil properties and vegetation patterns in Mediterranean to arid ecosystems in Israel.

The specific goals of the project are:

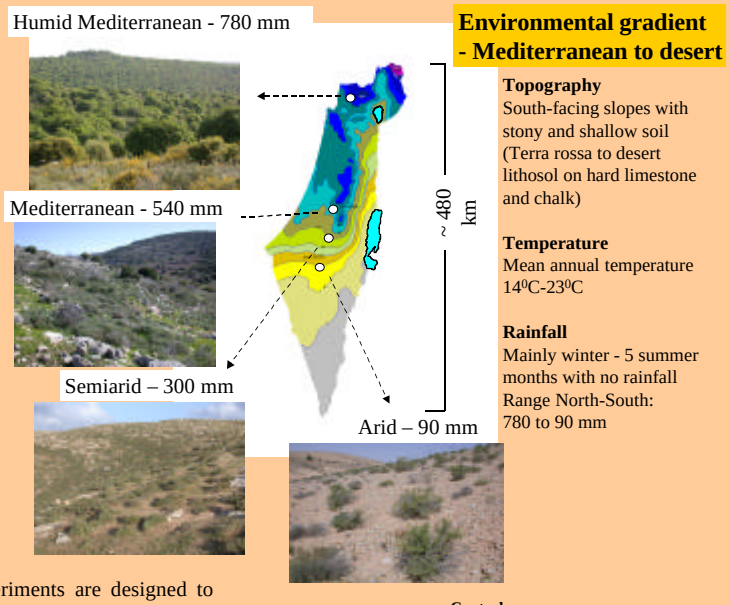
1) to provide empirical data much needed for modeling and predicting ecosystem responses to climate change in an environmentally sensitive area, serving as a model system for other dry areas in the world.

2) to obtain knowledge of the factors that control ecosystem composition and structure in the face of global climate change.

Such major advances in ecological information are needed to understand human-induced ecosystem changes. Using a basic experimental approach, the experimental manipulation of rainfall amounts and consecutive monitoring of soil and plant responses will produce the data needed for the two goals. We will integrate these results with modeling and landscape scale, socio-economic approaches.

(2) The Gradient, Climate Manipulations and Modes of Comparisons *or* How do we approach our goals?

Natural climatic gradients, which include environmental factors such as altitude, topography, temperature and rainfall variations provide an ideal framework for studying the effects of climate change on the structure and functioning of ecosystems and on the consequences for the economy of the region. Particularly, the steep environmental North-South gradient in Israel provides unique natural environments to test predictions regarding such effects of global climate change. This project uses a combination of descriptive approaches with experimental climate manipulations. We hypothesize that both climate gradients and local climate manipulations will exert differential effects on soil properties, water redistribution, overland flow generation, the seed bank, plant establishment, growth and reproduction amongst species and growth forms.



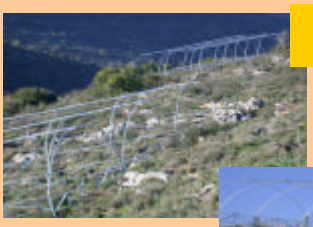
Environmental gradient - Mediterranean to desert

Topography
South-facing slopes with stony and shallow soil (Terra rossa to desert lithosol on hard limestone and chalk)

Temperature
Mean annual temperature 14^0C-23^0C

Rainfall
Mainly winter - 5 summer months with no rainfall
Range North-South: 780 to 90 mm

Experimental Design

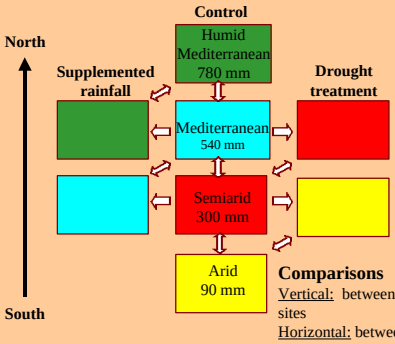


Retractable Rainout Shelters (25 x 10 m)

and:
Sprinkler Irrigated Plots
(25 x 10 m)

Climate change scenarios are experimentally tested by manipulations of rainfall amount with large-scale rainout shelters and irrigation. In the two central study sites, the responses of the ecosystem to both an increase and a decrease by 30% of natural precipitation will be studied and compared to unchanged control areas.

The experiments are designed to test whether the effects of climate change on ecosystems can be predicted by direct comparisons of current ecosystems found in differing climates (i.e., locations along gradients) or whether effects of climate change are more complex and require also experimental approaches. The combined approach of using direct comparisons of existing local climatic conditions along an aridity gradient and experimental climatic manipulations will allow refining this test.



Comparisons
Vertical: between climates and sites
Horizontal: between treatments within sites
Diagonal: between different sites with similar climates

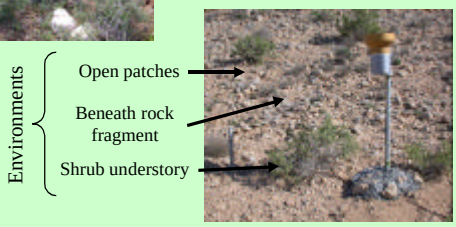
(3) Data Acquisition *or* How do we do it?

(a) Overland Flow and Soil Properties

The redistribution of "water accepting patches" and "overland flow contributing patches" as a strategy of water conservation is studied. Run-off plots at different microenvironments (under shrubs, between shrubs and combined under+between shrubs) have been installed at each of the four sites. Runoff and sediments are being collected in order to determine the specific runoff yield, runoff coefficient, sediment yield and dispersed seeds at each microenvironment.

The spatial and temporal patterns of soil properties as a controlling factor regarding natural resources losses is studied. Soil samples from different microenvironments (under shrub, between shrubs, under rock fragment and under tree) have been collected, in the summer, winter and spring, at all sites. For each soil sample, macro and micro structure, moisture content, organic matter, pH, electrical conductivity, and soluble ions (Ca, Mg, Na, K, HCO_3 and Cl) content, are determined. The soil chemical, mechanical and biological properties are being compared among the climatic regions, among climatic manipulations and among microenvironments.

Overland flow measurements



(b) Vegetation - Plant Communities and Populations

Investigations are underway to determine the effects of climate change on important traits of plant communities and plant populations.

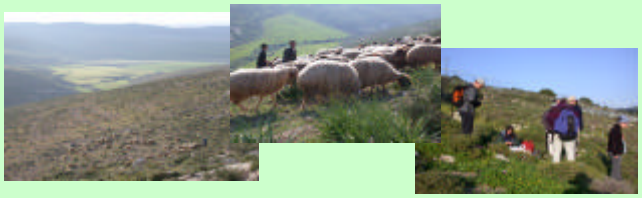
- We test whether plants are able to evolve with climate change and adjust traits related to fitness (e.g., seed dormancy and breeding systems).
- We monitor changes in the amount and composition of soil seed banks.
- We monitor changes in germination strategies, species diversity, composition, density, survival and fecundity of plants.
- We monitor changes in biomass production of annuals and dominant shrub species.

Vegetation sampling is done on permanent plots. Biomass production is determined with harvest methods.

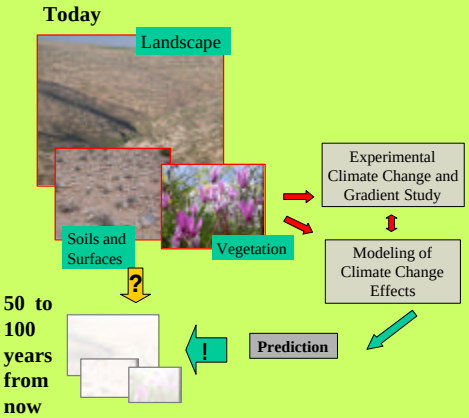
(c) Socio-Economic Evaluations

The impact of climate change on the economic value of Landscape. Open spaces and their landscapes are an important base for a variety of recreational activities. Thus, inhabitants of a region elicit utility from the landscape that can be estimated in monetary values. Climate change affects, among other things, the landscape and thus the value of utility. We estimate these changes using data on economic production potential and non-market values of different landscapes. The later will be acquired based on interviews with people seeking recreation in the outdoors. Further, photographic landscape sampling is used.

The value of open space: ways to benefit from landscapes: grazing and "plant watching".



(4) Integration *or* How do we put all this together?



Models that intend to integrate the collected data are currently outlined and planned. We are using rule-based computer simulations to integrate existing knowledge. Gaps of knowledge will be identified and addressed in experiments or surveys and their results feed back into the simulations as new rules. We start the process by modeling the soil-plant interactions of individual plants. The results of fine-scale processes are entered as rules for larger-scale simulations. We expect to end with a model simulating landscape-level vegetation dynamics and their interactions with precipitation processes and landforms with results suitable for input into a GIS.

This will put us in reach of our ultimate goal, a confident, fine-scale prediction of the geo-ecological and socio-economic ramifications of climate change.

Bar-Ilan University, Dept. of Geography **The Hebrew University of Jerusalem**, Faculty of Agriculture, Dept. of Agricultural Botany and Dept. of Agricultural Economics and Management, Faculty of Agriculture **University of Potsdam**, Dept. of Biochemistry and Biology, Section for Vegetation Ecology and Nature Conservation **Tel Aviv University**, Dept. of Plant Sciences

Contact address: Dr. Marcelo Sternberg, *MarceloS@tauex.tau.ac.il*